Grid Modernization Research at Sandia: Energy Storage

Sandia provides advanced energy storage technologies and integrated solutions for large-scale adaption of energy storage across the electricity infrastructure.

Sandia's Grid Modernization Program Vision

The electricity grid is central to the nation's infrastructure and security. Modernization of the electricity infrastructure is critical for the economic vitality and the future of the country. Sandia National Laboratories supports the national interest through advanced research in power systems, renewable generation and integration, energy storage, microgrids, cyber security, and enabling technologies including power electronics and advanced materials.

Sandia's support for this grid modernization vision includes a broad research program in energy storage technologies and systems. The laboratories' work is focused on making energy storage cost effective through research and development (R&D) in new battery technology development and advancements in power electronics and power conversion systems, improving the safety and reliability of energy storage systems, and enabling the deployment of new energy storage technologies in the electric grid. Sandia's grid energy storage research is primarily supported by the U.S. Department of Energy's (DOE) Office of Electricity Delivery and Energy Reliability – Energy Storage Program.

Energy Storage Research Areas

Energy Storage Technologies

Sandia's energy storage program addresses a range of topics in materials and systems as well as power electronics related to energy storage. Sandia researchers have addressed the high cost of membranes—a critical bottleneck in flow battery commercialization—by developing a new class of polymeric membranes with superior electrochemical properties and lower cost starting materials. Along with conducting extensive research in battery technologies, including lower temperature Na batteries and rechargeable alkaline batteries, Sandia has also developed lightweight nanocomposite materials for flywheels with increased rotational speeds.



Power Electronics

Sandia is advancing power conversion systems (PCS) for grid-tied and off-grid applications. This is driven by the development of new semiconductor switching circuits, as they determine the overall cost, reliability, and performance of the converter. Next generation PCS use advanced semiconductor materials known as wide band gap semiconductors (i.e. Silicon Carbide and Gallium Nitride) that allow for faster switching frequencies, improved voltage breakdown characteristics, and higher operating temperatures. These high voltage switches, in conjunction with advances in ceramic capacitors, controls, magnetics, and packaging, lead significant improvements in system performance through increased power density and efficiency compared to PCS systems using silicon devices.

Validated Reliability and Safety

Sandia has a significant focus on safety and reliability of grid energy storage systems. This effort includes coordinating DOE Energy Storage Systems (ESS) Safety Working Groups which bring together over 150 stakeholders from industries that range from national laboratories, electric utilities, standards organizations, and manufacturing companies. The working groups are exploring gaps in safety R&D; enabling the development of codes, standards, and regulations (CSR); and educating first responders on storage system safety. Sandia also provides workshops and organizes technical conferences, including the Energy Storage Safety Forum which is slated to become an annual technical meeting for the world wide research community.

Energy Storage Industry Acceptance and Analysis

Sandia is the lead DOE lab in the development and implementation of energy storage demonstration projects and in performance analysis of energy storage systems in the field. Sandia works with the DOE in enabling energy storage systems deployment, and supports the U.S. Department of Defense, state energy offices, utilities, industry, and universities by providing design analysis, operational evaluation, and technology verification of energy storage systems. Sandia also has developing international collaborations with entities in the European Union, Japan, and Singapore.

Sandia's role in grid-tied field demonstration projects allows DOE and the nation to understand energy storage operation in grid applications, optimization of energy storage, system reliability, and the economic impact of energy storage in different market environments.

Through the lab's battery analysis program, Sandia assesses batteries ranging from the cell level to large utility class systems. Capabilities at the lab include reconfigurable command and control to simulate various use cases; analysis of advanced inverter functionality (up to 200kW); and grid simulation to measure changes in voltage, frequency, phase imbalance, and power quality.

Regulatory Environment

Sandia supports research to enhance the regulatory environment for energy storage through a range of activities. These include estimating the value of energy storage for different applications and scenarios; developing control strategies that maximize revenue or benefit to the grid; identifying new control strategies and applications for energy storage; assessing public policy to identify and mitigate barriers for energy storage; developing standards; and evaluating projects.

Strategic Outreach

Sandia collects key information on current and future storage technologies and acts as a clearinghouse for the information so that it can be effectively disseminated among key stakeholders and the community. Outreach activities include conducting strategic communication initiatives, managing the ESS website, improving the DOE Global Energy Storage Database, updating the DOE/EPRI Energy Storage Handbook, and organizing the Peer Review meeting and the Electrical Energy Storage Applications and Technologies Conference.

Facilities

Sandia offers a network of interconnected laboratory facilities providing capabilities for real-world R&D for a variety of advanced grid technologies. The Energy Storage Systems Analysis Laboratory and its MW-scale Energy Storage Test Pad are user facilities enabling experimentation on battery cells, modules, and systems to improve performance, safety, and reliability. The Battery Abuse Testing Lab is a national center of excellence in energy storage system safety analysis. Research at this center includes studies on failure propagation phenomena, development of fire suppression methods to improve safety, and the development of high fidelity models. These facilities enable Sandia to partner with industry to remove barriers to for the large scale deployment of energy storage in the grid.



Sandia's Energy Storage Test Pad (above) and Battery Abuse Testing Lab (below)

Partnering with Sandia

Sandia's energy storage research program relies on collaboration and partnerships with a range of stakeholders, including other national laboratories, universities, electric utilities, industry, federal and state agencies, and international consortia. These partnerships help enable the rapid adaption of new design and simulation capabilities, software tools, and provide guidance for developing appropriate policy and regulatory framework.

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Sandia National Laboratories is a multi-mission laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND2016-8669 M.