U.S. DOE Office of Electricity and Energy Reliability
Energy Storage Program
at Sandia National Laboratories

Summary of Accomplishments and Impacts for FY17
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Introduction

Energy storage can play a key role in creating a resilient, reliable, and secure U.S. electric grid. Currently, grid energy storage technology is being deployed for selected applications, and further cost reductions and performance improvements are needed to make energy storage cost effective across all applications in the electricity infrastructure. Sandia National Laboratories’ Energy Storage Program 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. During FY17, Sandia executed R&D work supported by U.S. Department of Energy’s (DOE) Office of Electricity Delivery and Energy Reliability – Energy Storage Program under the leadership of Dr. Imre Gyuk. This document summarizes the impact of Sandia’s contributions through notable accomplishments, journal publications, patents, and technical conferences and presentations.

Notable Accomplishments

During this period, Sandia contributed to multiple energy storage system installations, received prestigious professional and technical recognition, including an R&D100 Green Tech Special Recognition Award, and organized the 2017 ESS Safety Forum and other technical symposium. Brief descriptions of these and other selected accomplishments are provided on pages 5 through 8.

Publications

Sandia researchers produced a large number of energy storage-related publications, including 20 published peer-reviewed journal papers and 8 Sandia technical reports. A list of publications is provided on pages 10 through 12.

Patents

Sandia’s efforts have produced a number of patents and applications on topics that include redox flow batteries, sodium ion batteries, lithium primary batteries, and control systems. Two granted patents and 12 patent applications have been filed and are listed on page 14.

Technical Conferences and Presentations

Sandia researchers were invited to talk at multiple conferences, contributed to 51 conference papers, participated in webinars and on conference panels, and organized symposiums. These technical conference contributions and additional presentations are listed on pages 16 through 22.
Notable Accomplishments
Research Updates & Accomplishments

Sandia’s Research in Ultrawide Bandgap Technology Could Help Improve the Grid
January 2017 - Sandia researchers are currently studying how ultrawide bandgap semiconductor materials could be used to create more compact and efficient power electronics, leading to higher absolute voltages for distributing power grid energy. These materials, such as AlGaN, allow devices to operate at higher voltages, frequencies, and temperatures than wide bandgap materials, such as silicon carbide (SiC) and GaN. When made into transistors, the materials have the potential to vastly improve the performance and efficiency of not only electrical power grids, but also electric vehicles, computer power supplies, and motors for such things as heating, ventilation, and air conditioning (HVAC) systems.

Sandia Joins Forces with Singapore Energy Market Authority to Develop Energy Storage System
January 2017 - Sandia’s Energy Storage Projects team within the Stationary Energy Storage Program is working with the government of Singapore’s Energy Market Authority (EMA) to help set up Singapore’s first grid energy storage test-bed. This will lead to the selection and development of three energy storage test-beds at existing electrical substations. Sandia will help develop standards and guidelines for grid integration and fire safety, assess the economic case for energy storage systems, offer guidance on the policy and regulatory frameworks, and provide periodic reports to EMA on the performance of the test systems. Sandia is working with EMA under a four-year Cooperative Research and Development Agreement sponsored by the U.S. Department of Energy’s (DOE) Office of Electricity’s Stationary Energy Storage Program managed by Dr. Imre Gyuk.

Installation of New England's Largest Battery Energy Storage System is Underway
January 2017 - With support from Sandia, NEC Energy Solutions has begun the installation and commissioning of a 2-MW, 3.9-MWh GSS® grid energy storage solution for the Sterling Municipal Light Department in Sterling, Massachusetts. Once complete, it will be the largest system of its kind installed in New England and the first utility scale project in the state. In the event of an extended grid outage due to a natural disaster, this utility scale Battery Energy Storage System can be used to power local emergency response facilities using power generated from two nearby solar plants. The system will also provide enhanced clean energy usage and cost savings to the town.
Grid-Scale Vanadium Flow Energy Storage System to be Installed in Hawaii

July 2017 - A 100kW/500kWh advanced vanadium energy storage system will be installed later this year at the Hawaii Ocean Science and Technology Park (HOST Park) administered by Natural Energy Laboratory of Hawaii Authority. Sandia will develop a test plan for the system, evaluate test results, and analyze how a flow battery performs in an island climate and on an island grid.

National Labs Partner with EPB to Energize Flow Battery in Support of Grid Modernization Efforts

On September 22, the Electric Power Board of Chattanooga, TN (EPB) energized a 100kw/400kWh Vanadium Redox Flow Battery as part of a GMLC project led by Sandia in partnership with Oak Ridge National Laboratory, Pacific Northwest National Laboratory, and UniEnergy Technologies. The battery system will be used for a wide variety of applications including solar integration, voltage regulation, back-up power, advanced microgrid operations, and energy management. EPB will work with the national labs to hone the control strategies, maximize the value proposition, and analyze the different benefits from the project. Learn more.

Awards

Sandia Receives R&D 100 Award for Precision High-Power Battery Tester

January 2017 - Sandia’s Precision High-Power Battery Tester, co-developed with Arbin Instruments, Ford Motor Co., and Montana Tech, received the 2016 Green Tech Special Recognition Award presented by R&D Magazine. The tester significantly improves battery life predictions, helping meet the growing demand for better, longer-life electrified vehicle and grid storage batteries.

Ray Byrne Named 2017 IEEE Fellow

January 2017 - Ray Byrne, Distinguished Member of the Technical Staff, has been named an IEEE Fellow for his contributions to miniature robotics and grid integration of energy storage. The IEEE Grade of Fellow is conferred by the IEEE Board of Directors upon a person with an outstanding record of accomplishments in any of the IEEE fields of interest. The total number selected in any one year cannot exceed one-tenth of one-percent of the total voting membership. IEEE Fellow is the highest grade of membership and is recognized by the technical community as a prestigious honor and an important career achievement.
Sterling Municipal Light Department Energy Storage Project wins Grid Edge Award
May 2017 - Sandia contributed to the analysis, request for proposal, and deployment of a grid energy storage system for the Sterling Municipal Light Department project that has been named as a 2017 Grid Edge Award winner by Greentech Media. This 2 MW, 3.9MWh GSS® grid energy storage system is the largest system of its kind installed in New England and the first utility scale project in the State. Using solar energy, the system can provide up to 12 days of clean backup power to critical facilities during an outage. The team will receive the award at the Grid Edge World Forum in June.

Julian Vigil receives National Science Foundation Graduate Research Fellowship
May 2017 - Julian Vigil, a student intern in Sandia’s Materials, Devices, and Energy Technologies Department, was awarded a 2017 National Science Foundation (NSF) Graduate Research Fellowship. The award was based on Vigil’s demonstrated potential to contribute to strengthening the vitality of the U.S. science and engineering enterprise. Vigil, who has worked with Sandia since his junior year of high school, researches electrochemical catalysis related to energy conversion and storage. The work is done under the supervision of Sandia researcher Timothy Lambert, with whom Vigil has co-authored seven peer-reviewed publications, including three as first author. Prior acknowledgments include the Barry Goldwater Scholarship Award, The Churchill Scholarship, and a 2016 ACS Division of Inorganic Chemistry Award for Undergraduate Research.

Jon Ihlefeld receives American Ceramics Society’s Richard M. Fulrath Award
May 2017 - Jon Ihlefeld, a Distinguished Member of the Technical Staff at Sandia, has been selected to receive the 2017 Richard M. Fulrath Award from The American Ceramics Society. Jon was selected by unanimous decision for his contributions to electronic ceramics research and development. This award recognizes individuals under the age of 45 that have demonstrated excellence in research and development in the ceramics sciences. Presented to 2 American researchers and 3 Japanese researchers annually since 1978, this award promotes technical collaboration among the diverse cultures surrounding the Pacific Rim. Dr. Ihlefeld is internationally recognized for his work on dielectric integration, funded, in-part, by the DOE Office of Electricity’s Energy Storage Program managed by Dr. Imre Gyuk; ferroelectrics, funded, in-part, by the Laboratory Directed Research Development Office at Sandia; and fast ion conductors, funded, in-part, by the Office of Nuclear Energy. The award will be presented at the 119th annual meeting of The American Ceramics Society, in Pittsburg PA, October 9th, 2017.
Sterling Energy Storage Project Selected as a Finalist for 2017 Energy Storage North America Awards
July 2017 - The Sterling Municipal Light Department (SMLD) Energy Storage Project has been selected as one of eight finalists for the 5th Annual Energy Storage North America (ESNA) Innovation Awards. The projects were selected based on their outstanding achievements in either centralized or distributed storage and their impact on the energy storage ecosystem, services supplied to customers and the grid, and unique technology application. Sandia contributed to the analysis, request for proposal, and deployment of this 2 MW, 3.9MWh GSS® grid energy storage system.

Sandia Researchers Present Best Papers at IEEE Power & Energy Society General Meeting
July 2017 - Two Sandia papers were selected to be presented as Best Conference Papers submitted to the 2017 IEEE Power & Energy Society General Meeting July 16-20 in Chicago, IL. The first was authored by Mohamed Elkhatib and Abraham Ellis, titled “Communication-assisted Impedance-based Microgrid Protection Scheme,” and presented during the session on Microgrids, Renewables, and Distributed Energy Resources. The second was authored by Felipe Wilches-Bernal, Brian Pierre, Ryan Elliott, David Schoenwald, Raymond Byrne, Jason Neely, and Daniel Trudnowski, titled “Time Delay Definitions and Characterization in the Pacific DC Intertie Wide Area Damping Controller,” and presented during the session on Power System Stability, Control, and Protection. Sandia provided a total of 16 technical presentations.

Events
Energy Storage Systems Safety Forum
May 2017 - Over 130 participants from industry, academia, national labs, the Department of Energy, Singapore, South Korea, and Canada, came together February 22-24 in Santa Fe, NM for Meeting the Challenge: 2017 ESS Safety Forum. Participants discussed the current state of energy storage system safety and mitigation strategies for improving cell to system level safety and reliability. A summary report will be generated with these findings.
Journal Publications


Patents


**Patents**

**Issued**


**Applications**


Technical Conferences and Presentations
Technical Conferences

Invited Talks


4. B. Schenkman, presented and chaired the “Long Duration Energy Storage” session, presentation title “Cordova Energy Storage”.


18. S. Atcitty, Keynote address signifying success as an American Indian professional at a National Laboratory and student mentorship, Shiprock High School Graduation Commencement, May 2017.


Conference Papers


**Award Winning Conference Papers**


Invited Conference Panels


2. R. H. Byrne, panel member on “Impacts of Rate Structure on Storage Margins and ROI”, 2017 Storage Week, Oakland, CA, February 2017.


Organization of Symposia


4. S. Ferreira: Chair and organizer of ESS Safety Forum: Meeting the Challenge two-day workshop and half-day ESS Safety Working group meeting, Santa Fe NM, MRS Endorsed event, February 2017.


Additional Presentations

Tutorials/Webinars


**Seminar Presentations**


**Technical Briefing to Industry**

1. B. Schenkman, presented “Energy Storage and Energy Security” to the following:
   a) Gil’s River Indian Community Utility Authority
   b) Eastern Band Cherokee Indian Council
   c) Taos Water Treatment Plant

2. S. Ferreira, provided RFP review of safety aspects for Massachusetts CEC proposals; developed checklist for evaluating safety of proposals and grading criteria.