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Energy storage is beginning to play a growing role in improving the reliability and resiliency of the electric grid. Currently, grid energy storage systems are being deployed for a wide range of applications. Further improvements in cost and performance metrics are needed to make energy storage cost effective across all application markets in the electricity infrastructure. The Grid Energy Storage Program at Sandia National Laboratories is focused on making energy storage cost effective through research and development (R&D) in new battery technologies, advancements in power electronics and power conversion systems, improving the safety and reliability of energy storage systems, development of analytical tools for valuation of energy storage, and validation of new energy storage technologies through demonstration projects. During the 2022 fiscal year, Sandia executed R&D work supported by the U.S. Department of Energy’s (DOE) Office of Electricity – 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.

Babu Chalamala
Program Manager, Energy Storage
Notable Accomplishments & Recognitions
During this fiscal year, Sandia contributed to multiple energy storage system installations, received prestigious professional and technical recognition, and organized multiple technical symposia. Brief descriptions of these and other selected accomplishments are provided on pages 02 through 15.

Publications
Sandia researchers produced a large number of energy storage-related publications, including 42 peer-reviewed journal papers. A list of publications is provided on pages 16 through 22.

Patents & Patent Applications
Sandia’s efforts have produced a number of patents and applications on topics that include Molten Inorganic Electrolytes, Zinc Battery with Improved Cycling from an Ion-Selective Separator, Integrated Power Converters, Distributed Energy Storage for Photovoltaic Systems, and many more. Additionally, a portfolio of patents related to membranes was licensed by Advent Technologies. One patent granted and nine additional patent applications have been filed and are listed on pages 23 through 25.

Presentations
Sandia researchers were invited to talk at multiple conferences, contributed to numerous technical presentations, participated in organizational workshops and symposia, and webinars. These technical conference contributions and additional presentations are listed on pages 31 through 46.
BATTERY MATERIALS RESEARCH

Sandia hosted the DOE Energy Storage for Manufacturing and Industrial Decarbonization (Energy StorM) Workshop in collaboration with Pacific Northwest National Laboratory, Oak Ridge National Laboratory, National Renewable Energy Laboratory, Argonne National Laboratory, Lawrence Berkeley National Laboratory, Idaho National Laboratory and Brookhaven National Laboratory. This virtual, two-day workshop brought together industry, national labs, government agencies, utilities, academia, and other stakeholders to discuss decarbonization of energy intense industrial processes and opportunities for energy storage technologies to support industrial decarbonization. Presentations and videos from the workshop are available at Energy StorM website.


Leo Small was recognized for his service as a reviewer by the Industrial and Engineering Chemistry Journal (American Chemical Society) and was named an “Outstanding Reviewer” for the fifth year in a row by RSC Advances (Royal Society of Chemistry).

Amalie Frischknecht served as the Past Chair of the Division of Polymer Physics (DPOLY) of the American Physical Society (APS) through March 2022. The Division of Polymer Physics was established in 1944 and is the second oldest division of the APS.
Stephen Percival was nominated for the 2022 Sandia Postdoc Development (SPD) Distinguished Mentorship Award for being such an excellent advisor. This award acknowledges the value that Sandia places on postdoctoral mentorship and is meant to highlight examples of outstanding mentorship by Sandia staff and managers. Stephen Percival also contributed to developing iron nitride based soft magnetic materials by developing scalable processes for synthesis of these new magnetic materials.

Ion-selective membrane development at Sandia, led by Cy Fujimoto, continued its leap toward industrial impact this year. Several of Fujimoto’s OE-supported membrane patents were licensed by Advent Technologies, an innovation-driven company in the fuel cell and hydrogen technology space. The licensed patents are:

- U.S. Patent No. 10,053,534, “Functionalization of Diels-Alder Polyphenylene Polymers” issued August 21, 2018 (SD-13592.1)
- U.S. Patent No. 10,442,887, “Functionalization of Diels-Alder Polyphenylene Polymers” issued October 15, 2019 (SD-13592.5)
- U.S. Patent No. 10,294,325, “Halo-Containing Anion Exchange Membranes and Methods Thereof” issued May 21, 2019 (SD-14264.0)
Todd Monson and his team, in collaboration with University of California at Irvine, continue to make progress in developing new magnetic cores based on iron nitride (Fe₄N) based soft magnetic materials. For advances in this technology, Sandia National Laboratories (Todd Monson, Stan Atcitty, Charles Pearce, Tyler Stevens, Melinda Hoyt, and Robert Delaney), DOE Office of Electricity (Imre Gyuk), and UC Irvine (Enrique Lavernia, Baolong Zheng, Yizhang Zhou) received R&D Magazine’s prestigious R&D 100 Award for developing iron nitride (Fe₄N) soft magnetic cores. Soft magnetic materials enable low loss inductive switching in high frequency power converters. Fe₄N can be used as the magnetic core in both inductors and solid-state transformers – a key enabling component technology for advanced power converters.

https://www.rdworldonline.com/rd-100-winners-for-2022-are-announced/

Members of the Systems Integration and Power Electronics team (Oindrilla Datta, Robert Wauneka, Jacob Mueller, Kenneth Gordon, and Valerio De Angelis) developed a modular energy storage system integration platform for rapid integration and validation of hybrid battery technologies. This open source, modular architecture allows users to rapidly test and validate new batteries and power converters and development of battery models.
The Safety and Reliability team continues to make impactful contributions to advance the reliability of commercial lithium-ion batteries. This is reflected by the fact that the following paper continues to be among the top three most-read papers of the Journal of the Electrochemical Society for two years (downloaded over 50K times):


The Safety and Reliability team initiated new research covering their foundational work evaluating the safety of solid-state batteries. Early results were published in an impactful journal article and has attracted significant reach from the battery industry. A.M. Bates, Y. Preger, L. Torre-Castro, K.L. Harrison, S.J. Harris, and J. Hewson “Safer, More Powerful Batteries for Electric Cars, Power Grid” https://newsreleases.sandia.gov/safer_batteries/.

The Safety and Reliability team initiated new research on the safety of aqueous batteries including studies on gas evolution in aqueous flow battery system. A perspective paper summarizing the industry challenges and research needs was published (R. Wittman, J. Electrochemical Society).
Lorraine Torres-Castro was the lead organizer of “Symposium EN05: Emerging Materials for Electrochemical Energy Storage Devices—Degradation and Failure Characterization—From Composition, Structure and Interfaces to Deployed Systems” at the 2022 MRS Spring Meeting & Exhibit held in Honolulu, Hawaii. The symposium brought together researchers from around the world discussing the role of interfaces, intercalation mechanisms on the degradation and failure associated with advanced electrochemical energy storage technologies, and emerging materials for improved performance, safety, sustainability, and reliability of all types of rechargeable batteries and supercapacitor devices.
NOTABLE ACCOMPLISHMENTS

ANALYTICS

In FY22, QuESt version 1.6 was released with updated python code base and an executable program. Specifically, QuESt Performance Tool was added to employ a building and HVAC model to properly size energy storage systems in extreme (hot and cold) climates. QuESt Equity Tool was also developed (currently under testing) to evaluate peaker plant replacement with storage plus solar while considering energy justice considerations (e.g., negative impacts of pollution from peaker plants in urban areas).

The Analytics team collaborated with industry partners to expand capabilities and tools for energy storage analytics. For example, collaboration with Quanta Technology resulted in a tool that adds energy storage as a key component in an integrated resource planning process. In FY22, a study in collaboration with Public Service of New Mexico (PNM) analyzed the reserve requirements to meet New Mexico's decarbonization goals and published the results in a SAND report – J.F. Ellison, C.J. Newlun, A.G. Benson “An Analysis of PNM’s Renewable Reserve Requirements to Meet New Mexico's Decarbonization Goals” May 2022, SAND2022-6704.

Through Policy and Outreach efforts, Sandia has established partnerships with state regulators and policy makers. In FY22, Outreach efforts in New Mexico led to a partnership and project with the New Mexico Public Regulation Commission (NMPRC) aimed at helping the NMPRC develop a roadmap for meeting the terms of NM’s legislative mandate to decarbonize the state's electricity. The outreach with the Illinois Commerce Commission (ICC) led to a similar modeling project aimed at helping the ICC meet stringent decarbonization goals mandated by Illinois legislation.
The Analytics team had a number of impactful publications. Examples include:


DEMONSTRATION PROJECTS

Sandia entered into a Memorandum of Understanding (MOU) with the New York State Energy Research and Development Authority (NYSERDA) to foster cooperative work on energy storage demonstrations, testing, and analysis. As part of this MOU, Sandia will assist NYSERDA in general policy areas of cooperation and joint activities including review of planned NYSERDA projects consistent with the mission of advanced research and development which includes technical support in project deployment, demonstration, and testing and commissioning activities.

Sandia entered into a Memorandum of Understanding (MOU) with the California Energy Commission (CEC) to foster cooperative work on energy storage demonstrations, testing, and analysis resulting from the CEC's Electric Program Investment Charge (EPIC). As part of this MOU, Sandia's Energy Storage Demonstration program will assist the CEC in technical review of energy storage technologies and solicitations, review of project scopes, benefits analysis, project schedules, and costs as requested. This work will serve as a mechanism for Sandia to evaluate innovative energy storage projects, applications, and technologies being implemented in a real-world environment.

Sandia began engagements with 14 underserved and disadvantaged communities in the Energy Storage for Social Equity program in preparation for the Project Development and Deployment phase of the program. In addition to the community engagements, the Demonstrations team was invited to speak at the Energy Storage Grand Challenge community of practice and Energy Storage and Energy Justice community of practice meetings.

The first of three UEP Zinc Manganese Dioxide 3kW / 13kWh demonstration battery systems for the Navajo Tribal Utility Authority (NTUA) project has been deployed and is in operation serving an off-grid single family residence on the Navajo reservation in northeast Arizona. The Urban Electric Power (UEP) system utilizes a new rechargeable zinc technology with a chemistry that is similar to that of common alkaline batteries. The deployment enables the evaluation of a new technology for application in off-grid rural communities where access to power is often limited and costly or not available at all. Sandia, UEP and NTUA will assess the performance of the technology and compare it to more common battery technologies, such as flooded lead acid batteries.
The Energy Storage Demonstration Projects team is active in projects across the county and supports utilities, state energy offices, academia, and the overall energy storage industry to proliferate the use of energy storage on the nation’s grid. The team commissioned two projects:

- **Albuquerque Public Schools (APS)**
  Sandia ES Demonstrations team, working in close collaboration with APS, commissioned a 850 kW/4 hour battery system at the APS Atrisco Heritage Academy High School. The project installed 850 kW of behind-the-meter rooftop solar PV and a 721kW / 4-hour battery energy storage system (BESS) for peak shaving and resiliency.

The Demonstrations team established a partnership with Green Mountain Power and the Vermont Electric Cooperative and executed a contract for cost-share funding and project support for the **Vermont Wind Curtailment Project**. The $2M of cost-share funding was vital to advancing this proposed project into implementation. The project will install a 3 MW / 12 MWh battery energy storage system to demonstrate the application of energy storage for storing renewable generation from the 63 MW Kingdom Community Wind generation plant that would otherwise be curtailed due to transmission constraints. Stored energy will be strategically dispatched to reduce the Vermont Electric Cooperative’s peak demand charges for monthly regional and annual New England ISO system peaks.
National Rural Electric Cooperative Association (NRECA) Rural Energy Storage Deployment Program (RESDP) Projects

The NRECA RESDP projects are a partnership between DOE OE, Sandia, PNNL, NRECA, and rural cooperatives that are installing ESS to meet the needs of their customers in terms of reliability and resiliency. The Energy Storage Demonstration Projects team provided technical assistance for sizing, economic analysis, and project development. The two remaining projects (of four) described below are in the final safety compliance and equipment procurement phase. Both are expected to be commissioned in 2023.

- **West River Electric Association (WREA) – South Dakota**
  
  This project with Ellsworth AFB will provide a battery energy storage system to a mission critical site that needs to be operated 24/7. The WREA microgrid will be paired with an existing generator. Current Codes/Standards (NFPA 855) requirements have necessitated a change in battery supplier impacting the overall project schedule. The new supplier has completed UL 9540A testing of the batteries to the module level and is in the final stages of the enclosure design to meet explosion mitigation requirements. The Demonstrations team provided guidance to both the local co-op and the supplier on how to meet Codes/Standards requirements for installation on a military site.

- **Sandhills Utility Services (SUS) – Fayetteville, NC**
  
  The Department of Defense (more specifically the Department of the Army) identified a mission critical resilience need at the Fort Bragg Army Base. An ESS microgrid will be installed on the base to provide resiliency services and power factor correction for the critical load. With guidance from the Deployments team to both the local co-op and the battery supplier, UL 9540A large-scale fire testing was completed to provide an NFPA 855 compliant ESS. Sandia involvement included safety support and reporting to DOE-OE.
POLICY & OUTREACH

The Energy Storage Outreach team (Howard Passell, Will McNamara, Marisa Montes, Dylan Poindexter) conducted a series of educational workshops for state PUCs, energy offices, and other stakeholders aimed at streamlining the adoption of energy storage and modernizing the grid. Over the course of the year, the Outreach Program helped inform hundreds of policy and decision makers across a dozen states. These workshops provided everything from introductions to Energy Storage Technologies to Cost-Benefit Analysis to Streamlining Interconnections, giving these states and policymakers the tools necessary to enact policy to enhance clean, renewable energies that lead to a modernized, decarbonized and resilient grid. The workshops series included: Illinois Commerce Commission (ICC); Microgrids & ES for Emergency Grid Resilience, in collaboration with Iowa State University’s Electric Power Research Center and FEMA Regions 5 & 7 and FEMA HQ; and a Southeast Energy Storage Workshop Series at the request of Southern Research Institute (focused on energy storage technology, economic and policy issues impacting the Southeastern U.S regulators). See the Webinars section for more details.
Babu Chalamala received significant accolades for his leadership and technical contributions. He was elected as a Fellow of the American Association for the Advancement of Science and the National Academy of Inventors. He was also selected as a Distinguished Lecturer of the IEEE Power & Energy Society, for lecturers related to energy storage and electrification. Read more at [https://www.sandia.gov/labnews/2022/02/25/sandia-engineer-elected-fellow-of-two-prestigious-national-societies/](https://www.sandia.gov/labnews/2022/02/25/sandia-engineer-elected-fellow-of-two-prestigious-national-societies/).


David Rosewater served as chair of the IEEE Working Group 2686 – Battery Management Systems in Energy Storage Applications, and Tu Nguyen has served as Vice Chair of the Vice chair of IEEE Working Group P2688 on energy storage management system. David also received the 2022 Outstanding Young Engineer Award from IEEE Albuquerque Section.

Mike Ropp served as a co-chair of the Working Group that published IEEE Standard 1547.9-2022, “IEEE Guide for Using IEEE Std 1547 for Interconnection of Energy Storage Distributed Energy Resources with Electric Power Systems.” This new standard was published August 5, 2022. Mike also co-chaired the Comment Resolution team during voting and is leading the educational effort. David Rosewater was a subgroup lead, active in content development for this standard.

Ujjwol Tamrakar was named one of the best reviewers for IEEE Transactions on Sustainable Energy journal for 2021.
There are many examples of Sandia’s support to State funding energies. State regulators are introducing renewable generation mandates that require additional energy storage capacity. Therefore, the agencies that support energy R&D projects in states are issuing RFPs for energy storage demonstrations. At the same time, the federal government is introducing several initiatives to facilitate the development of U.S.-based energy storage technologies. Sandia provides technical support for the evaluation of companies and technologies. For example, Valerio De Angelis served as reviewer for the NYSERDA program on Long Duration Energy Storage Technology and Product Development. He also served as a judge for The Clean Flight Competition. The Clean Fight is a non-profit business accelerator, supported by New Energy Nexus, NYSERDA and the Department of Energy, that identifies top growth-stage clean energy and EE startups from around the world and helps them scale in NY.
03 PUBLICATIONS
JOURNAL PUBLICATIONS


MANUSCRIPTS ACCEPTED


MANUSCRIPTS SUBMITTED

• A. Benson “Customized Predictions of the Installed Cost of Behind-the-Meter Battery Energy Storage Systems” Energy Reports.


• D. Xing, B. Hu, X. Li, Q. Cheng, J. Wang, S. Atcitty “Survey and Comparison of Modular Multilevel Converter Based High Voltage-Step-Down Ratio DC/DC Converters” IEEE Transactions on Power Electronics.

OTHER PUBLICATIONS


- M. Kim “Low-Cost MnO₂ Intercalation Cathodes Enabled by Using Bismuth as a Pillaring Agent” PhD Dissertation, Department of Chemical Engineering, Northeastern University, May 2020.


- Yuliya Preger, R. Fioravanti, K. Kumar, S. Nakata, B. Chalamala were invited to write “Adopting Predictive Maintenance Practices for Battery Energy Storage System Safety” for T&D World magazine. This three-part series advocates for the use of predictive maintenance of grid-scale operational battery energy storage systems as the next step in safely managing energy storage systems.

- The Sandia Energy Storage program wrote, edited, managed, and published the following chapters for the DOE Energy Storage Handbook:
  - Chapter 7: Flywheels – Don Bender

- Sandia contributed extensive writing for the “Cambridge University Press “Elements in Grid Energy Storage” series. Sandia’s contributions included:
  - “Beyond Li-ion Batteries for Grid-Scale Energy Storage” G.P. Wheeler, L. Wang, A.C. Marschilok (funded by Sandia through our partnership with Brookhaven University)
  - “Energy Storage Applications in Transmission and Distribution Grids” H. Othman (funded by Sandia through our partnership with Quanta Technologies)
  - “Li-ion Batteries” L. Torres-Castro, Y. Preger, A.M. Bates, J. McDowall, M. Abreu-Sepulveda
04 PATENTS
PATENTS

Patents Issued


Patent Applications


Sandia Technical Advances


Copyrights

- Battery Lifecycle Framework – The Battery Lifecycle Framework is an open-source package designed to import, analyze, and visualize battery data. The tool includes a web interface to import data streams and build graphs and dashboards. It also includes an API that can be used to extract the data and use it in tools like Jupyter Notebook or MATLAB. The software is the engine that runs www.batteryarchive.org – the largest repository of cycling battery data that has been visited by over 10,000 users.
CONFERENCE PROCEEDINGS


DOI: 10.1109/PESGM48719.2022.9916822.

• Z. Zhang, B. Hu, Y. Zhang, J. Wang, J. Mueller, L. Garcia Rodriguez, A. Ray, S. Atcitty “An Isolated Bidirectional DC-DC Converter with High Voltage Conversion Ratio and Reduced Output Current Ripple” IEEE 8th Workshop on Wide Bandgap Power Devices and Applications (WiPDA), Redondo Beach, CA, November 7-11, 2021,
DOI: 10.1109/WiPDA49284.2021.9645131.
06 PRESENTATIONS
INVITED TALKS

- D. Borneo, S. Schoenung “Why is Data So Important to Powering Your Community?” Isolated Power System (IPS) Connect, Cordova, AK, July 26-29, 2022.
- B.R. Chalamala “Modernization of T&D Grid – Decarbonization and Adapting to Climate Change” Hart Center for Engineering Leadership, Southern Methodist University, March 25, 2022.
- B.R. Chalamala “Modern Electronics Technology - Silicon Materials” Lyle School of Engineering, Southern Methodist University, March 25, 2022.
• B.R. Chalamala, IEEE Distinguished Lecture, Grid Modernization and Energy Storage, IEEE PES Chapter Seminar, Texas Tech University, Lubbock, TX, March 10, 2022.


• B.R. Chalamala, Panel Session on Semiconductors, Purdue Center for Tech Diplomacy, Washington, DC, November 15, 2021.


• V. De Angelis “Energy and Battery Management Systems” Texas Tech University Seminar, Electrical Engineering Department, March 10, 2022.


• A.L. Frischknecht “Morphology and Ion Transport in Hydrated Ion-Containing Polymers” American Physical Society March Meeting, Chicago, IL, March 14-18, 2022.


PRESENTATIONS


• E.D. Spoerke “Materials Chemistry in Large-Scale Energy Storage: A Key to Unlocking our ‘Potential’ Energy Future” Spring 2022 Department of Materials Science and Engineering Colloquium at The Ohio State University, January 28, 2022.


CONFERENCE PRESENTATIONS


• S. Atcitty participated as an invited panel member for the American Indian Science & Engineering Society Graduate/Industry Discussion Panel, University of New Mexico, November 30, 2021.


• S. Atcitty participated in the “Power Electronics - What to Consider in PCS technology in the Near Term?” panel session at the 2022 Energy Storage System Safety and Reliability Forum, May 4-5, 2022.


• S. Atcitty co-chaired the “Power Converters for Utility Applications” session at the Applied Power Electronics Conference and Exposition (APEC), Houston, TX, March 20-24, 2022.


• A.M. Bates co-chaired the “Emerging Energy Storage Materials — Lithium-Metal Batteries” session at the 2022 MRS Spring Meeting & Exhibit, Honolulu, HI, May 8-13, 2022.
• A.M. Bates and A. Kurzawski co-chaired the “Safety and Reliability I” session at the 2022 MRS Spring Meeting & Exhibit, Honolulu, HI, May 8-13, 2022.


• V. De Angelis participated in a “Long Duration Energy Storage Technologies” panel discussion at the Global Clean Energy Action Forum, Pittsburgh, PA, September 21-23, 2022.

• V. De Angelis co-chaired the “Novel Materials for Li-Ion Technologies” session at the 2022 MRS Spring Meeting & Exhibit, Honolulu, HI, May 8-13, 2022.

• V. De Angelis “Analyzing and Manipulating Data with the PyData Stack” part of the Introduction to Data Science for Battery Degradation tutorials, 2022 MRS Spring Meeting & Exhibit, Honolulu, HI, May 8-13, 2022.

• V. De Angelis “Battery Systems Integration and Communication” IEEE PES ESSB Committee Meeting, Gulf Shores, AL, January 24-28, 2022.

• V. De Angelis was an invited panelist on the “Non-Li Technologies and Solar Integration” session at the Southern Africa Energy Storage Systems Symposium, sponsored by the American National Standards Institute (ANSI), October 20-21, 2021.

• A.L. Frischknecht “Phase Behavior of Polymer-Grafted Nanoparticles” 2022 MRS Spring Meeting & Exhibit, Honolulu, HI, May 8-13, 2022.


• M Garcia “Sandia and UT Collaboration: Power System Resilience Investment Projects” Sandia Day at the University of Texas at Austin, Austin, TX, March 30-31, 2022.


• T. Gao, M.J. Stevens, A.L. Frischknecht, I. Nakamura “Molecular Dynamics Simulations for the Molecular Polarization of Salt-Free and Salt-Containing Liquids with Stockmayer Fluids and Ensemble Neural Networks” 2022 MRS Spring Meeting & Exhibit, Honolulu, HI, May 8-13, 2022.


• M.L. Meyerson, S. Rosenberg, S. Dickens, L.J. Small “Redox Mediated Li-S Flow Battery for Grid-Scale Energy Storage Applications” Southwest Regional Meeting of the American Chemical Society, Austin, TX, October 31 - November 3, 2021.

• J. Mueller co-chaired the “Medium Voltage Circuit Topologies and Controls” session at the Sandia Power Electronics Workshop, August 23-24, 2022.

• J. Mueller co-chaired the “Design & Control of Power Converters for Utility Applications” session at the Applied Power Electronics Conference and Exposition (APEC), Houston, TX, March 20-24, 2022.


• J. Neely co-chaired the “Devices & Components” session at the Applied Power Electronics Conference and Exposition (APEC), Houston, TX, March 20-24, 2022.


• N.B. Schorr, D.J. Arnot, A.M. Bruck, J. Gallaway, T.N. Lambert “Copper Oxide Cathodes for Rechargeable Alkaline Zinc Batteries” 2021 MRS Fall Meeting and Exhibit, November 30 - December 7, 2021.


• R. Shurtz and L. Torres-Castro co-chaired the “Characterizing Battery Degradation and Failure Modes” session at the 2022 MRS Spring Meeting & Exhibit, May 8-13, 2022.


• E.D. Spoerke and A. Maraschky co-chaired the “A03- Large Scale Na and Li Batteries” session at the 241st Electrochemical Society (ECS) Meeting, Vancouver, BC, Canada, May 29 – June 2, 2022.


• L. Torres-Castro co-chaired the following sessions at the 2022 MRS Spring Meeting & Exhibit, Honolulu, HI, May 8-13, 2022:
  • “Characterizing Degradation and Failure Modes”
  • “Emerging Energy Storage Materials II”
  • “Fast Charging II”
  • “Interphase and Interfaces”
  • “Safety and Reliability II”
  • “Thermal Characterization of Energy Storage Materials and Devices I”
  • “Thermal Characterization of Energy Storage Materials and Devices II”


• R. Wittman, M. Dubarry, S. Ivanov, J. Kustas, J. Langendorf, R. Grant, G. Taggart, B Chalamala, Y. Preger “Path Dependence of Li-Ion Battery Degradation During Cycling to 80% Capacity” 2022 MRS Spring Meeting & Exhibit, Honolulu, HI, May 8-13, 2022.

• R.M. Wittman, A. Fresquez, B. Chalamala, Y. Preger “Systematic Long-Term Cycling of 18650 Li-ion Batteries Beyond 80% Capacity” The Electrochemical Society (ECS) Fall 2021 Conference, October 10-14, 2021.

• X. Zhou, Chris Nowak, M. Foster, R. Sills, J.A. Ronevich, C. San Marchi “Machine-Learning Studies of Hydrogen Effects on Stacking Fault Energies in an Fe$_{0.70}$Ni$_{0.11}$Cr$_{0.19}$ Austenitic Stainless Steels” 2022 MRS Spring Meeting & Exhibit, Honolulu, HI, May 8-13, 2022.
TUTORIAL SESSIONS

The Government Accountability Office (GAO) has been conducting a utility-scale energy storage technology assessment. As part of this effort, Energy Storage program conducted a two-day tutorial program. This two-day series of tutorials included the following presentations:

- D. Bender “Flywheels”
- A. Bera “Pumped Hydroelectric Storage Systems”
- R. Byrne “Energy Storage Applications”
- B. Chalamala “Grid Energy Storage Technology and Applications Tutorial Session”
- V. De Angelis “Energy Storage System Integration”
- F. Farzan, R. Masiello “ESS Evaluation and Economics”
- R. Fioravanti “Summary of Long Duration Energy Storage (LDES)”
- W. McNamara “ES Regulations and Policies”
- Y. Preger “Lithium-Ion Technology”
- E.D. Spoerke “Sodium-Based Batteries”
- R. Wittman “Introduction to Redox Flow Batteries”
- B.R. Wygant, T.N. Lambert “Zinc Batteries”


Sandia team led a day-long tutorial program: Grid Energy Storage Technology and Application - Tutorial, IEEE T&D Conference and Expo, New Orleans, April 25, 2022
https://resourcecenter.ieee-pes.org/education/tutorials/PES_ED_TUT_02GEST_042522_SLD.html

Sandia teams – including Tu Nguyen, David Rosewater, and David Schoenwald – led working groups P2686 (Battery Management Systems) and P2688 (Energy Storage Management Systems) at the 2022 IEEE ESSB Summer Meeting.
ORGANIZATIONAL WORKSHOPS & SYMPOSIA

• MRS Spring Meeting & Exhibit, Honolulu, HI, May 8-13, 2022.


• Tu Nguyen, David Rosewater and David Schoenwald led working groups P2686 (Battery Management Systems) and P2688 (Energy Storage Management Systems) at the IEEE PES ESSB Summer 2022 Meeting, Sonoma, CA, June 13-17, 2022.


• Chris San Marchi co-organized the “Advanced Materials for Hydrogen and Fuel Cell Technologies” symposium at the 2021 MRS Fall Meeting and Exhibit, November 30 - December 7, 2021.


• Erik Spoerke co-organized the “Ion-Conducting Ceramics” symposium at Electronic Materials and Applications (EMA) 2022, Orlando, FL, January 19-21, 2022.

• Loraine Torres-Castro co-organized the “Emerging Materials for Electrochemical Energy Storage Devices—Degradation and Failure Characterization—From Composition, Structure and Interfaces to Deployed Systems” symposium at the 2022 MRS Spring Meeting & Exhibit, Honolulu, HI, May 8-13, 2022.
07 WEBINARS
WEBINARS

- A. Bera “Installation and Troubleshooting of QuEst” QuEst Introductory Tutorials, August 10-11, 2022.

The Energy Storage Systems Policy and Outreach Program continued its series of energy storage webinars with the Introduction to Microgrids & Energy Storage for Emergency Grid Resilience, in collaboration with Iowa State University’s Electric Power Research Center and FEMA Regions 5 & 7 and FEMA HQ. All sessions included introductory comments from Dr. Imre Gyuk. Topics included:

- November 05, 2021 – An introduction to microgrids and energy storage (ES), with Will McNamara and Summer Ferreira, and others.
- November 12, 2021 – “Stakeholder” presentations on emerging threats to the grid and the response from microgrids and ES.
November 19, 2021 – Microgrids and ES applications for resilience and energy equity, with Stan Acticly

December 03, 2021 – Microgrids an ES engineering challenges for interconnection and interoperability, including Mike Ropp and Dave Schoenwald, and others.

December 10, 2021 – Microgrids and ES for emergency grid resilience policy and regulatory topics, including Will McNamara.

The Energy Storage Systems Policy and Outreach Program continued its series of energy storage webinars with the Illinois Commerce Commission. Topics included:

- November 16, 2021 – An introduction to energy storage (ES), with Howard Passell, Will McNamara, and others.
- November 30, 2021 – A roundtable with speakers from various other states about their ES strategies.
- December 07, 2021 – Engineering details, including project development with Dan Borneo, interconnection with Mike Ropp, and others.
- December 14, 2021 – ES Benefit-Cost Analyses and ES valuation, with Howard Passell, Will McNamara, Tu Nguyen, and others.
- January 11, 2022 – Battery storage for generation and transmission/distribution deferral.

The Energy Storage Systems Policy and Outreach Program continued its series of energy storage webinars with the Southeast Energy Storage at the request of Southern Research Institute (focused on energy storage technology, economic and policy issues impacting the Southeastern U.S regulators). Topics included:

- April 05, 2022 – An introduction to energy storage (ES), with Howard Passell, Ray Byrne, and Will McNamara.
- April 19, 2022 – ES system integration, including interconnection and safety.
- May 03, 2022 – ES technology life cycle issues, including recycling and second use.