



FY23

Electric Grid Security (EGS)

Annual Report



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INTRODUCTION



Sandia's Electric Grid Security program advances a national vision of a secure, resilient, and sustainable electric system for all users. Our achievements reflect a strategic approach that combines technology development; modeling, simulation, and data analytics; and partnered demonstrations and outreach to further the adoption of advanced grid and storage technologies.

Our FY23 efforts leverage the strengths of our partnerships—spanning Sandia's core science and technology competencies as well as external technology leaders—to develop the solutions today which enable the grid of tomorrow. Our FY23 successes also include accomplishments of our dedicated staff, including [Stan Atcitty](#) and [Michael Ropp](#) being named Fellows in the Institute of Electrical and Electronics Engineers and the [election of Babu Chalamala into the National Academy of Engineering](#).

This report describes key areas of research and engagement and summarizes Sandia's contributions through notable accomplishments, journal publications, patents, and technical conferences and presentations. It is provided with the hope that readers discover ways we can further develop partnerships to create our modern grid and apply the outcomes of our efforts. The bulk of work described herein is funded by the DOE Office of Electricity and key programs within the DOE Office of Energy Efficiency and Renewable Energy.

As we indicated in our report from last year, the contributors to our successes are too numerous to name here, though our team wishes to express our deep gratitude to the numerous program and project sponsors at the US Department of Energy, who often function equally as technical collaborators; our many partners in industry, academia, utilities, and other national labs; and fellow researchers and business partners at Sandia whose leadership and creativity have enabled the accomplishments described herein.

A handwritten signature in black ink that reads "Charles Hanley". The signature is written in a cursive, flowing style.

Charles Hanley
[Electric Grid Security](#) Program Manager
Sandia National Laboratories

HIGHLIGHTS

Publications

39

Journal
Articles

42

Conference
Proceedings

8

Other
Publications

Intellectual Property Advancements

8

Patents

2

Copyrights

Presentations

83

Invited Talks

47

Conferences

33

Workshops

11

Webinars

53

Notable Accomplishments

During this fiscal year, Sandia contributed to research and development to modernize the grid and advance grid technologies, received prestigious professional and technical recognitions and organized multiple technical symposia.

89

Publications

Sandia researchers produced many grid modernization and energy storage-related publications, including over 39 journal articles.

10

Patents and Technical Advances

Sandia's efforts have produced a number of patents, technical advances, and patent applications on topics that include active damping control of inter-area oscillations, systems and methods for controlling electrical grid resources, and collaborative controls to maintain unintentional islanding standards.

174

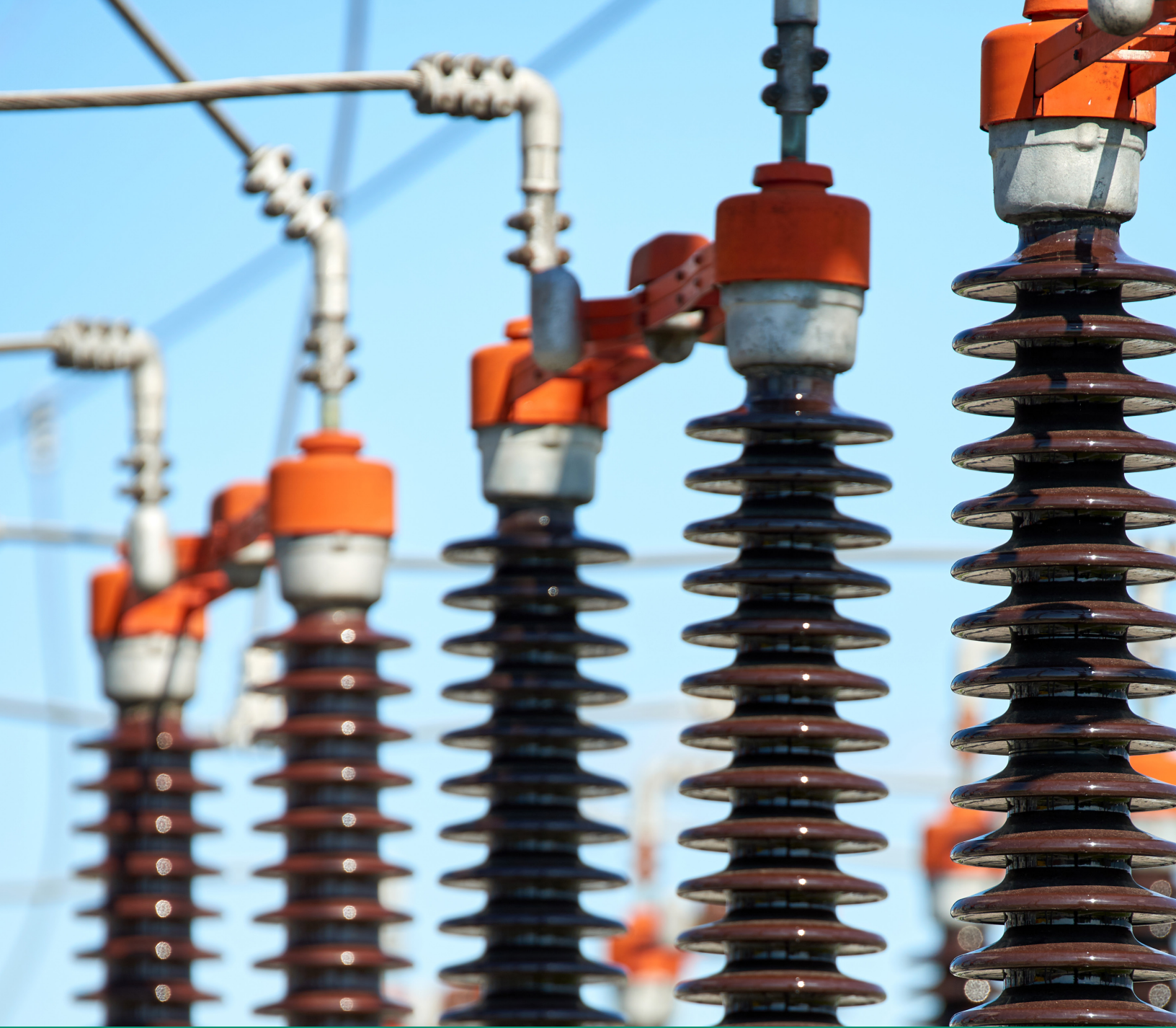
Technical Conferences & Presentations

Sandia researchers were invited to talk at multiple conferences; contributed to numerous technical presentations; and participated in conference and workshop panel leadership, symposia, and webinars.

ACRONYM LIST

Abbreviation Definition

Abbreviation	Definition
ADDSec	Artificial Diversity and Defense Security
BRIC	Building Resilient Infrastructure and Communities
CAPSec	Containerized Application Security for Industrial Control Systems
CESER	Cybersecurity, Energy Security, and Emergency Response.
CPUC	California Public Utilities Commission
CLEAP	Communities Local Energy Action Program
DETL	Distributed Energy Technologies Laboratory
DOE	Department of Energy
EEJ	Energy Equity and Environmental Justice
EERE	Energy Efficiency and Renewable Energy
ERMA	Energy Resilience for Mission Assurance
ESIG	Energy Systems Integration Group
FEMA	Federal Emergency Management Agency
GDO	Grid Deployment Office
GMLC	Grid Modernization Laboratory Consortium
HMGP	Hazard Mitigation Grad Program
HTCM	High Altitude EMP Transmission Consequence Model
IEEE	Institute of Electrical and Electronics Engineers
MOU	Memorandum of Understanding
NAATBatt	National Alliance for Advanced Transportation Batteries
NAERM	North American Energy Resilience Model
NASA	National Aeronautics and Space Administration
NRECA	National Rural Electric Cooperative Association
OE	Office of Electricity
ReNCAT	Resilient Node Cluster Analysis Tool
RTAC	Real-time automation controller
SCADA	supervisory control and data acquisition
SCE	Southern California Edison
SETO	Solar Energy Technologies Office
SSIM	Storage Sizing and Placement Simulation
WETO	Wind Energy Technologies Office
WPTO	Water Power Technologies Office



NOTABLE ACCOMPLISHMENTS



NOTABLE ACCOMPLISHMENTS

Renewable & Distributed Systems Integration

Robust DC Microgrids: Sandia developed a hierarchical supervisory control system for lunar bases that consists of feedforward and feedback control. The system is based on solving a simplified reduced order model of a lunar grid. The team implemented this supervisory control on an external controller and integrated with real-time simulation via ModBus communications. Sandia demonstrated the integrated controller hardware-in-loop simulation to NASA management and demonstrated the ability to control the system through a number of contingencies, including predicted loss of irradiance, unpredicted loss of irradiance, and unpredicted loss of asset.

Alaska Resilience Planning: Sandia and Launch Alaska finalized a microgrid sizing study for the Port of Alaska. This study utilized energy and power requirements obtained through the metering of the port main electrical interconnection and large inductive loads (cranes) and evaluated different ownership and operational models for the multi-tenant port to reduce ongoing costs for a PV + Battery system. Sandia conducted additional analysis that will eventually enable operation of critical port facilities under contingency situations.


PowerModelsONM receives R&D 100 Award: Sandia's Matt Reno and the [PowerModelsONM: Optimizing Operations of Networked Microgrids for Resilience Organizations](#) team was selected as a R&D 100 winner. The work focused on evaluating the operational and resilience benefits of systems with networked microgrids. The research was completed in partnership with Los Alamos National Laboratory, National Renewable Energy Laboratory, and the National Rural Electric Cooperative Association.

DynaGrid Dynamic Microgrids for Large-Scale DER Integration and Electrification: The DynaGrid project is developing a framework for dynamic formation and operation of networked microgrids, where the boundaries of the microgrids are designed to be dynamically adapted during operation. Sandia demonstrated self-healing protection schemes that can work for a fractal grid with distributed inverter-based generation. The scheme was shown to work without communication and restored power to the maximum number of customers under various fault scenarios.

Next-Generation Marine Energy Software Needs Assessment: A report was provided to the DOE Water Power Technologies Office (WPTO) that identifies existing software gaps and related needs and assists WPTO in planning the next wave of marine energy software development. The need for software tools to model Wave Energy Converter (WEC) arrays and their connection to the power grid was emphasized. Also, it was pointed out that there are concerns about grid integration of WECs and how energy storage systems could be used to address these concerns. The report, co-authored by the National Renewable Energy Laboratory, is available [online](#).

Protection of Low-Voltage Secondary Networked Systems: Sandia is developing new protection schemes for low-voltage spot and meshed networked systems with distributed energy resources (DER) and microgrids. Through detailed hosting capacity analysis, Sandia demonstrated how much DER can be interconnected in low-voltage networks before creating false trips on the network protectors. Working with Quanta Technology, hardware-in-the-loop simulations showed the limitations of network protectors that generally restrict interconnections of DER in low-voltage networks. New protection algorithms using negative sequence, rate of change of current, or communication will allow increased use of DERs in secondary networks, and ultimately contribute to the deployment of high-reliability, high-resilience microgrids in and with looped distribution.

GMLC-AK RADIANCE: Through the RADIANCE project, Sandia commissioned an ABB PCS100 grid-forming inverter under multiple modes of operation, including P/Q and V/f. Additionally, a SEL Real-Time Automation Microgrid controller was used to communicate with the ABB PCS100. A real-time simulation



model of Cordova, Alaska was developed, calibrated, and validated using SCADA data provided by Cordova Electric Cooperative and was adapted for Power Hardware-in-the-Loop (PHIL) experiments to test the ABB PCS100 grid-forming inverter. These experiments considered different case scenarios disconnecting various generation sources in the Cordova simulation model to study the dynamic responses of the ABB PCS100 grid-forming inverter and will inform in situ scenarios that could impact Cordova residents.

Adaptive Protection: Sandia developed adaptive protection algorithms to allow high penetrations of distributed energy resources in distribution systems and microgrids. A real-time optimization was demonstrated to determine optimal protection settings for each device to keep the system coordinated for a given state of the grid. The algorithm was released open source at <https://github.com/sandialabs/Protection-settings-optimizer>. Then, new traveling wave-based protection devices were developed using high-frequency sampling and machine learning to accurately and quickly detect faults and their locations in the distribution system. This was demonstrated in a full-scale microgrid on Kirtland Air Force Base.

Community-Oriented Pilot Initiative: Sandia is providing technical assistance to communities selected to participate in the Department of Energy's [Communities-LEAP](#) initiative. In 2023 Sandia partnered with four communities: the Iowa Tribe of Kansas and Nebraska; Bakersfield, CA; Pembroke, IL; and Minneapolis, MN and delivered energy resilience planning support and social burden evaluations. Sandia also developed several supporting open-source tools, including the open-source QGIS Social Burden Plugin, for which copyright has been secured. In partnership with the Iowa Tribe of Kansas and Nebraska, Sandia also hosted a "Train the Trainer" training session and provided the community with reference materials on ReNCAT, the QGIS Social Burden plugin, and Energy Resilience planning.

Grid Forming Consortium: In the UNIFI Grid Forming (GFM) Consortium, Sandia has led the Integration and Validation team in delivering a commissioning testing document laying out the GFM testing capabilities of UNIFI as well as a laboratory plan for evaluating GFM units. Sandia also developed a method of interfacing a voltage-source grid simulator and GFM unit for power hardware in loop measurements. This method was demonstrated and improved to achieve stability under dynamic conditions, facilitating GFM hardware in loop testing of black start and islanding operation without instability.

Social Burden Evaluation in California: Sandia partnered with the California Public Utilities Commission (CPUC) and Southern California Edison (SCE) to perform a social burden evaluation using Sandia's ReNCAT tool for equitable resilience planning in California. As a result of preliminary data and analysis collected from CPUC and SCE, this work will inform future Social Burden analysis factors. The work was also incorporated into SCE's Community Resilience Metric that includes Social Burden as an attainment factor.

Advanced Grid Modeling

Live Demonstration on Kirtland Air Force Base Microgrid: Sandia performed a live demonstration of a fault taking down a functioning microgrid on Kirtland Air Force Base. The protection device demonstrated how it could very quickly (<1 millisecond) detect the fault and de-energize the microgrid. The speed of the protection and the special discharge circuit significantly reduces the risk of fire ignition and electrical shock hazards for people. This work is done in partnership with Emera Technologies, owners of the microgrid system.

Frontiers in AI for Science, Security and Technology: Sandia provided planning support and key contributions to an upcoming Department of Energy Office of Artificial Intelligence report for the Frontiers in AI for Science, Security and Technology (FASST) initiative. The initial use case for the initiative focused on the electric grid.

Energy Resilience for Mission Assurance (ERMA): The Energy Resilience for Mission Assurance (ERMA) project completed a multi-infrastructure resilience analysis on Coast Guard Base Kodiak. Teams from five different national laboratories and several civilian organizations simulated power, water, steam, communications, and building infrastructures and used the results to relate infrastructure resilience to base level mission assurance. The process and results have significantly impacted base operations and plans for capital investments going forward.

Open-Source Code to Detect Electrical Phase Changes and Group Customers by Service: Sandia released [open-source code to the Sandia GitHub](#) for an online algorithm that detects changes to customer electrical phase in power grid distribution systems. Sandia also released a second version of the distribution system model calibration algorithm that groups customers by service transformer. The updated version released open-source to the Sandia Github, has different input data requirements determined to be a better option for National Rural Electric Cooperative Association member utilities.

Small-Signal Stability Webinar with Industry: Sandia co-organized a Western Electricity Coordinating Council webinar with Pacific Northwest National Laboratory to share new findings on small-signal stability with industry stakeholders. Sandia research that, for the first time, comprehensively identified the interaction paths associated with the North American western electric interconnection system's inter-area modes.


Grid Security

Containerized Application Security for Industrial Control Systems (CAPSec): Sandia completed a final report for the integration of the Artificial Diversity and Defense Security (ADDSec), CAPSec, and Survivable Industrial Control Systems (ICS) projects. ADDSec focuses on automatically detecting and responding to cyber threats within Operational Technology (OT) environments. The detection techniques are based on machine learning algorithms and the responses are based on moving target defense strategies. The objective of the Survivable ICS project is to detect both cyber and physical based threats within OT environments. The cyber-physical threats are detected using a combination of machine learning algorithms and modeling and simulation tools to detect deviations in the physical environment and the modeled environment. The report was submitted to the Department of Energy (DOE) and showed that automated detection and response can be combined with live updates without operational impacts of OT networks. Findings identified in this report highlight energy sector implementations to leverage Sandia research and develop more secure environments.

ESSec Commercial Application: Using Energy Storage Lab capabilities, Sandia completed live-updates using Docker containers within the commercial SEL-3355 RTAC industrial computer. As a result of this project, users can now use the software developed for the ESSec project and directly apply the capabilities on commercially available software. The team is also drafting a report that will allow utilities to replicate the process to run their own software on a real-time automation controller or equivalent.

Byzantine Security Grid Modernization Laboratory Consortium: Sandia completed the Byzantine Security evaluation of fault tolerant algorithms and the corresponding assessment report, including a live demonstration of the security work. As a result of the evaluation, several security findings were identified and the Sandia team provided mitigation strategies so that the fault tolerant algorithms can be deployed without risk of becoming compromised.

Survivable ICS: The objective of the Survivable Industrial Control Systems (ICS) project is to detect both cyber and physical based threats within Operational Technology (OT) environments. The cyber-physical threats are detected using a combination of machine learning algorithms and modeling and simulation tools to detect deviations in the physical environment and the modeled environment. The Survivable



ICS technology, including Internet Protocol (IP) randomization and port randomization, was deployed within Sandia's Distributed Energy Technologies Laboratory (DETL). Sandia also installed Schweitzer Engineering Laboratories (SEL)-2740 switches, a Ryu Software Defined Networking (SDN) controller, and Artificial Diversity and Defense Security (ADDSec) technology into the DETL laboratory environment. The Survivable ICS and ADSec technologies can detect and respond to cyber threats at the early stages of an attack. As a result, cyber-physical attacks can be prevented and better situational awareness is provided to operational staff who manage the network.

Papers Published on DOE Website: Sandia, in collaboration with Oak Ridge National Laboratory, Idaho National Laboratory, Pacific Northwest National Laboratory, and DOE Office of Electricity, had two white papers titled “Secure Communications Interoperability Challenges in the Power Grid” and “Power Grid and Communications Interdependencies” published on the DOE website. These paper publications showcase Sandia's electric grid communications capabilities.

Defense Energy

Gap-filling E1 Arrestor Prototype Advancement: Sandia successfully demonstrated an E1 arrestor prototype operation for medium- to high-voltage distribution-class applications. This work proves that the arrestor successfully actuates with <10-ns response time in response to 5 kV conducted E1 insult. The prototype has the potential to operate at higher voltages as well and could eventually be developed for commercialization to act as a valid electromagnetic pulse mitigation technology that can be adopted by utilities.

Electromagnetic Pulse Vulnerability Test Resource: As part of an NNSA-funded project complementing the DOE CESER Lab Award efforts, this work commissioned an RS105 radiated susceptibility test capability as defined by MIL-STD-461 inside the 4.5 m Gigahertz Transverse Electromagnetic (GTEM) test facility. This effort involved reconfiguring the source and feed structures of the GTEM to generate a radiated waveform in the test volume that aligns with early-time high-altitude EMP signals. While a planned concurrent EMP vulnerability test was not able to be completed, the RS105 capability was successfully commissioned and will serve as an EMP vulnerability test resource for grid components and device qualification in the future.

Energy Storage Technologies & Systems

The following achievements are summarized from the report, *U.S. DOE Office of Electricity Energy Storage Program at Sandia National Laboratories: Summary of Accomplishments and Impacts for FY23*. For more details and information, refer to the complete report.

Battery Materials Research

DOE Storage Innovations Leadership Team: Sandia's staff served on the [DOE Storage Innovations \(SI\) 2030 Leadership Team](#), leading the [Lithium-ion Batteries Flight Paths Listening Session \(DOE Technology Strategy Assessment for Zinc Batteries\)](#) and the [Na-batteries Flight Paths Listening Session \(DOE Technology Strategy Assessment for Sodium Batteries\)](#).

U.S.-India Energy Storage Webinar Series: As part of an Energy Storage Task Force, members of Sandia, the DOE Office of Electricity, Pacific Northwest National Laboratory, and DOE Office of International Affairs, created a [U.S.-India Webinar Series on Energy Storage](#). These seminars, jointly held between the India Energy Storage Association and the U.S. Department of Energy, are part of a series put forth under the auspices of the U.S.-India Strategic Clean Energy Partnership.

Supercapacitors Flight Paths Listening Session: Sandia and Idaho National Laboratory co-organized the Supercapacitors Flight Paths Listening Session for the [DOE Storage Innovations \(SI\) 2030](#), organizing

and leading the assembly of industry experts from across the Supercapacitor community for a DOE-sponsored listening session about challenges and opportunities in Supercapacitor development. Sandia also co-authored the [DOE Technology Strategy Assessment for Supercapacitors](#).

Power Electronics

2022 R&D Award: Iron Nitride Soft Magnetics received the 2022 R&D 100 Award in the Process/Prototyping category. Sandia and researchers at UC Irvine showed that Iron nitride (Fe₄N) is a high magnetization (1.89 T) and resistivity (200 μΩ•m) soft magnetic alloy capable of operating at temperatures exceeding 200 °C. Fe₄N will increase the efficiency of smart grid power electronics, transformers, and electric machines while reducing their size and weight by an order of magnitude. Read more at <https://www.rdworldonline.com/rd-100-2022-winner/iron-nitride-soft-magnetics/>.

Large Power Transformers Report: Sandia contributed to a report on Large Power Transformers (LPTs) to the DOE Grid Deployment Office (GDO). The key purpose is to update Congress on the vulnerability of the North American power grid to the loss of LPTs. The final report was delivered to the GDO on August 31, 2023.

Safety and Reliability

2023 Energy Storage Safety & Reliability Forum: Sandia successfully organized and held the [2023 Energy Storage Safety & Reliability Forum](#) for the DOE Office of Electricity June 6-8 in Santa Fe, NM. The Energy Storage program sponsored the first forum in 2016 after recognizing that energy storage was proliferating and stakeholders across the industry needed to share best practices for safe and reliable operation. Attendees span academia, policymakers, manufacturers, utilities, and first responders. This year, the forum had the highest attendance ever.

Analytics

QuEST Version 2.0: [QuEST has evolved to version 2.0](#), an open-source platform that offers centralized access to multiple tools and improved data analytics. It aims to simplify ES analysis, democratize access to tools, aligning with the goals of the DOE's Energy Storage Program. The main components of QuEST 2.0 platform include: 1) QuEST Application Hub: acts as an app store that provides access all applications developed by independent developers, 2) QuEST Workspace: provides an environment for integrating multiple applications within a work process; streamlines the process of connecting different tools; enhances efficiency and analysis capabilities, and 3) QuEST GPT: utilizes generative AI to perform more advanced data analytics, providing deeper insights from diverse data sources.

QuEST Equity Release: QuEST Equity has been released as an open-source software tool. The software is built off the QuEST python platform and enables analysts, regulators, and community interests to assess the energy equity and environmental justice of certain energy storage projects. The initial functionality included in release version: 1.0 allows the user to calculate how big a battery and how much PV would be required to replace the output of a given powerplant under specific assumptions. This, in turn, enables the estimation of the health and climate impacts, through the [EPA's COBRA tool](#), from the powerplant's early retirement and hence a social net present value for the potential investment. The analysis also looks at how much of the health benefits would go to disadvantaged and low-income communities. The open-source code can be downloaded from the [Sandia GitHub repository](#).

Storage Sizing and Placement Simulation (SSIM) software: The Storage Sizing and Placement Simulation (SSIM) software helps a distribution system or microgrid operator interested in adding energy storage decide how many batteries are needed, how big they should be, and where they should be located. After a copyright was asserted for the open-source product, the team distributed the first alpha release to a select group of storage program participants to begin the process of gathering feedback.

SSIM will help users define reliability characteristics for grid components and optimize both sizing and placement of storage elements, and the ability to do so over many measures of solution quality (grid physics, cost, load service, operations, etc.).

Demonstration Projects

UEP Zinc Manganese Dioxide (ZnMnO₂) Demonstration Battery Systems: The first deployment of Urban Electric Power's (UEP) Zinc Manganese Dioxide (ZnMnO₂) demonstration battery systems in partnership with the Navajo Tribal Utility Authority has concluded after a year of operation. The experimental ZnMnO₂ system was deployed as a first of its kind in an off-grid application serving a remote home on the Navajo reservation. The UEP system utilizes a new rechargeable zinc technology with a chemistry like that of common alkaline batteries. The deployment allowed UEP to demonstrate use of these batteries in this type of role and assess design improvements for this type of operational environment to optimize performance for future deployments. The lessons learned for this deployment will be incorporated into a second deployment on the Navajo Nation planned for FY24.

Energy Storage Demonstration Projects Team MOU: The Energy Storage Demonstration Projects Team entered a Memorandum of Understanding (MOU) with ITC Holdings Corp. (ITC) to foster cooperative work and information sharing on their Project Starlight energy storage project. Project Starlight was a hybrid flow/li-ion battery system that represents a unique opportunity to perform data analytics, in combination with ITC's operational knowledge, of precursors to known failure events that occurred during the operational lifetime of the system (flow battery portion was decommissioned in 2022).

New York State Energy Research and Development Authority MOU: Sandia has a signed MOU with the New York State Energy Research and Development Authority (NYSERDA) that provides technical assistance and support in the following areas 1) NY Governor's inter-agency fire safety task force to ensure the safety and security of energy storage systems across the state and 2) Technical assistance for developing Long Duration Energy Storage (LDES) markets, policies, and demonstration projects.

Codes, Standards, and Regulation Development: Deploying energy storage systems provides the experience necessary for members of the Energy Storage Demonstration Team to lead and support the development of Codes, Standards, and Regulations (CSRs). In 2023 Demonstration Team members lead and provided input to two EPRI Energy Storage and Integration Council (EPRI ESIC) publicly available guides; 1) "Electrical Energy Storage Data Submission Guidelines, Version 3", published in February 2023 and available both through ESIC and as a Sandia SAND publication, and the 2) "ESIC Energy Storage Commissioning Guide", published in May 2023 and available through ESIC.

Sandia's Energy Storage Demonstration Projects team active projects: Sandia's Energy Storage Demonstration Projects team is active in projects across the country 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. Project locations include: the Municipality of Villalba; St. Mary's and Mountain Village, Alaska; Troy, Vermont; and Ellsworth Air Force Base.

Policy & Outreach

Federal Emergency Management Agency Webinars: Sandia completed a series of webinars customized for the Federal Emergency Management Agency (FEMA), entitled "Energy Storage and Microgrids for Energy Resilience and Reliability." The four weekly sessions were structured as follows: Session 1: Introduction to Microgrids; Session 2: Energy Storage & Microgrid Success Stories; Session 3: Energy Storage and Microgrids in Puerto Rico and California; and Session 4: Q&A Panel: Obtaining Building Resilient Infrastructure and Communities (BRIC), Hazard Mitigation Grad Program (HMGP), and

DOE Funding.

Illinois Commerce Commission Analysis: An educational webinar series that took place in 2022 led to a further engagement with the Illinois Commerce Commission, focusing on an analytical modeling exercise to assess the minimum amount of energy storage required to adequately serve load in a system where fossil fuel generators are being replaced by renewable energy resources over the next two decades. The analytical modeling resulted in a public SAND report, "[Energy Storage & Decarbonization Analysis for Energy Regulators — Illinois MISO Zone 4 Case Study](#)" that was provided to the Illinois Commerce Commission.

Decarbonization Report: In February 2023, Sandia published "[States Energy Storage Policy – Best Practices for Decarbonization](#)" a report on state regulatory best practices for decarbonization. Written and published as a collaboration between Sandia and Clean Energy States Alliance (CESA), the report, unprecedented in the industry, compiled survey results from states developing energy storage policies to support aggressive decarbonization goals. The survey responses validated that supportive state policies are essential for building energy storage markets.

Standards

Standards Education: Sandia continues educational efforts around [IEEE Std 1547.9-2022, "IEEE Guide for Using IEEE Std 1547 for Interconnection of Energy Storage Distributed Energy Resources with Electric Power Systems"](#), including presentations at Distributech (February 2023) and the IEEE Power and Energy Society General Meeting (July 2023). This work helps establish the U.S. as the global leader in energy storage by developing the first and best set of requirements and recommendations around battery management, energy storage management, and energy storage interconnection. Since its publication in June 2022, 1547.9 has been downloaded over 3,000 times.

2023 IEEE Standards Association Emerging Technology Award: The IEEE Std 1547.9-2022 Working Group won the 2023 IEEE Standards Association Emerging Technology Award. This award is presented to "...an individual, working group, or company that has advanced, initiated, or progressed a new technology within the IEEE SA open consensus process...". Michael Ropp of Sandia, co-chair of the Working Group, accepted the award on the group's behalf.


Other Achievements & Recognitions

Microgrid Program Review: Sandia hosted the DOE Office of Electricity Microgrid Program Review February 21 and 22 in Albuquerque, NM. The review highlighted Sandia's microgrid research and development capabilities, along with those of several partner national labs and universities.

New DETL Virtual Tour: Sandia created a new a virtual tour video of the Distributed Energy Technologies Laboratory. The tour will help citizens, partners, and customers better understand Sandia's distributed energy research capabilities. View the tour [here](#).

Marine Energy Research Facility: Sandia submitted a request to the DOE-funded Testing Expertise and Access for Marine Energy Research (TEAMER) program to have Distributed Energy Technology Laboratory (DETL) registered and featured as a facility for marine energy research. Applicants to TEAMER funds can now [request to use DETL](#) and partner with Sandia to do research in marine energy.

IEEE Best Technical Paper: Dave Schoenwald won The Best Technical Paper Award at the IEEE Electrical Energy Storage Applications and Technologies conference for his paper on Recommended Practice for Energy Storage Management Systems in Grid Applications.



IEEE Emerging Technology Award: The IEEE P2800 standard development committee, [received an IEEE Emerging Technology Award](#) on December 4, 2022 for the development of uniform technical requirements applied to inverter-based generation resources interconnecting with electric transmission and sub-transmission systems. The working group included more than 175 subject matter experts and was vice-chaired by Sandia's Ross Guttromson.

Energy Systems Integration Group (ESIG) Excellence Award: Sandia's Ross Guttromson received an Energy Systems Integration Group (ESIG) Excellence Award for his work as Vice Chair in the development of IEEE Standard *P2800 "IEEE Standard for Interconnection and Interoperability of Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems"*. The award was presented at the ESIG Spring Technical Workshop in Tucson, AZ on March 28th, 2023.

Energy Systems Integration Group (ESIG) Excellence Award: Babu Chalamala received the Energy Systems Integration Group (ESIG) Excellence Award for technical contributions and leadership in grid energy storage technology and service to the science and engineering community, March 2023.

Certificate of Appreciation for Industry Leadership: Babu Chalamala received a Certificate of Appreciation for Industry Leadership from the IEEE Power & Energy Society, Industry Technical Leadership Committee, July 19, 2023.

Excellence in Review award: Stephen Percival received an "Excellence in Review" award from the [Industrial and Engineering Chemistry Research journal](#).

DOE Joint Strategy Team for Batteries: Erik Spoerke was selected to serve as a Sandia representative on the DOE Joint Strategy Team (JST) for Batteries. Commissioned by DOE Deputy Secretary David Turk, JSTs are essentially a higher-level version of cross-office coordination and are tasked to develop an overarching, multi-year DOE strategy in key areas. Erik will lead the lead the DOE Battery JST with Eric Hsieh, Deputy Assistant Secretary for Energy Storage at DOE.

New Approaches and Advances in Electrochemical Energy Systems Symposium: Loraine Torres-Castro co-organized Symposium A01: New Approaches and Advances in Electrochemical Energy Systems at the 243rd Electrochemical Society Meeting held in Boston, MA on May 28-June 2, 2023.

Symposium A01 focuses on "outside the box" approaches and developments in materials, components, and systems for addressing the grand challenges in electrochemical energy systems. Of particular interest are innovations in materials, methods, designs, and analytical strategies for energy storage, conversion, and transmission technologies, not limited to fuel cells, batteries, capacitors, and photovoltaics. The symposium had over 100 papers accepted for oral and poster presentations.



PUBLICATIONS

PUBLICATIONS

Journal Publications

Renewable & Distributed Systems Integration

Jones, B., C. Bresloff, R. Darbali-Zamora, "Electric Grid Vulnerability Analysis to Identify Communities Prone to Wildfires," *IEEE Access*, March 2023. DOI: [10.1109/ACCESS.2023.3256980](https://doi.org/10.1109/ACCESS.2023.3256980).

Jones, B., W. Vining, W., T. Haines, "Spatial Adoption Forecast Methodology for Photovoltaic Systems Throughout a City". *Elsevier Sustainable Cities and Society*, June 2023. DOI: <https://doi.org/10.1016/j.scs.2023.104430>.

McCarty, M., J. Johnson, B. Richardson, C. Rieger, R. Cooley, J. Gentle, B. Rothwell, T. Phillips, B. Novak, M. Culler, B. Wright, "Cybersecurity Resilience Demonstration for Wind Energy Sites in Co-Simulation Environment," *IEEE Access*, 2023. DOI: [10.1109/ACCESS.2023.3244778](https://doi.org/10.1109/ACCESS.2023.3244778).

Advanced Grid Modeling

Galarza-Jimenez, F., D. Ochoa, F. Wilches-Bernal, D. Schoenwald, J. Poveda, "Control Systems for Low-Inertia Power Grids: A Survey on Virtual Power Plants," *IEEE Access*, 2023. DOI: <https://doi.org/10.1109/ACCESS.2023.3249151>.

Gilletly, S., N. Jackson, A. Staid, "Evaluating the impact of wildfire smoke on solar photovoltaic production," *Applied Energy*, 2023. <https://doi.org/10.1016/j.apenergy.2023.121303>.

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Defense Energy

Donnelly, T.J., D. Wilson, R. Robinett III, "Top-Down Control Design Strategy for Electric Power Grid EMP (E3) Protection," 2023 IEEE Texas Power and Energy Conference (TPEC), College Station, TX, USA, 13-14 February 2023, DOI: [10.1109/TPEC56611.2023.10078616](https://doi.org/10.1109/TPEC56611.2023.10078616).

Accepted Manuscripts

Energy Storage Technologies & Systems

D'Ambrose, M.J., D.E. Turney, M.N. Nyce, T.N. Lambert, S. Banerjee, G.G. Yadav "Cost-effective Performance Improvement for the Industrial-design Zn Alkaline Anode" ACS Appl. Energy Mater. 2023.

Other Publications

Renewable & Distributed Systems Integration

Johnson, J., "Cybersecurity for Electric Vehicle Charging Infrastructure," SAND2022-9315 cited in Wall Street Journal, "Could Electric Vehicles Be Hacked? Cybersecurity experts warn that EVs will be ripe targets for hackers unless more attention is paid to the risks," Bart Ziegler, Feb. 14, 2023, <https://www.wsj.com/articles/could-electric-vehicles-be-hacked-71a543e3>.

Energy Storage Technologies & Systems

Clark, W.T., H. Guan, B. Schenkman, S. Schoenung “U.S. DOE Energy Storage Handbook, Chapter 22 – Energy Storage Deployment & Lessons Learned” Available: <https://www.sandia.gov/ess/publications/doe-oe-resources/eshb>.

Clark, W., Y. Preger, R.D. Trevizan, V. De Angelis, D. Rosewater, S. Willard, C. Cooper, P. Ip, J. Thompson, L. Srinivasan, M. Smith “Electrical Energy Storage Data Submission Guidelines, Version 3” February 2023, [SAND2023-12079](#).

Ditch, B., D. Zeng, J.C. Hewson, “Lithium-ion Batteries and Energy Storage Systems” in [SFPE Handbook for Fire Protection Engineers](#), Ch 9-9, to be published 2023.

Flicker, J.D., L.A. Garcia Rodriguez, J. Mueller, L. Gill, J.C. Neely, E. Schrock, H.P. Hjalmarson, E. Bellotti, P.A. Schultz, J.M. Lehr, G. Pickrell, R. Kaplar “[Light-Triggered Solid-State Circuit Breaker for DC Electrical Systems](#)” In: *Power Systems*, Springer, ISSN 1612-1287.

McNamara, W., H. Passell, T. Olinsky-Paul “States Energy Storage Policy: Best Practices for Decarbonization” Jointly published by Sandia National Laboratories and the Clean Energy States Alliance. February 2023, [SAND2023-125200](#).

Reno, M., M. Ropp, U. Tamrakar, J.A. Hernandez, R. Darbali-Zamora, A. Summer, R. Broderick, D. Lovelady, E. L. Seiter, P. Barker “Designing Resilient Communities: Hardware Demonstration of Resilience Nodes Concept” December 2022, [SAND2022-17004](#).

Grid Security

Sangoleye, F., J. Johnson, A. Chavez, E. Tsiropoulou, N. Marton, C. Hentz, A. Yannarelli, “Networked Microgrid Cybersecurity Architecture Design Guide: A New Jersey TRANSITGRID Use Case”. United States: N. p., 2022. DOI: <https://doi.org/10.2172/1900087>.



INTELLECTUAL PROPERTY ADVANCEMENTS



INTELLECTUAL PROPERTY ADVANCEMENTS

Patents

Energy Storage Technologies & Systems

Bock, J.A., E.D. Spoerke, H.J. Brown-Shaklee, L.J. Small "Solution-Assisted Densification of NaSICON Ceramics" Patent No. [11,600,856 B2](#). Date of Patent: 2023-03-07.

Fujimoto, C., E. Baca "Ion Selective Membranes for Redox Flow Batteries" Patent No. [11600838](#). Date of Patent: 2023-03-07.

Gill, L., L.A. Garcia Rodriguez, J. Mueller, J.C. Neely "High Voltage Switch with Cascaded Transistor Topology" Patent No. 11,728,804. Date of Patent: 2023-08-15.

Lavernia, E.J., B. Zheng, Y. Zhou, T.C. Monson "Isostatic Pressure Spark Plasma Sintering (IP-SPS) Net Shaping of Components Using Nanostructured Materials" Application No. 17/909,301. Filed: 2023-03-03.

Maraschky, A.M., M.L. Meyerson, S.J. Percival, E.D. Spoerke, L.J. Small "Bi-material Electrode for Molten Sodium Batteries" Application No. 63/420,515. Filed: 2022-10-28.

Maraschky, A.M., M.L. Meyerson, S.J. Percival, E.D. Spoerke, L.J. Small "Passive Gas Phase Cell Balancing for Molten Salt Batteries" Application No. 63/449,093, Filed: 2023-03-01.

Spoerke, E.D., M.M. Gross, S.J. Percival, M.A. Rodriguez, and L.J. Small "Sodium Electrochemical Interfaces with NaSICON-Type Ceramics" Patent No. [11,545,723 B2](#). Date of Patent: 2023-01-03.

Spoerke, E.D., M.M. Gross, S.J. Percival, and L.J. Small "Method to Improve Sodium Electrochemical Interfaces of Sodium Ion-Conducting Ceramics" Application No. 18/092,373. Filed: 2023-01-02.

Copyrights

Renewable & Distributed Systems Integration

Hart, O., E. Moog "QGIS Social Burden Plugin" ©National Technology and Engineering Solutions of Sandia, LLC (NTESS), 2023.
Open-Source Software, SCR# 2933.0

Energy Storage Technologies & Systems

Vining, W., J. Eddy, U. Tamrakar, "Energy Storage Sizing, Placement, and Valuation for Distribution Networks" ©National Technology and Engineering Solutions of Sandia, LLC (NTESS), 2023.
Open-Source Software, SCR# 2847.0



PRESENTATIONS



PRESENTATIONS

Invited Talks

Renewable & Distributed Systems Integration

Wachtel, A., "Mathematical Analysis and Decision Scientist", Sandia National Laboratories, C.P Smith visit, Albuquerque, NM, March 2023.

Darbali, R., "Wind Hybrid Integration Platform (WHIP) Project", 2023 Distributed Wind Energy Association (DWEA), Residence Inn Arlington Capital View, Virginia, Feb. 27, 2023.

Darbali, R "Approaches for Accelerating Power Converter Certification", 2023 Distributed Wind Energy Association (DWEA), Residence Inn Arlington Capital View, Virginia, Feb. 28, 2023.

Darbali-Zamora, R., A. Wachtel, M. Lave, E. Aponte, "FEMA's Public Relations Team in Puerto Rico," University of Puerto Rico, Mayaguez, March 30, 2023.

Johnson, J., B. Wright, "Protecting Wind Energy Systems from Cyber Threats" uploaded to Renewable Energy and Cybersecurity Video Streams. This promoted the recently released results from a 3-year DOE WETO Wind Cybersecurity project.

Advanced Grid Modeling

Elliott, R.T, "Multichannel Modal Analysis of Ringdowns," University of Wyoming Mini-Conference on Power System Oscillations, Laramie, Wyoming, October 2022.

Elliott, R. T., J. Follum, "WECC Oscillation Modes Report Update," NERC Synchronized Measurements Working Group (SMWG) Meeting, Charlotte, October 2022.

Hernandez-Alvidrez, J., M. Jimenez-Aparicio, M. Reno "Testing Double-Ended Traveling-Wave Protection Schemes in Distribution Systems" at Power & Energy Society (PES) General Meeting in Orlando, FL July 16-20, 2023.

Hosseinpour, H., L.Matzen, K.Divis, S. Castro, L. Padilla, "Examining the limits of small multiples: Set size impacts accuracy in line graph judgments," Gordon Research Conference on Visualization in Science and Education, Lewiston, Maine, July 2023.

Jimenez- Aparicio, M., M. J. Reno, J. Hernandez-Alvidrez, "Fast Traveling Wave Detection and Identification Method for Power Distribution Systems Using the Discrete Wavelet Transform". 2023 Innovative Smart Grid Technologies North America (ISGT NA), Washington D.C., USA, Feb. 2023.

Matzen, L., "Investigations of the Impact of Information about Uncertainty on Human Decision Making," PNNL Human Factors Workshop, Richland, Washington, May 2023.

Pierre B., "Protection and Control: Smart Grid Initiatives at Sandia National Laboratories," invited talk on panel session: "Challenges and Opportunities in Smart Grid: A Pragmatic View," IEEE Integrated Smart Grid Technologies Latin America (ISGT LA), San Juan, Puerto Rico, Nov. 2023.

Pierre B., "Engaging MSI Students to Enhance Power Engineering Research and Education Towards Sustainable Energy Workforce: Sandia Laboratories' Experience," invited talk on panel session: "Role of Minority Serving Institutions (MSIs) on Power and Energy Research and Education." 2023 IEEE Power and Energy Society General Meeting (PES GM), Orlando, Florida, USA, July 2023.

Pierre B., "Multi-objective Grid Planning Frameworks and Analysis," Invited Panel Talk for 2023 Innovative Smart Grid Technologies North America (ISGT NA), Washington D.C., USA, Feb. 2023.

Pierre, B., "Sandia National Labs CREPES Program and Grid Modernization Program," 2nd Annual Consortium of Research and Education for Power and Energy Systems (CREPES) Workshop, El Paso, TX, Sept. 2023.

Reno, M., "Machine Learning for Fault Detection and Classification" Invited Panel Talk for 2023 IEEE Power and Energy Society General Meeting (PES GM), Orlando, Florida, July 2023.

Reno, M., "Machine Learning for Traveling Wave Protection and DC Systems" Invited Panel Talk for 2023 IEEE Power and Energy Society General Meeting (PES GM), Orlando, Florida, July 2023.

Reno, M., "Phase Identification with Smart Meter Data for Distribution System Model Calibration," Sandia Grid Modernization & Energy Storage Webinar Series, virtual, Oct. 4, 2022.

Reno, M., "Real-Time Adaptive Protection Optimization using CAPE," CAPE User Group Meeting, June 27, 2023.

Reno, M., "Machine Learning for Fault Detection and Classification," IEEE PES General Meeting, July 18, 2023.

Reno, M., "Machine Learning for Traveling Wave Protection and DC Systems," IEEE PES General Meeting, July 18, 2023.

Schoenwald, D., "Expressing Grid Resilience with Dynamic Stability Metrics," IEEE Power & Energy Systems General Meeting, Orlando, FL, July 18, 2023.

Schoenwald, D., "The Use of Synchrophasors in Real-Time Grid Controls: Success Stories and Future Challenges, Session title: Past, Present, and Future with Synchrophasor Technology," IEEE Power & Energy Systems General Meeting, Orlando, FL, July 19, 2023.

Schoenwald, D., "Resilience and Reliability of Electricity and Gas Networks Under Extreme Events," Invited panel presentation, Super Session, ISGT Europe, Novi Sad, Serbia, October 11, 2023.

Schoenwald, D., "Dynamic Resilience Indices," Invited talk, Mini-Conference on Signal Processing for Power System Applications, University of Wyoming, Laramie, WY, September 30, 2022.

Schoenwald, D., S. Ojetola, "The Use of High-Speed Synchronized Measurements to Create Dynamic Indicators of Grid Resilience," Invited panel presentation, North American SynchroPhasor Initiative (NASPI) Work Group Meeting & Vendor Show, Tempe, AZ, April 4, 2023.

Schoenwald, D., "Expressing Grid Resilience with Dynamic Stability Metrics, Session title: Challenges and Opportunities Toward 100% Clean Energy", July 18, 2023.

Schoenwald, D., "The Use of Synchrophasors in Real-Time Grid Controls: Success Stories and Future Challenges, Session title: Past, Present, and Future with Synchrophasor Technology," July 19, 2023.

Schoenwald, D., "Dynamic Resilience Indicators," Sandia's Grid Modernization & Energy Storage 2023 Lunch & Learn Series, virtual, July 11, 2023.

Schoenwald, D., S. Ojetola, "The Use of High-Speed Synchronized Measurements to Create Dynamic Indicators of Grid Resilience," NASPI Work Group Meeting & Vendor Show, Tempe, AZ, April 4, 2023.

Schoenwald, D., "Sandia Power Systems R&D Overview," Navajo Technical University, Dec. 7, 2022.

Schoenwald, D., "Resilience and Reliability of Electricity and Gas Networks Under Extreme Events," Super Session, ISGT Europe, Novi Sad, Serbia, October 11, 2022.

Schoenwald, D., "Dynamic Resilience Indices, Mini-Conference on Signal Processing for Power System Applications," University of Wyoming, Laramie, WY, September 30, 2022.

Trudnowski, D.J., R.T. Elliott, J. Follum, "Modes of Inter-Area Power Oscillations in the Western Interconnection," WECC webinar, October 2022.

Energy Storage

Atcity, S., "Native American Energy Sovereignty and TCU – Building a Robust Workforce in Electrical Power Engineering" Diversity, Equity, & Inclusion Speaker, NSF & NAE sponsored workshop, Santa Ana Pueblo, NM, March 16, 2023.

Atcity, S., "Electricity Infrastructure, Energy Storage, Power Electronics, and Tribal Energy Sovereignty" Technical Seminar sponsored by the Fort Lewis College Native American Center, Durango, CO, February 27, 2023.

Atcity, S., "Electricity Infrastructure, Energy Storage, Power Electronics, and Tribal Energy Sovereignty" Technical Seminar Series sponsored by San Juan College, Farmington, NM, January 30, 2023.

Atcity, S., "Tribal Engagement, Energy Storage, and Power Electronics", Energy Storage Community of Practice on Equity, Lawrence Berkeley National Laboratory (Virtual), January 13, 2023.

Atcity, S., "Energy Storage 101" DOE Energy Storage Grand Challenge's Future Workforce Development in Energy Storage Workshop – Round Table Conversation with Tribal Colleges (Virtual), November 10, 2022.

Atcity, S., "Energy Storage, Power Electronics, Tribal Energy Sovereignty", Rochester Institute of Technology's (RIT) Native American Heritage Month, Rochester, NY, November 2, 2022.

Banerjee, S., "Development of Commercial-Scale High Energy Density Aqueous Zinc Manganese Dioxide Alkaline Batteries for Long Duration Storage" 243rd Electrochemical Society (ECS) Meeting, Boston, MA, May 28 – June 2, 2023.

Bates, J. Langendorf, J. Lamb, Y. Preger, L. Torres-Castro, M. Diaz "How Safe Are Solid-State Batteries? An Exploration of Heat Release" The Minerals, Metals & Materials Society (TMS) Annual Meeting & Exhibition, San Diego, CA, March 19-23.

Byrne, R.H., "Energy Storage Applications and Signal Processing Challenges", The School of Energy Resources and the Department of Electrical Engineering & Computer Science Joint Seminar, University of Wyoming, Laramie, Wyoming, September 29, 2022.

Byrne, R.H., "Sandia National Laboratories Energy Storage Program" Alaska Sustainable Energy Conference, Anchorage, AK, May 20-23, 2023.

Byrne, R.H., and T.A. Nguyen "Energy Storage Applications and Valuation" Energy Storage Tutorial, 2023 IEEE Power & Energy Society General Meeting, Orlando, FL, July 16-20, 2023.

Chalamala, B., "Role of Power Electronics in Grid Modernization" Workshop on Harsh Environment Electronics, University of Texas at Dallas, November 1, 2022.

Chalamala, B., "Energy Storage for Grid Modernization and Deeper Decarbonization" (Distinguished Lecturer) King Abdullah University of Science and Technology, Thuwal, Saudi Arabia, January 26, 2023.

Chalamala, B., "Planning Implications with Storage and IBRs: Long Duration Energy Storage" Energy Systems Integration Group (ESIG) Spring Technical Workshop, Tucson, AZ, March 27-30, 2023.

Chalamala, B., "State of Enabling Technologies and Markets for Energy Storage, Chemical and Electrochemical Energy Storage" Smart Grid Observer Utility-Scale Energy Storage Forum, Chicago, IL, April 16-17, 2023.

Chalamala, B., "Advanced Current Technologies: Li-ion and Flow Batteries" (Tutorial Lecturer) 2023 IEEE Power & Energy Society General Meeting, Orlando, FL, July 16-20, 2023.

Chalamala, B., "Energy Storage and Grid Modernization" (Edge Lecture) FTC Solar Inc., Austin, TX, July 31, 2023.

Clark, W.T., and W. McNamara "Sandia National Laboratories ESS Demonstration and Policy Program Capabilities & Partnership Opportunities" CESA Annual Members Meeting, Washington, DC, May 15-16, 2023.

Cowles, G., "Alternative to Lithium-ion Batteries" Batteries Event, Lyon, France, October 20, 2022.

De Angelis, V., Y. Preger "Open-Source Software and Open Data to Accelerate the Development of Energy Storage Systems" 243rd Electrochemical Society (ECS) Meeting, Boston, MA, May 28 – June 2, 2023.

Frischknecht, A.L., "Using Molecular Dynamics Simulations to Relate Morphology to Water and Ion Dynamics in Hydrated Polymers" 243rd Electrochemical Society (ECS) Meeting, Boston, MA, May 28 – June 2, 2023.

Frischknecht, A.L., "Insights into Hydrated Ion-Conducting Polymers from Molecular Dynamics Simulations" Complex Fluids Design Consortium Annual Meeting, University of California, Santa Barbara, January 27, 2023.

Frischknecht, A.L., "Insights into Hydrated Ion-Conducting Polymers from MD Simulations" Departmental Seminar, Chemical Engineering Department, University of New Mexico, Albuquerque, NM, October 26, 2022.

Frischknecht, A.L., "Insights into Hydrated Ion-Conducting Polymers from MD Simulations" Departmental Seminar, Chemical and Biological Engineering Department, Princeton University, Princeton, NJ, October 5, 2022.

Hawkins, B., "Rechargeable Zinc Manganese Dioxide Batteries for Stationary Energy Storage" NAATBATT Zinc Battery Workshop V, Online, November 10, 2022.

Lambert, T.N., B.R. Wygant, C. Wright, J. Gallaway, A. Stavola, E. Zimmerer, V. De Angelis, J. Mueller, O.

Dutta, I. Vasiliev, K. Acharya, N. Paudel, B.A. Magar, G.G. Yadav, G. Cowles, S. Banerjee "Energy Dense Rechargeable Cu-based Cathodes for Alkaline Zn/Cu Batteries" American Chemical Society (ACS) Fall 2023 Meeting, San Francisco, CA, August 13-17, 2023.

Lambert, T.N., B.R. Wygant, C. Wright, J. Gallaway, A. Stavola, E. Zimmerer, V. De Angelis, J. Mueller, O. Dutta, I. Vasiliev, K. Acharya, N. Paudel, B.A. Magar "Progress Towards the Development and Understanding of Energy Dense Rechargeable Batteries Utilizing Zn and Cu" 243rd Electrochemical Society (ECS) Meeting, Boston, MA, May 28 – June 2, 2023.

McNamara, W., "Sandia Policy & Outreach Team: State Engagements" DOE Energy Storage Grand Challenge Leadership Team (requested by Eric Hsieh, DOE Acting Deputy Assistant Secretary for Energy Storage), January 3, 2023.

Newlun, C.J., "Power System Planning for Decarbonization & Energy Storage" Public Service Company of New Mexico (PNM) Integrated Resource Planning stakeholder meeting, August 22, 2023.

Preger, Y., "Experiments and Data Requirements to Validate Grid Energy Storage Systems at Different Stages of Development" International Battery Seminar, Orlando, FL, March 20-23, 2023.

Preger, Y., "Grid Energy Storage Safety and Reliability Research at Sandia" EDGE in Tech Symposium, Virtual, March 2, 2023.

Preger, Y., J. Jeevarajan "A Broad Review on the Safety of Aged Lithium-ion Batteries" Electrochemical Society and Physics World Battery Week, Virtual, November 2022.

Preger, Y., "Adopting Predictive Maintenance Practices for Operational Safety of Battery Energy Storage Systems" 14th Annual Conference of the Prognostics and Health Management Society, Nashville, TN, November 1-4, 2022.

Preger, Y., J. Mueller, G. Baker, A. Fresquez "Beyond Single Cell Characterization: Impacts of Module Configuration on Li-ion Battery Performance and Degradation" 242nd Electrochemical Society (ECS) Meeting, Atlanta, GA, October 9-13, 2022.

Spoerke, E.D., "Aqueous Batteries: Transforming Prehistoric Chemistry to Meet Next Generation Storage Needs" American Chemical Society (ACS) Fall 2023 Meeting, San Francisco, CA, August 13-17, 2023.

Spoerke, E.D., "Energy Storage Technologies: Keys to Unlocking a Secure Energy Future" Alaska Sustainable Energy Conference Virtual Workshop: Energy Storage beyond Lithium-Ion Batteries, Virtual, May 22-25, 2023.

Spoerke, E.D., L.J. Small, M. Gross, S.J. Percival, A.S. Peretti, R. Lee, J. Lamb "Toward Large-Scale, Long Duration Energy Storage: Big Materials Challenges for a Big Energy Future" Dept. of Materials Science and Engineering Colloquium at University of Texas at Dallas, February 10, 2023.

Torres-Castro, L., "Framework for Safety Evaluation" UL Research Institutes 2023 Annual Research Symposium, July 31 – August 2, 2023.

Torres-Castro, L., "Effect of Li Plating on the Safety Response of Li-ion Batteries" Battery Safety Council, June 22, 2023.

Torres-Castro, L., "Overview of Battery Safety and Reliability at Sandia" America's Frontier Fund/Roadrunner Studios, June 14, 2023.

Torres-Castro, L., "Thermal Runaway Detection with Multiple Diagnostic Strategies" Advanced Automotive Battery Conference, San Diego, CA, December 5-8, 2022.

White, B., "Maximizing the Benefits of Renewables + Storage" New York Battery and Energy Storage Technology (NY-BES+), New York, NY, May 16-18, 2023.

Wittman, R.M., C. Poirier, H. Pratt, T. Anderson, Y. Preger "Quantifying Chlorine Gas Evolution from Mixed-Acid Vanadium Redox Flow Batteries" American Chemical Society (ACS) Fall 2023 Meeting, San Francisco, CA, August 13-17, 2023.

Wittman, R.M., "Why do Flow Batteries Fail? A Test Case with Mixed-Acid Redox Flow Batteries" Invited Seminar for the University of Memphis Mechanical Engineering Department, April 20, 2023.

Yadav, G.G., "The Renaissance of Zinc | Manganese Dioxide Batteries: Revolutionizing the Landscape of Energy Storage Enabled Through Material Science Breakthroughs" 2022 AIChE Annual Student Conference, Phoenix, AZ, November 11-14, 2022.

Yadav, G.G., "Improvements in Performance and Cost Reduction of Large-Scale Rechargeable Zinc | Manganese Dioxide Batteries Driven through Real World Applications" 2022 AIChE Annual Student Conference, Phoenix, AZ, November 11-14, 2022.

Yadav, G.G., J. Huang, M. Weiner, S. Yang, K. Vitale, S. Rahman, S. Banerjee "Improvements in Performance and Cost Reduction of Large-Scale Rechargeable Zinc | Manganese Dioxide Batteries Driven through Real World Applications" AIChE 4th Battery and Energy Storage Conference, The City College of New York, New York, NY, October 26-28, 2022.

Yadav, G.G., "The Renaissance of Zinc | Manganese Dioxide Batteries: Revolutionizing the Landscape of Energy Storage Enabled Through Material Science Breakthroughs" Battery and Energy Storage Conference (BESC), AIChE 4th Battery and Energy Storage Conference, The City College of New York, New York, NY, October 26-28, 2022.

Conference Presentations

Advanced Grid Modeling

Pierre B., "Protection and Control: Smart Grid Initiatives at Sandia National Laboratories," invited talk on panel session: "Challenges and Opportunities in Smart Grid: A Pragmatic View," IEEE Integrated Smart Grid Technologies Latin America (ISGT LA), San Juan, Puerto Rico, Nov. 2023.

Energy Storage

Bates, A.M., "Defining Diagnostic Parameters for Early Detection of Thermal Runaway" DOE ESS Safety & Reliability Forum, Santa Fe, NM, June 6-8, 2023.

Bates, A.M., L. Torres-Castro, Y. Preger, K. Harrison, R. Shurtz, J. Hewson "Are Solid-State Batteries Safe?" Advanced Automotive Battery Conference, San Diego, CA, December 5-8, 2022.

Chalamala, B., "Grid Energy Storage Technologies" IEEE Applied Power Electronics Conference and

Exposition (APEC), PSMA ES Presentation for the Industry Session, Orlando, FL, March 19-23, 2023.

Cho, J., P. Yang, D.E. Turney, G.G. Yadav, M. Nyce, T.N. Lambert, S. Banerjee "Understanding of Ion Diffusion for Non-Spillable Zn|MnO₂ Rechargeable Batteries Allowing for 2nd Electron MnO₂ Cycling in Hydrogel Electrolytes" AIChE 4th Battery and Energy Storage Conference, The City College of New York, New York, NY, October 26-28, 2022.

Clark, W.T., J. McDowell, A. Yao, S. Edley, O. Dutta "Technology and Topics in Long Duration Energy Storage" IEEE ESSB Summer Meeting Technical Symposium, King of Prussia, PA, June 12-15, 2023.

Clark, W.T., "Sandia National Laboratories Energy Storage Program" Operational Energy and Logistics Summit (OELS), Honolulu, HI, August 24, 2023.

Diaz, M., A. Bates, Y. Preger, L. Torres-Castro, R. Shurtz "Investigation of Exothermic Reaction Pathways in Solid-State Batteries: Implications for Safety" 2023 Materials Research Society (MRS) Spring Meeting & Exhibit, San Francisco, CA, April 10-14, 2023.

Diaz, M., A. Bates, Y. Preger, L. Torres-Castro, K. Harrison, S. Harris, J. Hewson "Are Solid-State Batteries Safer Than Lithium-ion Batteries?" DOE ESS Safety & Reliability Forum, Santa Fe, NM, June 6-8, 2023.

Dutta, D., D.E. Turney, R. Messinger, T.N. Lambert, S. Banerjee "Koutecky-Levich Study of the Hydrogen Evolution Reaction on a Zinc Rotating Disk Electrode in Traditional Alkaline and Acetate-Based Water-in-Salt (WiSE) Electrolytes" AIChE 4th Battery and Energy Storage Conference, The City College of New York, New York, NY, October 26-28, 2022.

Dutta, O., J. Mueller, R. Wauneka, A. Dow, V. De Angelis "Power Electronics and System Integration for Long Duration Energy Storage" IEEE PES ESSB General Meeting, King of Prussia, PA, June 12-15, 2023.

Flicker, J., E. Schrock, R. Kaplar "Reverse Breakdown Time of Wide Bandgap Diodes" 9th IEEE Workshop on Wide Bandgap Power Devices & Applications (WiPDA), Redondo Beach, CA, November 7-9, 2022.

Hewson, J., A. Kurzawski "Avoiding Cascading Failure in Battery Packs Through Thermal Analysis" U.S. National Combustion Meeting, College Station, TX, March 19-23, 2023.

Hill, R.C., A.S. Peretti, A.M. Maraschky, L.J. Small, E.D. Spoerke, Y.T. Cheng "Molten Sodium Penetration Through Solid-State NaSICON Electrolytes Under High Current" 243rd Electrochemical Society (ECS) Meeting, Boston, MA, May 28 - June 2, 2023.

Hill, R.C., A.S. Peretti, A.M. Maraschky, L.J. Small, E.D. Spoerke, Y.T. Cheng "Molten Sodium Penetration Through Solid-State NaSICON Electrolytes Under High Current" 2023 Materials Research Society (MRS) Spring Meeting & Exhibit, San Francisco, CA, April 10-14, 2023.

Kowalchuk, E., J. Quintana, L. Gray, R. Shurtz, J. Hewson, A. Bates, L. Torres-Castro "Increase Large Scale Testing Capability" DOE ESS Safety & Reliability Forum, Santa Fe, NM, June 6-8, 2023.

Kurzawski, E., J. Hewson "Exploring Parameters that Affect Propagating Thermal Runaway in Lithium-ion Batteries at the Module and Intermodule Scale" 12th FM Global Open Source CFD Fire Modeling Workshop, Norwood, MA, April 4-5, 2023.

Kurzawski, E., M. Meehan, R.H. Weston-Dawkes, J. Hewson "Slowing and Mitigating Thermal Runaway: A Heat Transfer Perspective" DOE ESS Safety & Reliability Forum, Santa Fe, NM, June 6-8, 2023.

Lambert, T.N., B.R. Wygant, C. Wright, J. Gallaway, A. Stavola, E. Zimmerer, V. De Angelis, J. Mueller, O. Dutta, I. Vasiliev, K. Acharya, N. Paudel, B.A. Magar "Progress Towards the Development and Understanding of Energy Dense Rechargeable Batteries Utilizing Zn and Cu" TechConnect World Innovation Conference and Exposition" Washington, DC, June 19-21, 2023.

Langendorf, J., L. Torres-Castro, L. Gray, J. Quintana, A. Bates, H. Wang "Database Development of Large-format Li-ion Cells via Thermal Runaway Testing" DOE ESS Safety & Reliability Forum, Santa Fe, NM, June 6-8, 2023.

Maraschky, A.M., M.L. Meyerson, S.J. Percival, A.S. Peretti, D. Lowry, S. Meserole, R.Y. Lee, J. Williard, E.D. Spoerke, L.J. Small "Keep It Lewis-Basic: Stability of NaSICON Separators in AlCl₃-NaI Catholytes for Molten Sodium Batteries" The Minerals, Metals & Materials Society (TMS) Annual Meeting & Exhibition, San Diego, CA, March 19-23, 2023.

Maraschky, A.M., M.L. Meyerson, S.J. Percival, A.S. Peretti, M.S. Gross, E.D. Spoerke, L.J. Small "Optimizing the Current Collector for Sodium Iodide-Metal Halide Catholytes in Low-Temperature Molten Sodium Batteries" 242nd Electrochemical Society (ECS) Meeting, Atlanta, GA, October 9-13, 2022.

Maraschky, A.M., M.L. Meyerson, S.J. Percival, A.S. Peretti, D. Lowry, S. Meserole, R.Y. Lee, J. Williard, E.D. Spoerke, L.J. Small, "Molten Sodium Batteries – Lewis Acidity of AlCl₃/NaI Catholyte Impedes NaSICON Interface" 243rd Electrochemical Society (ECS) Meeting, Boston, MA, May 28 – June 2, 2023.

Maraschky, A.M., L.J. Small, E.D. Spoerke, S.J. Percival "Al-Fe Based Molten Salts for Long Duration Energy Storage" 243rd Electrochemical Society (ECS) Meeting, Boston, MA, May 28 – June 2, 2023.

Matthews, R., T. Patel, A. Summers, M. Reno "A Graph Theory Approach for Placing Overcurrent Relays and Reclosers for Economical Protection of Meshed Transmission Networks" North American Power Symposium (NAPS), Salt Lake City, Utah, October 9-11, 2022.

Matthews, R., T. Patel, A. Summers, M. Reno "Optimal Coordination of Distance and Overcurrent Relays with Sparse Placement" North American Power Symposium (NAPS), Salt Lake City, Utah, October 9-11, 2022.

McNamara, W., "What is Currently the Biggest Barrier to Deploying Energy Storage in the US?" Energy Storage Summit USA, Austin, TX, March 28, 2023.

McNamara, W., "Energy Storage Policy: Observations" Advancing Towards 100% Clean Energy: A State-Federal Summit, Washington, D.C., May 17-18, 2023.

Meehan, M., R.H. Weston-Dawkes, A. Kurzawski, J. Hewson "Flow Dynamics Through Simplified Battery Rack Configurations" DOE ESS Safety & Reliability Forum, Santa Fe, NM, June 6-8, 2023.

Meyerson, M.L., A.M. Maraschky, S.J. Percival, L.J. Small "Higher Energy Density Mediated Lithium-Sulfur Flow Batteries" 243rd Electrochemical Society (ECS) Meeting, Boston, MA, May 28 – June 2, 2023.

Meyerson, M.L., A.M. Maraschky, S.J. Percival, L.J. Small "Higher Energy Density Mediated Lithium-Sulfur Flow Batteries" 242nd Electrochemical Society (ECS) Meeting, Atlanta, GA, October 9-13, 2022.

Meyerson, M.L., A.M. Maraschky, S.J. Percival, L.J. Small, "Higher Energy Density Mediated Lithium-Sulfur Flow Batteries." 2022 Materials Research Society (MRS) Fall Meeting, Boston, MA, November 27, 2022 – December 2, 2022.

Obrien, V., V. Rao, R.D. Trevizan "Detection of False Data Injection Attacks in Ambient Temperature-Dependent Battery Stacks" Texas Tech University 22nd Annual Graduate Student Research Poster Competition, Lubbock, TX, March 30, 2023.

Quintana, J., J. Langendorf, L. Gray, C. Grosso, E. Kowalchuk, A. Bates, L. Torres-Castro "Mechanically Extracting Cylindrical Cell Headspace Gas Without Inducing a Thermal Runaway" DOE ESS Safety & Reliability Forum, Santa Fe, NM, June 6-8, 2023.

Ropp, M., M. Reno, J. Azzolini "Sandia Research Activities" DistribuTech, San Diego, CA, February 5-9, 2023
Schoenwald, D., T. Nguyen, J. McDowall "Recommended Practice for Energy Storage Management Systems in Grid Applications" (Best Technical Paper Award) Electrical Energy Storage Applications and Technologies (EESAT), Austin, TX, November 7-9, 2022.

Spoerke, E.D., M. Gross, A.S. Peretti, S.J. Percival, L.J. Small, Y.T. Cheng, R.C. Hill "'Dirt Cheap' Energy Storage: Clay-Based Separators for Solid State Storage" 2023 Materials Research Society (MRS) Spring Meeting & Exhibit, San Francisco, CA, April 10-14, 2023.

Spoerke, E.D., A.M. Maraschky, M. Meyerson, A. Peretti, S. Percival, M. Gross, S. Meserole, D. Lowry, L. Small "sTable Salt Batteries: Understanding Materials Challenges to NaSICON Ceramics in Low-Temperature Molten Sodium Batteries" Electronic Materials and Applications 2023, Orlando, FL, January 17-20, 2023.

Spoerke, E.D., A.M. Maraschky, M.L. Meyerson, A.S. Peretti, S.J. Percival, M.S. Gross, S. Meserole, D. Lowry, R.Y. Lee, L.J. Small "Enabling Low-Cost Molten Sodium Batteries Through Engineered Catholyte-Separator Materials Chemistry" 2022 Materials Research Society (MRS) Fall Meeting & Exhibit, Boston, MA, November 27, 2022 – December 2, 2022.

Spoerke, E.D., A.M. Maraschky, M.L. Meyerson, A.S. Peretti, S.J. Percival, M.S. Gross, S. Meserole, D. Lowry, R.Y. Lee, L.J. Small "Exploring a Battery Worth Its Salt: Ceramic-Salt Interactions in a Low-Temperature Molten Sodium Battery" 32nd Rio Grande Symposium on Advanced Materials, Albuquerque, NM, October 24, 2022.

Wittman, R.M., A. Fresquez, B. Chalamala, C. Rich, Y. Preger "Degradation of Li-ion Cells Beyond 80% Initial Capacity" 49th Power Sources Conference, National Harbor, MD, June 27-29, 2023.

Wittman, R.M., A. Fresquez, B. Chalamala, Y. Preger "Long Term Cycling of 18650 Li-ion Cells Beyond 80% Capacity" DOE ESS Safety & Reliability Forum, Santa Fe, NM, June 6-8, 2023.

Wittman, R.M., C. Poirier, H. Pratt, T. Anderson, Y. Preger "Quantifying Chlorine Gas Evolution from Mixed-Acid Vanadium Redox Flow Batteries" 2022 Materials Research Society (MRS) Fall Meeting & Exhibit, Boston, MA, November 27, 2022 – December 2, 2022.

Wittman, R.M., A. Fresquez, B. Chalamala, Y. Preger "Update on Systematic Cycle Aging of NMC and NCA 18650 Li-ion Batteries" 242nd Electrochemical Society (ECS) Meeting, Atlanta, GA, October 9-13, 2022.

Wygant, B.R., C.N. Wright, B.A. Washington, G.A. Goenaga-Jiménez, T.A. Zawodzinski, T.N. Lambert "Compositional Tuning of Nickel Sulfoselenides for Use as Bifunctional Oxygen Electrocatalysts in Aqueous Electrochemical Energy Storage" 243rd Electrochemical Society (ECS) Meeting, Boston, MA, May 28 – June 2, 2023.

Yang, P., D.E. Turney, T.N. Lambert, S. O'Brien, S. Banerjee "Studying the Addition of Metallic Zinc (Zn)

to Rechargeable Alkaline Calcium Zincate (CaZn₂(OH)₆·2H₂O) Anodes” AIChE 4th Battery and Energy Storage Conference, The City College of New York, New York, NY, October 26-28, 2022.

Webinars

Renewable & Distributed Systems Integration

Leon-Quiroga, J., G. Bacelli, R. Coe, “Hardware-in-the-loop testing of a hydraulic wave energy power take-off system,” WEC webinar, March 2023.

Advanced Grid Modeling

Mammoli, A., A. Wachtel, “ReNCAT – What it is, What it Does and Why it Matters,” April 12, 2023 presented at EPRI Value of Resilience Working Group Bi-Monthly that was attended by several stakeholders and utility representatives

Reno, M., “Phase Identification with Smart Meter Data for Distribution System Model Calibration,” Sandia Grid Modernization & Energy Storage Webinar Series, Oct. 2022.

Schoenwald, D., “Dynamic Resilience Indicators,” Invited webinar, Sandia Grid Modernization & Energy Storage 2023 Lunch & Learn Series, Albuquerque, NM, July 11, 2023.

Trudnowski, D., R.T. Elliott, J. Follum, “Modes of Inter-Area Power Oscillations in the Western Interconnection,” WECC webinar, October 2022.

Energy Storage

Chalamala, B., “Role of Energy Storage and Power Electronics in Grid Modernization” PSMA Technology Roadmap Webinar: Power Sources Manufacturers Association, November 29, 2022.

Clark, W.T., “Sandia National Laboratories Energy Storage Demonstration Team & Energy Storage for Social Equity (ES4SE) Program” US-India Energy Storage Partnership, US-DOE -- IESA Webinar Series on Energy Storage, August 17, 2023.

Clark, W.T., “Microgrid for Resilience Project—Villalba, Puerto Rico” FEMA Energy Storage and Microgrids for Energy Resilience and Reliability webinar series, April 26, 2023.

Clark, W.T., Y. Preger, S. Willard, J. Norris “Storage Data Guide v3 and Data Calculator Overview” Electric Power Research Institute (EPRI) Energy Storage Integration Council (ESIC) webinar, April 14, 2023.

Clark, W.T., “Energy Storage Systems Safety & Operational Best Practices” Washington, D.C. Department of Energy and Environment (DOEE) Energy Storage webinar, November 2, 2022.

H. Guan “Off-grid Deployment of Zinc Manganese Dioxide BESS on the Navajo Nation” [Energy Storage in the Southwest: Battery Case Studies from Albuquerque Public Schools and the Navajo Tribal Utility Authority](#), CESA Webinar, December 1, 2022.

Conference and Workshop Panel Leadership

Alex Bates moderated the Ensuring the Safety of BESS Systems panel at the Energy Storage USA Summit, Austin, TX, March 28, 2023.

Alex Bates was the lead organizer for the EN05: Solid-State Batteries—Life, Safety, and Scalability symposium at the 2022 Materials Research Society (MRS) Fall Meeting & Exhibit, Boston, MA, November

27, 2022 – December 2, 2022.

Andrew Benson chaired the Nuclear Energy panel session at the 39th USAEE/IAEE North American Conference, Houston, TX, October 23-26.

Atri Bera organized and chaired the Addressing Grid Reliability & Resilience through Energy Storage session at the 2023 IEEE Power & Energy Society General Meeting, Orlando, FL, July 16-20, 2023.

Ray Byrne moderated the Energy Storage Optimization technical session at the Electrical Energy Storage Applications and Technologies (EESAT), Austin, TX, November 7-9, 2022.

Babu Chalamala chaired the Long Duration Energy Storage panel session at the 2023 IEEE Power & Energy Society General Meeting, Orlando, FL, July 16-20, 2023.

Waylon Clark moderated the “Energy Storage for Social Equity (ES4SE)” session at the annual DOE Energy Storage Grand Challenge Summit, Atlanta, GA, July 26, 2023.

Waylon Clark chaired the “Technology and Topics in Long Duration Energy Storage” session at the IEEE ESSB Summer Meeting Technical Symposium, King of Prussia, PA, June 12-15, 2023.

Waylon Clark served on the Sandia Energy Storage Deployment Team round-table discussion, Sandia Energy and Homeland Security External Advisory Board, Albuquerque, NM, May 23, 2023.

Waylon Clark moderated the “Energy Storage Policy for Decarbonization” panel session at the Advancing Towards 100% Clean Energy State-Federal Summit, Washington, D.C., May 17-18, 2023.

Valerio De Angelis moderated the Advanced Power Electronics technical session at the Electrical Energy Storage Applications and Technologies (EESAT), Austin, TX, November 7-9, 2022.

Megan Diaz chaired at Solid Electrolytes Design for Next Generation Solid-State Batteries II and Solid Electrolytes Design for Next Generation Solid-State Batteries IV sessions at the 2022 Materials Research Society (MRS) Fall Meeting, Boston, MA, November 27, 2022 – December 2, 2022.

Megan Diaz chaired the Advanced Materials for Energy Conversion and Storage 2023 symposium at The Minerals, Metals & Materials Society (TMS) Annual Meeting & Exhibition, San Diego, CA, March 19-23, 2023.

Megan Diaz chaired the Interface Design and Studies in Solid-State Batteries session at the 2023 Materials Research Society (MRS) Spring Meeting & Exhibit, San Francisco, CA, April 10-14, 2023.

Jack Flicker co-chaired the Reliability of Power-Electronic Systems for Solar Energy session at the IEEE Energy Conversion Congress & Expo (ECCE), Detroit, MI, October 9-13, 2022.

Henry Guan chaired the Ensuring Safety During Operation session at the DOE ESS Safety & Reliability Forum, Santa Fe, NM, June 6-8, 2023.

Bob Kaplar co-chaired the GaN Devices – Advanced Characterization session at the 9th IEEE Workshop on Wide Bandgap Power Devices & Applications (WiPDA), Redondo Beach, CA, November 7-9, 2022.

Bob Kaplar co-chaired the GaN Devices – Industry and Others session at the 9th IEEE Workshop on Wide

Bandgap Power Devices & Applications (WiPDA), Redondo Beach, CA, November 7-9, 2022.

Ramesh Koripella served on the Long Duration Energy Storage, Developing a Roadmap for Policy, Planning, and Operations panel discussion at the 2023 IEEE Power & Energy Society General Meeting, Orlando, FL, July 16-20, 2023.

Will McNamara served on the How Energy Storage Can Benefit from Federal Legislation panel discussion at the DOE Energy Storage Financing Summit, New York, NY, January 26, 2023.

Will McNamara served on the Storage Procurement in California panel discussion at the California Clean Energy Procurement Summit., San Francisco, CA, May 3-4, 2023.

Todd Monson co-chaired the Passives session at the 2023 Power Electronics & Energy Conversion Workshop, Albuquerque, NM, August 2-3, 2023.

David Rosewater moderated the Energy Storage Sub-Committee Panel Session: A Window into the Energy Storage Future at the Electrical Energy Storage Applications and Technologies (EESAT), Austin, TX, November 7-9, 2022.

David Rosewater chaired the Certifying Batteries to Ensure Safety, Reliability, and Performance panel discussion at the DOE ESS Safety & Reliability Forum, Santa Fe, NM, June 6-8, 2023.

Erik Spoerke helped organize and participated as a speaker at the DOE Energy Storage Grand Challenge Summit, Atlanta, GA, July 25-27, 2023.

Erik Spoerke co-chaired the Ion-Conducting Ceramics symposium at the Electronic Materials and Applications 2023. Orlando, FL, January 17-20, 2023.

Erik Spoerke co-chaired the Energy Storage: Beyond Lithium symposium at the TechConnect World Innovation Conference and Exposition" Washington, DC, June 19-21, 2023.

Ujjwol Tamrakar co-chaired the Modeling, Control, and Operation of Energy Storage Systems to Enable Grid Decarbonization panel session at the IEEE Innovative Smart Grid Technologies (ISGT) North America Conference, Washington D.C., January 16-19, 2023.

Reed Wittman chaired the Safety and Reliability of non-Li-ion Technologies session at the DOE ESS Safety & Reliability Forum, Santa Fe, NM, June 6-8, 2023.

Reed Wittman co-chaired the Solid Electrolytes Design for Next Generation Solid-State Batteries III session at the 2022 Materials Research Society (MRS) Fall Meeting & Exhibit, Boston, MA, November 27, 2022 – December 2, 2022.



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