FY24
Electric Grid Security (EGS)

Annual Report

CONTENTS

Sandia's Electric Grid Security program advances a national vision of a secure, resilient, and affordable electric system for all users. Our achievements reflect a strategic approach combining technology development; modeling, simulation, and data analytics; and partnered demonstrations and outreach to further the adoption of advanced grid and storage technologies. Our FY24 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.

Key accomplishments in this report that support our strategy span our technical program areas and include:

- The advancement of energy storage technologies, including creation of a national Long Duration Energy Storage Consortium;
- Applications of artificial intelligence and machine learning to enhanced grid operations and planning;
- Development of solid-state power conversion technologies and a new medium-voltage research lab;
- New technologies to assess wildfire vulnerabilities and mitigate potential impacts;
- Advanced applications of new cybersecurity technologies with industry partners;
- Contributions to understanding the impacts of electromagnetic pulses and geomagnetic disturbances on grid components; and
- Digital twin development for hybrid microgrids with multiple generators, storage, and loads.

This report indicates key areas of research and engagement and summarizes the impact of 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 team to create our modern grid and apply the outcomes of our efforts.

The bulk of work described herein is funded by several offices within the U.S. Department of Energy (USDOE), including the Office of Electricity (OE); Cybersecurity, Energy Security, and Emergency Response (CESER); the Office of Energy Efficiency and Renewable Energy (EERE); the Grid Deployment Office (GDO); the Office of Clean Energy Demonstrations (OCED); and other key programs at USDOE.

As we continue to state in these annual reports, 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.

Charles Hanley

Charles Hanley
Electric Grid Security Program Manager
Sandia National Laboratories

Publications

31 Journal Articles

37 Conference Proceedings

Intellectual Property Advancements

4 Patents

## Presentations

28 Invited Talks

52 Conferences

15 Webinars

ACRONYM LIST

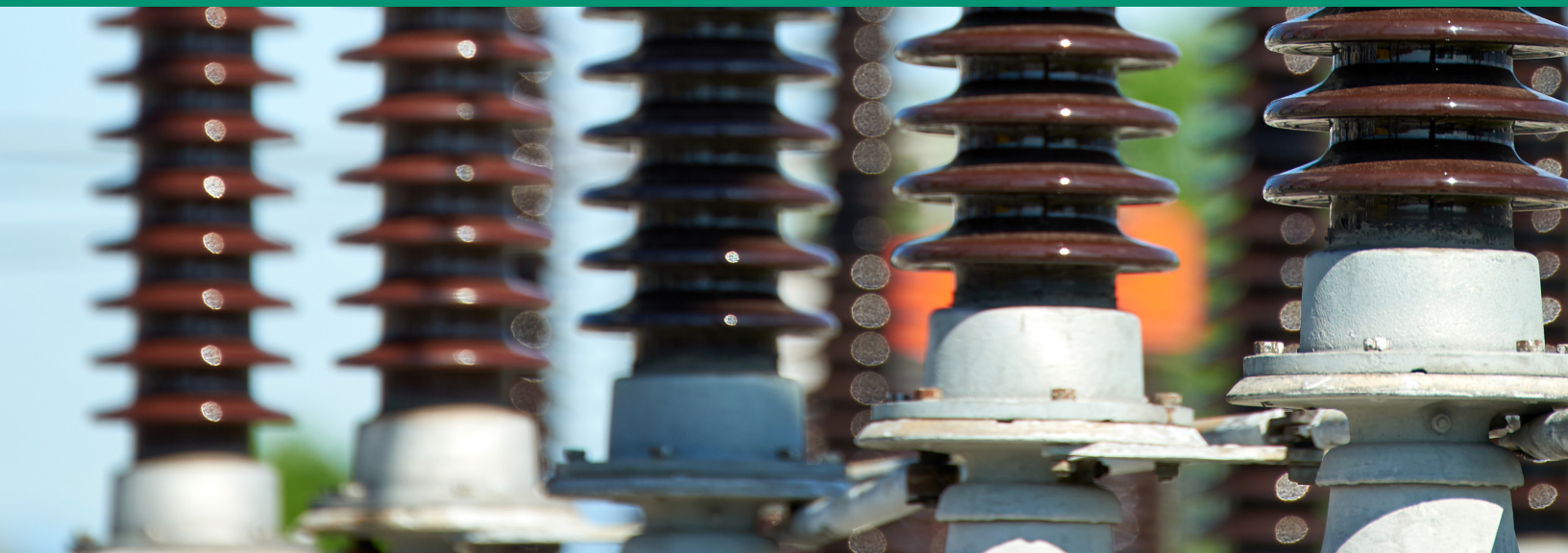| Abbreviation	Definition
ADDSec	Artificial Diversity and Defense Security
AI	Artificial intelligence
AMI	Advanced metering infrastructure
ANL	Argonne National Laboratory
APS	American Physical Society
ARPA-E	Advanced Research Projects Agency–Energy
BES	Battery energy storage
BLC	Battery Lifecycle Framework
CAISO	California Independent System Operator
CAST	Cluster to Advance Cyber-Security and Testing
CEC	Californica Energy Commission
DER	Distributed energy resources
DERM	Distributed Energy Resource Management System
DETL	Distributed Energy Technologies Lab
DOE	Department of Energy
DOE – OE	Department of Energy Office of Electricity
DPOLY	Division of Polymer Physics
EMP	electromagnetic pulse
Energy StorM	Energy Storage for Manufacturing and Industrial Decarbonization
EPRI	Electric Power Research Institute
ES4SE	Energy storage for social equity
ESS	Energy storage system
ESGC LCT	Energy Storage Grand Challenge National Laboratory Coordinating Team
EV	Electric vehicle
EVSE	Electric Vehicle Supply Equipment
FEMA	Federal Emergency Management Agency
GMLC	Grid Modernization Lab Consortium
I&EC	Industrial and Engineering Chemistry
ICC	Illinois Commerce Commission
IEEE	Institute of Electrical and Electronics Engineers
LANL	Los Alamos National Laboratory
LDES	Long Duration Energy Storage
MDT	Microgrid Design Toolkit
NAERM	North American Energy Resilience Model

Abbreviation	Definition
NFPA	National Fire Protection Association
NGFW	Next Generation Firewalls
NIDS	Network-Based Intrusion Detection System
NRECA	National Rural Electric Cooperative Association
OAJPE	Open Access Journal Of Power And Energy
OMF	Open Modeling Framework
ORNL	Oak Ridge National Laboratory
PIDMS	Proactive Intrusion Detection And Mitigation System
PNNL	Pacific Northwest National Laboratory
PNM	Public Service Company Of New Mexico
PPL	Pulsed Power Loads
PRM	Performance Reliability Model
ReNCAT	Resilient Node Cluster Analysis Tool
RONM	Resilient Operation Of Network Microgrids
SOAR	Security Orchestration, Automation, And Response
SPD	Sandia Postdoc Development
SWE	Society Of Women Engineers
UFLS	Under-Frequency Load Shedding
UL	Underwriters Laboratories
U.S.	United States
VVUQ	Verification, Validation, And Uncertainty Quantification
WIMRG	Western Interconnection Modes Review Group
WNTR	Water Network Tool For Resilience
WPT	Wireless-Power Transfer
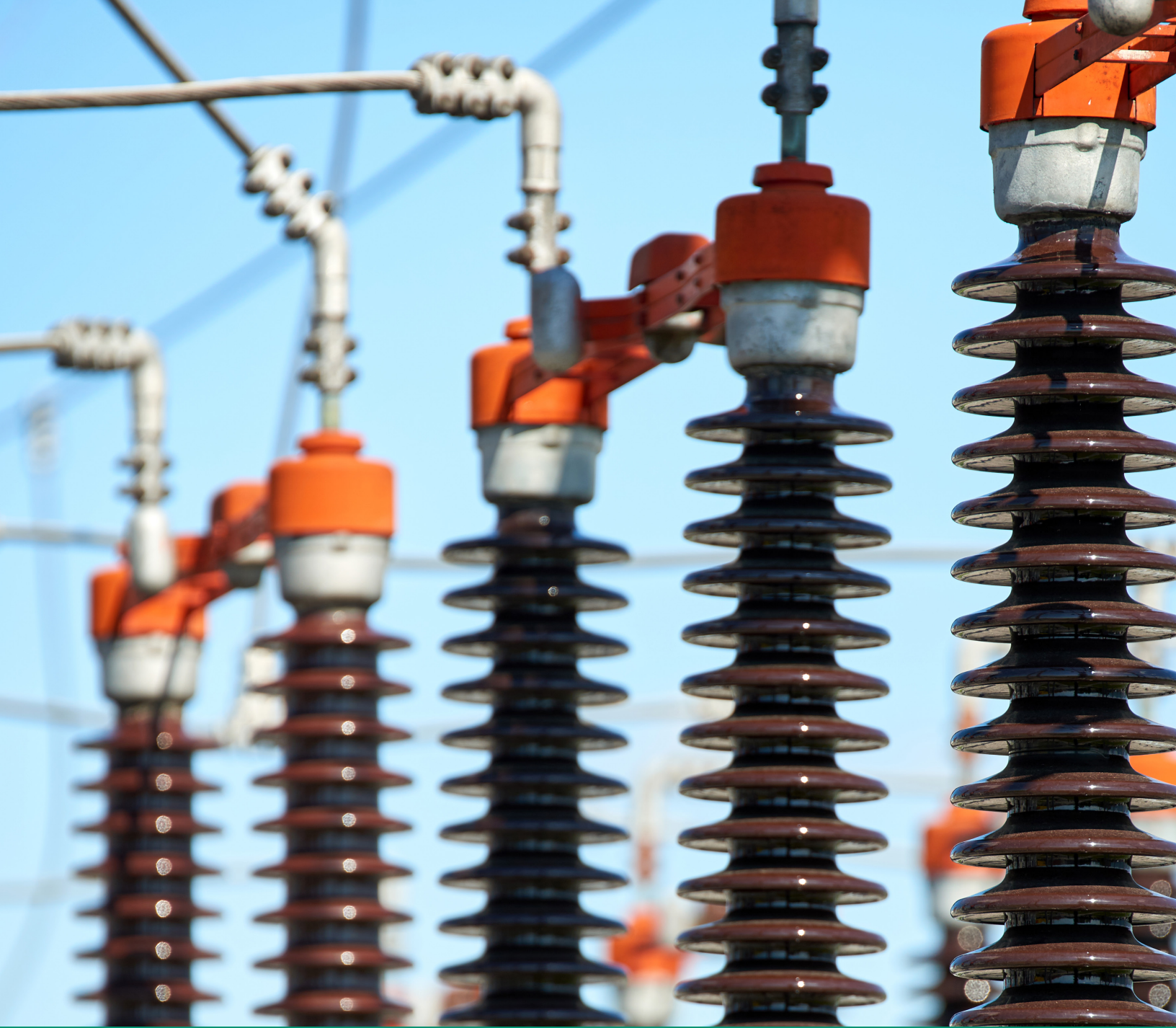
TECHNICAL & PROGRAM ACHIEVEMENTS

Technical and Program Achievements

Energy Storage Technologies and Systems

Launch of the Long Duration Energy Storage (LDES) National Consortium: Sandia successfully led a six Department of Energy laboratories team to launch the first ever Long Duration Energy Storage (LDES) National Consortium. The consortium provides a forum through which industry stakeholders across the LDES ecosystem work together and identify barriers, determine potential synergies, and collaboratively develop and implement strategies necessary to achieve LDES technology commercialization within the next decade.
The first-ever LDES National Consortium Annual Workshop was held on September 10-11, 2024 in Commerce, California and brought together nearly 200 industry stakeholders to discuss the future of LDES technologies. The LDES Consortium is funded through the Department of Energy Office of Technology Transitions and the Department of Energy Office of Clean Energy Demonstrations.

IEEE P2686, Recommended Practice for Battery Management Systems in Energy Storage Applications: Sandia led the Institute of Electrical and Electronics Engineers (IEEE) P2686 Recommended Practice on Battery Management in Energy Storage Applications to approval for publication. The publication represents six years of consensus building with over 150 working group members, 39 organized working group meetings, and three rounds of public balloting, resulting in unanimous approval. The adoption of this recommended practice will make the next generation of grid connected battery systems safer, more reliable, and less expensive.

National Fire Protection Association Battery Worker Safety Practices: The National Fire Protection Association (NFPA) 70E standards committee adopted changes to battery worker safety practices that were developed over the last four years at Sandia, in collaboration with the Energy Facility Contractors Group and IEEE Energy Storage and Stationary Battery Committee. These changes were presented to the committee in July 2024 and will take effect in the 2027 edition. Improved safety guidance will accelerate battery workforce development and reduce the number and severity of electrical injuries in the future.

California Energy Commission Cooperative Research and Development Agreement (CRADA): Sandia collaborates closely with California Energy Commission (CEC) to assist in the evaluation, selection, and implementation of energy storage projects, optimization of the energy storage analysis tools, and assimilate the information in the public domain for nationwide use. Establishment of a CRADA formalizes a twenty-year collaboration between Sandia and the CEC. This collaboration will lower barriers to widespread deployment of long duration energy storage technologies.

QuESt Release 2.0: Sandia released an updated version of QuESt, an energy storage tool suite for making decisions regarding energy storage deployments. The tool includes capabilities to estimate potential revenue in market areas as well as behind the meter solar plus storage deployments. This release includes a QuESt App Hub and QuESt workspace which make it easier to integrate with other tools. QuESt lowers barriers to widespread deployment of energy storage by simplifying energy storage analysis.

Mediated Lithium-Sulfur Flow Batteries: Sandia is developing a lithium-sulfur-based chemistry for use in a flow battery for grid scale energy storage. In 2024, Sandia partnered with Albuquerque-based startup, GridFlow, and early results led to GridFlow licensing Sandia intellectual property and New Mexico state funding to help GridFlow commercialize the technology. This collaboration has allowed GridFlow to gain attention necessary to further develop a battery technology for grid applications.

Low Temperature Molten Sodium Batteries: An important aspect of producing low temperature molten sodium batteries is the manufacturing of Sandia's Na-ion conductive solid-state separator

NaSICON, which requires precise conditions to synthesize. This year Sandia developed a synthetic route that is more tolerant of lab humidity, allowing us to send NaSICON precursor powders to collaborators or ceramic processors that reside in more humid (>20% RH) areas of the U.S. This development will enable collaboration between Sandia and groups with more expertise in forming ceramics in complicated shapes and sealing ceramics to other materials. These processes are necessary to manufacture low temperature sodium batteries for grid scale energy storage.

Zinc Bromine Battery Separators: Bromine batteries are attractive for large scale energy storage; however, they use unreliable membrane separators that lower energy and lifetime efficiencies. Sandia has developed membranes with engineered polymer architectures that allow for selective ion (species) transport through the membrane. The new polymer membranes have significantly lower bromide diffusion and provide five-times lower resistance. This display of high ion selectivity is a significant breakthrough and Sandia is working with partners to perform Zn/Br battery testing on the new promising membrane candidates.

Large Scale Battery Testing Capability: Sandia's Large-Scale Battery Testing Capability elevates destructive testing of field-scale battery configurations from 25 kWh to 100 kWh. This work positions the U.S. at the forefront of battery safety testing and represents an historic milestone. The Large-Scale Testing Capability research directly addresses the increasing demand from the energy sector for robust testing solutions.

Vermont Public Utility Commission Energy Storage Systems Workshops: Sandia's Energy Storage Policy and Outreach team conducted the Vermont Public Utility Commission Energy Storage Systems Workshops. The five-workshop series was held virtually in November and December of 2023 and over 200 individuals participated. The series included presentations from energy storage experts and provided an overview on unleashing the power of renewables and relieving generation, transmission, and distribution demands.

IEEE Guide P3434: The Institute of Electrical and Electronics Engineers (IEEE) SA Standards Board approved the proposed IEEE Guide P3434, "Guide for the Project Development, Facility Design, Installation, Operations and Maintenance (O&M) for Grid Connected Energy Storage Systems (ESSs)." The document provides guidance for the five phases of deploying and operating a grid-connected energy storage system, including decommissioning.

DOE Energy Storage Safety Strategic Plan: The DOE Energy Storage Safety Strategic Plan was revised for the first time since 2014 and is now available online. Sandia worked alongside an external advisory board of ten U.S. energy storage entities to publish revisions that identify general gaps and outstanding questions for energy storage safety, focusing on: science-based safety validation, incident preparedness, and emergency response. The document helped identify critical research and development gaps that Department of Energy labs can help address in the future.

2023 and 2024 DOE OE Energy Storage Program Annual Meeting and Peer Review: Sandia successfully organized and hosted the 2023 DOE Office of Electricity Energy (DOE-OE) Storage Program Annual Meeting and Peer Review was held in Santa Fe, NM October 24-26, 2023. Lab employees delivered presentations of their DOE-OE funded work and accomplishments over the last year, with substantive discussions of energy storage technologies, policies, projects, and related issues throughout the three-day event.

Sandia also hosted the 2024 DOE Office of Electricity Energy Storage Program Annual Meeting in Bellevue, Washington August 5-7, 2024. The event included 221 attendees and highlighted highlights energy storage research and development performed at Sandia, Pacific Northwest National Laboratory, Argonne National Laboratory, and Oakridge National Laboratory.

Vermont Electric Cooperative Project Commissioning: Sandia provided technical assistance that led to the successful deployment of a 3-MW/ 12-MWh EVLO energy storage system in Troy, Vermont. The commissioning ceremony was held on Friday, August 16, 2024. This energy storage system is the first deployment in the United States to address transmission constraints caused by renewable generation. The deployed system will reduce curtailment of wind generation in the region, allowing more energy to reach the grid.

Renewable and Distributed Systems Integration

New Microgrid Design Toolkit Video Tutorials: The Microgrid Design Toolkit (MDT) webpage now includes new video tutorials that pair with the existing MDT User's Manual. The videos include screen recordings and custom narration to walk users through the tool. The webpage also includes a new software download button, allowing users to access all resources and tools in one streamlined location.

Resilient Node Cluster Analysis Tool Training: Sandia hosted a full-day training workshop on energy resilience, the Resilient Node Cluster Analysis Tool (ReNCAT), and the new QGIS Social Burden plugin to individuals from Ten Power, SunSource, Green Energy Corp, and Grey Snow Management Solutions, who are the partner organizations for Sandia's Communities Local Energy Action Program (C-LEAP) project with the Iowa Tribe of Kansas and Nebraska. This training was part of a week-long program organized at National Renewable Energy Laboratory to "train the trainer" and help enable members of these organizations to learn how to use the tools so they may use them to assist other tribal communities going forward.

QGIS Plugin Now Available: The QGIS social burden plugin was approved by the QGIS plugin repository maintainers and is now publicly available. The Social Burden plugin can be used to identify "hotspots" of need in a community, broken down by food access, medical care, and any other relevant services. By modifying the inputs to design different hypothetical configurations of people, facilities, and services, it can also be used to test "what if" scenarios.

Advanced Grid Modeling

Standards Guide: Sandia partnered with the IEEE Power System Relaying and Control Committee to publish the first Standards Guide for implementing Artificial Intelligence (AI) into power system protection. The multi-year effort from the working group resulted in PES-TR112 "Practical Applications of Artificial Intelligence and Machine Learning in Power System Protection and Control," which will inform future applications in the AI power system protection space.

Traveling Wave Protection System Video: In November 2023, Sandia published a video overview of the traveling wave protection system work to Sandia's YouTube channel. The video highlights how Sandia is pioneering new ways to keep people connected to the electric grid. Leveraging advanced signal processing and machine learning, the traveling wave protection team created a prototype protections device capable of detecting faults ten times faster than today's modern tools.

North American Energy Resilience Model (NAERM): The North American Energy Resilience Model (NAERM) is a collaboration of eight Department of Energy laboratories. NAERM provides a toolset, dataset, and capabilities for multi-domain simulation of energy infrastructure and threats to this infrastructure. In 2024, Sandia updated NAERM's tools and processes to improve compliance with Secure Software Development Framework (SSDF), implemented NAERM data access security, and incorporated periodic security monitoring system. This work keeps Critical Energy/Electric Infrastructure Information (CEII) used in the NAERM simulations safe and secure. Sandia also implemented an architecture for NAERM system verification testing and performed a sensitivity analysis to determine parameter uncertainty impacts to the models. Sandia improved the scalability of NAERM and released technical

documentation on NAERM usability.

Stability Preserving Adaptive Load Shedding with Energy Justice Aware Actuators: In 2024, Sandia designed conventional multi-stage, adaptive, and data-driven Under-Frequency Load Shedding (UFLS) schemes. The new adaptive load shedding schemes were tested on three grid systems with social economic data, and a new metric called "Criticality Functions" was developed as a result.

Optimizing Vegetation Treatments for Wildfire Resiliency: Sandia developed a new way to run wildfire simulations that characterize ground vegetation. These new machine learning algorithms, coupled with real-time weather data, will help utilities understand the risks near electric infrastructure and prioritize vegetation management to minimize electric grid ignited wildfires. The work capitalizes on partnerships with the Public Service Company of New Mexico (PNM) and the U.S. Forest Service to better understand the risks of grid-initiated wildfires including wildfire identification, simulated fire response to fuel treatments, and downstream impacts to the grid and surrounding communities.

Improving Resiliency During Evacuations for Increased Electric Vehicle Penetration: The increased amount of electric vehicle (EV) charging load and the incapability of serving it during natural disasters will impact both the electric utility and the transportation sector, jeopardizing disaster evacuation plans. Sandia's research addresses the critical need to provide evacuation plans to EV drivers during disaster scenarios that may impact access to working charging stations. Additionally, this research evaluates demand needs to adjust the load corresponding to each charging. Initial findings indicate congestion both electrically and in the transportation network, which provides indispensable knowledge when planning for future natural disasters where EVs have a higher penetration.

Instant Arc Detection to Reduce Wildfire Ignition with Fast Protective Relaying: The potential for fire ignition from the electric grid, either through vegetation contact or equipment failure, is proportional to the duration of the arc, and existing protection schemes generally take 100 milliseconds to a second to engage. Sandia completed successful modeling of the main types of faults that lead to wildfire ignition and developed hardware and software solutions to extract relevant frequency-domain features from recorded signals to match the signature with the fault location. Application of Sandia's hardware and software solutions could greatly impact detection and mitigation of electric grid ignited wildfires.

Power Electronics and Energy Conversion Systems

Commissioning of the Advanced Power Conversion - Medium Voltage (APEX-MV) lab: Sandia's APEX-MV Lab facilitates development and validation of modular power conversion systems up to 15kV AC or DC. The facility is connected to Sandia's medium voltage distribution system through a 705kVA transformer. The facility is used for the scale up several power electronics devices developed at Sandia, including the Solid-State Transformer and the Hybrid Energy Storage Controller. These systems use advanced 3.3kV, 6.5kV, and 10kV components that operate in the hundreds of amperes and will become the building blocks of the modern grid.

Hybrid Energy-Storage System: Battery companies do not have the expertise necessary to integrate their products with the grid and rely on integrators to build expensive and sub-optimal DC/AC connection. This project created an open-source architecture to integrate any cell-based battery technology into the grid; thus reducing time-to-market and improving the chance of success of new battery technologies.

In 2024, Sandia scaled up the design of the power electronics, mechanical, and control component of a standardized hybrid energy storage system. The system can operate Li-ion, Lead-Acid, and Zinc-based batteries. It includes active control methods to limit the impact of thermal run away through real-time

energy redistribution—all of which will inform new battery technologies and testing.

Power Electronics and Energy Conversion Workshop: The Sandia Power Electronics and Energy Conversion Workshop took place on July 30-31 in Albuquerque, New Mexico and included over 130 attendees. The workshop hosted speakers from the DOE Office of Electricity and Advanced Research Projects Agency–Energy (ARPA-E) programs, industry, academia, and National Labs in seven different panel sessions. The topics ranged from needs of utilities, innovation in power electronics systems and components, supply chain, and markets. The 2025 workshop will include the DOE Transformer Resilience and Advanced Components Peer Review meeting.

Electric Grid Security and Communications

Mobile Cybersecurity Test for Electric Vehicle Charging Stations: Sandia developed a new approach that allows for agile, mobile cybersecurity testing of electric vehicle (EV) charging stations. The new testing method, which focuses on communications and cybersecurity functionality of electric vehicle supply equipment (EVSE), could fill a critical need in the future of grid security related to electric vehicle use. Prior to development of this more agile testing, electric vehicle original equipment manufacturers and EVSE vendors were forced to bring pre-production or production vehicles and charging stations to in-person testing, which is a cumbersome and expensive process. The new process uses commercial-off-the-shelf hardware and open-source software to demonstrate a more agile and productive approach that tests cybersecurity and interoperability. This work was completed in partnership with Argonne National Laboratory.

Cybersecurity for Electric Vehicle Charging and Hydrogen Surface Vehicle Fueling Infrastructures: Communications protocols currently being used in Electric Vehicle (EV) charging and Hydrogen Surface Vehicle (HSV) fueling infrastructures are vulnerable to cyber exploits. Sandia researchers identified IEEE 802 LAN/MAN (Layer 2) standards and technologies as alternatives to deliver significantly improved system security, performance, control, flexibility, and integration of AFV fueling with other 'energy edge' systems. Application of IEEE 802® standards and technologies to next-generation EV and HSV infrastructure communications and cybersecurity enable a wide range of next-generation, converged AFV fueling and energy edge use cases.

Distributed Energy Resources Network-Based Intrusion Detection (DER-NIDS) System: Sandia worked with network-based intrusion detection system (NIDS) companies to create a standardized parsing scheme to gather IEEE Std 1547 information from DER equipment. This data is used to perform cyber-physical analyses of DER networks to detect adversary operations—including insider threats, false data injection attacks, and machine-in-the-middle attacks—that would otherwise go undetected. Detection rules have been previously created for physical data and control setpoints, but there previously was no way to perform analyses with NIDS tools because there lacked a scalable way to import data into an analytics engine.

Increased Security for Distributed Energy Resource Management Systems: Distributed Energy Resource (DER) and Electric Vehicle Supply Equipment (EVSE) rely on cloud connections for updates, maintenance, and control. Most of these communication links are encrypted and not decrypted until reaching the backend systems, which increases the risk that malicious data could be packaged into these encrypted payloads and go undetected until processed or executed at the vendor, operator, or utility. Sandia created a template for all DER vendors, operators, aggregators, and utilities to deploy defense-in-depth solutions for Distributed Energy Resource Management Systems (DERMS) systems with Next Generation Firewalls (NGFWs) and Security Orchestration, Automation, and Response (SOAR) solutions. The Sandia team developed open-source SOAR playbooks that can be employed on a range of SOAR platforms for the entire DER industry. With successful NGFW and SOAR demonstrations from

SCE, PPL, DERSec, or ChargePoint wider adoption is expected in the utility, aggregator, and operator environments.

Defense Energy and Electromagnetics

Multi-scale Vulnerability and Propagation Testing of Power Delivery Equipment: Sandia completed vulnerability testing of a Basler Automated Voltage Regulator to conducted electromagnetic pulse (EMP) signals. This is part of a series of electric grid component testing to determine the ability of components to withstand different levels of EMP by implementing realistic EMP radiated, conducted, and combined threat environments at the system, subsystem, and component levels. Information gathered will be utilized by DOE to inform other agencies, industry, and manufacturers to improve decisions involving EMP risks and mitigations.

Materials Development for Hybrid Core Inductors for Shipboard Power: Sandia successfully fabricated a toroidal hybrid inductor that saturates at higher field — on the inside of the toroid — where the magnetic field is greatest, and at a lower field — on the outside of the toroid —where the magnetic field is weakest. This allows users to drive the inductor to higher current without saturating the interior of the toroid and enhances the energy density of the toroidal inductor. The toroid was fabricated in a two-step molding process with superparamagnetic ferrite nanoparticles deposited in a liquid epoxy matrix. This toroid will allow for an inductor that can operate at greater than a MHz, with vanishingly small losses, and with enhanced size, weight, and power (SWaP) considerations in support of the Navy's advanced power electronics goals.

E1-arrester for Improved EMP Protection: Sandia developed a solid-state surge arrester device to protect the grid from nanosecond EMPs and high voltage transients that threaten grid reliability and performance. These arresters take advantage of the properties of granular metals — a composition of metal nanoparticles within an insulating matrix — to divert sudden and short-lived high-voltage and high-current surges of energy safely away from the grid. The proposed arrester responds on a nano-second timescale, which is faster than existing lightning surge arresters currently on the grid.
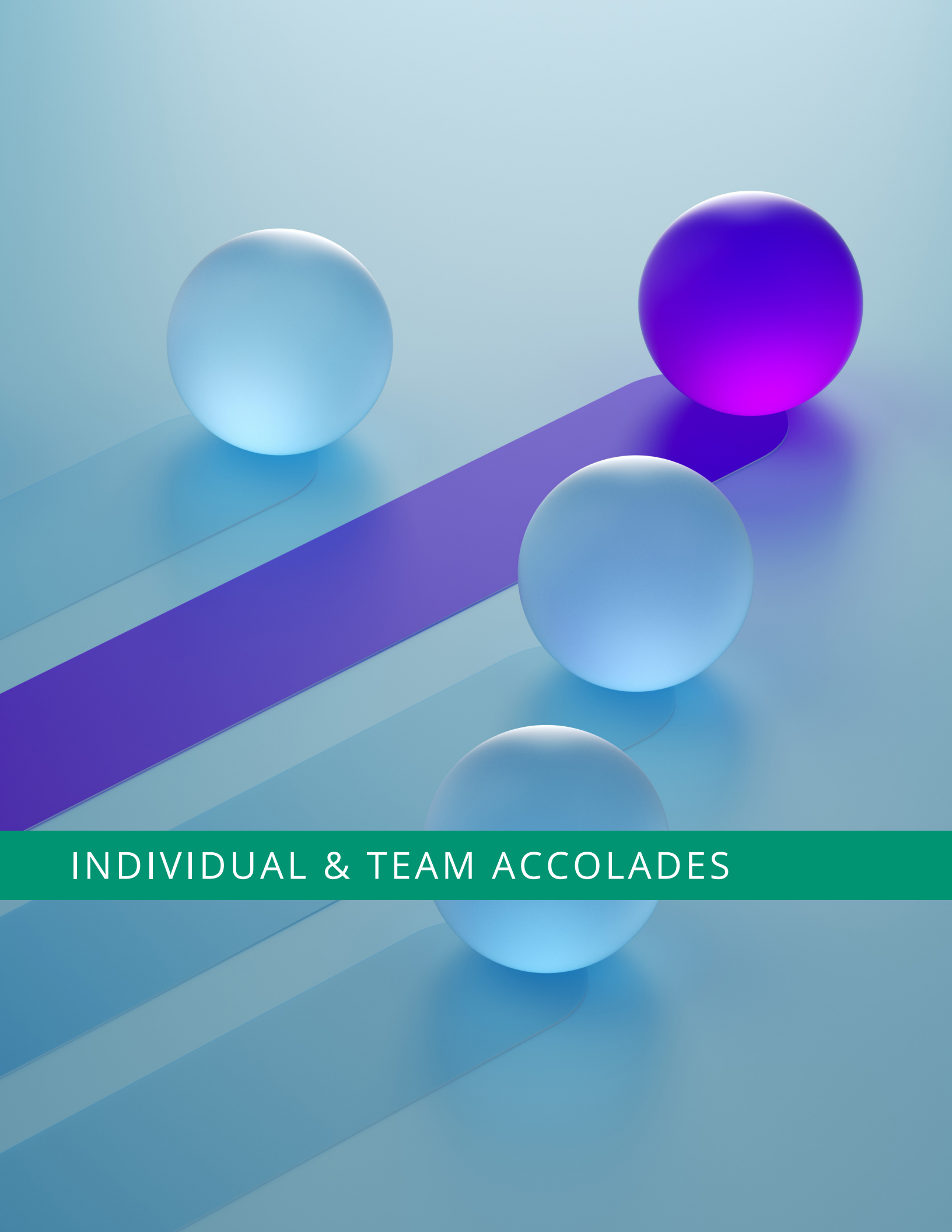
INDIVIDUAL & TEAM ACCOLADES

Individual and Team Accolades

Best Paper Award: Arturo Bretas' paper, "Network Security Challenges and Countermeasures for Software-Defined Smart Grids: A Survey" was selected as the featured article for the Smart Cities Journal 2024 September edition.

Great Minds in STEM Luminary Award: Rachid Darbali-Zamora was selected as a recipient of the Great Minds in STEM's Luminary Award. Luminary honorees "represent professionals in science, technology, engineering and mathematics who initiate, collaborate and lead key programs and research within their companies. These individuals have made significant contributions to the Hispanic technical community as leaders and role models."

IEEE Excellence Award: Stan Atcitty was selected as the recipient of the 2024 IEEE PES IAS A. P. Seethapathy Rural Electrification Excellence Award. This award was created to recognize exceptional power engineers who have worked, implemented, or innovated better and cheaper electrification technologies for the rural sector. Stan received the award for his outstanding impacts in "leadership and innovation in rural electrification of U.S. tribal nations."

IEEE Fellow: Michael Ropp was named a Fellow of the Institute of Electrical and Electronics Engineers, one of the world's largest technical professional organizations. IEEE Fellow is the highest grade of membership, and fewer than 0.1% of IEEE voting members can be selected as fellows each year after a rigorous evaluation process. Ropp was featured in a Sandia News Release in April 2024.

Emerging Technology Award: Michael Ropp and David Rosewater received an IEEE Standards Association Emerging Technology Award for the IEEE Standard 1547.9 Working Group. Michael Ropp acted as the working group co-chair and David Rosewater was a key technical content contributor. The award was presented to the working group on December 3, 2023.

IEEE PES Technical Support Leadership Committee Lead: Brian Pierre was appointed to be a lead of the Training and Education team of the IEEE PES ITSLC. Brian joined committee meetings at conferences to discuss training and education opportunities through IEEE to support power and energy workforce development.

Book Co-authorship: Ryan Elliott co-authored a book titled, *Power System Oscillations, Second Edition: An Introduction to Oscillation Analysis and Control*. This fully revised and expanded edition discusses the core ideas behind wide-area measurement systems (WAMS), real-time situational awareness, and wide-area control as they pertain to power system oscillations. The book was published as part of the Power Electronics and Power Systems book series.

Audience Choice Award: Michelle Bester won the Audience Choice Award at the 17th Annual Sandia Postdoctoral Technical Showcase on July 10, 2024 for her presentation, "Decoding the Canopy: Working towards a Machine Learning Approach for Canopy Bulk Density Estimations using Lidar coupled with Auxiliary Data."

Outstanding Young Engineer Award: Rachid Darbali-Zamora and Atri Bera were awarded the IEEE Albuquerque Section Outstanding Young Engineer Award. The award "recognizes engineers 35 years of age or under for outstanding contributions in the leadership of technical society activities including local and/or transnational PES and other technical societies, leadership in community and humanitarian activities, and evidence of technical competence through significant engineering achievements."

Best Poster Award: Rachid Darbali-Zamora won the "Best Poster Award in Area 9: Power Electronics and Grid Integration" at the 52nd IEEE Photovoltaic Specialist Conference (PVSC) for his poster titled "Implementation of an Analytical Active Power Curtailment Method for Photovoltaic System Applications".

Associate Editor for IEEE Open Access Journal of Power and Energy: Ujjwol Tamrakar was appointed Associate Editor for the IEEE Open Access Journal of Power and Energy (OAJPE), a leading journal in the field of power and energy systems.

Technology Development Track of the DOE Energy Storage Grand Challenge Co-Chair: Yuliya Preger was invited to serve as Co-Chair — transitioning to Chair next year — of the Technology Development Track of the DOE Energy Storage Grand Challenge (ESGC). The ESGC is a multi-office DOE effort to accelerate the development, commercialization, and utilization of next-generation energy storage technologies.

Runner Up Best Paper Award: At the 2024 IEEE IAS Electrical Safety Workshop David Rosewater accepted an award for the second best paper presented at the 2023 IEEE IAS ESW. The paper was titled 'Reducing Risk When Performing Energized Work on Batteries' and has since been accepted for publication in the IEEE Transactions on Industry Applications journal.

Sandia Employee Recognition Award: The Battery Leak Remediation Team received an Employee Recognition Award in May 2024 for their response to an onsite grid-scale flow battery leak. The team successfully remediated the leak and met all DOE and New Mexico reporting requirements. Team members included Mark Andrew Zuverink, Anita Reiser, Dezbah Tso Jesus, Reed Wittman, David Rosewater, Marc Williams, Joel Horvath, Sharon Ruiz, Daniel Hermanns, Waylon Clark, Jesse Farr, Ray Byrne, Ben Martinez.

Journal Publications

Energy Storage Technologies and Systems

Choi, H., R. Elliott, D. Trudnowski, D. Venkat, "Transient stability quantification of power systems with inverter-based resources via koopman operator based machine learning approach," Electric Power Systems Research, no. 237, DOI: 10.1016/j.espr.2024.111035.

Hill, R., A.S. Peretti, L.J. Small, E.D. Spoerke, and Y-T. Cheng. "Shorting at Long Duration: Impact of Extended Discharge Capacity on Battery Solid Electrolytes." 2024 Journal of the Electrochemical Society, DOI: 10.1149/1945-7111/ad3bec.

Murphy, E., B. Sun, M. Martina Rüscher, Y. Liu, W. Zang, S. Guo, Y-H. Chen, U. Hejral, Y. Huang, A. Ly, I.V. Zenyuk, X. Pan, J. Timoshenko, B.R. Cuenya, E.D. Spoerke, and P. Atanassov, "Synergizing Fe_2O_3 nanoparticles on single atom Fe-N-C for nitrate reduction to ammonia at industrial current densities," (2024) Advanced Materials, April 2024, DOI:10.1002/202401133.

Pandit, D., A. Bera, R. K. Saket, J. Mitra and N. Nguyen, "Probabilistic Sizing of Energy Storage Systems for Reliability and Frequency Security in Wind-Rich Power Grids," IEEE Transactions on Industry Applications, January 2024, DOI: 10.1109/TIA.2024.3356451.

Pandit, D., A. Bera, T.A. Nguyen, R.H. Byrne, B. Chalamala, J. Pierre, D. Duan, N. Nguyen, "Frequency Support from Electric Vehicles for Advancing Renewable Energy Integration," IEEE Transactions on Power Systems, April 2024, DOI: 10.1109/TPWRS.2024.3391211.

Rosewater, D., "Reducing Risk When Performing Energized Work on Batteries," in IEEE Transactions on Industry Applications, vol. 60, no. 2, pp. 2732-2741, March-April 2024, DOI: 10.1109/TIA.2023.3332828.

Turney, D., D. Dutta, S. Banerjee, T. Lambert, N. Bell, "Electrochemical and Cycle Analysis of Water-in-Salt K-Acetate Electrolyte Zn-Ion Batteries Under Commercially-Relevant Conditions," Journal of The Electrochemical Society, July 2024, DOI: 10.1149/1945-7111/ad5769.

Wittman, R., M. Dubarry, S. Ivanov, B. W. Juba, J. Roman-Kustas, A. Fresquez, J. Langendorf, R. Grant, G. Taggart, B. Chalamala, Y. Preger, "Characterization of Cycle-Aged Commercial NMC and NCA Lithium-ion Cells: I. Temperature-Dependent Degradation," Journal of The Electrochemical Society, December 2023, DOI: 10.1149/1945-7111/ad1450.

Renewable and Distributed Systems Integration

Fragkos, G., L. Blakely, S. Hossain-McKenzie, A. Summers and C. Goes, "Cyber-Physical Data Fusion & Threat Detection with LSTM-Based Autoencoders in the Grid," *2024 IEEE Kansas Power and Energy Conference (KPEC)*, Manhattan, KS, USA, 2024, pp. 1-6, DOI: 10.1109/KPEC61529.2024.10676133.

Gunda, T., A. Wachtel, S.K. Mishra, E. Moog, "Quantitative Approaches for Including Equity in Risk and Resilience Infrastructure Planning Analyses," Risk Analysis, September 2023, DOI:10.111/risa.14230.

Hill, R.C., M.S. Gross, S.J. Percival, A.S. Peretti, L.J. Small, E.D. Spoerke, and Y-T. Cheng. "Molten sodium batteries: advances in chemistries, electrolytes, and interfaces." (2024) Front. Batter. Electrochem., 3, 1369305. (Published 08, March, 2024) DOI: 10.3389/fbael.2024.1369305.

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Trevizan, R.D., V.A. Obrien, V.S. Rao, "Adaptive Battery State Estimation Considering Input Noise Compensation," International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), Ischia, Italy, June 19-21, 2024.

Renewable and Distributed Systems Integration

Fragkos, G., B. Jones, M. McCarty, V. Venkataramanan, "An Artificial Intelligent Intrusion Detection System for Wind Networks," NAWEA/WindTech 2024 Conference, New Brunswick, NJ, October 30 - November 1, 2024.

Fragkos, G., L. Blakely, S. Hossain-McKenzie, A. Summers, C. Goes, "Cyber-Physical Data Fusion & Threat Detection with LSTM-Based Autoencoders in the Grid", IEEE KPEC, April 25-26, 2024 in Manhattan, KS.

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Barba, P., R. Byrne, T. Nguyen, "Break-even capital costs for energy storage participating in the CAISO day-ahead energy and ancillary services markets," 2024 IEEE PES GM; Seattle, WA, July 21-25, 2024.

Blakely, L., G. Fragkos, S. Hossain-McKenzie, C. Goes, A. Summers, K. Haque, K. Davis, "A Comparison Study of Features Extraction and Data Fusion Techniques for Improving Cyber-Physical Situational Awareness", Conference Paper accepted to IEEE Transmission & Distribution Conference & Exposition, Anaheim, CA, May 6-9, 2024.

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Dow, A., M. Reno, M. Jimenez-Aparicio, D. Bauer, B. Ward, D. Ruiz, "Testing and Characterization of Fault Scenarios of a Hierarchical DC Microgrid for Residential Applications," CIGRE USNC Grid of the Future, Kansas City, MO, October 9-12, 2023.

Doyle, C., K. Stamber, R. Abbott, A. Jones, B. Arguello, R. Garrett, W. Beyeler, D. Schoenwald, S. Ojetola, "Integrated simulation of blackstart grid restoration with cognitive operator modeling control implementation," 2023 IEEE SmartGridComm Conference, Glasgow, Scotland, Oct. 31-Nov. 3, 2023.

Newlun, D., "Power System Planning for Decarbonization and Energy Storage", 2023 DOE Office of Electricity Energy Storage Peer Review Panel Presentation, October 26, 2023.

Ojetola, S., "Advanced Protection for DC Microgrids and Meshed Distributed Systems", RE+ 2023, Las Vegas, NV, September 11, 2023.

Ojetola, S., "Safeguarding the Future: Advancement in Protection Solutions for DC Microgrid", RE+ 2023, Las Vegas NV, September 12, 2023.

Schoenwald, D., T. Nguyen, J. McDowall, "Development and Deployment of Energy Storage Management Systems in Grid Applications," 2024 IEEE Electrical Energy Storage Applications and Technologies (EESAT), San Diego, CA, January 29-30, 2024.

Yusuf, J., A. Summers, "Evacuation Planning Under Increasing Electric Vehicle Penetration: Challenges and Solutions", in 2024 IEEE PES General Meeting, Seattle, Washington, USA, 21-25 July, 2024.

Power Electronics and Energy System Controls

Gill, L., L. Garcia Rodriguez, J. Mueller, R. Kaplar, A. Michaels, "Novel Dynamic ON-Resistance Measurement Circuit for GaN HEMTs," Energy Conversion Congress and Exposition (ECCE2023), Nashville, TN, October 29- November 2, 2023.

Kelly, D., T. Patel, R. Matthews, A. Summers, M. Reno, Y. Dong, "Incorporating Conductor Damage Constraint for Adaptive Protection Optimization in Distribution Networks" PES Innovative Smart Grid Technology, Latin America (ISGT-LA) 2023, Nov 6-9, 2023.

Mueller, J., J. Bock, L. Garcia Rodriguez, "Ripple Current and Temperature Distribution in Ceramic Capacitors for DC Link Applications," Energy Conversion Congress and Exposition (ECCE2023), Nashville, TN, October 29- November 2, 2023.

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Baquedano-Aguilar, M., A. Bretas, S. Meyn, "Coherency-Constrained Spectral Clustering for Proactive Load Shedding: A Tri-Level Model," IEEE Power & Energy Society General Meeting, Seattle, WA, July 21-25, 2024.

Baquedano-Aguilar, M., S. Meyn, A. Bretas, "Reduced-Order Models of Static Power Grids Based on Spectral Clustering," 2023 North American Power Symposium (NAPS), Asheville, NC, October 15-17, 2023.

Bretas, A., "Analytical Data-Driven Method for Geomagnetic Disturbance Uncertainty Quantification Compensation," 24th EEEIC International Conference on Environment and Electrical Engineering (EEEIC 2024), Jun 2024, Rome, Italy.

Bretas, A., K. Brown, V. Hartoonian, J. Snodgrass, "Geomagnetic Disturbance Uncertainty Quantification Modeling: An Electromagnetic Transient and Steady-State Simulation based Approach," 2023 IEEE PES Innovative Smart Grid Technologies Europe (ISGT EUROPE), Grenoble, France, October 26, 2023.

Mathieu, R., S. Boamah, A. Cooper, D. Agnew, J. McNair, A. Bretas, "Communication Network Layer State

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Paramo, G., A. Bretas, S. Meyn, "Microgrid Frequency Stability: A Proactive Scheme Based on Dynamic Predictions," 2024 IEEE PES Innovative Smart Grid Technologies (ISGT) Conference, Washington D.C., February 19-22, 2024.

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Trevizan, R.D., V.A. O' Brien, V.S. Rao, "Detecting Stealthy False Data Injection Attacks in State of Charge Estimation Using Sensor Encoding," IEEE Power and Energy Society General Meeting, 2024, Seattle, WA, July 21–25, 2024.

INTELLECTUAL PROPERTY ADVANCEMENTS

Patents

Energy Storage Technologies and Systems

Nguyen, T., R. Byrne, B. Chalamala, "Energy Storage-based Packetized Delivery of Electricity," U.S. Patent 11936185-B1, March 19, 2024.

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Mueller, J., Y. Preger, J. Hewson, A. Kurzawski, Dispersion of Stored Energy within a Battery System at Risk of Failure," U.S. Patent 11.855.264, December 26, 2023.

PRESENTATIONS

Invited Talks

Energy Storage Technologies and Systems

Bera, A., "Impact of BESS Failures and Aging on System Reliability," IEEE P762 Working Group, May 30, 2023.

Choi, H., "Application of Linear Operator Theory to Power System Stability Analysis with IBRs" 2023 IEEE Energy Conversion Congress & Expo: ECCE, Nashville, TN, Oct 29-Nov 2, 2023.

Diaz, M., A. Bates, Y. Preger, L. Torres-Castro, N. B. Johnson "Characterizing the Cathode Degradation Process from Thermal Abuse in Solid State Batteries" The Electrochemical Society (ECS), Gotenborg, Sweden, October 8-12, 2023.

Dutta, O., R. M. Wittman, S. Macchi, J. Cordova, T. Anderson, J. Mueller "Impact of Power Electronic Converter Ripples on Vanadium Redox Flow Batteries", The 244th Meeting of the Electrochemical Society, Gothenburg, Sweden, Oct 9-12th, 2023.

McNamara, W., "Advancements in Long Duration Energy Storage," Edison Electric Institute (EEI) Renewable Energy and Energy Storage Committee (REESC) Meeting, Washington, D.C., November 7, 2023.

McNamara, W., "Long duration energy storage", Energy Storage Working Group of the Smart Electric Power Alliance, June 12, 2023.

Oindrilla Dutta, "The Importance of BMS Testing Today: From EVs to Grid Storage" webinar organized by OPAL-RT as part of their Innovations in BMS Webinar Series.
Preger, Y., "Accelerating next-generation battery R&D through data-driven approaches", 2024 Electrochemical Society Fall Meeting, Honolulu, HI, October 6-11, 2023.

Preger, Y., "Newly revised DOE Energy Storage Safety Strategic Plan," 2024 Energy Storage Systems Safety and Reliability Forum, Richland, WA, May 14-16, 2023.

Rosewater, D., "Reducing Risk When Performing Energized Work on Batteries", IEEE Industry Applications Society (IAS) webinar, virtual, June 5, 2023.

Spoerke, E., "Beyond Li," NAATBatt meeting, Carlsbad, CA, February 19-22, 2023.

Spoerke, E., "Emerging Grid-Scale Energy Storage: A Key to Unlocking a Resilient Energy Future" Naval Postgraduate School Seminar, Monterey, CA, January 30, 2023.

Trevizan, R. "Research on Grid Energy Storage at Sandia National Laboratories" Texas Tech University, Lubbock, TX, October 13th 2023.

Wittman, R., O. Lavrova, U. Anwer, J. Huang, G. Cowles, S. Augustine, D. Terry, S. Atcitty, H. Guan, "Analysis of Battery Testing Protocols in the Transition from the Lab to the Field: A Test Case Using Advanced Zn-MnO2 Batteries in Off-Grid Solar Microgrids," The 244th Meeting of the Electrochemical Society, Gothenburg, Sweden, Oct 9-12th, 2023.

Renewable and Distributed Systems Integration

Darbali-Zamora, R., "Tomorrow's Grid for Behind-the-Meter DER's: Grid-forming Inverters and Low-cost Storage," 2024 Distributed Wind Energy Association, Arlington, VA, February 26-28, 2023.

Darbali-Zamora, R., R. Tremont, E. Aponte, A. Malave, "Microgrid Design Toolkit Evaluation and Trade-offs Analysis for Rural Community in Cayey Puerto Rico", 2023 IEEE PES Conference on Innovative Smart Grid Technologies Latin America (ISGT LA), San Juan, Puerto Rico, November 6-9, 2023.

Fragkos, G., "AI and Cybersecurity," Center of Cybersecurity/AI Research at University of North Dakota, Grand Forks, ND, July 18, 2023.

Mammoli, A., "Assisting Communities with Resilience Planning" 13th Annual Arizona Student Energy Conference, Tucson, AZ, April 4, 2023.

Mammoli, A., "Technical Assistance - Success Stories and Lessons Learned", 2024 Alaska Sustainable Energy Conference, Anchorage, AK, May 20-24, 2023.

Advanced Grid Modeling

Azzolini, J.A., M. J. Reno, "Interconnection Process Innovations and Use Cases," GridTECH Connect Forum, Newport, RI, June 25, 2023.

Elliott, R., "Stabilizing Actions in High-Renewable Systems (STAHRS)," RES Mission Campaign, Albuquerque, NM, Jan 29, 2023.

Newlun, C., "Overview of Long-term Power System Capacity Expansion Planning Models," New Mexico Public Regulation Commission Lunch N' Learn Series, Albuquerque, NM, March 20, 2023.

Pierre, B., "CREPES - Consortium for Research and Education in Power and Energy Systems," Sandia MSIPP Knowledge Share Community of Practice, Albuquerque, NM, March 2023.

Reno, M., and J. Azzolini, "Flexible Interconnection Strategies and Approaches," i2X Webinar, virtual, August 14, 2023.

Power Electronics and Energy System Controls
De Angelis, V., and G. De Carne, "The Role of Energy Storage Systems for a Secure Energy Supply: A Comprehensive Review of System Needs and Technology Solutions," Power System Computation Conference, Paris, France, June 2023.

Flicker, J., "Working Group 3 of the AMMTO Power Electronics Roadmap", AMMTO Listening session on Life Cycle Analysis for Grid Power Electronics, May 29, 2023.

Mueller, J., "MERIT: Medium Voltage Resource Integration Technologies – SNL Section," Power Electronics Accelerator Consortium for Electrification (PACE) Annual Meeting, Knoxville, TN, Aug. 14-15, 2023.

Electric Grid Security and Communications

O'Brien, V. "Cybersecurity for Energy Storage Systems" Columbia University, New York, NY, November 14, 2023.

Conference Presentations

Energy Storage Technologies and Systems

Bera, A., "Evaluation of Energy Storage and Introduction to QuESt" US DOE Energy Storage Financing Summit, New York City, NY, January 23, 2023.

Bera, A., "Energy Storage Applications" IEEE ISGT Conference in Washington, D.C., February 19, 2023.

Bhujel, N., A. Rai, U. Tamrakar, D. Hummels, and R. Tonkoski, "Integrated Voltage and Frequency Support in Microgrids Using Droop and Model Predictive Control with Energy Storage Systems," 2024 International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), Ischia, Italy, June 2023.

Byrne, R., A. Bera, T.A. Nguyen, "Reliability of the Future Smart Grid and the Role of Energy Storage," in 2024 International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), Ischia, Italy, June 2023.

Clark, W., R. Koripella, H. Guan, T. Wilcox, "Utility-scale Energy Storage Deployment: Insights from Project Lifecycles and Fielded Experiences," 2024 IEEE PES T&D Conference, Anaheim, CA, May 6-9, 2023.

Dutta, O., A. Dow, J. Mueller, R. Wauneka, V. de Angelis, "A Modular Prototype of Hybrid Storage Technologies for Grid Applications," 2024 International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), Ischia, Italy, June 2023.

Koripella, R., "Non-Lithium Energy Storage Demonstration Projects in California," Clean Energy States Alliance (CESA) 2024 Members Meeting, Chicago, IL, June 4, 2023.

McNamara, W., "LDES National Consortium," Clean Energy States Alliance (CESA) Members Only Meeting, Chicago, IL, June 4, 2023.

McNamara, W., "LDES National Consortium," LDES Council Summit, Washington, D.C., April 8, 2023.

O'Brien, V., "Cybersecurity of Battery Energy Storage Systems," 2024 Energy Storage Systems Group Monthly Meeting, Virtual, Aug. 13, 2023.

O'Brien, V., "Detecting False Data Injection Attacks in Battery Sensors," Sandia National Laboratories Electric Grid Security Lunch and Learn Series 2024, Virtual, Apr. 30, 2023.

O'Brien, V., "Increasing Battery Management System Resilience Following Identification of Sensor Anomalies Using Unknown Input Observer" 2023 DOE Office of Electricity Energy Storage Program Annual Meeting and Peer Review, Santa Fe, NM, USA, Oct. 24, 2023.

O'Brien, V., "Towards Deploying Anomaly Detection Algorithms in Battery Management Systems," 2024 DOE Office of Electricity Energy Storage Program Annual Meeting and Peer Review, Bellevue, WA, USA, Aug. 5, 2023.

O'Brien, V., and R.D. Trevizan, "A Comparison of Online Model-Based Anomaly Detection Methods for a Lithium-Ion Battery Cell," 2024 International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), Ischia, Italy, June 2023.

Preger, Y. "Impact of Module Configuration on Battery Performance and Degradation" at the International Battery Seminar, Orlando, FL, March 13-15, 2023.

Ray, A., U. Tamrakar, N. Bhujel, D. Hummels, R.H. Byrne, R. Tonkoski, "Frequency Security Index-Based State of Health Monitoring of a Microgrid using Energy Storage Systems," 2024 International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), Ischia, Italy, June 19-21, 2023.

Spoerke, E., "Generational' Electrical Energy Transformation through the DOE Office of Electricity," 2024 NY-BEST Annual Conference and Expo: Capture the Energy, Albany, NY, May 14, 2023.

Trevizan, R.D., V.A. O'Brien, V.S. Rao, "Adaptive Battery State Estimation Considering Input Noise Compensation," 2024 International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), Ischia, Italy, June 19-21, 2023.

Wittman, R., and Y. Preger, "Degradation of Commercial Lithium-Ion Cells Beyond 80% Capacity covered the cycling of Li-ion cells down to 80% capacity, the materials characterization done at 80% capacity and the cycling of the remaining cells to an end of life of 40% capacity," Electrochemical Society's regular webinar series, virtual, June 12, 2023.

Advanced Grid Modeling

Aghajan, A., M. Jimenez Aparicio, J. I. Poveda, M. E. Ropp, "Adaptive Under-Frequency Load Shedding in Power Systems with Socio-Technical Criticality Functions", 2024 IEEE Kansas Power & Energy Conference, April 2023.

Azzolini, J., M. Reno, "A Data-Driven Framework for Evaluating the Impacts of Advanced PV Inverter Control Functions," IEEE PVSC, Montreal, QC, CA, June 13, 2023.

Azzolini, J., M. Reno, "A Data-Driven Framework for Evaluating the Impacts of Advanced PV Inverter Control Functions," 52nd IEEE Photovoltaic Specialists Conference, Seattle, WA, June 9-14, 2023.

Bera, A., C. Newlun, A. Lopez, "Modeling Wind and Solar Power Generation for Grid Reliability Assessment," Analytics for Climate and Earth Sciences (ACES) poster symposium, Albuquerque, NM, April 3, 2023.

Blakely, L., G. Fragkos, S. Hossain-McKenzie, C. Goes, A. Summers, K. Haque, K. Davis, "A Comparison Study of Feature Extraction and Data Fusion Techniques for Improving Cyber-Physical Situational Awareness," IEEE/PES Transmission & Distribution Conference, Anaheim, CA, May 9, 2023.

Blakely, L., M. Reno, J. Azzolini, "Model Free Hosting Capacity Analysis," IEEE/PES Transmission & Distribution Conference, Anaheim, CA, May 8, 2023.

Blakely, L., S. Hossain-McKenzie, G. Fragkos, A. Chavez, "Cyber-Physical Situational Awareness Challenges and Opportunities in a Modern Smart Grid," IEEE/PES Transmission & Distribution Conference, Anaheim, CA, May 9, 2023.

Newlun, C., W. Olis, A. Benson, T. Nguyen, J. Mitra, "Reliability-based Capacity Expansion Planning for Decarbonization with the Aid of Energy Storage," 2023 IEEE ISGT Europe, Grenoble, France, Oct 26, 2023.

Reno, M., "Short circuit modeling of inverter-based resource (IBR) systems," NERC Inverter-Based Resource Performance Subcommittee (IRPS), January 18, 2023.

Reno, M., J. Azzolini, "Improving Protection of Low-Voltage Networks with High DER," IEEE/PES Transmission & Distribution Conference, Anaheim, CA, May 8, 2023.

Schoenwald, D., T. Nguyen, J. McDowall, "Development and Deployment of Energy Storage Management Systems in Grid Applications," 2024 IEEE Electrical Energy Storage Applications and Technologies (EESAT), San Diego, CA, January 2023.

Serna-Torre, P., V. Shenoy, J. Poveda, D. Schoenwald, P. Hidalgo-Gonzalez, "Non-cooperative Game to Control Learned Inverter Dynamics of Distributed Energy Resources," 23rd Power Systems Computation Conference (PSCC), Paris-Saclay, France, June 4 -7, 2023.

Shenoy, V., P. Serna-Torre, D. Schoenwald, P. Hidalgo-Gonzalez, J. Poveda, "Fast Frequency Regulation of Virtual Power Plants via Droop Reset Integral Control," 23rd Power Systems Computation Conference (PSCC), Paris-Saclay, France, June 4 -7, 2023.

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Power Electronics and Energy System Controls

De Angelis, V., "Open-Source Energy Storage Management Tools" Linux NA, Seattle, WA, April 17, 2023.

Dow, A., M. Reno, M. Jimenez-Aparicio, D. Bauer, B. Ward, D. Ruiz, "Testing and Characterization of Fault Scenarios of a Hierarchical DC Microgrid for Residential Applications," CIGRE Grid of the Future Conference, Kansas City, MO, October 9-12, 2023.

Elliott, R. "Suppressing Post-Fault Active Power Transients in Grid Forming Inverters." IEEE Photovoltaic Specialists Conference (PVSC, Seattle, WA, June 13, 2023.

Flicker, J., "PV System Reliability and Asset Management with U.S. Department of Energy" RE+ Anaheim, CA, September 12, 2023.

Gill, L., "Overview of Gallium Nitride (GaN) Power Device Reliability Assessment Approach," 2nd Annual Aging and Lifetimes Workshop, Albuquerque, NM, April 9-11, 2023.

Matthews, R. C., Donnelly, T. J., Rashkin, L. J., "Hamiltonian Control of a 4-Leg Converter for Mitigation of Common Mode-Induced Current Offset," Texas Power and Energy Conference (TPEC), College Station, TX, February 12, 2023.

Mueller, J., "Inverter Based Generation: 20MW-60MW at 13.8kV-69kV," SHARCC Grid Resilience Workshop, July 17th, 2023.

Mueller, J., "Protection and Control for Utility Interface and UPS," 2024 Applied Power Electronics Conference, Long Beach, CA, February 25, 2023.

Rodriguez, L., "A Solid-State Circuit Breaker Based on a Cascaded SiC JFET Topology and a GaN Photoconductive Semiconducting Switch," Sandia's Grid Modernization & Energy Storage 2023 Lunch & Learn Series, October 10, 2023.

Ropp, M., "Application of Direct Transfer Trip to Distributed Energy Resources", presentation to be given to i2X workshop on DTT and DTT alternatives, November 27, 2023.

Ropp, M., "IEEE 1547.9-2022: Guide for Using IEEE Std 1547 for Interconnection of Energy Storage Distributed Energy Resources with Electric Power Systems", EUCI workshop "Energy Storage Fundamentals," virtual, November 8, 2023.

Ropp, M., "Unintentional Islanding Detection: How it works, how we should look at it, and where it's headed in the future", presentation given to the Minnesota Public Utilities Commission and other stakeholders, November 17, 2023.

Ropp, M., O. Lavrova, E. Silva, "Avoiding asynchronous connections of adjacent microgrids in self-healing power systems", CIGRE Grid of the Future Conference, Kansas City, MO, October 9-12, 2023.

Silva, E., M. Ropp, O. Lavrova, "Demonstration of a self-healing power system concept using manufacturer specific inverter models," CIGRE Grid of the Future Conference, Kansas City, MO, October 9-12, 2023.

Yusuf, J., M. Ropp, M. Reno, "Protection Approaches for Self-Healing Microgrids Using Only Local Measurements" IEEE ISGT-NA poster session, Washington, D.C., February 20, 2023.

Electric Grid Security and Communications
O'Brien, V., "Cybersecurity of Battery Energy Storage Systems," 2024 DOE Office of Electricity Energy Storage Program Annual Meeting and Peer Review, Bellevue, WA, USA, Aug. 5, 2023.

O'Brien, V., "A Comparison of Online Model-Based Anomaly Detection Methods for a Lithium-Ion Battery Cell," 2024 International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), Ischia, Italy, June 19, 2023.

O'Brien, V., "False Data Injection Attack Detection Methods for Battery Stacks with Input Noise," 2024 IEEE PES Innovative Smart Grid Technologies Conference (ISGT), Washington DC, USA, Feb. 20, 2023.

O'Brien, V., "Increasing Battery Management System Resilience Following Identification of Sensor Anomalies Using Unknown Input Observer" 2024 IEEE Electrical Energy Storage Application and Technologies Conference (EESAT), San Diego, CA, USA, Jan. 29, 2023.

O'Brien, V., R.D. Trevizan, V. Rao, "Increasing Battery Management System Resilience Following Identification of Sensor Anomalies Using Unknown Input Observer" 2023 DOE Office of Electricity Energy Storage Program Annual Meeting and Peer Review, Santa Fe, NM, USA, October 24, 2023.

Webinars

Energy Storage Technologies and Systems

Dutta, O, "The Importance of BMS Testing Today: From EVs to Grid Storage," Virtual webinar OPAL-RT BMS Webinar Series, virtual, May 16, 2023.

McNamara, W, "Mapping the commercialization pathways for long-duration energy storage (LDES) technologies", 2024 TechConnect World Innovation Conference and Expo, Washington, DC., June 17-19, 2023.

Advanced Grid Modeling
Bera, A., "Introduction to QuESt" US DOE—India Energy Storage Alliance (IESA) Webinar Series on Energy Storage, February 15, 2023.

Matzen, L., "How Uncertainty Visualizations Impact Human Decision Making," EPRI hosted webinar for utilities, December 2023.

Pierre, B., "Wildfire Electric Grid Resilience Program Overview," EPRI hosted webinar for utilities, December 2023.

Reno, M. and J. Azzolini, "Technical updates to the Industry Advisory Board for the MoHCA Project 4", virtual presentation, April 29, 2023.

Power Electronics and Energy System Controls

Cardoza, A., "Multi-Port AC-Interfacing Converters with Common High-Frequency Link," 2023 DOE OE Energy Storage Peer Review, Santa Fe, NM, October 24-27, 2023.

Flicker, J., "Commissioning Test Procedures for GFM", UNIFI Consortium Evaluation Protocols for large Grid Forming Inverter Plants, August 8, 2023.

Flicker, J. "Grid Forming Inverter Usage in Power Systems" INEEL Advanced Converter Technologies for Smart Grid Application Workshop on uses of Grid Forming Inverters, Mexico City, Mexico (Virtual), July 29, 2023.

Monson, T., L. Garcia Rodriguez, J. Mueller, C. Pearce, M. Hoyt, R. Delaney, S. Atcitty, "Design and Circuit Evaluation of Advanced Iron Nitride Magnetics," 2023 DOE OE Energy Storage Peer Review, Santa Fe, NM, October 24-27, 2023.

Mueller, J., L. Garcia Rodriguez, A. Dow, M. Rios, "Development of Modular Hardware Architectures for Medium Voltage Energy Storage Systems," 2023 DOE OE Energy Storage Peer Review, Santa Fe, NM, October 24-27, 2023.

Preger, Y., J. Mueller, A. Fresquez, G. Baker, C. Rich, "Impacts of Module Configuration on Lithium-ion Battery Performance and Degradation," 2023 DOE OE Energy Storage Peer Review, Santa Fe, NM, October 24-27, 2023.

Zhang, Z., 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," 2023 DOE OE Energy Storage Peer Review, Santa Fe, NM, October 24-27, 2023.

Electric Grid Security and Communications

Obrien, V., R. D. Trevizan, V. Rao, "Increasing Battery Management System Resilience Following Identification of Sensor Anomalies Using Unknown Input Observer," presented at 2024 IEEE Electrical Energy Storage Application and Technologies Conference (EESAT), San Diego, CA, USA, Jan. 2024.

Obrien, V., V. S. Rao, R. D. Trevizan, "False Data Injection Attack Detection Methods for Battery Stacks with Input Noise," presented at 2024 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT), Washington, DC, USA, Feb. 2023.