

U.S. DEPARTMENT OF ENERGY  
OFFICE OF ELECTRICITY ENERGY STORAGE PROGRAM  
at SANDIA NATIONAL LABORATORIES

# FY20

S U M M A R Y

## Accomplishments & Impacts



Sandia  
National  
Laboratories

# Table of Contents

Introduction.....	1
Notable Accomplishments .....	3
Analytics .....	3
Demonstration Projects.....	4
Materials Research .....	5
Policy & Outreach .....	7
Power Electronics .....	8
Safety.....	8
Recognitions.....	10
Publications.....	12
Published Journal Articles.....	12
Manuscripts Submitted .....	14
Other Publications .....	15
Conference Proceedings .....	16
Patents.....	17
Issued.....	17
Applications.....	17
Sandia Technical Advances .....	18
Presentations .....	19
Invited Talks.....	19
Technical Presentations .....	21
Organizational Workshops and Symposia .....	24
Webinars .....	25



# INTRODUCTION

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Energy storage plays an increasingly growing role in improving the reliability and resiliency of the electric grid. Currently, grid energy storage systems are being deployed for a wide range of applications. Further improvements in cost and performance metrics are needed to make energy storage cost effective across all application markets in the electricity infrastructure. The Grid Energy Storage Program at Sandia National Laboratories is focused on making energy storage cost effective through research and development (R&D) in new battery technologies, advancements in power electronics and power conversion systems, improving the safety and reliability of energy storage systems, development of analytical tools for valuation of energy storage, and validation of new energy storage technologies through demonstration projects. During the 2020 fiscal year, Sandia executed R&D work supported by the U.S. Department of Energy's (DOE) Office of Electricity – Energy Storage Program under the leadership of Dr. Imre Gyuk. This document summarizes the impact of Sandia's contributions through notable accomplishments, journal publications, patents, and technical conferences and presentations.

14

## Notable Accomplishments

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During this fiscal year, Sandia contributed to multiple energy storage system installations, received prestigious professional and technical recognition, and organized multiple technical symposium. Brief descriptions of these and other selected accomplishments are provided on page 3 through page 11.

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## Publications

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Sandia researchers produced a large number of energy storage-related publications, including almost 30 published peer-reviewed journal papers. A list of publications is provided on page 12 through page 15.

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## Patents

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Sandia's efforts have produced a number of patents and applications on topics that include Diels-Alder Polyphenylene Polymers, Block Copolymers, and Metal-Organic Framework Electrodes for Sodium Ion Batteries. Three granted patents and seven additional patent applications have been filed and are listed on page 17 through page 18.

125+

## Technical Conferences and Presentations

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Sandia researchers were invited to talk at multiple conferences, contributed to numerous technical presentations, participated in organizational workshops and symposia, and webinars. These technical conference contributions and additional presentations are listed on page 19 through page 23.



# Notable Accomplishments





# NOTABLE ACCOMPLISHMENTS

## ANALYTICS

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**Sandia's energy storage analytics work focuses on developing algorithms and tools for optimal energy storage valuation, sizing, and placement.** In FY20, the analytics team investigated the benefits of storage + solar, the role of storage in a 100% renewable grid, and opportunities for energy storage as a transmission asset. Examples include valuation of storage + PV in New York state; valuation of storage + PV for energy arbitrage in the CAISO market; sizing energy storage for a 100% renewable grid in Puerto Rico; and valuation of energy storage for transmission congestion relief in vertically integrated utilities and market areas. The analytics team also provides analysis support for the energy storage demonstration projects. Examples of FY20 analysis projects include resilient microgrids in Puerto Rico, storage for tribal microgrids, and storage for NRECA's electric cooperatives. In FY20, the team published multiple peer reviewed journal and conference articles, organized workshops and gave invited talks and webinars on energy storage analytics.

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Sandia National Laboratories, in cooperation with Mustang Prairie Energy, organizes annual **energy storage finance summits** to bring together leaders from the finance and energy storage industry to discuss ways to lower barriers to energy storage financing. The San Francisco finance summit was held October 22, 2019, and the New York City finance summit was held January 14, 2020. Topics include software tools for energy storage valuation, warranties for energy storage systems, standardized contracts, and energy storage financing.

# DEMONSTRATION PROJECTS

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The Energy Storage projects team was selected to **manage a \$5M Congressional Appropriation for energy storage in rural applications**. Through this program, Sandia is managing five projects to determine the value of ES in rural applications. Sandia has performed techno-economic analysis and is providing technical consulting to the projects, e.g., development of the request for System Proposals (RFPs); vetting system technology, components and proposals; identifying the appropriate codes and standards; and providing best practices for operation and safety.

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In FY20 Sandia's projects team was involved in approximately **25 projects ranging in size from 500 KW -1 hour to 2 MW- 2 hours ES systems**. The team conducted analysis to determine optimum use and size for the energy storage system to provide the best return on investment. In six projects, on behalf of the DOE Energy Storage program, Sandia provided cost share funding to help the project, while also providing technical support through the project implementation and operation. Project partners include Albuquerque Public Schools; Arizona Public Service; Cordova (Alaska) Electric; Aliant Electric; New Mexico Energy, Minerals, and Natural Resources Department (ENMRD); Puerto Rico Mountain Consortium; and Energy Power Board of Tennessee (EPB).

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The projects team also manages the **Energy Storage Control and Analytics Lab (ESCAL)** and Energy Storage Test Pad (ESTP). The ESCAL lab works to refine the control systems associated with electrical energy storage such as the battery management and energy management systems. The lab also tests smaller battery systems to understand their operational performance over time. Currently the lab has two battery energy storage systems (BESS) on which they are conducting analysis.

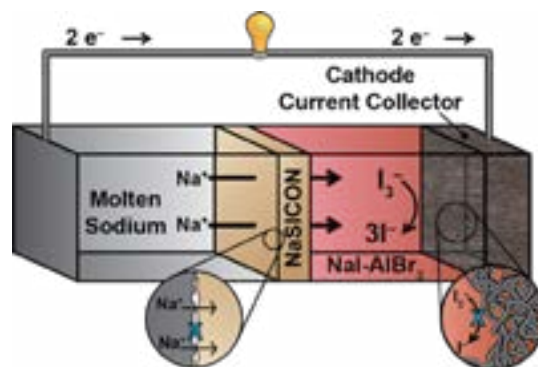
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**Community outreach is also part of the Project team's charter.** The outreach program provides project information and lessons learned through webinars, conferences and workshops. In FY20 the team conducted approximately eight webinars, and 12 conference/workshops presentations.

# MATERIALS RESEARCH

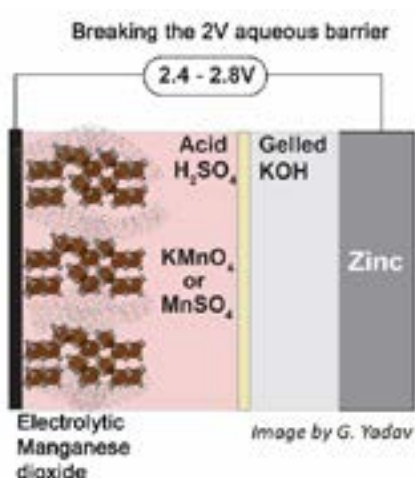
## Sodium (Na) battery research at Sandia this year, led

by Leo Small and Erik Spoerke, showed dramatic and promising advances toward “low temperature” molten Na batteries that operate near 100°C. Employing a molten Na anode, Sandia-synthesized solid-state separators, and an engineered iodide-based molten salt catholyte, these low temperature batteries aim to eliminate high materials and operational costs that limit traditional high temperature (~300°C) molten Na batteries. Researchers Martha Gross, Stephen Percival, and Amanda Peretti devised materials chemistry solutions at critical charge transfer interfaces and in the molten salt catholyte to enable a 10X improvement in current density, a 25X increase in usable battery capacity, and a >10X increase in battery lifetime at 110°C. Targeting publication of these dramatic improvements in Nature Energy, these advances represent important progress toward Na-based safe, low-cost, long-lifetime grid-scale storage.



## Sandia researchers Travis Anderson and Cy Fujimoto teamed with Los Alamos National Laboratory

Principal Investigator Rangachary Mukundan to tackle several major challenges in the field of redox flow batteries (RFBs). Working along complementary paths, Anderson and Mukundan developed new materials chemistries to advance emerging non-aqueous RFBs, using low-cost, earth-abundant active materials, such as iron and nickel complexes, in a system built for higher voltages ( $\geq 3V$ ) that promise higher energy density performance compared with traditional aqueous systems, such as vanadium redox flow batteries. Meanwhile, Fujimoto and LANL researcher Sandip Maurya demonstrated that a newly engineered ion-exchange membrane developed at SNL exhibited 2X ionic conductivity and 100X improved vanadium selectivity over commercial state-of-the-art materials.



Led by Principal Investigator Tim Lambert, along with lead collaborators Gautam Yadav and Professor Sanjoy Banerjee from Urban Electric Power (UEP), **Sandia and UEP are pursuing a game-changing innovation to create high-voltage Zn-MnO<sub>2</sub> batteries.** Their creative emerging technology breaks the critical 2V barrier in an aqueous Zinc anode battery and outperforms current state of the art rechargeable Zn-MnO<sub>2</sub> batteries in both voltage and capacity, making it a safer and competitive alternative to Li-ion chemistries. Initially reported by Yadav, et al. (ACS Energy Lett. 2019, 4, 9, 2144–2146) further high impact publications of this work are in preparation with the first one targeted for submission to Science.



Ion-selective membrane development at Sandia, led by Cy Fujimoto, took a leap toward industrial impact this year. Seven of Fujimoto's OE-supported **membrane patents were licensed by Xergy, Inc.**, a Delaware-based company with a commitment to engineering solutions with ion-exchange membranes. The licensed patents are:

- U.S. Patent No. 7,301,002, "Sulfonated Polyphenylene Polymers" issued November 27, 2007 (SD#7565.1)
- U.S. Patent No. 9,580,541, "High Performance, Durable Polymers Including Poly(Phenylene)" issued February 28, 2017 (SD# 12691.1)
- U.S. Patent No. 7,888,397, "Polyphenylene Based Anion Exchange Membrane" issued February 15, 2011 (SD# 10987.0)
- U.S. Patent No. 10,053, 534, "Functionalization of Diels-Alder Polyphenylene" issued August 21, 2018 (SD#13592.1)
- U.S. Patent No. 10,442,887, "Functionalization of Diels-Alder Polyphenylene," issued October 15, 2019 (SD#13592.5)
- U.S. Patent No. 10,294,325, "Halo Containing Anion Exchange Membranes & Methods Thereof" issued May 21, 2019 (SD#14264.0)



**Loraine Torres-Castro was selected as a judge for the 2019 MRS Fall meeting and 2020 MRS Spring Meeting student awards.** The judges were invited to participate based on their expertise and chose Gold/Silver winners based on an application package, presentation, and Q/A session. MRS Graduate Student Awards are intended to honor and encourage graduate students whose academic achievements and current materials research display a high level of excellence and distinction.

Sandia National Laboratories (T.N. Lambert et al.) **developed a thin, flexible polymeric separator that selectively impedes zincate transport without sacrificing overall conductivity.** Using an anodic stripping voltammetry assay, this material showed no detectable zincate penetration, while maintaining a hydroxide diffusivity and ionic conductivity on par with commercial battery separators. Furthermore, Zn-Ni cells incorporating this separator show a 897+% and 198+% increase in cycle life at substantial Zn utilizations of 20% and 50% respectively.

Resurrecting a battery chemistry thought to be only primary, Sandia National Laboratories (T. N. Lambert et al.) **demonstrated the first example of a rechargeable alkaline Zinc/Copper Oxide battery.** The batteries perform at very high areal capacities of ~ 40 mAh/cm<sup>2</sup> and unprecedented energy densities of ~ 260 Wh/L, with near 100% coulombic efficiency. Numerous spectroscopic methods, including working with Professor Joshua Gallaway (Northeastern University) and his team to obtain *in operando* energy dispersive X-ray diffraction measurements, were conducted to understand the facilitation of electrochemical reversibility. This work revitalizes a historically primary battery chemistry and opens opportunity to future work in developing copper-based conversion cathode chemistries for realization of a new class of low-cost, safe, and energy dense secondary batteries.

# POLICY & OUTREACH

The Policy & Outreach team conducted a series of energy storage webinars for regulators at utility commissions across the United States, officially hosted by the DOE Office of Electricity, Sandia National Laboratories, and Pacific Northwest National Laboratory. These free workshops assist regulatory commissions and related institutions (including utilities, NGOs, and academia) develop the expertise they need to more quickly and efficiently integrate energy storage into their regional operations. The workshops, custom-designed in close collaboration with regulatory commission staff, have already engaged regulators from over a dozen states with one- or two-day workshops on topics including energy storage technologies, performance, economics, valuation, interconnection, commissioning, safety, and policy.



In the fall of 2020, a new policy section was added to the Department of Energy Office of Electricity (DOE OE) Global Energy Storage Database, managed by Sandia. The Database now provides analysis of emerging policy specific to energy storage in the U.S., both at the federal and state levels. Analysis regarding energy storage policymaking at the state level is provided through state-specific summaries with independent analysis of key legislative, regulatory and executive policies within a state that directly affect energy storage. The objective of this site is to provide current and comprehensive analysis of key policy initiatives that are defining the emerging marketplace for energy storage solutions, so that regulators have a baseline from which to assess policy needs in their own jurisdictions.



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The capabilities of the Sandia Energy Storage Systems group have been expanded with the new **Grid Storage Management and Security (gSMS) Laboratory**. The gSMS facilitates the security investigation of battery management systems, energy storage management systems, energy storage system controllers and supervisors, among other operational technology devices that perform control, monitoring and safety functions of energy storage systems. The research scope encompasses vulnerability assessment of the aforementioned devices, assessment of consequences of security flaws and cyberattacks, as well as software and hardware solutions to improve their security.

## POWER ELECTRONICS

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The energy storage program, in January 2020, began work on the **Sandia Advanced Power Electronic Conversion Systems (APEX) laboratory**, a research facility dedicated to the development of advanced hardware topologies and intelligent control strategies for utility-scale energy storage applications. The lab's capabilities are designed to meet the research challenges of next-generation grid-tied storage systems. The lab is driven by a system integration perspective on power conversion research which cuts across traditionally separate disciplines. This interdisciplinary approach links the diverse portfolio of projects within the power electronics thrust area of the energy storage program and strategically positions the lab to address the complex challenges of real-world grid storage.



## SAFETY

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In the Safety Roadmap developed after the 2017 Safety Forum at Sandia, battery risk (safety) data was identified by the R&D working group as an important area for future expansion of stationary energy storage applications. Sandia researchers Loraine Torres-Castro and Joshua Lamb worked with Hsin Wang and Artem Trofimov from ORNL on **cell level thermal runaway testing and have developed unique techniques to establish a “battery thermal runaway risk” database**. This is a joint effort to develop test protocols and database for the ESS community. The final goal of the project is to utilize the database and electrochemical based models to simulate and predict safety performance of Li-ion batteries in energy storage.

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Members of the Energy Storage Safety thrust area traveled to Japan in January 2020 to **reinforce the relationship with the National Institute of Technology and Evaluation (NITE)** and discuss a path forward for collaboration efforts between the entities. They finalized an experimental plan for abuse testing of the same batteries at Sandia and NITE to help establish a standardized protocol for battery abuse procedures. Future plans under discussion include 1) statistical analysis by NITE of their abuse tests at the rack level and above and 2) investigating suppression of thermal runaway at the module level. This collaboration leverages NITE's unique large-scale test facilities and Sandia's substantial thermal modeling capabilities.

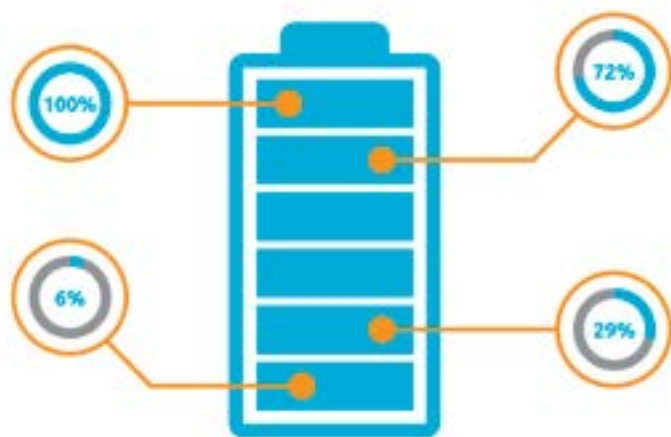
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In 2020, Yuliya Preger began developing the **Battery Energy Storage Test (BEST) Lab** which focuses on providing the most accurate state of health metrics and optimized performance outcomes for sealed batteries by bridging the gap between battery cell level studies and assessment of grid-scale units. This is accomplished by studying the aging of batteries beyond the cell level with field-relevant testing protocols. Batteries are cycled by both commercial battery testers and alternative power electronics topologies to identify the control strategies that are most suited for different battery module architectures and converters.

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In collaboration with the CUNY Energy Institute, **Yuliya Preger developed [batteryarchive.org](https://batteryarchive.org)**, the first public, searchable database of battery cycling results. This website is a repository for easy visualization, analysis, and comparison of battery data across research institutions. Within a few weeks of launch, batteryarchive.org had 100 users from 11 countries. Though initiated with data from Sandia alone, other institutions are beginning to support this open access initiative and upload their battery data.

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Led by David Rosewater, with support from Joshua Lamb and John Hewson, **Sandia performed a systematic grid-scale energy storage hazard analysis** in collaboration with PNNL to develop design objectives for system safety in support of Arizona Public Service (APS) to prevent accidents in future installations. The design objectives help utilities to structure their procurement process to make fires and vent gas explosions less likely in new and retrofitted energy storage systems. The analysis is summarized in the report "[Grid-scale Energy Storage Hazard Analysis & Design Objectives for System Safety](#)."

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# RECOGNITIONS

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The DOE Office of Electricity Energy Storage Program, in partnership with the Sandia energy storage program and GeneSiC Semiconductor, Inc., received special **Green Tech Gold recognition from R&D World Magazine** in December 2019 for developing a silicon carbide-based monolithic transistor-rectifier semiconductor switch. This leading-edge device is the world's first commercially available multi-functional 1.2 kV SiC-based power device. The performance advantages of these devices are expected to spur key innovations in utility-scale power electronics hardware and increase the accessibility and use of distributed energy resources.

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**QuEST, an open-source software tool for energy storage evaluation developed by Sandia's energy storage analytics team, was nominated for a 2021 R&D100 award.** The QuEST open source Python code allows users to easily evaluate energy storage systems in both market and behind the meter applications. For behind the meter applications, the tool can import utility tariff data as well as solar irradiance data for solar + storage applications.

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**Yuliya Preger and Martha Gross** were nominated by Sandia and accepted to present at the **7th World Materials Research Institutes Forum (WMRIF) Workshop for Early Career Scientists**. WMRIF is a 28 country, 53 institute forum that represents the largest common voice for materials science and technology in the world. The biannual Early Career workshop series concentrates on early career scientists in WMRIF institutes with the goals of network building, and knowledge and experience exchange, along with the chance to examine facilities of the host institute.





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Martha Gross, a postdoctoral appointee with the Materials Research team, earned **first place in Sandia's 2019 Postdoctoral Technical Showcase** at the National Museum of Nuclear Science and History. Gross's award-winning poster "Interfacial Engineering in Sodium Batteries" was one of 46 posters, including 15 from Los Alamos National Laboratory postdocs, who had been invited to participate in the annual Sandia event. The annual Showcase brings together early-career postdoctoral scientists and engineers with Labs' leaders and decision-makers for a technical poster competition and mentor awards.

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**Cy Fujimoto was one of the recipients of Sandia's 2019 Employee Recognition Awards (ERAs).** The ERAs celebrate Sandians' exceptional accomplishments in the areas of Safety & Security, Quality, Collaboration, Efficiency, Technical, Leadership, and Inclusion & Diversity. Cy's materials expanded the state-of-the-art in hydrogen energy technology. This work led to three patents, four publications, six Department of Energy (DOE) talks, and external program development in DOE's Office of Energy Efficiency and Renewable Energy, HydroGEN consortium, and the DOE Office of Electricity.

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**Leo Small was named an "Outstanding Reviewer" by the Royal Society of Chemistry** for the third consecutive year (2017, 2018, 2019) for contributions to the peer review process.





A close-up photograph of a stack of books, showing the edges of many pages. A semi-transparent teal rectangle is overlaid on the upper portion of the image, containing the word 'Publications' in white text.

# Publications

# PUBLICATIONS

## PUBLISHED JOURNAL ARTICLES

1. A. Bera, S. Almasabi, Y. Tian, R.H. Byrne, B.R. Chalamala, T.A. Nguyen, J. Mitra "Maximising the Investment Returns of a Grid-Connected Battery Considering Degradation Cost" IET Generation, Transmission & Distribution, September 2020, DOI: [10.1049/iet-gtd.2020.0403](https://doi.org/10.1049/iet-gtd.2020.0403)
2. M.M. Gross, L.J. Small, A.S. Peretti, S.J. Percival, M. Rodriguez, E.D. Spörke "Tin-Based Ionic Chaperone Phases to Improve Low Temperature Molten Sodium-NaSICON Interfaces" J. Mater. Chem. A, 05 Aug 2020, DOI: [10.1039/d0ta03571h](https://doi.org/10.1039/d0ta03571h)
3. M.B. Lim, T.N. Lambert, E.I. Ruiz "Effect of ZnO-Saturated Electrolyte on Rechargeable Alkaline Zinc Batteries at Increased Depth-of-Discharge" J. Electrochem. Soc. 2020, 167, 060508. DOI: [10.1149/1945-7111/ab7e90](https://doi.org/10.1149/1945-7111/ab7e90)
4. S. Madhusoodhanan, A. Sabbar, S. Atcitty, R. Kaplar, A. Mantooth, SQ. Yu, Z. Chen "High-Temperature Analysis of GaN-based Blue LEDs for Future Power Electronic Applications" IEEE Journal of Emerging and Selected Topics in Power Electronics, 02 October 2019, DOI: [10.1109/JESTPE.2019.2945166](https://doi.org/10.1109/JESTPE.2019.2945166)
5. S. Madhusoodhanan, A. Sabbar, S. Atcitty, R. Kaplar, A. Mantooth, SQ. Yu, Z. Chen "High-Temperature Optical Characterization of GaN-Based Light-Emitting Diodes for Future Power Electronic Modules" Phys. Status Solidi A 2020, 217, 1900792, Dec 18, 2019, DOI: [10.1002/pssa.201900792](https://doi.org/10.1002/pssa.201900792)
6. S. Madhusoodhanan, A. Sabbar, H. Tran, B. Dong, J. Wang, A. Mantooth, SQ. Yu, Z. Chen "High-Temperature Analysis of GaN-based MQW Photodetector for Optical Galvanic Isolations in High-Density Integrated Power Modules" IEEE Journal of Emerging and Selected Topics in Power Electronics, Feb 18, 2020, DOI: [10.1109/JESTPE.2020.2974788](https://doi.org/10.1109/JESTPE.2020.2974788)
7. B.A. Magar, N. Paudel, T.N. Lambert, I. Vasiliev, "Ab Initio Studies of Discharge Mechanism of MnO<sub>2</sub> in Deep-Cycled Rechargeable Zn/MnO<sub>2</sub> Batteries" Journal of the Electrochemical Society, February 5, 2020, Vol. 167, Issue 2, 020557, DOI: [10.1149/1945-7111/ab6eec](https://doi.org/10.1149/1945-7111/ab6eec)
8. Y. Preger, H.M. Barkholtz, A. Fresquez, D.L. Campbell, B.W. Juba, J. Román-Kustas, S.R. Ferreira, B.R. Chalamala "Degradation of Commercial Lithium-ion Cells as a Function of Chemistry and Cycling Conditions" J. Electrochem. Soc., vol. 167, 120532, 2020. 167 120532., DOI: [10.1149/1945-7111/abae37j](https://doi.org/10.1149/1945-7111/abae37j)
9. D. Rosewater, R. Baldick, S. Santoso "Risk-Averse Model Predictive Control Design for Battery Energy Storage Systems" IEEE Transactions on Smart Grid, vol. 11, no. 3, pp. 2014-2022, May 2020, DOI: [10.1109/TSG.2019.2946130](https://doi.org/10.1109/TSG.2019.2946130)

10. D.M. Rosewater, D.A. Copp, T.A. Nguyen, R.H. Byrne, S. Santoso "Battery Energy Storage Models for Optimal Control" IEEE Access, vol. 7, pp. 178357-178391, December 4, 2019, DOI: [10.1109/ACCESS.2019.2957698](https://doi.org/10.1109/ACCESS.2019.2957698)
11. A. Sabbar, S. Madhusoodhanan, S. Al-Kabi, B. Dong, J. Wang, S. Atcitty, R. Kaplar, D. Ding, A. Mantooth, SQ. Yu, Z. Chen "High Temperature and Power Dependent Photoluminescence Analysis on Commercial Lighting and Display LED Materials for Future Power Electronic Modules" Sci Rep 9, 16758 (2019), <https://doi.org/10.1038/s41598-019-52126-4>
12. A. Sabbar, S. Madhusoodhanan, B. Dong, J. Wang, H.A. Mantooth, SQ. Yu, Z. Chen "High-Temperature Spontaneous Emission Quantum Efficiency Analysis of Different InGaN MQWs for Future Power Electronics Applications" IEEE Journal of Emerging and Selected Topics in Power Electronics, May 22, 2020, DOI: [10.1109/JESTPE.2020.2995120](https://doi.org/10.1109/JESTPE.2020.2995120)
13. R.C. Shurtz and J.C. Hewson "Materials Science Predictions of Thermal Runaway in Layered Metal-Oxide Cathodes: A Review of Thermodynamics" J. Electrochem. Soc., vol. 167, no. 9, p. 090543, 2020, DOI: [10.1149/1945-7111/ab8fd9](https://doi.org/10.1149/1945-7111/ab8fd9)
14. L. Torres-Castro, A. Kurzwski, J.C. Hewson, J. Lamb "Passive Mitigation of Cascading Propagation in Multi-Cell Lithium Ion Batteries" J. Electrochem. Soc. 167(9):090515, 2020, <https://doi.org/10.1149/1945-7111/ab84fa>
15. N. Turner, M. Freeman, H. Pratt, A. Crockett, D. Jones, M. Anstey, T. Anderson, C. Bejger "Desymmetrized hexasubstituted [3]radialene anions as aqueous organic catholytes for redox flow batteries" Chemical Communications, March 4, 2020, vol. 56, 2739-2742, DOI: [10.1039/c9cc08547e](https://doi.org/10.1039/c9cc08547e)
16. L. VanGelder, H. Pratt, T. Anderson, E. Matson "Surface functionalization of polyoxovanadium clusters: generation of highly soluble charge carriers for nonaqueous energy storage" Chemical Communications, October 18, 2019, vol. 55, 12247-12250, DOI: [10.1039/c9cc05380h](https://doi.org/10.1039/c9cc05380h)
17. R.M. Wittman, M.L. Perry, T.N. Lambert, B.R. Chalamala, Y. Preger "Perspective – On the Need for Reliability and Safety Studies of Grid-Scale Aqueous Batteries" Journal of the Electrochemical Society, May 28, 2020, Vol. 167, No. 9, 2020 167 090545, DOI: [10.1149/1945-7111/ab9406](https://doi.org/10.1149/1945-7111/ab9406)

# MANUSCRIPTS SUBMITTED

- 18.** D.J. Arnot and T.N. Lambert "Bismuth Detection in Alkaline Electrolyte via Anodic Stripping Voltammetry for Battery Separator Evaluation" *Electroanalysis*, Submitted August 2020
- 19.** A. Bera, S. Almasabi, J. Mitra, R.H. Byrne, B.R. Chalamala, T.A. Nguyen "Spatiotemporal Optimization of Grid-Connected Storage considering Battery Degradation Cost" *IET Generation, Transmission, and Distribution*, Accepted May 2020
- 20.** A. Bera, B. Chalamala, R.H. Byrne, J. Mitra "Sizing of Energy Storage for Grid Frequency Stability" *IEEE Trans. Power Systems*, Submitted August 2020
- 21.** R. Concepcion, T.A. Nguyen, F. Wilches Bernal, D.A. Copp "QuEst: An Open-Source Software Tool for Energy Storage Valuation" *IEEE Transactions on Power Systems*, Submitted August 2020
- 22.** D.A. Copp, T.A. Nguyen, R. Thomson, R.H. Byrne, B.R. Chalamala "Energy Resource Planning for 100% Renewable Grid" *IET Generation, Transmission and Distribution*, Submitted August 2020
- 23.** D.A. Copp, T.A. Nguyen, R.H. Byrne "Real-time Dispatching for Energy Aggregators with Energy Storage and Stochastic Renewable Generation in Markets" *IET Generation, Transmission and Distribution*, Submitted September 2020
- 24.** R. Fioravanti, K. Kumar, S. Nakata, B.R. Chalamala, Y. Preger "Adopting Predictive Maintenance Practices for Battery Energy Storage System Safety" *IEEE Power & Energy*, Accepted 2020
- 25.** Z. Kaynat, P. Anusha, L. Wei-Jen, D. Rosewater "Determine the Electrode Configuration and Sensitivity of the Enclosure Dimensions when Performing Arc Flash Analysis" *IEEE Transactions on Industry Applications*, Accepted July 2020
- 26.** I.V. Kolesnichenko, D.J. Arnot, M.B. Lim, G.G. Yadav, M. Nyce, J. Huang, S. Banerjee, T.N. Lambert "Zincate-Blocking Functionalized Polysulfone Separators for Secondary Zn/MnO<sub>2</sub> Batteries" *ACS Applied Materials and Interfaces*, Submitted August 2020
- 27.** M.B. Lim, T.N. Lambert, B.R. Chalamala "Rechargeable Alkaline Zinc–Manganese Oxide Batteries for Grid Storage: Mechanisms, Challenges and Developments" *Mater. Sci. Eng. R Rep.* 2020, Submitted August 15, 2020
- 28.** N.B. Schorr, D.J. Arnot, A.M. Bruck, J. Duay, M. Kelly, R.L. Habing, L.S. Ricketts, J.A. Vigil, J.W. Gallaway, T.N. Lambert "Rechargeable Alkaline Zinc / Copper Oxide Batteries" *ACS Applied Energy Materials*, Submitted September 2020
- 29.** R.C. Shurtz "A Thermodynamic Reassessment of Lithium-Ion Battery Cathode Calorimetry" *Journal of the Electrochemical Society*, Submitted September 2020

- 30. U. Tamrakar, D.A. Copp, T.A. Nguyen, T.M. Hansen, R. Tonkoski “Optimization-based Fast-Frequency Estimation and Control of Low-Inertia Microgrids” IEEE Transactions on Energy Conversion, Submitted March 2020
- 31. U. Tamrakar, D.A. Copp, T.A. Nguyen, T.M. Hansen, R. Tonkoski “Online Moving Horizon Estimation of Inertia and Damping Constant of Microgrids” IEEE Access, Submitted August 2020

## OTHER PUBLICATIONS

- 32. C. Ashton, B. Chalamala, R. Masiello, J. McDowall, D. Novosel, V. Rabl, M. Ropp, M. Siira, C. Vartanian, C. Wong “Energy Storage Primer” IEEE Power & Energy Society, pp. 13, April 2020
- 33. W. McNamara “Policy Analysis State Profiles” completed for AZ, CA, CO, HI, IL, MA, MD, NM, NV, NY, and OR. All policies completed October-November 2019 and posted online in the [DOE Global Energy Storage Database](#)
- 34. D.M. Rosewater “[Battery Energy Storage Control: Modeling, Uncertainty, and Applications](#)” PhD Dissertation, The University of Texas at Austin, SAND2020-4029 T, May 2020
- 35. D.M. Rosewater, J. Lamb, J.C. Hewson, V. Viswanathan, M. Paiss, D. Choi, A. Jaiswal “Grid-scale Energy Storage Hazard Analysis & Design Objectives for System Safety” Report prepared for Arizona Public Service, SAND2020-9360, August 2020
- 36. B. Schenkman, D. Rosewater, S. Willard, P. Ip, M. Evans, M. Simpson, J. Thompson “[Electrical Energy Storage Data Submission Guidelines](#)” by Sandia National Laboratories and the Electric Power Research Institute, Technical Update, SAND2020-2569R, February 2020
- 37. E.D. Spoerke, M.M. Gross, S.J. Percival, L.J. Small Molten Sodium Batteries in eds. M. Alston, T. Lambert, Energy – Sustainable Advanced Materials, in Press, Springer Nature, London, 2020 <https://www.springer.com/gp/book/9783030574918>
- 38. C. Wong, C. Ashton, B. Chalamala, D. Houseman, H. Huang, R. Masiello, J. McDowall, D. Novosel, V. Rabl, M. Ropp, M. Siira, C. Vartanian, *Energy Storage Opportunities and Research Needs*, IEEE Power & Energy Society, pp. 50, June 2020





# Conference Proceedings





# CONFERENCE PROCEEDINGS

1. A. Bera, S. Almasabi, J. Mitra, B. Chalamala, R.H. Byrne "Spatiotemporal Optimization of Grid-Connected Energy Storage to Maximize Economic Benefits" 2019 IEEE Industry Applications Society Annual Meeting, Baltimore, MD, pp. 1-7, DOI: [10.1109/IAS.2019.8912342](https://doi.org/10.1109/IAS.2019.8912342)
2. R.C. Brost "Siting Energy Storage and Distribution Resources for Societal Benefit During Long-Term Outages" (Selected for "Best Paper") IEEE Power & Energy Society (PES) General Meeting, August 3-6, 2020
3. R.H. Byrne, T.A. Nguyen, A. Headley, R. Trevizan "Opportunities and Trends for Energy Storage Plus Solar in the CAISO Real-Time Market: 2014-2018" IEEE International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), June 24-26, 2020, DOI: [10.1109/SPEEDAM48782.2020.9161956](https://doi.org/10.1109/SPEEDAM48782.2020.9161956)
4. R.H. Byrne, T.A. Nguyen, A. Headley, F. Wilches Bernal, R. Concepcion, R. Trevizan "Opportunities and Trends for Energy Storage Plus Solar in CAISO: 2014-2018" IEEE Power & Energy Society (PES) General Meeting, August 3-6, 2020
5. A.J. Headley, B.L. Schenkman, D.M. Rosewater "Discrete vs Optimized Dispatch for Energy Storage in a Microgrid" 2020 IEEE Power & Energy Society (PES) General Meeting, August 3-6, 2020
6. A. Hussain, K. Raj, K. Rajashekara, H. Krishnamoorthy, S. Atcitty "Current Controlled Operation of Cascaded H-Bridge Converter for Fast SoC Balancing in Grid Energy Storage" 2019 IEEE Energy Conversion Congress and Exposition (ECCE), Baltimore, MD, September 29 - October 3, 2019, DOI: [10.1109/ECCE.2019.8913198](https://doi.org/10.1109/ECCE.2019.8913198)
7. E. Langlois, J. Watt, D. Huber, M. McDonough, T.C. Monson, J. Neely "Design and Evaluation of Nano-Composite Core Inductors for Efficiency Improvement in High-Frequency Power Converters" IEEE Applied Power Electronics Conference and Exposition (APEC), March 15-19, 2020, DOI: [10.1109/APEC39645.2020.9123995](https://doi.org/10.1109/APEC39645.2020.9123995)
8. T.A. Nguyen, R.H. Byrne, R.D. Trevizan "Utilization of Existing Generation Fleets Using Large-scale Energy Storage Systems" 2020 IEEE Power & Energy Society (PES) General Meeting, August 3-6, 2020
9. D. Rosewater, B.L. Schenkman, S. Santoso "Adaptive Modeling Process for a Battery Energy Management System" IEEE International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), June 24-26, 2020, DOI: [10.1109/SPEEDAM48782.2020.9161886](https://doi.org/10.1109/SPEEDAM48782.2020.9161886)
10. R. Trevizan, T.A. Nguyen, R.H. Byrne "Sizing Behind-the-Meter Energy Storage and Solar for Electric Vehicle Fast-Charging Stations" IEEE International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), June 24-26, 2020, DOI: [10.1109/SPEEDAM48782.2020.9161848](https://doi.org/10.1109/SPEEDAM48782.2020.9161848)
11. F. Wilches-Bernal, B.J. Pierre, D.A. Schoenwald, R.T. Elliott, R.H. Byrne, J.C. Neely, D.J. Trudnowski "Forced Oscillations in the Western Interconnection with the Pacific DC Intertie Wide Area Damping Controller" IEEE Innovative Smart Grid Technologies (ISGT), Washington, DC, February 2020, DOI: [10.1109/ISGT45199.2020.9087750](https://doi.org/10.1109/ISGT45199.2020.9087750)



# Patents



# PATENTS

## ISSUED

1. C. Fujimoto “Functionalization of Diels-Alder Polyphenylene Polymers” U.S. Patent No. 10,442,887, October 15, 2019
2. C. Fujimoto “Block Copolymers including Poly(phenylene) and Methods Thereof” U.S. Patent No. 10,479,866, November 19, 2019
3. D. Sava Gallis, H. Pratt, T. Anderson, N. Hudak “Metal-Organic Framework Electrodes for Sodium Ion Batteries” U. S. Patent 10,497,971, December 3, 2019

## APPLICATIONS

1. J.A. Bock, E. D. Spoerke, H. J. Brown-Shaklee, L. J. Small “Solution-Assisted Densification of NaSICON Ceramics” US Patent Application No. 62/963,980, January 21, 2020
2. C. Fujimoto “Ion Selective Membranes for Redox Flow Batteries” US Patent Application No. 63/067,989, August 20, 2020 (SD 15330.0)
3. L.J. Small, S.J. Percival, and E.D. Spoerke “Nanostructured Polyelectrolytes for Ion-Selective Membranes” US Application No. 2020/0078736 A1, June 10, 2020
4. L.J. Small and E.D. Spoerke “Alternating Current Electrodialysis” US Application No. 2020/0189942 A1, June 18, 2020
5. E.D. Spoerke, M. M. Gross, S.J. Percival, L. J. Small “Surface Treatments of NaSICON Ceramics for Improved Sodium Electrochemical Interfaces,” US Patent Application No. 62/940,697, November 26, 2019
6. E.D. Spoerke, S.J. Percival L.J. Small “Molten Inorganic Electrolytes for Low Temperature Sodium Batteries,” US Patent Application No. 16/564,751, September 2019
7. B. Zheng, Y. Zhou, E.J. Lavernia, T.C. Monson “Isostatic Pressure Spark Plasma Sintering (IP-SPS) Net Shaping of Components Using Nanostructured Materials” Provisional Patent Application No. 62/985,223, March 4, 2020

# SANDIA TECHNICAL ADVANCES

1. S. Atcitty, S. Ranade, V. De Angelis "Solar-Battery Integrated DC System" SD-15501/S167257, July 07, 2020
2. C. Fujimoto, E.D. Baca "High Ion Selective Membranes for Flow Battery Applications" SD-15330
3. T.N. Lambert "Improved Copper Oxide Electrodes and Battery builds for Electrochemical Applications" May 11, 2020, SD-15465
4. J. Mueller, Y. Preger, J. Hewson, A. Kurzawski "Dispersion of Stored Energy Within a Battery System at Risk of Failure" SD-15111

# Presentations



# PRESENTATIONS

## INVITED TALKS

1. S. Atcitty “Disaster Recovery, Disadvantaged Communities and Displaced People” [Invited speaker and panel member] IEEE Global Humanitarian Technology Conference (GHTC), Seattle, WA, October 18, 2019
2. S. Atcitty “Energy Storage Power Electronics Program” Energy Storage Systems Safety & Reliability Forum, Richland, WA, March 4, 2020
3. S. Atcitty “Role of Power Electronics and Wide Bandgap in Grid-tied Energy Storage System” Kansas Power and Energy Conference, Manhattan, KS, July 13-14, 2020
4. D. Borneo “Grid Energy Storage – Overview and Trends” Energy Storage Reliability Workshop, Newport, OR, October 29, 2019
5. D. Borneo “Energy Storage Demonstration Project Review” Mountain Consortium Review, Villalba, PR, November 7, 2019
6. D. Borneo, S. Schoening “Energy Storage Procurement and Commissioning” NM Public Regulatory Commission Meeting, Santa Fe, NM, January 14, 2020
7. D. Borneo “Sandia National Laboratories’ Energy Storage R&D Program Update” NAATBatt Conference, Pasadena, CA, February 10-13, 2020
8. D. Borneo “McMicken Event: What we learned” Energy Storage Systems Safety & Reliability Forum, Richland, WA, March 3-6, 2020
9. D. Borneo “DOE/SNL Energy Storage Project Team Case Studies: Sterling, MA; Cordova, AK” Utah PUC Meeting, July 22, 2020
10. D. Borneo, S. Schoening “Energy Storage RFP Development” NREL-NRECA Meeting, August 31- September 1, 2020
11. D. Borneo “DOE/SNL Energy Storage Project Team Case Studies: Sterling, MA; Cordova, AK” Iowa PUC Meeting, September 11, 2020
12. R.H. Byrne “Energy Storage Economics, Valuation, and Finance” New Mexico Public Regulation Commission Meeting, Santa Fe, NM, October 31, 2019
13. R.H. Byrne “Energy Storage Applications and Value Stacking” PNM Public Advisory Committee Meeting, Albuquerque, NM, November 19, 2019



14. R.H. Byrne “Energy Storage Applications and Value Stacking” Nevada Public Utility Commission Meeting, Carson City, NV, January 21, 2020
15. B.R. Chalamala “Emerging eT&D Grids: Energy Storage, Electrification, and the Increasing Role of Power Electronics” IEEE Energy Conversion Congress & Expo, Baltimore, MD, September 30, 2019
16. B.R. Chalamala “Energy Storage and Electric Vehicle Impacts on the Grid, National Governors Association” New Mexico Grid Modernization retreat, Santa Fe, NM, December 12, 2019
17. B.R. Chalamala “Emerging eT&D Grids: Energy Storage, Electrification and the Increasing Role of Power Electronics” University of Central Florida, February 12, 2020
18. J. Lamb “Battery Safety” Public Safety Workshop, Case Western Reserve University, February 2020
19. J. Lamb “Impact of energy density on thermal runaway” Energy Storage Systems Safety & Reliability Forum, Richland, WA, March 4, 2020
20. J. Lamb “Accelerating Rate Calorimetry of Large Format Cells” International Battery Seminar, Virtual Meeting, July 2020
21. T.N. Lambert “Recent Progress in Alkaline Zn/MnO<sub>2</sub> Batteries” NAATBatt International Workshop on Zinc Battery Technology II, the Advanced Science Research Center at CUNY, New York, New York, November 7, 2019
22. W. McNamara “Policy Analysis at Sandia Labs” National Association of National Regulatory Utility Commission’s (NARUC’s) Executive Management Committee, February 12, 2020
23. W. McNamara “Modeling for Resilience: Sandia’s Approach” Joint Committee Meeting, National Association of National Regulatory Utility Commission’s (NARUC’s) Executive Management Committee and the National Association of State Energy Offices (NASEO), February 13, 2020
24. W. McNamara “U.S. Policy Trends Affecting Energy Storage” Institute of Electrical and Electronics Engineers (IEEE) Power & Energy Society (PES) Education Database, April 2020
25. S.J. Percival, M.M. Gross, L.J. Small, E.D. Spoeke “Advances in Low Temperature Molten Sodium Halide Catholytes for Sodium Batteries” ACS Southwest Regional Meeting, El Paso, TX, November 2019
26. Y. Preger “Rigorous Approaches to Quantifying Cell Failure to Enable Large-Scale Failure Modeling – Materials, Mechanics, and Electrochemistry” 10th Annual Battery Safety Summit, Alexandria, VA, October 2019
27. Y. Preger “Degradation of Commercial Lithium-ion Cells Beyond 80% Capacity” Energy Storage Systems Safety & Reliability Forum, Richland, WA, March 4, 2020
28. E.D. Spoeke, M.M. Gross, S.J. Percival, L. Small, A. Peretti, J. Lamb, and B.R. Chalamala “Really Cool Molten Sodium Batteries: Material Innovations to Enable Low Temperature Operation” 31st Rio Grande Symposium on Advanced Materials, Albuquerque, NM, September 16, 2019

29. E.D. Spoerke, A.S. Peretti, S.J. Percival, L.J. Small, M.M. Gross, E. Schindelholz, M. Melia, S.B. Rempe, D. Nelson, S. Russo "The Ions Seeps Tonight: Assessing Ionic Transport in Multilayered Nanocomposites" Composites at Lake Louise 2019, Lake Louise, Alberta, Canada, November 2019
30. E.D. Spoerke "Toward Lower Temperature Molten Sodium Batteries for Grid Scale Applications" International Conference on Sodium Batteries (ICNaB-2019), Naperville, IL, November 2019
31. E.D. Spoerke, A.S. Peretti, S.J. Percival, L.J. Small, M.M. Gross, E. Schindelholz, M. Melia, S.B. Rempe, D. Nelson, S. Russo, R. Hill, and Y.T. Cheng "Controlling Ion Transport in Multilayered Polymer Composites" Layered Polymeric Systems (ACS Polymer Division) – 2020, Windsor, CA, February 2020
32. E.D. Spoerke and B.R. Chalamala "What Role Will Innovation & Grid Modernization Play in Renewable Energy Development Nationally?" Renewable Energy Development, Grid Modernization & Distributed Generation Workshop, Milwaukee, WI, March 2020
33. L. Torres-Castro "Understanding the factors impacting battery failure propagation and its mitigation" Materials Research Society (MRS) Fall Meeting, Boston, MA, December 2019
34. L. Torres-Castro "Understanding the factors impacting battery failure propagation and its mitigation" Energy Storage Systems Safety & Reliability Forum, Richland, WA, March 2020

## TECHNICAL PRESENTATIONS

1. D.J. Arnot, I.V. Kolesnichenko, M.L. Lim, T.N. Lambert "Permselective Separators for Rechargeable Alkaline Zn/MnO<sub>2</sub> Batteries" 2019 Annual AIChE Student Conference Poster Competition, Orlando, Florida, November 8-11, 2019
2. A. T. Binder, R. J. Kaplar, and J. R. Dickerson, "Limitations in Impact Ionization Modeling for Predicting Breakdown in Wide Bandgap Power Semiconductors" Virtual Electronic Materials Conference, June 2020
3. J. Cho, G. Yadav, J. Huang, D. Turney, M. Nyce, M. Lim, T. N. Lambert, S. Banerjee "The Study on the Factors Affecting the Single Discharge Curve of the Zn/MnO<sub>2</sub> Primary Battery and Their Effects on the Energy Density Performance" AIChE Battery and Energy Storage Workshop, New York, NY, October 21-22, 2019
4. E. Deichmann, L. Torres-Castro "Analyzing the Effects of Lithium Plating on the Safety Performance of Lithium-Ion Batteries" 236th Electrochemical Society (ECS) Meeting, Atlanta, GA, October 13-17, 2019
5. M.M. Gross, A.S. Peretti, S.J. Percival, L.J. Small, B.R. Chalamala, E.D. Spoerke "Interfacial Engineering in Sodium Batteries" [Best Poster Award] Sandia National Laboratories and Los Alamos National Laboratories 2019 Postdoctoral Technical Showcase, Albuquerque, NM, December 2019
6. M.M. Gross, A.S. Peretti, S.J. Percival, L.J. Small, M. Rodriguez, and E.D. Spoerke "Interfacial Engineering of Ceramic Separators in Sodium Batteries" American Ceramic Society's Electronic Materials and Applications meeting, Orlando, FL, January 2020

7. B. Hawkins, D. Turney, G.G. Yadav, T.N. Lambert, R.J. Messinger, S. Banerjee “The Electrochemical Activity of Zinc Oxide Discharge Product in Zinc Alkaline Electrodes” 2019 AIChE Battery and Energy Storage Workshop, New York, NY, October 21-22, 2019
8. T.N. Lambert “Recent Progress in Alkaline Zn/MnO<sub>2</sub> Batteries” NAATBatt International Workshop on Zinc Battery Technology II, the Advanced Science Research Center at CUNY, New York, NY, November 7, 2019
9. M.B. Lim, I.V. Kolesnichenko, D.J. Arnot, T.N. Lambert “Effect of ZnO-Saturated Electrolyte on Rechargeable Alkaline Zn–Ni and Zn–MnO<sub>2</sub> Batteries at High Zinc Depth-of-Discharge” 236th Electrochemical Society (ECS) Meeting, Atlanta, Georgia, October 13-17, 2019
10. B.A. Magar, N. Paudel, T.N. Lambert, I. Vasiliev, “Bi- and Cu-Modified  $\delta$ -MnO<sub>2</sub> Electrodes in Rechargeable Zn/MnO<sub>2</sub> Batteries: An Ab Initio study”, Four Corners Section Meeting of the American Physical Society, Prescott, AZ, October 11-12, 2019
11. T.A. Nguyen “QuEST – Storage Evaluation Open-source Tool,” Energy Storage Financing Summit, New York, NY, January 2020
12. T.A. Nguyen “Energy Storage Planning for Grid of the Future” [Conference Session Chair] IEEE Innovative Smart Grid Technologies (ISGT), Washington, DC, February 2020
13. T.A. Nguyen “Energy Storage for Resilience Applications,” IEEE Innovative Smart Grid Technologies (ISGT), Washington, DC, February 2020
14. T.A. Nguyen “Analytical tools for Market and Behind-the-meter Applications” IEEE Power and Energy Society (PES) General Meeting, August 2020
15. H. Passell “Energy Storage Systems” New Mexico Public Regulatory Commission, October 31, 2019
16. H. Passell “Energy Storage Systems” PNM Public Advisory Board, November 19, 2019
17. H. Passell “Energy Storage Overview” Public Utilities Commission Nevada, January 22, 2020
18. N. Paudel, B. Ale Magar, T.N. Lambert, I. Vasiliev “Theoretical Studies of Zinc Contamination of  $\gamma$ -MnO<sub>2</sub> in Deep-Cycled Rechargeable Zn/MnO<sub>2</sub> Batteries” Four Corners Section Meeting of the American Physical Society, Prescott, AZ, October 11-12, 2019
19. S. Peretti, E. Coker, M. Rodriguez, M. Gross, E.D. Spörke “Ceramic Sodium Ion-Conducting Separator Processing” [Poster Award Winner] 31st Rio Grande Symposium on Advanced Materials, Albuquerque, NM, September 16, 2019
20. H. Pratt, L. Small, T. Anderson “Diagnostics for failure modes in non-aqueous flow batteries” 236th Electrochemical Society (ECS) Meeting, Atlanta, GA, October 13-17, 2019
21. Yuliya Preger – Featured in “[Modeling Goes A Long Way To Prevent Lithium-Ion Battery Safety Failure](#)” Battery Power Online, October 2019

22. Y. Preger, A. Fresquez, B.R. Chalamala, S.R. Ferreira “Degradation of Commercial Lithium-ion Cells Beyond 80% Capacity” 236th Electrochemical Society (ECS) Meeting, Atlanta, GA, October 13-17, 2019
23. Y. Preger “Degradation of Commercial Lithium-ion Cells Beyond 80% Capacity” Battery Safety Council Forum, Washington, DC, November 2019
24. Y. Preger “Safety and Performance of Commercial Li-ion Cells” Batteries Gordon Research Conference, Ventura, CA, February 2020
25. D. Rosewater “IEEE Draft Battery Management System (BMS) Recommended Practice” Energy Storage Systems Safety & Reliability Forum, Richland, WA, March 4, 2020
26. D. Rosewater “Battery Energy Storage Control: Modeling, Uncertainty, and Applications” PhD Defense Presentation, March 2020
27. A. Sabbar, S. Madhusoodhanan, S. Al-Kabi, B. Dong, J. Wang, S. Atcitty, R. Kaplar, A. Mantooth, S. Yu, and Z. Chen “High Temperature Spontaneous Emission Quantum Efficiency Analysis from Blue and Green LED Materials” IEEE Photonics Conference (IPC), San Antonio, TX, September 29 – October 3, 2019
28. R.C. Shurtz and J.C. Hewson “Modeling Thermal Decomposition of Metal Oxide Cathodes in Non-Aqueous Electrolytes for Prediction of Thermal Runaway in Lithium-Ion Batteries” 236th Electrochemical Society (ECS) Meeting, Atlanta, GA, October 13-17, 2019
29. E.D. Spoerke, M.M. Gross, S.J. Percival, L.J. Small, A.S. Peretti, J. Lamb, B.R. Chalamala “Tailoring Materials Chemistry to Advance Low Temperature Molten Sodium Batteries” 236th Electrochemical Society (ECS) Meeting, Atlanta, GA, October 13-17, 2019
30. E.D. Spoerke – Co-Chair of international composites meeting: Composites at Lake Louise, Alberta, Canada, November 2019
31. E.D. Spoerke – Symposium Organizer “Ion Conductors” American Ceramic Society’s Electronic Materials and Applications Conference in Orlando, FL, January 2020
32. E. D. Spoerke, A. S. Peretti, E. Coker, M. Rodriguez, M. M. Gross, S. J. Percival and L. J. Small, “Synthetic Designs for Improved NaSICON-Based Sodium Ion Conductors,” American Ceramic Society’s Electronic Materials and Applications Meeting, Orlando, FL, January 2020
33. L. Torres-Castro “Understanding the factors impacting battery failure propagation and its mitigation” Materials Research Society (MRS) Fall Meeting, Boston, MA, December 2019
34. L. Torres-Castro “Investigations of the Structural and Electrochemical Properties of Overheated Li-Ion Batteries and Its Effects in Single Cells Vs. Multi-Cells Packs” 236th Electrochemical Society (ECS) Meeting, Atlanta, GA, October 13-17, 2019
35. V. Veliadis, R. Kaplar, J. Zhang, S. Khalil, J. Flicker, J. Neely, A. Binder, S. Atcitty, P. Moens, M. Bakowski, M. Hollis “International Technology Roadmap for Wide-Bandgap Power Semiconductors Chapter 6: Roadmap for WBG and UWBG Materials and Devices” ITRW Kick-Off Meeting at the IEEE Energy Conversion Congress and Exposition, Baltimore, MD, September 29 – October 3, 2019

# ORGANIZATIONAL WORKSHOPS AND SYMPOSIA

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B.R. Chalamala, C. Ashton, R. Byrne, B. Cantor, J. McDowall, T. Nguyen, Y. Preger, C. Searles, V. Sprenkle, C. Vartanian  
— Grid Energy Storage Technology and Applications Tutorial:

- Session 1: Overview & Technologies, July 21, 2020
  - Session 2: Applications and Valuation, July 21, 2020
  - Session 3: Engineering Energy Storage Systems, July 23, 2020
  - Session 4: A Closer Look at Safety, Codes and Regulations, July 23, 2020
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Howard Passell organized the following Energy Storage workshops:

- New Mexico Public Regulatory Commission Workshop Series, October 31, 2019 – January 10, 2020 (3-session workshop)
- Public Utility Commission Nevada Energy Storage Workshop, January 22, 2020
- Maryland Public Service Commission Webinar, March 25 - April 15, 2020 (4-session workshop)
- SNL Energy Security Capabilities for the State of New Mexico, SNL/NM Energy, Minerals, and Natural Resources Dept. Webinar, July 7, 2020
- Utah Governor's Office of Energy Development Energy Storage Webinar Summer Series, July 8 – August 12, 2020 (6-session webinar)
- Iowa State University Electric Power Research Center/MISO States Energy Storage Webinar Series, July 31 – October 23 (7-session webinar)

E.D. Spoerke served on SNL team to DOE Energy Storage Grand Challenge development and organization of Southwest Regional Workshop

D. Xing, C. Xie, K. Wang, T. Liu, B. Hu, J. Wang, A. Agarwal, R. Singh, S. Atcitty "3.3-kV SiC MOSFET Performance and Channel-Length Related Short-Circuit Capability" IEEE Workshop on Wide Bandgap Power Devices and Applications in Asia (WiPDA-Asia), September 23-25, 2020

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A photograph of a laptop screen showing a video conference. The screen is divided into five windows. The top-left window shows a man with a beard and mustache, wearing a light blue and white striped polo shirt, smiling. The top-right window shows a man with dark hair, wearing a dark shirt, looking towards the camera. The bottom-left window shows a woman with dark hair, wearing a dark top, looking towards the camera. The bottom-right window shows a man with dark hair and a beard, wearing a light blue and white striped shirt, smiling. The middle window shows a group of three people, including a man in a red shirt and a woman in a black shirt, standing outdoors. The word "Webinars" is written in white text across the center of the screen.

# Webinars





# WEBINARS

1. S. Atcitty “Introduction to Energy Storage” Tribal Energy Webinar Series: Tribal Energy Project Technology Options, May 27, 2020
2. D. Borneo “DOE/SNL Energy Storage Projects Team Overview 2020” Decorah Project Webinar, July 13, 2020
3. R.H. Byrne “Energy Storage Applications and Value Stacking” Maryland Public Utility Commission, April 1, 2020
4. R.H. Byrne “Energy Storage Applications and Value Stacking” Utah Public Utility Commission, July 15, 2020
5. R.H. Byrne “Energy Storage Applications and Value Stacking” 2020 IEEE Power and Energy Society (PES) General Meeting Tutorial, July 21, 2020
6. R.H. Byrne “Energy Storage Applications and Value Stacking” Iowa State University Electric Power Research Center/MISO States Energy Storage Workshop Series, August 28, 2020
7. R.H. Byrne “Energy Storage Applications and Value Stacking” IEEE presentation to the Federal Energy Regulatory Commission (FERC), September 23, 2020
8. W. McNamara “Introduction to Energy Storage Policy” New Mexico Public Regulatory Commission, December 4, 2019
9. W. McNamara “Procurement Mandates for Energy Storage” New Mexico Public Regulatory Commission, January 14, 2020
10. W. McNamara “Introduction to Energy Storage Policy” Public Utilities Commission Nevada, January 22, 2020
11. W. McNamara “Introduction to Energy Storage Policy” Maryland Public Service Commission, April 8, 2020
12. W. McNamara “Regulatory Consideration of Energy Storage Ownership Models” Maryland Public Service Commission, April 8, 2020
13. W. McNamara “Introduction to State-Level Policy Analysis & Outreach to NM PRC” Energy, Minerals, and Natural Resources Department of New Mexico (EMNRD), July 7, 2020
14. W. McNamara “Introduction to Energy Storage Policy” Utah Public Utilities Commission, July 8, 2020
15. W. McNamara “[Introduction to Energy Storage Policy](#)” Iowa State University Electric Power Research Center/ MISO States 7-Session Energy Storage Webinar Series, July 31, 2020

16. W. McNamara “Incorporating Energy Storage into Integrated Resource Plans” Utah Public Utilities Commission, August 5, 2020
17. W. McNamara “Tax Credits & Financial Subsidies for Energy Storage” Utah Public Utilities Commission, August 5, 2020
18. T.A. Nguyen “[QuEST – Storage Evaluation Open-source Tool Webinar](#)” Clean Energy Alliance webinar series, November 2019
19. T.A. Nguyen “[QuEST – Storage Evaluation Open-source Tool Webinar](#)” Clarkson University Seminar Series, March 2020
20. T.A. Nguyen “Energy Storage Tutorial – Energy Storage Management System” IEEE Power and Energy Society (PES) General Meeting, July 2020
21. H. Passell “[Energy Storage Overview](#)” Maryland Public Service Commission Storage Workshop, March 25, 2020
22. H. Passell “[Energy Storage and Resilience](#)” Maryland Public Service Commission Storage Workshop, April 15, 2020
23. H. Passell “Decarbonization Modeling for New Mexico” NM Energy, Minerals, and Natural Resources Department, July 7, 2020
24. H. Passell “[Energy Storage Systems Overview](#)” Utah Governor’s Office of Energy Development 6-Session Energy Storage Webinar Summer Series, July 8, 2020
25. H. Passell “[Energy Storage Systems Overview](#)” Iowa State University Electric Power Research Center/MISO States 7-Session Energy Storage Webinar Series, July 31, 2020
26. Y. Preger “System Safety and Reliability” IEEE Power and Energy Society (PES) Tutorial, July 2020
27. B. Schenkman “Introduction to Diesel Generators” Tribal Energy Webinar Series: Tribal Energy Project Technology Options, May 27, 2020
28. E.D. Spoerke “Materials Chemistry to Advance Na-Batteries” Materials Science & Engineering Department Seminar, University of North Texas, Denton, TX, September 2019

