

U.S. Department of Energy
Office of Electricity Energy Storage Program

at SANDIA NATIONAL LABORATORIES

FY19 Summary

Accomplishments and Impacts

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

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Introduction

Energy storage can play a key role in creating a resilient, reliable, and secure electric grid. Currently, grid energy storage technology is being deployed for selected applications, and further cost reductions and performance improvements are needed to make energy storage cost effective across all applications in the electricity infrastructure. Sandia National Laboratories Energy Storage Program is focused on making energy storage cost effective through research and development (R&D) in new battery technology development and advancements in power electronics and power conversion systems, improving the safety and reliability of energy storage systems, and enabling the deployment of new energy storage technologies in the electric grid. During the 2019 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.

Notable Accomplishments

14

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 **pages 5 through 12**.

Publications

22

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 **pages 13 through 17**.

Patents

12

Sandia's efforts have produced a number of patents and applications on topics that include alkaline batteries, copper and sulfur-based electrodes, zinc-anode batteries, and Diels-Alder polyphenylene polymers. Six granted patents and six additional patent applications have been filed and are listed on **pages 23 through 25**.

Invited Talks and Technical Presentations

79

Sandia researchers were invited to talk at multiple conferences, contributed to 15 conference papers, participated in webinars and on conference panels, and organized symposiums. These technical conference contributions and additional presentations are listed on **pages 27 through 36**.

Notable Accomplishments

Notable Accomplishments

October 2018

Sandia, with support from Mustang Prairie, organized two U.S. Department of Energy (DOE) Energy Storage Financing Summits. The first one was held October 4, 2018, in San Francisco, CA, and the second was January 23, 2019, in New York City. The summits focused on advancing standardized contract development in the energy storage market and are part of DOE's effort to promote market development through reducing barriers to entry, reducing transaction costs, and promoting wider access to low cost capital. Both summits were held in the offices of Morrison & Foerster LLP.

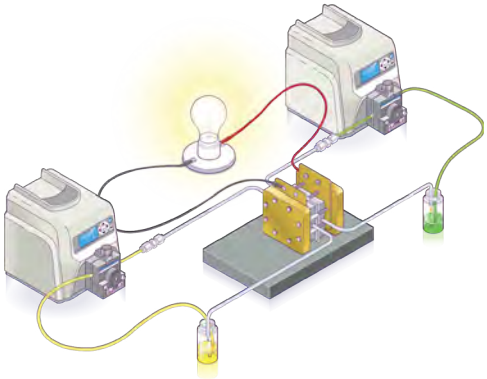
November 2018

Released QuESt v1.1 in November 2018, featuring energy storage valuation in all seven US market areas with stacking ISO/RTO services. Released QuESt v1.2 in March 2019, featuring cost savings estimation using behind-the-meter energy storage systems for time-of-use and net metering customers.

November 2018

NAATBatt International, in collaboration with Sandia and PNNL and with support from DOE Office of Electricity, hosted a workshop on zinc battery technology on Friday, November 16, 2018, at The Advanced Science Research Center at the Graduate Center of the City University of New York (CUNY). The workshop examined the principal zinc battery technologies on the market today, how they work, what their particular characteristics are, and where they might be able to pay in the energy storage market today and tomorrow. This overflow event with 100+ attendees featured speakers and guests from around the globe.

January 2019



Sandia and Los Alamos National Lab organized the Workshop on Non-Aqueous Flow Batteries in Santa Fe, NM, from January 30-31, 2019. The workshop identified key research needs that can enable the commercialization of non-aqueous flow battery systems. Bringing together experts from national labs, universities, and industry, the workshop identified the limitations of state-of-art non-aqueous flow battery technology and developed a research roadmap to advance this system into a commercially viable product.

January 2019

Two prominent researchers supported by DOE OE Energy Storage program were elected for the 2019 class of IEEE Fellows. Prof. Bruce Gnade, Southern Methodist University, is recognized for his contributions to electronic materials and device technologies. Prof. Joydeep Mitra, Michigan State University, is recognized for his contributions to the development of power system reliability methods. Both are actively collaborating with the OE Energy Storage program at Sandia. Dr. Gnade on developing experimental methods to understand and improve the reliability of high voltage capacitors and Dr. Mitra on development of optimization methods for evaluating energy storage and on the development of improved models for energy storage systems.

February 2019

Sandia organized and chaired four sessions at the 2019 IEEE Innovative Smart Grid Technologies (ISGT) conference February 17-20, 2019. The conference included Energy Storage Valuation by Ray Byrne, Improving Small Signal Stability using Wide-Area Measurements by Felipe Wilches-Bernal, Research Needs for Transforming the Grid Edge by David Copp, and Energy Management in a 100% Renewable Grid by Tu Nguyen.

March 2019

Sandia hosted the 2019 Energy Storage Systems (ESS) Safety & Reliability Forum in Albuquerque, NM, from March 6-8. The event was well attended by a diverse and engaged set of attendees. Participants represented academia, industry, government, code officials, first responders and more, with over 120 participants. The 40+ speakers and poster presenters touched on areas such as Understanding Failure, Incident management, Codes & Standards, Designing Robust Systems, and Reliability & Abuse R&D. Senator Martin Heinrich gave motivating opening remarks, while Dana Schulze from the National Transportation Safety Board gave a compelling keynote address about preventing accidents through shared knowledge. The ESS Safety & Reliability Forum provided a platform for discussing the current state of ESS safety and reliability (ESS-SR) and mitigation strategies for improving cell to system level safety and reliability.

March 2019

Stan Atcitty, leader of the Sandia Energy Storage Systems Power Electronics subprogram, was recognized by the New Mexico Legislature for his career achievements. State Representative Abbas Akhil joined Stan at the New Mexico Legislature on the floor of the State House of Representative on March 6, 2019. Rep. Akhil presented Dr. Atcitty with a certificate of recognition on the floor of the House of Representatives where he also met with Gov. Michelle Lujan Grisham.

May 2019

Members of the Sandia Energy Storage Safety & Reliability subprogram organized a satellite workshop on Lithium-ion Battery Calorimetry in conjunction with the 235th Electrochemical Society Meeting on understanding the thermal response of Li-ion batteries. This workshop is intended to serve as a starting point for a broader, multi-year collaborative effort on battery calorimetry between experimental and computational researchers at institutions across the U.S.

May 2019

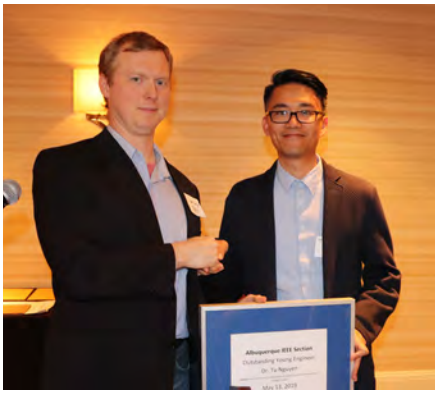


Photo: Dr. Tu Nguyen

Dr. Tu Nguyen and Dr. Felipe Wilches-Bernal were awarded "Outstanding Young Engineer" by IEEE Albuquerque Section. Dr. Nguyen received his award for his outstanding achievements in developing algorithms and software tool for evaluating and optimizing energy storage systems for grid and customer applications. Dr. Wilches-Bernal was recognized for the development of control algorithms for distributed energy resources and wide area damping control. They were both received their awards at a ceremony on Monday, May 13, 2019.

June 2019

The DOE Office of Electricity Energy Storage Program team, consisting of staff from Sandia National Laboratories and Pacific Northwest National Laboratory, organized the first annual Renewable Energy Technologies – Energy Storage Symposium for the California Energy Commission (CEC). The event was held in Sacramento on Friday, June 14, and was open to CEC staff. With the increasing penetrations of renewable generation in California and the recent decommissioning of several power plants, there was a keen interest in energy storage by the 30 attendees. Research staff from the DOE labs gave presentations on the following topics: energy storage component testing; performance metrics; commissioning; fire hazard elimination and suppression; system design, assembly consideration, and interconnection; and reliability and degradation analysis.

June 2019

Prof. Sanjoy Banerjee, City College of New York and City University of New York Energy Institute, and Urban Electric Power, Inc., Sandia National Laboratories, Brookhaven National Laboratory, and the Energy Storage Research Program in the Department of Energy Office of Electricity, won the 2019 US Environmental Protection Agency Green Chemistry Challenge Award in the Academic category. They were recognized for creating large-scale zinc-manganese oxide batteries that can be recharged thousands of times without the typical decrease in the length of the battery's lifetime. These batteries do not have some of the limitations of lithium-ion and lead-acid batteries, and they use materials that are abundant and common in existing supply chains. Read more at *https://www.epa.gov/greenchemistry/green-chemistry-challenge-winners*.

June 2019

Sandia Energy Storage Demonstrations team and PNNL, working in collaboration with Cordova Electric Cooperative, ABB, and SAFT, commissioned a 1MW/1MWh Lithium-ion Energy Storage System into the isolated electrical grid that powers Cordova, AK. The event was attended by many including U.S. Senator Lisa Murkowski and Dr. Imre Gyuk from the Department of Energy Office of Electricity. This energy storage system is the first phase for Cordova to maximize their renewable energy and reduce their dependency on fossil fuel.

July 2019

The Southeast Energy Storage Symposium and PUC Workshop took place at Southern Research in Birmingham, Alabama, July 17-18, 2019, and was organized by Sandia, PNNL, and Southern Research. The Symposium on the first day was open to the public and drew about 80 attendees who participated in presentations by the national labs and industry leaders on energy storage topics including policy and regulatory perspectives, interconnection, economics and valuation, development and finance, and safety. The PUC Workshop on the second day was open only to PUC commissioners and staff, with 24 participants from eight southeastern states. The PUC commissioners and staff participated in a round table describing their respective energy storage programs, and also participated in presentations from the national labs on energy storage technologies, valuation, resilience, and emerging policies.

Journal Publications

Journal Publications

1. H.M. Barkholtz, Y. Preger, S. Ivanov, J. Langendorf, L. Torres-Castro, J. Lamb, B.R. Chalamala, S.R. Ferreira "Multi-scale thermal stability study of commercial lithium-ion batteries as a function of cathode chemistry and state-of-charge" Journal of Power Sources, September 30, 2019, vol. 435, 226777, *https://doi.org/10.1016/j.jpowsour.2019.226777*

2. B.R. Chalamala, S.R. Ferreira, R.H. Byrne, D. Borneo and I. Gyuk "Batteries for Stationary Energy Storage Applications" Linden Handbook of Batteries, 6th Edition, Chapter 27, pp. 1155-1195, McGraw-Hill, 2019

3. J. Duay, T.N. Lambert, M.A. Kelly, I. Pineda-Dominguez "Rechargeable Solid-State Copper Sulfide Cathodes for Alkaline Batteries: Importance of the Copper Valence State" Journal of the Electrochemical Society, March 5, 2019, Vol. 166, Issue 4, A687-A694, *doi: 10.1149/2.0261904jes*

4. M. A. Elizondo, R. Fan, H. Kirkham, M. Ghosal, F. Wilches-Bernal, D.A. Schoenwald, J. Lian "Interarea Oscillation Damping Control Using High-Voltage DC Transmission: A Survey" IEEE Transactions on Power Systems, November 2018, Vol. 33, Issue 6, https://doi: 10.1109/TPWRS.2018.2832227

5. C. Fujimoto, E. Sorte, N. Bell, C. Poirier, E. Joo Park, S. Maurya, K. Lee, Y. Seung Kim "Acid-catalyzed Benzoylation Reactions of Diels-Alder Polyphenylenes" Polymer, December 2018, Vol. 158, pp. 190-197, *https://doi.org/10.1016/j.polymer.2018.10.060*

6. C. Lackner, F. Wilches-Bernal, B.J. Pierre, D.A. Schoenwald "A Tool to Characterize Delays and Packet Losses in Power Systems with Synchrophasor Data" IEEE Power and Energy Technology Systems Journal, Vol. 5, No. 4, pp. 117-128, December 2018, *doi: 10.1109/JPETS.2018.2876523*

7. S.B. Lee, H.D. Pratt III, T.M. Anderson, K. Mitra, B.R. Chalamala, V.R. Subramanian "Open Data, Models, and Codes for Vanadium Redox Batch Cell Systems" ASME Journal of Electrochemical Energy Conversion and Storage, April 12, 2019, *doi:10.1115/1.4044156*

8. Q. Li, C. Yang, S. Santhanagopalan, K. Smith, J. Lamb, L.A. Steele, L. Torres-Castro "Numerical investigation of thermal runaway mitigation through a passive thermal management system" Journal of Power Sources, July 31, 2019, Vol. 429, Pages 80-88, *https://doi.org/10.1016/j.jpowsour.2019.04.091*

9. F.A. Mier, M.J. Hargather, S.R. Ferreira "Experimental Quantification of Vent Mechanism Flow Parameters in 18650 Format Lithium Ion Batteries" Journal of Fluids Engineering, April 4, 2019, 141(6), 061403, *doi: 10.1115/1.4042962*

10. T.C. Monson, B. Zheng, R.E. Delany, C.J. Pearce, E.D. Langlois, S.M. Lepkowski, T.E. Stevens, Y. Zhou, S. Atcitty, E.J. Lavernia "Soft Magnetic Multilayered FeSiCrB–FexN Metallic Glass Composites Fabricated by Spark Plasma Sintering" IEEE Magnetic Letters, March 2019, Vol. 10; 1949-307X, *https://doi.org/10.1109/LMAG.2019.2906832*

11. T.A. Nguyen, D.A. Copp, R.H. Byrne, B.R. Chalamala "Market Evaluation of Energy Storage Systems Incorporating Technology-Specific Nonlinear Models" IEEE Transactions on Power Systems, September 2019, Vol. 34, Issue 5, *doi: 10.1109/TPWRS.2019.2909764*

12. S.J. Percival, L.J. Small, E.D. Spoerke "Electrochemistry of the NaI-AlCl3 Molten Salt System for Use as Catholyte in Sodium Metal Batteries" Journal of the Electrochemical Society, November 15, 2018, Vol. 165, Issue 14, A3531-A3536, *doi: 10.1149/2.1191814jes*

13. B.J. Pierre, F. Wilches-Bernal, D.A. Schoenwald, R.T. Elliott, D.J. Trudnowski, R.H. Byrne, J. Neely "Design of the Pacific DC Intertie Wide Area Damping Controller" IEEE Transactions on Power Systems, March 8, 2019, *doi: 10.1109/TPWRS.2019.2903782*

14. D. Rosewater, S.R. Ferreira, D.A. Schoenwald, J. Hawkins, S. Santoso "Battery Energy Storage State-of-Charge Forecasting: Models, Optimization, and Accuracy" IEEE Transactions on Smart Grid, Vol. 10, No. 3, pp. 2453-2462, May 2019, *doi: 10.1109/TSG.2018.2798165*

15. R.C. Shurtz, J.D. Engerer, J.C. Hewson "Predicting High-Temperature Decomposition of Lithiated Graphite: Part I. Review of Phenomena and a Comprehensive Model" Journal of the Electrochemical Society, December 14, 2018, Vol. 165, Issue 16, A3878-A3890, *doi: 10.1149/2.0541816jes*

16. R.C. Shurtz, J.D. Engerer, J.C. Hewson "Predicting High-Temperature Decomposition of Lithiated Graphite: Part II. Passivation Layer Evolution and the Role of Surface Area" Journal of the Electrochemical Society, December 14, 2018, Vol. 165, Issue 16, A3891-A3902, *doi: 10.1149/2.0171814jes*

17. R.C. Shurtz, Y. Preger, L. Torres-Castro, J. Lamb, J.C. Hewson, S.R. Ferreira "Perspective¬—From Calorimetry Measurements to Furthering Mechanistic Understanding and Control of Thermal Abuse in Lithium-Ion Cells" Journal of the Electrochemical Society, 2019, Vol. 166, Issue 12, A2498-A2502, *doi: 10.1149/2.0341912jes*

18. J.M. Silveyra, E. Ferrara, D.L. Huber, T.C. Monson "Soft magnetic materials for a sustainable and electrified world" Science, October 26, 2018, Vol. 362, Issue 6413, eaao0195, *doi: 10.1126/science.aao0195*

19. O. Slobodyan, T. Smith, J. Flicker, S. Sandoval, C. Matthews, M. van Heukelom, R. Kaplar, S. Atcitty "Hard-switching reliability studies of 1200 V vertical GaN PiN diodes" MRS Communications, December 2018, Vol., Issue 4, pp. 1413-1417, *https://doi.org/10.1557/mrc.2018.204*

20. L.J. Small, H.D. Pratt III, T.M. Anderson "Crossover in Membranes for Aqueous Soluble Organic Redox Flow Batteries" Journal of the Electrochemical Society, 2019, Vol. 166, Issue 12, A2536-A2542, *doi: 10.1149/2.0681912jes*

21. I. Vasiliev, B. Ale Magar, J. Duay, T.N. Lambert, B.R. Chalamala "Ab Initio Studies of Hydrogen Ion Insertion into β-, R-, and γ-MnO2 Polymorphs and the Implications for Shallow-Cycled Rechargeable Zn-MnO2 Batteries" Journal of The Electrochemical Society, November 14, 2018, 165 (14) A3517-A3524, *doi: 10.1149/2.1161814jes*

22. G.G. Yadav, D. Turney, J. Huang, X. Wei, S. Banerjee "Breaking the 2 V Barrier in Aqueous Zinc Chemistry: Creating 2.45 and 2.8 V MnO2−Zn Aqueous Batteries" ACS Energy Letters, August 8, 2019, *doi: 10.1021/acsenergylett.9b01643*

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23. D.A. Copp, T.A. Nguyen, R. Thomson, R.H. Byrne, B.R. Chalamala "Optimal Sizing of Distributed Energy Resources for 100% Renewable Planning" (Submitted July 29, 2019, to Applied Energy)

24. D.A. Copp, T.A. Nguyen, R.H. Byrne "Real-time Dispatching for Energy Aggregators with Energy Storage and Stochastic Renewable Generation in Markets" (Submitted July 31, 2019, to Energy)

25. A. Headley, D.A. Copp "Energy Storage Sizing for Grid Compatibility of Intermittent Renewable Resources: A CAISO Case Study" (Submitted May 24, 2019, to Applied Energy)

26. M.B. Lim, I.V. Kolesnichenko, D.J. Arnot, T.N. Lambert "Effect of ZnO-Saturated Electrolyte on Rechargeable Alkaline Zinc Batteries at High Depth-of-Discharge" (Submitted September 2019 to Journal of The Electrochemical Society)

27. J. Mueller, M.A. Moonem, S. Atcitty, B.R. Chalamala "Power Conversion Systems for Utility-Scale Electrochemical Energy Storage" (Submitted September 2019 to IEEE Access)

28. D. Rosewater, D.A. Copp, T. Nguyen, R.H. Byrne, B.R. Chalamala, S. Santoso "Models for Optimal Control of Battery Energy Storage" (Submitted May 14, 2019, to IEEE Access)

29. L. Wang, Q. Wu, A. Abraham, P.J. West, L.M. Housel, G. Singh, N. Sadique, E.S. Takeuchi, A.C. Marschilok, K.J. Takeuchi "Silver-Containing α-MnO2 Nanorods: Electrochemistry in Rechargeable Aqueous Zn-MnO2 Batteries" (Submitted July 20, 2019, to Journal of the Electrochemical Society)

Conference Proceedings and Other Publications

Conference Proceedings

1. R.A. Biroon, P. Pisu, D.A. Schoenwald "Inter-Area Oscillation Damping in Large-Scale Power Systems using Decentralized Control" 2018 ASME Dynamic Systems and Control Conference, Atlanta, GA, September 30-October 3, 2018

2. R. J. Concepcion, F. Wilches-Bernal, R. H. Byrne "Revenue Opportunities for Electric Storage Resources in the Southwest Power Pool Integrated Marketplace" 2019 IEEE Power and Energy Society General Meeting, Atlanta, GA, August 4-8, 2019

3. D.A. Copp, T. Nguyen, R.H. Byrne "Adaptive Model Predictive Control for Real-Time Dispatch of Energy Storage Systems" 2019 IEEE American Control Conference, Philadelphia, PA, July 10-12, 2019

4. A. Ingalalli, A. Luna, V. Durvasulu, T. Hansen, R. Tonkoski, D.A. Copp, T. Nguyen "Energy Storage Systems in Emerging Electricity Markets: Frequency Regulation and Resiliency" (Collaboration with South Dakota State University) 2019 IEEE Power and Energy Society General Meeting, Atlanta, GA, August 4-8, 2019

5. T. Nguyen, D.A. Copp, R.H. Byrne "Stacking Revenue from Energy Storage Providing Resilience, T&D Deferral and Arbitrage" 2019 IEEE Power and Energy Society General Meeting, Atlanta, GA, August 4-8, 2019

6. D.A. Schoenwald, F. Wilches-Bernal, B.J. Pierre, R.T. Elliott, D.J. Trudnowski "Data Considerations in Real-Time PMU Feedback Control Systems" North American SynchroPhasor Initiative (NASPI) Work Group Meeting, San Diego, CA, April 15-17, 2019

7. U. Tamrakar, D.A. Copp, T. Hansen, R. Tonkoski "Model Predictive Frequency Control of Low Inertia Microgrids" 28th IEEE International Symposium on Industrial Electronics, Vancouver, Canada, June 12-14, 2019

8. Y. Tian, A. Bera, J. Mitra, B. R. Chalamala, and R. H. Byrne "Effect of Operating Strategies on the Longevity of Lithium-ion Battery Energy Storage Systems" 2018 IEEE Industry Applications Society Annual Meeting (IAS), Portland, OR, September 23-27, 2018, doi: 10.1109/IAS.2018.8544518

9. F. Wilches-Bernal, D.A. Copp, G. Bacelli, R.H. Byrne "Structuring the Optimal Output Feedback Control Gain: A Soft Constraint Approach," 57th IEEE Conference on Decision and Control, Miami Beach, FL, December 17-19, 2018

10. F. Wilches-Bernal, R.J. Concepcion, R.H. Byrne "Participation of Electric Storage Resources in the NYISO Electricity and Frequency Regulation Markets" 2019 IEEE Power and Energy Society General Meeting, Atlanta, GA, August 4-8, 2019

Other Publications

1. A. Headley, C. Hansen, T. Nguyen "Maximizing Revenue from Electrical Energy Storage Paired with Community Solar Projects in NYISO" Sandia National Laboratories Technical Report, August 2019, Albuquerque, NM, SAND2019-10124

2. C. Rawlins, D.A. Schoenwald, B.J. Pierre, F. Wilches-Bernal, R.T. Elliott "PDCI Oscillation Damping Controller Software Documentation," Sandia National Laboratories Technical Report, September 2018, Albuquerque, NM, SAND2018-10048

3. D.A. Schoenwald, C. Rawlins, B.J. Pierre, F. Wilches-Bernal, R.T. Elliott "Executive Summary to PDCI Oscillation Damping Controller Software Documentation," Sandia National Laboratories Technical Report, September 2018, Albuquerque, NM, SAND2018-10049

4. D.A. Schoenwald, D.J. Trudnowski, B.J. Pierre, F. Wilches-Bernal, R.T. Elliott, R.H. Byrne, J.C. Neely "PDCI Damping Controller Summary of Project Achievements" Sandia National Laboratories Technical Report, May 2019, Albuquerque, NM, SAND2019-5971

5. D.A. Schoenwald, D.J. Trudnowski, B.J. Pierre, F. Wilches-Bernal, R.T. Elliott, R.H. Byrne, J.C. Neely "PDCI Damping Controller Test Results and Project Summary" Sandia National Laboratories Technical Report, May 2019, Albuquerque, NM, SAND2019-5972

Patents

Patents

Issued

1. C. Fujimoto "Functionalization of Diels-Alder Polyphenylene Polymers" US Patent No. 10,053,534 B2, August 21, 2018
2. C. Fujimoto "Halo-Containing Anion Exchange Membranes and Methods Thereof" US Patent No. 10,294,325 B2, Issued May 21, 2019
3. T.N. Lambert, M. Hibbs "Electrochemical Cell having a Vanadium Phosphorous Alloy Electrode" US Patent No. 10,186,740 B1, January 22, 2019
4. D. F. Sava Gallis, H. D. Pratt III, T. M. Anderson, N. S. Hudak "Electrodes for Sodium Ion Batteries" U. S. Patent No. 10,320,028 B2, Issued June 11, 2019
5. L.J. Small, H.D. Pratt, T.M. Anderson "Nonaqueous Redox Flow Battery Electrolyte Comprising an Ionic Liquid with a Metal Cation Coordinated to Redox-Active Ligands" US Patent No. 10,305,133 B2, Issued May 28, 2019
6. L.J. Small, P.G. Clem, E.D. Spoerke "Electroless Process for Depositing Refractory Metals" US Patent No. 10,263,241 B2, April 16, 2019

Applications

1. C. Fujimoto "Functionalization of Diels-Alder Polyphenylene Polymers" US Pub. No. 2018/0319931 A1, Pub. Date: November 8, 2018
2. J. Huang, G.G. Yadav, J. Gallaway, M. Nyce, S. Banerjee "Rechargeable Alkaline Battery Comprising Metal Hydroxide Separator" US Pub. No. 2019/0088915, Pub. Date: March 21, 2019
3. T.N. Lambert and J. Duay "Rechargeable Copper and Sulfur-based Electrodes for Electrochemical Applications" US Pub. No. 2019/0044145 A1, Pub. Date: February 7, 2019
4. X. Wei, M. Nyce, G.G. Yadav, A. Couzis, S. Banerjee "for Increasing Lifespan of Rechargeable Zinc-Anode Batteries" US Pub. No. 2018/0316064, Pub. Date: November 1, 2018

5. G.G. Yadav, M. Nyce, S. Banerjee "Electrode Designs for High Energy Density, Efficiency, and Capacity in Rechargeable Alkaline Batteries" US Pub. No. 2018/0323429, Pub. Date: November 8, 2018

6. G.G. Yadav, M. Nyce, X. Wei, R. Yakobov, J. Gallaway, S. Banerjee "Rechargeable Alkaline Manganese Dioxide-Zinc Bipolar Batteries" US Pub. No. 2019/0044129, Pub. Date: February 7, 2019

Sandia Technical Advances

1. T.A. Nguyen, R.H. Byrne, B.R. Chalamala "Packetized Delivery of Electricity" SD-14930

2. E.D. Spoerke, A.S. Peretti, S.J. Percival, M. Gross, L.J. Small "Solid State Ion Conductors Based on 2D Materials" August 2019, SD-15127

3. E.D. Spoerke, M. Gross, S.J. Percival, A.S. Peretti, L.J. Small "Surface Treatments of NaSICON Ceramics for Improved Molten Interfaces" August 2019, SD-15128

Invited Talks and Technical Presentations

Invited Talks

1. D.J. Arnot, I. Kolesnichenko, J. Duay, T.N. Lambert "Ion Selective Separators for Rechargeable Alkaline Zn-MnO2 Batteries" 2018 Annual AIChE Student Conference, Pittsburgh, PA, October 26-29, 2018
2. S. Atcitty "Wide Bandgap-based Power Conversion System for Grid-tied Energy Storage" IEEE Workshop on Wide Bandgap Power Devices and Applications, Taipei, Taiwan, May 23-25, 2019
3. S. Atcitty "Wide Bandgap-based Power Conversion System for Grid-tied Energy Storage" University of North Carolina – Charlotte, June 12, 2019
4. D. Borneo, V. Sprenkle "Grid Energy Storage" Technical Battery Storage Workshop for Utility Engineers, Sequim, WA, November 8, 2018
5. D. Borneo, Session Chair, Resiliency in Force Majeure Situations such as Lava and Hurricanes panel discussion, NELHA Conference on Energy Storage Trends and Opportunities, Kailua-Kona, Hawaii, December 5-6, 2018
6. D. Borneo, R.H. Byrne, J. Twitchell "Grid Energy Storage Overview" Training for the Hawaii PUC, Honolulu, HI, December 7, 2018
7. D. Borneo, R. H. Byrne "Grid Energy Storage: ES 101" National Rural Electric Cooperative Association (NRECA) Meeting, Houston, TX, December 12, 2018
8. D. Borneo, R.H. Byrne, J. Twitchell "Grid Energy Storage Overview" Energy Mineral and Natural Resource Department of New Mexico (EMNRD), Santa Fe, NM, January 9, 2019
9. D. Borneo, S. Schoenung "ES201: More Details of Electrical Energy Storage" CEATI-SOIG Meeting, Birmingham, AL, April 10, 2019
10. R.H. Byrne "Energy Storage for Resilience Applications" UC Riverside Energy Storage Technologies & Applications Conference, Riverside, CA, April 11, 2019
11. R.H. Byrne "Sandia Energy Storage Research" Energy Innovation 2019, Nanyang Technological University, Singapore, May 28, 2019

12. C. Fujimoto, S. Maurya "Ion Exchange Membranes in Flow Batteries" Workshop on Non-Aqueous Flow Batteries, Santa Fe, NM, January 30-31, 2019

13. J. Lamb, L. Torres-Castro, M. Karulkar, and J. Stanley "Mechanisms and Material Impacts of Overcharge in Lithium ion Batteries" 2018 Materials Research Society (MRS) Fall Meeting & Exhibit, Boston, MA, November 25-30, 2018

14. J. Lamb, L. Torres-Castro, M. Karulkar, and J. Stanley "The Scalability of Accelerating Rate Calorimetry (ARC) with State of Charge and Capacity" 235th ECS Meeting, Dallas, TX, May 26-30, 2019

15. T.N. Lambert "Effect of Additives and Selective Separators on Alkaline Zn-based Batteries" NAATBatt International Workshop on Zinc Battery Technology, New York, NY, November 16, 2018

16. T.N. Lambert, J. Duay, M. Kelly, B.A. Magar, I. Vasiliev, M.B. Lim, D. Arnot, I.V. Kolesnichenko, B.R. Chalamala "Advances in Alkaline Storage Batteries and their Potential Impact for Society" World Materials Research Institute Forum (WMRIF) Symposium and General Assembly, Budapest, Hungary, June 17-20, 2019

17. T.C. Monson, T.E. Stevens, D.A. Vargas, R.M. Van Ginhoven, B. Zheng, Y. Zhou, M. Fraga, E. Lavernia "Synthesis of Nanostructured Ferroic Materials for Energy Conversion" Materials Science & Technology Conference & Exhibition, Columbus, OH, Oct. 14-19, 2018

18. D.A. Schoenwald "Challenges in the Use of PMU Data for Real-Time Feedback Control," PNNL PMU Metrology Meeting, Richland, WA, April 16, 2019

19. L.J. Small "Standardization Requirements for Redox Flow Batteries" Workshop on Non-Aqueous Flow Batteries, Santa Fe, NM, January 30-31, 2019

20. E.D. Spoerke "Advancing Grid-Scale Electrical Energy Storage" 2nd NELHA Conference on Energy Storage Trends and Opportunities, Kailua-Kona, Hawaii, December 5-6, 2018

21. E.D Spoerke, S.J. Percival, L.J. Small, A. Peretti, J. Lamb "Molten Sodium Batteries: Promise for Advancing Grid-Scale Battery Utility" NAATBatt 2019 Annual Meeting and Conference, Litchfield Park, AZ, March 11-14, 2019

22. L. Torres-Castro, J. Lamb, M. Karulkar, J. Stanley, C. Grosso, L. Gray "Determination of Battery State of Stability Through Advanced Diagnostics" IAPG Chemical Working Group Safety Panel Meeting 2019, Pasadena, CA, February 12-14, 2019

23. L. Torres-Castro, J. Lamb, M. Karulkar "Mechanisms and Material Impacts of Overcharge in Lithium-Ion Batteries" 235th ECS Meeting, Dallas, TX, May 26-30, 2019

Technical Presentations

1. T. Anderson, L.J. Small, H. Pratt, C. Fujimoto "Sandia Flow Battery Prototyping and Testing" Workshop on Non-Aqueous Flow Batteries, Santa Fe, NM, January 30-31, 2019

2. S. Atcitty, R. Jeffers, S. DeRosa "Resilient Communities: A Consequence-based Approach, Microgrids, Energy Storage, and Power Electronics" IEEE Decentralized Energy Access Solutions, Atlanta, GA, February 5-7, 2019

3. S. Atcitty, J. Mueller "Energy Storage Power Conversion System Lab", 3M visit to Sandia, February 21, 2019

4. S. Atcitty "From the Navajo Nation to a Distinguished National Laboratory" Utah State University Technical Symposium, Blanding, UT, April 10, 2019

5. S. Atcitty "Minority Serving Institute Program Advanced Manufacturing Network Institute Sandia National Laboratories", MSIP technical meeting with Turtle Mountain Community College and Candeska Cikana Community College, June 24-25, 2019

6. S. Atcitty "Electric Utility Infrastructure and Alternative Energy" Energy Sovereignty Tribal Energy Workshop, Albuquerque, NM, June 27-28, 2019

7. H.M. Barkholtz, Y. Preger, J. Langendorf, J. Lamb, B.R. Chalamala, S.R. Ferreira, S. Ivanov "Thermal Stability Study of Commercial Lithium-Ion Batteries as a Function of Cathode Chemistry and State-of-Charge" 235th ECS Meeting, Dallas, TX, May 26-30, 2019

8. D. Borneo "Commissioning Overview: A Safety Focus" Energy Storage Systems (ESS) Safety & Reliability Forum, Albuquerque, NM, March 6-8, 2019

9. R.H. Byrne "Designing Storage to Provide Multiple Benefits" 2018 NREL Energy Security Meeting, Golden, CO, October 2, 2018

10. R.H. Byrne "Designing Storage to Provide Multiple Benefits" 2018 DOE Energy Storage Finance Summit, San Francisco, CA, October 4, 2018

11. R.H. Byrne "Small Signal Stability – Opportunities for Energy Storage" CEATI International Transmission 2018, Tucson, AZ, November 29, 2018

12. R.H. Byrne, Session Chair, Storage for Grid Reliability panel discussion, NELHA Conference on Energy Storage Trends and Opportunities, Kailua-Kona, Hawaii, December 5-6, 2018

13. R.H. Byrne "Grid Reliability and Resilience - Opportunities for Energy Storage" 2018 Natural Energy Laboratory of Hawaii Authority (NELHA) Energy Storage Conference, Kona, HI, December 5, 2018

14. R.H. Byrne "Overview of Sandia's Energy Storage Analytics Research" 2019 DOE Energy Storage Finance Summit, New York, NY, January 23, 2019

15. R.H. Byrne "Energy Storage Applications" The 10th Conference on Innovative Smart Grid Technologies (ISGT 2019), Washington, DC, February 18, 2019

16. R.H. Byrne "Designing Energy Storage to Provide Multiple Benefits" 2019 Clean Energy States Alliance Annual Meeting, Golden, CO, May 1, 2019

17. R.J. Concepcion "QuESt: An Energy Storage Application Suite" Energy Storage Valuation Workshop at the DOE Energy Storage Finance Summit, New York, NY, January 20, 2019

18. R.J. Concepcion "QuESt: An Energy Storage Application Suite" Energy Storage Valuation panel at the 2019 IEEE ISGT Conference, Washington, DC, February 18, 2019

19. R.J. Concepcion "Energy Storage Evaluation Tools: How do you value energy storage?" NAATBatt 2019 Annual Meeting and Conference, Litchfield Park, AZ, March 13, 2019

20. R.J. Concepcion "QuESt: An Energy Storage Application Suite" 2019 PV Systems Symposium, Albuquerque, NM, May 15, 2019

21. R.J. Concepcion, F. Wilches-Bernal, R.H. Byrne "Revenue Opportunities for Electric Storage Resources in the Southwest Power Pool Integrated Marketplace" IEEE PES General Meeting, Atlanta, GA, August 4-8, 2019

22. D.A. Copp "Real-Time Market Participation of Aggregators with Energy Storage" DOE Energy Storage Finance Summit, New York, NY, January 23, 2019

23. D.A. Copp "Real-Time Market Participation of Aggregators with Energy Storage" IEEE Smart Grid Technologies (ISGT) Conference, Washington DC, February 18, 2019

24. D.A. Copp (Organizer and Chair of session) "Research Needs for Transforming the Grid Edge" IEEE Smart Grid Technologies (ISGT) Conference, Washington DC, February 19, 2019

25. P.T. Dickens M.T. Brumbach, P. Kotula, R. Chow, K. Ferri, S. Atcitty, JP Maria, J.F. Ihlefeld, E.A. Paisley "Structural and electrical properties of epitaxial MgO on 4H-SiC" 2019 New Mexico American Vacuum Society (NMAVS) Symposium and Exhibition, Albuquerque, NM, June 3-6, 2019

26. P.T. Dickens, M.T. Brumbach, P. Kotula, R. Chow, K. Ferri, S. Atcitty, JP Maria, J.F. Ihlefeld, E.A. Paisley "Structural and electrical properties of epitaxial MgO on 4H-SiC" 61st Electronic Materials Conference (EMS 2019), Ann Arbor, MI, June 26-28, 2019

27. B. Ehrhart, L. Klebanoff, E. Hecht, A. Headley, M. Ng, C. Markt "Impact of Hydrogen for Rail Applications" H2@Rail Workshop, Lansing, MI, March 26-27, 2019

28. A. Headley "Maximizing Value of Solar and Energy Storage Installations in NY" 2019 PV Systems Symposium, Albuquerque, NM, May 14-16, 2019

29. A. Headley, R. Concepcion "Maximizing Storage Value in Regional Markets and the QuESt App" Southeast Energy Storage Symposium and PUC Workshop, Birmingham, AL, July 17-18, 2019

30. J. Lamb "Failure Propagation Work and Abuse Testing" Advanced Automotive Battery Conference, San Diego, CA, June 24-25, 2019

31. J. Lamb, L. Torres-Castro, M. Karulkar, and J. Stanley "Evaluating the Impact of Initiation Methods on Propagating Thermal Runaway in Lithium-Ion Batteries" Battery Safety Summit 2018, Arlington, VA, October 29-31, 2018

32. M.B. Lim, M. Kelly, J. Duay, I.V. Kolesnichenko, T.N. Lambert "Improving Cycle Life and Active Materials Utilization for Rechargeable Alkaline Zn-MnO2 Batteries" 235th ECS Meeting, Dallas, TX, May 26-30, 2019

33. T. Nguyen "Optimal Time-of-use Management for Utilities Customers Using Behind-the-Meter Energy Storage Systems" 2018 South Dakota Regional Power Conference, Brookings, SD, Oct 1, 2018

34. T. Nguyen "Evaluation of Behind-the-Meter Energy Storage," 2019 Energy Storage Financing Summit, New York, NY, January 2019

35. T. Nguyen "Evaluation of Behind-the-Meter Energy Storage" 2019 IEEE Innovative Smart Grid Technologies (ISGT), Washington DC, February 17-20, 2019

36. T. Nguyen "Energy Management in a 100% Renewable Grid" Conference Session Chair, 2019 IEEE Innovative Smart Grid Technologies (ISGT), Washington, DC, February 17-20, 2019

37. T. Nguyen "Maximizing the Cost Saving for Utility Customers using Behind-the-Meter Energy Storage Systems" Phoenix Section - IEEE Life Member Affinity Group, Phoenix, AZ, May 7, 2019

38. T. Nguyen "Overview of Energy Storage Management System" California Energy Commission Energy Storage Workshop, Sacramento, CA, June 2019

39. T. Nguyen "Stacking Revenue of Energy Storage System from Resilience, T&D Deferral and Arbitrage," 2019 IEEE Power and Energy Society General Meeting, Atlanta, GA, August 4-8, 2019

40. S.J. Percival, L.J. Small, E. Alcorn, E.D. Spoerke "Molten Salt Catholyte Development for Low Temperature Na-Halide Batteries" [Best Poster runner-up] SPD's 12th Annual Postdoctoral Technical Showcase, Santa Fe, NM, November 2018

41. A. Peretti, S.J. Percival, L.J. Small, B.R. Chalamala, E.D. Spoerke "Sodium Ion Conducting Separator Development" 30th Rio Grande Symposium on Advanced Materials, Albuquerque, NM, October 8, 2018

42. Y. Preger, H.M. Barkholtz, A. Fresquez, F.A. Mier, L. Torres-Castro, J. Langendorf, J. Lamb, B.R. Chalamala, S.R. Ferreira, "Comprehensive Study of Commercial Lithium-Ion Cell Aging Behavior and Abuse Response" Battery Safety Conference, Arlington, VA, October 30-31, 2018

43. Y. Preger, H.M. Barkholtz, A. Fresquez, F.A. Mier, L. Torres-Castro, J. Langendorf, J. Lamb, B.R. Chalamala, S.R. Ferreira, "Durability and Reliability of Commercial Lithium-Ion Cells as a Function of Chemistry and Cycling Conditions" Energy Storage Systems Safety & Reliability Forum, Albuquerque, NM, March 6-8, 2019

44. Y. Preger, H.M. Barkholtz, A. Fresquez, F.A. Mier, B.R. Chalamala, S.R. Ferreira, "Durability and Reliability of Commercial Lithium-Ion Cells as a Function of Chemistry and Cycling Conditions" 235th ECS Meeting, Dallas, TX, May 26-30, 2019

45. D. Rosewater, A. Headley, F.A. Mier, S. Santoso "Optimal Control of a Battery Energy Storage System with a Charge-Temperature-Health Model" IEEE PES General Meeting, Atlanta, GA, August 4-8, 2019

46. D.A. Schoenwald, F. Wilches-Bernal "Real-Time Damping Control Using PMU Feedback" Joint Synchronized Information Subcommittee (JSIS) Meeting, Portland, OR, November 9, 2018

47. D.A. Schoenwald "Data Considerations in Real-Time PMU Feedback Control Systems" North American SynchroPhasor Initiative (NASPI) Spring Meeting, San Diego, CA, April 9, 2019

48. L.J. Small, H.D. Pratt, C. Fujimoto, T.M. Anderson "Crossover Mechanisms in Polymer Membranes for Redox Flow Batteries" Materials Research Society (MRS) Spring Meeting & Exhibit, Phoenix, AZ, April 22-26, 2019

49. E.D. Spoerke, S.J. Percival, L.J. Small, A. Peretti, and J. Lamb. "Tailoring Molten Sodium-Halide Battery Chemistry for Safe, Low Temperature, Rechargeable Batteries" 2018 Materials Research Society (MRS) Fall Meeting & Exhibit, Boston, MA, November 25-30, 2018

50. E.D. Spoerke, S.J. Percival, L.J. Small, A. Peretti, J. Lamb, B.R. Chalamala "Advancing 'Low' Temperature Molten Sodium Batteries" International Coalition for Energy Storage and Innovation and Pacific Power Source Symposium Joint Meeting (ICESI - PPSS 2019), Waikoloa Village, Hawaii, January 5-10, 2019 (Plenary)

51. E.D. Spoerke, A. Peretti, S.J. Percival, J. Bock, H. Brown-Shaklee, L.J. Small, B.R. Chalamala "Rethinking Solid State Sodium Ion Conductors for Low Temperature Molten Sodium Batteries" Conference on Electronic Materials and Applications, Orlando, FL, January 23-25, 2019

52. E.D. Spoerke, A. Peretti, S. Percival, J. Bock, H. Brown-Shaklee, L.J. Small, B.R. Chalamala "Adapting Processing and Structure Toward Improved NaSICON-Based Sodium Ion Conductors" Materials Research Society (MRS) Spring 2019 Meeting, Phoenix, AZ, April 22-26, 2019

53. E.D. Spoerke, S.J. Percival, L.J. Small, A. Peretti, J. Lamb, B.R. Chalamala "Low Temperature Molten Sodium-Based Batteries for Large Scale Electrical Energy Storage." 235th ECS Meeting, Dallas, TX, May 26-30, 2019

54. E.D. Spoerke, S.J. Percival, L.J. Small, A. Peretti, J. Lamb, B.R. Chalamala "Materials Advances to Enable Low Temperature Molten Sodium Batteries for Grid-Scale Energy Storage" World Materials Research Institute Forum (WMRIF) Symposium and General Assembly, Budapest, Hungary, June 17-20, 2019

55. T. Stevens, R. Lewis, C. Pearce, M. Rodriguez, S. Dickens, B. McKenzie, S. Atcitty, T.C. Monson "Synthesis and Magnetic Properties of Iron Nitrides" American Chemical Society National Meeting & Expo, Orlando, FL, March 31 – April 2, 2019

56. F. Wilches-Bernal "Structuring the Optimal Output Feedback Control Gain: A Soft Constraint Approach" 2018 IEEE Conference on Decision and Control, Miami, FL, December 18, 2018

Seminars and Webinars

Seminars and Webinars

1. D. Borneo, A. Headley "Oregon's New Energy Storage Project for Resiliency and Cost Savings" (*https://www.cesa.org/webinars/oregons-new-energy-storage-project-for-resiliency-and-cost-savings/?date=2018-12-18*) CESA webinar, December 18, 2018

2. D. Borneo "State of the U.S. Energy Storage Industry: 2018 Year in Review" (*https://cesa.org/webinars/state-of-the-u-s-energy-storage-industry-2018-year-in-review/?date=2019-02-28*) CESA webinar, February 28, 2019

3. D. Borneo "Energy Storage 101, Part 1: Battery Storage Technology, Systems and Cost Trends" (*https://www.cesa.org/webinars/energy-storage-101-part-1-battery-storage-technology-systems-and-cost-trends/*) CESA webinar, March 26, 2019

4. D. Borneo "PR Energy Storage: Batteries vs Fuel Cells?" (*https://www.eventbrite.com/e/web-panel-pr-energy-storage-batteries-vs-fuel-cells-tickets-59348919215*) hosted by Fundación Borincana, Coalición de los Dispuestos, April 2, 2019

5. B. Chalamala "Advances in Battery Technologies for Electric Vehicles and Grid Storage" Morton Antler Lecture, 64th IEEE Holm Conference on Electrical Contacts, Albuquerque, NM, October 16, 2018

6. B. Chalamala "Energy Storage and Modernization of the Electric Grid" IEEE/Sigma Xi/UNM Distinguished Public Lecture, University of New Mexico, October 17, 2018

7. B. Chalamala "Energy Storage and Modernization of the Electric Grid" IEEE Albuquerque Section Joint Chapter Seminar, October 18, 2018

8. B. Chalamala "Energy Storage and Grid Modernization" ECE Speaker Series Seminar, University of Houston, November 8, 2018

9. B. Chalamala "Grid Modernization, Energy Storage and the Role of Power Electronics" School of Electrical Engineering and Computer Science Lecture, University of Central Florida, Orlando, FL, November 29, 2018

10. B. Chalamala “Grid Energy Storage Technologies and the Future Electric Grid” Notre Dame Energy Institute, Distinguished Lecture, University of Notre Dame, October 30, 2108

11. D.A. Schoenwald “Lecture on Technology Transfer at Sandia National Labs,” hosted by Portland State University Technology Transfer, invited by Dr. Judith Estep, February 19, 2019

12. D.A. Schoenwald “Real-Time Damping of Power Grid Oscillations Using Synchrophasor Feedback” CURENT Industry Seminar, Knoxville, TN, March 1, 2019




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