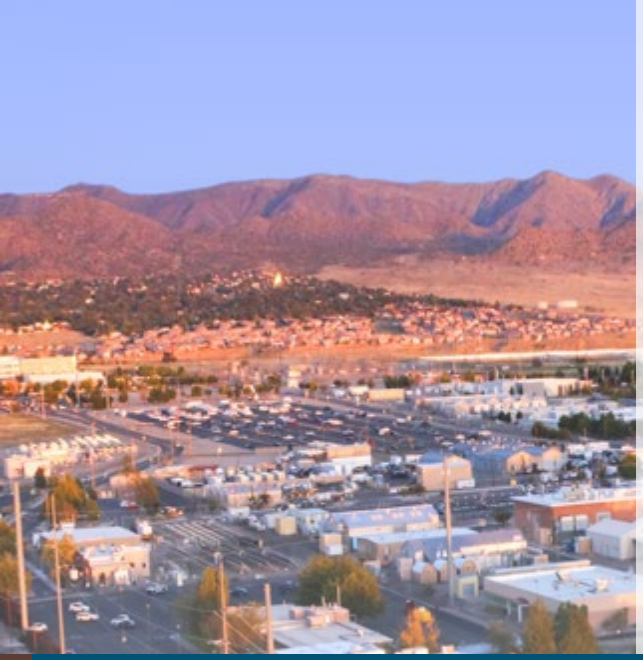

DOE OE Energy Storage Program at Sandia – FY18 Summary

Dr. Babu Chalamala

FY18 Accomplishments and External Recognition

Notable Accomplishments

- Contributed to multiple energy storage system installations, received one R&D100 Award and a best paper presentation at IEEE PES General Meeting. Organized Four MRS Symposia, one ACeRS Symposium, tutorials at MRS, IEEE T&D, and FERC. Led Sessions at IEEE PES General Meeting, MRS and ECS. Organized DOE Energy Storage Finance Summit. Released QuESt1.0, an open source optimization software suite.

Publications

- 32 journal papers (15 published and 17 under peer review), 16 papers in conference proceedings, and 6 technical reports

Patents

- 5 patents granted, 3 new patent applications filed. 3 Technical Advances awaiting patent filing.

Technical Conferences and Presentations

- 23 Invited talks at multiple conferences, 3 IEEE Smartgrid Webinars, 12 webinars through ESTAP and GESDB. Contributed over 60 technical presentations at major conferences.

R&D 100 Award

Best Paper Presentation at 2018 IEEE PES GM

Overview of Sandia Energy Storage Program

Multidisciplinary R&D program with synergetic collaboration with several departments across Sandia

- Materials Research - Advancing battery chemistries through technology development and commercialization
- Power Electronics - Optimization at the interface between power electronics and electrochemistry. New power converter topologies, high voltage passives and magnetics.
- Energy Storage Safety – Cell and module level safety test and analysis. Engineered safety of large systems. Predictive models for ES safety. Storage safety standards and protocols.
- Energy Storage Analytics and Controls - Developing competencies in analytics and controls for integration of utility class storage systems. Lower BOS and integration costs. Software tools for optimal use of energy storage across the electricity infrastructure. Standards development.
- Energy Storage Project Development – Support for DOE demonstration projects
- Industry Outreach - Outreach to utilities, regulators, and the industry.

Outward looking program with significant external reach to industry and academic collaborators. Leveraging resources across the labs and outside partners.

Active University Collaborations

CUNY Energy Institute

Davidson College

Northeastern University

Stony Brook University

University of Kentucky

University of Washington

UC Irvine

University of Alaska Fairbanks

University Texas at Austin

New Mexico State University

Ohio State University

University Texas Arlington

New Mexico Tech

University New Mexico

Washington University at S. L.

Michigan State University

University of Utah

South Dakota State University

Clemson University

Southern Methodist University

$2.2M in funding to universities

Industry and Utility Collaborators

GeneSic Semiconductor

Creare

InnoCit

Mainstream Engineering

Powdermet

Urban Electric Power

Helix Power Corporation

Eugene Water and Electric Board

Cordova Electric Cooperative

Strategen

Mustang Prairie Energy

ANZA Electric

PNM Resources

WattJoule

UniEnergy Technologies

Sterling Municipal Light Department

Public Service of New Mexico

National Rural Electric Cooperative Association

Hawaii Electric Light

Green Mountain Power

Electric Power Board of Chattanooga

Electric Power Research Institute

Ecoult Battery

Demand Energy

Burlington Electric Department

NELHA

Energy Storages Materials Research

Improving the performance of Flow Batteries, Sodium batteries, and Zn -MnO_2 through materials research

Key Projects

- Zn-MnO_2 rechargeable batteries (in collaboration with CUNY, Northeastern Univ, New Mexico State, Stony Brook University, Urban Electric Power)
- Low cost membranes and new electrolytes for flow batteries (in collaboration with University of Washington, Davidson College, LANL, WattJoule)
- Sodium batteries (in collaboration with University of Kentucky, Field Upgrading (former Ceramatec)

FY18 Accomplishments

- Developed in-operando membrane screening method for laboratory-scale flow batteries that is useful understanding of membrane behavior as function of battery SOC and operational performance
- Identified, characterized, and demonstrated a fully molten Br-based catholyte salt system that shows reversible iodide electrochemical cycling at 90C. This is an important advance in the development and demonstration of a Na-NaI battery that will cycle at or below 100C
- Developed chemistry and processing approach that allows to low temperature synthesize of functionally conductive NaSICON-based composites suitable for molten sodium batteries and aqueous batteries and molten sodium batteries
- Demonstrated increased cycle life and energy density of Zn-MnO_2 batteries. Development of a manufacturing roadmap to reach price target of $50/kWh at scale by 2021.

Presentations and Posters

- 7 Oral Presentations and 11 Poster Presentations

Power Electronics and Power Converters

Optimization at the interface between power electronics and electrochemistry. Development of power converters using SiC and GaN. Reliability of WBG Power Converters

Key Projects

- High-temperature iron-nitride transformer for high frequency converters (with UC Irvine)
- Development of advanced gate oxide for wide band gap devices
- SiC and GaN-based power inverters (in collaboration with GeneSiC, Creare, and Innocit)
- High energy dielectrics for scalable capacitors (in collaboration with SMU/UT Dallas)
- Low voltage and high current bidirectional converters for flow battery systems (with UT Austin)
- Medium-voltage power electronics and reliability of MV power converters (with Ohio State and Univ of Houston)
- Power converter integration with large format batteries and PV panels (New Mexico State and Urban Electric Power)

FY18 Accomplishments

- Developed high voltage and high density SiC-based topologies for grid-tied energy storage applications with the design, build and testing of 500kW rated SiC-based inverter. A 2.5X increase in power density improvement was achieved compared to Si-based designs
- Developed high voltage and high density GaN-based topologies for grid-tied energy storage applications. In collaborations with Innocit, a 20kW rated GaN-based inverter was designed, built and tested.
- Developed 250kW rated SiC-based power inverter at 4.3X greater power density than existing systems
- Developed micro dual active bidirectional dc-dc power converter to optimize integration of power electronics and energy storage at the cell level. Patent filed. Integration with batteries in progress.

Presentations and Posters

- 5 Oral Presentations and 8 Poster Presentations

Energy Storage Safety and Reliability

Cell and module level safety test and analysis. Engineered safety of large systems. Predictive models for ES safety. Storage safety standards and protocols.

Key Projects

- DC Arc flash analysis of energy storage systems (with Univ Texas Arlington)
- Analysis of Li-battery failure mechanisms through spectroscopy (with New Mexico Tech)
- Energy storage safety working groups
- Energy storage materials safety
- Fire suppressant analysis and failure mitigation analysis
- Electrochemical abuse testing and electrochemical safety modeling
- Improved safety through integration of power electronics

FY18 Accomplishments

- Initiated new research DC Arc Flash issues relevant for energy storage in collaboration with UT Arlington. This will lead to an update of IEEE P1584 arc flash standard.
- Developed improved model for thermal runaway of Li-ion batteries. Two papers under with JECS
- Set up a new Energy Storage Safety Collaborative as a repository for energy storage safety R&D

Presentations and Posters

- 3 Oral Presentations and 7 Poster Presentations

Energy Storage Analytics and Controls

Developing analytics and controls for integration of utility class storage systems. Software tools for optimal use of energy storage across the electricity infrastructure. Standards development. Engineering analysis for demo projects.

Key Projects

- Open Source Tools for Energy Storage Analytics
- Control of Distributed Energy Storage, Optimal control and dispatch of energy storage
- Modeling for ES Enabled Distribution Grid (NRECA, Univ collaboration)
- Energy Storage in the Transmission System
- Tech Specific Modelling & Optimization (University of Utah)
- Market Survey-Financing-Insurance Energy Storage Financing Roadmap (Mustang Prairie)
- Hydrogen Energy Storage Analytics
- Holistic Optimization Framework for Grid Integrated Energy Storage (Michigan State Univ)
- Integrating Virtual Inertia in Energy Storage Systems and Energy Markets (South Dakota State University)
- Distributed Control Algorithms Wide-Area Power Grids using Energy Storage (Clemson Univ)

FY18 Accomplishments

- Wide area damping control work was recognized with an R&D100 award for real time control using phasor measurement unit feedback to damp wide area power system oscillations. A provisional patent was filed on the damping controller system. non-provisional patent application.
- Developed and released QuESt 1.0 an open source software tool for storage valuation in market areas. This tool kit allows users to analyze potential revenue from various market activities. Additional capabilities are being integrated and released.
- Developed a methodology for the optimal time of use management together with power factor correction using behind-the-meter energy storage systems. Presented at the 2018 IEEE PES GM Best Paper Session.
- Developed a methodology for optimal operation of energy storage systems with nonlinear operating characteristics. Improved performance compared to linear energy flow models (paper in IEEE Tran. Power Systems)
- Organized the 2018 Energy Storage Finance Summit in New York City on January 18 with over 150 participants from the energy storage project finance industry. Paper in IEEE Electrification on engineering and project finance aspects of energy storage (with Mustang Prairie)

Presentations and Posters

- 9 Oral Presentations and 10 Poster Presentations

Energy Storage Demonstration Projects

Enable confident development, deployment and operation of energy storage through controlled testing of prototype commercial storage technologies

Key Projects

- Energy storage projects with states (with CESA)
- Energy storage state projects focused on rural resiliency (with NRECA)
- SW Regional demonstration projects in NM, AZ and CO
- Industry support for energy storage engineering and commissioning
- International collaborations (EMA Singapore)
- California/Hawaii projects and technical support
- Flywheel energy storage demonstration project (with Helix Power)

FY18 Accomplishments

- Initiated ESS project at Cordova Electric Cooperative (CEC). Completed the analysis to determine ES sizing. Partnered with CEC to develop the RFP, and provided analysis for the selection of Battery vendor/installer. 1MW, 1-hour Li-ion system will be installed in FY19.
- Provided engineering, developed and issued contracts to install a 125KW, 4-hour flow battery at Natural Energy Lab of Hawaiian Authority (NELHA). This project will provide renewable firming, as well as be a test bed for the local utility (HELCO) to demonstrate ES in an island situation.
- Completed design for a 500kw 2-hour Li-ion system at Eugene Water and Electric Board (EWEB). Supported RFP development, vendor/installer selection, and engineering review of the construction package and application analysis to determine potential stacked benefits. Project is presently in construction and will be commissioned later this year.

Presentations and Posters

- 3 Oral Presentations and 6 Poster Presentations

Industry Outreach

Disseminate ES information to diverse stakeholders through educational workshops, webinars, technical meetings, and global database

Key Projects

- DOE/OE ESS Website
- DOE SNL Global Energy Storage Database
- DOE/EPRI/SNL/NRECA Electricity Storage Handbook
- Workshops for PUCs and Utilities
- DOE OE Energy Storage Annual Peer Review

FY18 Accomplishments

- Completed a full update of the DOE Global Energy Storage Database
- Update of the ESHB and DOE ES website is in progress

Presentations and Posters

- 1 Oral Presentation and 3 Poster Presentations

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Members of Sandia Grid Energy Storage program

National lab partners at PNNL and ORNL

Our collaborating partners around the country at universities, utilities, companies, state and regional entities

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