

Sandia  
National  
Laboratories

# DOE OE Energy Storage Program at Sandia – FY19 Summary



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# FY19 Accomplishments by the Numbers



**30**

## Journal Articles

22 published

8 under peer review

**10**

## Conference Proceedings

5 Technical Reports

**12**

## Patents

6 granted

6 Applications filed

**23**

## Invited Talks

**50**

## Technical Presentations

**12**

## Seminars and Webinars

CESA, IEEE, and  
prominent universities

# Where We Focus Our Energy



## Materials

Advancing battery chemistries through development and commercialization

## Regulatory Outreach

Collaborating with States and other National Labs  
State Policy Analysis

## Safety & Reliability

Testing, Analysis, Standards, Protocols

## Demonstration Projects

Support, Analysis, Implementation, Monitoring

## Power Electronics

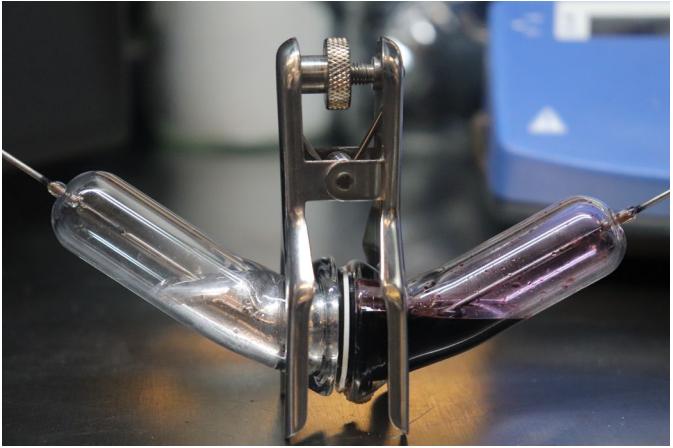
Reduce installed cost and footprint  
Improve control capability  
Increase reliability

## Outreach

DOE ESS Website  
Global Energy Storage Database  
Regulatory Outreach & Education

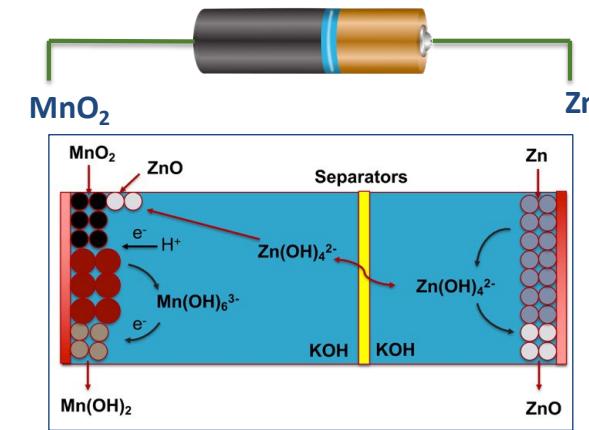


## SODIUM BATTERIES



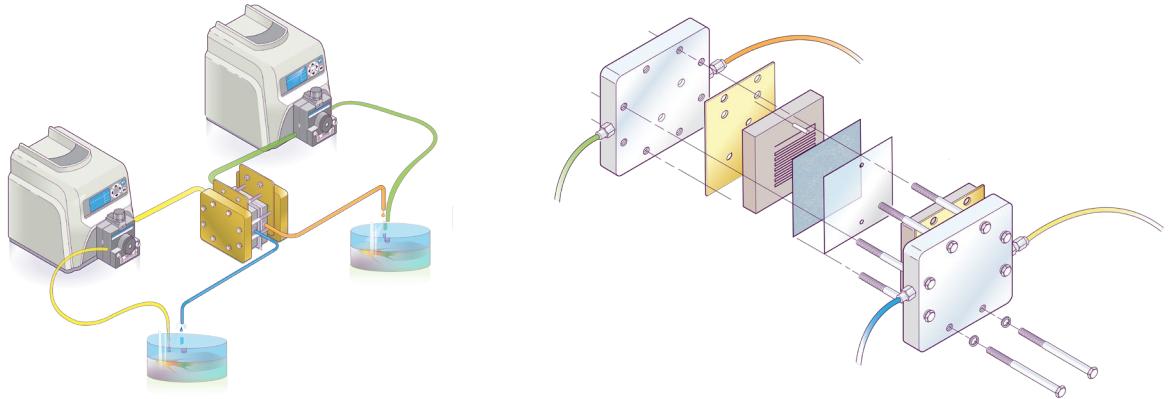
- New Na-battery cell testing design implemented that exhibits improved sealing, chemical compatibility, and molten reagent utilization
- Solid state separator development has yielded improved in-house NaSICON production and new alternative ion conductive ceramics and composites
- Interfacial modifications in both anode and cathode have led to drastically improved cell cycling performance, enabling >100 cycles in lab-scale prototypes

## ZINC BATTERIES



- Developed permselective polymer separators to block zincate crossover while promoting promising ionic conductivity competitive with current commercial materials
- Using Zn/Ni analogs, developed strategy in which ZnO-saturated KOH electrolyte leads to increased cycle life and more effective utilization of Zn-anodes
- Developed high voltage aqueous Zn-MnO<sub>2</sub> rechargeable battery operating at 2.8 V without the use of expensive ion selective membranes

## FLOW BATTERIES



- Through testing of variable electrolyte compositions and membrane chemistries, determined new insights into the the foundation of flow batteries: the interplay between solvent, salt, and membrane
- Several university collaborations are developing new models and promising tunable redox active materials for flow batteries

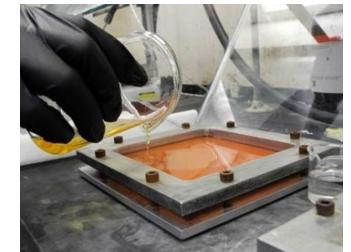
## MEMBRANES

Developed new process of synthesizing SNL anion exchange membrane for the specific use in flow batteries

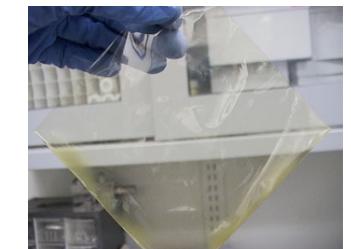
Currently looking for commercial partners



Solvent cast



Film





## Public Data and Open-Source Tools

To enable risk assessment, selection, and adoption of ESS, we are developing:

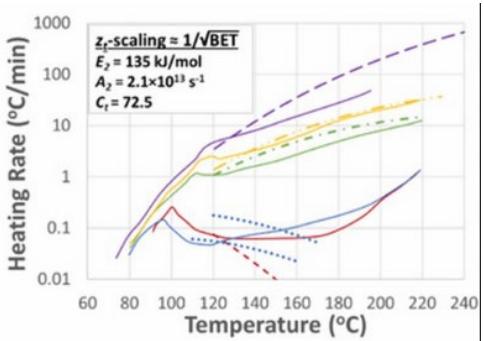
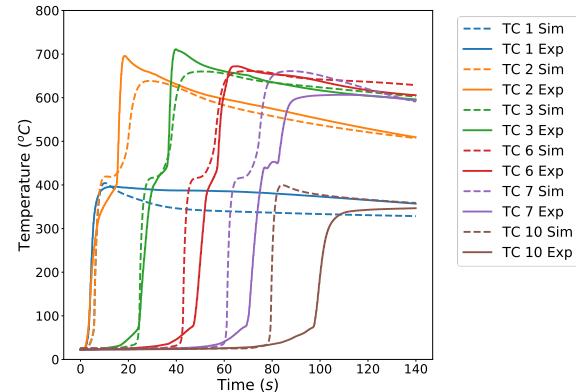
- Battery data repository and open source analytics tool in collaboration with UT-Austin
- Open-source python tool for modeling thermal runaway propagation
- Multi-institution battery calorimetry collaborative and workshop series to identify best practices for data collection and analysis
- Thermodynamics calculator for lithium ion battery cathodes
- Thermal runaway database with risk scores in collaboration with ORNL



## Modeling

Spearheading advancements in multi-scale modeling of Li-ion battery failure, including development of:

Models for thermal runaway propagation in pouch cells

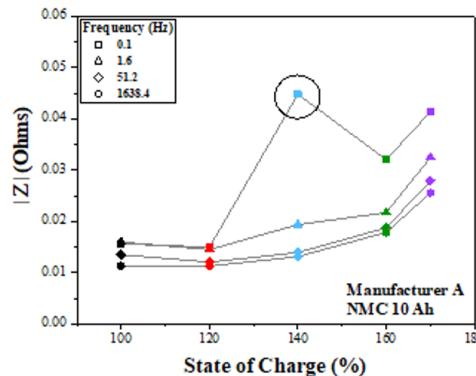
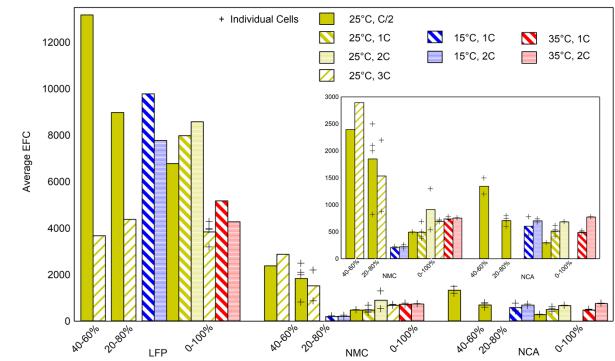


Comprehensive models of lithiated graphite and metal oxide cathode decomposition

## Experimental

Advancing quantification of battery degradation and failure at the cell and materials level, including:

Completed multi-year head-to-head comparison of cycling, materials stability, and whole cell thermal runaway of popular commercial Li-ion cells



Identified universal degradation markers for NMC cells, providing early warning of failure

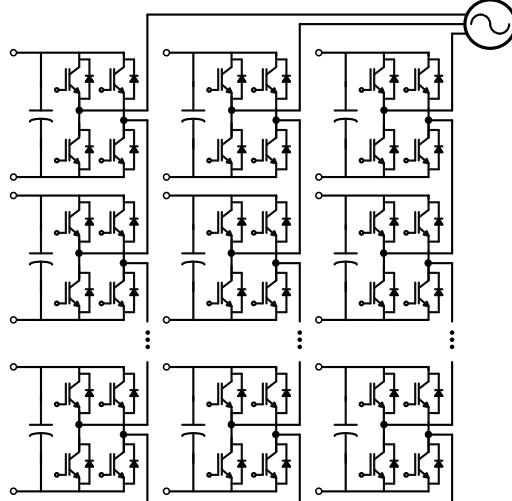


## FY19 Accomplishments

- Review of challenges and opportunities for power electronics in utility-scale storage applications
  - Review paper on power electronics for energy storage in IEEE Access
- Commissioning APEX laboratory
  - Jump-start internal power electronics research program
  - Leverage Sandia's unique strengths in component and material R&D
  - Maximize strategic impact of external collaborations

## FY20 Plans

- Power conversion systems for next-generation energy infrastructure
  - Modular, fault-tolerant, reconfigurable hardware architectures
- Applications of power electronics in storage system safety
  - Stranded energy extraction
  - Active responses to thermal runaway



# 9 | Regulatory Outreach



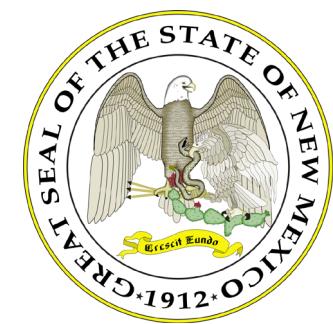
**Hawaii PUC** – December 2018 – Energy Storage Introductory Workshop

**California Energy Commission (CEC)** – June 2019 – Energy Storage Academy

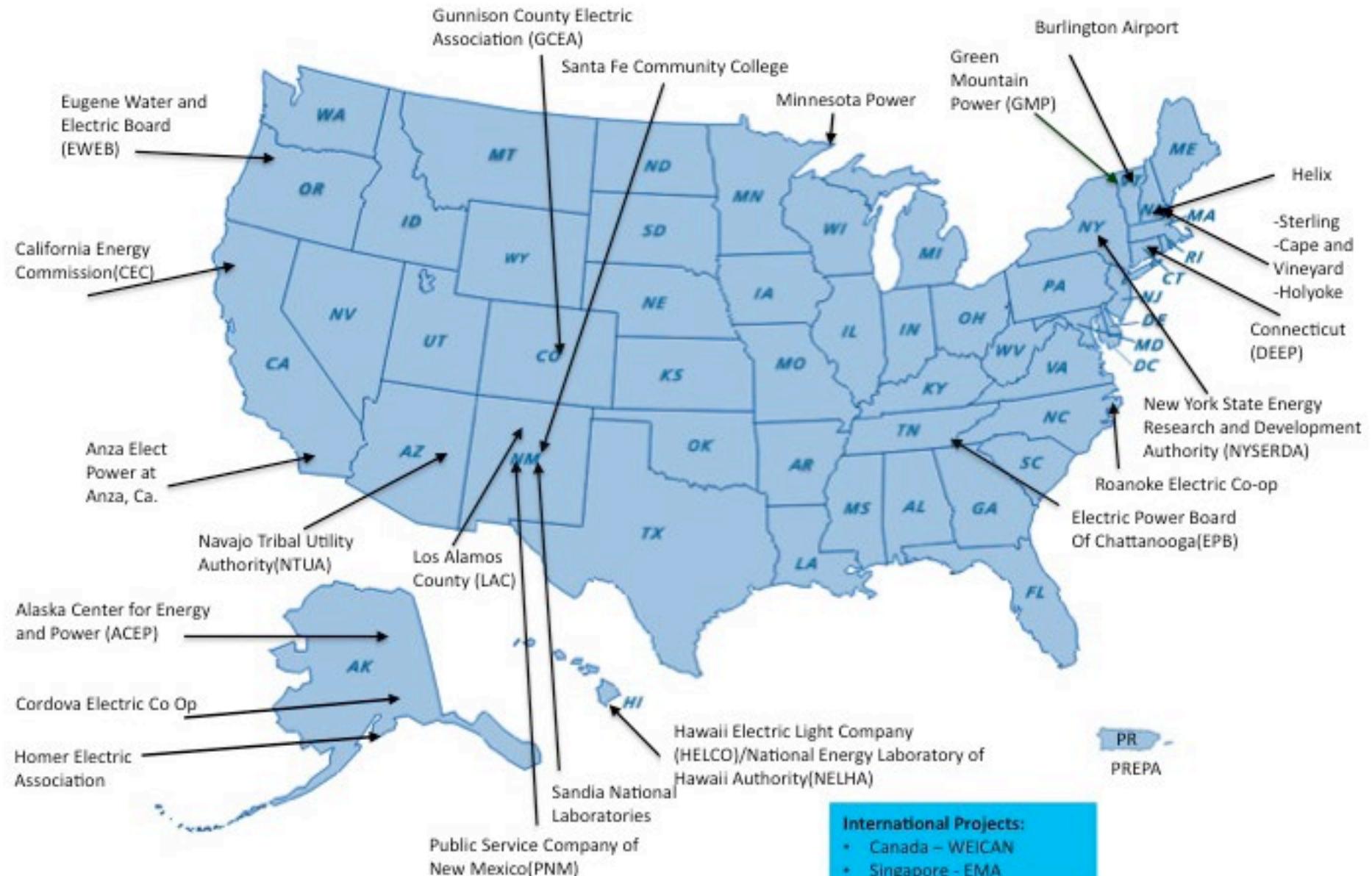
**Southeastern PUCs – Alabama, Arkansas, Florida, Georgia, Kentucky, Maryland, New Jersey, North Carolina, Virginia** – July 2019 – 2<sup>nd</sup> Southeast Energy Storage Symposium and PUC Workshop

**New Mexico PRC and Nevada PUC** – workshops in planning stages

**New Jersey, Texas, Minnesota, Iowa PUCs** – in the pipeline



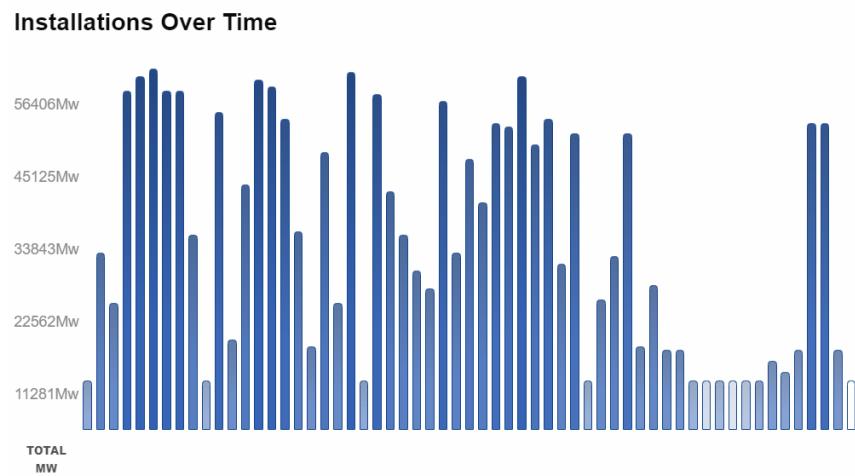
# Demonstration Projects



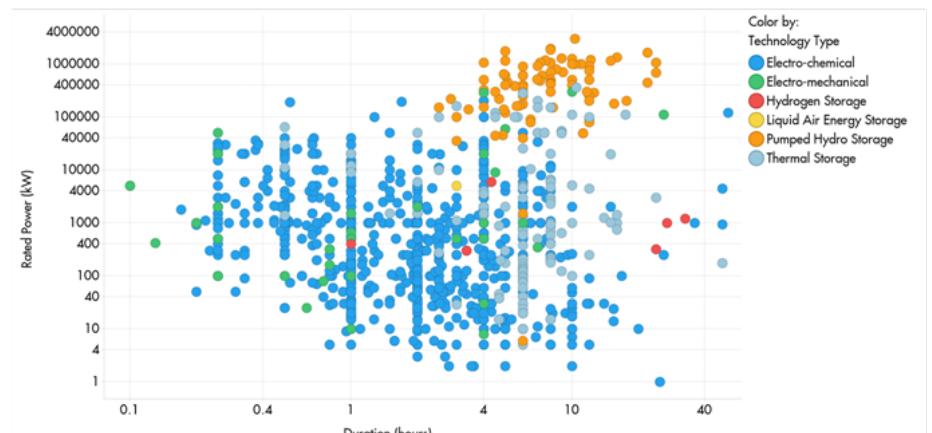
# Global Energy Storage Database



- 1,579 total energy storage project profiles
- Over 178 GW operational capacity
- 9,600 unique users have exported the data 70,000+ times since its inception in 2013.
- There have been 3500+ exports since September 2018.
- There is no widely available alternative source of information – all known private data sources reference data from DOE's Global Energy Storage Database.



Range of Energy Storage Technologies Used for Different Applications



Source: US DoE Energy Storage Database, June 2018, <https://www.energystorageexchange.org/>  
Analysis by Shell International Exploration & Production (US) Inc.; presented by Shell 11 March 2019, ARPA-e DAYS kickoff meeting

# Partnerships



## ACADEMIA





# Partnerships (cont.)

## INDUSTRY

Anza Electric Cooperative, Inc.

A Touchstone Energy® Cooperative 



BURLINGTON  
ELECTRIC  
DEPARTMENT



Creare®

**EPRI**

ELECTRIC POWER  
RESEARCH INSTITUTE



Energy  
Storage  
Association



GREEN  
MOUNTAIN  
POWER



Hawai'i  
Electric  
Light

**GeneSiC™**  
SEMICONDUCTOR

**STRATEGEN**

**WattJoule**

**URBANELECTRIC POWER**



**LOS ALAMOS**  
where discoveries are made



**NAATBatt**  
INTERNATIONAL

**NRECA**  
America's Electric Cooperatives

**UET** UniEnergy  
Technologies

## STATE PARTNERS



CALIFORNIA  
ENERGY  
COMMISSION



ENVIRONMENTAL  
PROTECTION  
AGENCY



NELHA



NEW MEXICO  
Energy, Minerals and Natural Resources Department



DOER  
Massachusetts Department  
of Energy Resources

## STANDARD BODIES



**IEEE**  
Advancing Technology  
for Humanity



## FEDERAL PARTNERS



**NHTSA**

## INTERNATIONAL



**nite**  
Smart Energy. Sustainable Future.  
National Institute of Technology and Evaluation

# Acknowledgements



## Organization Team

Jaci Hernandez, Gina Fresquez, Sam Roberts-Baca, Sharon Ruiz, David Sokoloff

## Facilitator

Jim Greenberger, NAATBatt, Facilitator

## Partner Laboratories

Oak Ridge National Laboratory

Pacific Northwest National Laboratory

## Other Collaborating Partners

Universities, utilities, companies, state and regional entities

## Department of Energy

DOE Office of Electricity and Dr. Imre Gyuk, Director of the Energy Storage Program