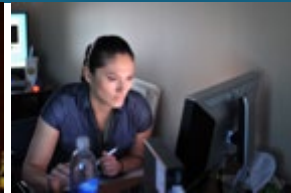




Sandia  
National  
Laboratories

# DOE OE Energy Storage Program at Sandia – FY19 Summary



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Program Manager, Grid Energy Storage



Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525. SAND2019-11290 C

# 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

## Safety & Reliability

Testing, Analysis,  
Standards, Protocols

## Power Electronics

Reduce installed cost and footprint  
Improve control capability  
Increase reliability

## Regulatory Outreach

Collaborating with States  
and other National Labs  
State Policy Analysis

## Demonstration Projects

Support, Analysis,  
Implementation, Monitoring

## Outreach

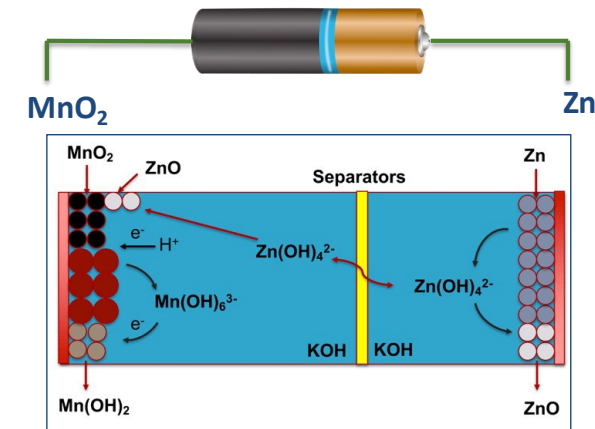
DOE ESS Website  
Global Energy Storage Database  
Regulatory Outreach & Education

## 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

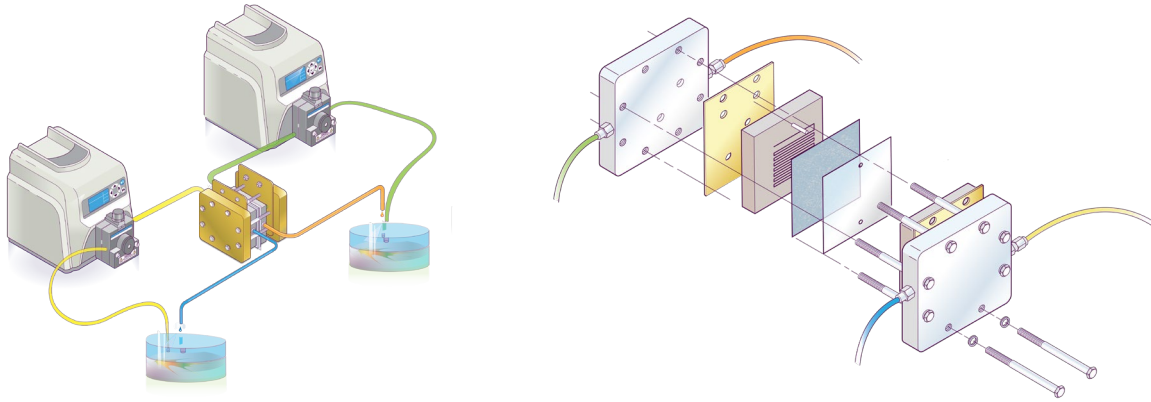
## ZINC BATTERIES



- 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

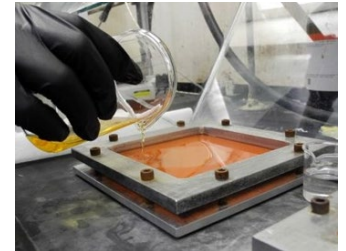
## MEMBRANES

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

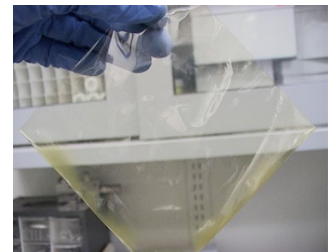
Currently looking for commercial partners



Solvent  
cast



Film





## Public Data and Open-Source Tools

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

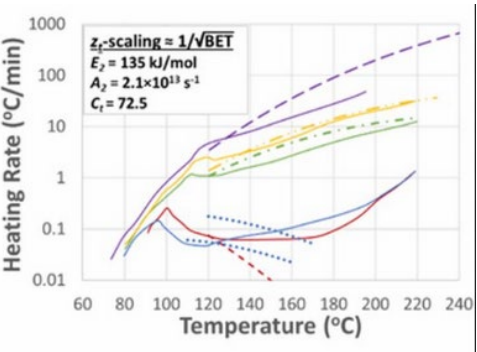
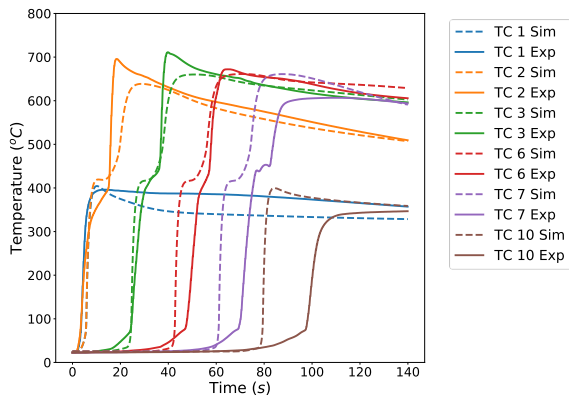
- Battery data repository and open source analytics tool in collaboration with UT-Austin
- Open-source python tool for modeling thermal runaway propagation
- Multi-institution battery calorimetry collaborative and workshop series to identify best practices for data collection and analysis
- Thermodynamics 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

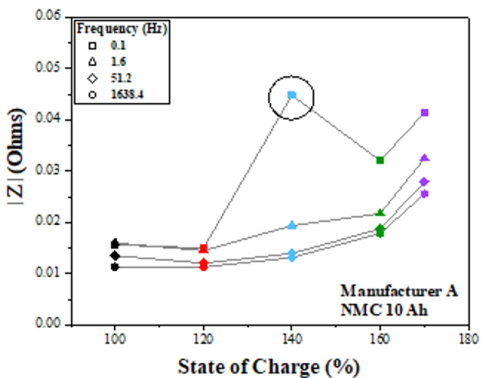
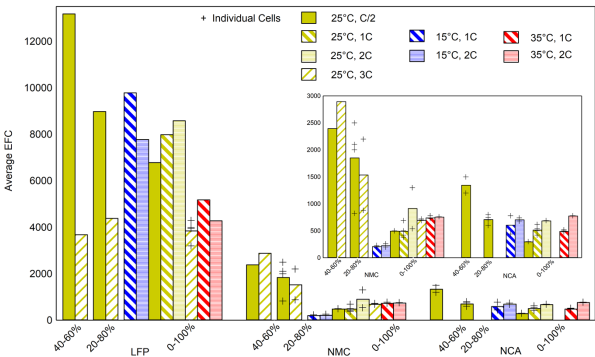


Comprehensive models of lithiated graphite and metal oxide cathode decomposition

## 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



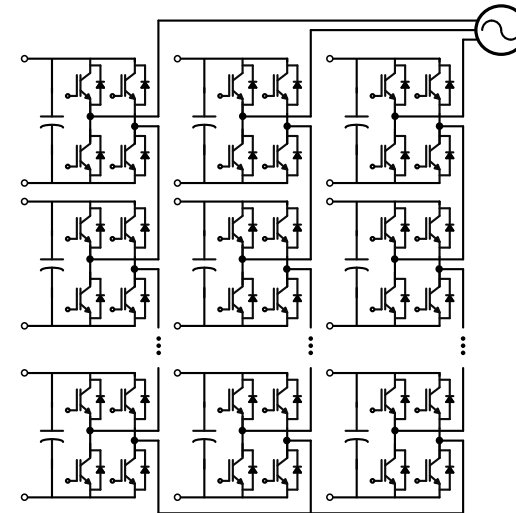
Identified universal degradation markers for NMC cells, providing early warning of failure

## 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



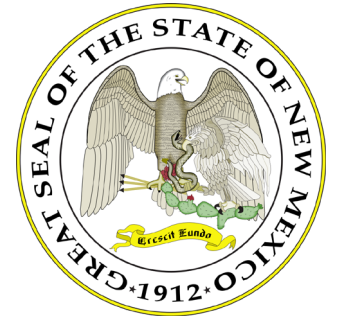
**Hawaii PUC** – December 2018 – Energy Storage Introductory Workshop

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

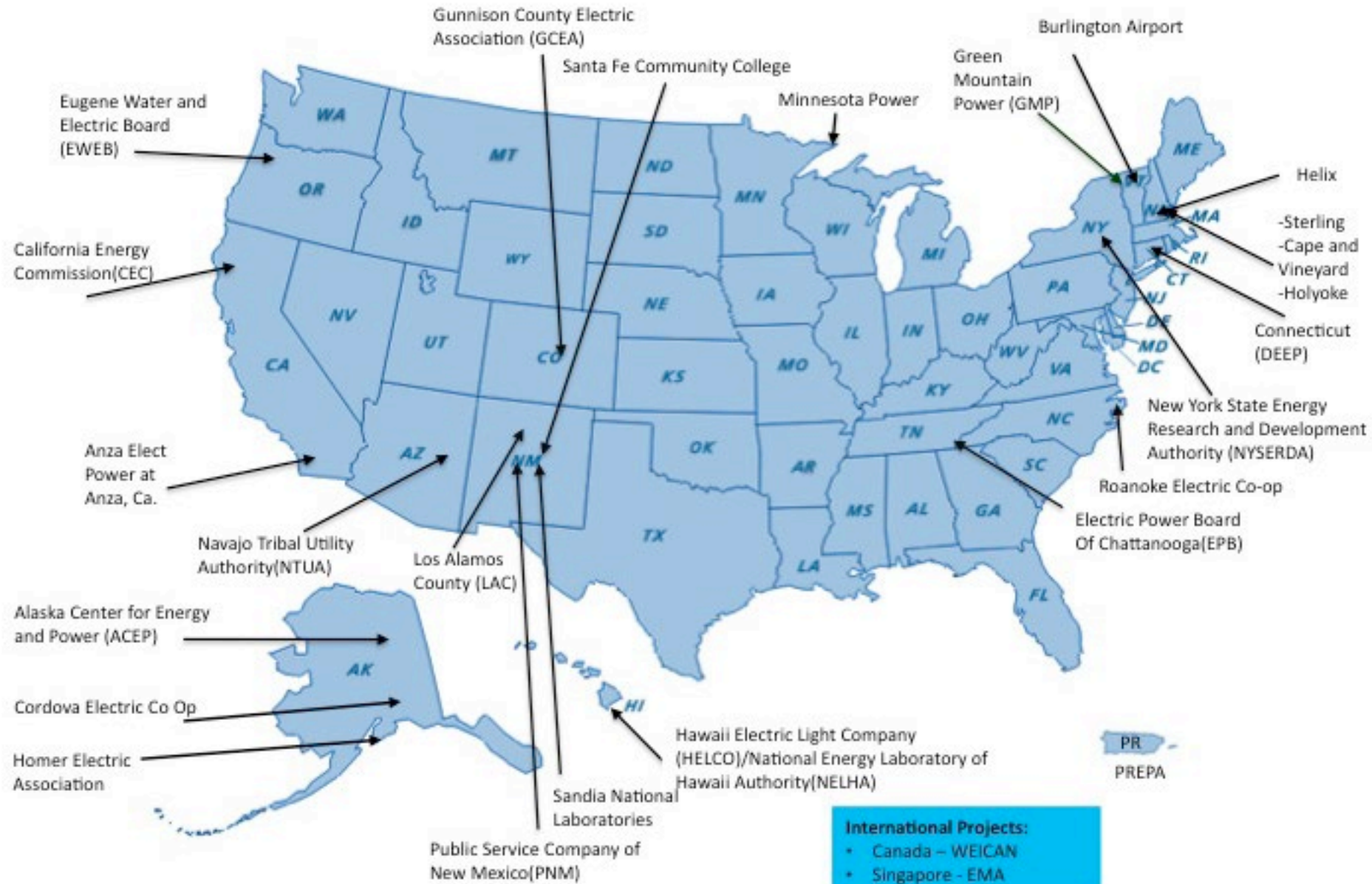
Southeastern PUCs – **Alabama, Arkansas, Florida, Georgia, Kentucky, Maryland, New Jersey, North Carolina, Virginia** – July 2019 – 2<sup>nd</sup> Southeast Energy Storage Symposium and PUC Workshop

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

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



# Demonstration Projects



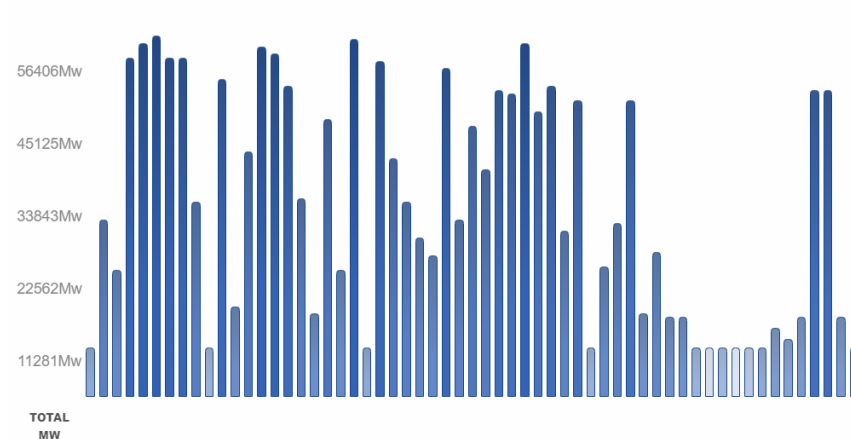
# Global Energy Storage Database



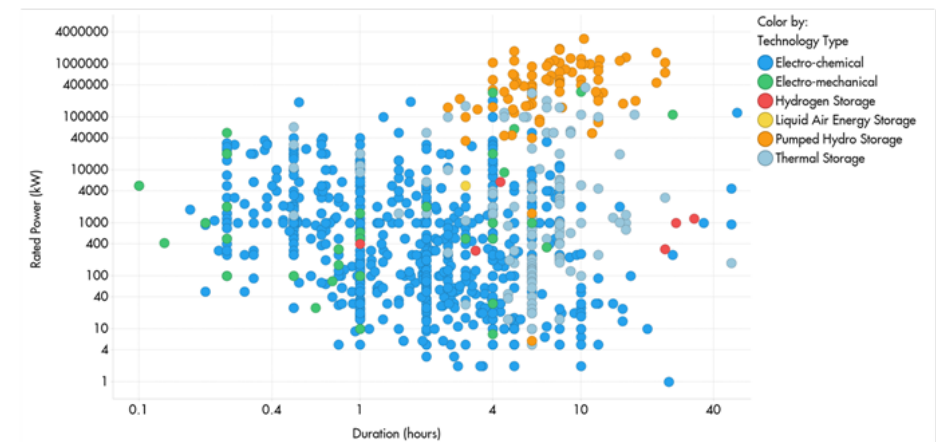
- 1,579 total energy storage project profiles
- Over 178 GW operational capacity
- 9,600 unique users have exported the data 70,000+ times since its inception in 2013.
- There have been 3500+ exports since September 2018.
- There is no widely available alternative source of information – all known private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



Installations Over Time

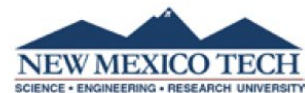


Range of Energy Storage Technologies Used for Different Applications





## ACADEMIA



# Partnerships (cont.)



## INDUSTRY

Anza Electric Cooperative, Inc.  
A Touchstone Energy® Cooperative



BURLINGTON  
ELECTRIC  
DEPARTMENT



Creare

EPRI | ELECTRIC POWER  
RESEARCH INSTITUTE



EAST ecoult  
Energy Storage Excellence

ESA Energy  
Storage  
Association



GREEN  
MOUNTAIN  
POWER

Hawai'i  
Electric  
Light

GeneSiC™  
SEMICONDUCTOR

STRATEGEN

WattJoule

URBANELECTRIC POWER

Helix Power

LOS ALAMOS  
where discoveries are made



NAATBatt  
INTERNATIONAL



NRECA  
America's Electric Cooperatives

UET UniEnergy  
Technologies

## STATE PARTNERS



## STANDARD BODIES



## FEDERAL PARTNERS



## INTERNATIONAL



# 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