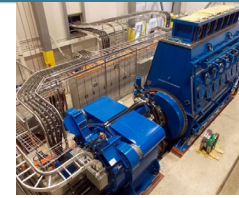




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# Sandia National Laboratories Energy Storage Program



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# Overview of Sandia Energy Storage Program



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

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

- **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.



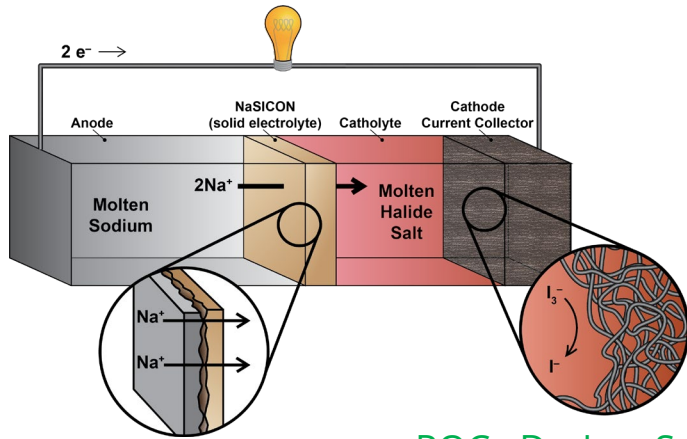


# Battery R&D



## Sodium Batteries

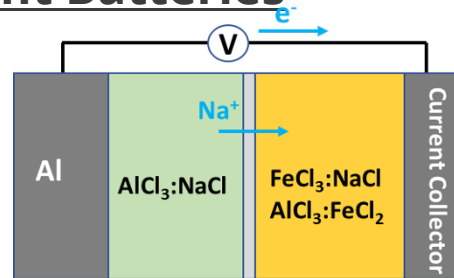
- High voltage, low temperature molten Na
- Novel Na-ion
- High conductivity NaSICON solid electrolyte



POC: Dr. Leo Small (ljsmall@sandia.gov)

## Earth Abundant, Multivalent Batteries

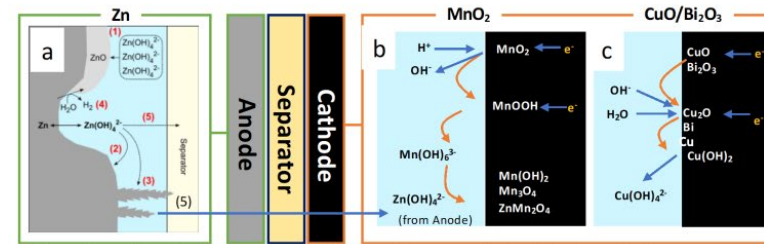
- Iron
- Aluminum
- Molten Salts
- Aqueous Chemistries
- Long-Duration Applications



POC: Dr. Stephen Percival (sperciv@sandia.gov)

## Zinc Batteries

- Zn-CuO
- Zn-MnO<sub>2</sub> (with URBAN ELECTRIC POWER)
- Zn-Air



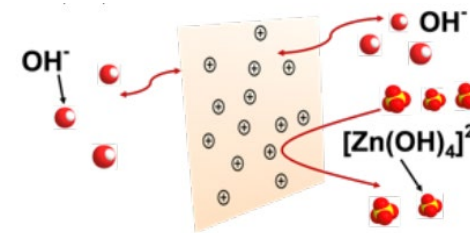
Adapted from "A Critical Comparison of Mildly Acidic versus Alkaline Zinc Batteries" Acc. Mater. Res. 2023 4, 4, 299-306.



Photos provided by UEP

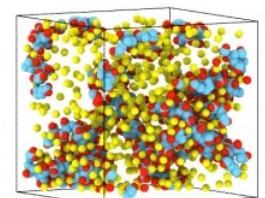


- Ion-Selective Separator Development



POC: Dr. Tim Lambert (tnlambe@sandia.gov)

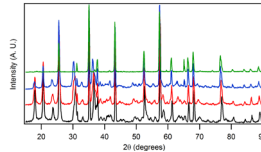
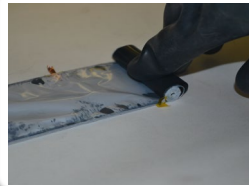
- Computational Modeling of Electrolytes



blue = C  
red = O  
yellow = K<sup>+</sup>

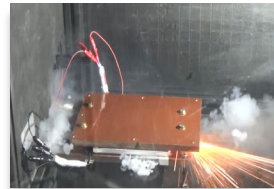
Dr. Amalie Frischknecht





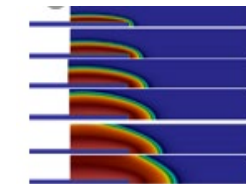
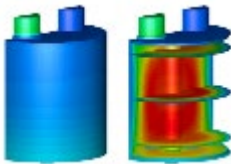
## Materials R&D

- Thermal stability and aging impact on battery components
- Vent gas composition
- Solid state battery safety
- Aqueous battery gas evolution



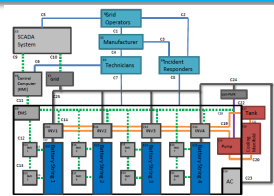
## Cell and Module Testing

- High precision cell cycling and degradation
- Electrical, thermal, mechanical abuse testing
- Failure propagation testing on batteries/systems



## Simulations and Modeling

- Multi-scale models for understanding thermal runaway
- Fire Dynamic Simulations to predict the size, scope, and consequences of battery fires



## System Level Design and Analysis

- Hazard analysis methods to avoid fire and explosion
- Post accident analysis
- Predictive maintenance
- Improved control using power electronics



## Outreach, Codes, and Standards

- Energy storage safety working group/conference + international
- IEEE battery management system standard
- EPRI Energy Storage Data Submission Guidelines
- Energy storage safety training sessions

# Energy Storage Analytics & Industry Outreach



Sandia has developed software tools for energy storage valuation, sizing and placement

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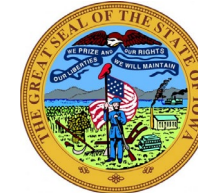
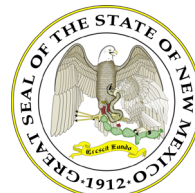


ES analytics supports the deployment team, recent successes include:

- Atrisco Heritage High School (Albuquerque, NM)
- Picuris Pueblo (Northern NM)
- Sterling Municipal Light Department (Sterling, MA)

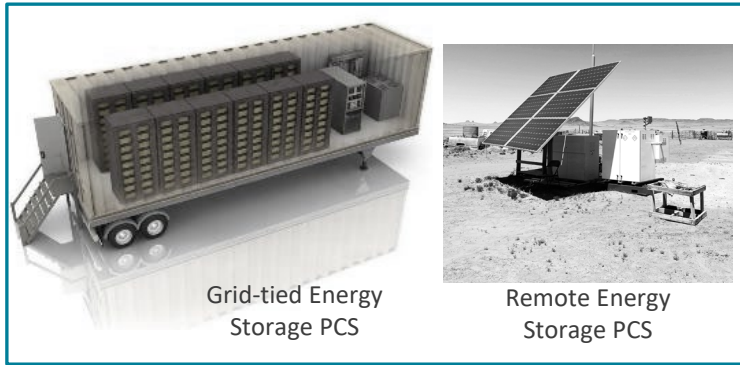


SNL and PNNL organize educational outreach activities with state public regulatory commissions





# Power Electronics: Materials to Megawatts



Grid-tied Energy Storage PCS

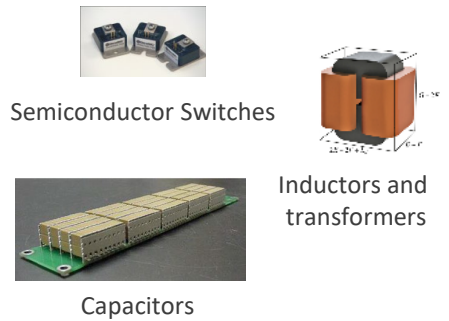
Remote Energy Storage PCS

## Systems

- Multiple subsystems together form the system or Power Conversion System (PCS)
- Self-contained, fully functional unit that performs the end-use application
- Includes DC/AC disconnects, system controls, final packaging, etc.

## Components

- Materials are combined together to form components
- Basic building blocks circuit
- Includes switches, capacitors, inductors, etc.



Semiconductor Switches

Inductors and transformers

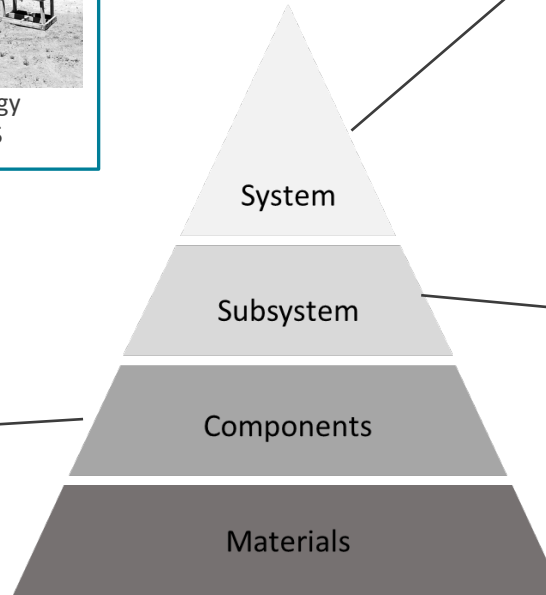
Capacitors

## Subsystems



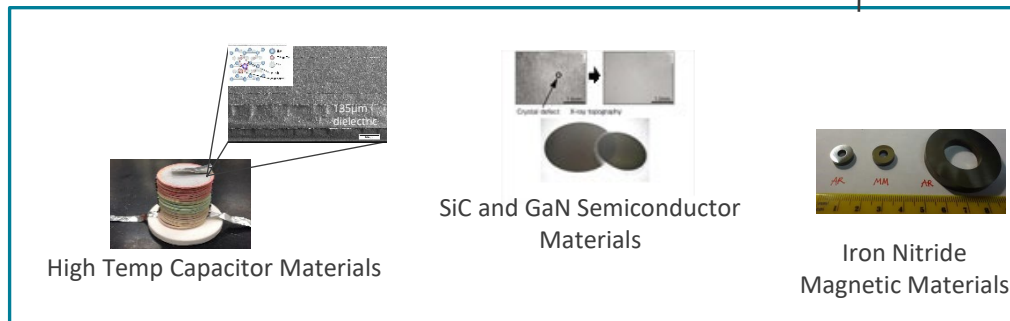
Power Converter Modules

- Multiple components together form subsystems
- Perform a specific task within the PES
- Includes subsystem controls, sensors, thermal management, protection, power stage, etc.



## Materials

- Bottom layer in the PE R&D spectrum (non-application specific)
- Foundation for other technological improvements
- Advanced semiconductor, magnetic materials, new capacitor dielectrics, etc.



High Temp Capacitor Materials

SiC and GaN Semiconductor Materials

Iron Nitride Magnetic Materials

# Summary



For more information, please refer to the DOE OE Energy Storage program website:

[www.sandia.gov/ess](http://www.sandia.gov/ess)