Sandia National Laboratories

Sandia National Laboratories Energy Storage Program

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U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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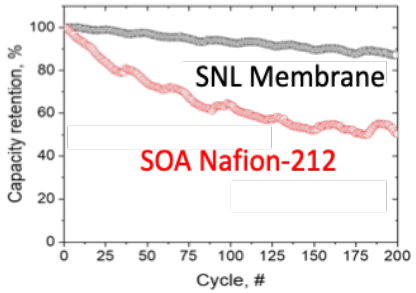
Overview of Sandia Energy Storage Program

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.

Cost Competitive / LDES Technology R&D

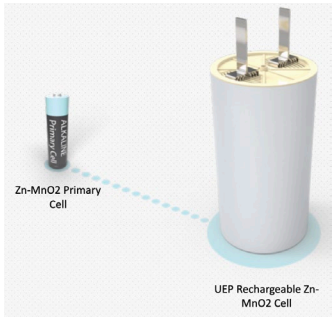


Non-aqueous Organic RFBs
- Enable Unprecedented High Voltage Performance

Aqueous Organic RFBs Promise Stable Performance
- 99.9989% Capacity retention/cycle
- >99.9% Coulombic Efficiency

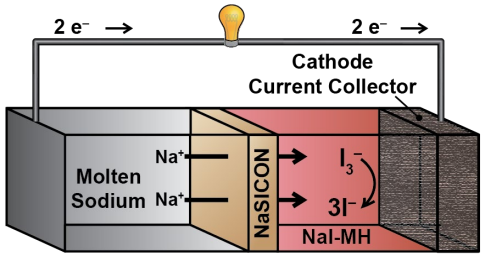
Low Cost Poly(Phenylene) Membrane Separators
- ~4X Improved Capacity Retention vs. Nafion

Redox Flow Batteries (RFBs)



Deployments:
- San Diego Super Computing Center (SSCC)
  - 1MW/2MWh High Rate UPS
- Navajo Tribal Utility Authority (NTUA)
  - 13 kWh Solar Microgrid Systems

Rechargeable Alkaline Zn Batteries, w/ UEP



High Voltage, Low-Temp, All Inorganic Molten Na-NaI Batteries
- Unprecedented Cycling (>5 months)
- Low Cost, Earth Abundant Mat'ls
- 20X Increased Current Density
- Domestic Commercial Interest

Molten Sodium (Na) Batteries

Edison-LaLande Battery.
PAT. Mar. 20, 1883.
OTHER PATENTS APPLIED FOR

- 1st reported cycling of *rechargeable* Zn-CuO battery
- 140 years after Edison patented the chemistry!

Emerging Earth-Abundant Chemistries

Energy Storage for Social Equity (ES4SE)

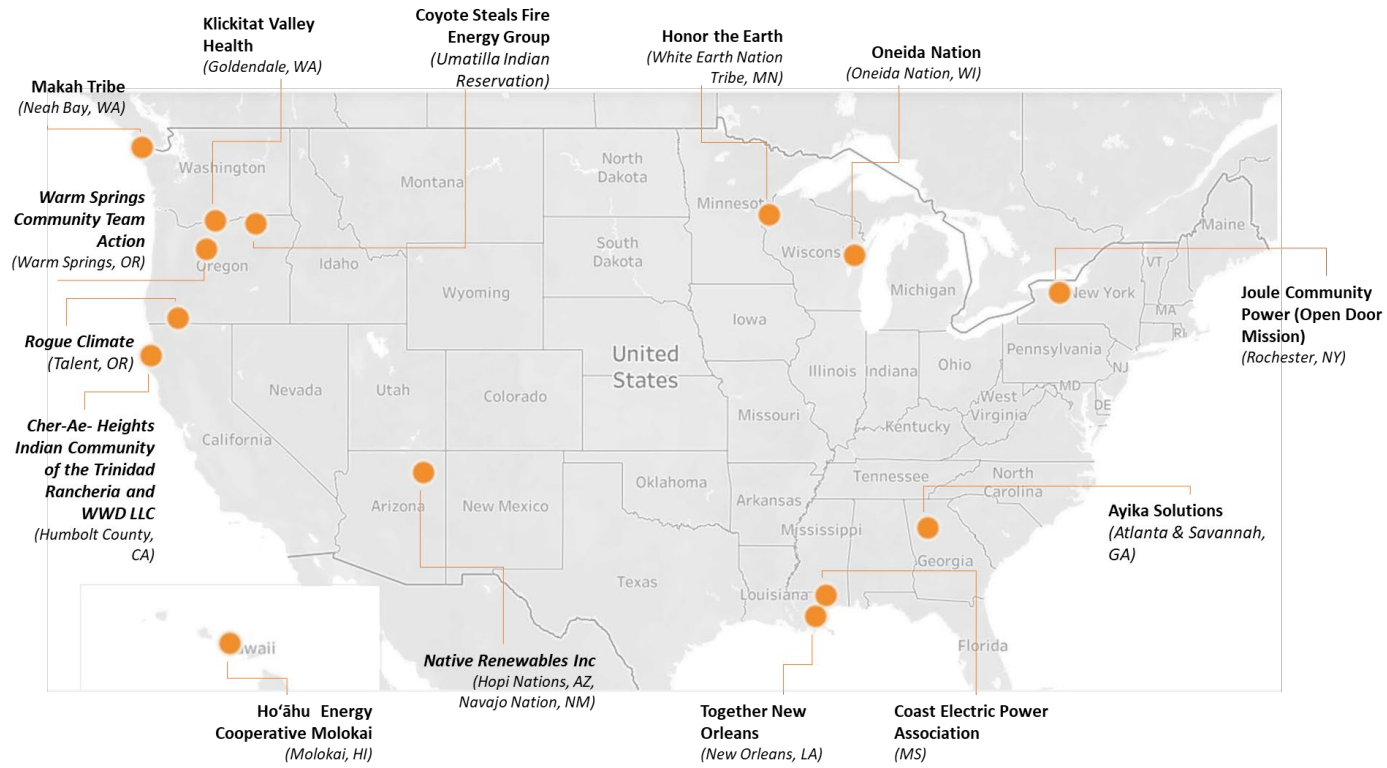
Initiative to increase energy equity and resilience in disadvantaged communities

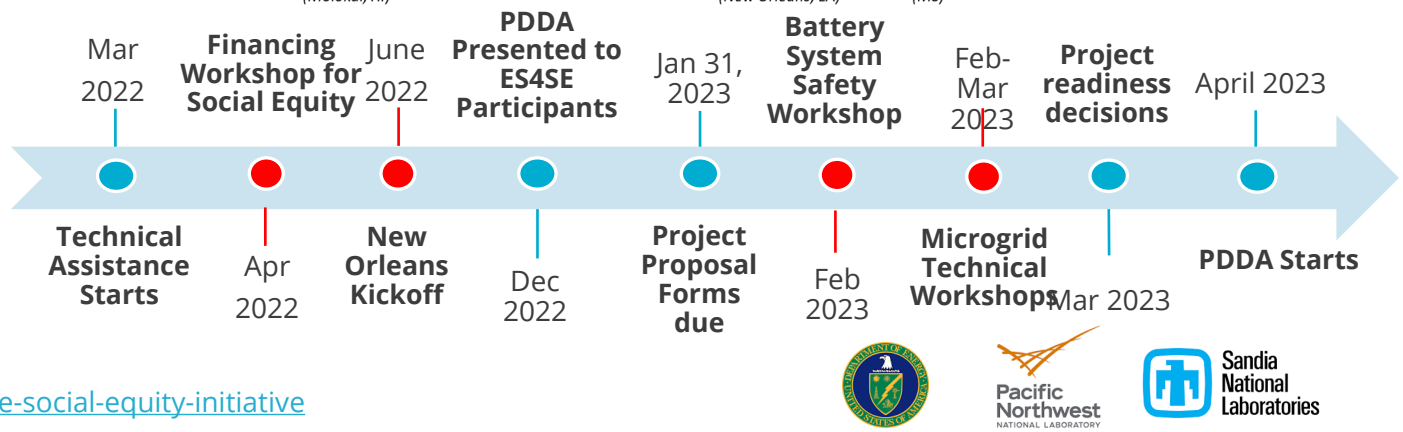
Phase 1: Technical Assistance (TA), managed by PNNL

Phase 2: Project Development and Deployment Assistance (PDDA), managed by Sandia

14 communities selected out of 64 applications

- Held over 600 community meetings, April to December 2022, including in-person meetings.
- Participated with communities to engage state and commission stakeholders.
- Supported and educated communities on interconnection requirements and processes with respective IOUs, Co-ops, and PUDs.
- Completed equity, workforce and social benefit analysis for each community.
- Hosted technical workshops and created educational materials.
- Funding opportunities researched and tailored for each community.
- Supported 3 FEMA BRIC Applications including executing Benefit Cost Analysis.
- Technical assistance leveraged to secure additional funding of more than $9M for Together New Orleans project.





More information: https://www.energy.gov/oe/energy-storage-social-equity-initiative

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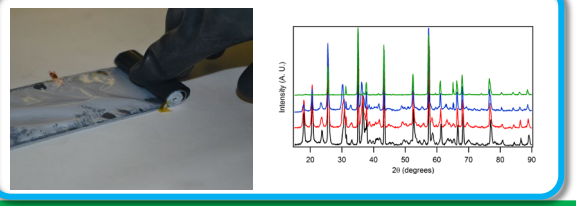
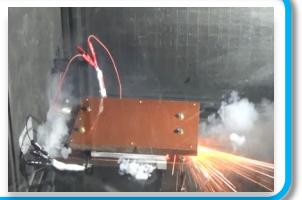
Reliability and Safety R&D



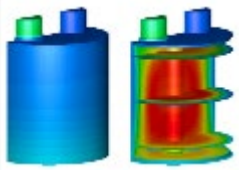
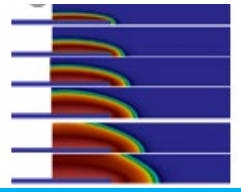
Materials R&D

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

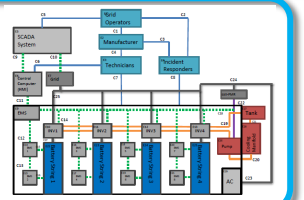
Cell and Module Testing

- 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 & Regulatory Outreach

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

- Market applications
- BTM storage plus solar applications
- Peaker plant replacement with energy justice (air quality/health) models
- Models performance in extreme climates (hot and cold)

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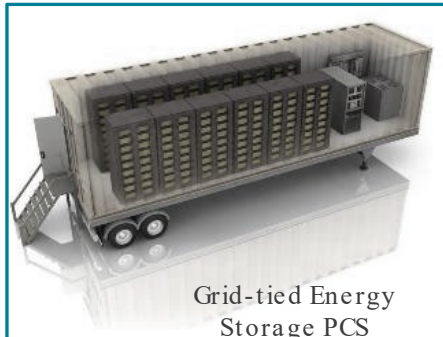
Quest

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

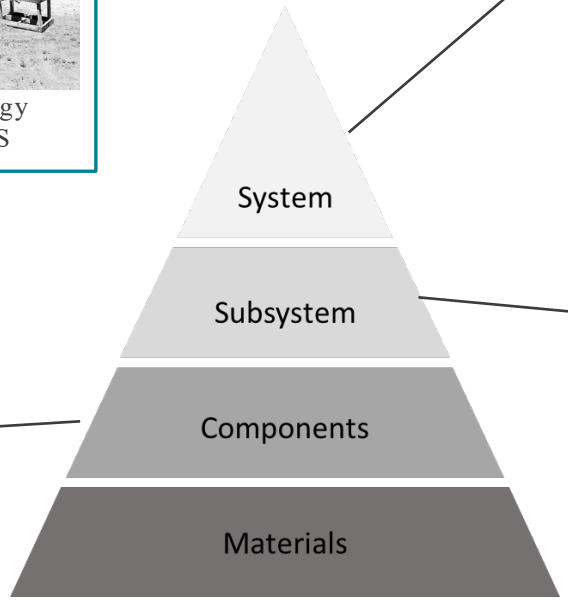


Grid-tied Energy Storage PCS

Remote Energy Storage PCS

Systems

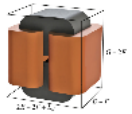
- Multiple subsystems together form the system or Power Conversion System (PCS)
- Self-contained, fully functional unit that performs the end-use application
- Includes DC/ AC disconnects, system controls, final packaging, etc.



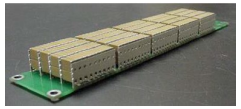
Components

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

Semiconductor Switches



Inductors and transformers

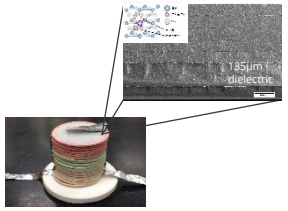


Capacitors

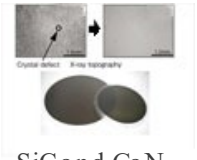
Power Converter Modules

Subsystems

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



High Temp Capacitor Materials



SiC and GaN Semiconductor Materials

Iron Nitride Magnetic Materials

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.

Summary

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

www.sandia.gov/ess

Upcoming events

Energy Storage Safety Workshop, June 6-8, 2023, Santa Fe, NM

Power Electronics Workshop, August 2-3, 2023, Albuquerque, NM

DOE OE Energy Storage Program Peer Review, October 24-26, 2023, Santa Fe, NM