Sandia National Laboratories

Energy, Climate, & Infrastructure Security

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Sandia's Energy Storage Research Program

Sandia works to reduce the nation's dependence on fossil fuels both by integrating renewable energy generation into the electricity transmission/distribution grid *and* enabling widespread electrification of the nation's transportation fleet by improving energy storage performance, economics, and safety. Sandia's longstanding responsibility for all nuclear weapon power sources equips us with unique capabilities and expertise to develop technologies and methodologies that address this national security issue.

Vision

To enhance the nation's security and prosperity through sustainable, transformative approaches to our most challenging energy, climate, and infrastructure problems.

Sandia is a national security laboratory with a long history of leading energy storage technology R&D. We have cradle-to-grave responsibility for all power sources for DOE defense programs, and apply our expertise to support DoD applications. Sandia provides leadership to the DOE Office of Electricity Delivery and Energy Reliability's Energy Storage Systems program through advanced technology development, device testing, technology demonstrations, and grid analysis. We play the lead role in evaluating the safety and reliability of energy storage (ES) devices for transportation systems. We apply fundamental scientific expertise in electrochemistry, materials science, advanced diagnostics, and modeling and simulation to advance the ES programs. Facilities such as the Center for Integrated Nanotechnologies, the Advanced Materials Laboratory, our battery safety and abuse testing laboratory, our Power Sources Technology Group which houses 6,700 ft^2 of dry room space with advanced diagnostics and prototyping facilities, and the Red Sky computing platform provide unique capabilities for fundamental science and university and industry partnerships.

Integrating Renewable Energy into the Grid

The contemporary transmission/distribution (T&D) grid model limits renewable energy (RE) and other distributed energy sources from being economically and reliably integrated into the grid. Utilities use controllable generators to not only meet electricity demand but to maintain its reliability. RE generation (primarily wind and solar) cannot be controlled in this way. As RE generation becomes a larger portion of a utility's portfolio, it disrupts the utility's ability to provide predictable

This Sandia-led DOE Office of Electricity demonstration project proved the effectiveness of sodium-sulfur batteries in peak shaving and capital deferment.

U.S. DEPARTMENT OF ENERGY

service. Sandia's ES research seeks to develop innovative solutions for industry to deploy nationwide to support a T&D grid that serves the nation's 21st century needs. Using the research facilities mentioned earlier, Sandia scientists and engineers work to address ES research from the nano-scale through applied R&D to large-scale testing and demonstration.

Through Sandia's historic emphasis on approaching research from a systems engineering perspective, our expertise and analysis help industry and regulators develop the policies and economics that facilitate integrating RE generation into the national grid. This includes developing market structure analyses that assign a proper value to the services that energy storage can bring to the grid and analyzing the policies that dictate electricity system operations to facilitate energy storage deployment.

Transportation Energy Storage

Efficient transportation will be key to any path toward reducing oil use and greenhouse gas emissions. *Vehicle electrification* provides one key approach to realizing efficient transportation. However, current battery technology imposes mobility limitations consumers are reluctant to accept.

Reliability and safety are also critical factors to the widespread adoption of battery technology in plug-in hybrid electric vehicles (PHEVs) and electric vehicles (EVs) in the marketplace. Sandia's decades of experience in applied materials R&D and systems and abuse testing assists industry in implementing advanced, science-based safety features that can avoid incidents of vehicle/property

damage due to poorly designed vehicle batteries which could destroy consumer confidence in PHEVs/EVs and set back transportation fleet electrification by years or even decades.

Sandia researchers are working to create a *science-based* understanding of electrochemical atomic/ molecular processes and connect them with the macroscopic response of packaged batteries to mitigate safety concerns, extend battery lifetimes, and increase battery efficiency through three highly coordinated thrusts:

1. Large-scale battery testing to measure critical end-of-life mechanisms,
2. In situ nano-scale characterization to gain an atomistic understanding of these mechanisms, and
3. Multi-scale modeling, building predictive models linking atomistic processes with macroscopic responses.

These thrusts, working in conjunction with materials/systems from industry partners, will enable the predictive simulations of battery performance so critically needed to increase the capacity, lifetime, and safety of battery materials.

Sandia's Energy Storage Research Addresses Important National Security Issues

Energy storage is a national issue in both the T&D grid and transportation application areas. Batteries suffer from low energy/power density, poor low-temperature performance, limited cycle life, intrinsic safety limitations, and high cost. Sandia leadership and the broader national scientific community recognize that dramatic ES improvement is required for affordable, secure energy distribution and non-petroleum-based transportation options. Over the decades, DOE/NNSA has invested a great deal to equip Sandia with world-class science and engineering research capabilities and personnel to develop power sources necessary for national defense. Laboratory management views bringing these capabilities to bear on industry and consumer ES needs as both a duty to the nation and an opportunity to expand our impact. Sandia's expertise in battery safety and reliability, advanced energy storage materials technology, advanced manufacturing techniques, and large-scale testing and demonstration can help the nation and its industries remain competitive in the 21st century.

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