



## GRID MODERNIZATION RESEARCH AT SANDIA

*Sandia envisions a world of interdependent and variable distributed systems that are optimized at multiple scales—including transmission—to maximize local resources in providing secure, resilient, and clean energy to all users at all times.*

### SANDIA'S GRID MODERNIZATION PROGRAM VISION

The U.S. electricity grid is vital to the nation's security and economy and is facing ever-increasing threats from severe weather events, cyber and physical attacks, and the impacts of an aging infrastructure. The emerging grid will include more renewable and distributed generation and widespread deployment of energy storage, as well as a robust communications and cyber infrastructure to support efficient use of local resources in interconnected infrastructures.

Sandia's vision of grid modernization includes better use of resources; enhanced system reliability; adaptation to and rapid recovery from power disruptions; a more efficient infrastructure; a market system that supports increased consumer choice and efficient end use; security against natural, cyber, and man-made threats; and better responsiveness to variability and uncertainty.

To achieve this vision, Sandia employs world-class competencies in advanced materials, nanodevices and microsystems engineering, computing and information sciences, and engineering sciences to perform:

- Engineering of devices and systems
- Modeling, simulation, and advanced analytics
- Deployment support through assessment of policy options, development of standards, and commercialization

### GRID MODERNIZATION RESEARCH THRUST AREAS

#### Grid Analytics and Resilience

Sandia and our partners develop analytical solutions that address emerging issues in our evolving transmission



and distribution systems. New algorithms in advanced optimization, wide-area controls, and dynamic systems modeling are developed and coupled with commercial modeling packages to address reliability, grid services, and stability problems. Sandia also employs a suite of complex systems analytical toolsets to conduct cross-infrastructure analyses.

Sandia's metrics framework for grid resilience is described in the U.S. Department of Energy's Quadrennial Energy Review. Sandia's grid resilience thrust area provides decision support tools for planning improvements and real-time operations, while helping to drive policy and research investment decisions.

#### Renewable Energy and Distributed Systems Integration

Distributed energy resources (DER) decentralize the use of loads, generation, and storage, and provide support for the entire grid during normal operation, outages, and emergencies. Sandia's DER research includes advanced dispatch, advanced communications, grid modeling and analysis, interconnection and interoperability standardization, distribution management systems, and technology validation through integrated demonstrations. Much of this is done in coordination with transmission research, ensuring a holistic approach to grid evolution.

#### Cyber and Physical Security

Both cyber and physical security research at Sandia leverage a long history of meeting critical national security needs and are applied across all of our grid modernization research areas. Laboratory scientists and engineers are threat-informed and develop technologies to identify, protect, detect, respond, and recover from cyber-attacks through



monitoring, vulnerability assessments, data analysis, supply chain management, and situational awareness, to provide integrated cyber-physical security solutions. This in turn offers unique insights and options for stakeholders based on deep technical understanding of electrical, computing, and network technology as well as physical infrastructures and systems analysis.

### Energy Storage

Energy storage is vital to the stability and resiliency of the electric grid. Sandia's energy storage research includes advanced battery technologies, power electronics and power conversion systems, and algorithms and controls for optimum utilization of energy storage assets. Working with partners, Sandia implements full-scale technology demonstration projects across the country to further our understanding of a future with ubiquitous grid-connected storage. Sandia is also a research center of excellence for safety and reliability of grid-scale energy storage systems.

### Defense Energy

Sandia leverages our long-standing history in national security and our cross-disciplinary strengths in cybersecurity, analytics, and lab-based integration and test platforms to address difficult defense-related questions. We utilize a variety of analytical tools to provide solutions to complex energy and operational problems for defense customers, including the U.S. Air Force, the Army, the Navy, and the Office of the Secretary of Defense.

### Power Electronics and Controls

Sandia's significant investments in material science and device research related to power electronics and controls includes fabrication of diodes, photoconductive switches, transistors, and many other components; research and development of wide bandgap materials and devices; and investigation of advanced materials such as III-V semiconductors, optoelectronics, and magneto-elastic and other smart sensors for grid applications. Sandia also conducts dynamic simulations to evaluate the impacts of potential future grid topologies. This basis of hardware, models, and simulation capabilities is leveraged to further advance controls spanning traditional to model predictive, Hamiltonian, and Exergy-based approaches to solve some of the more complex nonlinear distributed challenges.

### Integrated Research, Development, and Deployment

Our **Energy Surety Design Methodology (ESDM)** ensures optimal system designs that meet stakeholder needs with an emphasis on criticalities and all applicable threats while addressing interdependencies among infrastructures. The ESDM has been applied in the development of secure, resilient microgrids; advanced distribution systems; and

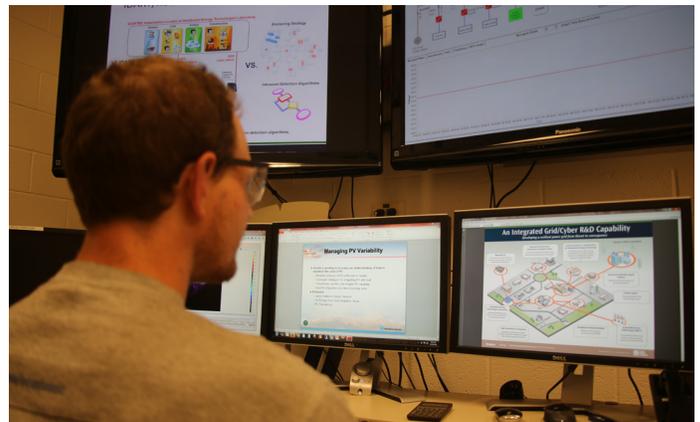
remote campus or military base power systems. Sandia is also exploring advanced microgrids to integrate distributed generation with power demand controls and optimized resource allocation for islanded and grid-tied systems. Sandia's microgrid work crosscuts our grid modernization research areas and addresses real-time controls, operational optimization, power quality, and protection and standards.

### FACILITIES

Sandia conducts experiments via a network of interconnected laboratory facilities that support full-scale research and development of a range of advanced grid technologies, including distributed energy, supervisory control and data acquisition, vulnerability assessments, advanced controls, informatics, microgrids, energy storage, and power system optimization. Sandia also maintains data and controls links to other external laboratories, allowing broader experiments and testing.

### PARTNERING WITH SANDIA

Sandia's grid modernization research is founded on partnerships with a range of stakeholders, including other national laboratories, electric utilities and utility research organizations, U.S. industry, U.S. states, the U.S. military, several universities, and international advanced grid consortia. These partnerships help the lab apply jointly developed tools and solutions, broaden technical capabilities, and gain insight into policy and regulatory issues and impacts.



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