Energy &
Homeland Security

GRID MODERNIZATION RESEARCH AT SANDIA: RENEWABLE ENERGY & DISTRIBUTED SYSTEMS INTEGRATION

Sandia conducts multi-disciplinary research and development to enable grid modernization and large-scale deployment of renewable and distributed energy resources.

SANDIA'S GRID MODERNIZATION PROGRAM VISION

The U.S. electricity grid is central to the nation's infrastructure, security, and economy. Modernizing this complex system of interconnected networks and enhancing its resiliency ensures availability of sustainable and secure electricity. Sandia National Laboratories supports this goal as a national research leader in cross-disciplinary fields including grid integration, cybersecurity, power electronics, microgrids, controls, materials science, and energy storage.

THE CHALLENGE

The existing power grid delivers electricity one-way from large dispatchable generators to distant load centers. Increased deployment of Distributed Energy Resources (DER) and Renewable Energy (RE) is fundamentally transforming the grid. Technical innovation is necessary to ensure that the future grid will meet the nation's need for performance, reliability, sustainability, safety, and cost-effectiveness.

SANDIA'S SOLUTION

To enable future large-scale deployment of DER and RE, Sandia develops disruptive solutions including advanced simulation tools, new power electronics concepts, adaptive control and protection systems, and new testing methodologies and standards. Sandia maintains and continually improves capabilities, including technical expertise and state-of-the-art research and development (R&D) facilities to address complex technical challenges, in partnership with government agencies, national laboratories, universities, and industry stakeholders.

RESEARCH AREAS

Advanced Modeling and Simulation

Sandia develops and applies advanced modeling and simulation tools to analyze the impact of large-scale DER and RE deployment on the grid. Sandia develops and validates multi-domain models for grid analysis and advanced decision support tools for T&D operations and planning. Sandia also pioneers quasi-static time series (QSTS) power flow, state estimation, and stochastic analysis techniques that are computationally efficient and scalable. Using these tools, researchers study challenges such as emerging dynamic behavior introduced by smart inverters, distribution feeder hosting capacity, optimal generation dispatch under high uncertainty, and grid stability with high-shares of variable renewable generation. We partner with utilities and software providers to ensure these advances are broadly applicable and widely available.

Power Electronics and Controls Research and Development

Sandia's comprehensive power electronics and controls R&D program focuses on improving capabilities, efficiency, and reliability of next-generation inverters and converters. The lab also designs cyber-secure controls that aggregate RE and DER optimally into microgrids or virtual power plants that support grid resilience. Sandia's solutions include development of controls that enable grid support functions, development of new power electronics converters, and development of interoperability test protocols.

Technology Validation and Demonstration

Sandia works with industry, utilities, and government agencies to validate and demonstrate advanced smart grid technologies in laboratory environments and in the field. Sandia applies automated testing platforms to evaluate cybersecurity, interoperability, grid compatibility, controls

Sandia is pioneering solutions for anti-islanding technology, grid compatibility, validation of interoperability and advanced inverter functionality, and associated standards.

performance, reliability, and safety of RE and DER devices and systems. Sandia also applies advanced control and power hardware-in-the-loop capabilities. These include Sandia's SCEPTRE emulytics platform that combines controls, cybersecurity, communications, and power systems domains and the System Validation Platform (SVP) that is used to accelerate the development, certification, and standardization of DER technologies through rapid and fully automated laboratory evaluation. Sandia also conducts full-scale demonstrations involving customer and utility assets.

Standardization

In partnership with major stakeholders, Sandia pursues standardization and implementation of best practices related to interconnection, interoperability, and safety of RE and DER. Sandia has been a major contributor to standards related to safety, interoperability, disturbance tolerance, and grid support functionality. Sandia's contributions span scientific basis, development of testing procedures, and standards harmonization across the industry. Sandia leads working groups under the International Smart Grid Action Network Smart Grid (ISGAN) International Research Facility Network (SIRFN), IEEE 1547, Smart Inverter Working Group, UL 1741, Smart Grid Interoperable Panel (SGIP), and multiple other collaborations.

STATE-OF-THE-ART FACILITIES

Sandia maintains integrated laboratory facilities that provide capabilities for real-world research and development of RE and DER technologies, including the Distributed Energy Technologies Laboratory (DETL), Secure and Scalable Microgrid (SSM) Testbed, Scaled Wind Farm Technology Facility (SWIFT), Control & Optimization of Networked Energy Technologies (CONET) Laboratory, Energy Storage Test Pad (ESTP), and Emulytics and Threat Analysis Laboratory. These facilities, combined with technical expertise in power electronics, cybersecurity, high performance computing, visualization, controls, and reliability science, provide a test platform to support advanced research and development on a wide variety of DER and RE technologies.

Distributed Energy Technologies Laboratory

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