NREL
NATIONAL RENEWABLE ENERGY LABORATORY

ENERGY SYSTEMS INTEGRATION

ESI optimizes the design and performance of electrical, thermal, fuel, and water pathways at all scales.

ADVANCING MICROGRID RESEARCH AT NREL

COMPETITIVE PROCUREMENT BOOSTS RESEARCH CAPABILITIES FOR NREL'S MICROGRID RESEARCH TESTBED

NREL expanded its microgrid research capabilities at the Energy System Integration Facility (ESIF) with the purchase of a Schweitzer Engineering Laboratories (SEL) microgrid controller, resulting in a more comprehensive microgrid research platform. NREL's microgrid research platform allows manufacturers, utilities, and integrators to develop and evaluate their technology or configuration at full power before implementation—something only possible at a handful of facilities in the world.

The SEL technology was selected for purchase after a rigorous 21-week dual-stage competitive procurement process, where ESIF engineers ran controllers from multiple vendors through several challenging power systems and cybersecurity performance evaluations.

NREL Engineer Przemyslaw Koralewicz and and SEL Engineer Scott Manson run evaluation tests on SEL's microgrid controller in the ESIF's Power Systems Integration Laboratory. *Photo courtesy of SEL*.

Evaluation & Selection

NREL evaluated the power systems functionality and cybersecurity of each company's controller. To assess power systems functionality, ESIF engineers ran the microgrid controller through a series of 100-minute test sequences in controller-hardware-in-the-loop (CHIL) and power-hardware-in-the-loop (PHIL) configurations. The test sequences included events such as generator faults, unintentional islanding, solar shading, and utility commands—demanding quick decisions and intelligent control strategies from the controller. NREL also evaluated each controller against a variety of cyber-related threats.

Controllers were evaluated against eight key performance parameters (KPP) to measure a range of functions from power quality and reliability to the use of renewable versus fossil fuel generation. Each KPP was assigned a price or cost factor and calculated into the final score.

The CHIL platform included a real-time digital simulator that modeled an urban-scale microgrid, which consisted of 4 megawatts (MW) of diesel, 3.5 MW of combined heat and power, a 5-MW photovoltaics (PV) plant, a 3-MW battery, and 14 MW of controllable loads using 50 protective relays. The PHIL platform included a real-world microgrid that consisted of a 250-kilowatt (kW) battery inverter, a 100-kW PV inverter, a 100-kW controllable load bank, and an 80-kW diesel generator, coupled to a grid simulator through a network-controlled microgrid switch. All power hardware interfaced with the microgrid controller, supplied by the vendors.

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The SEL controller was selected for its ability to most effectively transition between modes while preserving power quality for critical loads, using intelligent high-speed load shedding of interruptible and priority loads as necessary. The controller was built around the SEL powerMAX Power Management and Control System, and its software-defined networking technology was used to provide pre-engineered security and optimization of network traffic. SEL optimized fuel costs using renewables as much as possible and dispatching traditional generation near optimal fuel consumption. The company's strategic battery storage state of charge control and automatic synchronization capabilities helped demonstrate its ability to outperform all other controllers for advanced microgrid research at the ESIF.

Impact

This competitive procurement process provided NREL with a platform for comparative evaluation on controllers, leading to new insights that are being offered to the Institute for Electrical and Electronics Engineering with the hope to improve industry standards by including more advanced microgrid functionalities. Additionally, the 100-minute sequences that can run on a real-time simulator will be made publicly available on GitHub.com, providing utilities, academia, and hardware manufacturers with NREL's testing methodologies and microgrid model to simulate and evaluate their own microgrid systems.

Sharing this knowledge will help industry across the country to improve emerging microgrid technologies, boost deployment, and enhance grid resilience when disturbances occur. With the permanent installation of SEL's microgrid controller in the ESIF, NREL researchers and partners can more readily conduct research on the hardware, communications, and security performance of a microgrid--from small, local levels to those interfaced with utilities.

Funding for this pilot procurement program was provided by the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy's Technology-to-Market Program. Guidance and support came from the DOE Office of Electricity Delivery and Energy Reliability, and the DOE Grid Modernization Initiative. MIT Lincoln Laboratory transferred its Hardware-in-the-Loop Laboratory Testbed and Open Platform (HILLTOP) to NREL as the foundation for the ESIF microgrid test setup.

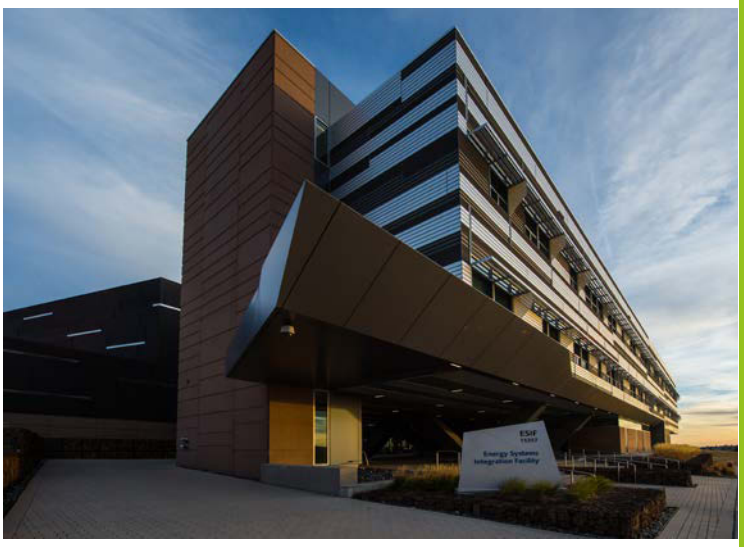

Photo by Dennis Schroeder, NREL 40870

The Energy Systems Integration Facility (ESIF) at the National Renewable Energy Laboratory (NREL) provides the R&D capabilities needed for private industry, academia, government, and public entities to collaborate on utility-scale solutions for integrating renewable energy and other efficiency technologies into our energy systems.

To learn more about the ESIF, visit: ***www.nrel.gov/esif***.

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