SPIDERS microgrid project secures military installations

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Bill Waugaman is the SPIDERS operational lead at Sandia National Laboratories. (Photo by Randy Montoya)

When the lights go out, most of us find flashlights, dig out board games and wait for the power to come back. But that's not an option for hospitals and military installations, where lives are on the line. Power outages can have disastrous consequences for such critical organizations, and it's especially unsettling that they rely on the nation's aging, fragile and fossil-fuel dependent grid.

A three-phase, $30 million, multi-agency project known as SPIDERS, or the Smart Power Infrastructure Demonstration for Energy Reliability and Security, is focused on lessening those risks by building smarter, more secure and robust microgrids that incorporate renewable energy sources.

Sandia was selected as the lead designer for SPIDERS, the first major project under a Memorandum of Understanding (MOU) signed by the Department of Energy (DOE) and the Department of Defense (DoD) to accelerate joint innovations in clean energy and national energy security. The effort builds on Sandia's decade of experience with microgrids – localized, closed-circuit grids that both generate and consume power – that can be run connected to or independent of the larger utility grid.

The goal for SPIDERS microgrid technology is to provide secure control of on-base generation.

"If there is a disruption to the commercial utility power grid, a secure microgrid can isolate from the grid and provide backup power to ensure continuity of mission-critical loads. The microgrid can allow time for the commercial utility to restore service and coordinate reconnection when service is stabilized," said Col. Nancy Grandy, oversight executive of the SPIDERS Joint Capability Technology Demonstration (JCTD). "This capability provides much-needed energy security for our vital military missions."

SPIDERS is addressing the challenge of tying intermittent clean energy sources such as solar and wind to a grid. "People run single diesel generators all the time to support buildings, but they don't run interconnected diesels with solar, hydrogen fuel cells and so on, as a significant energy source. It's not completely unheard of, but it's a real integration challenge," said Jason Stamp, Sandia's lead project engineer for SPIDERS.

Currently, when power is disrupted at a military base, individual buildings switch to backup diesel generators, but that approach has several limitations. Generators might fail to start, and if a building's backup power system doesn't start, there is no way to use power from another building's generator. Most generators are oversized for the load

and run at less-than-optimal capacity, and excess fuel is consumed. Furthermore, safety requirements state that all renewable energy sources on base must disconnect when off-site power is lost.

A smart, cybersecure microgrid addresses these issues by allowing renewable energy sources to stay connected and run in coordination with diesel generators, which can all be brought online as needed. Such a system would dramatically help the military increase power reliability, lessen its need for diesel fuel and reduce its "carbon bootprint."

"The military has indicated it wants to be protected against disruptions, to integrate renewable energy sources and to reduce petroleum demand," Stamp said. "SPIDERS is focused on accomplishing those tasks, and the end result is having better energy delivery for critical mission support, and that is important for every American."

SPIDERS uses existing, commercially available technologies for implementation, so the individual technologies are not novel. "What's novel is the system integration of the various technologies, and demonstrating them in an operational field environment. Microgrid concepts are still fairly new, and that's where Sandia's microgrid design expertise is coming into play," said Sandia researcher Bill Waugaman, SPIDERS operational lead.

It is common practice to connect diesel generators to buildings, but integrating significant amounts of energy from intermittent clean sources such as solar and wind to that system is unique, and it is a challenge that Sandia and SPIDERS are working to address.

Such integration requires data to determine the most efficient and effective way to operate, but that can open system vulnerabilities, so cybersecurity is paramount. SPIDERS addresses that issue by incorporating an unprecedented level of cybersecurity into the system

from the outset.

“Any perturbation of information flow by an adversary would possibly cause an interruption to electrical service, which can have significant consequences,” Stamp said. “It’s important that if we build a microgrid system that depends explicitly on greater information flow, that it operate as intended: reliably and securely.”

SPIDERS is funded and managed through the DoD’s JCTD, which joins the efforts of other government organizations and companies to rapidly develop, assess and transition needed capabilities to support DoD missions. With the DOE’s support, the SPIDERS transition plan includes civilian facilities.

“The SPIDERS approach has many applications beyond military uses. Our interest in SPIDERS extends to organizations, like hospitals, that are critical to our nation’s functionality, especially in times of emergency,” said Merrill Smith, DOE program manager.

Sandia’s microgrid expertise spans the past decade, beginning when Sandia designed microgrids for the DOE’s Federal Energy Management Program (FEMP) and the DOE’s Office of Electricity Delivery and Energy Reliability (OE). The DOE initially asked Sandia to develop a conceptual design for a microgrid at Fort Carson in Colorado Springs, Colo., and another for Camp H.M. Smith in Hawaii.

After Sandia conducted a feasibility analysis and modeling and simulation work for the two bases, U.S. Pacific Command (USPACOM) and U.S. Northern Command (USNORTHCOM) asked Sandia to prove the concept through field work under a JCTD. The two commands pulled together a team of national labs and defense organizations, and selected Sandia to lead the development of the initial designs for three separate microgrids, each more complex than the previous.

The Army Construction Engineering Research Laboratory will use the Sandia designs as a basis for developing contracts with potential system integrators, who will construct the actual microgrids. Other partners in the SPIDERS JCTD include National Renewable Energy Laboratory for renewable energy and electrical vehicle expertise, Pacific Northwest National Laboratory for testing and transition, Oak Ridge National Laboratory to assist with control system development and Idaho National Laboratory for cybersecurity.

The first SPIDERS microgrid will be implemented at Joint Base Pearl Harbor Hickam in Honolulu, and will take advantage of several existing generation assets, including a 146-kW photovoltaic solar power system, and up to 50 kW of wind power. The integrator for the project has been selected and the final design and construction process is underway.

The second installation, at Fort Carson, is much larger and more complex and will integrate an existing 2 MW of solar power, several large diesel generators and electric vehicles. Large-scale electrical energy storage will also be implemented to ensure microgrid stability and to reduce the effects of PV variability on the system. Camp H.M. Smith, the most ambitious project, will rely on solar and diesel generators to power the entire base, which will be its own self-sufficient 5 MW microgrid when the national grid is unavailable.

Integration and implementation are scheduled through 2014. The goal is to install the circuit level demonstration at Pearl Hickam and Fort Carson next year, with Camp Smith installed in 2013.

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