CASE STUDY
MICROGRID

S&C ELECTRIC COMPANY
Excellence Through Innovation

Mission-Critical Military Base Enhances Power Resiliency with S&C's Microgrid Control System

S&C Featured Solution: GridMaster® Microgrid Control System, Microgrid EPC

Location: Fort Belvoir, Virginia

Customer Challenge

Federal power systems support critical missions at the forefront of national defense operations. With the weight of national security on the line, truly resilient power is essential for federal entities. Because power grids have aging infrastructure and are becoming a prime target of foreign actors, physical damage and cyberattacks have the potential to shutter the grid and cause unprecedented consequences.

For these reasons, the Department of Defense's (DoD's) Environmental Security Technology Certification Program (ESTCP) funded research to demonstrate the viability of implemented cybersecure microgrids at military installations. The project objective was to create a cybersecure microgrid that would reduce operational costs and sustain critical missions, vetting it as a reliable and resilient solution for military operations and as a replicable model for future DoD installations.

Because of the increasing vulnerability of power delivery, the microgrid had to include the ability to island from the electrical grid for five days and maintain the islanded grid during times of peak demand. Acknowledging the cyber-vulnerabilities of simplistic microgrid control technologies, such as Programmable Logic Controllers (PLCs), the DoD sought a control technology containing inherent cybersecurity protection.

In addition to energy security, S&C sought to demonstrate a cost-effective way to deploy a microgrid without accumulating substantial capital costs. To do this, existing base assets were incorporated into the microgrid at U.S. Army Base Fort Belvoir, located in Fairfax County, Virginia. These existing assets included three fixed natural gas generators (205-kW, 325-kW, and 375-kW) and four 400-kW mobile diesel generators. The mobile generators are traditionally used for emergency response but sit idle much of the year. The intent of integrating the mobile assets was to validate that these temporarily available assets can be used to support a microgrid in spot scenarios. S&C also designed the system to include seamless entry and re-entry into the microgrid, so the mobile assets could be ready for deployment at a moment's notice.

"S&C's demonstration of their GridMaster control system has provided DOD with a real-world example of how microgrids can be implemented by leveraging existing energy assets and integrating with legacy systems. Demonstrations like this help inform installation staff, mission owners, and other DoD stakeholders about how these systems work and the energy security and resiliency benefits they provide."

– Tim Tetreault,
Installation Energy and Water Program Manager
OSD ESTCP

The S&C-developed microgrid at Fort Belvoir serves as a model for future power systems at mission-critical military bases.

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The Army base at Fort Belvoir, Virginia.

S&C Solution

To achieve the project's goals, ESTCP knew successfully deploying a resilient system required skillfully navigating such factors as upfront capital costs, cybersecurity threats, and integration risks. IPERC, a subsidiary of S&C, was one of the project contenders because IPERC had deployed mission-critical microgrids at a variety of U.S. military bases. In addition to IPERC's microgrid-deployment track record, IPERC was the first microgrid provider to receive an Authorization to Operate (ATO) from the DoD. While an ATO applies to the specific implementation, elements of the approval unique to the GridMaster microgrid controller can be applied to future projects for use at other DoD installations. This status greatly streamlines the process for determining whether a control system is effective and secure enough for use in a federal microgrid.

After a competitive selection process, ESTCP chose IPERC, which was acquired by S&C during the project, to provide the control system and Engineering, Procurement, and Construction (EPC) services for the microgrid in conjunction with Fort Belvoir. IPERC participated in one of 10 ESTCP projects selected to demonstrate various aspects of cybersecure military energy infrastructure.

S&C began by strategizing how to integrate the base's existing generation assets into the microgrid and facilitating the microgrid's utility interconnection. S&C needed to integrate a 2.5-MW microgrid containing two existing diesel and natural gas generators with a secure connection to the local utility. These generation sources would power 13 Fort Belvoir buildings of significant or critical status, ensuring resiliency during islanding events.

Key to ensuring the microgrid would operate properly, S&C incorporated its GridMaster Microgrid Control System, a distributed control system that provides automated, intelligent decision-making coupled with embedded cybersecurity protection. The control system directs every microgrid asset, seamlessly balancing and optimizing the system. It is also built from the ground up with seven layers of cybersecurity protection, including defense-in-depth measures such as whitelisting, encryption, and authentication.

During the design phase, the team also identified the importance of conducting regular O&M services on the generation assets. Because the base's generators had not been frequently used over the years, the generators' control systems were outdated. S&C's engineers upgraded the

generator control systems with new models that have network connectivity and external communication capabilities, allowing these existing devices to be successfully integrated into the microgrid. S&C engineers also added low-voltage contactors to bypass the generators' existing automatic transfer switches.

In addition to integrating the control system with existing assets, the engineering team coordinated with the local utility to deploy new reclosers to ensure they were properly placed for sectionalizing, which enables the microgrid to properly isolate itself in black-start conditions.

The black start capabilities, a key application of the microgrid, trigger a methodical restoration of power to avoid overloading the generation sources. The microgrid control system monitors utility power supply and automatically triggers islanding when it senses utility voltage is lost because of an unexpected outage.

When the microgrid operates in Island mode, the controller continuously monitors the status of the microgrid's generation assets, scanning for any unexpected contingencies that may affect the microgrid's ability to remain islanded. The microgrid's capabilities also include the automatic dispatch of the generators, curtailing generation based on measured demand, prioritized load-shedding, and handling advanced contingencies.

Prior to energizing the microgrid, the S&C cybersecurity team carefully evaluated all available security measures and selected those that optimally ensure security without placing an undue operational risk on the system. It was paramount to address key areas of risk without introducing new risks caused by added complexity.

The microgrid was integrated within the existing base closed-restricted network, and these thorough evaluations confirmed the microgrid met cybersecurity standards, including the Risk Management Framework (RMF), National Institute of Standards and Technology Special Projects (NIST SP) 800-53 and 800-82, and North American Electric Reliability Corporation Critical Infrastructure Protection (NERC-CIP).

Testing and commissioning of a mobile generator integrated into the microgrid at Fort Belvoir.

Monitoring the mobile generators during microgrid operations.

Results

The ESTCP project culminated in two microgrid tests spanning several days. During the preliminary extended test period, the microgrid successfully islanded from grid power and demonstrated all critical operational objectives.

During the second extended test period, the GridMaster Microgrid Control System responded flawlessly to an unforeseen contingency event when a generator dropped because of an unusually large load swing. S&C's microgrid control system was able to handle this unexpected contingency and reform the microgrid without a loss of power, ensuring reliable power for the mission-critical loads.

Overall, S&C demonstrated that existing generation assets, including mobile, can be successfully integrated into a microgrid. Incorporating the base infrastructure greatly reduced the total cost of the installation. In addition, the base's mobile diesel generator maintains the capability to be applied for other missions beyond the microgrid at Fort Belvoir.

Including mobile generation within a microgrid is a novel concept that has prompted installations to assess their ability to integrate existing mobile assets. Because microgrids typically only contain fixed assets, S&C has pushed the boundaries concerning asset types that can be encompassed within a microgrid.

Because of the success of the extended tests, the microgrid at Fort Belvoir sets the stage for supporting 14-day resiliency requirements, which is the DoD's commitment to reduce risk for critical missions by enabling power systems to provide energy for a minimum of 14 days. By choosing S&C to develop the microgrid, Fort Belvoir has provided a model for future power systems to deliver resilient power for mission-critical operations on more military bases.