



# S&C Engineers Overcome Real-World Challenges Constructing a Groundbreaking Microgrid

**S&C Featured Solution:** Microgrid Engineering Support

**Location:** Lancaster, Texas

## Customer Challenge

At its System Operations Services Facility in Lancaster, Texas, Oncor wanted to construct a sophisticated microgrid capable of showcasing the latest advancements in energy storage and smart grid technology. Within this approximately 1-MW microgrid, Oncor wanted the system to incorporate a variety of distributed generation sources ranging from a propane-fueled microturbine to photovoltaic (PV) solar arrays and battery energy storage. Equally important, Oncor wanted the microgrid to have manual and autonomous control capable of advanced functionality, including self-healing, islanding, and load balancing. To complicate the task at hand, Oncor had an ambitious timeline for project completion.

## S&C Solution

Oncor needed a project partner well versed in distribution automation, communication, and electrical-system protection and control. Oncor chose to partner with S&C Electric Company because of its extensive expertise in these fields.

Oncor's initial vision for the microgrid was to implement an entirely greenfield system. However, to ensure the solution was consistent with Oncor's budget, S&C proposed to construct a mixed brownfield and greenfield microgrid. This would require engineers to make a previously established electrical infrastructure and repurposed generation equipment function harmoniously with modern generation, switching, and protection equipment. This ultimately would create additional challenges around maintaining proper voltage and frequency references among multiple generation sources, automatic islanding, live-site testing, and working within existing protection schemes.

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*"In order to test 21<sup>st</sup> century grid innovation for its customers, Oncor partnered with S&C to deliver engineering expertise and state-of-the-art equipment to build and operate the most advanced microgrid in North America."*

*—Michael Quinn  
Vice President and CTO, Oncor*

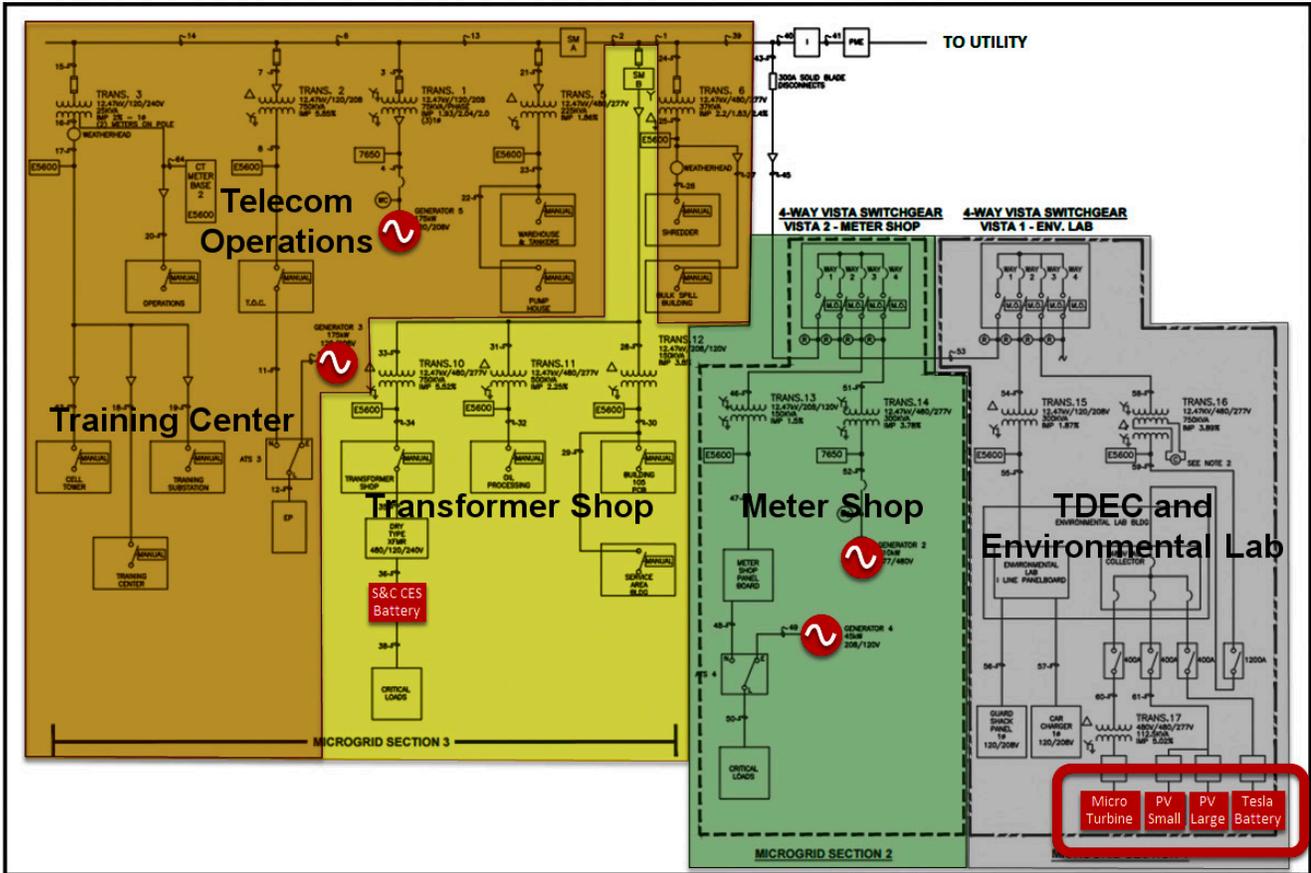
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Upon project commencement, S&C's first task was to assess the site's various distributed generation assets and evaluate how to achieve the desired microgrid functionality. The system design required new generation sources, including PV solar arrays, a propane-fueled microturbine, and battery energy-storage systems, to function with existing onsite generation assets that included repurposed emergency generators from the 1980s. S&C quickly concluded that automatic islanding—one of the main functions of the microgrid—would be a particularly difficult challenge with such a wide variety of distributed generation sources.

When a microgrid islands from the utility grid, the system loses its voltage and frequency reference. A new reference needs to be established if an islanded system is to have multiple distributed generation sources operating within the same electrical system. At the Oncor Microgrid, S&C Engineers devised several ways to establish this new reference during islanding. The method of establishing a new reference depended upon the system's current operating mode. Different operating scenarios were required because of the system's ever-changing generation capacity and load demand.

*S&C was faced with integrating 30-year-old repurposed diesel generation equipment into a state-of-the-art microgrid.*

Oncor Facility's Microgrid Operations



A colorized schematic view of the system's four smaller microgrids.

Under the first islanding mode, the system was designed to dispatch battery energy storage to establish the new voltage and frequency reference. Once that reference was established, PV solar generation was initiated by following that reference. The system would operate in this mode as long as generation met demand. If not, the system would

switch to a second mode where a propane-fueled microturbine would be dispatched to further support the campus load.

If a scenario arose where the battery energy storage, PV solar, and propane-fueled microturbine could not support the load, the system would operate under an additional scenario where existing diesel distributed generation would be dispatched. Unfortunately, designing this last operating mode was particularly challenging. All of the facility's diesel distributed generation sources could not operate together within the same electrical system because of control limitations and their various pitches. The difference in pitch between each generator meant the harmonic content of the output of each generator would be different. Operating in this manner would lead to considerable power quality issues.



Existing emergency generation equipment at the Oncor facility's site.

To effectively use the existing diesel generators and avoid installing new generation sources for this mode, S&C's design incorporated them by

dividing the microgrid into four smaller microgrids, or operating zones. With four separate zones, generation sources that could not be paralleled could operate independently. Additionally, the zones double as a method to effectively balance the generation sources with the load across campus.

Within the four-zone system, two zones were designed to contain the repurposed diesel generators, one zone to contain a community-scale battery energy storage system, and the fourth to contain the two solar arrays, battery energy storage, and the propane-fueled microturbine. This fourth zone had additional design requirements because of its multiple inverter-based generation sources. When in island mode, this zone requires a ground reference for the inverter-based generation sources to function properly. To overcome this challenge, S&C proposed the unique

idea of installing a custom grounding transformer. The transformer, specified by S&C, operates with a ground reference from the utility source when grid-connected and provides the microgrid power system and generation assets with a ground reference when disconnected from the electric grid. Ultimately, this ingenuity helped ensure the four-zone microgrid could be constructed with a total of nine distributed generation sources.

Once S&C engineers settled on the design of the four separate zones, they tackled the next challenge of devising a way to sectionalize the microgrid during the required operating modes. S&C's solution was to deploy advanced switching and protection equipment at strategic locations within the system. An overhead 12.47-kV distribution line is the single point of service for the entire site. At this location, engineers chose



**Crews install S&C Vista® Underground Distribution Switchgear.**

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S&C's IntelliRupter® PulseCloser® Fault Interrupter to provide the advanced switching and sensing requirements. The IntelliRupter fault interrupter detects a voltage loss on one or more phases and quickly isolates the microgrid to perform islanding. When the source is suitable for reconnection, the IntelliRupter fault interrupter detects this state and quickly reconnects to the grid.

Downstream from the IntelliRupter fault interrupter and serving the four microgrid zones, engineers deployed S&C's Scada-Mate® Switching System on the overhead lines and used S&C Vista® Underground Distribution Switchgear on the underground system. Collectively, this equipment not only provided the desired isolating and sectionalizing functionality, but it also enabled the distribution network to have automatic fault-isolation and circuit-restoration capabilities. The equipment also served as the backbone of the microgrid's load-balancing scheme.

S&C also addressed issues related to the site's existing electrical-protection scheme. When connected to the electric grid, the available fault current at a particular location within the microgrid depends heavily on the utility grid and is typically a stable, strong source. However, when islanded, the magnitude of the available fault current on site is substantially reduced because of limited onsite generation. As a result, the microgrid required a protection scheme that would operate expediently and securely across both grid-connected and islanded operations. However, like many electrical systems today, the facility's electrical infrastructure had traditional overcurrent-protection devices, such as current-limiting fuses, instead of dynamic protection equipment.

S&C responded by installing eight protective relays on the Vista Switchgear. Fiber-optic and copper Ethernet cables were installed between these relays for communications. This enabled the microgrid to alter its protection scheme according to the current operating mode. Via peer-to-peer communication, the relays use IEC 61850 Generic Object Oriented Substation Events (GOOSE) messaging to perform collective decision protection. This provides a secure and reliable way to implement a dynamic protection system. With this solution, it can appropriately protect itself regardless of whether the microgrid is grid-tied or islanded.

### Results

Microgrids are rarely constructed from a blank canvas, and customers seldom have the budget or timetable to construct a microgrid from the ground up. For the Oncor microgrid, S&C's engineering team used creative engineering to design around the limitations of an existing electrical infrastructure and 30-year-old generation equipment. This ingenuity ultimately helped to ensure the project timeline, delivery of the technology showcase, and that the desired microgrid functionality were all achieved. The Oncor project clearly illustrates that, with the right expertise, a state-of-the-art microgrid can be constructed even when faced with tough challenges.



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Excellence Through Innovation