CASE STUDY

Duke Energy Corporation—Charlotte, North Carolina

Duke Energy Builds Microgrid Control System With Standard Power System Components

Charlotte, NC—Duke Energy Corporation is an energy utility that serves 7.4 million electric customers in six states in the Southeast and Midwest regions of the United States. Prompted by recurring severe weather events and a goal of incorporating more renewable generation into the electric power grid, Duke Energy decided to integrate their existing renewable resources into a microgrid at their McAlpine Creek Substation.

Duke Energy's key requirement for the proposed microgrid was that it use standard Duke Energy distribution equipment and off-the-shelf components as opposed to specialized devices. Using standard off-the-shelf components for the microgrid allows for more integrated support from the distribution organization. It also allows Duke Energy to develop a model from the lessons learned at McAlpine Creek Substation that can be implemented at future microgrid installations.

The area just outside the McAlpine Creek Substation fence houses a 50 kW photovoltaic (PV) installation as well as a 240 kW, 500 kWh battery energy storage system (BESS). These two systems are connected in parallel to import and export energy. The microgrid was proposed in this area to add resiliency for customers as well as provide economic benefits to Duke Energy and to the owner of the PV installation and the BESS.

Charlotte Fire Department Station 24 (FS24) is located adjacent to and is served by the McAlpine Creek Substation. Intrigued by Duke Energy's energy ideas, FS24 agreed to participate in a proof-of-concept microgrid project that they felt would be mutually beneficial. The ability of the PV installation and the BESS to ensure reliable and resilient power even in extreme weather events, which usually cause prolonged grid outages, was important to FS24 because their critical services are most required during those times. Along with serving the critical load of the fire station, Duke Energy wanted to demonstrate that a utility-owned microgrid could provide other distribution system benefits:

- Frequency regulation
- Circuit voltage support (VAR dispatch)
- Demand response through islanding
- Mitigation of solar intermittency at the source

Planning

One of Duke Energy's first steps was to create a technical advisory group with representatives from the company's numerous working groups and divisions to be involved in rolling out the microgrid. Creating the technical advisory group ensured that best practices would be shared with everyone involved and that all stakeholders had a seat at the "concept" table.

This facilitated company-wide cooperation and buy-in. Because all of Duke Energy's business units had SEL equipment installed and were already comfortable using SEL technology, it was easy to decide to go "all blue" and design an SEL-based microgrid control solution.

A defining characteristic of any microgrid is its ability to island. Duke Energy decided to make the SEL-651R Advanced Recloser Control and SEL Real-Time Automation Controller (RTAC) the two key components of their microgrid control and protection scheme. By using the advanced built-in capabilities of the SEL-651R, Duke Energy was able to easily incorporate features such as an automatic synchronization check that interfaces at the point of common coupling (PCC) between the microgrid and the bulk electric power system. Synchronization was key because it played an important role when defining the microgrid's control and operating scenarios.

The RTAC's modular software allowed Duke Energy to easily develop a mix of ladder, function-block, and text programming languages. This user-friendly flexibility meant that the team could easily adapt the microgrid control based on lessons learned as they tested their microgrid. Because this microgrid was a brownfield installation with existing equipment, it was important to integrate robust components that could handle multiple communications protocols and other design features to facilitate integration with legacy components. The RTAC provided this key functionality.

Collaboration

Duke Energy collaborated with SEL to incorporate sophisticated protection algorithms into the SEL-651R to take advantage of its built-in synchronization functions. As part of the process, they defined three control modes for the microgrid:

- Mode 1 – automatic mode with manual resynchronization
- Mode 2 – automatic mode with automatic resynchronization
- Mode 3 – manual mode

The collaboration extended to many other phases and components of the microgrid project, including layering the RTAC as a

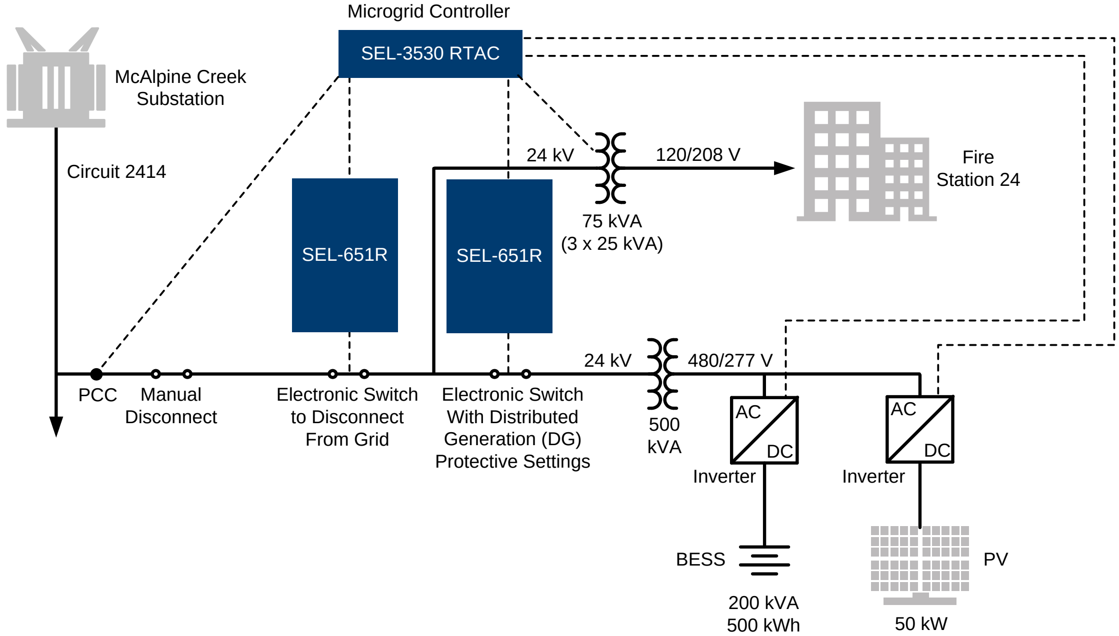

Figure 1 One-Line Diagram of the Microgrid

supervisory control and data acquisition (SCADA) system and creating an intuitive human-machine interface (HMI) for operators. This helped the team define the main operating modes of the microgrid:

- Grid outage
- Automatic resynchronization
- Manual resynchronization
- Manual islanding

The Duke Energy microgrid, shown in Figure 1, has been in service since July 2015. Since then, the microgrid has been providing peak shaving and a resilient energy supply, benefiting end users as well as the utility. It has operated manually under operator supervision and also automatically during outages and disturbances. Because they can seamlessly island and resynchronize automatically during extreme weather events, FS24 can rely on available power to maintain their mission-critical services for the community.

Success

By collaborating with SEL and using standard, off-the-shelf utility control equipment, Duke Energy was able to develop a process for building microgrids. The microgrids that are the output of this process operate more reliably and more economically than traditional solutions because they use affordable, proven, utility-grade off-the-shelf components. Plus, they are simpler to implement and maintain for the distribution utility than a microgrid that has not gone through this kind of process.

Duke Energy is now uniquely positioned to develop long-term plans to incorporate microgrids into their network, potentially defer transmission and distribution capital expenditures, and scale this type of design into larger microgrids with more distributed energy resources based on lessons learned.

# # #

Company Bio

Duke Energy Corporation is one of the largest electric power holding companies in the United States and is headquartered in Charlotte, North Carolina. Its Regulated Utilities business unit serves 7.4 million retail electric customers in six states in the Southeast and Midwest regions of the United States, representing a population of approximately 24 million people. Duke Energy is a Fortune 125 company. More information about the company is available at http://duke-energy.com.

About SEL

Schweitzer Engineering Laboratories, Inc. (SEL) has been making electric power safer, more reliable, and more economical since 1984. This ISO 9001:2000-certified company serves the electric power industry worldwide through the design, manufacture, supply, and support of products and services for power system protection, control, and monitoring. For more information, please contact SEL at 2350 NE Hopkins Court, Pullman, WA 99163-5603; phone: +1.509.332.1890; fax: +1.509.332.7990; email: info@selinc.com; website: http://selinc.com.

SCHWEITZER ENGINEERING LABORATORIES, INC.
2350 NE Hopkins Court • Pullman, WA 99163-5603 USA
Tel: +1.509.332.1890 • Fax: +1.509.332.7990
www.selinc.com • www.selindustrial.com
Email: marketing@selindustrial.com

LCS0035