SMART ENERGY CONSUMER COLLABORATIVE

A Testbed for the Distributed Energy Future

PROGRAM AT A GLANCE

Ameren Illinois developed one of the nation's first utility-scale microgrids at its Technology Applications Center as a testbed facility to prepare for the changes coming in the energy ecosystem, including new consumer expectations and an influx of distributed energy resources.

RESULTS SO FAR

In the original distributed energy resource integration plan for the testbed facility, there were 16 total use cases developed. Several of these have already been completed; however, Ameren Illinois plans to complete the remainder in the coming years.

About Ameren Illinois

Ameren Illinois, a subsidiary of St. Louis-based Ameren Corporation, is a regulated electric and gas delivery company located in Collinsville, Illinois. As a delivery-only company, Ameren Illinois is in the business of energy distribution. All customers can choose their electric supplier, and non-residential customers can choose their gas supplier.

Ameren Illinois delivers electricity to 1.2 million electric and 816,000 natural gas customers across 43,700 square miles in central and southern Illinois, roughly three-quarters of the state. Their complex delivery system includes about 4,500 miles of electric transmission lines, 46,000 miles of distribution lines, 18,200 miles of natural gas transmission and distribution mains and 12 underground natural gas storage fields with a total capacity of approximately 25 billion cubic feet.

Landmark Legislation Boosts Grid Modernization in Illinois

In 2011, the Illinois legislature passed the landmark Energy Infrastructure Modernization Act (also known as the "smart grid bill"), which accelerated investments in grid modernization in the state. The bill enabled the state's electricity providers to invest billions of dollars into the power grid. It developed a progressive, accountability-based regulatory model and provided funds to engage low-income consumers in energy-saving programs, among many other provisions.

For Ameren Illinois specifically, the legislation allowed the investment of an additional $643 million into their systems over a 10-year period. These grid modernization efforts began in 2012 and involved thousands of infrastructure improvements, including many smart grid enablement projects.

These smart grid upgrades included the installation of distribution automation equipment, the deployment of Advanced Metering Infrastructure and development of a smart grid testbed facility. The facility, called the Technology Applications Center (TAC), provides an on-grid testing infrastructure for companies to test new smart grid technologies. It also allows for the thorough study of systems and products that Ameren Illinois may want to deploy on their own systems at some point in the future.

New Consumer Expectations Necessitate Utility Changes

The development of the Technology Applications Center was guided by Ameren Illinois' vision of the customer-driven grid of the future. The traditional approach to energy distribution has been to deliver electricity from centralized sources with power flowing in one direction. But with the introduction of distributed energy resources (DERs), like wind, solar and biomass generators, the grid is evolving and needs to support electric energy flowing in two directions.

These changes in the power grid are being driven in large part by customer demand. To adequately prepare and plan for the grid of the future, Ameren Illinois conducted extensive customer research on what individuals and businesses actually want from the future power grid.

These investigations confirmed a number of the major trends that the industry has been witnessing in the past several years. Some residential customers today are already adopting distributed energy resources, and more are interested in potentially moving from just being consumers of electricity to being "prosumers" (users and producers of electricity).

In the commercial and industrial sectors, some customers whose businesses require exceptional levels of reliability and power quality are looking for ways to further improve reliability and resiliency and avoid even momentary outages. Some manufacturers, for example, need to shut down and restart their processes for even a momentary fluctuation in voltage. These customers are looking to microgrids — distributed energy resources integrated to provide continuous power even when there is a grid outage — as a possible solution for improving electricity quality.

Further, many communities are interested in pursuing distributed energy projects, like community solar or a small wind farm, to provide environmental and economic benefits to residents. Price reductions in such systems over the past few years have made these systems more attainable and have amplified community interest.

Together, these customer interests point to an evolved energy ecosystem of the future, where power is no longer being generated and delivered from one central location.

Investigating Potential Changes to the Distribution System

To address all of these changes in customer expectations and to prepare the grid for an increase in distributed energy resources, a team within Ameren Illinois began developing a plan to install distributed energy resources — and associated control, communication and switching systems — at the Technology Applications Center. The goal of the facility would be to test new concepts for the integration of distributed energy resources and prepare for changes in the distribution system.

The plan investigated a number of areas related to DER integration and microgrids, including:

- The design, control and operation of distributed energy resources;
- The resiliency and reliability improvements that microgrids could provide customers;
- The interoperability, islanding, ancillary services and voltage control aspects of microgrids;
- And the demand response and energy choice concepts that distributed energy resources and microgrids could offer customers.

With a distributed energy resource integration infrastructure, Ameren Illinois would seek to understand both individual DER characteristics as well as how integrated distributed energy systems would affect the electric distribution system of the future.

An additional benefit of the DER infrastructure was the ability to improve employees' technical and operational knowledge of these systems. By providing employee training at the testbed facility, Ameren Illinois employees would already have practical knowledge of these new technologies if they were deployed to the main distribution grid.

Developing One of the First Utility-Scale Microgrids

The team that developed the distributed energy resource integration infrastructure plan had a few fundamental design concepts for the project. The first was that the infrastructure had to operate at the normal, utility-scale voltage (12,000 volts). The team also wanted to have as many different types of DERs in the infrastructure as possible, so that they could maximize the research opportunities and plan for potential future scenarios. The infrastructure had to be able to island and operate as a microgrid and independently serve customers on a connected circuit. Finally, the microgrid needed to switch seamlessly between grid and islanded operation modes so customers did not experience an outage. With these goals in mind, a final plan was approved for construction in March 2016.

Ameren Illinois made history as the first microgrid in the United States capable of seamlessly transitioning the power source for an entire distribution circuit from exclusively distributed energy resources to the traditional grid.

In the ensuing months, Ameren Illinois successfully designed and constructed the distributed energy resource integration infrastructure with utility-scale microgrid capability adjacent to the University of Illinois campus in Champaign, Illinois. Construction was completed in December 2016, followed by testing in the first quarter of 2017.

When the microgrid capabilities were tested and confirmed in May 2017, it made history as the first microgrid in the United States capable of seamlessly transitioning the power source for an entire distribution circuit from exclusively distributed energy resources to the traditional grid. The completed microgrid was capable of delivering up to one megawatt of residential load to customers on an actual distribution circuit without experiencing an outage using the following onsite generation assets:

- Northern Power Systems Wind Turbine – 100 kW
- Yingli Solar Array – 125 kW
- Caterpillar Natural Gas Generator – 1,000 kW
- S&C Electric Co. Battery Storage – 250 kW, two-hour lithium-ion battery

In August 2017, Ameren Illinois reached another milestone when it successfully demonstrated the microgrid's ability to seamlessly switch between grid and islanded operations. For 24 hours, the microgrid functioned exclusively on renewable energy, and when generation produced from wind and solar exceeded the facility's need for power, the excess power was used to charge the battery. The test successfully demonstrated that the microgrid can automatically coordinate resources and ensure power does not falter even without any human interaction.

Looking at What's Next

Although the distributed energy resource integration infrastructure has already proven to be highly useful for research, Ameren Illinois plans to continue to look at ways to improve technology at the facility and its potential customer applications. In the original distributed energy resource integration plan, there were 16 total use cases developed. Five of these have been successfully completed to date, leaving 11 remaining for Ameren Illinois to complete in the coming years.

Ameren Illinois is also exploring other microgrid control vendors to see if there are opportunities to improve these technologies at the testbed facility, and the utility plans to execute larger demand response testing through interaction with building management systems. The infrastructure can also test third-party solutions to see howthey integrate with the microgrid.