# Renovating the Grid and Revitalizing a Neighborhood

Successes from Kansas City Power & Light's Smart Grid Demonstration Project

## Introduction

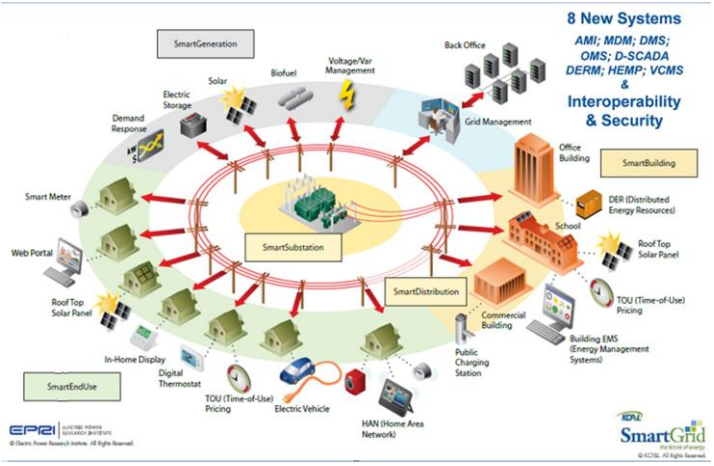
At its best, the smart grid interweaves diverse technologies to form a seamless whole, like a tightly woven piece of cloth. As the grid modernizes, Kansas City Power & Light (KCP&L) is using its Smart Grid Demonstration Project to show how distribution systems such as advanced metering infrastructure, distribution management, outage management, and supervisory control and data acquisition (SCADA) can interoperate to improve reliability and cost of service.

The project, called the Green Impact Zone SmartGrid Demonstration, was awarded nearly $24 million in American Recovery and Reinvestment Act funds, for a total project value of $49.8 million, to demonstrate, test, and assess the feasibility of integrating new and existing technologies in an end-to-end smart grid. KCP&L deployed smart grid technologies across a 5-square-mile area of Kansas City, Mo., serving 13,427 customers. Several major aspects of the project included the modernization of a distribution substation, the implementation of several new systems to prevent and shorten outages, and the installation of devices in customers' homes to help them control their energy use. (*See Figure 1.*)

## Enhanced Substation

At the heart of the project was an aging distribution substation. KCP&L has retrofitted it, and it is now up and running with an International Electrotechnical Commission (IEC) 61850 network operating in parallel with the existing, hardwired infrastructure. IEC 61850 was created to provide faster protection communications and more verbose device data than Distributed Network Protocol 3.0, its state-of-the-art cousin. The utility has already seen an improvement in operational awareness due to IEC 61850. Because IEC 61850 supplements, but does not replace, the substation's legacy equipment, KCP&L can still turn IEC 61850 on and off as needed. According to Ed Hedges, KCP&L manager of smart grid technology planning and project principal investigator, "the legacy system does most of the control on a day-to-day basis, but IEC 61850 handles all of the monitoring and reporting."

*Figure 1.* The devices and systems KCP&L deployed could be found in a substation, in customers' homes, and everywhere in between. This case study focuses on the substation KCP&L retrofitted, the smart meters it deployed, and the web portal it launched. *Image courtesy of KCP&L.*



To exploit IEC 61850, KCP&L installed an interface that acts as "a distribution SCADA system within the substation," Hedges says. Previously, operators monitored only five or six points on the substation's breaker relays. Now they monitor close to 100, not only to determine the relays' status in real time but also to keep track of their operational characteristics and better plan operations support and maintenance. The interface includes a workstation that lets operators see, at a glance, the status of equipment throughout the substation. "Historically, they would have to walk to each breaker to see where the load was," Hedges says. "Now they can see that from one location." Another benefit: operators can use the workstation to open or close a breaker remotely, rather than having to do so in person. "There's a safety factor involved there," Hedges says.

"We were lucky to get 25 percent of the outages reported. Now we're seeing 90 percent of the outages coming in."

## SmartGrid Innovation Park

The newly constructed SmartGrid Innovation Park, adjacent to the substation, also involves increased security. The fenced-in park encompasses a ground-mount solar array; a 1-MW, 1-MWh battery in a 60-foot-long enclosure; and an inverter inside a 30-foot-long enclosure, in Hedges' words, "both enclosures resemble railway shipping containers." The battery, an Exergonix lithium polymer battery, is tied into the grid, and it let KCP&L test how energy storage systems can shave peak load on a circuit, enable volt/VAR control, and support circuit islanding. The solar panels contribute power to a 12-by-30-foot control building (also on Innovation Park grounds) that houses all of the control servers and electronics that keep the substation running.

"We also used [the Innovation Park] to evaluate a lot of the cybersecurity and physical-security standards that would be needed in the future," Hedges says. These standards include video surveillance, laser tripwire alarms, and cybersecurity firewalls. "We actually deployed those in the Innovation Park facility, which allowed us to evaluate them without imposing those security requirements on our production crews and our substation."

Although the Innovation Park is highly secure, visitors are still welcome to tour it. Educational kiosks show visitors what happens inside the substation without subjecting anyone to the safety risks associated with entering the substation itself. "People can see the [interface] at the substation," Hedges says. "They can see the distribution management system view of things, and we can explain how the technology works without going into our active substation."

Visitors can also get an up-close look at the solar array and enclosures for the battery and inverter.

But opening the Innovation Park to the public is not the only way that KCP&L's project has directly affected residents of Kansas City.

## Advanced Metering Infrastructure

Because the automated meter reading (AMR) system was aging and failures were increasing, it was economical and effective to replace the AMR infrastructure with advanced metering infrastructure (AMI). The 13,000 Landis+Gyr meters that KCP&L deployed have already confirmed that AMI technology can save money for electric utilities. They give KCP&L usage data every 15 minutes — instead of once a day, as the AMR meters had — and they support time-of-use pricing. They enable remote connects and disconnects and dramatically improve power-outage and power-restoration notifications. The daily read performance has been above 99%, two percentage points better than the previous AMR meters. The data coverage from properly functioning meters is 99.96%, indicating that the system

performance will improve further as malfunctioning meters are replaced.

"When we'd have an outage with AMR, we were lucky to get 25 percent of the outages reported," Hedges says. "Now we're seeing 90 percent of the outages coming in, and more than 95 percent of the restoration messages are getting through. So it will help improve our outage processing capabilities."

Due to the improvement in outage management, 5,206 truck rolls were avoided during the testing period, saving an estimated $104,120.

AMI is also compatible with KCP&L's SmartGrid meter data management (MDM) system. The eMeter EnergyIP MDM system acts as a single system for collecting AMI meter data, as well as data from meters in rural areas, which are still read manually. Currently, those two data sets reside on different systems. AMI also supports KCP&L's SmartGrid outage management system (OMS), made by Intergraph. The OMS can analyze outage notifications from KCP&L's customer information system and integrated voice response, as well as from AMI, and it considers input from SCADA systems. The upshot: proactive monitoring for potential problems on the grid, and more precise pinpointing of faults.

## Outage Management System improves reliability

Outages can be eliminated or shortened in duration by equipment on the distribution system, named Fault Isolation and Service Restoration (FISR). KCP&L efforts with AMI and FISR implemented on the 11 circuits serving 13,427 customers had dramatic effects on reliability indices, as Table 1 indicates.

| Testing Period | Normal | With FISR | Percent Improvement |
|---|---|---|---|
| SAIFI | 3.253 | 1.5813 | 51.4% |
| SAIDI | 403.3 | 262.1 | 35.0% |
| CAIDI | 124.0 | 165.8 | (33.7%) |

Table 1 Reliability Indices

Because the FISR eliminated more of the short outages, CAIDI went up 33.7%, as FISR reduced the frequency of outages by 51.4%. AMI also can impact outages, as the meters communicate with the meter data management (MDM) station, which then sends messages to the Outage Management System (OMS). According to Mr. Hedges, "The new OMS and AMI are operational. The outage handling flows are more streamlined and efficient than they were with the legacy AMR data."

*Figure 2.* KCP&L routinely interacted with customers from within the Green Impact Zone, an area of Kansas City, Mo., to increase adoption and understanding of the SmartGrid project. Current economic conditions are reflected by high rates of property abandonment and unemployment. *Image courtesy of KCP&L.*

## Green Impact Zone

The project was carried out within the Green Impact Zone, an area of Kansas City that U.S. Rep. Emanuel Cleaver II, D-Kansas City, has targeted for revitalization. Because residents in the zone tend to occupy lower socioeconomic brackets than other city

residents, decreasing their electricity bills is especially significant. That's what KCP&L strove for by launching an online home energy management portal: 2,000 customers with active portal accounts can see how much electricity they are using and get suggestions for using less. Each day, the portal predicts what customers' bills would be if their electricity consumption held steady until the end of the billing period.

"When you really talk to some of the customers, you find out that some of the biggest value they got was from that daily bill true-up message [on the portal]," Hedges says.

KCP&L also gave more than 1,100 customers in-home displays to monitor and track energy use. Other customers received direct load control devices and home area networks (132 and 61 customers, respectively), but if early indications are correct, customers find the portal the most beneficial.

"Although you can use an in home display to see how much energy home appliances use, the customers didn't get that much value from them," Hedges says. "They got value out of, 'Hey, this is what my bill would be if I keep using at this rate.' And they'd change their usage and see that change reflected the next day."

Another way that KCP&L helped Green Impact Zone residents was by hiring locally. An electrical contractor who resides within the zone installed all of the thermostats and home area networks. And when KCP&L swapped out customers' old, AMR meters for new AMI models, the utility hired people who live in the zone to do the exchanges and a firm within the zone to train them.

## Conservation Voltage Reduction

Leveraging the substation and feeder upgrades, KCP&L did a detailed study with a conservative 2% drop in voltage, yielding a 1.6% decrease in energy use. KCP&L also studied peak power reduction, achieving 1.13% active power reduction by reducing voltage over numerous peak days by an average of 1.64%. The team found CVR to be less effective on high peak load days. This is consistent with the idea that all assets need to be maximally utilized during system emergencies. An implication of this is that CVR can be used to defer some future capacity investments but not emergency (highest priced) standby generation.

## Going Forward

Because AMI, MDM, and OMS showed that they could improve electricity distribution as intended, KCP&L has already decided to deploy them across its service area. KCP&L is also weighing which other technologies it should deploy, and when. By investigating how today's systems can best be combined with the smart grid technologies of tomorrow, KCP&L may help jump-start the renovation of distribution systems far beyond the Green Impact Zone.

## Further Reading

For more information about KCP&L's project and the technologies it demonstrated, see the utility's interim technology performance report on the SmartGrid.gov website, where you can also learn more about the Smart Grid Demonstration Program.

Under the American Recovery and Reinvestment Act of 2009, the U.S. Department of Energy and the electricity industry have jointly invested more than $1.5 billion in 32 cost-shared Smart Grid Demonstration Program projects to modernize the electric grid, strengthen cybersecurity, demonstrate energy storage, improve interoperability, and collect an unprecedented level of data regarding smart transmission, distribution operations, and customer behavior.