Nation's largest smart grid demo provides lessons for future grid modernization

July 10 2015, by Franny White

Avista Utilities of Spokane installed smart transformers to help improve the efficiency of its distribution system in Pullman as part of the Pacific Northwest Smart Grid Demonstration Project. Credit: Avista Utilities

Smart meters, automated control of power distribution and other intelligent energy technologies can improve energy efficiency and possibly reduce power costs, according to the final results of a comprehensive, five-year regional smart grid pilot project.

But more research and development is needed to support utility-led smart grid deployment throughout the United States, concluded the leaders of the Pacific Northwest Smart Grid Demonstration Project.

"As one of the nation's largest and most complex smart grid demonstration projects to date, the Pacific Northwest Smart Grid Demo experienced much success, while also identifying many opportunities for growth," said project director Ron Melton of Battelle, which led the project on behalf of the region and the Department of Energy's Office of Electricity Delivery and Energy Reliability.

"The knowledge gained through this project will help prepare the region and nation for a bright energy future that strengthens our economy, protects our environment and enhances our quality of life."

The project's extensive results are in an 840-page document called the Technology Performance Report. The report includes a summary of key findings, chapters for each of the project's 11 test sites and results related to conservation and efficiency, reliability and a new approach to energy management called transactive control, which was the heart of the overall project.

Saving energy and money

The project evaluated 55 different technologies, many of which showed they can reduce energy use and possibly also cut power bills. The degree of savings varied with each technology and test location, as is shown in the following examples:

- Smart meters with remote capabilities enabled Avista Utilities to

immediately start and stop electric service in Pullman, Washington, which the utility reported saved time for its customers and could both eliminate 2,714 service calls in a year and save about $235,000 annually.
- A 5-megawatt, 1.25 megawatt-hour battery installed in Salem, Oregon, could save Portland General Electric up to $146,000 annually by providing an alternative power source during periods of extreme peak power demand up to 300 times a year.
- Voltage controls reduced Avista's distribution system voltage by 2.1 percent, which is expected to translate into about 7.8 Gigawatt-hours of annual energy savings and $500,000 in reduced annual costs for its Pullman feeder distribution power lines.

Tests also showed some technologies can improve reliability:

- NorthWestern Energy determined the fault detection, isolation and restoration system it installed significantly reduced two power outages. A June 2013 outage in Helena, Montana, lasted just 51 seconds for customers served by a power feeder line connected to the fault detection system, while customers served by another line were in the dark for 119 minutes.
- Avista reported the fault detection, isolation and restoration system and other reliability enhancements it installed led to an annual average of 17 percent fewer outages and more than 12 percent shorter outages, as well as 353,336 avoided outage minutes between August 2013 and December 2014.
- Idaho Falls Power anecdotally reported it could have cut fewer services for a required power reduction during a December 2013 cold snap if it had smart grid technologies installed throughout its territory.

Portland General Electric installed a 5-megawatt, lithium-ion battery in Salem, Oregon, as part of the Pacific Northwest Smart Grid Demonstration Project. Credit: Portland General Electric

Transactive control works

The project also demonstrated the concept of transactive control works and potentially provides many benefits on a regional power grid. Transactive control, initially developed by Pacific Northwest National Laboratory, involves automatic, electronic transactions between energy providers and users about whether or not to sell or buy power. These transactions are designed to improve energy efficiency and reliability, reduce power costs and enhance renewable energy use.

To test the concept, the project used transactive signals that represented the predicted price and availability of power in the present and several days into the future. The project's transactive signals were updated every five minutes and sent to participating utilities. When transactive signals predicted peak power demand, and therefore also high costs, the project's smart grid technologies were designed to reduce power use.

To help test the transactive control technology, Alstom Grid built a model of the regional grid. The model ran in parallel with the actual grid while using both real data and estimations. Analysis showed the transactive signals would have correctly advised smart grid equipment to alter their operations during two critical moments on the actual regional grid:

- An unexpected outage at a nuclear power plant in Washington state on Feb. 5, 2014, when the plant dropped to less than half its normal generating capacity
- A sudden increase in winds on Feb. 15, 2014, which peaked wind power generation at 2,884 Megawatts

"Dramatic events such as these wouldn't normally be on the radar of individual utilities, but can significantly impact utility operations," Melton said. "Being able to respond to such events with transactive signals illustrates the importance of having system-wide transactive engagement.

"It also represents an important step toward a future where end users can be equipped and empowered to play an active role in their power use."

To evaluate the potential impact of transactive control beyond the project and for the entire Northwest, IBM created another model that rapidly simulated different scenarios on the regional grid. Tests run on that model showed the Northwest's peak power demand could be reduced about 7.8 percent if 30 percent of the regional electric grid used transactive, demand-responsive equipment. This modeling also showed transactive energy approaches can lower the Northwest's overall power costs by taking advantage of wind energy when it's abundant and inexpensive.

The City of Ellensburg, Washington, installed new solar panels and wind turbines to its existing Renewable Energy Park as part of the Pacific Northwest Smart Grid Demonstration Project. Credit: City of Ellensburg

Lessons learned

As is common in scientific research, not all of the project's tests went as expected. Such discoveries are providing important insights into the challenges that must be overcome before national grid modernization can take place. Key lessons learned include:

- Better tools are needed to ensure smart grid data is of high quality and the equipment generating that data is working correctly. Many participants were not prepared to deal with the onslaught of data and sometimes mislabeled data with incorrect units or times.
- Smart grid technologies should be designed to work together and smart grid technology standards should be further developed. This would have reduced the great efforts required of project participants to make equipment from various vendors work together.
- Smart grid technologies and their markets need to mature and stabilize for smart grid deployment to succeed. Some manufacturers went out of business or stopped servicing their products, while some equipment simply failed.
- Public involvement is the key to a successful smart grid deployment, though there is no one-size-fits-all approach. Montana's Flathead Electric created a customer-friendly "Peak Time" brand, while the University of Washington used social media and contests to connect with students.

Next steps

Idaho Falls Power tested requirements for connecting plug-in hybrid electric vehicles to the grid as part of the Pacific Northwest Smart Grid Demonstration Project.

Though the demonstration project has come to a close, regional and national smart grid efforts are ongoing. For example, several project participants are continuing smart grid programs on their own:

- Idaho Falls Power plans to implement conservation voltage reduction throughout its entire power distribution system
- Flathead Electric will install 1,000 residential and small business water heater load controls annually during the next five years
- Avista Utilities will install voltage controls and fault detection, isolation and restoration technologies throughout its service

territory and start installing smart meters for its Washington customers in 2016

"The $80 million in equipment installed for the project provides a key opportunity for the Northwest to continue and expand its smart energy management, with regional ratepayers being the ultimate beneficiary," Melton noted.

More information: "Technology Performance Report," technical results of Pacific Northwest Smart Grid Demonstration Project, published online July 9, 2015. www.smartgrid.gov/document/Pac … ogy_Performance.html

"Technology Performance Report Highlights," layman's summary of Pacific Northwest Smart Grid Demonstration Project results, published online July 9, 2015. www.pnwsmartgrid.org/docs/PNW_ … GDP_AnnualReport.pdf

Provided by Pacific Northwest National Laboratory