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Smart inverters key to integrating more distributed solar generation, experts say

By Esther Whieldon

Bulk power system operational challenges triggered by the current growth spurt in residential generation such as rooftop solar panels could be more easily managed through the use of smart inverters, according to experts.

Utilities, regulators and researchers have for years been looking for ways to accommodate the ongoing growth in generation from renewables, particularly the reliability challenges they pose given that their output is largely dependent on the weather. The need for solutions has become more urgent after incentive programs encouraged consumers to install on-site generation and allowed some to sell excess power back to the system.

Inverters convert generation output from one form of electrical current to another so it can be put onto utility lines.

Yet many existing inverters could go beyond this basic function with changes to firmware, according to experts and utilities. Smart inverters could provide voltage regulation and reactive power. They also could be used to help manage microgrids.

Smart inverter functions could be autonomous or controlled externally through utility dispatch and management programs, according to James Cale, senior electrical engineer and manager of distributed energy systems integration at the National Renewable Energy Laboratory.

Using smart inverters to provide grid support can improve reliability and allow more renewable generation on the grid, California Energy Commission staff said in an April report. "If additional smart inverter functions successfully demonstrate grid benefits, these functions can be standardized to reduce the cost of smart inverters and reduce the amount of equipment on the distribution system," the staff report said.

Solar photovoltaic panels typically produce direct current, or DC, power, Cale said in an interview. The inverter converts that DC power into alternating current before injecting it onto the grid. "You can typically make it into a smart inverter with just a change to the firmware, because the hardware is typically already able to provide advanced features such as reactive power."

According to a white paper by Sempra Energy subsidiary San Diego Gas & Electric Co., "with only modest increases in manufacturing costs, firmware could be added during the manufacturing process to produce smart inverters with enhanced functionality that would generate or consume reactive power and mitigate voltage swings associated with PV systems."

The problem is "some of the functionalities have sort of been held back" by the Institute of Electrical and Electronics Engineers, or 1547 standards, Cale said. He noted that IEEE is amending its standards to allow certain types of advanced functions.

Avoiding Germany's mistakes

A recent research paper by the Electric Power Research Institute suggests the U.S. needs to establish smart inverter standards sooner rather than later to avoid repeating Germany's solar integration woes.

Compared to Germany, the U.S. has very low penetration of residential solar. The nearly 10 GW of installed solar photovoltaics in the U.S. by the end of 2013 represented less than 2% of total installed generation capacity in the country, the EPRI paper said. Germany has about 36 GW of solar generation capacity while the country's daily system peak demand ranges from about 40 GW to 80 GW, according to the EPRI paper.

Germany's explosion in distributed generation occurred without first considering how to integrate these resources with the existing power system, the EPRI paper said. Germany has since ordered a mass retrofit of smart inverters and is updating grid support requirements to avoid distribution voltage issues and mass disconnection risks.

"The rate impacts and technical repercussions observed in Germany provide a useful case study of the high risks and unintended consequences resulting from driving too quickly to greater [distributed energy resources] expansion without the required collaboration, planning, and strategies," the EPRI paper said.

Smart inverters may prove most helpful in U.S. states where renewables and residential generation are more concentrated, such as California, Arizona and Hawaii, according to the EPRI paper.

The Western Electric Industry Leaders Group, or WEIL, in an August 2013 letter to state governors, regulators and legislators suggested the states require that smart inverters be installed on all new solar installations to prevent the situation in Germany from happening in the U.S.

This change would be well worth the small cost to consumers, WEIL said. It estimated that for a solar installation costing $12,000, smart inverters would add only $150 to the price.

WEIL said a number of member companies installed smart inverters adjacent to photovoltaic systems that had been causing voltage fluctuations and saw "immediate and measurable improvement."

Current state, federal efforts

At least one Western state is examining the issue. The California Public Utilities Commission is revising its generation interconnection rules. Under that Rule 21 proceeding, the Smart Inverter Working Group in December 2013 recommended the state require inverters for distributed generation have seven autonomous functions. According to the more recent CEC staff report, these same functions are proposed to be part of IEEE Standard 1547.

IEEE is considering revising its standards for interconnecting distributed resources and scheduled a working group meeting for late April in Las Vegas.

While IEEE wants to look at the full version of that standard, it will "very soon" publish an amendment to 1547.1 that will address three main issues: voltage ride-through, frequency ride-through and abnormal operations in some cases, Dick DeBlasio, chair of the IEEE 2030 working group, said in an interview.

In the Mid-Atlantic region, PJM Interconnection LLC is examining what, if anything, it can or should do to encourage the use of smart inverters given that this is mostly a retail issue.

"To protect the generators, the existing trip setting requirements prescribed in IEEE 1547 include both under and over voltage and under and over frequency limits," PJM said in a problem statement. "However, these limits pose a risk to grid reliability as they prevent generators from staying online during a temporary system disturbance and effectively worsen the impact of the disturbance."

Therefore, "new standards may need to be developed to take advantage of the enhanced inverter functionalities to expand the ride-through capability without damaging … generators and to increase reactive support to the system during and after a disturbance."

But Southern California Edison Co. advanced technology manager Robert Sherick contends it would be better to have one national standard instead of multiple state versions. "National smart inverter standards would reduce interoperability issues and reduce costs as opposed to vendors having to accommodate various state standards that might arise if a national standard is further delayed," he said in an April 24 emailed statement.

As for research, DOE in 2011 awarded millions of dollars to several solar grid integration advanced concept projects that included partnerships among utilities, academic and research institutions. And DOE in 2013 announced its new Energy Systems Integration Facility would partner with Advanced Energy Industries Inc. to develop lower-cost and better-performing solar power inverters.

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