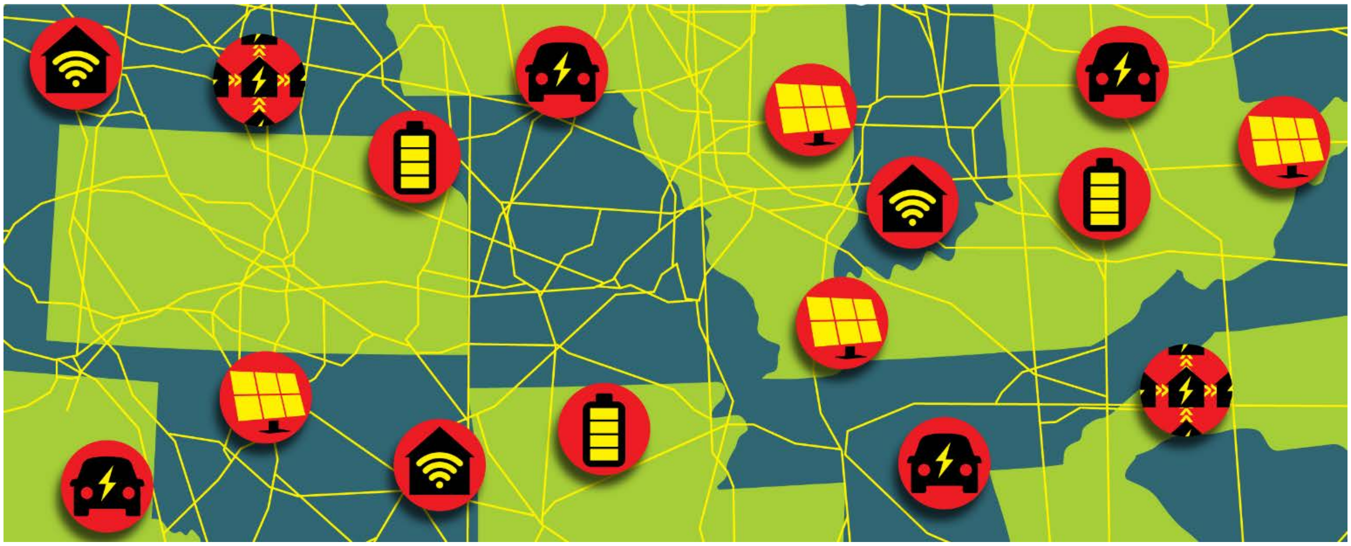
Learning by Doing



Two-Plus Years of Integrated Grid Pilots Have Yielded Important Lessons

By Chris Warren

When EPRI launched the Integrated Grid initiative in 2014, it highlighted the need for a grid that integrates all resources, from large power plants to the smallest of distributed energy resources (DER). To help the industry move toward a well-functioning integrated grid, EPRI researchers have emphasized the importance of hands-on experience with solar photovoltaics (PV), energy storage, microgrids, and other technologies.

"Demonstration projects with utilities are key opportunities to address gaps between theory and implementation in advancing these technologies," said EPRI Senior Project Engineer Steven Coley. This understanding prompted EPRI and its members to initiate more than two dozen Integrated Grid pilot projects in the U.S. and internationally.

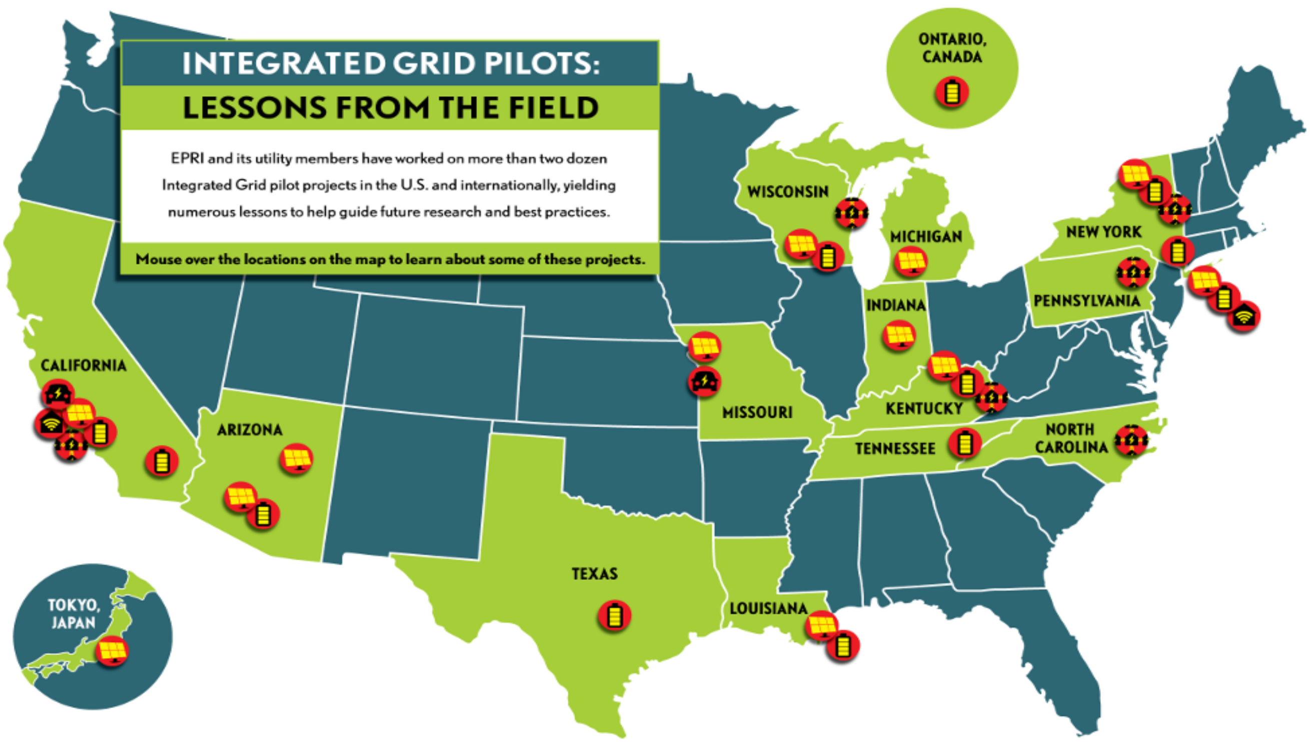
More than two years of field work have yielded numerous lessons that will help guide future research and best practices for integrating DER. Here, we describe several insights, grouped according to the four-part action plan in EPRI's Integrated Grid concept paper.

Interconnection Rules and Communications Technologies and Standards

In an integrated grid, large numbers of solar panels, smart inverters, energy storage, and other technologies need to mesh seamlessly with utility operations. "Common languages and open protocols reduce the complexity of coordinating distributed resources," said Coley. "But we are finding that there is limited deployment experience, and customized control configurations are used, so there is still a lot of room for improving and streamlining the process."

Louisville Gas and Electric experienced a problem with its deployment of energy storage because its vendor's technology did not originally communicate properly with grid operations, and a unique system-control topology had to be developed and implemented. This type of case-specific fix underscores the need for more coordination between utilities and DER vendors.

“Too often, customized solutions are needed to achieve suitable control of DER—an approach that is not streamlined enough for broad deployment,” said Coley.



Click here to enter this interactive graphic.

EPRI has been heavily involved in the efforts of the IEEE Standards Association—in collaboration with DER vendors and developers, distribution and transmission utilities, researchers, and other public stakeholders—to develop and revise the IEEE 1547 standard, which governs the interconnection of DER. The revised standard is expected to take effect in 2018 and requires that DER have at least one means of open communication.

“Most of our pilot projects have demonstrated the necessity of updated interconnection standards,” said Dr. Ben York, technical leader in EPRI’s Distributed Energy Resources program. “The standard’s development is being informed by our experience with the pilots.”

Over the past four years, EPRI’s technical expertise and thought leadership have contributed to a successful, timely revision of the standard.

“An example of this is EPRI’s 2015 white paper on low-voltage ride-through, which helped stakeholders on the standard’s working group better understand this highly technical topic and reach consensus on new requirements for this function,” said Dr. Jens Boemer, a senior technical leader in EPRI’s Grid Operations & Planning program. Adequate ride-through requirements for DER help to maintain power system reliability and keep the lights on, even with extremely high levels of DER connected to the system.

Because the previous version of IEEE 1547 lacked a common approach to communications and grid support, it is a challenge for utilities to communicate with DER installed on the distribution grid, leading to reduced awareness of grid conditions and potential system reliability risks.

“Every time you connect a new inverter to the system, you have to learn a new language. It’s like having to learn French or Spanish every time you want to talk to a different inverter,” York said. “If you have 10 different inverter manufacturers, you have to learn 10 different languages. What ends up happening is that utilities don't communicate with any of them."

Through activities such as presentations at IEEE conferences and public utility commission hearings, EPRI plans to educate the industry and all interested stakeholders about the revisions to the IEEE 1547 standard as they are rolled out.

"Our education is vital so that the standards are interpreted and implemented appropriately," said Coley.

Assessment and Deployment of Advanced Distribution and Reliability Technologies

The pilots are examining how several technologies perform in actual operating conditions on distribution circuits. Confirming prior EPRI modeling work, the Arizona Public Service pilot demonstrated that smart inverters—by providing voltage support—can help address technical challenges that limit the safe interconnection of solar power. The project also showed that allowing smart inverters to adapt certain functions autonomously produced the most benefit to the grid. The inverters provided voltage support without noticeable impact on solar energy production.

"Even during hot Arizona summers, the temperature varies widely throughout the day. As air conditioning ramps up, voltage support from inverters needs to adapt," said York. "The Arizona Public Service project showed us that sizing your inverter even slightly larger than the amount of solar power that comes through it can create big opportunities for grid support."

Strategies for Integrating DER with Grid Planning and Operations

Pilots with Southern California Edison (SCE) and Hydro One are exploring how the sizing, location, and control functions of distributed energy storage systems impact grid planning and operations.

"EPRI is working with these utilities to develop a framework that can help them extract the most benefit from these resources," said Coley. "We're evaluating various scenarios, including one in which the utility controls where the storage is located and how it operates and another in which utility customers have all the control."

Both projects have shown that there are no simple answers about optimal location and operations of storage. Utilities must evaluate the trade-offs for each case. For example, locating storage near the end of a feeder near load might significantly reduce capacity constraints, benefiting distribution grid operations.

"However, if you want to maximize the value of the storage at the bulk transmission level, you may want to locate it closer to the substation, where its output is not as constrained by the distribution feeder. This could yield greater returns from interacting with the wholesale markets," said Coley. "Utilities need to determine where the value is higher and assess capacity constraints in the distribution system. It can be difficult to balance these considerations."

In Michigan and Indiana, American Electric Power connected four PV plants to its distribution grid and estimated that in one month of operation, snow on the panels reduced power generation from one of the four plants by 20%. This finding has implications for how utilities interpret results from solar plant performance models and how they account for snowfall—a known source of error.

"The performance models estimated energy output to be plus or minus 5% of actual production. But in the snowy winter months, energy generation can vary a lot more," said Coley. "Utilities need to consider the reality that snow can drastically affect performance and adjust their planning accordingly."

Enabling Policy and Regulation

While EPRI does not advocate for specific policies and regulatory frameworks, the pilot projects are designed to provide policymakers with research and data to inform good decisions.

“For each demonstration project, we are documenting costs, benefits, grid constraints, and other relevant information for policymakers,” said Coley. “We’re also demonstrating how the application of EPRI’s Integrated Grid benefit-cost framework can inform policymakers and regulators.”

The utilities WEC Energy Group and PECO are using the benefit-cost framework to evaluate proposed microgrids. In these microgrids, DER would serve local loads and provide electricity to communities when weather or other emergencies disrupt transmission and distribution systems.

“Through these feasibility studies, we learned that a clear understanding of the objectives for the specific microgrid application is important in finding the most value,” said Coley. “Each microgrid is different, and there are many case-specific factors that drive what is and isn’t valuable.”

The PECO study evaluated a utility-integrated, community microgrid that would deliver electricity to medical centers, shelters, a fire station, and other essential service providers during a utility outage. The study led to important insights on microgrid sizing and design, required distribution system reconfigurations, customer energy use, costs, and benefits. PECO withdrew its regulatory filing on the project as a result of a lack of statutory clarity regarding ownership of some microgrid assets. Now, the utility is engaging with legislators and regulators to help establish a statutory and regulatory framework to guide microgrid development in the state. All these experiences and lessons are informing PECO as it embarks on a new microgrid project, with EPRI serving as a technical advisor.

With funding support from New Energy and Industrial Technology Development Organization, Tokyo Electric Power Company Holdings, Inc. (TEPCO) is conducting research to help integrate large amounts of PV in Japan. EPRI is providing technical support to TEPCO. “The initial focus was how the grid responds to excess solar and how to manage that,” said York. “It has since morphed into understanding all the potential benefits of inverter technology in managing solar energy.”

One lesson is that the challenges and benefits of integrating solar into the distribution and bulk power grids depend on how much is interconnected. In some cases, modest amounts of solar can improve grid management while larger amounts may pose grid management challenges.

“We are learning about a lot of the technical issues that come from high levels of solar,” said York. “International experience helps everyone understand the role technology and policy can play in making DER integration as smooth as possible.”

Key EPRI Technical Experts

Steven Coley, Ben York