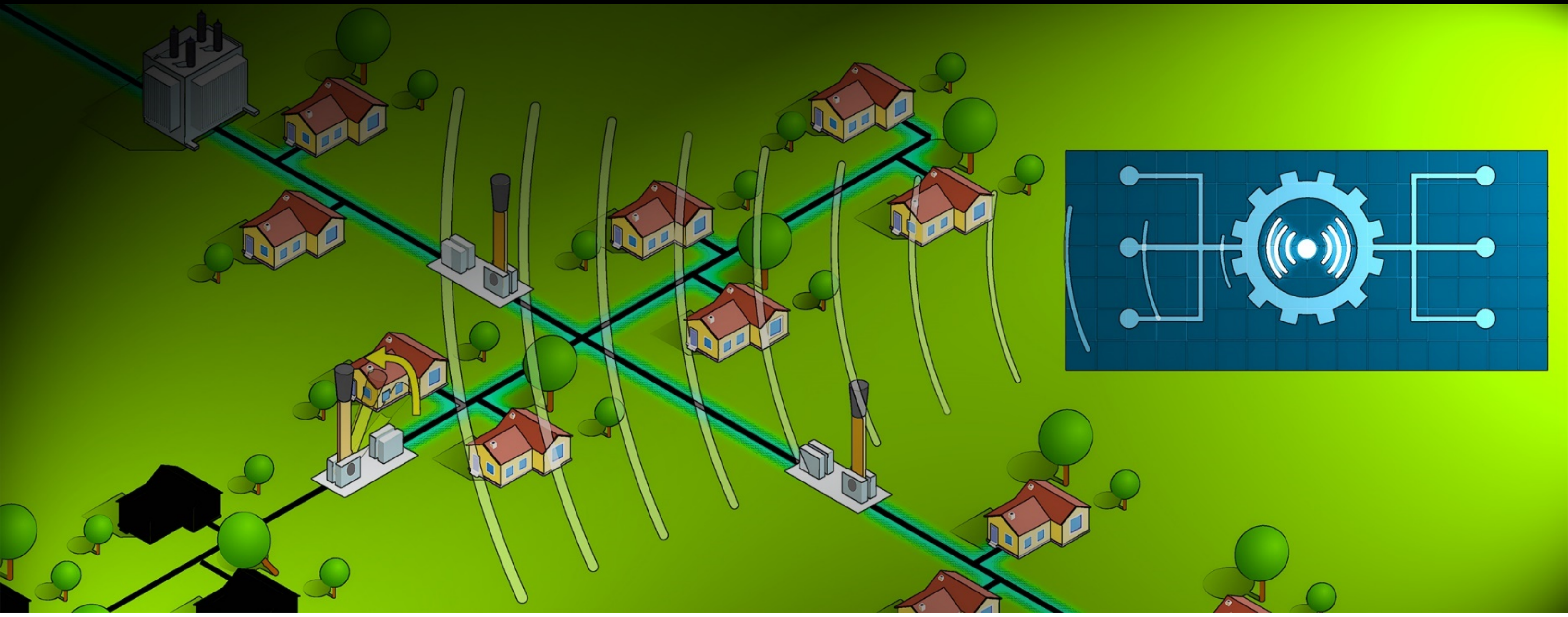
EPRI JOURNAL



Orchestrating the Distribution System

EPRI Examines New Technologies and Methods to Help See, Manage, and Optimize New Energy Resources

By Mary Beckman

In New York, renewable energy is set to grow by leaps and bounds in the coming decade. By 2030, the Empire State's utilities are required to source 50% of the state's electricity from solar, wind, hydropower, and biomass. According to the U.S. Energy Information Administration, renewables (including hydropower) contributed 28% in 2017. With rising renewable energy, power generation is expected to become more distributed—with enormous implications for distribution system operations.

"New York has very aggressive climate goals that make significant use of clean, distributed energy resources," said Dave Crudele, a program manager in distributed energy integration at the New York State Energy Research and Development Authority (NYSERDA).

Distribution systems across the country, including New York's, were not originally designed for distributed energy resources (DER). Control and operating systems need to be upgraded to better incorporate these new dynamic sources of power distributed along the system.

"Without better awareness and control of distributed resources, many of these resources will not be operating in concert with the distribution system," said EPRI Senior Program Manager Jeff Smith. "The guiding principle here is measurement leads to improvement. If you can measure something, you can understand it. If you can understand it, you can manage it. If you can manage it, you can improve it."

Now, EPRI is working with NYSERDA and three New York utilities to develop software and tools that can help improve awareness of real-time DER operations and make control systems more responsive to them, improving reliability and power quality.

"EPRI has proposed a number of innovative R&D projects to make it easier to have more distributed energy resources on New York's grid," said Crudele.

With increasing rooftop solar, the distribution system has become much more dynamic, with power flowing in multiple directions.

HYBRID CONTROL

The power system in the United States has been designed for one-way power flow: Energy is generated at one end, transmitted to substations, and distributed to customers at the other end. For many years, managing the system was straightforward. Utilities kept track of how much power they generated and how much power users consumed. They used that historical information to forecast and plan.

"You could do that because all the power flowed downstream from the generating station. There wasn't anything going on dynamically on the distribution system, like we see today with distributed energy resources," said EPRI Senior Technical Executive Brian Deaver.

With more distributed, intermittent energy sources such as solar and wind, the distribution system has become much more dynamic, with power flowing in multiple directions. Conventional control systems are not sophisticated enough to manage these flows.

Consider a neighborhood of houses with rooftop solar. On a sunny day when solar panels are producing power, utility control systems are not aware of the generation and may only sense that the houses are consuming a small amount of grid electricity. Consequently, operators may only account for a certain level of demand when routing power through the distribution system. But when a cloud floats over the neighborhood and solar production decreases, many houses suddenly need utility power—and operators are faced with unexpected high demand.

To help manage a grid with intermittent, distributed resources, EPRI is investigating 'hybrid control' approaches that combine existing controls and new methods to perform three functions: pinpoint the location of distributed resources, monitor their energy production, and optimize their contributions to power flow.

The objective is to program a utility's distribution management system (DMS) to coordinate distributed resources with utility infrastructure, local autonomous controls, and centralized controls.

"The way the grid works now, a solar plant's generation may be causing high voltage locally, but the DMS is unable to adjust its output to mitigate the problem. With new control methods and algorithms, the DMS will be able to factor in distributed resources in deciding how to operate the system," said EPRI Senior Project Manager Lindsey Rogers, who leads the hybrid control project.

SEEING IS POWER

Today's grid can't 'see' nontraditional energy resources, such as rooftop solar, wind turbines, fuel cells, and energy storage. In other words, utility operators and control systems have limited ability to measure the real-time output of small generators distributed across the grid.

Orange & Rockland Utilities is working with EPRI to explore how to give the DMS 'eyes' for distributed resources. Researchers are modeling the operations of various sensors along three feeders in the utility's service territory in the northwestern suburbs of New York City. These sensors monitor the status and production levels of DER and transmit that information to the DMS. This modeling study will help the team determine where sensors need to be added, assess the costs and benefits of metering distributed resources, and identify the minimum size commercial solar or wind facility for which metering should be required.

EPRI researchers also are evaluating computational techniques that can enable these sensors to accurately characterize the state of the system at key locations. One technique is *distribution state estimation*, which reconciles measurements with different accuracies while identifying and ignoring bad measurements.

LOCAL KNOWLEDGE

Once a DMS has access to measurements of distributed resources, it can be 'trained' to manage them. EPRI is working with National Grid in upstate New York to model this aspect of the NYSERDA project.

"We want to meet customers' increasing expectations for reliability along with state policy goals for the integration of clean, renewable, distributed energy sources," said Rob Sheridan, National Grid's director for grid modernization solutions. "We are deploying advanced distribution management systems and aggressively pursuing renewable distributed generation interconnections at the same time. This study will help us with these efforts."

The team is modeling the impacts of distributed generation on a key DMS application known as *automated restoration*. This application automatically responds to a distribution system fault by locating it, isolating it to the smallest possible area, and automatically restoring power for as many customers as possible.

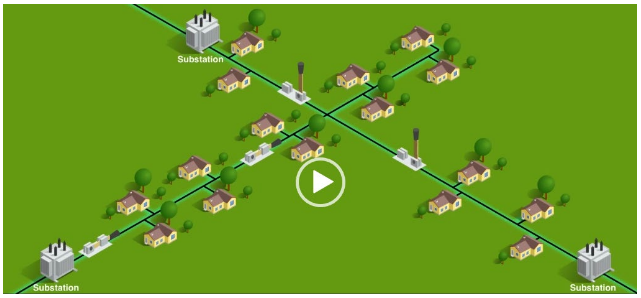
The control algorithms that manage automated restoration do not monitor distributed resources. When a fault occurs, these resources are required to disconnect from the grid for safety reasons. The algorithms are unaware of the resulting loss of production, which can potentially cause overloads, outages, or other undesirable outcomes.

"An automated restoration scheme can fail if it can't see the distributed energy resources," said Rogers.

When distributed resources challenge automated restoration operations, utilities may simply turn off the application and dispatch workers to address outages manually.

EPRI and National Grid are enhancing automated restoration algorithms so that the application knows where distributed energy resources are located and how much power they are producing. This can enable the algorithms to make the appropriate decisions to reroute power, maximize customer restoration, and minimize overloads or other adverse impacts.

"We would like to understand how the sensitivity of the automated restoration algorithms developed in this study can impact our reliability metrics," said Sheridan.



Watch an animation about research to enhance automated restoration.

THE BEST THE GRID CAN BE

Once the grid can monitor the operations of intermittent power generators, it can be optimized for efficiency. That means delivering electricity in the right voltage range.

EPRI is working with Central Hudson Gas & Electric on control system upgrades to enable stable power flow and enhance voltage control.

"Solar developers tend to gravitate toward lower cost rural land," said Heather Adams, director of electric distribution and standards at Central Hudson. "But those sites are often supplied by smaller wires many miles from a substation, making them more vulnerable to overloading and voltage levels that fall outside of allowable standard ranges. Those areas are ripe for additional tools to facilitate integration."

For example, when a solar power plant produces electricity, the local voltage increases. Making fixed changes to inverter settings to mitigate voltage increases may create other challenges for the grid, such as decreased power factor. As smart inverters are rolled out and adopted, they can mitigate voltage increases by changing their settings dynamically and autonomously. Sometimes, however, the voltage increase can be too great for the inverters to manage locally. EPRI and Central Hudson are developing enhanced DMS algorithms to coordinate local autonomous controls with controls at the substation or distribution control center.

"Central Hudson is interested in determining the appropriate balance of centralized and decentralized control of smart inverters and utility infrastructure," said Adams.

Rogers expects algorithm development and other DMS improvements to last about a year, after which EPRI and Central Hudson will demonstrate them in the field.

"Distributed energy resources are interconnecting at a rapid pace," said Deaver. "We intend to stay ahead of that curve."

KEY EPRI TECHNICAL EXPERTS

Brian Deaver, Jeff Smith, Lindsey Rogers