Feature—A Rigorous Framework for the Grid's Transformation

New Bottom-Up Methodology to Assess Benefits and Costs of Distributed Energy Resources Starts at Local Circuits and Builds to System Level

By Chris Warren

The Story in Brief

As the grid transforms from a one-way power delivery system to a far more complex system, utilities, regulators, and other interested stakeholders need a common language to understand and agree on the best future path. EPRI's new analytical framework provides this language, outlining an approach to comprehensively and transparently assess the benefits and costs of integrating new distributed energy resources into the grid.

In April 2014, the New York Public Service Commission launched Reforming the Energy Vision, a fundamental reimagining of how the state produces, consumes, and manages electricity. Utilities, grid operators, generation owners, and other stakeholders are working to guide the grid's transformation from a network of central power plants delivering electricity to homes and businesses to a more complex, dynamic system that includes extensive energy storage, demand management, rooftop solar, and other distributed energy resources (DER). New York's initiative relies on collaboration to ensure that the electric system remains as reliable and resilient as it has been historically while optimizing diverse emerging energy resources.

New York is not alone in its effort to establish rules, policies, technologies, and incentives to successfully guide these changes. In August 2014, the California Public Utilities Commission kicked off a rulemaking process requiring the state's investor-owned utilities to integrate distribution resource plans with DER into long-range grid planning. Also in 2014, the Tennessee Valley Authority launched an initiative to develop a methodology to assess the value DER bring to the grid, taking into account where solar and other resources are interconnected and the resulting costs. There is great diversity among the organizations working to ensure that DER connected to the distribution system benefit the grid and society, including utilities, grid operators, renewable energy developers, environmental nonprofit groups, regulators, policymakers, and consumers.

While the initiatives have different names and methodologies, they share a key objective that is neatly summarized in New York's proposal: "to make energy efficiency and other distributed resources a primary tool in the planning and operation of an interconnected modernized power grid."

Providing a Template: EPRI's Integrated Grid Benefit-Cost Framework

The need for a roadmap and tools to guide the grid's transformation spurred EPRI to launch its Integrated Grid initiative. EPRI's 2014 concept paper, The Integrated Grid: Realizing the Full Value of Central and Distributed Energy Resources, outlined key issues to address in moving toward a power system that maximizes the benefits of the existing grid and DER. Following up this initial work, EPRI unveiled the Integrated Grid Benefit-Cost Framework in February.

The Benefit-Cost Framework is not a one-size-fits-all analysis to determine exactly how to incorporate DER. Instead, utilities, regulators, and third-party stakeholders can use its methodology to more accurately and transparently assess the benefits and costs of adding DER in specific locations and for the power system as a whole. "This work shows that you have to take a system perspective and examine local and distribution issues and then aggregate those to assess impacts on transmission, generation, and overall resource planning," said Mark McGranaghan, vice president of EPRI's Power Delivery & Utilization research sector. "The kinds of studies that need to be done each step of the way are laid out, though we don't tell you how you have to do those studies."

This presents a new paradigm for utility planners, who have historically focused on the one-way delivery of energy from power plants through transmission and distribution systems to customers. With more DER feeding electricity into the distribution system, there's an acute need to understand and plan for two-way power flows. "Not that long ago, planners were basically able to separate the transmission and distribution systems," said Ben York, senior project engineer in EPRI's Distributed Energy Resources program area. "Now you have distributed resources on the distribution system potentially pushing power back onto the transmission grid. That is forcing tighter connection between bulk system planning and distribution planning, where bulk planners take into account generation resources on the distribution system."

To do that properly, EPRI's Benefit-Cost Framework accounts for the importance of the distribution system, down to individual feeders, or circuits. EPRI's approach is rooted in engineering and quantitative rigor, distinguishing it from studies such as value-of-solar analyses that seek to quantify the impact of additional DER on the entire grid. "One of the limitations of prior studies is that they take a top-down look, starting at the transmission level and relying on broad assumptions about how much distributed generation the distribution grid can handle and the impacts," said Jeff Smith, a senior project manager in EPRI's Power System Studies Group. "This can result in significant inaccuracies in assessing the costs and benefits."

By contrast, EPRI's methodology starts at individual distribution feeders, quantifying each feeder's DER hosting capacity and the resulting costs and benefits of adding DER within that feeder. Then, it aggregates these local costs and benefits and determines impacts at the transmission and overall system levels. "Our method is bottom-up, not top-down," said Smith. "Quantifying the value impacts where the DER are connecting is fundamental to any analysis."

The Basics of the Framework

The EPRI Benefit-Cost Framework outlines four steps for a comprehensive assessment of the implications of adding DER: core assumptions, distribution impacts, bulk power impacts, and benefit-cost analysis. Identifying core assumptions helps stakeholders account for the unique attributes of the power system, policies, and conditions in their state, region, or country. "The core assumptions step defines the scenarios to be evaluated and the questions that utilities, regulators, consumers, and others will need to answer as they determine how and where to deploy DER most effectively," said York.

An Overview of EPRI's Benefit-Cost Framework:

Core assumptions:
Because no two power systems are exactly alike, the starting point for utilities, consumers, regulators, and other stakeholders is to account for their unique market conditions and study objectives. Identifying the questions that must be answered helps to define potential scenarios to study and the assumptions behind them.

Distribution impacts:
Distributed energy resources connect at the distribution level. Understanding how they impact parameters such as voltage, safety, and reliability is key to determining the costs and benefits

Bulk power impacts:
Two-way electricity flows between the distribution and transmission systems can affect the capacity and flexibility required to serve demand. Assessing those impacts is vital

Benefit-cost analysis:
Quantifying the actual costs and benefits of integrating distributed energy resources in real dollars is the framework's final step. These costs and benefits don't accrue equally to society, utilities, and consumers.

For example, what level and what types of DER penetration are sought? Is the aim to deploy enough solar photovoltaic (PV) generation to supply 10, 15, or 30 percent of residential and commercial load? Is the goal to add one, two, or three gigawatts of storage? The range of scenarios is as wide as the varying market conditions and policies around the world. Once those scenarios are determined, a deeper look at the assumptions behind them is essential. Utilities and regulators planning for significant solar deployment should fully consider the costs of integration and ways to ensure that the grid remains resilient and flexible with added intermittent generation. "You are assuming things about the cost of PV and the amount, location, and timing of the adoption," said York. "These and other assumptions go into each scenario."

The next step is to examine the distribution impacts. "Any holistic assessment of the entire grid requires you to first consider where DER are connecting within the distribution system," said Smith, pointing to five parameters that must be measured to gauge the effects of new DER: voltage, safety, thermal capacity, energy, and reliability. "Investigating all five allows you to assess the potential impact that results in a cost or potential value," he said. One cost, for instance, may be incurred by the need to reconductor power lines to accommodate more DER. An offsetting benefit might be realized by delaying or avoiding the upgrade of a substation transformer because the added distributed generation can serve local peak demand.

A similar assessment of DER impacts is then applied to the bulk power system, with a primary focus on the system's ability to serve demand. The transmission system's performance, flexibility, and operations are examined to again determine potential costs and benefits yielded by additional DER.

The framework's final step involves quantifying in real dollars the costs and benefits at both the distribution and bulk power levels. Keep in mind here that costs and benefits don't accrue equally to every stakeholder. "If the utility wants to look at them from their perspective, they can do that," said McGranaghan. "But regulators and policymakers might want to look at them from a societal perspective, supporting decisions on incentives for applications with value streams that might not get realized by utilities."

Integrated Grid Pilot Projects

Though essential, EPRI's detailed framework is not sufficient by itself to guide the journey to the Integrated Grid. "It's great that it's written down, but what we need next is real-world application," said McGranaghan.

EPRI is doing this with utilities through dozens of pilot projects over the next several years to examine costs and benefits of a wide range of DER. These include microgrids, electric vehicle charging infrastructure, distributed energy storage, and utility-scale solar. In part, these pilot projects are designed to test the framework's effectiveness. For example, EPRI is helping Salt River Project develop and customize an automated tool to analyze its distribution system's hosting capacity.

These and other pilots will inform and refine the benefit-cost framework by providing system-specific data about the costs, benefits, and challenges of DER integration. "Many of these technologies are new, and all you have is what the manufacturers tell you is the cost," said York. "Deploying and scaling up these technologies give you a much better idea of the real costs, benefits, and impacts."

Along with the pilot projects and the framework, EPRI has organized a broader scope of work through "research imperatives" to guide the development of analytical tools and standards needed to make the Integrated Grid a reality. These include DER interconnection standards and improvements to smart inverters. "Even if the framework says something is worthwhile to do, we still have to have the technology, standards, and tools to actually do it," said McGranaghan.

EPRI's Benefit-Cost Framework is intended to bolster trust and transparency among the many groups interested in the grid's evolution. "Integration of the grid impacts everyone—not only utilities and regulators, but also individuals and businesses that own solar power systems and other distributed energy resources and have a genuine interest in the power system," said York. "The framework provides a common language for all these people to understand and buy into the benefits and costs."

For more information, visit EPRI's Integrated Grid website.

Key EPRI Technical Experts

Jeff Smith, Ben York