Modeling the Grid for De-Centralized Energy

How Proper Management of DER Integration Will Alleviate Pressure on the Grid

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Utilities are facing massive changes that affect all aspects of their business, from planning through operations. Once an industry characterized as technology-risk averse, utilities have been shifting to more agile approaches with a higher tolerance for risk. Modeling the grid to accommodate these changes requires new approaches and closer relationships with trusted technology partners. This paper will examine what methodologies have driven the acceleration of grid decentralization and what technologies still need to be applied for smooth integration and success.

Certain Trends Have Led to an Overworked Grid

Growth in generation at grid edge, also referred to as distributed energy resources (DER), has inarguably reached critical mass. Approximately 75 percent of survey respondents in a recent Siemens report indicated that DERs will be somewhat or significantly more important in the next 12 to 24 months. Industry newsletters are also reporting about the implementation of renewable generation projects almost daily.

Although T&D networks with centralized generation sources have traditionally been modeled using GIS and other network management capabilities, managing assets over the complete lifecycle is a foundational component of modeling for a de-centralized grid. As DER supplements, or even replaces coal and nuclear generation, the management of utility assets becomes a larger issue: there are more assets to manage and maintain, which makes reliability and predictability more challenging.

Regulation uncertainty will continue as regulators who share the same technology issues as utilities struggle with how to represent to their constituencies. It is difficult to answer questions about which approaches to incentivize and how to balance consumer issues with using utilities to recover costs, especially when renewable sources, such as rooftop photo voltaic (PV), clouds the definition of customer and supplier. How these considerations will affect the underlying asset model is not clear as different regulatory models are being tested.
Aging assets remain a lingering problem. Replacing assets, notably transmission and generation assets that are operating well past their design life, have been delayed due to the uncertainty around cost recovery, shifting environmental policies, and uncertainty over replacement choices. While utilities grapple with replacement issues, managing aging assets increases the importance of full documentation of an assets’ operational history to understand and support predictive and preventative maintenance.

Investment deficit has been a problem in the past that must be addressed in emerging economies to support societal and economic growth. This means rapid development of infrastructure and greenfield design of projects that incorporate DER and renewable energy sources from the beginning.

Cyber threats are growing as rogue states target utilities for offensive tactical advantage and criminals attempt to hijack and hold systems for ransom. Whether or not an asset’s vulnerability to cyber-attack is a component of its criticality attribute or something that needs to be separately managed is a question that has not yet been answered.

The effects of these trends are far reaching and include reinforcing existing policies and practices, while forcing utilities to move outside their traditional comfort zones to try new approaches.

Common Connectivity is the Pathway to Adaptation

Utility systems must adapt to share information and interact. Managing assets is an area where interoperability is crucial and federating information through a connected data environment (CDE) must be part of the solution. The Internet of Things (IoT) has already become a key part of many industries, such as process control. IoT has extended into utility devices like smart meters, and increasing DER into the grid drives the need for the digitalization of information. “Smart” instrumentation and control devices produce a substantial amount of data, and much of it is important to understanding asset health. Existing and evolving standards such as IEC 61968 (information exchange), IEC 61850 (configuration of intelligent devices), IEC 30141 (IoT reference model), and ISO 55000 (asset management) all work to provide a standards-based architecture to facilitate exchange of information between utility systems to strengthen and improve the benefits of the CDE.

A utility’s baseload is increasingly being covered by renewable energy sources. Renewable generation goals are being met ahead of schedule with some reports of 100 percent renewable generation now considered possible, according to EUCI. Consisting of wind, solar, and more, renewable energy resources are being integrated with storage technology to improve the availability of power despite the variability of winds and sunlight, further driving the change to a de-centralized grid and systems that manage the grid. Utilities network models must change to meet those challenges.

Distributed energy sources have different operating models than traditional generation, such as coal-fired generation, nuclear, and gas. As a foundation for simulation and predictive analysis, utilities systems are expanding their capabilities to include support for DER.
Due to the nature of DERs, utilities are not always able to control how or when these resources are connected. Organizations are implementing microgrids to meet their own requirements for high availability rather than relying on the utility. Houston Health Systems is a topical example, as their gas-fired microgrid kept them in operation during Hurricane Harvey. Network feeders that serve customers with their own microgrid will likely have different criticality assessments than identical network feeders with customers who have no backup. Asset models must be flexible to accommodate these types of differences, especially when taking provider-of-last-resort scenarios into consideration.

Digitalization of the Operation

Network management systems have become more sophisticated, enabling data tracking, advanced decision support, and operational analytics. Using high volumes of digital data from many devices and integrating information technologies (IT) and operational technologies (OT) with engineering systems provides the basis to create a digital view of a utility. Combined with reality data from laser scans and high-resolution photography, this “digital twin” utilizes powerful capabilities for reliability analysis and design optimization. These capabilities are critical whether in response to unplanned external events or the need to evaluate design options for future system changes in both greenfield and brownfield situations.

As DERs grow in usage, the grid is concurrently becoming more populated with sensing and actuating devices as part of the process of digitalization. Gartner’s website states, “[digitalization] is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business.” A digital representation of the grid is visible at its fullest extension. This digital representation will provide massive volumes of data that can be used to better understand grid performance currently, previously, and potentially in the future.

By combining algorithms and simulation capabilities with the digital representation, a “digital twin” is created. As a concept, digital twins have been around for a long time, but the IoT has ensured that the implementation of a digital twin is now cost-effective.
Big data must contain an information model that documents the grid assets and maintains their status at any point in time. Asset lifecycle management documents when and where the asset was installed, its maintenance and service record, as well as other key information required for comprehensive asset stewardship from cradle to grave.

**Speaking a Common Language**

To make digitalization worthwhile, systems must be able to share information effectively and seamlessly. Therefore, systems should interoperate through a connected data environment. Reliability analysis, compliance and safety reporting, and operational analytics are core functions needed for asset stewardship, and they involve multiple database components and systems. Through enterprise interoperability, based on industry standards, data can be available whenever and wherever it is needed.

The IEC Common Information Model (CIM) is important to interoperability. CIM derives from the standards for distribution, transmission, and energy markets. Based on work begun by the Electric Power Research Institute (EPRI) and continued by the IEC, CIM provides a common language for communication between utility systems within the industry and with external entities, such as an independent system operator (ISO) for electric transmission.

Proprietary interfaces that have been standardized and made public are just as important for interoperability because they are able to export and import data from other systems and are transparent. In a network reliability study, network models from a geographic information system (GIS), combined with asset lifecycle information, were used by a planning engineer to examine poor performing, unreliable networks, and improve network maintenance. Furthermore, this approach can improve network modeling by determining where new DER will be most effective or considering the integration of privately-owned DER. Interoperability with the connected data environment can help identify optimum grid connection points. With thousands of DER, the grid will be constantly changing, and only an integrated digital infrastructure will be able to design, operate, and maintain the many assets that compose it.

**Connected Data Environment Critical for Efficient Management of DER**

Using asset lifecycle information to plan an asset’s reliability bolsters the value of network data because it is relied on from the engineering design phase to the analysis domain. This use of asset lifecycle information also demonstrates why interoperability with the connected data environment is critical for efficient management of a de-centralized grid. In this instance, a set of engineering analysis capabilities will utilize asset lifecycle information combined with GIS data and data internal to the engineering capability.
A utility will have regulatory and related internal standards for network design, including operating criteria, load conditions, failure modes, and digital catalogs of approved construction components (called compatible units or CUs) that define and guide how planning and design is performed and what parts are usable. Without a connected data environment, implementation and management of the many interfaces become challenging IT problems when facing a de-centralized grid. Making decisions about adding DERs to the grid based on factors like expected network performance, reliability, and power quality is difficult if not impossible.

Simulation uses digitalization to model the current grid or show the grid with proposed grid changes, such as a DER connection request where simulation can accelerate and improve the assessment of a DER interconnection request.

After identifying a connection point, the analyst needs to understand how the new DER will affect the network. For instance, the analyst must know if the connection will cause current and/or voltage to exceed limits or short circuit limits. In order to have all questions answered, a model of the DER is connected to a digital representation of the network and algorithms are applied to simulate network operation under varied conditions. The simulation is run in the design phase to ensure the DER will not cause network operation outside defined limits for variables like power/load flow, voltage limits, harmonics, frequency response, and more.

Predictive analytics is another capability that is essential in a network model that supports DER. The goal of predictive analysis is to find problems before they occur at a reasonable cost. The historical and real-time data available through a connected data environment can make seeing trends and understanding anomalies difficult without the necessary capabilities to track, analyze, and report important events, especially in a de-centralized grid populated with large numbers of DERs and even more IoT devices. An event can be something as simple as an unexpected change in frequency, or it can be as subtle as micro-cracks in a solar panel that impact system voltage. Analytics can provide perspectives of the event that help determine whether a change is a symptom or a cause, thus determining where corrective action needs to be applied.
Conclusion

As utilities face huge changes and work to adjust all aspects of their business with the integration of DERs, agile approaches to technology and information management will help them achieve their goals. To embrace the digitalization process, leaders need to emphasize the importance of the connected data environment, the need for integrated engineering and analysis, and the value of predictive analytics. In addition, new approaches to network modeling must be adopted to handle the new world of distributed generation. As costs reduce and DERs grow in popularity, it is important to the grid that DER integration, and not just connection, is carried out smoothly and reliably to the benefit of the utility and the customer. Incorporating DERs into the digital twin is one way of easing them into the grid right at the design phase to ensure all possible problems are brought to light before implementation. Once implemented, DERs can be monitored in the same manner as the rest of the grid to assess reliability and performance. Then, DERs become truly beneficial because they ease the burden of the central grid.