Smart Grid 101 - How the smart grid is changing system operations

Dr. Mani Vadari

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Meet the Author:

An IEEE Fellow, electricity industry visionary, and leader, Dr. Mani Vadari delivers strategic services to a global set of utilities, vendors, and service providers seeking deep subject matter expertise in setting the business and technical direction to develop the next-generation electric/energy system. As a Business Architect, Dr. Vadari has been delivering solutions focusing on Transmission/ Distribution/ generation operations, Energy markets, and Smart Grid for over 35 years. In addition, he is an Adjunct Professor at Washington State University and an Affiliate Professor at the University of Washington. He has published two popular books, "Smart Grid Redefined: Transformation of the Electric Utility" and "Electric System Operations – Evolving to the Modern Grid, 2nd Edition", in addition to over a hundred industry papers, articles, and blogs. His books are serving as textbooks at several universities in the US and around the world

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"Author, trainer and smart grid pioneer, Mani Vadari, is back to explain how the smart grid is changing the traditional roles played by system operators" -- Jesse Berst

The smart grid is driving key changes on the utility side that are largely invisible to the average customer. On the transmission and distribution side, sensors and digital relays are being installed on power lines to enable utilities to operate systems with greater efficiency and reliability. "Traditional" SCADA systems, for example, typically provide data every 2-4 seconds. Now phasor measurement units (PMUs) are being added that sample voltage, current, and other variables many times per second. This gives utility operators a far more accurate view of the grid's health. They can act as an early warning system to help halt or prevent power surges before they develop into massive blackouts.

Other sensors and controls are being added to provide more visibility into the flow of energy, such as IVVC (Integrated Volt-VAR Control) reclosers. These digital sensors and remote controls will make the grid smarter, greener, and more efficient. This new system will be far more responsive, interactive, and transparent than today's grid. It will also be able to cope with the changes on the way -- integrating new sources of renewable power, supporting the charging of electric vehicles, providing information to consumers about their usage, and allowing utilities to monitor and control their networks more effectively.

Other smart grid technologies are more visible to the customer. For instance, smart meters track electricity use in real time and can transmit that information back to the power company. Smart meters have been used by commercial and industrial customers for decades, but in recent years are slowly becoming cheaper to support deployment to residential customers as well.

Community changes

The end user community is also making changes that impact utility operations and drive the need for smart grid technologies. They are:

- *Distributed generation, including renewables and community-level storage. New sources of localized generation (sometimes supported by storage) are making a slow and steady move into neighborhoods. Generation can be gasoline, natural gas or diesel gensets, or even fuel cells. Or it can be of the renewable kind. The most common distributed renewable solar PV cells.*
    - *Distributed generation and storage impact system operations in several ways. Firstly, it brings in unpredictable sources of generation which can lead to fluctuations in power quality and/or back-flow to the grid. It also can represent a safety and protection issue due to its ability to cause two-way power flow in a system that is designed for one-way power flow.*

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Dr. Mani Vadari

- *The advent of electric transportation. Electric vehicles are making their mark in our society. As they become more popular, they'll be added to households already stuffed with power-hungry devices ranging from big-screen TVs to electric dryers. Adding a plug-in car to the grid is equal to about a third of the load of a house.*
  - *The key system operations issue is that these cars represent new load that tends to bunch up in some neighborhoods and can cause power outages. An equally important issue is associated with the life of distribution transformers at the local level. These transformers are designed to be used heavily during the daytime and cycle down in the night. This allows the oil to cool down (which is used as an insulator and coolant for the transformer). If electric cars charge for 4-8 hours every night, the transformers will not have a chance to cool down – potentially leading to more frequent replacement and more outages.*
- *Introduction of microgrids. Microgrids are slowly making their way into the modern grid, mainly on industrial campuses, university campuses, and military bases. By their definition, they are designed to be fully connected to the main grid or to operate independently.*
  - *The very feature that is their strength is also their complicating factor. When connected to the electric grid, all of their fluctuations need to be handled by the system operator who is still required to deliver high-quality electric supply to them. Microgrids also present the complexity of bi-directional power flow that needs to be managed for the safety and reliability of the grid.*
- *Introduction of smart appliances. Smart appliances are transitioning from development to commercialization. Appliance manufacturers are working with utilities to test various capabilities under different scenarios. It is anticipated that smart appliances will have an acceptance curve somewhat similar to that of the "Energy Star" appliances. If that happens, then it is quite probable that the percentage of smart appliances sold in the marketplace will slowly increase to become the default within the next 5-10 years.*
  - *From a systems operations perspective, the key is to leverage smart appliances to improve the stability and efficiency of the grid with limited impact on their owners' lives. The system operator's ability to manage discrete device components to reduce energy consumption at a moment in time, allows them to offer load management options such as demand response programs. System operators need to have tools that allow them to take advantage of these mechanisms.*

So what does this all mean to the system operator?

The smart grid changes everything for the system operator. The magnitude of change is very similar to the types of changes that happened during deregulation. Some of the key changes are:

Smart Grid 101 - How the smart grid is changing system operations

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- More automated processes are supported by trained people.
- Improved sensors that can instantly observe the state of the grid and transmit the information to different locations.
- Given the plethora of sensors and controls, there will be a paradigm shift from a centralized command and control mechanism to an advanced network of integrated systems both centralized and distributed which can make intelligent decisions.
- At the transmission level, the advent of PMUs is bringing in new tools that provide far more information to the system operator both at the predictive and at the reactive level. It is anticipated that transmission will still stay centralized.
- Distribution system operations will move from a paper-and-pin version of system control to more formal command and control centers using systems called DMS, OMS, SCADA, GIS, and others. It is anticipated that distribution will convert itself into a combination of centralized and distributed control mechanisms.
- The system operator needs to move from dispatching a centralized set of controllable generators to a combination of centralized and locally distributed generation sources some of which are controllable and some of which (like wind and solar) are not.
- Adding a whole new dimension of cyber security and privacy to operations. Cyber security is getting a whole new look. For the first time, utilities are looking at large-scale use of public networks (such as cellular networks) to communicate with their smart sensors and devices. Cybersecurity standards are being developed and should become normal and accepted in the near future.
- Similar to the focus on cyber security, privacy is becoming an issue. This stems primarily from demand response programs that allow the utility (or other entities like aggregators) to control loads inside the premise. Privacy advocates are demanding increased levels of attention on the use and wide-spread availability of personally identifiable information (PII) and are working on developing standards for them as well.

These changes will breathe a tremendous amount of new life into electric system operations and make the operators more capable of making better decisions faster, better, and cheaper.