FUTURE OF THE SMART GRID AND ITS IMPLICATIONS FOR ELECTRIC UTILITIES

It is a well-known fact that the electric grid has evolved considerably over the past 10 years.

The smart grid systems that have already been deployed have enabled utilities to improve the effectiveness and efficiency of their operations, particularly as it relates to reducing the frequency and duration of power outages, providing finer control of operating parameters (e.g., voltage), and enabling greater customer participation in the management of their electricity through the application of advanced metering infrastructure (AMI).

In addition, in recent years, there have been accelerated deployments in renewable energy resources (distributed energy), electric vehicle (EV) charging infrastructures, grid-interactive buildings, microgrids, and more.

These technologies, which consumers and technology service providers often own and control, are introducing significant complexity and uncertainty to grid planners and operators. Due to the changing resource mix and industry composition, the electric grid must now evolve to a new operating structure with advanced functional capabilities.

It will now need to manage variable power output, fluctuating and unpredictable load patterns, and bidirectional power flow, as well as enable novel grid designs. It will also require effective, time-dependent coordination among all participants (utilities, market operators, and emerging players) to ensure the reliable operation of essential and evolving grid functions.

The existing electric grid was not designed to handle these new demands and will require significant re-engineering, involving advancements in both technology and institutional planning processes. In specific, smart grid technology and strategies for deploying it are essential to addressing this new, evolving complexity.

What makes the grid “smart” is essentially the application of digital, cyber infrastructure working with the physical system to perform the functions of sensing, communications, control, computing, and data and information management to inform planning and operations.

As the grid evolves, it will need to build out a core cyber-physical electric platform that will ensure an ability to serve multiple purposes (e.g., resilience, security, efficiency, affordability) while addressing uncertainty with regard to future technological options and changing customer preferences and policies.

In addition, plans will need to be made for the convergence of the electric infrastructure with other systems, such as the transportation, building, natural gas, telecommunications, and even social-networking infrastructures.

In sum, electric utilities now face a dramatic structural transformation as the trend toward decentralization with greater customer participation, combined with increased use of renewable energy, will shape future grid designs. The ability to manage the transformation will require technological and institutional solutions and an industry that can organize sufficiently to make them possible.

Key Areas That Must Be Addressed

1 – One is the proliferation of a variety of distributed energy resources (DERs), which, as noted above, are often not owned by the utility. This scenario shifts the operational paradigm from one of control to one of control and coordination.

Coordination is the process that causes or enables a set of decentralized elements to cooperate in solving a common problem, such as working together to undertake a specific grid operation. As DERs begin to influence how we generate and use electricity, utilities will need to institute processes that can effectively coordinate grid planning, operations, and market design/implementation, not only among utility and nonutility participants, but also across federal and state jurisdictions.

This new focus on improving coordination is occurring, but it is in an early stage, especially among regional system operators and states. Coordination frameworks are thus needed in order to delineate the respective roles and responsibilities of all participants within the bulk power, distribution, and customer system domains.

2 - Research and development, combined with technology demonstrations focused on system integration, will be required in order to enable the transition from existing legacy infrastructures to more advanced grid infrastructures.

Utilities are understandably cautious as they test and install new systems that must integrate effectively with legacy infrastructure and perform to meet stringent requirements. For example, testing, demonstrating, and deploying new systems can take more than ten years.

In order to effectively advance the application of new technologies that will be needed to ensure

grid modernization, more efforts are needed to test and demonstrate the integration of new concepts in actual real environments.

Research, development, and demonstration (RD&D) efforts are needed in the following areas:

- The advancement of solid-state materials and components to improve the performance of power electronics devices that are needed to control the flow and characteristics of electricity as the nation becomes more reliant on renewable and distributed resources.
- The development of novel electrochemical approaches to improve the performance and reduce the cost of energy storage devices, while minimizing reliance on scarce or critical materials.
- The development and demonstration of low-cost, multiparametric sensors and supporting platforms that can provide observability of grid assets and the state of the system to support highly dynamic grid operations.
- The implementation of methods to enable the exchange of data using standardized data formats across disparate systems, combined with providing technical support to utilities, in order to advance data analytics practices across the industry.
- The advancement of communications networks that are scalable and that can support multiple functions, such as real-time control of DERs and automated feeder switching.
- The demonstration of grid architectures that address operational control, coordination, and scalability issues, as the electric grid begins to accommodate many more distributed assets and participants with potentially conflicting objectives.

3 - Achieving “plug-and-play” interoperability will remain a challenging and long-term task. Interoperability is the ability to safely, securely, and effectively exchange and use information among two or more devices and systems. This means that the myriad devices and systems deployed on the grid need to function in coordination under, potentially, a wide variety of operational situations.

Achieving true plug-and-play interoperability - having devices work perfectly when first used or connected without significant reconfiguration or adjustment of grid systems - will continue to be a challenging and long-term task, due in part to past decades of incremental modifications to grid systems, which have resulted in an often uncoordinated mixture of protocols that utilities have used in order to communicate and share data.

In addition, utilities have typically relied on customized, proprietary solutions provided by technology vendors to build their systems. Significant efforts to develop and institute industry standards will need to continue, so that disparate systems can communicate, and so that new devices can cooperate with each other within the operational environment of the grid.

Standards development efforts typically have been limited in scope, however, and generally have not addressed whole-system integration. To this end, efforts are being made to develop a set of interoperability profiles designed to provide a more holistic view of how devices and systems need to cooperate for given situations.

Industry is expending significant effort to apply software solutions (e.g., middleware) in order to enable interoperability between disparate devices and systems. Even so, interoperable systems are still relatively new, but, since they have such a great deal of potential, bear considerable time, attention, and scrutiny.

The long-term solution for seamless interoperability could involve building out a standards-based sensor/communication platform that will be able to take advantage of modern networking technology and provide multiple connection points for devices and applications. Such a platform, combined with standards and security protocols, would permit authorized devices and software to access the platform for data and to communicate with each other in a structured, but flexible environment.

In addition, evolving current legacy systems so they can apply a sensor/communication platform is a long-term undertaking that will require significant RD&D and coordination with industry stakeholders. Such a platform would enable future grid capabilities, including knowledge transfer and machine learning among smart devices.

4 - Finally, a discussion of the "future of the smart grid" would be incomplete without a discussion of the growing area of broadband implementation, which relies significantly on the "smart grid" for its success. This is often called the "energy internet," and it has emerged from the almost limitless possibilities of energy sharing networks formed by interconnection of electricity producers and consumers with renewable energy sources/systems, electric loads, and storage devices. The "energy internet" represents a radical transformation of the traditional electric grid by orchestrating real-time bidirectional power and communication flows. This transformation is expected to be resultant of ongoing renewable energy transitions and evolution in the energy technologies such as smart grids, storage devices, vehicle-to-grid, etc.

Utilities interested in receiving funding for integrating broadband with their smart grid technologies will be very interested in the new Broadband Equity Access and Deployment (BEAD) program. BEAD, which was established by the Infrastructure Investment and Jobs Act (IIJA), appropriates $42.45 billion for states, territories, and the District of Columbia (DC) to utilize for broadband deployment, mapping, and adoption projects.

In order to participate in BEAD, states, territories, and DC will be required to submit a Letter of Intent and then may request up to $5M ($1.25M for territories) to support planning efforts, including building capacity in state broadband offices and outreach and coordination with local communities.

If states, territories, and DC elect to receive the initial planning funds, they will be required to submit a five-year broadband action plan, which will be informed by collaboration with local and regional entities. Again, smart grid readiness is critical in this regard.

Finally, once the final financial allocations are determined, states, territories, and DC will be required to submit an Initial Proposal and a Final Proposal (both of which need to be approved by National Telecommunications and Information Administration) that outline the intended use of their funding allocation.

About Finley Engineering

Finley Engineering is a full-service engineering consultancy with a successful history of providing expertise in communications technology and energy engineering services for a wide variety of clients such as independent telecom providers, electric cooperatives, municipalities, competitive providers and government entities.