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Smart Transmission: Making The Pieces Fit

An emphasis on high-level automation must complement substantial investments in traditional transmission assets.

Many areas of the U.S. are overdue for large-scale transmission upgrades.

By Heath Knakmuhs

Today, North America's high-voltage electric transmission system is an aggregation of evolving networks of complex physical and information systems that enable the flow of electricity across and between regions. Transmission systems are already "smart" in the kind of sophisticated monitoring, market and control technologies that are employed to manage the flow of power.

However, the physical and public-policy demands on the grid are changing, and grid operators and transmission providers - both incumbent utilities and new market entrants that propose to build and own transmission facilities on a merchant basis - are making new investments in physical transmission and information technology infrastructure to modernize the grid and make it even more efficient, intelligent and secure.

Investments in smart transmission technologies can provide a range of benefits to power customers and to the markets that support the electricity trade. Although these benefits vary according to the type and location of smart technologies, the installation of new digital devices can yield functionalities aimed at achieving a number of improvements. The benefits include the following:

■ Increased reliability;

■ Increased electricity throughput at a lower delivered cost;

■ More efficient fuel use for generation, yielding lower air emissions;

■ Greater use of renewable and other clean generation resources, with lower operational integration costs;

■ More effective use of energy storage to lower the costs of peak electricity provision;

■ The facilitating of third-party participation in the power system; and

■ The fostering of wholesale and retail markets by improving the information available to customers and market participants on grid conditions and electricity prices and usage.

Smart grid ops

Every day, advanced technologies are proving their value on the grid. Although they are as widely deployed across the transmission system as on any other part of the electricity system, modern technologies themselves are not a panacea for what afflicts the system. Despite the installation of modern communications technologies on the high-voltage network, a significant reduction in direct, real-time human control of all aspects of the system in favor of equally (if not more) reliable automation is still needed.

The smart transmission system of

the future will include myriad devices scattered over a wide area to maintain the grid in a steady state - and it will do so faster than a human controller possibly could. In addition to improved relays and common control platforms, the development and deployment of an information-enabled dynamic control infrastructure - operating on autopilot from a reduced number of proprietary control platforms - will be essential in order to significantly reduce the potential for human error.

Moreover, the ability of the grid to "heal" itself promptly when an interruption threatens or occurs will depend on the use of system-monitoring platforms that archive millions of past system "states," against which adjustments can be made. In turn, the grid will actually evolve by itself.

Although smart grid investments will strengthen transmission and generation systems in many ways, they cannot replace conventional wires in the air and steel on the ground, in terms of new or upgraded facilities. Computers, information technology and communications alone cannot deliver generation from location-constrained renewable power plants to customers if physical transmission capacity either does not exist or is very limited.

Similarly, congested transmission lines cannot deliver high volumes of power between regions without the construction of new high-voltage lines. Large metropolitan areas with growing loads will need new smart substations and other equipment to maintain - at the very least - existing levels of reliability. Also, enhancements of the physical backbone of the high-voltage transmission system may be needed in order to improve system redundancy and resilience in response to the potential for terrorism and cybersecurity breaches.

The obstacles

On a per-capita basis, Americans are consuming more electricity than ever before. Even with the growing use of energy efficiency, demand response and distributed generation, new challenges - such as demographic shifts and concentrations of energy users, urban sprawl and changing patterns of energy use - will drive the need for new transmission facilities.

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Economists who have studied various future scenarios predict that the nation will require as much as $300 billion in transmission investment by 2030 - of which only about one-third will be a direct response to public-policy directives that necessitate increased reliance on renewable energy resources. Much of this investment will be driven by the reality that most of the existing transmission system was built over 30 years ago, and many of those facilities have been overutilized and insufficiently updated or maintained.

Consider that 70% of the U.S.' transmission lines are at least 25 years old, 70% of the large power transformers are at least 25 years old, and 60% of the circuit breakers are more than 30 years old. Consider further that most of those facilities were built before digital technologies were available. Failed or degraded transformers have caused restricted thermal ratings or rerouting that have caused hundreds of millions of dollars in congestion costs and reduced the country's grid reliability over the past few years. Such failures have resulted in local brownouts and outages and, on occasion, caused wide-area blackouts.

According to the U.S. Department of Energy, major power outages and power-quality problems cost the U.S. economy as much as $180 billion annually. With increased load on the system and electricity transmission over greater distances come greater line losses and wasted energy. In the absence of major load reductions, only technology-driven efficiencies or significant transmission capacity improvements will be capable of maintaining system throughput efficiency.

Dealing with constraints

Capacity constraints on existing transmission systems in some regions make any interconnection of new generation to the system more difficult. The challenge of integrating new capacity, especially where the demands of public policy are at stake, can be daunting. In the California Independent System Operator market, for example, there are 375 power plants in the queue awaiting interconnection agreements, representing over 52 GW of capacity, and another 30 projects with executed agreements. Approximately 70% of California's queued capacity represents renewable generation, which is favored under the state's renewable portfolio standard (RPS).

Regional transmission organizations and regulators continue to seek ways to streamline long and costly interconnection queues, where new generators are awaiting sufficient transmission capacity to enable delivery of their power to load. The integration of new renewable energy resources will, therefore, require new and upgraded transmission.

For instance, with the help of the Midwest Independent Transmission System Operator (Midwest ISO), the Upper Midwest Transmission Development Initiative (a coordinated effort among Wisconsin, Minnesota, Iowa, North Dakota and South Dakota) has developed plans to meet the five states' existing RPS. Those plans were developed by the Midwest ISO as part of the Regional Generator Outlet Study, which looked at the transmission needed to move 15 GW to 25 GW of incremental wind generation throughout Midwest ISO territory.

The grid operator also developed, and the Federal Energy Regulatory Commission recently approved, the so-called Multi-Value Project (MVP) cost-allocation proposal, which would allocate the cost of regional MVPs to the entire Midwest ISO footprint. Currently, the Midwest ISO is analyzing approximately $5 billion of new 345 kV and 765 kV transmission that would be eligible for MVP cost-allocation status and be built between now and 2020.

In Texas, Oncor Electric Delivery, Lone Star Transmission LLC and other investors are building over 2,300 miles of new 345 kV transmission lines and upgrading others dedicated principally to integrating more than 18 GW of wind power. Without these new transmission facilities, these wind generators would not be able to connect to the grid, and customers would be denied access to renewable generation that they may prefer and that state energy policy mandates.

In all of these cases, new communications and control technologies will be instrumental in optimizing the efficient use of the new transmission facilities. The combination of conventional transmission technologies with advanced smart grid elements will optimize the value of transmission investments and enhance transmission's value and service.

Heath Knakmuhs is director of federal affairs for American Transmission Co., and he also serves as vice president of WIRES (Working Group for Investment in Reliable and Economic Electric Systems), a nonprofit association of transmission providers, customers, and equipment and service companies that promotes investment in electric transmission and progressive state and federal policies. He can be reached at hknakmuhs@atcllc.com. For a more detailed look at smart grid issues related to the transmission network, see "Smart Transmission: Modernizing the Nation's High-Voltage Electric Transmission System," which is available on the WIRES website at wiresgroup.com.