Commissioner-Led Reliability Technical Conference
Panel II: Emerging Issues – Part II

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The integration of renewable energy could offer a number of benefits in power system generation, transmission, distribution, and delivery including the provision of clean energy with a long life, modular and expandable source with no T&D costs, fixed cost of electricity delivery (cents per kWh), pollution free and often quiet energy source, reliable energy supply in certain geographical regions with minimal maintenance, competitive with the cost of thermal energy, and minimal contribution to green-house gases. The application of demand response (DR) in competitive electricity markets could maximize/ leverage potential benefits associated with variable renewable energy and distributed energy resources. The implementation of DR could include the hourly shifting of non-essential local loads, hourly load curtailment (peak shaving), use of onsite generation, and battery supply for local load management.

A practical approach to combining the benefits of DR with those of renewable energy for enhancing reliability, resilience, economics, and security is the use of microgrids. Technically, a microgrid is a system with at least one distributed energy resource (DER) and one demand, which is considered as a controllable load from a utility's point of view. In practice, microgrids are introduced to address the emergence of a large number of DERs in distribution systems which can ensure optimal operations of potentially islanded power grids. Microgrids generate, distribute and regulate the flow of electricity to local customers, representing a modern small-scale power system with a high degree of flexibility and efficiency in both supply and demand sectors. The DERs located within a microgrid differ from conventional power plants as they possess a smaller capacity, are directly connected to the microgrid distribution network, and could be customized to supply local load requirements. The hourly operation of a microgrid is controlled by the microgrid master controller instead of a central dispatch provided by the utility. During main grid disturbances, microgrid is transferred from grid-connected to island mode and an uninterrupted supply of consumer loads is offered by local generation resources. The islanded microgrid would be resynchronized with the main grid once the disturbance is removed.

Considering the power system reliability (high probability/low impact events), electricity grid would have to be designed and operated so as to operate under a given range of critical conditions and be able to withstand credible contingencies. Here, the main focus of reliability enhancement is on N-1 and N-2 outages (i.e., events in which one or two system components would be on outage). Such low impact outages could be followed by insufficient awareness or preparedness for resilience (low probability/high impact events). Hurricane Sandy, for instance, was an N-90 contingency. Long Island lost the entirety of its tie lines to Connecticut and New Jersey, and New York City lost all its ties to New Jersey. The hurricane left about 7.5 million people without power across 15 states. At the same time the only sections of the power system that remained energized where the ones that were equipped with controllable microgrids. The widespread outages in the wake of such natural disasters cast light on the fact that the resilience cannot be ensured, but deterioration can often be controlled locally at a tolerable level until full services are recovered at the large grid level.

In addition, modern societies are often developed based on the interdependency of critical infrastructures such as electricity, communication, transportation, natural gas, and water. The potential for cascading outages can lead to numerous supply problems in such infrastructures. The control and the management of such large interdependencies could necessitate sophisticated modeling and simulation tools. The advent of distributed microgrids, however, could provide several coordination opportunities, thereby rendering the interdependent infrastructures resilient against extreme events.

In practice, a microgrid would be considered an energy hub where interdependent energy carriers are installed, converted, and conditioned. In this way, the coordination of energy infrastructures can improve the reliability, resilience, economics, and security of the associated interdependent infrastructures. For example, in critical circumstances the electricity for supplying a microgrid/energy hub load could be offered by electricity grid, natural gas pipeline, or other forms of energy supply converted to electricity.