Ensuring Reliability with Increasing Levels of Distributed Energy Resources

A BRIEF FROM ESIG

As levels of distributed energy resources (DERs) rise, strategies for maintaining a stable grid are also evolving. New approaches include revamped forecasting and modeling, updated DER actions during grid disturbances, revised calculations for load-shedding during major grid disturbances, and market mechanisms that allow DERs, when aggregated, to have fuller market participation and provide a range of grid services in support of a reliable power system.

Improved Modeling, Forecasting, and Planning

DERs' relevance for a stable grid includes the electricity they generate as well as their behavior during and after a grid disturbance (such as the loss of a large power plant). System operators' approaches to modeling, forecasting, and planning continue to evolve on both counts.

System operators assess peak and off-peak conditions in their analysis of critical study conditions, the circumstances most challenging for grid stability. For systems made up predominantly of central power plants, utilities were able to predict with good accuracy the daily and seasonal fluctuations of customer demand and had a good understanding of when the most challenging conditions for serving load would likely occur. Now, with increasing levels of DERs, critical system conditions may change to other times or be more influenced by weather conditions (figure 1). On winter days, for example, solar output is often highest in the hours around noon, while demand typically peaks early and late in the day. In summer, in contrast, an afternoon peak in demand (such as from air conditioning load) may tend to *coincide* with high solar production. In light of these shifts, sensitivity studies are being performed for scenarios with varying types, levels, and combinations of DERs, generation, loads, and periods when load or generation is quickly rising or falling.

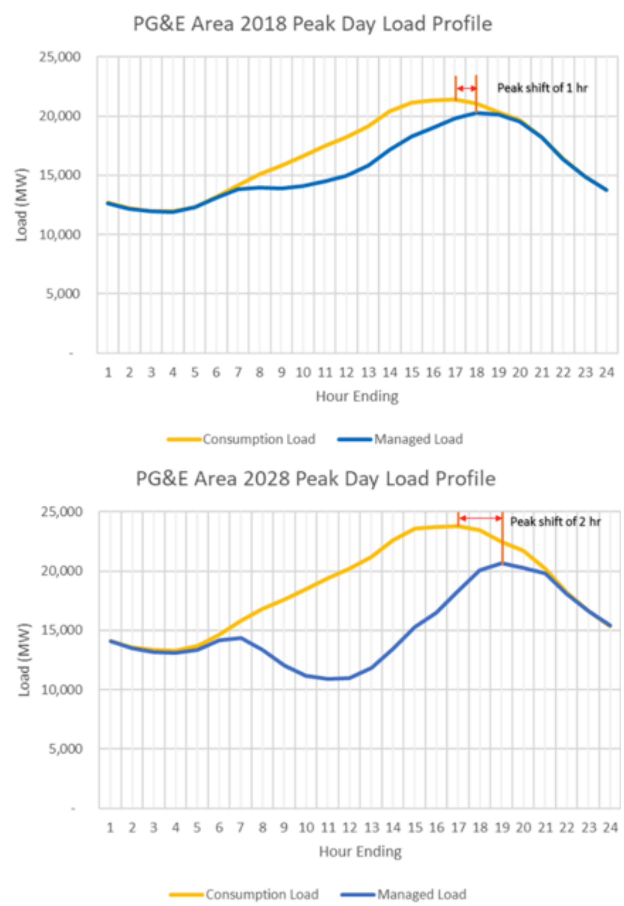

Figure 1. Impacts of DERs on net loads in the Pacific Gas and Electric system.

While DERs often appear in studies simply as subtractions to customer demand (treated as "net load"), the actual behavior of the power system is better predicted when customer demand and DER output are modeled independently. Such separate modeling of DERs captures not only their contributions of energy to the system but also their contributions to grid stability—both locally and for the bulk power system overall.

Evolving Responses to Grid Disturbances

The behavior of solar power systems and other DERs following a grid disturbance depends in part on the interconnection requirements at the time they were installed, with older, legacy DERs being more likely to disconnect from the grid. While older systems could be retrofitted to be able to fully "ride through" grid disturbances and respond differently, retrofitting can be costly and impractical. A more cost-effective option is to focus on new DER installations to ensure that they use the latest recommendations as outlined in IEEE 1547-2018 (the Institute of Electrical and Electronics Engineers' Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces).

A second trend in the maintenance of grid stability following disturbances is adaptive under-frequency load shedding (UFLS). Under-frequency load shedding is a preconfigured action by a protective relaying system that is taken after a major disturbance, intended to stabilize and protect the grid. Load is disconnected in carefully predetermined amounts and locations in order to rebalance the rest of the grid. However, as levels of distributed generation increase, the mixture and patterns of load (and now also DER generation) on a given distribution line becomes more complex. Disconnecting that line means not only shedding load (the goal), but also shedding generation (an undesirable consequence). Therefore, approaches to load shedding are being modified, moving from static relay settings to adaptive settings that use actual generation and load data for a distribution line rather than fixed values—thereby accounting for the actual system conditions at the time of the disturbance. These protective systems are likely to see continuing evolution with increasing levels of DERs.

Market-based Mechanisms for Grid Services

The reliability and economics of the transmission and distribution systems require enhanced operational coordination among the wholesale system, the distribution system, and DERs. DERs of different technologies at different physical locations can be aggregated and provide services to wholesale markets, retail markets, and end-use customers (figure 2). In some systems where market rules allow the aggregation of DERs to provide wholesale market services, DER aggregators work with the distribution system operator to meet local reliability criteria and coordinate with the operator to deliver the expected services.

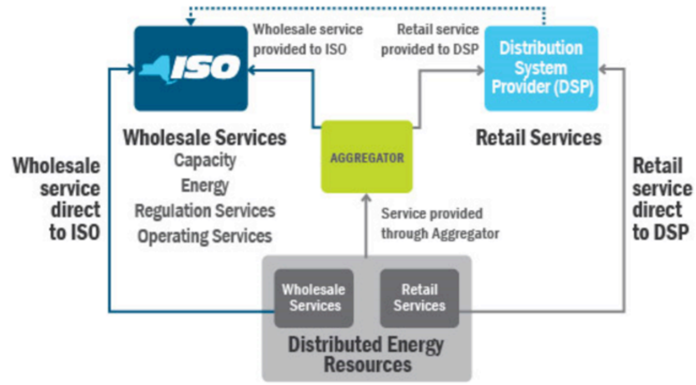

Figure 2. The New York Independent System Operator wholesale and retail market designs incorporating DERs.

In response to specific system needs—for example, transmission constraints—an aggregator can submit an offer to the system operator to provide certain grid services using all or a subset of the aggregated DERs (depending on their availability, cost, location, etc.). The aggregated DERs are evaluated along with offers from other generators on the system to provide the needed grid services.

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Requirements for grid connection of DERs are more important now than ever before, and interconnection standards are rapidly evolving to keep up with the transition from a power grid with centralized control to more distributed and decentralized architectures. Engagement with DERs by both distribution and transmission system operators is essential for maintaining the reliability of the bulk power system. The successful path forward will involve collaboration, communication, and coordination among all who generate, transfer, control, deliver, or use electric energy.

Adapted from Ryan Quint, Lisa Dangelmaier, Irina Green, David Edelson, Vijaya Ganugula, Robert Kaneshiro, James Pigeon, Bill Quaintance, Jenny Riesz, and Naomi Stringer, "The Impact of Distributed Energy Resources on Bulk Power Systems," IEEE Power and Energy Magazine November-December 2019. Guest editor, Charlie Smith, ESIG. DOI: 10.1109/MPE.2019.2933071.