

Smart Energy Management for Integration of Renewable Energies

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Abstract

Large-scale integration of wind power into power systems is happening in some regions of Europe and the US. Utility-scale wind farms and photovoltaic (PV) generation systems are interconnected to higher voltage transmission lines. Large share of these intermittent renewable energy generation in a power system leads to frequency problem and surplus power problem, not distribution voltage problem.

It is expected that large capacity of PV power systems will be installed in Japan and Germany. According to Japan's long-term energy outlook, the target capacity of installed PV systems for 2030 is about 53GW, which is greater than 25% of the peak load. Most of PV systems are interconnected to low distribution lines in Japan. One problem is the voltage rise at the distribution by the reverse power flow from roof-top PV systems. Another problem is over generation or surplus power by PV systems and it is difficult to keep frequency. Grid operators need more pumped storage hydro or battery storage. However, the storage battery solution cost a lot, as much as 16 trillion yen for integration of 28 GW of PV systems in 2020. These technical challenges for the grid need new solutions by smart grid. One of the solution is cooperative control of Distributed Energy Resources (DER) such as energy storage devices to reduce reverse power flow from PV systems. The smart house /building and devices with the responsive controls automatically respond to the signals from the system operator and optimize entire systems performance; comfort level, electricity costs, and CO₂ emissions. To adjust power balance at customer site, energy storage such as thermal storage and battery storage is one of viable options for smart energy management. The heat pump water heater can be operated with surplus power from a roof-top PV systems with a home energy management system.

The smart grid accommodates a greater emphasis on DERs and demand response (DR) to support integration of renewable energy generation as well as electric vehicle (EV) and plug-in hybrid vehicle (PHV). The Japanese government is promoting the development, installation of smart meters and relevant energy management systems, seeking to introduce them for all users, in principle, as early as possible in the 2020's. A Smart Pricing Pilot Program in Japan has conducted last summer. Next step is development and introduction of automated demand response system. It is an essential tool to make sure DR as a resource to control supply and demand in the future grid. We should reexamine the future resource mix of large-scale generation and DER as a smart grid after a solid assessment of the Japanese crisis in Fukushima.