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### “Demand and supply balancing technology under large penetration of renewable energy”

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#### Abstract

Large penetration of renewable energy of which output is changed by weather condition affects demand/supply balancing in utilities. Though demand/supply balancing can be achieved through renewable energy side or demand side, only supply side technology is considered in here. Progress of study and some demonstration projects in Japan on demand/supply balancing under large penetration of renewable energy will be explained.

The challenges of demand/supply balancing under large penetration of renewable energy will be summarized as follows:

(1) Uncertainties of output of renewable energy and operation planning/operation of generators.

(2) Insufficient balancing ability (quantity and speed) of thermal plants for long-period (slow) fluctuation component of renewable energy.

(3) Surplus power generated by insufficient step down ability of thermal plants.

(4) Increase of fluctuation of frequency by insufficient balancing ability of thermal plants for short-period (fast) fluctuation component of renewable energy.

Forecasting of the output of renewable energy becomes important to reduce uncertainties. Many methods to forecast the output of photovoltaics (PV) or wind power from several days earlier to several hours earlier are under development. Utilization of domestic interconnections is considered to support the balancing ability for relatively slow fluctuation of output of renewable energy. If the component of power correspond to slow fluctuation of output of renewable energy is transmitted to another area where there are enough balancing power, the rest of fluctuation becomes small and can be handled by existing thermal plants. For insufficient step down ability of thermal plants, it is considered as a practical approach to send constant base power via interconnections. This makes the increase of balancing ability of thermal plants of the sending area. Surplus power of PV generation becomes problem in spring and autumn when the electricity demand is relatively small and insufficient step down ability of thermal plants becomes obvious. In addition to the utilization of pumped storage, suppression of output of PV generation on demand from the control center of utility is planned as an effective approach. Large battery energy storage systems offer promise for frequency regulation as well as other balancing problems. Though the cost of battery energy system is high under present circumstances, it could be applied from many aspects. Transmission of the short-period (fast) fluctuation component of renewable energy via interconnections becomes one of the solutions for frequency regulation.