Integrated Control of Supply and Demand for Japanese Smart Grid

- Utilizing Surplus Electric Power of Photovoltaic Systems -

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Abstract

Large capacity photovoltaic (PV) systems will be installed in future power systems. According to Japan's energy outlook, the target capacity of PV systems for 2030 is about 50 GW. When a large number of PV systems are installed in a power system, the reverse power flow from PV systems may cause problems. One is the surplus electric power of PV systems because the supply becomes larger than the demand especially in low demand season.

To utilize the surplus electric power without the reduction of PV power generation, operation of customer equipment according to PV power generation may be effective. Therefore, integrated control of supply and demand for utilizing surplus electric power, which is including a new operation planning method of customer equipment such as heat pump water heater (HPWH) taking account of customer convenience, is proposed as one of the solutions.

The procedure of the proposed control method is as follows. First, the central control system of the power system estimates profiles of PV generation and load for the following day by the weather forecast and historical data. If the estimated PV generation is larger and there will be surplus electric power in the following day, the control system determines the maximum reverse power flow of the PV systems. Then, the control system sends the maximum reverse power flow at customer site to the Supply and Demand Interfaces (SDIs), which is a communication device installed at each customer site. The SDI determine the operation pattern of the HPWH taking account of customer convenience such as shortage of hot water, increase of electricity cost, and so on.

The effectiveness of the proposed control with HPWH is evaluated by simulation analyses using the model distribution system of residential area and solar radiation data in Tokyo. In the simulation analyses, it is assumed that the PV output is reduced when there is surplus electric power. By the simulation results, it was shown that the opportunity loss ratio of PV generation was reduced by the proposed control using HPWHs because the surplus electric power is utilized by the HPWHs. Influence of prediction errors of PV output estimation is also considered.