学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

Voltage Control via Residential Load Scheduling in Next Generation Power Distribution System

（次世代配電システムにおける住宅負荷スケジューリングによる電圧制御に関する研究）

Along with the development of smart grid, the power distribution system is changing greatly in recent years. Distributed generators (DGs) such as residential rooftop photovoltaic systems are integrated into the power distribution system. For the environmental concerns, electric vehicle (EV) technology is developing quickly. When the PV and EV are popular in the residential area, the voltage control in distribution system is becoming more complicated and challenging. High degree of PV penetration may cause overvoltage problem, while low voltage violation problem may happen when a large number of EVs are charging at the same time. On the other aspect, home energy management system (HEMS) and community energy management system (CEMS) are developed at demand side to visualize the energy usage in the home, control the smart household appliances automatically and manage the home energy consumption more efficiently.

This research aims to introduce load scheduling method for voltage control in next generation power distribution system. A central CEMS and multi-sub-CEMS model in the distribution system is proposed to utilize the load scheduling for voltage control. In this structure, central CEMS is the main controller, and each sub-CEMS independently and concurrently manage its covering customers' schedulable loads (SLs) for the voltage control. A day-ahead load scheduling and a real-time load rescheduling method are proposed based on the central CEMS and multi-sub-CEMS structure. The day-ahead scheduling is formulated as an optimization problem and genetic algorithm (GA) is applied to solve the optimization. The objectives are to maximize customers' profit and reduce the distribution system voltage violation frequency. The starting time of the SLs are decided through GA in the day-ahead scheduling. In the real-time operation, a coordinated real-time voltage control of an OLTC and CEMS is proposed. The main objectives of this control are to 1) relieve the stress in the OLTC tap operation by rescheduling the SLs working time by each sub-CEMS, and to 2) follow the day-ahead schedule as much as possible. The minimum real-time SLs rescheduling performed by each sub-CEMS is formulated as a nonlinear scheduling optimization problem, which is solved by a sequential search method named voltage ranking-based load combination search algorithm (VRLCS).

The proposed methods are first simulated on a 12-customer small distribution system and then on a 1800-customer large normal Japanese distribution system. The simulation results validate the effectiveness of the proposed methods. Besides, reactive power generated by PV inverter is also applied in the overvoltage regulation. At last, the value in voltage regulation of the proposed system is carried

out by a equivalent SVC capacity.

With the development of smart grid, demand side management (DSM) is recognized as an important part in the next generation power distribution system. The load scheduling program in the DSM introduced by this research can be a good supplement for voltage control in next generation distribution systems and may help save a large sum of control device investment.