Project Subjects

Integrated Operation and Control Techniques of Supply and Demand Sides in Autonomous Demand Area Power System

Background and Objective

Penetration of distributed power generation (DG) using renewable energy may be accelerated to cope with the problem of global warming. Photovoltaic power generation (PV) is expected to be a main renewable energy source in Japan. In addition to establishing the techniques in a utility distribution system level for grid stability, developing integrated operation techniques for both supply and demand sides including utilization of DG will be required for large penetration of DG. The purpose of the study is to develop proper operation and control techniques of Autonomous Demand Area Power System (ADAPS) using integrated technique of supply and demand sides to facilitate smooth introduction and efficient use of DG with renewable energy sources.

Main results

1. Development of utilization technique of PV surplus power

As a measure for coping with the surplus power problem with large penetration of PV, a planning method on next day operation of customer loads was proposed (Fig. 1-a). A heat pump type water heater, which has flexibility in its operation, was selected for the target of the control. The effectiveness of the method was confirmed through simulation in which annual supply and demand of a customer is analyzed using relationship between weather forecast and actual PV power output, load consumption data, etc. In the simulation, required limit of reverse power to the grid was changed as a parameter. The results show that PV energy loss due to reverse power limit[*1] can be reduced remarkably by the method so that the maximum monthly loss reduction rate reaches about 60% (Fig. 1-b) [R09023].

2. Stable operation of PV in voltage sag

To keep grid stability with large penetration of PV, it is required that each PV, for instance, recovers its generation power immediately after a voltage sag caused by a lightning strike on a transmission line. A voltage sag test of Japanese representative 10 power conditioners (PCS) for PV by 9 manufacturers was carried out. The results show that improvement of PCS control method is needed because output power of PCS generally tends to change remarkably after a voltage sag (Fig.2) [R09015].

3. Voltage regulation method of ADAPS taking account of customer's power factor

In examining voltage management of a distribution line in the near future, a voltage rise due to the "Ferranti effect" due to static capacitor installed in high voltage customers for power factor improvement should be taken into account in addition to the voltage rise due to reverse power flow from PV. A simulation study was conducted to establish proper voltage control methods with distribution line control devices such as SVC and SVR. The results show that combination of SVC with a centralized control[*2] and SVR is highly promising in minimizing both device capacity and distribution line loss (Table 1) [R09014].

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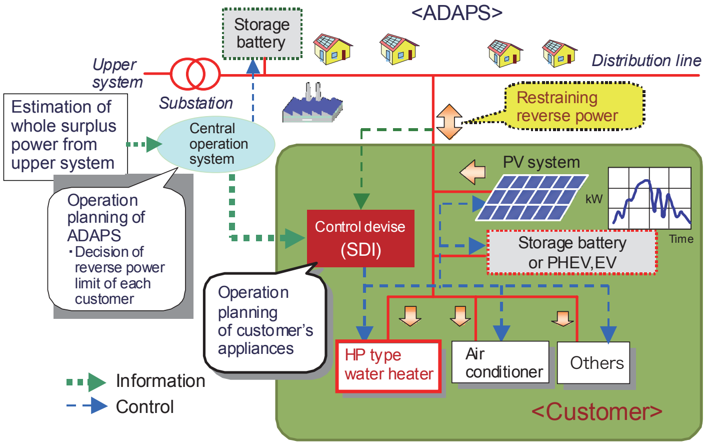
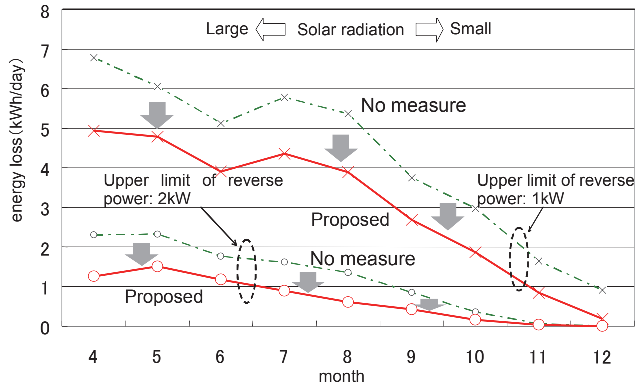
*1: Restrained PV generation energy for satisfying required limitation of reverse power.

*2: SVC control with remote communication functions to keep distribution line voltage within proper range for whole distribution line.



(a) Concept of operation planning method of customer's loads for coping with surplus power

The method carried out only when surplus power for the whole grid is expected according to weather forecast, etc. Uncertainty of forecast is taken into account in the method using past statistical data.



(b) Example of improvement of customer average daily PV energy loss in every month

4kW PV is assumed. If necessary, HP type water heater is operated during daytime for PV energy loss reduction. Upper limit of reverse power from customer to the grid is set constant during a year for the sake of simplification.

Fig. 1 Concept and effect of proposed customer operation planning method of next day for utilization of PV surplus power

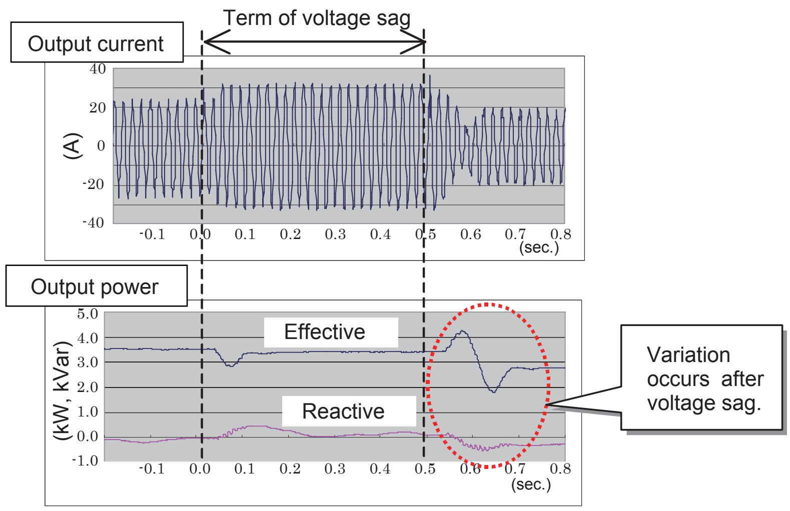


Fig. 2 Example of operation characteristics of PCS for PV in the event of voltage sag

The result is in case that voltage reduction rate is 30% and voltage sag continuance time is 0.5 sec. It is clear that PCS output power changes remarkably just after voltage recovery.

Table 1 Comparison of voltage regulation methods using SVC and SVR

	Conditions		Results		
Controlled devices	Control method	Installed site in distribution line	Loss in distribution line (kWh)	Required capacity (kVA)	Evaluation
SVC	Local	Middle, End	1036	1757	△
SVC	Centralized	End	873	1740	△
SVC+SVR	Centralized	End	684	1044	○

Note; Range of PV penetration ratio to maximum demand of distribution line is 0 to 100%. Necessary device capacity by which voltage can be controlled below 106V is calculated.