Project Research — Development of a Supply/Demand Infrastructure for Next-generation Electric Power

Operation of Trunk Power Systems in a Coordinated Manner with Autonomous Demand Area Power Systems

Background and Objective

In Japan, a high penetration of renewable generations such as photovoltaic (PV) generation and wind power generation is expected in the future. This high penetration may have an impact on power quality. For example, there are concerns that the quality of voltage and frequency will become much more difficult to manage because of the unpredictability and fluctuation of intermittent generation output. Up to now, generating units connected to trunk power systems provide all of the supply and demand-balancing capability, including LFC capacity and reserve capacity, which is essential to maintain power quality. In the future, a high penetration of intermittent generation requires much more reserve capacity because of the forecast error of their output. Also, it is expected that new facilities such as battery energy storage systems (BESSs) will be installed in power networks, including those in the demand side. These facilities potentially have a capability that contributes to supply and demand power balancing. Therefore, the utilization of facilities such as BESSs as resources of reserve capacity can be an alternative for effective power balancing in future power systems.

In this project, the utilization of non-generation resources such as BESSs for the compensation of PV generation output forecast errors is considered (Fig. 1). An evaluation method is developed to show how the operation of generating units can be improved by such a utilization to contribute to the development of a cost-effective scheme of resource utilization.

Main results

1 Evaluation of the Effect of Reserve Capacity by Non-generation Resources

An evaluation method is developed to assess the effect of the utilization of non-generation resources to compensate for PV generation output forecast error. The method uses a supply and demand simulation method and evaluates how the reserve capacity required for generating units can be reduced and, consequently, how the capacity factor of those units can be improved through the utilization of non-generation resources. In this research, non-generation resources are assumed to compensate for PV output forecast errors exceeding a specified level. The main features of the developed method are as follows:

1) The developed method can clarify the relation between the capacity of non-generation resources utilized (kW, kWh) and the improvement of the capacity factor of generating units. This is useful in finding out how effective the utilization of non-generation resources is.
2) The developed method evaluates the operational capacity factor of generating units, i.e., the ratio of average output in operating hours to the rated capacity. This means that the method can focus on the effect on the operation of generating units.

2 Numerical Example Using the Developed Method

As a numerical example using the proposed method, an assessment of the effect of reserve capacity by non-generation resources is made assuming a holiday in May (Table 1 and Fig. 2). The measured data of solar radiation at the Akagi testing center and the assumptions of a smoothing effect are used to estimate PV generation output in this example. Also, assumptions are made regarding the PV generation output forecast error. Under these assumptions, the results show that a relatively small amount of non-generation resources can improve the capacity factor of generating units, when PV output forecast error is large.

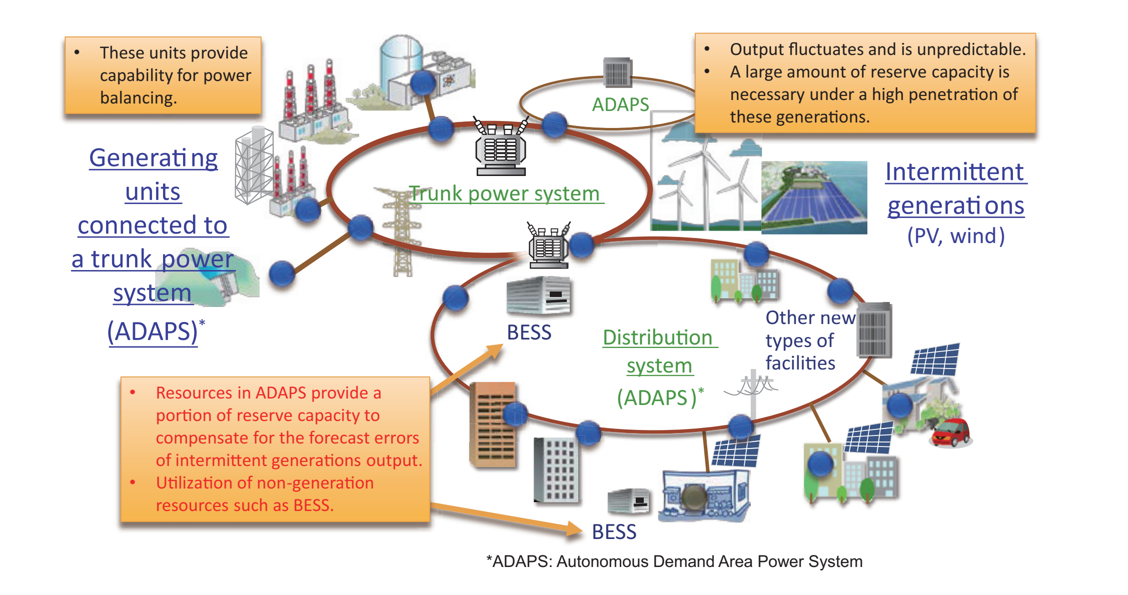
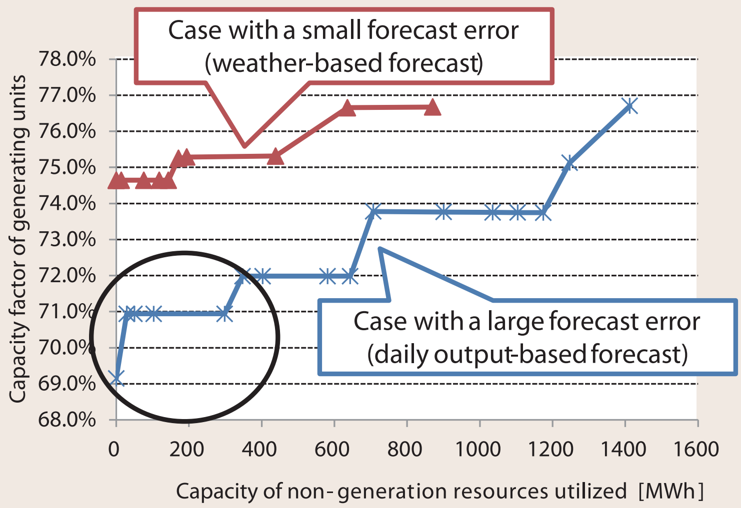


Fig. 1: Utilization of power-balancing resources under a high penetration of intermittent generations

Table 1: Assumptions in a numerical example

Demand	PV generation capacity	PV generation output	Hourly PV generations output forecast (one day ahead)	
			Estimation of forecasts	Maximum hourly forecast error (capacity-base)
･5,200 MW (on a holiday in May, 10 GW annual peak demand)	･2,940 MW (53 GW nationwide in Japan)	･Estimated based on measured data at the Akagi testing center and on the assumption of a smoothing effect	①Weather-based ･Based on hourly weather forecasts (no errors assumed) ･Small forecast error	18.6%
			②Daily output-based ･Bell-shaped forecast curve based on daily output (MWh) ･Large forecast error	31.6%



- A smaller forecast error and the larger utilization of non-generation resources cause the capacity factor of the generating units and, consequently, the generating efficiency to become higher.
- In this example, even a small capacity of non-generation resources can improve the capacity factor of the generating units, when the PV output forecast error is large, as pointed out by a circle in this figure.

Fig. 2: Relation between the capacity factor of generating units and of the non-generation resources obtained in the numerical example