Trunk Power System Planning and Operation Under Large Penetration of Intermittent Generations

Background and Objective

Large penetration of renewable generations is expected in the future. The output of these intermittent generations is difficult to predict and there is concern that the penetration of such generations will lead to degradation of power quality. Therefore, a novel operational scheme of power system to maintain power quality will be necessary.

In this project, a novel scheme is developed to allocate power balancing resources to both trunk power system and autonomous demand area power system, thus helping to maintain the quality of power frequency under a large penetration of photovoltaic (PV) generations. As a part of this development, an assessment method for necessary frequency regulation capacity is developed. Also, a control method of battery energy storage system (BESS) is developed to effectively compensate fluctuation of PV generation output in a coordinated manner with regulation resources in trunk power system.

Main results

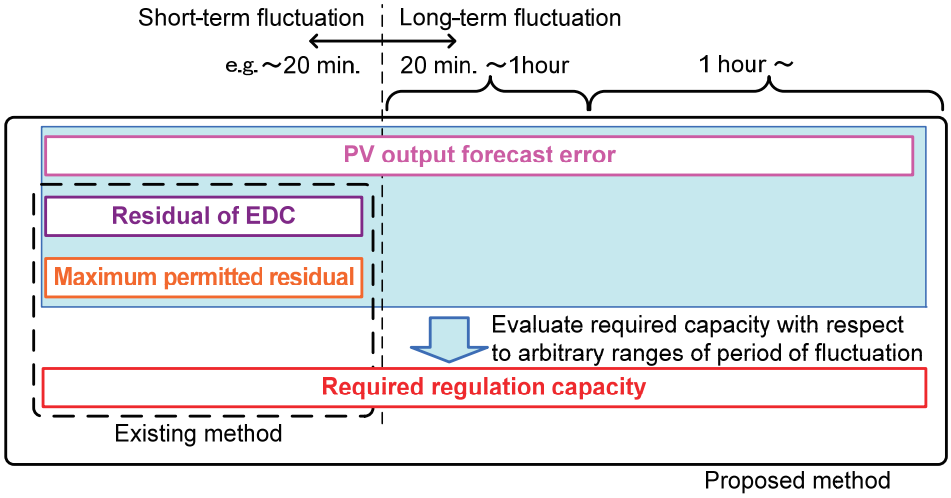
1. Development of assessment method for necessary frequency regulation capacity under a large penetration of solar PV generations

Frequency regulation capacity is required to compensate difference between ever-changing demand and generation output scheduled based on demand curve forecast. At present, this capacity is acquired mainly to compensate short term (up to 20 min.) fluctuation of demand.

However, under a large penetration of solar PV generations, additional capacity is required to compensate the forecast error of solar PV generation output. As the output of solar PV generations is difficult to predict, the forecast error can be large with respect to both short-term and long-term fluctuations. Therefore, a new assessment method for necessary frequency regulation capacity is developed, which is a modification of the commonly-used existing method (Fig. 1). The developed method can evaluate necessary frequency regulation capacity under a large penetration of solar PV generations (Fig. 2) [R10005].

2. Development of a control method for BESS to compensate output fluctuation of large-scale PV generation system in a coordinated manner with regulation resources in trunk power system

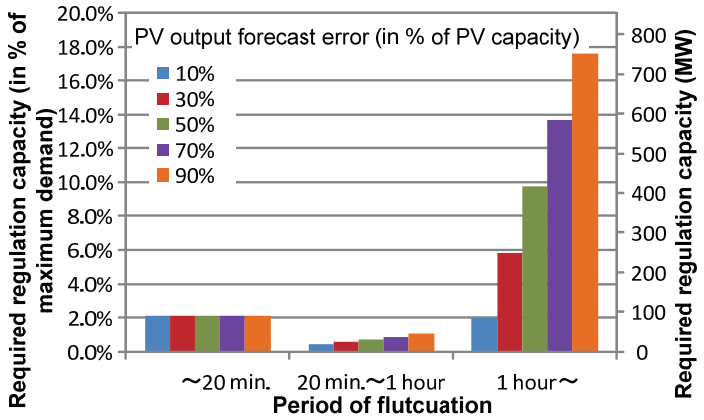
To compensate the output fluctuation of a large-scale PV generation system such as “Mega-Solar” systems, the coordinated use of regulation resources in trunk power system and BESS has been proposed, where regulation resources compensate long-term fluctuation and BESS compensates short-term fluctuation. However, existing control method of BESS has limitation in that BESS operates even when PV generation system output changes slowly. This leads to an undesirable increase of charge-discharge loss. Therefore, a novel control method of BESS is developed, which uses BESS only when the speed of output change of PV generation system is larger than the maximum speed of output change of regulation resources in power system [R10034]. The developed method can use effectively BESS according to the speed of output change of PV generation system (Fig. 3).



The proposed method can evaluate required regulation capacity under large penetration of solar PV generations by the following features:

1) Consideration of PV output forecast error
2) Evaluation of required capacity with respect to arbitrary range of period of fluctuation

Fig. 1 The developed frequency regulation capacity assessment method

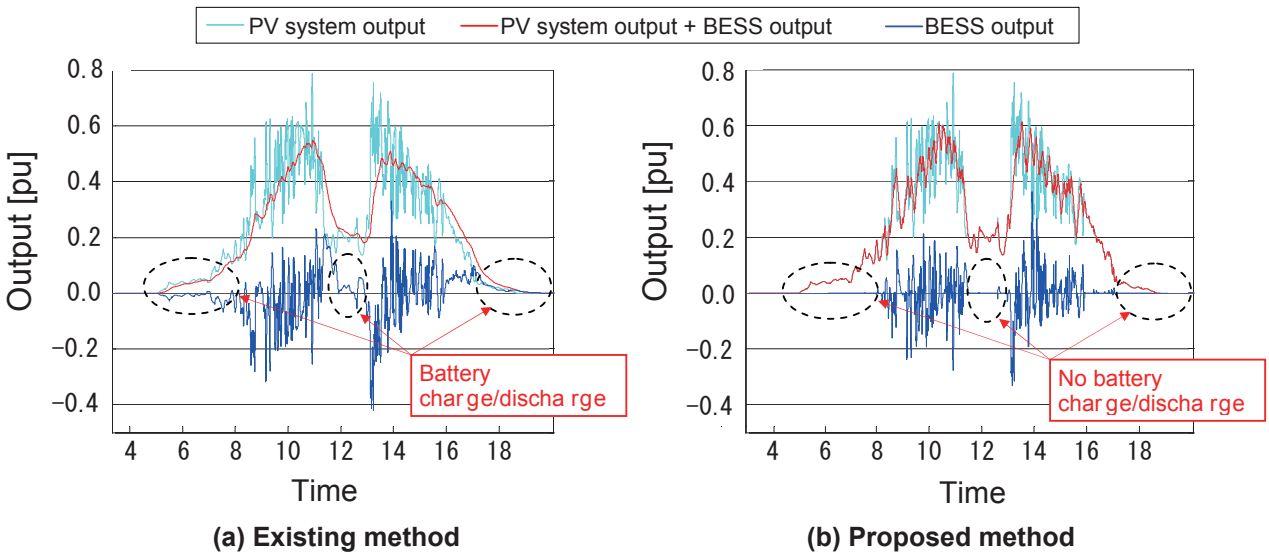


<Assumptions>

- PV output: assumed based on the measurements at CRIEPI Akagi testing center
- PV output forecast error (long-term)*): assumed to be proportional to PV output
- Demand: 4300MW (average in daytime)
- PV capacity: 1500MW
- Maximum permitted residual: 40MW (corresponds to 0.1Hz frequency deviation)

*) Short term (up to 20min.) fluctuation is assumed not to be predicted. Therefore, corresponding required regulation capacity is independent of forecast error.

Fig. 2 An example of required frequency regulation capacity assessment by the proposed method



(a) Existing method **(b) Proposed method**

Fig. 3 An example of compensation of large-scale PV generation system output

By the existing method, BESS operates even when PV system output changes not so rapidly, while the proposed method can avoid such operations.