Establishment of Control for a Battery Energy Storage System for Stabilization of Power Output of a Wind Farm

Background

Massive integration of wind power generation to electric power systems causes considerable concerns about operation of power systems due to a large fluctuation in its output. Therefore influence of the output fluctuation in wind power generation was examined in “New energy subcommittee of the Advisory Committee on Natural Resources and Energy” under Ministry of Economy, Trade and Industry. As a result, utilization of a battery energy storage system (BESS) was viewed as one of the promising measures for mitigating fluctuation on a wind farm (WF) side.

On the other hand, a demonstration project of a hybrid system composed of a wind farm and a BESS using a vanadium redox-flow battery has been conducted at “Tomamae Wind Villa Wind Farm” in Hokkaido since FY 2003 by the New Energy and Industrial Technology Development Organization (NEDO) (Wind Power Stabilization Technology Development Project). Stabilizing effects for short-term fluctuation have been examined in the project.

With this background, it is an urgent task to establish a set of controls for the BESS to achieve maximum stabilizing performance while capacity of the BESS becomes as small as possible.

Objectives

To establish a set of controls for the BESS to stabilize the WF output fluctuation (Fig.1); to clarify adequate capacity of the BESS in a sufficient performance to mitigate the WF output fluctuation for the short-term.

Principal Results

1. Numerical Simulation of Operation of the BESS

The simulation model, which had been already developed by CRIEPI, was adjusted to represent the features of the demonstration test facility. Fig.2 shows that numerical simulation results fully correspond to the results of demonstration tests. This made it possible to evaluate the stabilizing performance of the BESS even in the case of hybridizing with other wind farms.

2. Establishment of controls of the BESS

The BESS requires not only a control for maintaining charging-level within its proper range but also a control for reducing various losses in order to operate it in a stable and economic way. Therefore, we studied fundamental control scheme for realizing stable and economic operation, and examined a methodology for setting parameters of the controls. As an example, Fig.3 compares charging-levels with and without “State-Of-Charge Feed Back control” (SOC-FB control: to maintain the charging-level of the battery within its proper range). Fig.3 shows that the SOC-FB control maintains the charging-level of the battery within its proper range while stabilizing performance is not deteriorated much.

3. Analysis of required capacity of the BESS

Annual operation of the BESS in WFs was simulated to analyze required capacity (kW) of the system. As an example of the results, Fig.4 shows the distribution of required outputs of the BESS for Tomamae WF during each week on a representative winter month when the WF output varies remarkably. According to the results, it was confirmed that the required capacity was about 20% of the rated output of the WF if the capacity was determined so as to fulfill the stabilization task with probability of 98% during a year.

Moreover, according to a theoretical analysis on required energy capacity (kWh) of the battery, it can be estimated by the product of the rated output of the WF and the time constant T; T is the smoothing time constant of the first-order lag filter shown in Fig.1.

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Future Developments

Influence of wind power generation on electric power systems and its mitigation measures will be further examined.

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Reference

K. Yoshimoto, T. Nanahara, et.al., 2006, “New Control Method of Battery Storage System for Stabilizing Wind Farm Output (part 8)”, 2006 Proceeding of the Seventeenth Annual Conference of Power & Energy Society. IEE of Japan, 397 (in Japanese)

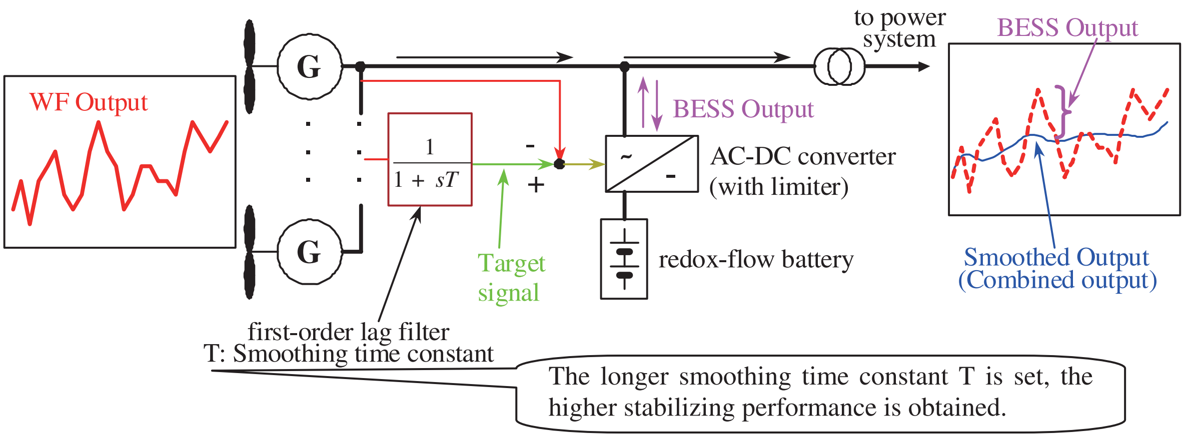

Fig.1 Outline of the hybrid system of the BESS and a WF

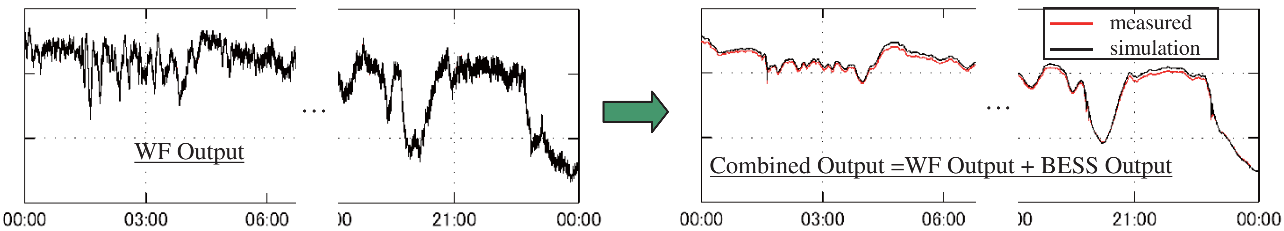

Fig.2 Comparison of a result of the demonstration test and that of the numerical simulation

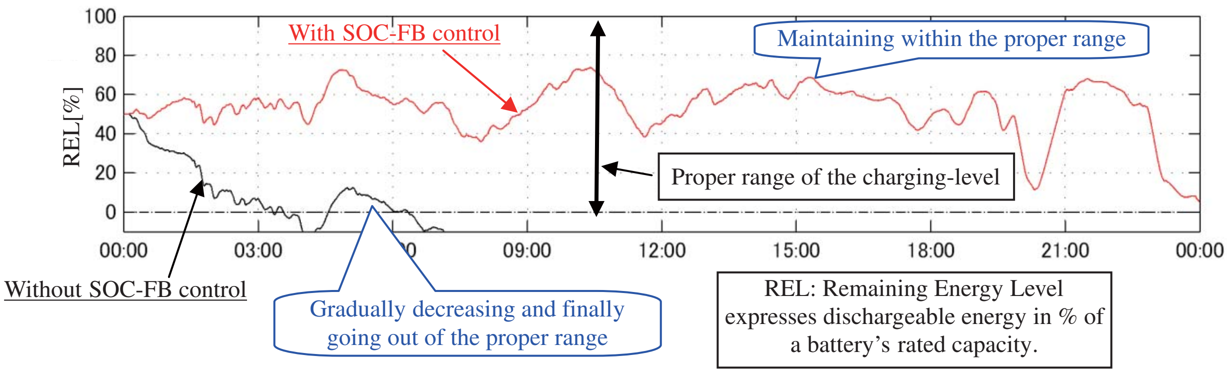

Fig.3 Charging-level in simulation results for the cases with and without the SOC-FB control

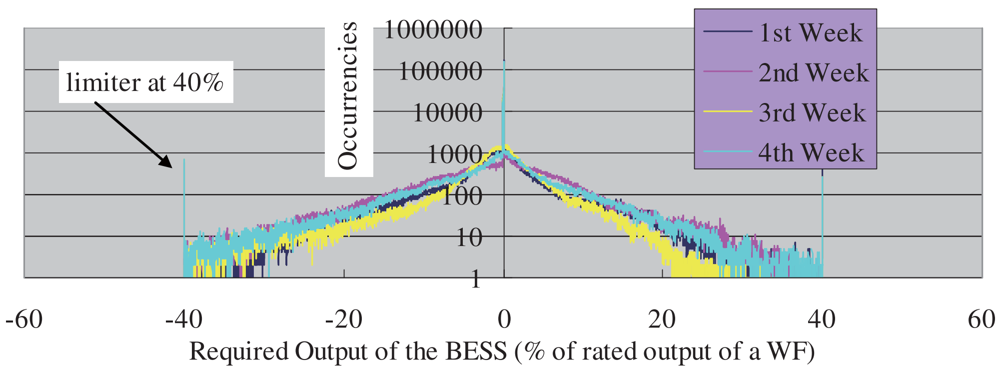

Fig.4 Distributions of required outputs of the BESS

(The simulation period of time is during a representative month in winter.)