Demonstration Project of Power System Stabilization with the Hybrid Battery Energy Storage System

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1 Abstract

The introduction of renewable energy is being promoted as a global warming countermeasure. The increase of naturally fluctuating power supplies, such as wind and photovoltaic power generation may influence the stability of the power supply. The introduction of a battery energy storage system is an effective method considered as a solution to this problem.

Hitachi group developed a hybrid battery energy storage system and started a demonstration project in 2015. The hybrid battery energy storage system was installed to solve problems occurring during an increase of the naturally fluctuating power supply on Izu-Oshima Island, Tokyo, where the effect of introducing the battery energy storage system could be tested relatively easily.

2 Purpose and Effect of Demonstration Test

- Verify the effectiveness on power supply stabilization of a hybrid battery energy storage system.
- Examine optimization of battery energy storage systems with capacity and output necessary for use in actual fields.
- Contribute to effective utilization and introduction of renewable energy.

3 Background of the Development

In a power system, hourly load fluctuations (power demand) caused by various factors and power generation (power supply) are controlled to keep them balanced. Loss of balance between the power demand and the power supply (demand and supply) causes fluctuations in the frequency and voltage and affects the stability of the power supply. Although adjustments to demand and supply are conventionally performed by controlling the output of the power generation (power supply) side, the larger scale introduction of naturally fluctuating power supplies might make the adjustment of output difficult within the current range. As a measure, attention is being paid to securing the ability to make adjustments using a power storage system; typical examples of focus are a variable-speed pumped-storage power generation system and a battery energy storage system. Although variable-speed pumped-storage power generation systems are a very effective means of making adjustments because the system can adjust power for large capacity and at high speed with a wide frequency control range, such systems have problems such as site conditions being restricted and the need for a long construction period.

This development concluded that a battery energy storage system can be applied to a wide frequency control range equivalent to that of a variable-speed pumped-storage power generation system (**Figure 1**). Hitachi Chemical has expanded the range of application of lead-acid batteries by achieving a longer service life and higher input/output based on safe, low cost lead-acid batteries with long sales records for industrial applications. In addition, in order to enable frequency control corresponding to pumped-storage power generation, we verified the effectiveness of the hybrid battery energy storage system by connecting this system to a real system for demonstration tests, in which frequency control function was enhanced by using lithium ion capacitors (hereinafter, LiC) that offer excellent short-time input/output. This research was implemented by Hitachi, Ltd., and Hitachi Chemical Co., Ltd., from 2011 to February 2016 in the NEDO Grant Program titled “Technology Development for Safe and Low Cost Large Scale Battery Energy Storage System.” In addition, demonstration tests are being conducted on Izu-Oshima Island, Tokyo, by connecting a 1.5 MW hybrid battery energy storage system to the real system from 2015 in cooperation with TEPCO Power Grid, Inc.

*NEDO: National Research and Development Agency New Energy and Industrial Technology Development Organization

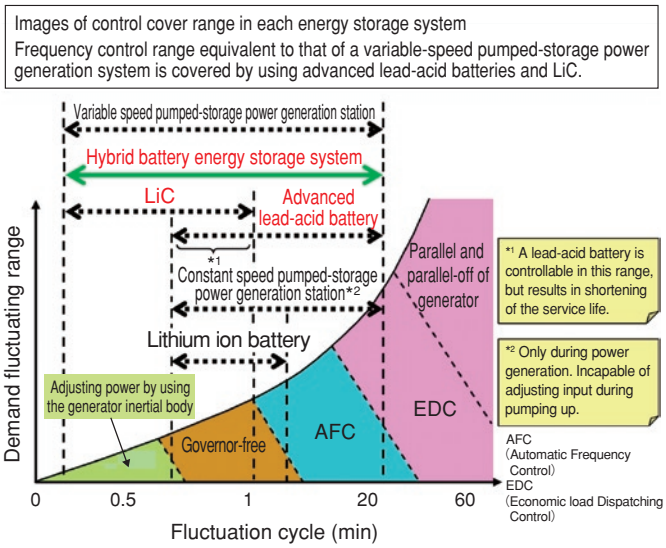

Figure 1 Conceptual diagram of each control range in the BESS

4 Technical Details

Introducing battery energy storage systems encounters the problems of cost and battery service life. Because a lead-acid battery has input/output characteristics lower than that of a lithium ion battery, the system requires larger battery capacity (Wh) in order to secure system output (W), which leads to the problem of a high initial cost. We consideredt improving the short-time output characteristics of a battery could decrease the battery capacity and reduce the initial cost and foot print of the battery in comparison with conventional batteries.

Table 1 shows the design concept of this development. In the new design, the coexistence of higher performance and a longer service life are the key points. At this time, an essential condition is that the adopted design avoids great increases in the manufacturing cost by utilizing existing manufacturing facilities and materials common to those for the current product group.

Table 2 shows the results of evaluating the designed battery. The newly designed product achieved all target values for higher performance. A trial calculation was performed to determine the effect brought about by achieving higher performance. As a result, we concluded that in the case of a system that discharges 1 MW of electricity for 0.25 h, the required battery capacity could be reduced by roughly 50% and the foot print by roughly 47% compared with the current product, leading to a reduced initial cost.

Figure 2 shows the advanced lead-acid battery actually installed on Izu-Oshima Island, and **Figure 3** shows the appearance of the LiC facility. In this battery where higher performance was achieved, the remaining problem is battery life in actual use. To evaluate the service life, we will retrieve the battery actually used on Izu-Oshima Island for investigation and continuously conduct in-house bench tests to clarify the difference from the designed value and pursue the feasibility of practical applications.

Table 1 Design concept of the advanced lead-acid battery

Item	Higher performance	Life elongation
Target	[Improvement in output characteristics] Achieve a maximum discharge current of 1.0 CA (Compared with current product*1: 2.5 times) [Higher capacity at high rate discharge] Improve one-hour rate capacity (Compared with current product: 1.4 times)	Design life: 20 years
Problem	Structure of current product makes it difficult to achieve higher input/output. →New design of battery structure required.	The result of a field product investigation revealed deterioration mainly due to corrosion of the positive electrode lattice.
Means for achieving	◇Increase the number of terminal poles. Examine the structure of the terminal part by simulations to reduce resistance of the part and to improve output characteristics.	Positive electrode lattice to be newly designed to achieve 20-year durability.
	◇Design of pole plate structure (Larger number of films) Reduce the current density to achieve higher capacity.	
Technical problem	Reduction in lattice thickness and increase in the number of pole plate structures improve the high rate discharge characteristics.	Reducing the lattice thickness lowers lattice durability and life durability.

Trade-off

*1 Compared with LL1500-W (manufactured by Hitachi Chemical Co., Ltd.) as the current product

Table 2 Test results of the advanced lead-acid battery

Check item	Current product*1	Target value	Result
Improvement in output characteristics	Discharge impossible due to voltage drop at discharge (F.V. = 1.8 V/cell)	Achieve max. discharge current of 1.0 CA	1.0 CA discharge achieved for 900 sec or more (F.V. = 1.8 V/cell)
Higher capacity at high rate discharge	Assume capacity at 0.60 CA discharge as 1 (F.V. = 1.8 V/cell)	1.4 times compared to the current product	3.1 times compared to the current product was achieved (actual value) (F.V. = 1.8 V/cell)
Life elongation	Investigation of field product performed Deterioration mode identified	Design life: 20 years	New design finished using past knowledge, etc. In-house bench tests and demonstration tests are continuously conducted for practical use evaluation.

Figure 2 Advanced lead-acid battery systems which were installed on Izu-Oshima

Figure 3 Lithium-ion capacitor systems which were installed on Izu-Oshima

5 Future Business Development

・Continuously evaluate life performance under practical use ・Productize an advanced lead-acid battery

【Reference】 Website of the National Research and Development Agency New Energy and Industrial Technology Development Organization: News Release, June 4, 2015