Large Format Hybrid Energy Storage System for Power Leveling

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1 Abstract

To prevent global warming, renewable energy sources, such as PV (photovoltaic) and wind power, are becoming increasingly popular. Since power generated via renewable energy sources fluctuates depending on the weather, when introduced on a large scale, power leveling using the BESS (Battery Energy-Storage System) is required. However, power-leveling applications also incorporate peak-cut, peak-shift, and power fluctuation suppression, for which different battery characteristics, e.g. in terms of power or capacity, are required. Accordingly, Hitachi Chemical Ltd. has joined Hitachi Ltd. to develop HBESS (Hybrid Battery Energy-Storage System), to provide an optimized combination of various battery technologies and a more compact and economical BESS with suitable capacity and power for the target application.

2 Key Features of HBESS (Hybrid Battery Energy-Storage System)

- Optimally combining multiple batteries with different performance characteristics can provide the BESS (Battery Energy-Storage System) with sufficient capacity and power for its targeted applications.
- The capacity, downsizing and service life of BESS (Battery Energy-Storage System) can all be successfully optimized.

3 Development Background

In recent years, to counter global warming, renewable energy sources such as PV and wind power generation have been drawing increasing attention as clean energies; eliminating carbon dioxide emissions. Renewable energy is also being deployed on a massive scale through FIT (Feed in Tariff) and concerns about power supply shortages by halting operations of almost nuclear power plants after the Great East Japan Earthquake. However, since power generated via renewable energy sources inherently fluctuates depending on the weather, power systems cannot absorb these fluctuations unaided and it becomes increasingly difficult to provide a stable power supply on a large scale. In actual fact, each electrical power company has started imposing temporary measures to limit the introduction of renewable energy as of October 1, and there is a urgent need to take countermeasures for power fluctuations.

Accordingly, we at Hitachi Chemical are planning the BESS (Battery Energy-Storage System), which includes a peak-shifting function, whereby BESS charges electricity generated by PV in daytime and discharges it overnight as well as a demand-response function by supplying electricity from storage batteries to a power system to control maximum demand in response to temporary peak power consumption occurring every few minutes. However, lead-acid batteries are best suited for peak shifting in terms of capacity and lithium-ion batteries preferable for demand response in terms of output power but no batteries suit both applications, which meant we had to adopt a system-based approach to solve this problem.

4 Technical Content

Figure 1 (a) shows the concept of HBESS, the (Hybrid Battery Energy-Storage System). The graph shows sloping lines by plotting power as the relation of power vs. capacity to show performance characteristics, while the red line represents the performance characteristics of power type LIB (Lithium-Ion Battery) and the blue line represents capacity-type LAB (Lead-Acid Battery). To build a BESS which meets the required capacity and power characteristics (☆) of targeted applications, excess battery capacity may be required to replace insufficient LIB capacity and insufficient power from LAB. By combining a capacity-type LAB and a power-type LIB responsible for storage capacity and a LIB responsible for power, the required battery energy can be reduced, allowing a more compact and economical BESS.

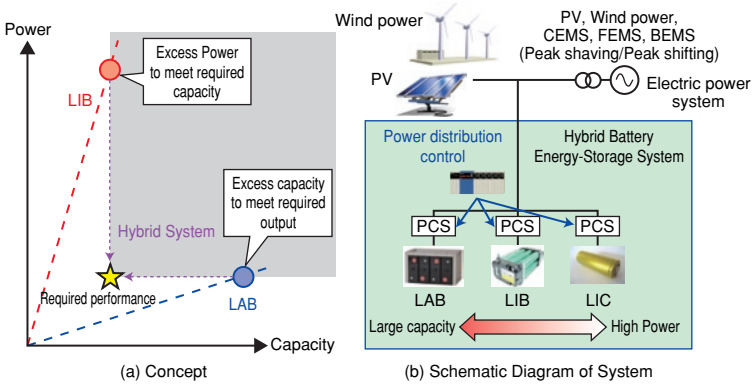

Figure 1 The concept of HBESS(Hybrid Battery Energy-Storage System)

Figure 1 (b) shows a schematic diagram of the HBESS (Hybrid Battery Energy-Storage System). PCS regulates the charging/discharging to batteries and converts electrical energy between AC and DC, while each battery is connected to the grid via PCS. The following steps will also be required to implement the power distribution control: 1) Detect the variation generated in electric power by wind power or PV and calculate the total required charge/discharge power for batteries, 2) Determine the charge/discharge power amount to distribute the calculated amount of power for each battery by taking into account their individual performance characteristics, and 3) Power charging/discharging instruction to each PCS.

Figure 2 shows the preliminarily calculated effect on power leveling for the case of wind power. Figure 2 (a) shows an example of charging/discharging electrical power wave forms in this case, while Figure 2 (b) shows the preliminarily calculated hybrid effects also in this case. Here, a LAB helps level out electric power at low frequencies requiring higher storage capacity, while LIB helps level out power at high frequencies requiring higher power, helping eliminate excess battery capacity. We determined that the potential cost saving allowed for storage batteries through HBESS could reach about 40%.

This preliminary calculation result may also be contingent on wind conditions and the operational philosophy behind the running of systems such as power distribution control between LAB and LIB.

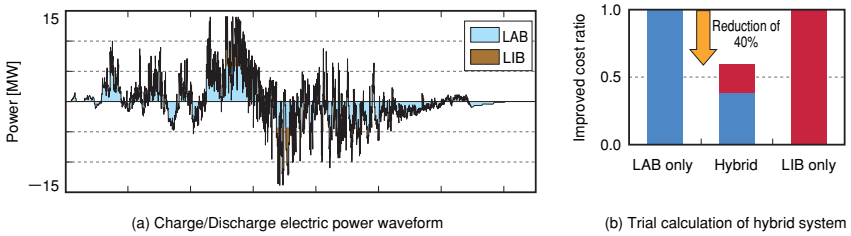

Figure 2 The application example of HBESS for the wind power

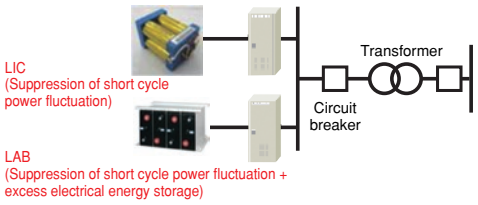

Figure 3 The application example of HBESS by LIC and LAB

5 Future Business Development

・Application of our HBESS (Hybrid Battery Energy-Storage System) to NEDO's "Technology Development for Safe, Low Cost and Large-Format Energy-Storage System (2023)" (joint project with Hitachi Ltd.)

【Reference】

1) Takeda, et al.: Design of Hybrid Energy Storage System using Dual Batteries for Renewable Applications, IEEE PES GM (2014)