Application and Verification of Battery Energy Storage System on Power Grid Automatic Frequency Control (Chemistry and Environment Research Laboratory: Wu, Cheng-Yeou; Chang, Shu-Wei)

1. Introduction

The impacts of intermittent renewable energy on the security of the power system are becoming apparent as the ratio of renewable generation increases rapidly. Due to the factors such as (1) technology maturity, (2) quick modular deployment, and (3) microsecond level response rate (far exceeds the response rate of traditional generators), battery energy storage systems have been placed high hopes to cope with the intermittent nature of renewable energy. In 2016, the National Grid of U.K. invited tenders for 201MW Enhanced Frequency Response (EFR) service (capable to respond within 1 second) to improve its grid resilience [1], and the winners turned out to be all battery energy storage project suppliers.

To promote market competition, Taiwan Power Company (TPC) has planned to start the pilot operation of Electricity Trading Platform in the end of 2020. The platform will comprise four sub-markets, namely (1) Capacity Market, (2) Day-ahead Market, (3) Hourly Adjustment Procedure and (4) Real-time Imbalance Market [2] and will be officially opened and in operation in 2024. Supply side and demand side resources, such as ancillary services (A.S.) and demand response (D.R.), will be invited to trade from the platform and add values to the efficiency and stability of power supply. Trading of Fast Response Resource (FRR) and Automatic Frequency Control (AFC) has been in operation since May 2020. [3,4].

The quantity of FRR to be procured in year 2020 is 15 MW, and the cumulative quantity till year 2025 will be about 251 MW. The contract period of FRR is three years. Good performance providers have the priority to renew contracts with the platform. FRR is designed to cope with deficient system inertia. When system frequency below standard, FRR providers have to cut off load immediately to help avoid system frequency to fall further.

The quantity of AFC to be procured in year 2020 is 50 MW, and the target quantity till year 2025 is about 300 MW. The contract period of AFC is three years. The main purpose of AFC is to utilize ESS's fast charging and discharging characteristics (capable to provide load following service) to help maintain the stability of system frequency.

This article aims to introduce and install 1MW/1.5MWh lithium-ion battery energy storage system (ESS) at Shulin District of Taiwan Power Research Institute (TPRI) for the following purposes: (1) to verify the implementation results of AFC program, and (2) to provide useful information, such as potential risks, to serve as a reference for market participants interested in ESS investment.

2. Research Methods

To verify the capability of ESS as AFC service providers, the following items have to be inspected: (1) the architecture of the energy storage system, (2) the frequency measurement resolution of the Power Condition System (PCS), (3) data acquisition and transmission rate, (4) built-in Automatic Frequency Control (AFC) mode. Along with the said requirements, winning vendors have to meet all of the specified performance tests under the supervision of TPC. After step-by-step output/input power and frequency sweep tests been approved, the winning vendors may then submit an official test report to TPC. Taking the service capability test item D-5 for example, a winning vendor has to go through the grid connection test [4] to qualify as an AFC service provider. As shown, Figure 1 is the system diagram of the equipment applied in this research, Figure 2 the photographs of the actual equipment, and Figure 3 the software page of the AFC performance test items D-1 to D-5.

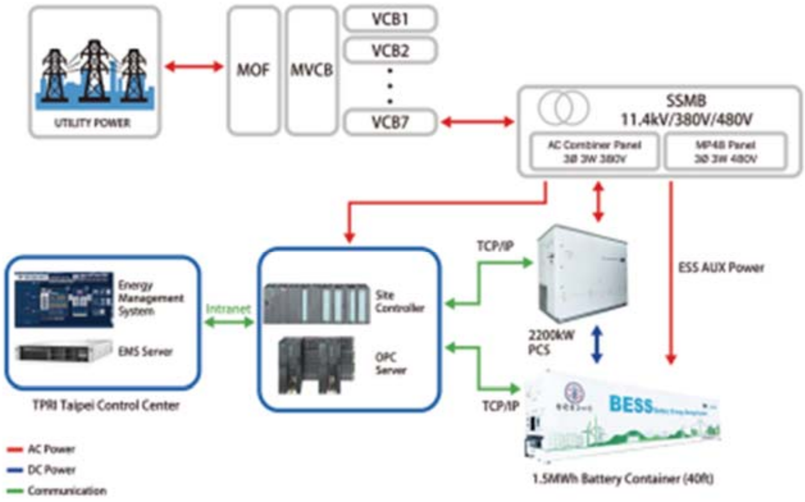

Figure 1 Schematic diagram of 1MW/1.5MWh containerized lithium-ion battery energy storage system

Figure 2 Photographs of 1MW/1.5MWh containerized lithium-ion battery energy storage system

Figure 3 Software page of AFC service

3. Research Results

During the actual grid connection test (item D-5), this research simultaneously recorded the grid frequency at the ESSsire of Shulin TPRI (No. 84 Da'an Road, Shulin District, New Taipei City). As shown as Figure 4, the grid frequency changes frequently. During a monitoring period of 24 hours, the maximum range of frequency change is about ±0.2 Hz. By analysing the frequency data during the test period of 8 pm, March 4 to 8 pm March 5, 2020, 31% of the time, the grid frequency was between 59.98 Hz and 60.02 Hz, one third of the time, the grid frequency was lower than 59.98Hz, and one third of the time, the grid frequency was higher than 60.02Hz- very similar to the statistics of TPC power grid frequency changes in December 2018, March 20193, and May 2019 [3].

By analysing the actual power grid frequency changes, the operation capability of the ESS under testing in this study is shown as Figure 5 (the distribution diagram of AFC D-5 controlled point). As Figure 5 indicates, the ESS power output are 100% within the SBSPM curve and the SPM reaches 100%, meeting the requirements of D-5 specification that SPM must not be less than 95% within 3 hours.

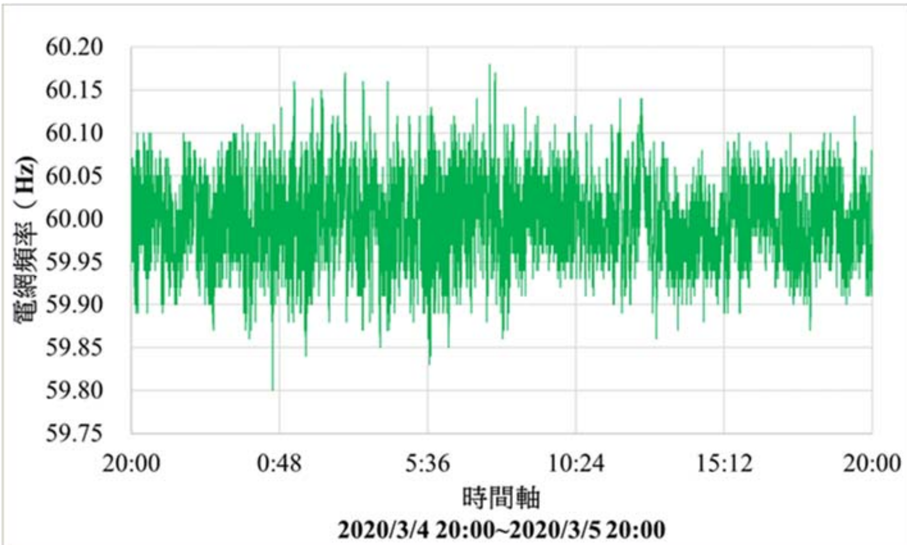

Figure 4 Time sequence diagram of power grid frequency change in Shulin district of Taipower Research Institute

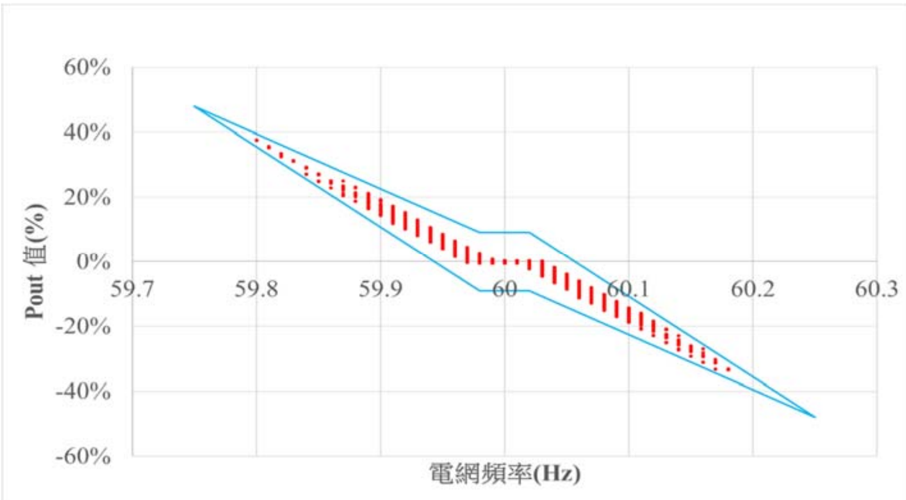

Figure 5 Distribution of AFC D-5 controlled points implemented by the energy storage system