Optimal Integration of Hybrid Energy Storage System with Wave Energy Converter Systems and Analysis of Spatial WEC Array Arrangement

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Abstract

Wave energy converter (WEC) devices are characterized by oscillating power generation, where the power being delivered to the grid may vary rapidly over short time scales. Injection of this oscillatory power directly to the grid can cause voltage fluctuations and affect the stability of the grid. By integrating an energy storage system (ESS), the oscillating power can be absorbed, and smoothed average power can be delivered to the grid.

Combining battery and supercapacitor makes an economical hybrid energy storage system (HESS) which can deliver high peak power and store enough energy for the required operation [1]. A frequency-based power sharing control scheme for HESS has been implemented, in which a Low Pass Filter (LPF) is used to separate high frequency and low frequency components of oscillating wave energy and are assigned to supercapacitor and battery respectively. Due to the seasonal variations in ocean waves, an adaptive LPF is implemented for the optimal power-sharing of the HESS. Figure 1 gives an overview of the WEC system integrated with HESS. Also, a framework to minimize the costs of sizing HESS to be integrated with a WEC has been developed. Moreover, multiple WEC systems are usually installed in a site to for return on investment. As the systems are spatially scattered, optimal array arrangement can provide natural power smoothing and increase the average power generated. This helps reduce the rating of HESS required and thus lead to lower cost of large scale WEC farms.

Emulation of actual WEC devices has been implemented using mathematical device models with a generator-motor set in the laboratory [2]-[3]. Using the emulated laboratory scale WEC systems, optimal operation of HESS and multiple WEC array arrangement is validated on hardware. Experimental setup of the hardware test bed - WEC Emulator and HESS integration is shown in Figure 2a and Figure 2b.