2026 IERE-KEPCO Seoul Energy Equation Workshop
Seoul, South Korea
May 19–22, 2026

Next-Generation ESS Strategies : Power-Energy Decoupling for Grid Applications Using a Supercapacitor and Batteries Storage Mix

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Keywords: *Energy Storage System, Frequency Regulation, Supercapacitor, Battery, Power Grid*

Abstract

With the increasing penetration of renewable energy sources, the role of Energy Storage Systems (ESS) in enhancing the stability and efficiency of power grids has become increasingly critical. Since 2015, the Korea Electric Power Corporation (KEPCO) has pioneered the deployment of ESS for frequency regulation(F/R), currently operating approximately 1.4 GW of power capacity through a series of large-scale initiatives.

Throughout the operational phase of these systems, various technical and practical challenges have emerged, with fire safety and accelerated lifespan degradation identified as primary concerns. To address these critical issues, KEPCO has been actively advancing the research and development of next-generation technologies and operational solutions.

Given their exceptional power density and superior cycle life, supercapacitors are highly optimal for F/R applications. By effectively decoupling power and energy demands, supercapacitors compensate for the dynamic power limitations of conventional batteries, enabling a substantial reduction in the required volume and overall footprint of battery-based F/R systems. Furthermore, integrating supercapacitors into a hybrid architecture alleviates the severe, high-frequency charge and discharge cycles typically imposed on batteries. Consequently, this synergistic approach not only mitigates the need for frequent, short-term battery replacements but also conserves maintenance resources and significantly extends the operational lifecycle of the entire grid storage infrastructure.

This presentation introduces innovative technologies and strategic frameworks aimed at improving the operational safety and extending the lifespan of ESS through the hybridization of supercapacitors and batteries, thereby ensuring the resilience of future power systems.