Hybrid ESS: Combining Redox Flow and Lithium-ion Batteries

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01 | INTRODUCTION

Hybrid energy storage systems (HESS) integrate multiple storage technologies e.g., flow batteries combined with lithium-ion batteries or flow batteries combined with supercapacitors. Such hybrid storage projects, from small pilots and microgrids up to GWh-scale projects, are developed and implemented globally to enhance grid stability and support renewable energy integration.

A few real-life examples include the 1GW/2GWh energy storage system in Yantai, Shandong Province, China which combines **redox flow batteries and lithium-ion** batteries, the HyFlow Horizon 2020 project which combined **flow batteries and supercapacitors**, and the Energy Superhub Oxford **lithium-ion-vanadium** hybrid energy storage system which was launched in 2022.

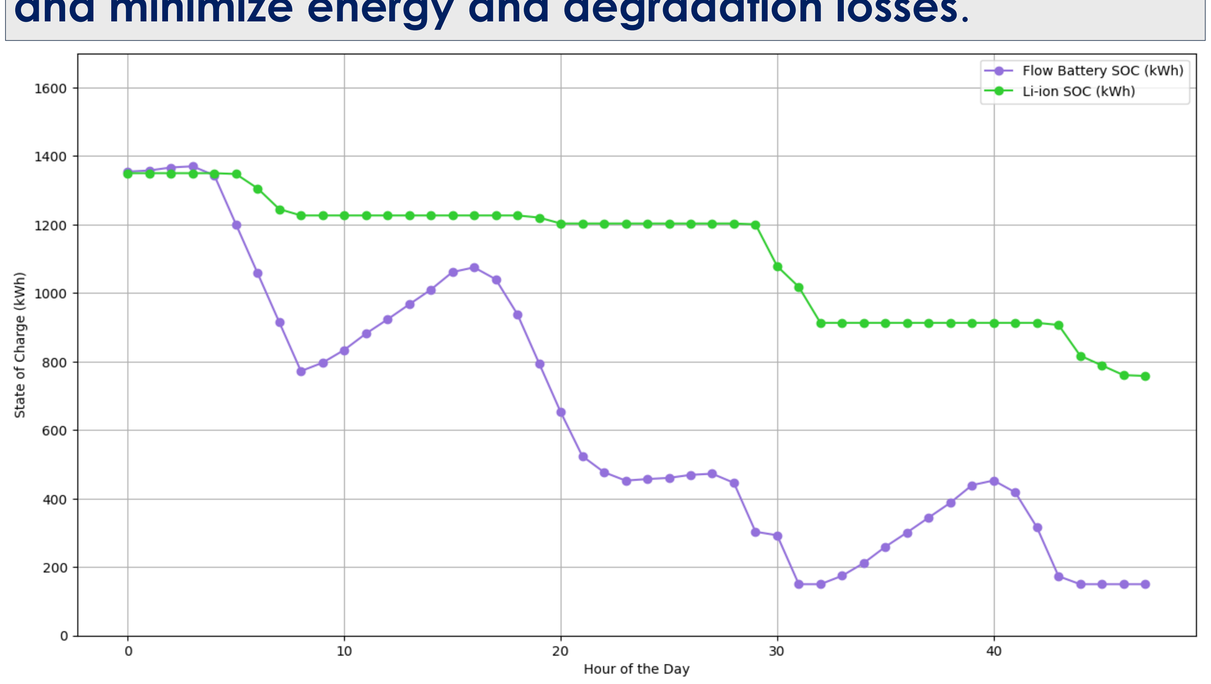
02 | WHY HESS?

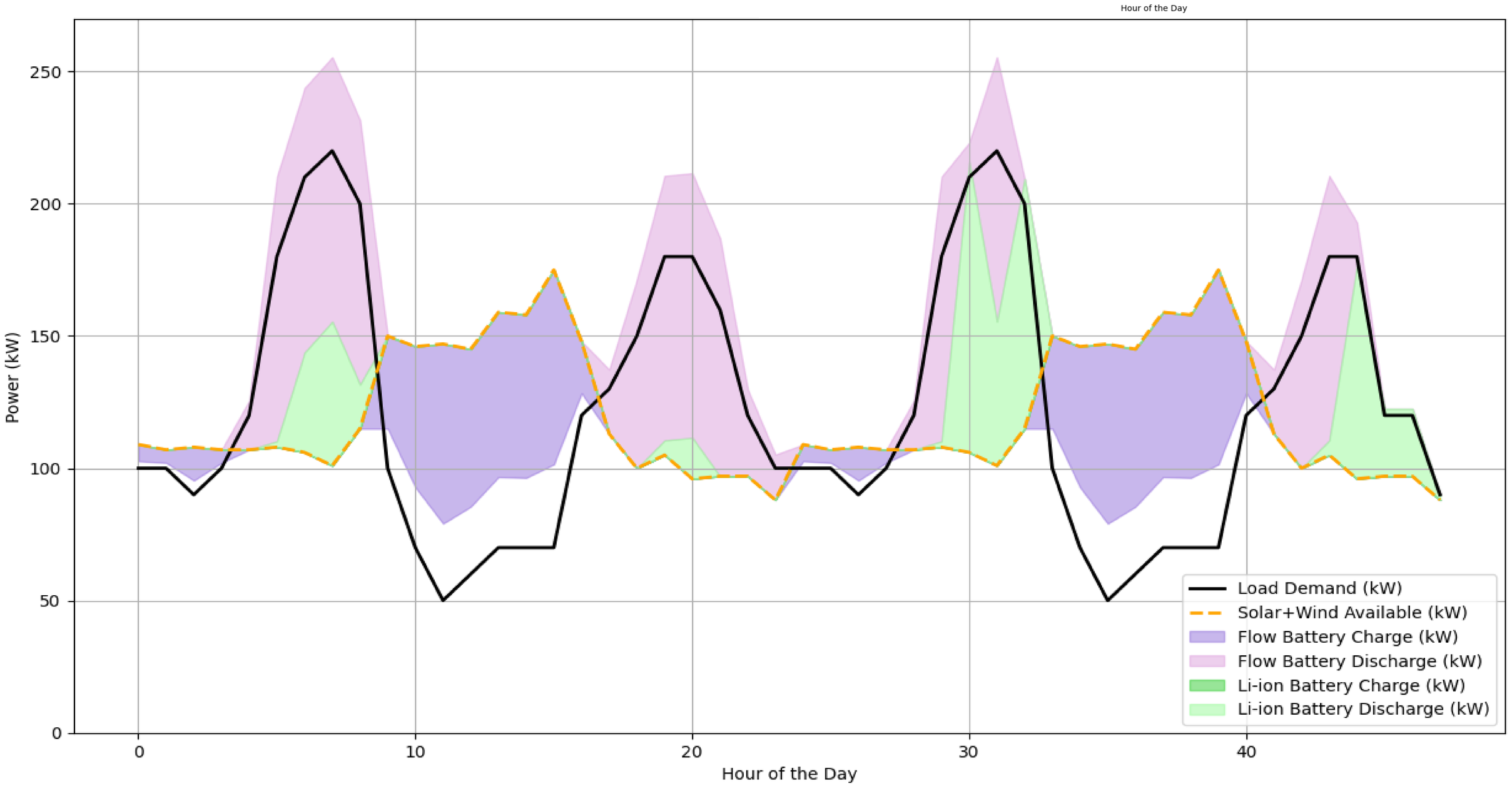
In comparison to the single ESS, HESS are used to improve fluctuations of wind and solar power more effectively considering those fluctuations are distributed across a wide range of power. In addition, avoiding frequent cycling charging and discharging of batteries that degrade more than others such as lithium ion, prevents their degradation and improves their lifespan. Several studies have shown that **lifespan of lithium-ion batteries can be significantly increased by combining them with other less degrading technologies such as flow batteries**. In many other cases, HESS are used to deal with voltage regulation, pulse loads and frequency regulation leading to improved stability and power quality.

Optimal sizing methodologies are necessary in order to realize the full potential of the HESS, along with **intelligent energy management systems that dispatch the different energy storage systems in an optimal way**, are required to achieve the techno-commercial benefit.

02 | INTELLIGENT HYBRID EMS

An optimization algorithm is developed to **optimally dispatch** a redox flow and lithium-ion battery in a hybrid renewable energy system configuration comprising solar PV, wind and demand. The algorithm considers **degradation, efficiency, power rates, and battery constraints**, when choosing which battery to charge/discharge at each hour. The objective is to **maximize renewable energy supply to demand ratio and minimize energy and degradation losses**.





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