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## Energy Storage: State of the Art and Power System Application

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### Abstract

The Iberian Peninsula Blackout demonstrated the challenges that can appear when a grid moves from dispatchable, rotating-mass generation to a system dominated by weather-driven, inverter-based resources. With more and more renewable energy integration and thermal generation gradually phasing out, power system is in need of more flexible resource. Having fast respond ability and flexible deployment requirement, energy storage is playing a more and more vital role, and has been growing rapidly since 2020, reaching 372.3GW total capacity by the end of 2024. However, “energy storage” is not a single technology, but a mix of electrochemical, mechanical, chemical, electrical, thermal technology, its further development depends on its cost effectiveness, ability to coordinate with different power system application scenarios. This presentation offers an overview on common energy storage applied, different technologies integration scale, cost-effectiveness, technical advantages and disadvantages are discussed, covering technology routes including pumped hydro, lithium-ion battery, sodium-ion battery, flow battery, compressed air, flywheel, hydrogen, superconducting magnetic. On top of that, energy storage application in power system is discussed, including its steady state regulation service such as energy shifting, fast ramping, frequency regulation and also transient state stability supporting ability such as inertia and voltage support. In the end, the future development requirement of energy storage is discussed, leading storage technology towards a reliable grid stability supporting source.