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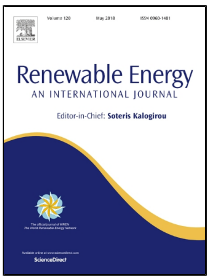

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A hybrid energy storage system with optimized operating strategy for mitigating wind power fluctuations

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Abstract

A novel method based on hybrid energy storage system (HESS), composed of adiabatic compressed air energy storage (A-CAES) and flywheel energy storage system (FESS), to mitigate wind power fluctuations and augment wind power penetration is proposed in this paper. Wind power fluctuates in different frequencies, mainly divided into low and high frequency, which can be coped with by A-CAES and FESS respectively. To fit with low frequency fluctuation exhibiting large magnitude, A-CAES with multi-operating strategies is first proposed to widen operational ranges. Mathematical model of key components' off-design performance is established. For a 49.5 MW wind farm in China, design and optimization of HESS are comprehensively investigated. More specifically, the selection of A-CAES system's key components, such as compressor and expander, and parameters of them are specified as well as the parameters of FESS. The key operating parameters of the HESS, when integrated with wind plant, are analyzed and the characteristics are revealed. The results indicate that by HESS, wind power with fluctuation within 0-49.5 MW (average 25.55 MW) can be stabilized to a steady electrical power output of 24.18 MW. The loss of wind power is 6.6%, far less than the wind power rejection rate 17.1% in China.

Keywords: Wind power, Compressed air energy storage, Flywheel energy storage, Optimum design, Wind power rejection rate

Nomenclature

Abbreviations

A-CAES	adiabatic compressed air energy storage	*FESS*	flywheel energy storage system
AVE	average wind power	*HESS*	hybrid energy storage system
CAR	compressed air reservoir	*SM*	surge margin
ESS	energy storage system	*TSM*	thermal storage medium

Symbols

A	surface area of compressed air reservoir, m^2	M	mass, kg
c_p	constant pressure specific heat, J/kg/K	$\dot{n}$	reduced rotating speed

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