Mechanism of high-efficient thermal energy storage and regulation methods of quality of energy

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The mechanism of highly efficient thermal energy storage and effective regulation methods of quality of energy are vital scientific issues to deliver an efficient utilization of large-scale storage in microgrids. The bottleneck problems are composed of the low thermal conductivity of phase-change thermal storage materials, the limited application ranges of design methods of phase-change thermal storage devices, and the difficulty in adjusting the energy grade regulation of the thermal energy storage and utilization system. Thus, this study is presented and composed of the following three aspects of the "material-device-system". First, various types of high energy-density thermal storage materials and the innovation method are developed. Second, an interpretable machine learning method is proposed for the quick design of thermal storage devices. The dynamic attenuation of the thermocline is considered to demonstrate the multi-scale constitutive relation of thermal storage materials and the macroscale parameters of thermal storage devices. Third, a novel regulation method of various typical energy storage systems is further conducted based on the Fourier transform. The fast response performance of thermal energy storage can be realized with the load command of the microgrid. Some related thermal energy storages developed by our research team are produced and applied in the commercial markets.

Based on the research, the systematic incremental methodology of thermal energy storage is obtained. The traditional customs of cascade utilization of thermal energy storage and electrical energy storage can be broken through. Different types of energy storage systems can be finally compared at the equivalent level, and the optimal capacity optimization of various storage systems is obtained under the same load command.

The results provide theoretical guidance and application value to understand the key basic scientific problems of regulation control of large-scale thermal storage systems, and to develop efficient and flexible new types of thermal storage systems.

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