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Editorial

Large-Scale Energy Storage for Carbon Neutrality

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The shift toward a dual-carbon strategy is expected to instigate extensive and profound changes across virtually all economic sectors and aspects of national life in China. The transformation and upgrading of energy systems and related infrastructure are particularly noteworthy. The future of energy supply will likely be dominated by renewable generation. One of the most significant challenges in this future landscape is the fluctuation and variability of wind and solar power, which often lead to a substantial amount of curtailed wind, solar, and hydropower. Such curtailment has shown an increasing trend, becoming a major obstacle to the swift deployment of renewable power generation. This challenge must be addressed to ensure the successful implementation of the dual-carbon strategy and the dominance of renewable energy in the future.

As we envisage a future dominated by renewable energy sources, several critical questions arise. First, can we effectively manage the intermittency inherent in renewable energy production, particularly wind and solar power, using energy storage solutions? Given the scale of renewable generation, large-scale energy storage technologies seem to be a plausible solution. Second, how can we tackle the economic hurdles associated with these storage technologies and renewable energy systems? Specifically, how can we secure the substantial investments required to establish a widespread renewable power system with integrated energy storage? Third, what technical challenges will we encounter when integrating large-scale renewable energy storage into the grid? Lastly, can this integration significantly enhance the efficiency of both the power system and regional energy systems? These are the primary questions that need to be addressed for a successful transition to a renewable-dominant energy future.

This special issue tackles these challenges by focusing on several key topics, woven together in an in-depth exploration of large-scale renewable energy storage. More specifically, this special issue consists of 12 contributions in the form of Views & Comments. Beginning with the utilization of hydrogen as a carbon-free energy carrier, we examine its potential for contributing to a sustainable future. This leads into an exploration of the potential and challenges of deep underground energy storage for achieving carbon neutrality. Building on this exploration, we delve into the prospects of the large-scale underground storage of renewable energy, coupled with Power-to-X technologies, specifically within China's context.

Moving from underground to industry, we shift our focus to the chemical sector, examining the potential of electrifying the industry with green electricity as a strategy for carbon neutrality. This possibility naturally segues into an analysis of green methanol as a sustainable energy carrier and its role in achieving carbon neutrality.

The discourse then transitions to bioenergy and green hydrogen, investigating their roles in large-scale energy storage for carbon neutrality. This investigation is followed by a detailed look at the industrial application of lignocellulosic biomass pyrolysis toward the same goal. To expand on bioenergy, we also consider the potential of oil crops as a source of biodiesel.

From bioenergy, our narrative moves to the technological aspects of the energy transition, focusing on the prospects of chemical looping clean energy technology for a low-carbon future and the potential of repurposing electric vehicle batteries for solar power storage. The conversation then moves on to the role of energy storage in large-scale entrained-flow coal gasification, before concluding with a comprehensive technical roadmap for upgrading the petrochemical industry for carbon neutrality.

Looking into the future, the field of energy storage and carbon neutrality is expected to gain further momentum. The integration of large-scale storage with renewable energy systems will be a critical factor in achieving a sustainable energy landscape. As these technologies mature, their costs are expected to decrease, making them more economically viable. Moreover, policy support and regulatory frameworks will play a significant role in facilitating this transition. Challenges will surely arise, but with continuous research, development, and innovation, we can confidently move toward a carbon-neutral future.

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