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Editorial: Advancements in thermal safety and management technologies for energy storage systems

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Editorial on the Research Topic
Advancements in thermal safety and management technologies for energy storage systems

In recent years, with the rapid development of renewable energy, energy storage systems have played an increasingly important role in power systems. Energy storage technology is a key technology for utilizing new clean energy sources. At present, energy storage technology is mainly composed of chemical energy storage, electrochemical energy storage, thermal mass energy storage, and energy storage system integration and safety (as shown in Figure 1), all of which pose long-term challenges related to thermal management and thermal security. As energy storage technology progresses, its safety, particularly thermal safety, has garnered widespread attention. Effectively managing heat in energy storage systems to ensure their safe operation has become a current hot topic in research and application. Based on this, this issue discusses the development of new technologies in the field of energy storage, thermal safety and management, and includes a total of 6 articles.

Driven by environmental emission standards and the energy crisis, hydrogen has become a zero-carbon, clean energy source (Zou et al., 2023). In recent years, fuel cell vehicles (FCVs) have become a significant focus for the future development of the automotive industry, with hydrogen refueling stations playing a crucial role in integrating hydrogen technology into daily transportation (Miao et al., 2024). Despite these advancements, the low density of hydrogen leads to rapid dispersion during leakages, posing substantial safety risks such as fires and explosions during storage, transport, and use. These issues hinder the global adoption of hydrogen energy applications and the development of related infrastructure (Wang et al., 2022). Although extensive research has focused on the dispersion characteristics of hydrogen leaks in various environments, most studies concentrate on open spaces. There is a noticeable lack of reliable data on hydrogen leak dispersion in enclosed spaces, such as ceilings. Moreover, while previous studies on free jets have identified specific patterns, research on enclosed spaces generally provides a broad

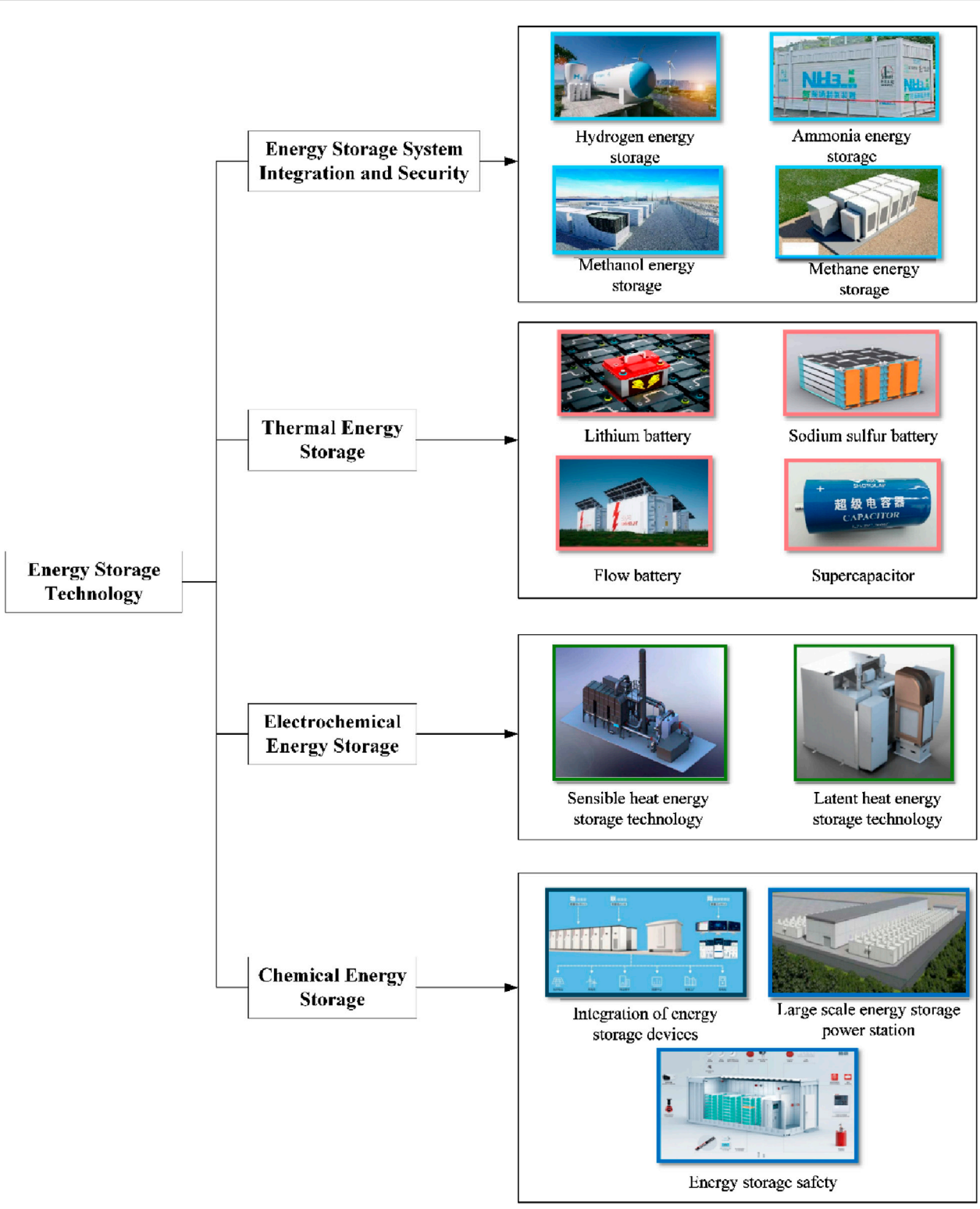

FIGURE 1
Classification of energy storage technologies.

overview of spatial distribution patterns based on parameters without detailed empirical formulas. Therefore, this study develops an experimental system to investigate hydrogen leak dispersion in enclosed spaces, summarizing the concentration distribution patterns of hydrogen leaks in ceiling-enclosed spaces, providing reference data for the prevention and control of future hydrogen refueling station infrastructure. At the same time, this issue explores: advanced thermal management technologies, innovative materials with superior thermal properties, design solutions for optimized thermal management, and recent

advances in cooling technology. In addition, this issue discusses safety measures to mitigate risks and strategies for responding to thermal runaway events, outlines challenges and solutions in thermal safety and management in energy storage systems and encourages further research and development in this critical area. In addition, as a core component of various electronic devices and electric vehicles, the safety and management of batteries are particularly important. With the rapid development of battery technology, especially the widespread application of lithium-ion batteries, many potential safety hazards have emerged, such as overheating, short circuits, and leaks. These problems can not only lead to damage to equipment, but in more serious cases, they can also cause fires and explosions, which can endanger personal safety. Therefore, studying the safety of batteries is not only the key to improving product reliability, but also an important measure to protect consumers and the environment. In addition, a scientific and reasonable battery management system (BMS) can monitor the operating status of the battery in real time, optimize the charging and discharging process, prolong its service life, and reduce the risk of accidents. Therefore, it is of great significance to promote the research of battery safety and management to achieve sustainable development and promote the green technology revolution. Ultimately, our goal is to contribute to the development of sustainable and safe energy storage technologies.

Furthermore, as energy storage technology continuously evolves, the traditional energy education model can no longer meet the industry's developmental needs. Currently, the energy sector urgently requires talents with comprehensive qualifications, necessitating corresponding reforms and innovations in the education system. Specifically, educational reforms should focus on the following aspects:

1) Curriculum Update: Revise course content to reflect trends in energy storage technology, focusing on thermal management, materials science, and systems engineering, while integrating practical case studies to enhance hands-on skills.
2) Interdisciplinary Collaboration: Promote cooperation between engineering, physics, chemistry, and computer science faculty and students to form multidisciplinary teams that boost innovation in energy storage systems.
3) Practical Experience: Strengthen partnerships with enterprises to create internship and research opportunities, enabling students to engage with real energy storage projects and stay updated on industry advancements, enhancing their competitiveness.
4) Innovation and Entrepreneurship: Foster innovation and entrepreneurship education to nurture students' creative thinking and practical skills, encouraging involvement in the research and application of energy storage technologies.

Through these reforms, these talents will play an important role in the design, research and development, management and other aspects of energy storage systems to promote the sustainable development of the industry.

In the future, energy storage systems will evolve alongside advancements in thermal management technologies. The combined progress in materials science, power electronics, and thermal management will enhance thermal safety and operational efficiency of these systems. We expect all sectors to foster technological innovation and collaboration, driving energy storage towards a safer, more reliable future. As a key technology in the energy sector, ensuring the thermal safety of energy storage systems is crucial. Through innovations in materials, design optimization, and technological advancements, we have made significant strides in thermal management. Moving forward, continued collective efforts are essential to address challenges, secure the safe operation of energy storage systems, and support green energy development.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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