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Editorial: Energy-efficient and energy-flexible buildings towards net-zero carbon emission

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Editorial on the Research Topic
Energy-efficient and energy-flexible buildings towards net-zero carbon emission

As the global community continues to grapple with the pressing Research Topic of climate change, the built environment emerges as a critical arena for transformative action. The Research Topic "Energy-efficient and energy-flexible buildings towards net-zero carbon emission" in Frontiers in Energy Research aims to present pioneering research that underscores the potential of buildings to contribute to global carbon neutrality goals. This Research Topic brings together five compelling papers, each elucidating innovative strategies and technologies essential for advancing energy efficiency and flexibility in buildings.

Yin et al. present a comprehensive review of predictive models for total carbon dioxide emissions in the Chinese construction sector, crucial for formulating decarbonization strategies in line with China's dual carbon goals. This work introduces carbon emission factors, and methods for obtaining building energy consumption data, and examines various predictive models, summarizing their advantages and limitations. It also highlights the shortcomings of existing research and suggests future research directions, emphasizing the importance of accurate calculation and prediction of building energy consumption and carbon emissions for achieving carbon neutrality in the building sector.

Liang and Yu present a comprehensive study on the Multi-Objective Energy-Saving Optimization Method (MOESOM) for residential buildings, aiming to enhance energy efficiency and reduce carbon emissions. The research introduces an innovative Osprey Optimization Algorithm (OOA) to optimize energy use, focusing on green energy systems and effective consumption habits. The study demonstrates MOESOM's effectiveness in achieving significant energy savings and operational cost reductions, while also contributing to environmental sustainability by lowering carbon emissions in residential structures. The method is validated using extensive data analysis and comparative studies, showcasing an 8.97% improvement in energy savings and an 8.04% increase in objective achievement over other methods. This work emphasizes the importance of agent-based optimization and multi-objective approaches in advancing energy management systems for low-carbon, sustainable residential buildings.

Shaw et al. present a comprehensive systematic review of the research landscape on climate mitigation options post-Paris Agreement, focusing on their potential contributions and barriers to achieving zero-carbon transitions. The review highlights the dominance of

supply-side research over demand-side studies, emphasizes the need for more local-level research, and identifies significant mitigation potential in wind and solar energy. It also notes discrepancies between academic and grey literature in the contributions of bioenergy and nuclear power. This work suggests that future research should address the knowledge gaps in demand-side mitigation and local-level studies to better inform policymakers and ensure a data-driven approach to a zero-carbon future.

Tang et al. examine the impact of high-quality rural logistics on the consumption of rural residents in China, highlighting the role of infrastructure development in economic growth. The study uses panel data from 31 provinces from 2011 to 2020 and employs a fixed-effects model to analyze the effects on consumption scale and quality. Findings reveal significant regional heterogeneity, with the eastern region showing the most substantial impact. Recommendations include enhancing logistics infrastructure in rural areas, especially in the western and northeastern regions, to stimulate consumption and promote economic development. This work contributes to understanding the relationship between rural logistics and consumption, suggesting that improved logistics can lead to consumption upgrades among rural residents, thereby supporting rural revitalization and addressing the "three rural issues" in China.

Bäcklund et al. explore the potential of digital twin technology in the built environment, focusing on a case study of a Swedish university's commercial building stock. They highlight the technology's ability to enhance both occupant experience and building management through features like 3D scanning, geospatial data, and a human-centric approach. The study reveals improvements in navigation, room booking, and building operations, suggesting that digital twins can contribute significantly to operational excellence and sustainable development in the building industry. The research also identifies challenges and future opportunities, emphasizing the need for data integration, open access, and occupant feedback to fully realize the benefits of digital twin technology in the built environment.

Collectively, these contributions offer a multifaceted perspective towards net-zero carbon buildings. They highlight the critical role of technological innovation, interdisciplinary research, and policy integration in driving the transition to sustainable built environments. As challenges posed by climate change persist, the insights and advancements presented in this Research Topic will undoubtedly inform and inspire future efforts in building engineering and sustainability.

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Conflict of interest

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