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Editorial: Advancing urban sustainability: integrating renewable energy for accelerated zero-carbon community transitions

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Editorial on the Research Topic
Advancing urban sustainability: integrating renewable energy for accelerated zero-carbon community transitions

1 Introduction

As global efforts to mitigate climate intensifies, innovative strategies for energy management, urban sustainability, and low-carbon development are becoming increasingly important (He et al., 2021; Liu et al., 2022; He et al., 2022; Liu et al., 2023; Luo et al., 2024). This Research Topic, comprising six peer-reviewed studies, provides valuable insights into these critical areas. The contributions cover adaptive strategies for airport energy management, optimizations in clean heating systems, feasibility studies on hybrid energy solutions in developing economies, the impact of energy storage on a green economy, the role of digital economies in low-carbon urban development, and integrated power flow design for EV charging stations. Collectively, these studies highlight the opportunities and challenges of sustainable energy transformation and emphasize the need for context-sensitive solutions. Through diverse case studies and practical frameworks, this Research Topic aims to inspire actionable strategies for urban planners, policymakers, and researchers dedicated to building sustainable, carbon-neutral cities.

2 Paper summaries and their broader contributions

Adaptive Energy Management for Green Airports: Goh et al. addressed the unique energy demands of airports, proposing a hybrid system combining solar, wind, and waste-to-energy (WTE) resources. Using Copenhagen Airport as a case study, the authors developed an adaptive model predictive control strategy to manage renewable energy generation in response to fluctuating seasonal demands. This approach highlights the crucial role of tailored energy management strategies in high-energy urban hubs, offering insights into how other transport nodes can transition to carbon neutrality through localized renewable systems.

Optimizing Clean Heating Systems in Diverse Climates: Recognizing the variability in climate conditions, Fu et al. assessed clean heating systems optimized for different regional needs within China. Employing TRNSYS software and a multi-objective optimization strategy, this study identifies cost-effective heating solutions tailored to various climate zones. This research emphasizes the need for region-specific renewable energy solutions, which could significantly enhance the effectiveness of carbon reduction policies across diverse geographic contexts.

Solar-Battery-Generator Hybrid Systems in Nigeria: Ijeoma et al. analyzed the feasibility of hybrid solar-battery-generator systems for supermarkets in Nigeria, particularly relevant to the removal of fuel subsidies, which has increased diesel costs. Through simulation, the study highlights the technical and economic benefits of these hybrid systems, including a reduction in CO_2 emissions. The findings are crucial for energy-reliant regions where grid instability and fuel dependency hinder sustainable energy adoption, offering a blueprint for renewable hybrid solutions that balance reliability, cost, and environmental benefits.

Energy Storage Industry and Low-Carbon Economy: Chen and Li explored the influence of energy storage on low-carbon growth in China, focusing on economic and environmental impacts across different regions. The study reveals that financial incentives and policy frameworks play crucial roles in promoting green industry growth, with northern China showing a more substantial benefit due to existing support structures. This underscores the strategic role of energy storage in reinforcing urban resilience and balancing the energy trilemma, particularly in policy-driven economies striving to scale low-carbon industries.

The Digital Economy's Role in Urban Low-Carbon Development: Song et al. assessed the transformative influence of the digital economy on urban low-carbon sustainability across 270 Chinese cities, examining factors like industrial upgrades and technological innovations. The findings reveal that digital economic growth significantly drives low-carbon initiatives by enhancing resource efficiency and promoting green technology adoption. This demonstrates the potential of digital solutions as a catalyst for urban sustainability, particularly in fast-developing regions where economic growth and sustainability targets intersect.

Triple Port Integrated Topology for EV Charging Stations: To address the growing energy demands of electric vehicles (EVs), Tiwari et al. introduced a Triple Port Integrated Topology (TPIT) for EV charging stations that leverage interactions among photovoltaic (PV), grid, and vehicle-to-grid systems. The model supports multiple power flows and is adaptable for further renewable integration, such as hydrogen cells. This research reflects the critical role of flexible and integrated charging infrastructure in urban low-carbon transportation and highlights the potential for scalable solutions in rapidly electrifying urban areas.

3 Broader context and future directions

Collectively, these papers showcase transformative approaches to renewable energy integration within urban context, addressing both technical and social dimensions of zero-carbon transitions. A recurring theme across these studies is the importance of hybrid and intelligent systems tailored to specific urban needs, regional climate variability, and evolving economic contexts. As urban centers account for a substantial portion of global energy use, these findings underscore the value of cross-disciplinary solutions that integrate engineering, economics, and environmental science.

Moving forward, there are several critical areas for further exploration. First, policy frameworks and financial incentives that enable widespread adoption of these technologies are suggested for further investigation. Research examining the economic models that support renewable infrastructure, such as subsidies or carbon credits, would provide a more comprehensive picture of how to incentivize zero-carbon transitions at the municipal level. Additionally, as cities become more interconnected through digital systems, further studies on the impact of cybersecurity on renewable integration are essential. Finally, as urban transportation transitions towards electrification, the role of EVs as mobile energy storage units, integrating renewable energy into transport networks, presents exciting research opportunities.

4 Conclusion

This Research Topic highlights a cross-section of innovative research that contributes valuable insights to urban sustainability, renewable integration, and energy resilience. From airport energy management to digital economies driving low-carbon policies, the Research Topic emphasizes that while urban zero-carbon transitions require scalable renewable solutions, integrating smart systems is equally critical. These studies provide a roadmap for achieving sustainable urban development and call for further research in policy frameworks, technology advancements, and economic incentives that can accelerate the zero-carbon transformations essential for our urban future. The insights presented here will be instrumental for urban planners, researchers, and policymakers as they work collectively towards a sustainable, zero-carbon world.

Author contributions

ZL: Conceptualization, Formal Analysis, Methodology, Writing–original draft, Writing–review and editing. JL: Writing–original draft, Writing–review and editing. YZ: Writing–review and editing. YS: Writing–review and editing. XZ: Writing–review and editing. ZY: Writing–review and editing.

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