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Editorial: Low-carbon transition of energy infrastructures

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Editorial on the Research Topic
Low-carbon transition of energy infrastructures

Introduction

Energy infrastructures generate substantial amounts of greenhouse gases and air pollutants during the exploration, production, transportation, and consumption of energy resources. These activities have serious adverse effects on climate change, environmental degradation, and human life (Xu et al.). Therefore, it is imperative to facilitate the low-carbon transition of energy infrastructures. The Research Topic, "*Low-carbon transition of energy infrastructures,*" includes 14 studies that deepen our understanding of the mechanisms that promote this transition. These studies examine the determinants, challenges, and potential socio-economic impacts of shifting to low-carbon energy systems. Below, we summarize these studies in five key areas: green innovation, economic development, spatial influence dynamics, policies, and pathways that facilitate the low-carbon transition of energy infrastructures.

Green innovation and the low-carbon transition of energy infrastructures

Green innovation can give rise to a series of advanced technologies that provide technical support for the low-carbon transition of energy infrastructures. In turn, the low-carbon transition of energy infrastructures offers abundant practical and verification scenarios for the achievements of green innovation. Three studies have deepened the understanding of green innovation by exploring its drivers, effectiveness, and impact on environmental outcomes across different sectors and regions.

Li, Zhu, et al., employing Fuzzy-set Qualitative Comparative Analysis, meticulously examined the intricate interplay among technological, organizational, and environmental factors and their strategic impact on the green innovation performance in China's logistics companies. The authors discovered that logistics firms can achieve superior green innovation performance via two driving pathways. One is driven by core competencies and market pressures, while the other is driven by technological innovation and government subsidies.

Liu et al. used China's balanced panel data at the prefecture level to investigate the impact of urban green innovation on total factor energy efficiency (TFEE). Their research reveals that green innovation has a positive U-shaped impact on TFEE, with an initial inhibitory effect followed by a promoting one. Notably, high-quality green innovation reaches the turning point more rapidly, indicating that a significant amount of green innovation can cross the turning point with a relatively small volume.

Li, Wang, et al. used the two-way fixed-effects model to investigate the impact of urban green innovation on haze pollution and carbon emission intensity. They found a significant inverted U-shaped relationship between green innovation, carbon emission intensity, and haze pollution for both resource-based and non-resource-based cities. However, this U-shaped relationship is restricted to non-environmental priority cities.

Economic development and the low-carbon transition of energy infrastructures

Numerous factors in economic development can have an impact on the low-carbon transition of energy infrastructures. Identifying the key factors and their mechanism of action is conducive to formulating targeted policies to promote the low-carbon transition of energy infrastructures. Two studies have provided valuable insights into how economic and institutional factors, such as financial development, urbanization, infrastructure, and governance, can either accelerate or hinder low-carbon development.

Kong et al. investigated the relationships between financial development, urbanization, economic growth, renewable energy consumption, and environmental quality in 27 countries in North, South, and East Africa from 1990 to 2019. They found that financial development improved environmental quality but with regional heterogeneity. Renewable energy has advanced environmental safety in the Northern and Eastern regions, but negatively impacted environmental sustainability in South Africa.

Zhang and Zhou utilized second-generation panel cointegration methods to assess the impact of infrastructure development, oil consumption, and institutions on carbon emissions. Their findings indicate that the economic complexity index, urbanization, and oil consumption led to an increase in carbon emissions. In contrast, infrastructure development and institutions significantly reduced carbon emissions.

Spatial influence dynamics and the low-carbon transition of energy infrastructures

The low-carbon transition of energy infrastructures exhibits spatial spillover effects, that may change the regional economic landscape, population distribution, and industrial structure, among other things. Two recent studies have highlighted the importance of understanding spatial dynamics by examining how digital economies and industrial agglomerations influence regional carbon emissions and pollution levels.

Zhang et al. used the spatial Dubin model to examine the spatial impact of the digital economy on carbon emissions. Their results show that while the digital economy directly reduces carbon emissions within cities, it exerts negative spatial spillover effects on carbon reduction in neighboring cities. Moreover, the digital economy impacts urban carbon emissions mainly through two channels: industrial structure upgrading and green technology innovation. The impact also varies across cities of different sizes.

Li, Xia, et al. employed spatial econometric models to assess the impact of three major industrial agglomerations on PM2.5 pollution. The authors discovered that primary industrial agglomeration reduces PM2.5 pollution and has negative spatial spillover effects. There is a non-linear connection between secondary industrial agglomeration and PM2.5 pollution. Tertiary industrial agglomeration, conversely, leads to an increase in PM2.5 pollution levels.

Policies facilitating the low-carbon transition of energy infrastructures

The low-carbon transition of energy infrastructures is intertwined with a multitude of policies. Gaining a clear understanding of the effectiveness and mechanisms of these policies is instrumental in optimizing and adjusting them. Three studies have examined the impact of specific policy instruments, including green finance initiatives, energy rights trading schemes, and credit-based regulatory frameworks, and demonstrated their varying effectiveness in driving the transition.

Lv and Guo utilized the staggered Difference-in-Differences model to assess whether and how the green finance reform policies impact energy consumption. Their findings reveal that green finance reform and innovation pilot zones substantially reduce energy consumption. This reduction mainly occurs because the policy optimizes the industrial structure and promotes green innovation.

Chen et al. used the Difference-in-Differences method to evaluate the impact of the Energy Consuming Right Trading Policy (ECRT) on the low-carbon transition of the energy structure. Their results show that the ECRT strongly drives the low-carbon transition of the energy structure by promoting the upgrading of industrial structure and new-quality productive forces. Regions with high industrial agglomeration and rich renewable energy see more significant promotion from new-quality productivity. Environmental regulation also positively moderates the link between the ECRT and the low-carbon transition of the energy structure.

Sun and Tian employed the Propensity Score Matching Difference-in-Differences method to examine the impact of the Double Credit Policy (DCP) implementation on innovation in new energy vehicle (NEV) enterprises. Initially, the DCP was found to have an inhibitory effect on innovation among NEV enterprises. However, as the policy stabilized over time, this negative impact gradually lessened and showed a trend of transforming into a positive driving force. The DCP exerts an influence on enterprise innovation output mainly by affecting their R&D investment.

Navigating the low-carbon transition pathways in energy infrastructures

Designing the low-carbon transition pathways in energy infrastructures in a scientific and rational manner is an essential step to ensure the smooth progress of this transition. Achieving this goal requires not only technological innovation but also strategic adjustments in economic structures and regulatory frameworks. Three studies have provided valuable insights in this area, covering volatility forecasting in energy markets, low-carbon urban development strategies, and the combined influence of environmental regulation and industrial structure adjustment.

Shu and Luo proposed the realized EGARCH model with jumps to model and predict crude oil futures volatility. This model can incorporate extreme-value information and time-varying jump intensity. Their research indicated the existence of time-varying jumps in the crude oil futures market. Significantly, they demonstrated that their proposed REGARCH-Jump model outperforms the GARCH, EGARCH, HAR, and REGARCH models in both fitting empirical returns and forecasting out-of-sample volatility.

Yu et al. used LMDI additive decomposition analysis to study the development path of Chengdu as a low-carbon city under the dual constraints of carbon emissions and economic growth. They found that economic expansion is the main driver of increased carbon emissions. In contrast, industrial structure adjustment and energy intensity reduction can help reduce carbon emissions.

Shao et al. investigated the combined impacts of environmental regulation and industrial change on the green economy. Their findings reveal that environmental regulations and the rationalization of the industrial structure both foster the growth of the green economy. However, the advancement of the industrial structure has a hindering effect on that growth.

Conclusions and future directions

The 14 studies featured in this Research Topic focus on the core theme of the low-carbon transition of energy infrastructures. They offer profound forward-looking insights and introduce practical innovative ideas that will substantially contribute to the development of this field. Future research on energy infrastructure can focus on two pivotal areas. First, studying sunk costs and devising effective countermeasures. Second, assessing their reliability and resilience during emergencies, such as natural disasters, man-made disruptions, and technical glitches, with the aim of formulating robust measures that enhance both disaster resilience and recovery capabilities.

Author contributions

FG: Conceptualization, Writing – original draft, Writing – review & editing. LW: Investigation, Writing – review & editing. LL: Writing – review & editing.

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.

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