frontiers | Frontiers in Energy Research

TYPE Editorial
PUBLISHED 29 December 2023
DOI 10.3389/fenrg.2023.1349129

OPEN ACCESS

EDITED AND REVIEWED BY
Ellen B. Stechel,
Arizona State University, United States

*CORRESPONDENCE
Rui Wang,
1610232@stu.neu.edu.cn

RECEIVED 04 December 2023
ACCEPTED 11 December 2023
PUBLISHED 29 December 2023

CITATION
Zhang H, Liu H and Wang R (2023), Editorial: New paths towards carbon-neutral future energy systems: planning, operation, and market design.
Front. Energy Res. 11:1349129.
doi: 10.3389/fenrg.2023.1349129

Editorial: New paths towards carbon-neutral future energy systems: planning, operation, and market design

Haoran Zhang, Hu Liu and Rui Wang*

College of Information Science and Engineering, Northeastern University, Shenyang, China

KEYWORDS

multi-energy systems, renewable energy generation, carbon neutrality, planning and operation, energy and carbon market

Editorial on the Research Topic
New paths towards carbon-neutral future energy systems: planning, operation and market design

Conventional energy infrastructures that heavily rely on fossil fuels are considered the primary cause of the energy crisis and climate change. In particular, the influence of global warming may be catastrophic, leading to heat waves, rising sea levels, and more frequent and severe droughts, storms, and hurricanes. The decarbonization of energy sectors is urgent. Various technical efforts, e.g., renewable energy (RE) generation, hydrogen-based clean energy storage and transmission, and demand response (DR) programs, are proposed. In addition, the development of the Energy Internet promotes the synergy and interaction of different energy-carrier systems (e.g., electrical power grids, heating networks, and gas supply systems), which offer more abundant measures for reducing carbon dioxide emissions. To utilize the full strength of emerging technologies and pave the way towards a carbon-neutral future society, the new structure of RE-based multi-energy systems needs to be analytically studied and optimally designed. To this end, this Research Topic seeks original thought and novel methodology to address the timely issues with regard to achieving synergetic multi-energy decarbonization.

This Research Topic aims to explore the latest developments in the field, focusing on 1) modeling, analysis, and simulation of multi-energy systems under a carbon-neutral perspective; 2) analytical tools of carbon footprint tracking and calculation for multi-energy systems; 3) low-carbon planning and operational scheduling of multi-energy systems; 4) carbon-free distributed energy systems with synergetic power, hydrogen, natural gas, heat, and cooling supply; 5) clean energy and carbon markets; 6) application of AI and Big Data techniques for developing carbon-neutral energy systems; 7) RE generation system evaluation and parameter evaluation of RE models; and 8) economic, environmental, and social benefit analysis of energy system decarbonization.

In the last few years, in China, there has been a high concentration of resources on the generation side of the market, and power market has been frequent. It is urgent that risk prevention mechanisms for the generation of power market are established. Xie et al. proposed a "stochastic evolutionary game market-clearing" model for the market regulation and risk measurement. Meanwhile, the authors provided a library of multi-dimensional monitoring and evaluation indicators for the market regulator and created a quantitative risk prevention strategy for the electricity spot market in China. Finally, it was confirmed that the generation-side power market risk prevention mechanism could lower market transactions and operational risks in a variety of power supply–demand scenarios.

In order to ensure that the voltage and frequency of the sending system with a high proportion of renewable energy access under transient port energy impact could be controlled within the allowed fluctuation range, Wang et al. proposed a nonlinear multi-objective transient voltage and frequency-coordinated control strategy for the renewable energy sending system. The simulation results showed that the proposed control method could realize voltage and frequency stability control under transient energy, which could effectively reduce the fluctuation amplitude of the transmission system, restore synchronization in a short time, and realize the rapid suppression of voltage and frequency fluctuations.

The electricity market (EM), carbon market (CM), and green certificate market (GCM) have traditionally operated independently, with little interaction between them. To explore the interaction and correlation between the three markets, Qiao et al. analyzed the trading patterns and mutual influencing factors of the EM, CM, and GCM, and proposed an optimal decision-making model of "carbon-electricity-certificate" integration of multiple markets based on the decision-making behavior of power producers in each market. Meanwhile, the golden jackal optimization (GJO) algorithm was used to solve the problem of network security. Finally, it was confirmed that the integration of multiple markets was more conducive to promoting the consumption of renewable energy sources (RES) and verified the feasibility and effectiveness of GJO in solving the main decision-making problems of power producers in EM.

The increasing penetration of renewable energy will result in insufficient system voltage regulation and reactive power support capabilities, and may cause high risks of nodal voltage and branch flow violations. Therefore, to hedge the operational risks under the realization of the most critical uncertainties of renewable energy sources, Li et al. proposed a two-stage robust unit commitment (UC) model. Meanwhile, the convexified AC power flow model was incorporated into the robust UC model to more accurately characterize the real-time operating status of power systems. Furthermore, to reduce the computational complexity caused by large-scale newly added constraints after the linearization process, a customized redundant constraint identification (RCI) method was developed, in which two different modes (i.e., cold and warm start modes) were designed, considering the differences in base case system operating conditions for linearizing branch losses. Finally, it was confirmed that the proposed model could accurately depict actual operation and scheduling conditions, and also verified that the proposed customized RCI method could effectively reduce the problem scale and improve the solution efficiency.

In recent years, there has been a contradiction between energy waste and power shortage in some regions of China, which needs to be resolved through reasonable planning of the capacity of multi-energy systems. In order to achieve the near-zero carbon goal, Linna et al. discussed the reasonable proposal of a power energy structure based on different carbon emission reduction goals. Finally, the authors discovered the relationship between investment costs and carbon reduction targets, where increasing carbon reduction targets would greatly increase investment costs. The authors also provide some suggestions for future planning.

Author contributions

HZ: Writing–original draft. HL: Writing–original draft. RW: Writing–review and editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

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

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.