frontiers | Frontiers in Energy Research

TYPE Editorial
PUBLISHED 03 April 2023
DOI 10.3389/fenrg.2023.1175280



OPEN ACCESS

EDITED AND REVIEWED BY
Valerie Eveloy,
Khalifa University, United Arab Emirates

*CORRESPONDENCE
Haochen Hua,
huahc16@tsinghua.org.cn

SPECIALTY SECTION
This article was submitted to Process and Energy Systems Engineering, a section of the journal Frontiers in Energy Research

RECEIVED 27 February 2023
ACCEPTED 24 March 2023
PUBLISHED 03 April 2023

CITATION
Hua H, Wu H, Shen J, Li K and Dong ZY (2023), Editorial: Machine learning to support low carbon energy transition. *Front. Energy Res.* 11:1175280. doi: 10.3389/fenrg.2023.1175280



# Editorial: Machine learning to support low carbon energy transition

Haochen Hua[1]*, Haoxing Wu[1], Jun Shen[2], Kang Li[3] and Zhao Yang Dong[4]

[1]College of Energy and Electrical Engineering, Hohai University, Nanjing, China, [2]College of Mechanical and Vehicular Engineering, Beijing Institute of Technology, Beijing, China, [3]College of Electronic and Electrical Engineering, University of Leeds, Leeds, United Kingdom, [4]College of Engineering, Nanyang Technological University, Singapore, Singapore

KEYWORDS

**low carbon, machine learning, renewable energy, load forecasting, cybersecurity**

Editorial on the Research Topic
Machine learning to support low carbon energy transition

## 1 Introduction

With the accelerated industrialization and urbanization over the past decades and consequent greenhouse gas emissions, climate change has today become a major challenge faced by mankind. To tackle these challenges, a number of countries worldwide have set ambitious targets to reduce carbon emissions substantially in the future (Dong et al.). As the largest source of carbon emissions, the energy sector plays a responsible role in achieving low carbon energy transition (Bamisile et al., 2022).

Given the worldwide background of low carbon energy transition, key carbon capture technologies have been developed rapidly, such as quantitatively evaluating carbon intensity and tracing carbon flow from generation to consumption (Lin and Li, 2022). Moreover, under the increasing penetration of renewable energy sources within power systems, it is urgent to handle the uncertainties caused by intermittent renewable energy output to maintain the reliability and stability of the power grid operations (Hua et al., 2019). Recently, with enabling technologies to achieve decarbonization, machine learning is becoming increasingly important in modelling, planning, operation, and control of the entire energy chain from different energy mixes of electricity, thermal, and natural gas to end-users, e.g., buildings, transportation. Notably, with the digitalization of the energy systems, massive amounts of data from a wide range of sources are available, which makes machine learning applications in the energy industry possible (Hua et al., 2022), including carbon emission estimation, renewable energy output, load forecasting and cybersecurity. With these new developments, it is necessary to integrate these data-driven technologies with model-based methods for achieving the powerful performance to support low carbon energy transition.

This Research Topic aims to attract innovative ideas and interdisciplinary research in energy sectors to support low carbon energy transition. This Research Topic has brought together recent developments in the following four areas: intelligent modelling and optimization for low-carbon energy system operation and control, data analytics of cyber-physical system security for low-carbon energy systems, machine learning based power load forecasting technologies, other machine learning applications.

## 2 Intelligent modeling and optimization for low-carbon energy system operation and control

A high penetration of various renewable energy is important for the improvement of low carbon energy transition. In Li et al., a coordinated control strategy for multi-energy heterogeneous loads (MEHL) is proposed to optimize green residences energy systems. It shows that the proposed strategy can effectively reduce carbon emissions and satisfy the basic resident comfort. Finally, it is pointed that, in the future, similar scenarios consisting of green residences would be extended, and data-driven technologies based on machine learning can be adopted to solve the low-carbon energy dispatching problems from large residential population. The authors in Sun et al. focus on developing a compensation method for the load reduction *via* renewable energy enterprises. Considering the uncertain renewable generation affecting power balance during peak load periods, the authors use a multi-round sequential auction method to determine the reduced and non-reduced loads. The analysis of the algorithm shows that the proposed scheme can reliably ensure the balance of power supply during the peak period of power system.

## 3 Data analytics of cyber-physical system security for low-carbon energy systems

As the continuous informatization and intellectualization development of energy systems, physical systems would be subject to security crisis from the information network system (Qin et al., 2021), which could impact the accuracy and integrity of energy systems data, e.g., carbon emissions. It is therefore vital to consider how to address the concerns of the energy system's safe and reliable operation. Zhao et al. propose an information attack scenario simulation method based on N-n predicted fault set for the case of the cyber physics system (CPS) on the basis of electricity-gas integrated energy system (EGIES). The proposed approach which is tested in IEEE57-NGS20 electricity-gas integrated system can significantly improve the ability of energy system to resist cyber-attack.

## 4 Machine learning based power load forecasting technologies

Machine learning has recently gained considerable research interest in power load forecasting (Yao et al.). Mu et al. propose a novel power load forecasting method based on an improved long short-term memory (LSTM) neural network. Compared with the conventional convolutional neural network (CNN) and recurrent neural network (RNN), the sequence-to-sequence (Seq2Seq) structure combining with LSTM model can reflect the sequence dependence between the output labels to improve the forecast accuracy. In this paper, the effectiveness of the LSTM-Seq2Seq method by performing simulations from two different datasets is verified. Besides, Yu et al. propose a fully-connected deep neural network (FDNN) based on the clustering results to predict the residential load. Compared to result without clustering, the proposed method could improve the accuracy of residential load forecast by 5.21%.

## 5 Other machine learning applications

For mitigating the uncertainty of grid operation caused by large-scale integration of renewable energy, Wang et al. propose a probabilistic power flow calculation method called principal component analysis-based compressive sensing (PCA-CS). Specifically, it includes a PCA step to increase the sparsity of expansion coefficient and adopts the idea of CS to reduce the number of expansion basis functions. In theory, a similar idea can be adopted when compressing the data transmitted between the neural network layers to improve the efficiency of model training. Practically, on the other hand, this method can help to improve the efficiency and accuracy of simulation and operation optimization of distribution networks, especially the medium and low voltage distribution networks connected with a large number of distributed generators and loads.

## 6 Conclusion

In summary, there are significant challenges associated with both renewable energy integration and the acceleration of industrialization and urbanization, which technologies such as machine learning can contribute to address. It is hoped that this Research Topic provides useful contents for further research in this area.

## Author contributions

HH and HW drafted the editorial. JS, KL, and ZD revised the editorial and approved it for submission.

## 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

10.3389/fenrg.2023.1175280

# References

Bamisile, O., Wang, X., Adun, H., Ejiyi, C., Obiora, S., Huang, Q., et al. (2022). A 2030 and 2050 feasible/sustainable decarbonization perusal for China's sichuan province: A deep carbon neutrality analysis and EnergyPLAN. *Energy Convers. manage.* 261, 115605. doi:10.1016/j.enconman.2022.11560510.3389/fenrg.2021.685021

Hua, H., Qin, Y., Hao, C., and Cao, J. (2019). Optimal energy management strategies for energy Internet via deep reinforcement learning approach. *Appl. Energy* 239, 598–609. doi:10.1016/j.apenergy.2019.01.145

Hua, H., Qin, Z., Qin, Y., Dong, N., Ye, M., Wang, Z., et al. (2022). Data-driven dynamical control for bottom-up energy Internet system. *IEEE Trans. Sustain. Energy* 13 (1), 315–327. doi:10.1109/TSTE.2021.3110294

Lin, B., and Li, Z. (2022). Towards world's low carbon development: The role of clean energy. *Appl. Energy* 307, 118160. doi:10.1016/j.apenergy.2021.118160

Qin, Z., Liu, D., Hua, H., and Cao, J. (2021). Privacy preserving load control of residential microgrid via deep reinforcement learning. *IEEE Trans. Smart Grid* 12 (5), 4079–4089. doi:10.1109/TSG.2021.3088290