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Editorial: Advancing demand response in renewable smart grid for a sustainable future

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Editorial on the Research Topic
Advancing demand response in renewable smart grid for a sustainable future

In the global energy landscape, the excessive dependence of traditional energy infrastructure on fossil fuels has triggered energy crises and climate change. Global warming has impacted human survival and hindered the process of sustainable development. In the face of such a severe situation, the low-carbon transformation of the energy industry is extremely urgent. As for a key component of deep decarbonization in the energy field, renewable energy smart grids have received widespread attention, while the demand response mechanism is of the utmost importance for their operation. These two sentences (with the first beginning with "As…") have been made into one for readability. Please confirm that "As for a key component of deep decarbonization in the energy field, renewable energy smart grids have received widespread attention, while the demand response mechanism is of the utmost importance for their operation" conveys the intended meaning. This can guide users to adjust their power consumption behavior, achieve precise matching of power supply and demand in terms of time and space, alleviate the intermittency of power generation from renewable energy sources, improve the efficiency of electricity utilization, enhance the stability of the power grid operation and, finally, contribute to the green transformation of the energy sector.

This Research Topic focuses on the latest developments in this field and pays particular attention to the following aspects: 1) In-depth exploration of the practical application effects of various demand response methods and how these can be optimized to significantly improve grid operation efficiency and achieve efficient allocation of power resources. The sentence starting with "This research …" has been edited for clarity. Please confirm that "This Research Topic focuses on the latest developments in this field and pays particular attention to the following aspects: 1) In-depth exploration of the practical application effects of various demand response methods and how these can be optimized to significantly improve grid operation efficiency and achieve efficient allocation of power resources" conveys the intended meaning. 2) Active exploration of innovative strategies to accelerate the low-carbon transformation of the energy industry and help achieve sustainable energy goals. 3) Comprehensive analysis of the influence of factors such as policy orientation, market dynamics, and technological progress on the implementation of the demand response mechanism to provide a scientific basis for relevant decision-making. 4) Study

and construction of effective mechanisms that can adapt to dynamic market changes and complex energy environments to enhance the flexibility and adaptability of the energy system. 5) Full use of the advantages of artificial intelligence technology in demand response: combine it with dynamic pricing strategies, optimize the power supply-demand relationship, and improve energy utilization efficiency. The sentence starting with "5)" has been edited to "5) Full use of the advantages of artificial intelligence technology in demand response: combine it with dynamic pricing strategies, optimize the power supply-demand relationship, and improve energy utilization efficiency." Please confirm that this conveys the intended meaning. 6) Promotion of the in-depth integration and innovative development of technologies in the smart grid field to improve the intelligence level and comprehensive performance of the grid. 7) Investigation of effective integration methods for distributed energy to achieve collaborative optimization of energy resources and improve the overall efficiency of the energy system.

A meta-learning architecture based on a Temporal Convolutional Network (TCN) was proposed to improve the prediction accuracy of residential flexible loads (Zhang et al.). This architecture uses CFF for data pre - processing to strengthen periodic features, and the TCN base model captures dependencies. Through a two - layer learning process, this achieved feature adaptation. Public dataset experiments have shown that it outperforms traditional models, and ablation experiments have verified the significance of CFF and the TCN architecture. Future research may incorporate more contextual information to enhance the model's accuracy in complex situations.

As carbon peaking and carbon neutrality strategies progress, the integration of new energy and EVs into the power system increases, but their uncertainty challenges grid frequency stability. In the sentence beginning with "As …", please review the wording in "their uncertainty challenges grid …" as the meaning is unclear. A coordinated frequency modulation strategy that considers source - load uncertainty was proposed, aiming to improve the frequency modulation ability and stability of the power system (Dong et al.). This strategy divides wind speed intervals by prediction errors and determines turbine modulation and capacity via control. Then, it creates an EV model, quantifies capacity, and makes power plans. Simulations have shown that it increases turbine capacity prediction accuracy by 9.27% and improves the modulation effect by 6.05% compared to a fixed ratio.

With a low-carbon society developing and renewable energy accessing the distribution network, voltage Research Topic are becoming more prominent. Using EVs for voltage regulation is a key area of research. An electric vehicle cluster distribution network voltage regulation strategy based on online parameter estimation was proposed to reduce voltage mismatch and regulation costs (Lyu et al.). An optimization problem that considers constraints and costs was formulated, which used a feedback-based algorithm and RLS to estimate parameters online. The sentence now beginning with "An optimization problem …" has been edited for clarity to the following: "An optimization problem that considers constraints and costs was formulated that used a feedback-based algorithm and RLS to estimate parameters online". Please confirm that the changes made convey the intended meaning. Theory has shown that errors converge exponentially. A 33 - node simulation proved its superiority in parameter estimation and voltage regulation. In the sentence beginning with "Theory …", please review the edits and confirm that they are correct. Also, please consider a rewording for "Theory" as it appears to be unclear/incomplete. Would "Theoretical analysis" work in this context?

As the proportion of renewable energy in the power system grows, traditional frequency regulation is facing Research Topic such as reduced inertia and a weakened ability. In the sentence now beginning with "As", please confirm that the changes made are correct. In addition, please review your use of "weakened ability" as it is unclear and consider a rewording to "weakened capacity", should that retain the intended meaning. A source-grid-load coordinated frequency modulation strategy for the DC sending-end grid considering the participation of electrolytic aluminum was proposed (Xing et al.). The authors analyzed the UHVDC sending-end system's frequency response, built an electrolytic aluminum load model, and proposed a hierarchical control strategy. The upper layer was found to allocate tasks, and the lower layer distributed commands to reduce costs. Simulations have shown that this stabilizes the system, reduces costs, and improves the performance of the power system. The part of the paragraph now beginning with "The authors …" was found to be unclear and it has been edited. Please review the following and confirm that it conveys the intended meaning: "The authors analyzed the UHVDC sending-end system's frequency response, built an electrolytic aluminum load model, and proposed a hierarchical control strategy. The upper layer was found to allocate tasks, and the lower layer distributed commands to reduce costs. Simulations have shown that this stabilizes the system, reduces costs, and improves the performance of the power system."

With fossil fuels depleting and renewable energy growing, the Integrated Smart Energy System (ISES) has emerged as a research hotspot. In the sentence beginning with "With fossil …", the wording "research hotspot" is unclear. Please consider a rewording ("important area of research", for instance). However, multi - energy flow interactions and the variability of renewable energy pose challenges to its static voltage stability. The static voltage stability of the ISES was studied through the analysis of multi - energy flows in n electricity - gas - heat energy system (Huang et al.). The study modeled interconnected energy subsystems as grid equivalents, converted gas and heating power flows into electrical active power, derived solution conditions using the Brouwer theorem, and validated conclusions via MATLAB/Simulink simulations.

As the proportion of renewable energy sources such as wind and solar in the grid keeps increasing, their variability and unpredictability challenge the stability and cost-effectiveness of power transmission systems. A new framework that combines robust optimization with online learning was proposed to dynamically manage the uncertainty of renewable energy power generation (Dongyang et al.). In this framework, robust optimization ensured system resilience in worst-case scenarios, while online learning updated operational strategies with real-time data. The sentence beginning with "In this framework …" has been edited for clarity. Please confirm that the changes made are correct. In the IEEE 30-node test system, when the renewable energy integration level rose from 10% to 50%, this framework cut operating costs by 12%, increased system reliability by 1.4%, and greatly reduced reserve power demand. This provides a dynamically adaptive solution for the sustainable management of power transmission systems, improving economic and environmental benefits, along with grid stability.

Author contributions

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

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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.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

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