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# Editorial: Advanced cooperative control and optimization strategies for integrated energy systems

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Editorial on the Research Topic
Advanced cooperative control and optimization strategies for integrated energy systems

With the increasingly serious problems of energy consumption and environmental pollution, the research and development of advanced energy infrastructures such as smart grids, smart transportation networks, and smart natural gas networks is extremely urgent. To this end, an integrated energy system (IES) that integrates multiple energy sources in a region and realizes coordinated planning, optimal operation, collaborative management, and complementation of multiple systems could improve resource utilization and reduce system operating costs and $CO_2$ emissions. Furthermore, IESs are regarded as a popular form of elastic energy utilization for future development. However, the current coordinated control and optimal strategies of integrated energy systems still have much room for improvement. Therefore, we must develop and optimize the control strategies of existing IESs to alleviate problems such as energy consumption and environmental pollution.

This Research Topic aims to explore the latest developments in this field, focusing on: 1) the distributed energy management structures and frameworks of IESs, 2) coupled mechanism modeling of IESs, 3) spatiotemporal data analysis and the cooperative control development of IESs, 4) optimal planning, operation, and control of IESs, 5) standard modeling of IESs, 6) nonlinear control and optimization of IESs, 7) the impact of cyber and physical security on the controller and optimizer of IESs, 8) the application of AI and 5G technologies on the controller and optimizer of IESs, and 9) distributed cooperative control and optimization strategies for IESs.

In recent years, with the growing popularity of electric vehicles, additional uncertainties have been added to the virtual power plant (VPP). To this end, Wensi et al. proposed a VPP economic dispatching model that considers the uncertainty factors of distributed power generation based on the classical scenario set. In this paper, Latin hypercube sampling combined with K-means clustering was used to generate the classical scene set; the model was solved using an improved particle swarm algorithm (PSO) that incorporated a genetic mechanism. A comparison of the classical scenario set and the general scenario set verified that the former was the optimal configuration of the VPP, significantly improving the net return of the VPP.

Considering the significant amount of data in a distributed power network and the low efficiency of communication between distributed units, Wang et al. proposed a consensus dispatch model based on multi-access edge computing (MEC) and a multi-agent system (MAS). The model solved the optimal dispatching scheme of the distributed power system by dividing the consistent variables of each unit. The established MEC-MAS–based power network communication model could provide a stable operating framework for distributed systems. This study constructed a hierarchical scheduling model consisting of edge nodes and cloud centers. The authors then divided and solved the consensus variables using the objective function of the hierarchical scheduling model; the distributed unit could optimize the unified objective under the constraints, obtaining an improved distributed grid scheduling scheme.

The broad development of integrated heat and electricity systems (IHES) has improved the energy utilization efficiency; however, it has also increased the risk of cascaded accidents and the difficulty of operation. To this end, Wang et al. proposed a method for constructing an IHES safe region considering thermodynamics based on the equivalent thermal model. In order to formulate an accurate security region (SR), a method of IHES SR construction that considers thermal dynamics was proposed. Based on the hyperplane method, an SR boundary formula was proposed. From the simulation, it was observed that this method was effective for heating system analysis. Due to the additional restrictions of the heating system, combined operation of the power system and the HS reduced the size of the SR.

The uncertainty and volatility of renewable energy generation leads to large amounts of abandoned electricity. An electricity-hydrogen coupling microgrid (EHCM) consists of a proton-exchange-membrane electrolytic cell, a liquid organic hydrogen carrier, hydrogen storage, and a proton-exchange-membrane fuel cell. This structure increases the utilization of wind and photovoltaic power. The scheduling of an EHCM is very challenging. To this end, Liu et al. proposed the optimal operation of microgrids considering the uncertainties of wind speed, light, electricity, and hydrogen coupling. An electricity-hydrogen coupling model and a hydrogen market model were constructed. The microgrid provided ancillary services to the grid while meeting hydrogen demand. The above model was solved using a two-stage optimization method involving day-ahead and intra-day time scales. The electricity-hydrogen coupling microgrid not only met the demands for hydrogen and electricity production, but also considered the application of liquid organic hydrogen carrier technology as well as the sale of oxygen, thereby improving safety and economy.

Large-scale, new energy sources such as photovoltaic power generation can reduce the original damping and inertia of a power system, resulting in oscillation of the system. Self-adaptive virtual synchronous generator (SDVSG)–controlled, grid-connected inverters can provide virtual damping and inertia to support the frequency and voltage of the grid. To combine SDVSG control with stand-alone PV systems, a mainstream solution to configure energy storage systems is required. To this end, Zhu et al. proposed a coordinated controlled, SDVSG, grid-connected photovoltaic energy storage system. An adaptive, variable-step conductance increment method was adopted to realize maximum power point tracking of the photovoltaic array, avoiding oscillation and untimely tracking near the maximum power point. A variable-domain, fuzzy logic, DC/DC control converter was designed for the grid connection of photovoltaic systems to overcome large overshoot and to rapidly obtain the required reference voltage. An adaptive virtual synchronous generator control strategy was also developed for the photovoltaic energy storage system's power supply to provide variable damping and inertia and to improve the stability of the power supply. The coordinated control strategy was proposed to realize the grid-connected power balance function, improving the generation efficiency and stabilizing the DC bus voltage.

## Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

## 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