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EDITORIAL

Planning, operation, and trading mechanisms of transactive energy systems in the context of carbon neutrality

1 | INTRODUCTION

In the context of carbon neutrality, the penetration ratio of renewable energy, flexible load, energy storage, and interactive equipment have been increasing, and the boundary between traditional energy producers and consumers has been getting more blurred. A new type of energy system, namely the transactive energy system (TES), has emerged. The TES uses the value (price) as a guide for market participants in optimizing decisions, realizing centralized/distributed coordination of large-scale energy systems, and developing these systems to improve energy efficiency, thus, reducing carbon emissions and improving the economy. However, the deep coupling between energy trading and physical energy flow complicates the planning, operation optimization, trading, and interaction of traditional energy systems. Based on the abovementioned background, this special issue, which focuses on the planning, operation, and trading mechanism of TES, has received considerable attention from the research community. The four papers selected for publication in this issue are briefly introduced below.

2 | PAPERS IN THE SPECIAL ISSUE

In the article 'Architecture and function analysis of integrated energy service stations considering cyber-physical integration', Chen et al. classified existing transactive energy market mechanisms according to the potential market structure and communication networks. Three potential practical problems related to information were proposed: asynchronous computing, real reporting, and privacy protection. Each practical problem was analyzed in detail through investigation and related research. Distributed algorithms for constrained optimizations, such as flexible and asynchronous alternating direction method of multipliers (ADMM), can help solve the problem of asynchronous computing. Mechanism design methods based on the principal-agent framework and Myerson's Lemma can provide some insights into the issue of real reporting. Two main approaches to addressing the challenge of privacy protection are homomorphic encryption and differential privacy. Based on these findings, several potential research directions were proposed to provide some insights for future research.

In the article 'Optimization of transactive energy systems with demand response: A cyber-physical-social system perspective', Han et al. focused on the distribution system and analyzed the challenges of TES in optimal operation of demand response (DR) in the context of cyber-physical-social system. An optimized framework of TES, which integrates artificial systems, computational experiments, and parallel energy optimization for DR modelling, was proposed. A data-driven artificial DR system was constructed based on limited data. A complete information on the Stackelberg game model that describes the relationship between distribution network operators and an artificial DR system was established to simulate the response relationship between distribution network operators and power users under different price incentives. In parallel energy optimization, a multi-time scale energy optimization method with day-ahead and intraday optimizations was proposed. The proposed method can reduce the cost for distribution network operators and users and promote renewable energy consumption.

In the article 'Energy-risk guided tuning of renewable bids: Enhanced Pareto-optimal profits for the utility and prosumers in microgrid', Mohan et al. constructed a microgrid energy portfolio based on the TES. Considering the large amount of renewable energy access and the interaction between energy and financial risks in TES, the portfolio was based on the adjustment of financial and energy risks and had a reasonable trade-off between utility and consumer profits. Based on the relative energy risk level quantified by the conditional value-at-risk, the authors pre-adjusted, and prioritized the bidding prices of wind and solar energy. Non-dominated sorting particle swarm optimization was used to simultaneously optimize the conflicting profits of utilities and consumers to obtain the risk-adjusted price Pareto optimal energy portfolio. Power companies can predict real-time net power balance cost from the dispatching time range using this method to mitigate the adverse impact of renewable energy uncertainty on collective welfare. The microgrid energy portfolio obtained using this method is more realistic, welfare optimized, and cost-effective.

In the article 'Comparative study on distributed generation trading mechanisms in the UK and China', Yao et al. discussed the trade mechanism of distributed generation (DG) in the context of TES through a comparative analysis between China and the UK. The policies and arrangements of DG trade in the UK and China, including market structure, connection classification, economic benefits, and practical problems, were comprehensively reviewed. The political, economic, social, and technical characteristics of the mechanisms of the two countries were qualitatively determined and compared based on strengths, weaknesses, opportunities, and threats using the framework of the SWOT-PEST model. The authors made a quantitative comparison between the trade arrangements of the UK and China, analyzed the economic benefits, and revealed the impact. Based on a comparative analysis, a direction for developing and perfecting the DG trading mechanism was proposed. Both UK and China, as well as other countries, can learn from their practical experiences.

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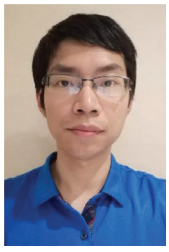

Yue Zhou received his B.Sc., M.Sc., and Ph.D. degrees in electrical engineering from Tianjin University, China in 2011, 2016, and 2016, respectively. He is a lecturer in Cyber Physical Systems at the School of Engineering, Cardiff University, Wales, UK. His research interests include demand response, peer-to-peer energy trading, and cyber-physical systems. Dr. Zhou is a managing editor of *Applied Energy* and an associate editor of *IET Energy Systems Integration*, *IET Renewable Power Generation*, and *Frontiers in Energy Research*. He is the chair of the CIGRE UK Next Generation Network (NGN) Committee. He is also a committee member of the IEEE PES UK and Ireland Chapters.

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