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Editorial: Energy efficiency analysis and intelligent optimization of process industry

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Editorial on the Research Topic

[Energy efficiency analysis and intelligent optimization of process industry](#)

Introduction

Given the rapid economic development, energy-saving and reduction of carbon dioxide emissions are now recognized as primary global goals. One of the most effective approaches for achieving energy efficiency and emissions reduction is the utilization of energy efficiency analysis and intelligent optimization methods, which find wide application in the process industry.

Common methods include traditional mechanism methods based on momentum transport, energy and quality transport (TT), as well as reaction engineering (RG) (TT-RG), in addition to data-driven artificial intelligence techniques. However, mechanism methods require well-defined parameters to achieve accurate modeling, posing a significant challenge within the process industry. In line with the advancement of artificial intelligence (AI) and big data, data-driven AI methods have progressively emerged as widely employed modeling tools, without considering internal mechanisms and strong nonlinear approximation ability, which can provide theoretical guidance for energy saving and emission reduction of the process industry.

The objective of this Research Topic is to establish an energy efficiency analysis and optimization model that employs machine intelligence, deep learning, and other AI methods to achieve energy savings and reduce carbon dioxide emissions. Advanced AI-based optimization algorithms are necessary to address the challenge of local optima and inability to attain global optima in the optimization process. To tackle issues like strong coupling, nonlinearity, and missing data in the process industry, effective data analysis and processing techniques including dimensionality reduction, matrix completion, and feature extraction should be proposed. Furthermore, it is crucial to construct a robust and highly generalized prediction model that can surmount problems related to low precision and poor generalization in process industry modeling.

It is important to highlight that following a rigorous peer review process, 10 articles have been accepted for inclusion in this Research Topic, spanning the following categories.

Energy system efficiency analysis and optimization

A plethora of innovative solutions were proposed by researchers to tackle multifaceted challenges in energy systems. Addressing the weak continuity and volatility of solar power generation data, [Liu et al.](#) proposed a photovoltaic power generation prediction method, which amalgamated Radial Basis Function Neural Networks (RBFNNs), the Adaptive Black Widow Optimization algorithm (ABWO), Similar Day Analysis (SDA), and K-means Clustering. The outcome is an enhanced stability and power quality for the grid. In the context of the burgeoning integration of 5G base stations, [Guo et al.](#) delved into the operational framework of microgrids and the carbon-reducing potential of these 5G stations on the power system, and crafted a multi-objective optimal operational model for microgrids access with 5G base stations to achieve the dual goals of minimizing microgrid operation costs and carbon emissions. [Wang and Liu](#) put forth a multi-objective evolutionary algorithm including the NDWA-GA and Pareto optimal space PCA for the optimal capacity allocation problem of multi-energy complementary systems to minimize both the system's total investment cost and battery capacity, thereby amplifying the utilization of clean energy. Empirical evidence showcased the superior convergence and economic viability of the proposed method. To address the energy loss observed in high temperature heat pump system under extensive temperature elevations, [Hao et al.](#) formulated a thermodynamic model for a double flash combined cycle system. Combined with the multivariate simulated annealing algorithm, the COP of the system was taken as the optimization objective to complete the calculation of the steady-state thermodynamic parameters of this system. The double flash combined cycle system was validated to possess superior steam generation capabilities under pronounced temperature rises and elevated condensation temperatures. Collectively, these research endeavors fortify the technical foundation for energy systems, ensuring they operate efficiently, stably, and with a reduced carbon footprint.

Optimization of energy system management and trading mechanism

For enhanced financial budgeting and localized operations, [Lu et al.](#) integrated the Support Vector Machine—based Recursive Feature Elimination (SVM-RFE) technique with a variant of the Autoregressive and Moving Average (ARMA) model to predict energy consumption and operational costs, thereby refining management in the process industry. The precision of the proposed method was corroborated through case studies. In pursuit of bolstering the resilience of the natural gas market, [Liu et al.](#) devised a novel customer value portrait framework based on different types of behavioral characteristics and emerging trends in the natural gas market to identify industrial customer value. By

harnessing varied behavioral data, it aptly encapsulates the value of natural gas industry clientele. Highlighting the economic and ecological potential of microgrids necessitates the creation of a proficient power trading mechanism. Traditional centralized power management models often grapple with issues of unreliability and confidentiality breaches during information exchanges. Therefore, [Wang et al.](#) introduced a blockchain-anchored distributed community energy trading mechanism, termed CE-SDT. And the thorough analysis affirmed its suitability. The introduction of various new technologies and strategies provided the possibility to achieve more efficient, economical and environmentally friendly energy utilization.

Energy system safety and fault detection

Within the realm of energy systems, the emphasis on technical safety and fault detection remains paramount. In view of the evident shortcomings in the standard interpretation of transformer fault detection and the inherent limitations of Adaptive Neuro Fuzzy Inference System (ANFIS), [Equbal et al.](#) introduced an online system for the early identification of transformer fault based on e-nose and ANFIS, which was demonstrated promising results upon testing. With the widespread deployment of the smart grid, as an open cyber physical system, it faces various security threats. Among them, False Data Injection Attack (FDIA) had become a major security risk, which bypassed the conventional detection of the system by constructing and injecting forged data. In order to cope with the diversity of this attack, [Lin et al.](#) unveiled a detection methodology for false data injection attacks, anchored in Deep Reinforcement Learning (DRL), which had notably enhanced detection efficacy. By integrating cutting-edge fault detection techniques with robust protection measures, a fortified safeguard for energy system was established.

Material science and environmental protection

The degradation of metals and alloys through corrosion can be effectively mitigated using corrosion inhibitors. However, traditional organic and inorganic inhibitors present issues related to toxicity, undesirable side effects, and environmental contamination. Recognizing these challenges, there has been a shift in research focus towards water-soluble polymer corrosion inhibitors, which offer environmentally benign, non-toxic, and minimal pollution attributes. [Yihang](#) conducted an extensive review on the action mechanisms of polymer-based inhibitors and the research status of natural polymer inhibitors and synthetic polymer inhibitors. This review aimed to furnish insights that could guide the advancement of eco-friendly metallic coatings.

In summary, this Research Topic encompasses a wide range of scholarly articles focusing on energy efficiency analysis and intelligent optimization in the process industry. The contributions within this compilation delve into various aspects of the field, exploring novel strategies and methodologies. A common thread among these works is the utilization of advanced

technological tools, including neural networks, the Internet, and blockchain, to enhance energy production, management, and utilization, as well as to improve the performance and reliability of energy systems.

The insights shared through this Research Topic will significantly contribute to the advancement of the field of energy efficiency analysis and intelligent optimization. This Research Topic of research exemplifies the potential of these innovations in propelling the energy sector forward, with the capacity to deliver greener, more efficient, and sustainable energy solutions. These solutions are instrumental in addressing the world's escalating energy demands while mitigating the impact on the environment.

Author contributions

YH: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Methodology, Project administration, Resources, Writing–original draft, Writing–review and editing. PW: Data curation, Formal Analysis, Methodology, Resources, Writing–original draft. ZG: Investigation, Project administration, Resources, Supervision, Writing–review and editing. XxZ: Conceptualization, Methodology, Resources, Validation, Writing–review and editing. XZ: Formal Analysis, Validation, 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.

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