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Editorial: Modeling and application of computational intelligence in sustainable energy systems

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Editorial on the Research Topic
Modeling and application of computational intelligence in sustainable energy systems

In recent years, the study of computational intelligence in sustainable energy systems has gained increasing attention due to its effectiveness and sophistication. Sustainable energy systems are designed, modeled and optimized by various computational intelligence methods, such as evolutionary computation and machine learning. These methods show the great value and significant contributions in energy research. As researchers continue to explore this area, new insights are being uncovered that have the potential to improve the role and significance of computational intelligence methods in modeling and optimizing sustainable energy systems.

In this Research Topic, several studies have contributed significantly to the advancement of computational intelligence in sustainable energy systems. In (Wang et al.), this study focused on optimizing the configuration and scheduling of integrated energy systems with flexible load resources to maximize energy efficiency and reduce environmental impact. By using Weibull and Beta distribution models to account for uncertainties in wind and solar power, and proposing an enhanced Kepler Optimization Algorithm (EKOA), the approach improved search scope and efficiency. A case study in southeastern China demonstrated that this method reduced energy curtailment and costs, while enhancing renewable energy use. Despite the success, the study only considered hydrogen for single-use and did not explore market benefits, leaving room for future research on hydrogen demand response and market integration. In (Punyam Rajendran and Gebremedhin), multi-energy microgrids (MEM) integrate various energy sectors to enhance renewable energy use while maintaining balance. This study analyzed the technical challenges of increasing renewable penetration, using an artificial neural network-based model for solar power forecasting, integrated with the EnergyPLAN tool. A case study on Norway revealed that combined heat and power plants hindered renewable integration, while heat pumps enhanced it. Additionally, photovoltaic system size strongly affected energy imports and exports compared to wind generation. In (Bao and Zhang), new energy resources like wind and photovoltaic systems are more vulnerable to non-ideal power grids than traditional thermal power generation, which can affect equipment safety and power quality. To address this, the study transformed LCL-type grid-connected inverters into linear systems using feedback linearization, allowing for the application of robust control strategies. A multi-functional control strategy based on feedback linearization and the Hamilton-Jacobi-Issacs inequality was developed. Simulations showed that this strategy outperformed traditional methods, improving performance in weak grid conditions and addressing Research Topic like low short-circuit ratios, voltage fluctuations, and harmonics. In (Ding et al.), accurately forecasting power dispatch flows is challenging due to the complexity, variability, and missing data in the network. To address this, the study proposed a transfer learning approach using a gated recurrent unit (GRU) to interpolate missing values, followed by Extreme Gradient Boosting (XGBoost) for future flow predictions. This GRU-XGBoost module was tested on power grid data from southern China and outperformed other machine learning and neural network models, proving highly effective for short-term flow prediction in power dispatch networks. In (Ye et al.), traditional biomass boiler operations rely on manual control, leading to inefficient resource use. To improve efficiency, this study introduced a controller based on the STM32 microcontroller with a modular architecture, cost-effective components, and a fuzzy PID control strategy. The controller supported both manual and automatic modes, allowed for data logging locally or on the cloud, and enabled remote monitoring and management. It optimized motor control and temperature measurement, reducing energy consumption and labor costs while promoting sustainability. The controller had undergone refinement and testing, proving its readiness for widespread use.

Despite these advancements, the study of computational intelligence in sustainable energy systems faces several challenges. For instance, large-scale and high-dimensional energy systems need to be effectively modeled and optimized. Simulation results of models are not robust. Computational cost of used methods is high. The interpretability of optimization methods is low. These challenges hinder the development of computational intelligence methods in sustainable energy systems.

Looking ahead, the future of computational intelligence in sustainable energy systems is poised for transformative growth. Emerging technologies such as metaheuristic algorithms and artificial neural networks and novel approaches to application and optimization of energy systems offer promising opportunities for breakthroughs. Collaboration between computational intelligence and traditional methods will also be crucial in overcoming current barriers and driving progress.

In conclusion, this Research Topic holds immense potential to enhance the modeling and application of computational intelligence in sustainable energy systems. While challenges remain, the continued dedication of the research community, coupled with innovative approaches, will undoubtedly propel the field forward, unlocking new possibilities for the development of sustainable energy systems.

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