Paper 254

Modeling and Energy Efficiency Analysis of Urban Energy Systems Coupled with Artificial Intelligence

With the rapid pace of urbanization and increasing energy demand, urban energy systems face challenges such as complex energy structures, significant peak load fluctuations, and growing environmental pressures. Traditional planning and operational methods often rely on experience and static analysis, which are insufficient to respond in real time to the dynamic demands of urban energy consumption and the variable integration of renewable energy. Therefore, improving operational efficiency, reducing energy consumption, and mitigating environmental impacts are critical for sustainable urban development.

The development of artificial intelligence (AI) provides new opportunities for modeling, optimization, and energy efficiency analysis of urban energy systems. Techniques such as machine learning, deep learning, and reinforcement learning can be applied to data mining, load forecasting, optimal scheduling, and operational control of multi-energy systems, including electricity, heating, gas, and renewable energy networks. Integrating AI enhances prediction accuracy and decision-making efficiency, enabling optimal energy flow allocation under complex operating conditions, improving overall energy efficiency, reducing energy costs, and mitigating environmental impacts.

In practical applications, AI-coupled urban energy system modeling requires consideration of multi-energy coupling, multi-objective optimization, and multi-time-scale operational characteristics. Key research areas include precise system modeling, energy flow and load matching analysis, energy efficiency metrics evaluation, and AI-driven optimization strategies. Through simulation and performance analysis of real urban energy systems, the impact of AI on system efficiency, economic performance, and sustainability can be quantified, providing scientific guidance for urban energy planning, management, and policy formulation.

This study aims to propose an AI-coupled modeling and energy efficiency analysis framework for urban energy systems, combining AI techniques with multi-energy system models to explore opportunities for optimizing energy flows, load control, and operational strategies. The findings are expected to provide theoretical and practical

support for smart city development, low-carbon urban operation, and sustainable energy planning.