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Building Integrated Urban Energy Systems: Exploring Sustainable Pathways to Urban Decarbonization

As global climate change intensifies, cities—being major centers of energy consumption and carbon emissions—are at the forefront of low-carbon transformation efforts. In this context, the construction of Integrated Urban Energy Systems (IUES) has emerged as a crucial approach for promoting urban sustainability. IUES seeks to integrate multiple forms of energy (such as electricity, heating, cooling, and gas), diverse technologies (including renewables, energy storage, and distributed energy systems), and various stakeholders (governments, enterprises, and end-users) to enable efficient energy flow and optimized distribution within urban environments. This, in turn, significantly enhances energy efficiency and reduces greenhouse gas emissions.

Traditional urban energy systems often rely on "single-energy, decentralized management" models, which suffer from low efficiency, weak regulation capabilities, and difficulties in accommodating renewable energy sources. In contrast, integrated systems emphasize multi-energy synergy, coordinated supply and demand, and intelligent control. These features allow for a more balanced and resilient energy infrastructure. In key urban sectors such as buildings, transportation, and industry, IUES enables coupling and optimization strategies that lower overall energy consumption and support carbon neutrality objectives.

This study aims to systematically examine the construction pathways and core technologies of integrated urban energy systems, and analyze their functional role in facilitating urban decarbonization. Drawing on case studies from representative cities, it further explores adaptable implementation models for cities at various stages of development. By combining system modeling, policy analysis, and empirical research, the study proposes actionable strategies and policy recommendations to optimize urban energy systems, offering both theoretical insights and practical references for the green transformation of cities in China and beyond.