

Current Situation of Urban Energy Consumption Under the Digital Economy Model

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Abstract: The digital economy has injected continuous momentum into the development of urban economy and plays a positive and important role in the transformation and upgrading of urban energy consumption. Specifically, the digital economy can significantly improve the efficiency of urban energy consumption by virtue of its distinctive characteristics of low pollution and high efficiency. Moreover, empowered by the digital economy, the pace of transformation and upgrading of high-pollution traditional industries has been accelerated. Particularly importantly, the urban energy consumption structure has been optimized and adjusted through the indirect role of intermediate factors. From this perspective, studying the current situation and countermeasures of urban energy consumption under the digital economy holds important practical significance both in theory and practice. This paper first briefly summarizes the relevant literature on the impact of the digital economy on the energy consumption structure; then, it focuses on detailed data to explore the current situation of urban energy consumption under the digital economy model; finally, based on the summary of the current situation, it puts forward practical and feasible suggestions, hoping to provide a decision-making basis for the implementation of policies in different types of cities and offer innovative ideas for promoting the high-quality development of urban energy systems.

Keywords: Current situation; Digital economy model; Suggestions; Urban energy consumption

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1. Introduction

In the context of the continuous and in-depth implementation of the “dual carbon” goals, cities, as the engines of national economic growth and the core of energy consumption, have attracted widespread attention from all sectors regarding the optimization and transformation of their energy consumption models. According to the analysis of data from 2023, China’s total energy consumption reached 5.72 billion tons of standard coal, among which fossil energy accounted for as high as 73.6%. In contrast, the proportion of clean energy was less than half of that of fossil energy, only 26.4%^[1]. Studies have shown that on the path to achieving the carbon neutrality goal, the high proportion of fossil energy poses severe challenges to the transformation of China’s energy consumption structure

and is one of the important factors affecting the realization of the carbon neutrality goal. Therefore, this paper focuses on an in-depth analysis of the current situation of urban energy consumption under the digital economy model, hoping to contribute a modest effort to promoting the integrated development of the digital economy and urban energy consumption in the future.

2. Literature review on the impact of digital economy on energy consumption structure

Relevant studies on the impact of the digital economy on the energy consumption structure mainly focus on two aspects: the green energy-saving effect and the energy rebound effect, aiming to analyze the internal impact mechanisms and practical effects of these two dimensions. Studies have shown that the digital economy serves as a crucial engine driving economic growth and provides an effective pathway for the optimization and upgrading of the energy consumption structure. Fundamentally, this relationship is essentially a “game” between the green energy-saving effect and the rebound effect ^[2]. In this game, the improvement of energy efficiency and the optimization of the energy structure represent specific opportunities; however, the total energy consumption may confront unprecedented challenges. To formulate scientific and effective energy policies, it is essential to pay equal attention to both opportunities and challenges, while clearly clarifying the relationship between them.

On one hand, regarding the green energy-saving effect, the digital economy not only triggers a technological revolution but also significantly enhances energy utilization efficiency. Meanwhile, it promotes industrial transformation and upgrading. Through these channels, the energy consumption structure can be optimized, driving it toward low-carbonization, greenization, and cleanization. Zhu et al. (2025) conducted a study using an improved stochastic frontier model and found that the digital economy can substantially improve energy efficiency while exerting a positive driving effect on economic growth. Under the influence of indirect effects, it can effectively reduce energy intensity per unit of output. Nevertheless, part of this energy-saving effect is still offset by the “substitution effect,” “income effect,” and “output effect” ^[3]. Mao et al. (2024), by extensively collecting and analyzing urban panel data, revealed that the digital economy is of great significance to the integration and mutual development of industrial digitalization and digital industrialization. On this basis, energy-intensive industries may be invisibly replaced by technology-intensive industries ^[4]. More importantly, this structural transformation effect is more prominent in cities with low endowments of fossil energy. In addition, the spatial spillover effect—a crucial characteristic of the digital economy—enables its role in optimizing the energy structure to break through geographical constraints, continuously radiate to surrounding regions, drive the optimization and upgrading of energy consumption structures in neighboring areas, and make cross-regional collaborative energy governance possible.

On the other hand, concerning the energy rebound effect, this effect of the digital economy may cause energy conservation and emission reduction outcomes to fall short of expectations. Specifically, as energy utilization efficiency improves, the total energy consumption may show an upward trend. Two primary factors contribute to this phenomenon: first, the decline in energy use costs, and second, the stimulation from economic growth. Some scholars point out that the factors triggering the rebound effect mainly include two aspects: first, the digital economy has an “incomplete substitution effect” on traditional energy sources, meaning it cannot fully replace the use of traditional high-energy-consuming energy; second, the digital economy has spawned a range of new business formats, including digital services and intelligent industries, which further expands energy demand. Relevant calculation data indicate that the current average level of urban energy rebound effect in China is

approximately 56.2%. This figure reflects indirectly that the actual energy-saving effect currently achieved in China is only about 40% of the theoretical value^[5]. The fundamental reason lies in the fact that although the digital economy drives technological innovation and boosts economic growth, it also gradually amplifies the overall demand for energy consumption. Building on theoretical foundations, some scholars have conducted a series of empirical studies. The results show that the popularization of the Internet has dual effects: on one hand, it effectively improves the efficiency of economic operation and stimulates the growth of electricity demand; on the other hand, it may intensify the pressure on energy consumption.

3. Analysis of the current situation of digital economy and energy consumption

3.1. Analysis of the current development situation of the digital economy

From 2012 to 2023, China's digital economy maintained a remarkable growth momentum, with its total volume increasing steadily from the initial 11.2 trillion yuan to 53.9 trillion yuan. This significant leap intuitively demonstrates the important position of the digital economy in China's overall economic system. Over these 11 years, the average growth rate of China's digital economy has remained at a high level, with the specific figure reaching 15.3%. From the perspective of growth rate, in 2023, the digital economy provided solid and strong support for achieving the goal of stable economic growth. The nominal growth rate of China's digital economy in that year was 7.37%, which was 2.73 percentage points higher than the nominal growth rate of GDP in the same period. From the perspective of contribution rate, the corresponding figure reached 66.45%^[6]. This set of data indicates that the digital economy can not only enhance the resilience of China's economic development but also inject a continuous stream of vitality into it.

In the process of the high-quality development of China's digital economy, the internal structure of the digital economy has been optimized. At the same time, a gradual balance has been achieved between digital industrialization and industrial digitalization, and the empowering capacity and integration capacity of the digital economy have been significantly improved. Relevant data show that in 2023, the economic scale of China's digital industrialization sector reached 10.1 trillion yuan, an increase of approximately 0.9 trillion yuan compared with 2022. This growth rate even exceeded the overall growth rate of the digital economy in the same period, which will provide stronger technological and industrial support for the future development of the digital economy^[7].

Finally, an analysis of the data on the development level of the digital economy in various regions of China shows that regional differences may lead to significant variations in the development level of the digital economy across different regions. Among them, the eastern coastal areas take the leading position, while the central and western regions are relatively weak in the development of the digital economy. Although the development level of the digital economy in these two regions still lags behind the national average, the gap in the central region is relatively smaller. From an overall perspective, in recent years, the development level of China's digital economy has been in a continuous growth trend, and the improvement of the national average level of the digital economy has also shown a stable trend across the country.

3.2. Analysis of the current situation of energy consumption

3.2.1. Current situation of total energy consumption

Between 2013 and 2024, China's total energy consumption increased from 4.17 billion tons of standard coal equivalent (SCE) to 5.92 billion tons of SCE, with an average annual growth rate of approximately 3.2%. However, during the same period (2013-2024), the average annual growth rate of China's national economy

was about 6%. Behind these figures lies the fact that China has not only ensured the high-speed development of its economy but also effectively controlled the growth rate of energy consumption. This is not merely a simple “quantity control”; on a deeper level, it reveals that China’s energy efficiency is steadily improving^[8].

3.2.2. Current situation of energy consumption structure

From 2013 to 2024, the consumption of coal—China’s traditional high-energy-consuming energy source—showed an overall downward trend. Relevant data indicate that in 2013, coal consumption accounted for as high as 67.4% of China’s total energy consumption; by 2024, this figure had gradually dropped to 53.2%. These data reflect, from a side perspective, that China’s energy structure is constantly transitioning toward a low-carbon direction. Nevertheless, the role of coal in the power supply system remains significant. Approximately 60% of total coal consumption is used in the field of electricity generation, and its position may be difficult to replace in the short term.

Besides coal, the proportion of oil in the energy consumption structure has remained relatively stable, fluctuating around 18% overall. Compared with oil, the proportion of natural gas in energy consumption showed a continuous upward trend between 2013 and 2024, with the corresponding figures being 5.30% and 8.2% respectively. Owing to its distinct characteristics of cleanliness and high efficiency, natural gas is playing an increasingly important role in the overall energy structure.

In addition, hydropower, wind power, solar power, and nuclear power—important representatives of non-fossil energy—have developed rapidly in recent years, and the proportion of each in the energy structure has increased year by year. Between 2013 and 2024 alone, the total proportion of these non-fossil energy sources achieved a leapfrog development from 10.2% to 21.3%^[9]. This signifies that China’s energy structure is gradually moving toward a new path of greenization and low-carbonization.

4. Suggestions for optimizing urban energy consumption structure under the digital economy model

4.1. Consolidate the foundation of digital infrastructure

To specifically address the unbalanced development of regional digitalization, the government should invest substantial funds, materials, and human resources in digital infrastructure construction. Priority should be given to the central and western regions, as well as regions with low energy endowments. In addition to expanding network coverage and improving network quality, it is also necessary to build a systematic and comprehensive digital financial service system. The core purpose of these measures is to provide convenient network, technical, and other support for the subsequent application of energy digitalization, enabling every region to benefit from digitalization^[10].

4.2. Promote the implementation of intelligent and green transformation

“Industrial intelligent and green transformation” specifically refers to the flexible use of various means to drive the continuous transformation and development of industries towards intelligence and greenization. Under the correct guidance of industrial policies, the integration of the digital economy and traditional industries should gradually shift from “superficial” to “in-depth”—especially for high-energy-consuming industries such as iron and steel, and chemical engineering. Solid and powerful digital technical support should be provided for these industries to achieve intelligent transformation and green upgrading^[11]. At the same time, focus should be placed on fostering

emerging industries such as cloud computing and 5G communications, which are characterized by low energy consumption and high added value. Furthermore, over-reliance on traditional energy sources such as oil and coal should be avoided. This suggestion is put forward from the perspective of optimizing the industrial structure, and its advantage lies in effectively promoting the transformation of energy consumption patterns towards higher efficiency and intensification.

4.3. Support green technology innovation

Greater efforts should be made to research and develop green and environmental protection technologies. To ensure the smooth progress of technology R&D, it is recommended to establish special R&D funds. Moreover, it is necessary to improve financial policies to provide guarantee and support for the development of green credit. For enterprises dedicated to green technology R&D, it is suggested to offer tax reductions and exemptions, as well as provide them with certain financial subsidies^[12]. Additionally, society, schools, and the government should strengthen collaboration, rely on the industry-university-research cooperation platform, and increase efforts in cultivating and introducing high-end talents. This will provide solid talent support for the R&D and innovation of green technologies^[13].

4.4. Implement regionally differentiated strategies

Each region should closely align with its actual conditions to carefully formulate strategies for advancing the development of the digital economy and also establish and improve policies facilitating energy transition. Specific strategies may be formulated in a context-specific manner based on the actual conditions of the eastern, central, and western regions. For instance, the eastern regions should give full play to the advantages of digital technologies and, with an innovative mindset, promote the integrated innovation of these technologies with green energy sources such as wind power and photovoltaic power; the central regions should focus on their local traditional industries, such as manufacturing, fully leverage the enabling role of digital technologies, and assist these traditional industries in advancing toward digitalization step by step; the western regions, on the other hand, should strengthen the construction of digital infrastructure and, more importantly, focus on exploring ways to enhance the effective utilization rate of local energy resources^[14,15]. Such differentiated strategies can enhance the rationality and effectiveness of the transformation of urban energy consumption against the backdrop of the digital economy.

5. Conclusion

To sum up, through various approaches including technological empowerment, industrial adjustment, and consumption transformation, the digital economy can directly change the energy consumption structure and drive its continuous transformation and development towards cleanliness and efficiency. Based on the above research, various regions can promote the optimized transformation of urban energy consumption structure under the digital economy model by taking measures such as consolidating the foundation of digital infrastructure, advancing the implementation of intelligent and green transformation, supporting green technological innovation, and implementing strategies tailored to regional differences.

Disclosure statement

The authors declare no conflict of interest.

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