



Research on the Paths of Digital Economy to Promote the Low-carbon Development of China's Energy Industry

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

At present, China's energy industry is undergoing revolutionary changes, in a critical period of new and old kinetic energy conversion and low-carbon transformation, of which the digital economy plays an important role in energy supply, green consumption and clean production. In the face of the problems of heavy secondary industry structure, coal energy consumption, low energy utilization efficiency, and insufficient supply of key minerals of new energy in China's energy industry in the low-carbon transformation, we should actively use the digital economy to promote a high degree of integration between the digital economy and the energy industry, consolidate the digital infrastructure of the energy industry, improve the independent innovation ability of key technologies in the energy industry, promote the low-carbon and green development of China's energy industry.

Keywords: Digital economy; the energy industry; digital technology; low carbon development; carbon emissions; energy technology innovation.

1. INTRODUCTION

Climate change is one of the biggest environmental issues and development crises

facing mankind. In order to prevent climate change from endangering human survival and development security, it has become a global consensus to achieve carbon emissions peak

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and carbon neutrality as soon as possible to protect our planet. At the 26th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), 153 countries, including the United States, Japan, the European Union and the Republic of Korea, proposed in their intended Nationally Determined Contributions (NDCs) that they would make commitments to achieve quasi-net zero emissions globally. Meanwhile, China has always attached great importance to carbon emissions peak and carbon neutrality. In September 2020, General Secretary Xi Jinping officially put forward the goal of achieving carbon emissions peak in 2030 and carbon neutrality by 2060 at the 75th session of the United Nations General Assembly [1]. The proposal of the "double carbon" goal is a major strategic decision made by the Party Central Committee with Comrade Xi Jinping as the core to coordinate the two overall situations at home and abroad. To achieve the "double carbon" goal, the energy sector is the main battlefield and main front, and the low-carbon transformation of the energy industry is an important path and strategic choice. At present, the digital economy is becoming a new engine for economic transformation and upgrading, "the development of the digital economy is a strategic choice to seize the new round of scientific and technological revolution and new opportunities for industrial change" [2]. Using digital transformation as a carrier to drive structural changes in the energy industry and promote low-carbon green development of the energy industry is not only a realistic and urgent demand, but also the direction of industry development." How to achieve low-carbon development of the energy industry with the help of digital economy has attracted much attention.

Most relevant research at home and abroad from the normative analysis and empirical analysis of the research perspective, focusing on green low carbon energy development or digital technology, digital transformation and low carbon development research, on how to implement low-carbon development of energy industry in China with the help of digital economy research was lacking, therefore, it is necessary for us, from the perspective of the digital economy, This paper explores the role of digital economy in supporting the low carbon development of Chinese energy industry, aims at the problems of Chinese energy industry in the second industry structure, energy consumption, energy utilization efficiency, key minerals of new energy, and puts forward

effective ways of boosting the low carbon development of Chinese energy industry with digital economy.

2. THE EFFECT OF THE DIGITAL ECONOMY IN THE LOW-CARBON TRANSFORMATION OF THE ENERGY INDUSTRY

There are two main problems facing the low-carbon transformation of the energy industry: First, the traditional energy consumption is large and the utilization rate is low; Second, the degree of new energy development is low. The root cause of these two aspects lies in the lack of energy technology innovation capabilities, which is exactly the problem that the digital economy can solve. Therefore, strengthening the integration of the digital economy and the energy industry is of great strategic significance to achieve the low-carbon development of China's energy industry.

2.1 The Digital Economy Can Improve the Quality of Energy Supply

In the era of digital economy, the application of data, Internet and digital technology can effectively improve the capacity and quality of energy supply. On the energy supply side, on the one hand, the application and promotion of digital technology can better understand the trend of energy market and price changes, and ensure energy supply. Through real-time collection, monitoring, transmission, analysis and utilization of energy data flow, it can guide the efficient allocation of energy factors and promote the smooth upgrade and optimization of energy flow [3]. On the other hand, digital technologies such as Internet of Things, cloud computing and big data can improve the efficiency of energy harvesting and online interconnection, realize the intensification and refinement of energy supply links, and provide safe and reliable technical support for energy production and operation [4].

2.2 The Digital Economy Can Drive Clean Energy Production

If the energy industry wants to form a clean production process, it is necessary to adopt non-toxic and harmless intermediate products, select less waste, no waste technology and efficient equipment, carry out internal recycling of materials, improve the main production management, and constantly improve the level of

scientific management. From the perspective of the production end, access to big data in the production link, through big data optimization parameters, can improve the energy use efficiency, realize the internal recycling of materials [3]; the application of digital technology in energy production equipment can improve equipment efficiency, increase output value per unit of energy, and reduce carbon dioxide emissions. In the main production management, big data, Internet, cloud computing and other digital technologies can achieve data exchange, reduce the traditional management links, improve management efficiency.

2.3 The Digital Economy Can Promote Green Energy Consumption

For a long time, the main energy consumption of China is coal, oil and other one-time energy, which also brings a large number of long-term carbon emissions. From the perspective of consumption, studies have shown that the promotion and application of information technology alone can reduce the carbon emissions by 13%-22% without increasing the overall energy consumption [5]. In the aspect of energy consumption, artificial intelligence and other digital technologies will subvert the traditional concept of energy consumption, constantly develop non-fossil energy, create new ways of energy consumption, and reduce energy consumption and consumption intensity [6].

To sum up, the digital economy plays a key role in the realization of low-carbon development in our energy industry. It is urgent to take the initiative to grasp and lead the trend of the new generation of information technology, change the concept of production and management, carry out all-round digital transformation from energy production, consumption, supply and other aspects, and promote low-carbon energy development.

3. THE PROBLEMS EXISTING IN THE DEVELOPMENT OF CHINESE ENERGY INDUSTRY AT PRESENT

China is the world's largest country in energy consumption and carbon emissions. According to the China Energy Development Report 2022, the China's coal and oil consumption accounted for 74.5 percent in 2021 [7]. The principal contradiction of China's energy development is not the rapid growth of the total energy demand

and supply ability, to the masses of the people to improve the ecological environment of high expectation and low energy of the contradiction between the development of quality, facing the second partial coal heavy industrial structure, energy consumption, energy efficiency is low key minerals are in short supply, new energy and other issues.

3.1 The Structure of the Secondary Industry is Heavy and the Energy Consumption is High

From the point of view of the development of our three major industrial structure, the proportion of the secondary industry once stood at more than 40% for a long time, and only decreased to below 40% in recent years. In 2021, China's secondary industry accounted for 39.4% of GDP (As shown in Fig. 1) [8]. While Germany only accounted for 29.39%, the United States about 18%, and the United Kingdom about 17%. Compared to the raw material mining of resource countries such as Brazil, Australia and the high-end manufacturing industry that developed countries occupy the advantage, China's processing and manufacturing process has a high energy resource consumption intensity and high carbon emissions per unit of GDP. The energy consumption of the second industry accounts for about 70% of the total energy consumption in China, among which steel, cement, non-ferrous metals, automobiles and other high energy consumption industries account for a high global proportion, which is an important reason for the large amount of energy consumption and high energy consumption intensity of unit GDP. China's manufacturing industry as a whole is at the middle and low end of the global value chain, and it is much more difficult to reduce carbon emission intensity by adjusting the industrial structure than that of developed countries.

3.2 Energy Structure is Coal, Coal Control and Carbon Reduction is Difficult

Our natural resource belongs to coal rich but gas insufficient, from the perspective of consumption structure, primary energy consumption structure is still mainly coal. The long-term coal plays a foundational role in the energy security strategy, and is the first main body of energy in China. Globally, China is the largest energy consumer and consistently ranks first in coal consumption (As shown in Table 1). Since 2000, the

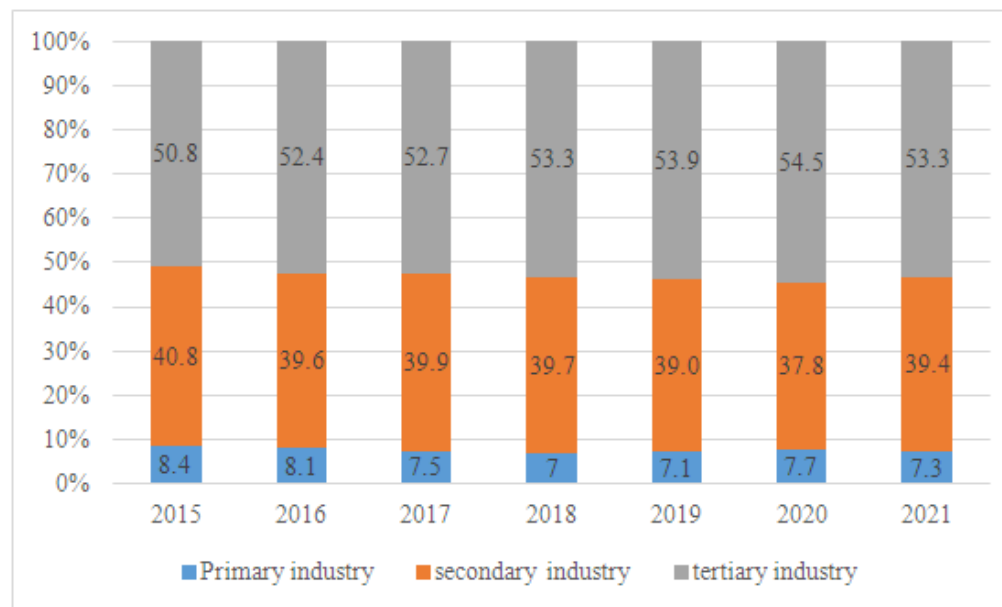


Fig. 1. The added value of the three sectors of industry accounted for the proportion of China's GDP from 2015 to 2021¹

Table 1. Ranking of the world's top five coal consuming countries in 2021(Unit: Aijo)²

Country	2021	2020	on year-on-year basis %
Total global consumption	160.10	151.07	6.3
China	86.17	82.38	4.9
India	20.09	17.40	15.8
America	10.57	9.20	15.2
Japan	4.80	4.57	5.2
South Africa	3.53	3.56	-0.5

¹ Data source: National Bureau of statistics of the People's Republic of China.

² Data source: BP Statistical Review of World Energy 2022.

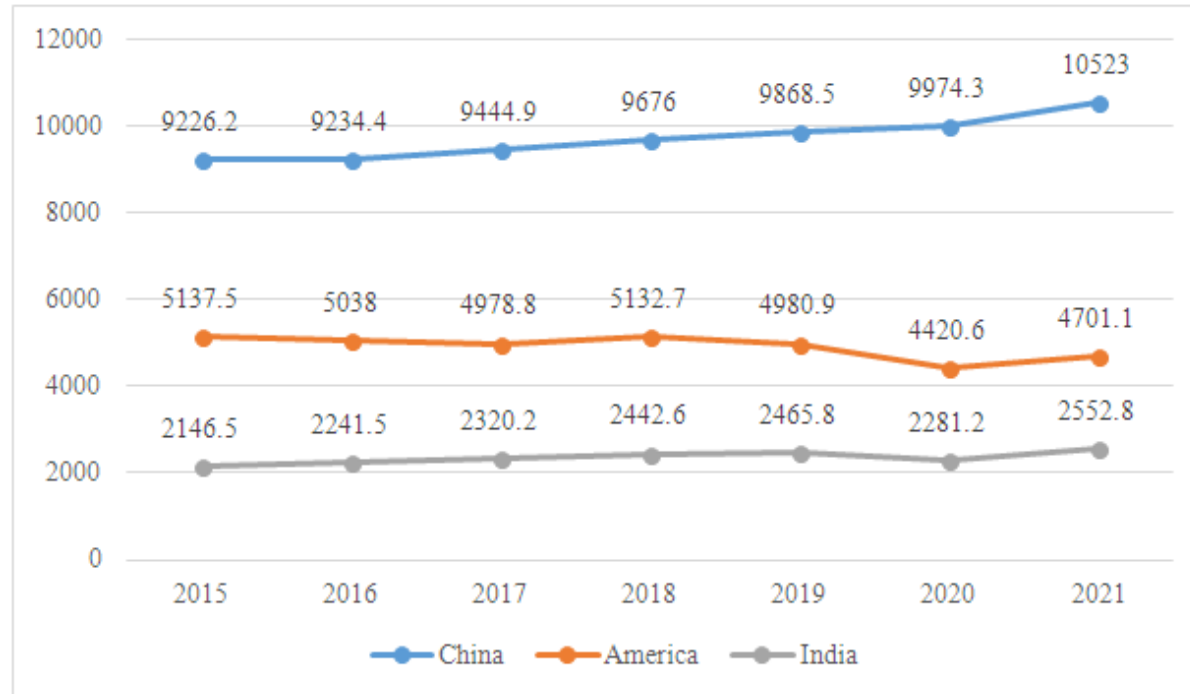


Fig. 2. CO₂ emissions of China, America and India from 2015 to 2021 (Unit: Million tons)³

³ Data source: BP Statistical Review of World Energy 2022

proportion of coal consumption in primary energy consumption in China has declined rapidly, but the proportion is still as high as 56% by 2021, much higher than the global average of 27%. In 2021, China's total energy consumption was 5.24 billion tons of standard coal, accounting for 56.0% of the total energy consumption [8]. About 4 times that of India, 8 times that of the United States.

Overall, China's and the world's total coal consumption is on the rise. Coal has a high carbon attribute, and its carbon emission per unit calorific value is 1.4 times that of oil and 2 times that of natural gas. The increase of energy consumption has brought about an increase in carbon dioxide emission level. Therefore, in the global scale, China still ranks first in carbon emission, and its emissions are far higher than those of the United States and India, which rank second and third (As shown in Fig. 2). As China's carbon emissions continue to grow, "Coal reduction" is regarded as the main measure of energy green and low-carbon transition. However, the "coal reduction" is too fast and too strong, and the role of coal in the safe operation of the energy system will be weakened, which will lead to energy security problems in the short term. For example, in the second half of 2021, the "power cut" phenomenon caused by the shortage of thermal coal supply in some areas. China's coal consumption is expected to peak during the 14th Five-Year Plan period and the coal will remain China's largest energy source until 2035. During this period, it will be increasingly difficult to control coal and reduce carbon emissions while making good use of coal as a ballast stone to ensure energy security.

3.3 The Energy Utilization Efficiency is Low, the Scientific and Technological Innovation Ability is Insufficient

Since 2000, China's energy consumption per unit GDP has been declining continuously, but it is still far higher than the global average level. According to BP Energy Statistics and the World Bank, In 2020, the energy consumption per unit of GDP in the EU was 1.22 tons of standard coal/10,000 US dollars, the United States was 1.69 tons of standard coal/10,000 US dollars, and China was 4.22 tons of standard coal/10,000 US dollars, China's energy consumption intensity is 3.5 times that of the EU and 2.5 times that of the United States. The reasons of unit energy consumption on the high side and energy efficiency on the low side are as follows: First, the secondary industry and energy-consuming

industries are high in the industrial structure; Second, some industrial processes are backward, and there are still a large number of backward and excess production capacity in coal, steel and other industries. Some local governments still rely on traditional industries and production models to sustain economic growth. Third, our energy science and technology innovation capacity is insufficient, low carbon, green, energy saving technology needs to be improved, some local financial capacity is limited, the financial support to energy saving and emission reduction is not high.

3.4 New Energy Development Faces Challenges, and Key Mineral Resources are Highly Dependent on Foreign Countries

Driven by policy guidance and technological progress, China has made great progress in non-fossil energy such as nuclear energy, hydro energy, wind energy and solar energy, as well as hydrogen energy, energy storage and new energy vehicles. However, large-scale development still faces many challenges. Some core components and basic materials of nuclear power still depend on imports, and the development and utilization of nuclear fusion energy is still in the exploratory stage. Hydropower project construction environment is complex, ecological environment is fragile, engineering technology, construction management and resettlement difficulties can not be underestimated. Compared with conventional power sources, wind and solar power generation has typical intermittency, volatility and randomness, and the reliability of power system is insufficient under the condition of high proportion of new energy sources. In terms of hydrogen energy, the cost of transmission and distribution and typical application scenarios is high, and there is still a big gap between high-pressure hydrogen storage equipment and fuel cells compared with foreign countries. In terms of energy storage, the development space of pumped energy storage is limited, the cost of electrochemical energy storage is high, and it cannot meet the demand of long-term energy storage, and the safety also needs to be improved. The reserves of key mineral resources such as lithium, cobalt and nickel required for new energy vehicles are insufficient, the consumption is large, and they are heavily dependent on imports. In 2021, China's external dependence on cobalt has approached 99%, and lithium's external dependence has reached 60% [9], there is a risk of supply interruption.

4. DIGITAL ECONOMY BOOSTS THE PRACTICE PATH OF LOW CARBON TRANSFORMATION IN CHINESE ENERGY INDUSTRY

4.1 Strengthen the Digital Infrastructure of the Energy Industry

Digital infrastructure is an important basis and prerequisite for digital economy to promote low-carbon development of energy industry. In the era of digital economy, data has become a key factor of production, and big data, the Internet and the Internet of Things have become core infrastructure. Great energy data and smart connected the Internet of things, as a new energy infrastructure, will be a new generation of energy system control and operation technology breakthrough to provide important support, in order to build a high availability, high reliability, high elastic energy industry Internet data platform as the goal, with a global perspective and overall method of forming uniform data of ideas, Systematic and systematic data capacity construction and the construction of "new energy infrastructure" based on the digital concept will provide an important guarantee for the low-carbon development of China's energy industry.

4.2 Improve the Ability of Independent Innovation of Key Technologies in the Energy Industry

"Building a clean and low-carbon energy consumption model and promoting energy technology innovation" [10]. It is the core and key to ensure that digital economy promotes the low-carbon development of the energy industry. To improve the independent innovation capacity of key technologies in the energy industry, first, we need to forge a long board of advantages in energy innovation. We will consolidate technological and equipment advantages in the field of non-fossil energy, continuously improve the technological level of the development and utilization of biomass energy, geothermal energy and ocean energy, carry out research on the optimization of third-generation nuclear power technologies, and strengthen technological innovation and application of renewable energy systems. Second, we will intensify efforts to tackle cutting-edge technologies such as energy storage and hydrogen energy. Key technologies to develop new energy storage concentrated research and enhance the energy technology innovation, speed up the implementation of energy storage self-independence of core

technology, strive to overcome renewable hydrogen and the hydrogen storage and transportation, the application and the core technology such as fuel cells, strive for the hydrogen breakthroughs in key technologies of whole industry chain, promote the hydrogen technology to carry out the application and demonstration, the core power for low carbon energy industry development in China.

4.3 Strengthen the Integrated Development of Digital Economy and Energy Industry

Digital economy is based on digital as a key factor of knowledge and information, digital technology as the core driving force, with modern information network as the important carrier, through the depth of the digital technology and the real economy, continuously improve the level of economic and social of digital, networked, intelligent, accelerate restructuring economic development and governance model of the new economic form [11]. Digital economy can provide new driving forces for the energy industry, reduce carbon emissions, improve energy consumption structure and improve energy utilization efficiency.

For the energy industry, The integration and application of digital technology and the energy industry is the difficulty and direction of technical research and innovation, energy companies should promote energy system of interconnection and interaction, change the participation of the multi-factor model, drive, the discuss of the upstream and downstream industry chain to build model of the multivariate innovation forms, around the supply chain and industrial chain, layout, ecology innovation at the same time, The deep integration of digital technology and energy consumption will provide consumers with energy services with higher preference flexibility and better economy. Therefore, we should strengthen the integrated development of digital economy and energy industry to build a good ecology for the low-carbon development of our energy industry.

5. CONCLUSION

By summarizing the existing research, the paper draws the following conclusions. First, digital economy is an important way for China's energy industry to achieve low-carbon development. Digital economy can promote the conversion of old and new drivers of energy and low-carbon

transformation in energy production, consumption and supply. Second, the digital economy is a key driver for the low-carbon development of China's energy industry. In the face of a series of problems in China's energy industry, digital economy provides technical support to solve these problems. Digital technology can improve the utilization rate of traditional energy and the independent innovation ability of key technologies in the energy industry, so as to promote the transformation and development of the energy industry to low-carbon and green. Third, the deep integration of the digital economy and China's energy industry is an inevitable requirement for realizing the "double carbon" goal. Under the background of carbon emissions peak and carbon neutrality, the energy industry needs to be transformed urgently, and the mode of energy consumption needs to be optimized. The deep integration of digital economy and energy industry is the trend of The Times.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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