

# Research on the Challenges and Path of China's Energy Transformation Under the Goal of "Carbon Neutrality"

## Based on the Law of International Energy Transformation\*

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### ABSTRACT

In order to achieve the second centenary goal and promote the building of a community with a shared future for mankind, China has proposed the goal of "carbon peak by 2030 and carbon neutrality by 2060" to address climate change and ecological and environmental deterioration and achieve high-quality development. In this process, the energy transformation is one of the most critical means, and the high-quality energy development is the inevitable requirement of the national high-quality energy development. Based on the law of international energy transformation and combined with the realistic characteristics of China's energy structure, research found that China in achieving the goal of "carbon neutral" energy transformation process is still facing many challenges, and address these challenges include: improve energy efficiency, promote the development and utilization of non-fossil energy, promote the core technology research, accelerate the development of digital intelligent energy industry, etc.

**Keywords:** Carbon neutralization, Energy transformation, International law.

## 1. INTRODUCTION

Energy transformation usually refers to the fundamental change of the energy structure of the energy supply side. Energy transformation is not only about simply increasing the proportion of renewable energy or non-fossil energy in the existing energy system, but also about the structural changes in the energy system.[1] From the perspective of economic history, there have been two transformations to new energy in modern society: the first from traditional biofuels (such as wood) to coal in the late 19th century, and the second from coal to oil and gas in the mid-20th century. At present, human society is undergoing the third energy transition process. Under the joint influence of resource endowment, energy structure, energy utilization efficiency and other factors, China's leapfrog development of energy

transformation is the only way in order to achieve the goal of energy production and consumption revolution.

In view of the path of energy transformation, the academic circle mainly has the following views: energy is the foundation of economic and social development, and high-quality energy development is the foundation of national high-quality development. To accelerate the transformation and upgrading of the energy structure, they need to optimize the energy structure and, second, optimize the regional energy space.(Xiaolong Liu, Leilei Cui, Bin Li, Xiangwan Du, 2021) China's way to control the total energy consumption is to improve energy efficiency, and they must vigorously promote the energy technology revolution.(Angang Hu, 2021) The world path of energy transformation should conform to the political coordination, technology driven, management driven and commercial driven to gradually realize the low-carbon revolution and promote the energy transformation.(Caineng Zou, Dongbo He, Chengye Jia, Bo Xiong, Qun Zhao,

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2021) In order to realize energy transformation, a new-generation energy system architecture will be formed that is market-driven, policy-driven, innovation-driven and behavior-driven. (Ying Fan, Bowen Yi, 2021) Clean and efficient use of coal has been promoted; they should play market mechanism to promote renewable energy; enhance comprehensive energy utilization and continuously improve energy efficiency.(Junjiang Li, Ning Wang, 2019) Core technology provides infinite possibilities for realizing carbon neutrality. Technological progress is the progress of science and technology, and will also promote economic progress. Core technology breakthrough is the breakthrough of energy transformation. Anyway, adhering to the demand-oriented core technology and equipment is an effective way to realize energy transformation.(Tuo Liu, Bo Xu, Xin Zheng, Yirui Deng, Wei Zhang, 2021) Regarding the diversification path of the energy transition, the diversification process initially was mainly dependent on fossil fuels, and countries are reducing their dependence on pollution and non-renewable energy sources (such as coal and oil).Current trends suggest that the energy mix is more diverse and the role of cleaner and renewable energy is increasing, so this is on a path to low-carbon energy systems.(Rubio-Varas Mar; Muñoz-Delgado Beatriz ,2019)

## 2. INTERNATIONAL LAWS OF ENERGY TRANSFORMATION

The core motivations of this round of energy transition can be divided into two aspects: climate change and energy security. The EU has been an advocate of climate change and energy security, in 1986 proposing the development of renewable energy as improving the EU's energy structure, Sweden supported and subsidized biomass combustion and conversion technologies in 1975 and wind power in 1989.

Climate change reflects the part of carbon emissions, and they are facing the goal of "carbon neutrality". In comply with the trend of world energy development, it is necessary to establish a clean, safe, low-carbon and efficient energy system, promote sustainable economic development and promote energy transformation and development. The impact of replacing fossil fuels with biofuels on carbon dioxide (CO<sub>2</sub>) emissions has been debated for many years. [2]

The energy transition has been a long, gradual process, taking more than 50 years to increase by

15% in 1877. It can be seen that the energy transformation takes a long time and span, so the energy transformation can't be realized in the short term. The proportion of renewable energy in the energy mix will take longer, with the share of renewable energy growing from 1% in 2008 to 3.2%. After eight years, they predict more than 30 years for renewable energy to reach 10%. However, energy transformation is a complex and extensive process. It needs more infrastructure construction to adapt to the supply and development of more new energy, and they must meet more conditions for the development of new energy. In the process of energy transformation, not only renewable energy, but also oil, natural gas, hydropower and nuclear power have also experienced a long time in the process of increasing the proportion of energy structure. So these energy increases are a slow and gradual share of the entire energy mix.

Energy transformation is a process of energy decentralization and high efficiency. Clean and efficient energy is the goal that people pursue by using energy. Carbon neutrality is the consensus of human development, but its implementation still faces many challenges in terms of politics, resources, technology, market and energy structure. It is proposed that carbon substitution, carbon emission reduction, carbon sequestration and carbon cycle are the four main ways to achieve carbon neutrality, among which carbon substitution is the core. New energy has become the dominant of the third energy conversion and will dominate the carbon neutral in the future.[3] In the first energy transition, high-carbon and low-efficiency firewood was gradually replaced by low-carbon and more efficient coal. In the second energy transition, coal was replaced by lower-carbon and more efficient oil. The ongoing third energy transition will increasingly use low-carbon and carbon-free energy sources. Energy transformation is not only the development of science and technology, but also people's reconsideration of the living environment. Only a low-carbon and carbon-free environment can develop for a longer time.

Energy is the important material basis for human survival and civilization development. Energy transformation is closely related to the industrial revolution. Every energy transformation is accompanied by the industrial revolution. The industrial revolution creates conditions for the energy transformation, and the energy transformation promotes the development of the industrial revolution. And the third revolution marks the invention of computers and the

emergence of the Internet, while the third energy transition is under way. The change of energy reflects the profound impact of energy demand in different times and the impact of scientific and technological progress. Coal is an important energy material for different times, but different from the progress of The Times has higher requirements for production and life. In addition, the large consumption of coal, oil and the long regeneration time will restrict the future social development. Looking at the world, the impact is the same. Energy changes its use and plays a crucial role in the realization of carbon neutrality goals. Therefore, they need to step up efforts to develop new energy sources and make them more efficient and environmentally friendly. Therefore, technological progress is the key driver of the energy transition. There are many factors driving the energy transition, and each time it is different, but technological progress is the key factor driving the energy transition.

### 3. CHALLENGES FACING CHINA'S ENERGY TRANSFORMATION UNDER THE CARBON NEUTRAL GOAL

Challenge 1: China's total energy demand and CO<sub>2</sub> emissions will continue to increase. China is the largest developing country in the world. Over the past 40 years of reform and opening up, its economy has witnessed sustained rapid growth. In 2019, China's current GDP reached 98.65 trillion yuan, making it the world's second largest economy, but its per capita GDP has just exceeded 10,000 US dollars, ranking only 66 in the world. China is expected to basically achieve socialist modernization by 2035. In recent decade, China has been in the process of continuous growth, declining in 2015 and a historic high in 2016. Production growth from 2012 to 4.2% in 2016, 3.6% in 2017, 5% and 5.1% in 2010, 4 percentage points from 9.1% in 2010. It can be seen that China's energy demand is still very large, and its annual output continues to increase. And China plans to peak its carbon by 2030, so its energy demand cannot be reduced in a short time. This means that China's non-fossil energy increment not only needs to offset the cuts in high-carbon energy, but also needs to meet the new energy demand. China's total energy demand and CO<sub>2</sub> emissions continue to increase, leading to great challenges in China's energy transformation. ("Table 1", "Figure 1", "Figure 2")

Table 1. Total production of major energy varieties in 2010-2019 (data source: National Bureau of Statistics)

Year	Raw coal output (100 million tons)	Crude oil production (ten million tons)	Natural gas production (one million cubic meters)	Power generation (100 million KWH)
2010	34.28	20301.40	957.91	42071.60
2011	37.64	20287.55	1053.37	47130.19
2012	39.45	20747.80	1106.08	49875.53
2013	39.74	20991.90	1208.58	54316.35
2014	38.74	21142.90	1301.57	57944.57
2015	37.47	21455.58	1346.10	58145.73
2016	34.11	19968.52	1368.65	61331.60
2017	35.24	19150.61	1480.35	66044.47
2018	36.83	18910.56	1602.65	71117.73
2019	38.50	19101.40	1761.70	75034.30

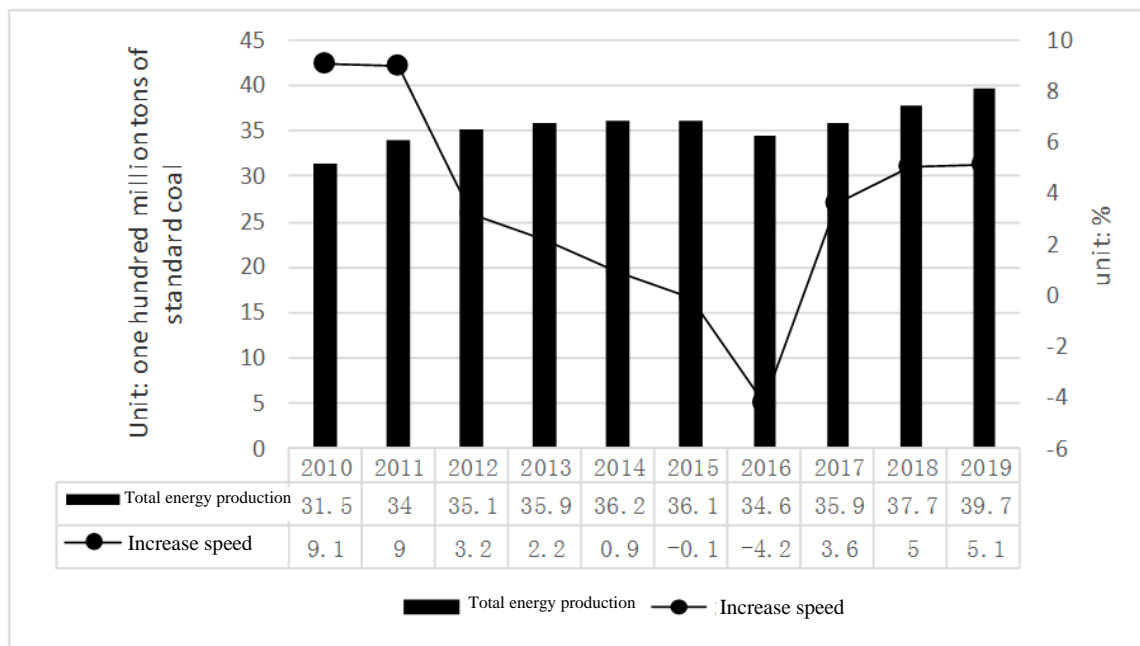


Figure 1 Total Energy Production and Growth Rate in 2010-2019 (data source: National Bureau of Statistics).

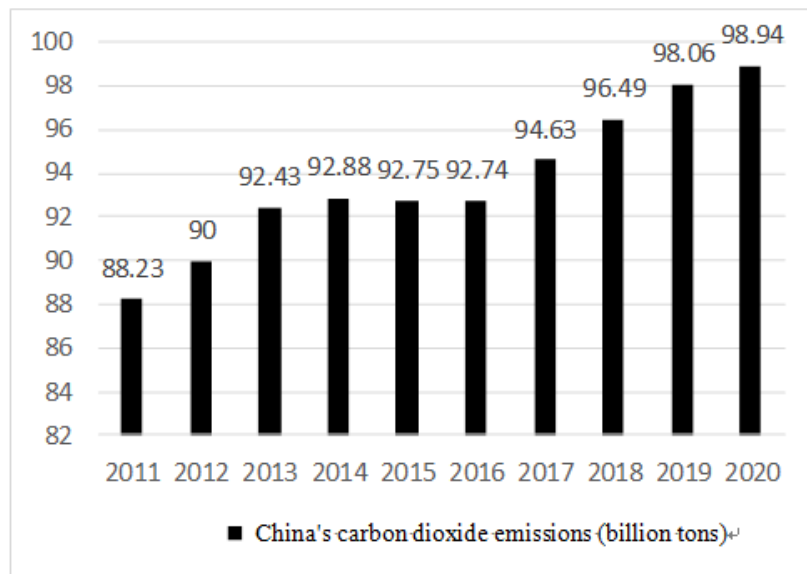


Figure 2 China's CO<sub>2</sub> emissions from 2011-2020 (Source: BP, Zhiyan Consulting) .

Challenge 2: China's carbon neutral target is more challenging than other countries. The United Nations Intergovernmental Panel on Climate Change (IPCC) estimates that if the Paris Agreement 2°C is achieved, the world must achieve net zero carbon dioxide emissions by 2050, or zero greenhouse gas emissions (greenhouse gas neutral or climate neutral), or greenhouse gas emissions beyond carbon dioxide.

At present, more than 120 countries and regions have proposed "carbon neutrality" goals. Most

countries and regions plan to achieve "carbon neutral" by 2050, such as the European Union, Britain, France, Germany, Japan, etc. U. S. President Joe Biden has made it clear that he promises to achieve "carbon neutrality" by 2050. Uruguay proposes "carbon neutrality" by 2030, Finland by 2035, Iceland and Austria in 2040, and Sweden by 2045. Today, some countries have achieved the goal of carbon neutrality, and Suriname and Bhutan have achieved carbon neutrality in 2014 and 2018, respectively, and have entered the era of negative emissions. The countries

that have proposed the goal of carbon neutrality have reached the carbon peak, but for China, it is still growing in carbon emissions, which means that China has to achieve the goal of carbon neutrality in less time, which is a great challenge. Compared to Europe's peak from 1990 to 2050 to achieve carbon neutralization required 60 years, China peaked in 2030 to 2060 years ago carbon neutral, only half of the EU, in such a short time, the energy demand is rising, the current fossil energy accounted for more than 80% of the energy system into zero carbon energy system, the challenge is unprecedented.

Challenge 3: China's energy structure transformation is more difficult than other countries. A century ago, the world energy structure was also dominated by coal, after decades of development, it is now dominated by oil and gas, oil and gas accounted for more than 50% of the primary energy, but they can now go to the next stage, mainly non-fossil energy.

However, China is different from the world. China's scarcity of fossil energy resources, which is "relatively rich in coal, short of oil and less of gas", determines the structure of China's energy consumption. Since the reform and opening up in 1978, the proportion of fossil energy consumption in China has decreased from 96.6% to 84.4% in 2020; coal consumption has decreased most from 70.7% to 56.8% in 2020, but coal remains the main energy in China; oil consumption is basically stable at around 20%; natural gas consumption has increased from 3.2% to 8.5% now; non-fossil energy consumption has increased from 3.4% to 15.6% now. In the first stage, China is also dominated by coal, but China will not enter the era of oil and gas. Its oil and gas cannot reach more than 50% of primary energy. China's energy transformation is in an urgent situation. China's economy accounts for 15% of the world economy and 23% of world energy consumption. Two-thirds of the country's crude oil and about half of its natural gas are dependent on imports, and their dependence on foreign countries continues to rise. Moreover, the production of fossil energy and consumption cause serious damage to the ecological environment, emitting a large amount of greenhouse gases. So in the process of energy transition, China faces even more serious difficulties.

In order to better promote the rapid development of energy transformation and achieve the goal of carbon neutrality, it is necessary to

analyze it from the essence of energy transformation. The essence of energy transformation is to achieve green, low-carbon and sustainable development of energy through the energy revolution. They will reduce energy consumption, improve energy efficiency, and ensure that the people can enjoy stable, green, economic and convenient modern energy services. In essence, they must realize that energy transformation is a long-term process, and China's energy transformation is more difficult: first, it is large; second, the energy structure is mainly coal; third, energy consumption is still growing. So the transformation of the energy structure that they face is more difficult than that in other countries.

#### **4. OPPORTUNITIES FOR CHINA'S ENERGY TRANSFORMATION UNDER THE CARBON NEUTRAL GOAL**

First, it can promote high-quality energy development. In China, coal is mainly energy. China's rapid economic development has attracted attention from the world and people's living standards are constantly improving. However, the extensive production and consumption model of fossil energy has also brought a series of problems, such as ecological damage, environmental pollution and increasing pressure on greenhouse gas emission reduction. In the initial stage of reform and opening up, it was the starting point of China's rapid economic development. China always paid attention to the output of energy development and did not emphasize the issue of energy efficiency. However, after they entered the process of industrialization and urbanization, the primary energy consumption once showed an unusual rapid growth trend. In recent years, they have used energy intensity and carbon intensity as assessment indicators, including energy efficiency in the five-year plan and local assessment indicators from the consumption side, and the elasticity coefficient of energy consumption has gradually declined. The decline of energy elasticity coefficient, representing the decline of energy intensity, is the beginning to change the extensive production and consumption mode of fossil energy. China's energy intensity (energy consumed per unit of GDP) doubled the world average in 2010 and, while gradually declining in the last decade, doubled the world average in 2018 (producing 15% of global GDP and consuming 23% of global energy consumption). China's high proportion of energy-intensive industries, improper industrial restructuring, and the

technology level is not efficient and energy-saving are the main reasons for China's still high energy intensity. So it is more to promote the energy transition under the goal of carbon neutrality. China has great potential for energy conservation and efficiency improvement. For example, coal-fired power plants, with 1 kilowatt-hour of power supply, consumed 471 grams of coal in 1978 and 308 grams in 2018. If our energy intensity reaches the world average (not to mention advanced levels), they can save 50% of our energy consumption per year, or about 1.5 billion tons. Therefore, energy saving and efficiency improvement is the first part of China's energy strategy, and energy efficiency is a symbol of an advanced national energy system. Energy transformation is the first step to be economical and efficient.

The transformation of energy structure is not only the goal of carbon neutrality and greenhouse gas emission reduction, but also the goal of eliminating ecological destruction and environmental pollution. The energy transformation brought about by this goal can just promote high-quality energy development. China is highly dependent on primary energy, and renewable energy has a huge gap, will form a huge industrial chain, not only boost high-quality energy development, but also promote a new driving force for China's economic development. China's current renewable energy for use is mainly wind, solar, biomass, water and geothermal energy. The essence of the carbon neutrality goal is to promote low-carbon energy transformation and high-quality energy development, and to improve the environment and climate while reducing energy and emissions, so as to achieve long-term development.

Second, they can master the core technology. Technological progress is a strong guarantee for energy transformation. China has always been dominated on coal energy. The intelligent development has promoted China's coal mining technology. The establishment of a carbon neutral target has led to a decline in the proportion of coal in energy use in China, thus creating opportunities to promote the clean and efficient use of coal. China's lack of oil and gas has also spawned improvements in other energy technologies. China has also made many achievements in the development of renewable energy. China ranks first in the world in the development scale of renewable energy, providing strong support for the transformation of green and low-carbon energy. For example, as of the end of 2020, China's total installed renewable energy power generation

capacity had reached 930 million kilowatts, an increase of 14.6 percentage points over 2012. Hydropower, wind power, photovoltaic power generation and biomass power generation have been ranked first in the world for 16 consecutive years, 11 years, 6 years and 3 years, respectively. The level of renewable energy utilization continues to improve, in 2020, renewable energy capacity reached 2.2 trillion KWH, compared with the 2012 electricity consumption proportion increased 9.5%, China's renewable energy utilization level rise, strong support China non-fossil energy primary energy consumption of non-fossil energy consumption accounted for 15% in 2020. China's installed renewable energy capacity ranks first in the world, and the level of technology and equipment has been greatly improved, providing energy for the development of renewable energy. China has formed a relatively complete industrial system of renewable energy technology. Hydropower has the world's largest million kilowatt turbine set independent design and manufacturing capacity, low wind speed wind power technology in the world, photovoltaic power generation technology rapid iteration many times refresh the battery conversion efficiency world record, photovoltaic industry occupies the global dominant position, photovoltaic modules in the world's top ten companies occupy seven. Integrated manufacturing in the whole industrial chain has given a strong impetus to the continuous decline in the cost of wind power and photovoltaic power generation, and continuously improved industrial competitiveness, injecting strong impetus into the vigorous development of new models of renewable energy. China should take advantage of its own development advantages to promote the further success of the energy transformation, which will become another opportunity brought by China's energy transformation.

Third is to establish a friendly international image. The goal of carbon neutrality is not only the goal of China, but also the common goal of all countries in the world. They are all facing common issues such as climate and environment. China has always practiced the value of "a community with a shared future for mankind". While pursuing its own development interests, China also fully considers the common interests of the international community. As the world's largest developing country, it has put forward the difficult carbon peak and carbon neutrality, and promote the comprehensive green transformation of economic and social development. China's transition from a

participant in global climate governance to a leader has not only injected strong impetus into global climate change and global confidence in low-carbon emission reduction, but also demonstrated the responsibility and responsibility of a major country. And China's carbon neutral goal, is in its carbon emissions is on the premise of long term, so the pressure on China is greater, and at the same time other countries put forward carbon neutral target time consistent with China, this is more highlights China's big bear, and China put forward "to build human destiny community". That is why China has a better image, demonstrating China's firm confidence in carbon neutrality and environmental and climate issues and laying a solid foundation for this.

## **5. THE MAIN PATH OF CHINA'S ENERGY TRANSFORMATION UNDER THE CARBON NEUTRAL GOALS**

Path 1: It is to give priority to energy conservation, and strive to improve energy efficiency. "Energy conservation and emission reduction" is an important basis for achieving the "dual-carbon" goal. Energy conservation is the first of China's energy strategy and a green and low-carbon "first energy source". Under the energy structure of fossil energy, energy conservation and efficiency improvement is the main force of emission reduction. Energy conservation is the most direct, effective and economical means to achieve the goal of "carbon peak and carbon neutrality", and also the most important way for the energy system to achieve massive emission reduction of carbon dioxide.

At the beginning of reform and opening up, China paid more attention to quantitative development, but did not emphasize the quality problem, which is essentially a problem of energy efficiency. Only by improving energy efficiency can energy give full play to its role. Into the century, with the process of industrialization and urbanization, primary energy consumption has shown unusual rapid growth, in recent years, with energy intensity, carbon intensity included in the assessment index, from the consumption of energy efficiency in the national five-year plan and local assessment index, energy consumption elasticity coefficient gradually decline.

The decline of the elasticity coefficient of energy consumption means that the decline of energy intensity is the first sign of changing the

extensive development. China's energy intensity (energy consumed per unit of GDP) was twice the world average in 2010 and gradually declined in the past decade, but it was still 1.5 times the world average in 2018 (producing 15% of the world's GDP and consuming 23% of global energy consumption). The decline in energy intensity also reflects a gradual improvement in energy efficiency, but the increased energy consumption is still huge.

Global energy-related CO<sub>2</sub> emissions will need to be reduced by 40 to 70 percent by 2050, if global temperatures are to be controlled to 2 degrees Celsius. If global greenhouse gas emissions fall from 33 billion tons today to about 10 billion tons by 2050, energy conservation and energy efficiency will contribute 37 percent to global carbon dioxide reduction by 2050, higher than the development of renewable energy, nuclear power, carbon dioxide capture, utilization and storage technologies. They can see the great importance of energy conservation work. China's high proportion of fossil energy and the characteristics of coal-based coal consumption will remain 50% by 2030, which is still the main energy source. Therefore, the foothold and primary task of China's energy transformation is to do a good job in the clean and efficient development and utilization of fossil energy, especially coal. They must always adhere to resource conservation, establish the concept of innovative, coordinated, green, open and shared development, and make every effort to greatly improve energy efficiency. To do energy conservation well, they should accelerate the upgrading of energy conservation in key energy-use areas such as construction, transportation and industry, especially the low-carbon or zero-carbon transformation of traditional industries, upgrade the industrial system to intensive, low-carbon and zero-carbon, and improve energy efficiency.

Only in this way can they strive to improve energy efficiency by giving high priority to energy efficiency. Form an organic combination between energy saving and energy transformation, strive to improve energy efficiency, and help the realization of energy transformation.

Path 2: It is to vigorously promote the development and utilization of non-fossil energy. In the process of achieving the "dual-carbon" target, China will achieve non-fossil energy accounting for about 20% of China's primary energy consumption by 2025 and 25% by 2030, and the total installed capacity of wind and solar power will reach more than 1.2 billion kilowatts. First of all, it is necessary

to increase the clean development and utilization of fossil energy, especially the clean development and utilization of coal. After all, China is relatively rich in coal, and the second energy transition is the process of coal to oil and gas. Although China is short of oil and gas, it can still improve its oil and gas exploration and development efforts. Second, China still has great defects in the storage and sales of natural gas, but they can build a natural gas production, supply, storage and marketing system. Finally, fossil energy is primary energy, mostly non-renewable, which means that it takes a long time to reappear, so increase the development of non-fossil energy and renewable energy; accelerate the development of non-fossil energy and renewable energy, especially wind, solar and biomass energy. Promoting low carbon energy to replace high carbon energy, renewable energy to replace fossil energy is what they strive to achieve today. China is a populous country and a big energy consumer. For present, coal is still the main source of electricity in China. By the end of 2019, China's installed coal power capacity reached 1.04 billion kilowatts and coal power generation reached 4.6 trillion KW-hours, accounting for 52.0 percent of the total installed power generation capacity and 62.3 percent of the total power generation. There is still a lot of room for improvement in the proportion of Chinese power clean energy and the environmental protection level. In 2018, China's clean energy consumption accounted for only 22.2%, and the environmental performance index was 50.74. For the UK, their average electricity consumption is not much different from that of China, but the clean energy consumption in the UK was 56%, and the environmental performance index was 79.89, more than twice that of China's clean energy consumption. The United States, France, Germany, Japan and other developed countries have a higher proportion of clean energy consumption and environmental performance index than China, and significantly higher than China. Compared with developed countries, halving the time for China to achieve carbon neutrality is more difficult and arduous task.

Then need to adhere to both centralized and distributed energy, the first is to improve the scale of a batch of clean energy generation, need to vigorously improve the scale of wind power generation, photovoltaic power generation, build a number of clean energy efficiency and complementary energy base; at the same time, accelerate the construction of new energy storage, improve the flexible regulation capacity of power

system and the level of new energy consumption. By vigorously promoting the development and utilization of non-fossil energy sources, they will promote the energy transformation and reduce carbon emissions.

Path 3: It is to adhere to the demand-oriented research on core technologies and equipment. To ensure the security and stability of the energy industry supply chain, the application of core technology and equipment is needed. The purpose of demand-oriented is to have the demand and solve the demand. The research and development and use of core technologies and equipment help us realize the transformation from "following, running and running" to "innovation and leading". In fact, the core technology is relying on enterprises and major projects, problems and demand oriented, the depth fusion, strengthen the key core technology and equipment of science and technology research, focus on solid foundation, Yang advantage, short, strength, accelerate the independent innovation and original innovation ability, the energy technology and information technology depth fusion. With Internet, big data, artificial intelligence and block chain of a new generation of information technology, and traditional energy and new energy technology depth fusion, spawned energy Internet, smart grid, new energy intelligent car and energy integrated service system of new forms, promote the energy system to more clean, low carbon, safe and efficient development.

Moreover, core technologies provide infinite possibilities for realizing carbon neutrality. Technological progress is the progress of science and technology, and will also promote economic progress. Core technology breakthrough is the breakthrough of energy transformation. Anyway, adhering to the demand-oriented core technology and equipment is an effective way to achieve energy transformation. Emphasis the importance of strengthening the resource governance of the whole low carbon technology supply chain and the institutional tools of circular economy practice.[4]

Only by mastering the core technology can they achieve a better technology level and achieve the energy transformation faster and better.

Path 4: energy industrialization is to form a good industrial cluster, the energy industry faster and better development. The 14th Five-Year Plan and the proposal of 2035 propose to develop digital economy, digital economy refers to digital industry and digital industrialization, better integrate the real



economy and digital economy, and build a competitive digital industrial cluster.

Energy digitization refers to the use of digital technology to guide the orderly flow of energy and build a more efficient, cleaner and more economical modern energy system. Improve the security, accessibility, and sustainability of energy systems through digital technology. In the energy sector, the use of data, analysis and connectivity is widely used. Their use can largely improve operational efficiency and even reduce energy use by about 10%. Digital energy systems can accurately judge who needs energy and how they can provide energy at the lowest cost at the right time and place, and new energy business models are taking shape.

Energy digitization conforms to the core requirements of energy transformation, cost reduction, efficiency increase and green development. Under the influence of the Internet age, they can establish the whole energy industry chain, is from energy exploration, production, transportation, sales and service of each link and digital platform depth fusion, depth fusion need efficient computing, massive data, instant messaging technology, these technology from one aspect is intelligent energy, they will use more information technology, promote energy authors efficiency green development, realize the accelerated transformation of energy industry. They present a power-centered integrated energy optimization model and establish the baseline and carbon-neutral scenarios to implement a systematic simulation of the energy Internet path to facilitate the energy transition.[5]

According to the IEA, Digital and Energy, the large-scale application of digital technology can reduce the cost of oil and gas production by about 10-20 percent, and increase the global recoverable reserves of oil and gas technologies. In the EU alone, increasing storage and digital demand response could reduce the reduction rate of solar photovoltaic and wind power from 7% to 1.6% by 2040, thus avoiding 30 million tonnes of carbon dioxide emissions by 2040. At the same time, digitization can also benefit from specific clean energy technologies, such as carbon capture and storage.

The development of digital economy is the general trend of a new round of scientific and technological revolution and industrial transformation. At present, the new generation of information technology represented by artificial

intelligence, big data, Internet of Things, cloud computing and blockchain is developing rapidly. The interdisciplinary integration of digital technology and energy constantly promotes new models, new forms of business and new industries. Accelerating digital transformation and intelligent development is not only a national economic and social development strategy, but also an important measure for enterprises to reduce costs and increase efficiency, enhance their core competitiveness and achieve high-quality development. Therefore, the digital transformation and intelligent development of the energy industry are very important measures to achieve carbon neutrality in the future.

## 6. CONCLUSION

China is a major country in energy consumption and carbon emissions. The energy transformation under the goal of "carbon neutrality" is a complex and systematic project, with epoch-making characteristics such as time urgency, active transformation and the emergence of new technologies. At present, energy transformation has become a major trend in the world. China should seize opportunities, meet challenges, and reduce its dependence on primary energy, especially coal. At the same time, the carbon neutral goal has more clarified the goals of China's energy transformation and high-quality energy development, and also puts forward new and higher requirements for the low-carbon energy transformation. Among them, the most critical one is to increase the use of renewable energy. And by continuing to adhere to energy saving priority efforts to improve energy efficiency, vigorously promote the development and utilization of non-fossil energy, adhere to the demand oriented research core technology and equipment, speed up the energy industry digital intelligent path can improve the utilization rate of renewable energy, increase the role of energy development and energy management, make more of renewable energy application in life. China's total energy demand and CO<sub>2</sub> emissions will continue to increase, China's carbon neutral targets are more challenging than other countries, and China's energy structure transformation is more difficult than other countries. At the same time, they should seize the opportunity to promote high-quality energy development, master core technologies and establish a friendly international image. The energy transition under the goal of "carbon neutrality" is a complex and systematic project, which is even more difficult for China. But they need to seize the opportunity to

promote high-quality development of energy transformation and help achieve carbon neutrality.

## AUTHORS' CONTRIBUTIONS

Han Qiao formulated the framework of the thesis and wrote the main part. Jin Liu organized materials and revised the paper.

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