Proceedings of the 4th International Conference on Business and Policy Studies
DOI: 10.54254/2754-1169/161/2025.19878

A Policy Review of China's Low-Carbon Energy Transition

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Abstract: The People's Republic of China, as one of the world's largest emitters, has a markedly different approach to achieving an energy transition in a relatively short period of time due to the specific characteristics of its population, geographic location, distribution of resources, and political policies, which collectively present significant challenges to the realization of its goals. This study examines China's current energy policy and how it balances economic growth, energy security, and environmental protection. The study found that China faces considerable challenges, including the need to reconcile the unequal distribution of resources and address issues such as the imbalance in population distribution, as well as the necessity to achieve a complete energy transition in a relatively short period of time. This study analyses China's current energy policy in order to ascertain how it balances economic growth, energy security, and environmental protection.

Keywords: Energy transition, China's energy transition, China, Policies, Energy security.

1. Introduction

As one of the world's most significant emitters of carbon, with an output of approximately 30 million tons of carbon dioxide per day, China is undertaking an unprecedented transition in its energy sources. The objective of China's energy transition is to achieve a reduction in emissions while simultaneously maintaining a balance between economic growth, energy security and environmental protection. The objective of this study is to analyze the current status of China's energy quasi-starter policies and their impacts at the economic, security and environmental levels, and to examine the specific measures that China has taken to achieve its carbon peak and carbon neutrality targets. By reviewing the relevant literature and analyzing the effects of policy implementation, this study aims to provide insights that can inform future policy formulation.

This paper aims to examine the challenges, difficulties encountered by the People's Republic of China (PRC) and responses in its energy transition progression.

This research is divided into two main sections. The first is a literature review, which aims to draw upon a range of data and information on the country's specific circumstances to present a comprehensive analysis of the impact of governmental and international policies and laws. The second is a discussion section, which will review the issues that have been successfully addressed, the obstacles that have been overcome, and the achievements that have been made in China up to this point in time.

DOI: 10.54254/2754-1169/161/2025.19878

2. Literature Review

The objective of this section is to examine the factors influencing China's energy transition, including environmental protection, international pressure, resource depletion, economic restructuring, and other considerations. Additionally, it will analyze the structure of China's energy production prior to the transition and its historical trajectory of energy transformation.

2.1. Reasons of Energy Transition

2.1.1. Pollution & Climate change

Climate change, a long-term change in the average weather patterns that have come to define Earth's local, regional, and global climates, has become the major challenge for global development [1]. More than a century of human activity has created a serious global warming problem through the burning of fossil fuels and unequal and unsustainable patterns of energy and land use. WMO (World Meteorological Organization) has confirmed that 2023 was the hottest year on record, with sea levels rising and extreme weather events occurring frequently, with massive negative impacts on numerous countries [2]

However, the main cause of global climate change is rising carbon dioxide emissions, and China is one of the largest emitters of carbon dioxide. The reason for the significant increase in CO2 emissions is that since the 19th century, the energy mixing on which mankind has relied has always been dominated by fossil fuels. As a result, the international community has begun to address the challenge of climate change by developing a series of programs and conventions, such as the AVD, the Paris Agreement, etc. [3] to reduce carbon emissions and begin the energy transition---a transformation of the global energy sector from fossil-based systems of energy production and consumption to renewable energy sources. China is one of the countries with the largest CO2 emissions in the world.

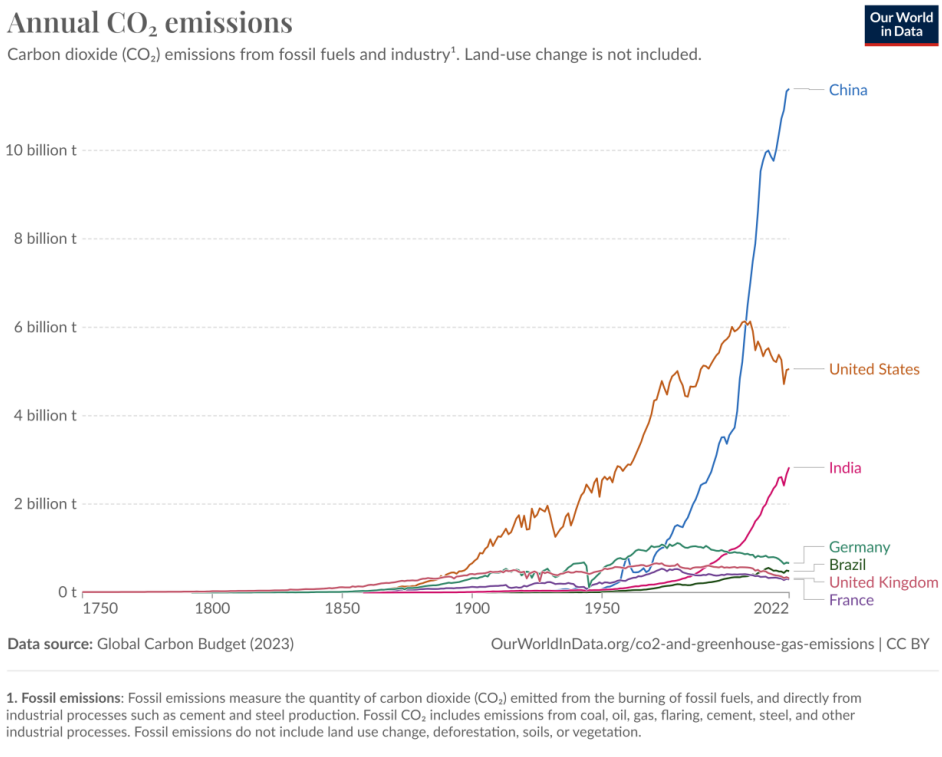

Figure 1: World CO2 emissions from 1750-2022 [4]

DOI: 10.54254/2754-1169/161/2025.19878

As illustrated in Figure 1, the data through 2022 show a rapid increase in global CO_2 emissions. China has become the world's fastest-growing emitter of greenhouse gases, largely as a consequence of its rapid economic growth, accelerated industrialization, dependence on coal for its energy mix, the sheer scale of its population and urbanization, and its pivotal role in the global manufacturing supply chain. These factors drive significant energy consumption and greenhouse gas emissions. Despite China's recent efforts to increase investments in environmental protection and green energy, the country's initial environmental protection measures were relatively inadequate during its initial stages of economic development, resulting in a notable surge in emissions, responding to climate change is China's challenge and China's response to international expectations. In order to combat climate change and reduce environmental pollution, China is undergoing a broad transformation of its energy structure.

2.1.2. Energy Security

2.1.2.1. Overdependence on import

Fossil fuels require millions of years to form, yet human consumption depletes them within decades.

Scientists predict that oil reserves will be depleted by 2043 [5]. The same goes for coal and natural gas - it's getting close to the time when we'll lose these non-renewable resources.

In 2018, China's primary energy consumption reached 3.2 billion tons of oil equivalent, with a deficit of 0.6 billion tons of oil equivalent, primarily in oil and gas, representing an external dependence of 19%. Since 2010, domestic oil production has exhibited considerable volatility, hovering around 0.2 billion tons. This output is insufficient to meet domestic consumption demands, and the external dependence on oil has increased markedly, rising from 55% in 2010 to 71% in 2018. This exceeds the 70% threshold for national energy security in China. The consumption of natural gas increased from 108.9 billion m^3 in 2010 to 283 billion m^3 in 2018, representing a growth rate of 160%. In parallel, the dependence on imported natural gas increased from 11% to 43%. In general, the energy consumption pattern in China is characterized by a stable oil consumption and an ever-increasing natural gas consumption [6]. The world's dependence on and consumption of non-renewable energy sources is increasing, energy depletion is in the near future, and energy transition initiatives are imminent. Therefore, the development of renewable energy is very necessary for mankind, especially for China.

2.1.2.2. Reduction in overdependence

Based on the data, the world's competition for oil has gradually intensified due to the growing shortage of oil supplies, with countries such as the United States and Europe strongly relying on the availability of oil from energy exporting countries (OPEC), exporting a whopping 41.43 million barrels of oil in April 2024 alone [7].

Similarly, China has long been heavily dependent on oil and gas from the Middle East. In 2020, China's crude oil imports will total approximately $176 billion. Nearly half (47%) of these official imports come from Middle Eastern countries. Notably, Saudi Arabia emerged as China's largest supplier of crude oil, remaining in the lead as of October 2021.Saudi Arabia exported $28.1 billion worth of oil to China in 2020, accounting for 15.9% of China's total crude oil imports. Iraq came in third, exporting $19.2 billion worth of oil (10.9%) to mainland China in 2020. Oman, the United Arab Emirates and Kuwait were also among the top ten suppliers to China, with exports worth $12.8 billion (7.3%), $9.7 billion (5.5%) and $9 billion (5.1%) respectively [8].

Nevertheless, this considerable reliance on imported resources entails a multitude of potential risks. For instance, price volatility could result in a gradual increase in the cost of imports. Furthermore, competition for energy with other countries may intensify international tensions. Additionally, the

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inclination to monopolize the energy import situation could jeopardize national security. Moreover, the imbalance in foreign trade may similarly exacerbate the pressure on foreign exchange. Consequently, energy transition represents the optimal strategy for China to circumvent the emergence and exacerbation of these issues.

Reducing dependence on imported resources can provide many opportunities for the development of some new energy-related industries, and many people are inclined to invest in these companies.

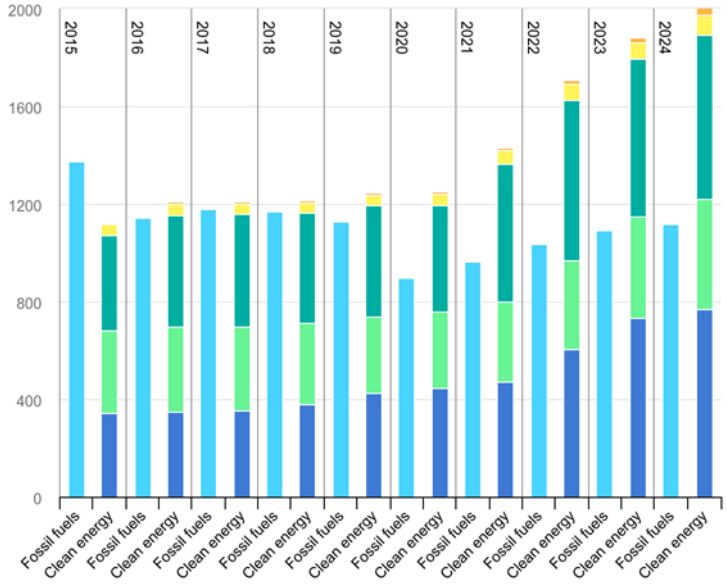

Figure 2: Investment tendencies in new energy sources around the world [9]

As shown in Figure 2, investment in new energy sources is growing significantly around the world. The investment will bring many positive effects, the most notable of which is that the gradually developed new energy industry chain requires more and more labor, providing a large number of jobs and future employment goals for many people. It is expected that the energy sector will create 122million jobs by 2050, including 43million in renewables only [10].

2.2. Energy Transition in China

2.2.1. Energy Structure of China

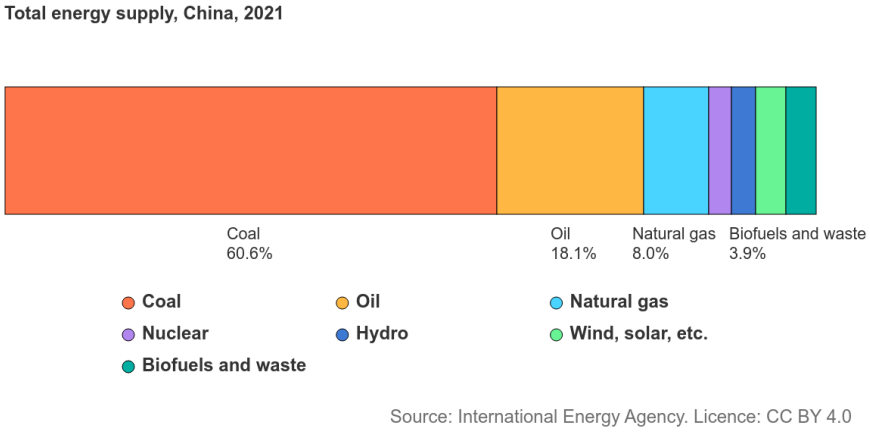

Figure 3: China's original energy structure [11]

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As shown in Figure 3, the China original energy structure was mostly depending on fossil fuels, especially coals. About 60% of Chinese energy supply was coals, which is mainly used in electricity production, industrial production and home heating. The dominance of coal in China's energy mix can be attributed to its low cost, abundance and technological maturity. Coal provides a stable baseload power in electricity production and is a key fuel in heavy industries such as steel and cement. Despite the gradual development of alternative energy sources such as renewable energy and natural gas, coal is difficult to replace in the short term due to its cost, technology and infrastructure advantages.

Oil is the second largest source of energy in China, accounting for about 20% of total energy supply. Oil is mainly used in transportation, chemical production and other fields. The proportion of natural gas is relatively small, but has grown rapidly in recent years, accounting for about 8-10% of total energy supply. Natural gas is mainly used for city gas, electricity production and industrial fuel.

Wind and solar energy, nuclear power and biomass energy have grown rapidly in recent years, but still account for a small share of the overall energy structure.

2.2.2. Brief History of China's Energy Transition

China has begun to implement a number of measures in order to transform its energy mix, which have been divided into the following three phases

2.2.2.1. Full commitment to energy efficiency: 1981-2000(6^{th} -9^{th} FYPs)

Between 1981 and 2000, China focused on modernizing its energy sector to increase efficiency and support economic growth. The government implemented energy conservation initiatives and prioritized the reduction of energy intensity, which was significantly reduced by more than half between 1990 and 2001. However, despite these efforts, fossil fuels continued to dominate the energy mix, accounting for more than 94% in 2000.

2.2.2.2. Energy policy with a dual objective: energy efficiency and energy security: 2001-2010(10^{th} -11^{th} FYPs)

Between 2003 and 2005, China's energy policy shifted to prioritize energy security due to rising energy intensity and increasing dependence on oil and natural gas imports. The Tenth Five-Year Plan (2001-2005) focused on meeting industrial energy demand, resulting in increased coal use and the creation of strategic oil reserves. Despite the goal of reducing energy intensity, China saw an 11% increase. The Eleventh Five-Year Plan (2006-2010) continued to emphasize reducing energy intensity and diversifying energy sources, including expanding nuclear and renewable energy. Climate change was acknowledged, but not prioritized until later plans.

2.2.2.3. An energy policy to start the energy transition: 2011-2020(12^{th} -13^{th} FYPs)

Over the past decade, China has shifted its focus towards improving energy efficiency, energy security, and addressing environmental concerns, especially climate change. The Twelfth Five-Year Plan (2011-2015) marked a "green revolution," introducing climate change as a significant economic challenge and setting targets for reducing energy and carbon intensity, which were successfully achieved. This plan also introduced carbon markets and promoted renewable energy. The Thirteenth Plan (2016-2020) continued this focus, setting new goals for energy efficiency, carbon reduction, and coal use, while emphasizing the transition to low-carbon energy. China's energy transition has led to significant growth in renewable energy, making it a global leader in hydroelectricity, wind, and solar power. Despite progress, challenges remain for a truly sustainable energy transition.

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3. Discussion: Policy and Performance of Energy Transition in China

Following an analysis and discussion of the historical background to China's energy transition, the objective of this section is to delineate the challenges confronted and legislation enacted during China's energy transition, and to provide a synopsis of the objectives and accomplishments of the energy transition at this juncture.

3.1. Energy Transition's Policy in China

3.1.1. Goals

The period preceding 2030, referred to as the 'peak carbon emission period', the processes of new industrialization and urbanization will continue at a relatively fast pace. However, following the peak in carbon dioxide emissions, a steady decrease will be observed. The share of non-fossil energy consumption reaches about 25% (15th FYP).

In the "deep emission reduction period" between 2030 and 2050, the pace of new industrialization and urbanization will decelerate and approach a state of equilibrium. Concurrently, low-emission and zero-emission technologies will transition from the experimental phase to a phase of large-scale implementation. Furthermore, the reduction of greenhouse gas emissions will accelerate on an economy-wide scale.

In the period preceding 2050-2060, which may be described as the "carbon neutral period," it is essential to pursue the vigorous development of negative-emission technologies and to utilize carbon sinks in terrestrial ecosystems with the objective of offsetting the remaining greenhouse gas emissions. Ultimately, the goal is to achieve total greenhouse gas neutrality [12].

To achieve these goals, the Chinese government has implemented policies such as *White Paper on Energy Development "Energy in China's New Era".* China is steadily advancing its green energy initiatives along the Belt and Road. Through key policy documents such as the "*Opinions on Promoting Green Development in the Joint Construction of the Belt and Road*," China has proactively promoted green energy partnerships with countries participating in the Belt and Road Initiative. In a significant move, China declared that it would stop building new coal power projects overseas in 2021, signaling a shift toward prioritizing green and low-carbon energy in its international cooperation. This shift has led China to collaborate with more than 100 countries and regions on green energy projects, resulting in both large, landmark projects and smaller, impactful initiatives that directly benefit local communities. These efforts have addressed challenges such as limited access to electricity and high energy costs in partner countries, while providing them with clean, safe and reliable energy solutions.

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3.1.2. Policies

3.1.2.1. Establishment of appropriate market mechanisms

The carbon emissions trading market, otherwise known as the carbon market, represents a policy instrument that employs market-based strategies to regulate and diminish the output of greenhouse gases. Since 2011, China has initiated the establishment of eight pilot carbon markets. After a decade of development, the national carbon market was launched on July 16, 2021. The inaugural cohort of participants comprised 2,162 power generation companies, collectively responsible for over 4.5 billion tons of emissions in the first year.

By the conclusion of 2023, a total of 442 million tons of carbon emission allowances had been traded within the national carbon market, with an accumulated turnover of RMB 24.919 billion. A fundamental institutional framework for the national carbon market has now been established, comprising rules that are scientifically sound, reasonable, and practical.

The system's institutional framework has been refined and its rules improved in terms of scientific validity and practicality. The accuracy of the data has increased, and companies have become more aware and capable of reducing emissions. These developments have been instrumental in facilitating the continued advancement of China's "dual-carbon" objectives as outlined in the "1+N" policy framework [13].

3.1.2.2. Encouragement of technological innovation

China has identified energy as a crucial element of its national innovation-driven development strategy and has elevated the status of energy science and technology innovation. *The Outline of the National Innovation-driven Development Strategy* has identified the development of safe, clean, and efficient modern energy technology as a significant strategic objective and priority area. The government has devised a comprehensive energy resources science and technology innovation plan and an energy and resources science and technology development strategic plan for 2035. It has also initiated a series of significant initiatives and tasks in the field of energy science and technology innovation, with the objective of strengthening the role of science and technology innovation in leading and supporting the country's development. Furthermore, the government has formulated *the Energy Technology Innovation Plan* and *the Innovation Action Plan for Energy Technology Revolution (2016-2030)*, which delineates the principal directions and technological roadmap for energy technology innovation. It is imperative to deepen the reform of the energy science and technology system, thereby establishing a government-guided, market-led, enterprise-oriented, socially participatory, and multi-party collaborative energy technology innovation system. It is similarly crucial to increase investment in scientific and technological innovation in important energy fields and emerging energy industries, strengthen the construction of talent teams, and enhance the innovation capacity of various types of subjects [14].

3.1.2.3. Promotion of international cooperation

The Belt and Road Initiative represents the primary avenue for collaborative engagement between China and other nations in the realm of energy transition. Guided by the principles of peaceful development, it endeavors to advance economic cooperation with partners, fostering the formation of a community of shared interests.

At the United Nations General Assembly in September 2021, President Xi Jinping announced that China will no longer support new overseas coal power projects. He also stated that China will strengthen its support for green and low-carbon energy in developing countries. It is evident that over the past decade since the inception of the "Belt and Road" initiative, China has engaged in

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collaborative endeavors with over 100 countries and regions to advance green energy initiatives. China's financial contributions to green and low-carbon energy projects in the countries where the "Belt and Road" is being constructed have surpassed those directed towards traditional energy sources. Energy cooperation represents a pivotal aspect of the "Belt and Road" initiative. Over the past ten years, China has adhered to the principle of "building and sharing" and has strengthened energy cooperation with other countries under the framework of "One Belt, One Road," thereby achieving concrete and substantial results.

The number of member countries of the "Belt and Road" Energy Partnership has reached 33. Six regional energy cooperation platforms have been established, including the APEC Sustainable Energy Center and the China-ASEAN Clean Energy Cooperation Center, with the objective of promoting the common development and prosperity of relevant countries and regions in the field of energy.

The individual responsible for the National Energy Administration indicated that the "Belt and Road" energy cooperation has provided a new impetus for promoting global economic prosperity and social development, established a new framework for reforming the global energy governance system, and made a significant contribution to enhancing the well-being of the people in the countries where it is being implemented [15].

3.2. Performances

3.2.1. Achievements

The energy transition has sped up the development of clean energy sources. In 2023, China's clean energy consumption is expected to reach 26.4%, a 10.9% rise since 2013. Meanwhile, coal use is projected to drop by 12.1%. Of China's 2.92 billion kW power capacity, 58.2% (about 1.7 billion kW) comes from clean energy. Clean energy accounted for 39.7% of the country's power generation, representing a 15-percentage-point increase since 2013. Over the past decade, more than half of new electricity demand has been met by clean energy. China has shut down outdated coal plants, cutting power sector emissions by over 90%. The rate of energy use being electrified has hit 28%.

Wan Jinsong from the National Energy Administration says China's energy shift aligns with protecting its environment. Since 2012, energy use per unit of GDP has dropped by over 26%, and the country is focusing more on green energy. Refined oil quality in China is now on par with global standards, and coal plant efficiency has improved to match natural gas plants in terms of emissions.

According to *the International Energy Agency's report*, China is the world leader in renewable energy, driving its rapid growth. From 2014 to 2023, the global share of non-fossil energy rose from 13.6% to 18.5%, with China contributing 45.2%. China has also partnered with over 100 countries to help solve their energy challenges and provide clean, secure energy solutions [16].

3.2.2. Challenges

China's energy transition is confronted with a multitude of significant challenges. As one of the largest emitters of pollution, China has set itself the challenging goal of achieving carbon neutrality by 2060. Secondly, as the largest developing country with a relatively late start in development and a large population base, China will encounter significant challenges in achieving its energy transition goals within a relatively short period of time. On average, it will take the world 53 years to move from peak carbon emissions to carbon neutrality. The United States is expected to take 46 years, while developed Western economies will take more than 70 years. In contrast, China has only 30 years to achieve this goal. This means that not only will China have to reduce its carbon emissions intensity faster than any other country, but it will also have to achieve carbon neutrality in the shortest time in world history, making it a challenging endeavour.

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A variety of factors, including geographic location and climate, contribute to the inconsistency in resource endowment, economic development level, and other characteristics observed across China's provinces. Sichuan Province, which is rich in water resources, has made significant advancements in its energy transition. In contrast, Guangdong Province has experienced a dramatic increase in population and a surge in energy demand since the reform and opening up, resulting in an oversupply of energy. Coal is highly carbon-intensive, producing 1.4 times more carbon emissions per unit of energy than oil and twice as much as natural gas. It accounts for 79% of China's energy-related carbon dioxide emissions, making "coal reduction" a key focus for green and low-carbon energy transformation. However, rapid and aggressive coal reduction may weaken its role in maintaining energy system stability, potentially leading to energy security issues. For example, in the second half of 2021, some regions will experience power shortages due to insufficient coal supply, resulting in restrictions on energy use. The three northeastern provinces have experienced a state of heightened tension due to power restrictions. They have been in a situation of limited power supply, which has persisted throughout the year [17]. The National Energy Board has issued the 'Emergency Notice on the Coordinated Resolution of Electric Coal Sources in the Three Northeastern Provinces'. However, the policy will not take effect immediately, as the release of coal production capacity requires the coordination and resolution of a number of ministries and commissions, including those responsible for safety supervision, environmental protection, land, and other relevant ministries and commissions. Following the Chinese government's announcement of its intention to achieve a carbon peak by 2030 and carbon neutrality by 2060. It is proposed that the '14th Five-Year Plan' should not include the construction of new coal plants in order to avoid the risk of stranded assets, or even the closure of existing coal plants. Nevertheless, the objective reality is that the power system requires real-time balance. Furthermore, China's power industry is currently in an incremental development stage, with the power load and electricity consumption reaching record highs year on year. Wind is a fluctuating power supply, energy storage technology is still in its infancy, and there is still a significant way to go before it reaches a scale that can meet the demands of peak power. The primary sources of peak power and the primary sources of power are still the traditional energy sources, especially coal power. In the event of a disruption to the supply of electricity, it is essential to quantify the resulting losses and to distribute them in a fair and equitable manner. Furthermore, it is vital to fully anticipate the potential consequences of such an event [18].

4. Conclusion

This paper employs a policy analysis approach to examine the progress made by China in enhancing energy efficiency, fostering clean energy development and curbing carbon emissions. Despite China's significant advancements in renewable energy, challenges remain. In particular, China still requires the implementation of additional measures in the future with regard to the unequal distribution of resources, the unbalanced regional development, and the trade-off between energy security and environmental protection. In order to further promote energy transition policies, China should implement more targeted regional policies at the national level, promote technological innovation and strengthen international cooperation. It should be noted that this article does not attempt to cover all aspects of China's energy transition policy in exhaustive detail. However, the arguments presented in this paper are based on the available data and lack sufficient specificity and detail.

China's energy transition strategy emphasizes key areas such as renewable energy development, smart grid implementation, and international cooperation. The first step is to focus on renewable energy. This will help reach peak carbon and carbon neutrality targets. Energy storage and smart grids will make sure that renewable energy is always available and stable. China will improve its carbon trading market and green financial system. It will also encourage businesses and society to take part in the energy transition. Finally, China will work with other countries on technology, manufacturing

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and standards to promote global green and low-carbon development. These measures will help China to change its energy structure for a cleaner, low-carbon and efficient future.

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