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Research on Energy Restructuring in China in the Context of Global Warming

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Abstract: Considering global warming, the development of countries and the normal life of people around the world have been affected. In addition, other derivative issues arising from global warming have impacted the entire planet's ecology. One of the primary causes of the rise in global temperatures is energy burning. China is a major coal energy-consuming country. Therefore, it has been searching for a cleaner and lower carbon energy mix in recent years. This paper investigates the current status of China's energy mix upgrade using literature research and case studies and finds that China currently suffers from a lack of clean energy technologies, uncertainty about the direction of alternative energy choices, and narrow social coverage of energy optimization plans. To address these problems, this study argues that China's energy mix upgrade should f develop traditional energy clean technologies, seek new alternative energy sources and include more social elements to help transform the energy mix toward cleanliness and low carbonization. New energy development has a key role in this paper, and therefore, the findings of this paper are beneficial to the further development of China's new energy sector. In addition, this paper further calls for more social elements to participate in the process of energy mix optimization, which helps to transform the public's awareness, reduce global CO2 emissions, and prevent further global temperature rise.

Keywords: global warming, energy restructuring, China

1. Introduction

1.1. Research Background

Global warming has been attracting widespread attention and discussion in the world since the 21st century. Global warming brings a series of derivative problems, such as sea level rise, glacial permafrost melting, and various kinds of extreme weather, which seriously threaten the ecological environment and human society. The IPCC Sixth Assessment Report has shown a sign that the average global temperature will increase by 1.5°C or even higher in the forthcoming two decades. The last four decades have been almost as warm as ever since temperature records have been kept. From 1850 to 1900, the temperature causing global warming is about 1.1°C [1].

Global warming is the primary source of carbon dioxide emissions produced by burning fossil fuels [2]. Since the beginning of the industrial revolution, atmospheric carbon dioxide levels have

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risen from 316 ppm in 1950 to more than 411 ppm in 2019, increasing the concentration by about 40% [1]. Therefore, in response to the call of the United Nations and the Governmental Panel on Climate Change, countries have committed themselves to reduce carbon dioxide emissions. This will help to effectively control the level of carbon dioxide gas in the atmosphere and prevent its impact on the climate. The overall energy production and consumption structure of China shows a coal-based, multi-energy complementary structure, with coal accounting for more than 60% of energy [2]. This energy structure poses a certain threat to China's energy security and an obstacle to the ecological environment and the transformation of the economic dynamics. Based on this reality, China has committed to reducing its coal use rate to less than 30% by 2035 [3]. In addition, to fill this energy gap, the Chinese government has to find and develop low-carbon, clean alternative energy sources to reduce greenhouse gas CO2 emissions from traditional fossil energy sources and promote the restructuring of new energy sources.

1.2. Literature Review

Global warming has led to many research discussions among experts and scholars. In terms of the current state of global warming, Hanna and Hall looked at the end of the glacial period and the beginning of the modern, warm period. Since 1850, the global temperature has gradually increased; with fossil energy, the rising level of greenhouse gases has led to the highest summer and warmest winter in history in the 1990s [4]. Letcher compiled the causes of global warming and concluded that since the Industrial Revolution, the main contributor to global warming had been human emissions of greenhouse gases [4]. This conclusion was supported by the findings of Mikhaylov et al. that greenhouse gases have a sustaining effect on surface temperature, which is maintained above 15 degrees [4]. The concentration of carbon dioxide, a major component of greenhouse gases, makes the insulating effect of greenhouse gases more pronounced. Letcher agreed that the major factor leading to global warming is greenhouse gases but he believed that there are two sources of carbon dioxide, one is the growing population, and the other is the consumption of fossil energy by human activities [4]. The effects of global warming were obvious, both in the destruction of the natural environment, such as reduced vegetation, melting glaciers, and reduced biodiversity, and in the social environment, such as increased social and political burdens on countries, agricultural production, and regional stability [5].

Moreover, Li et al. believed that China’s current energy structure principally falls on the coal, and the future energy restructuring should move in the direction of diversification and quality, i.e., vigorously developing renewable energy, appropriately developing nuclear power, promoting and developing clean coal technology, etc. [3]. Fu and Min believed that energy restructuring countermeasures should consider economic, population growth, and environmental factors. Therefore, developing renewable energy was the focus and key to optimizing energy structure [6]. In addition, energy conservation and emission reduction was an inevitable transition period in energy restructuring, which required active human participation and awareness building.

1.3. Research Gap

Based on the above statements, most scholars have studied the impact of greenhouse gases generated by human activities on global warming and have also proposed the concept of energy structure optimization in terms of developing new energy sources, energy conservation as well as reduction in emission in reconstructing the energy structure. However, very few scholars have made practical suggestions on how to optimize energy restructuring, and their studies also lack concrete analysis of China’s actual energy structure and the formulation of perfecting measures that have already been implemented, which makes the research conclusions of most scholars lack relevance to

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the research topic of energy restructuring in China. Therefore, this study will propose practical solutions based on China's current energy structure situation and the practice of optimization measures and provide recommendations for the energy restructuring of China om the future.

1.4. Research Framework

As a result, this paper begins by introducing the study's context, outlining its importance and value, and summarizing the findings of recent related research. Then, this paper will introduce the research methodology used in this paper. This paper uses literature study and case study as the main research methods to explore the theoretical support and factual practice of China's energy structure optimization. Third, this dissertation will present China's current status and the challenges of energy restructuring given the above relative researches. Finally, this study will propose targeted recommendations to address the practical challenges and suggest optimization ideas to help China achieve energy restructuring in terms of alternative energy sources, energy conservation and emission reduction, and related technological and economic strategies.

2. Methods

2.1. Literary research

Literary research is the scholarly, critical study of relevant research findings, usually used for analytical purposes [7]. In total, this paper critically analyzes the literature in two fields. On the one hand, by examining the status, causes, and effects of global warming, this paper further clarifies the direct role of the energy consumption structure on global warming. The burning of fossil energy required for human production activities causes an increase in global greenhouse gases, which directly contributes to global warming and causes non-negligible natural and social environmental impacts that directly damage the human living environment. This motivates energy restructuring. In addition, the literature on energy restructuring illustrates the possible optimization directions of the future energy restructuring of China, which provides theoretical support and a factual basis for the proposals in this paper. Since the structure of human energy consumption directly contributes to global warming, energy restructuring studies provide potential directions for energy restructuring in China, such as clean energy as an alternative energy source and the development of technologies.

2.2. Case Study

Case study research is a real-life method for studying complex issues that yields in-depth, multifaceted understanding. It is a well-known research strategy popular across many academic fields, particularly in the social sciences [8]. As a province with an energy consumption structure similar to the overall consumption structure of China, the energy optimization scheme of Xinjiang can provide practical suggestions for the energy restructuring of China. The Xinjiang energy structure is still dominated by coal, but the proportion of other energy sources is increasing. Its main method is constantly searching for new alternative energy sources, which include but are not limited to wind, water, and solar energy. In addition, the energy mix in Xinjiang is gradually linked to economic dynamics, which supports energy restructuring at the economic level, such as pricing strategies for different types of energy sources. In conclusion, the existing state of the energy structure in Xinjiang and the successes being made in energy optimization may serve as important benchmarks and lessons for the improvement of the energy structure of China. This gives concrete, practical meaning to the factual basis and theoretical foundation related to energy restructuring in China and provides conditions for its widespread replication.

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3. Results

3.1. Technology Inadequate in Current Energy Restructuring

Energy restructuring technologies refer to various technologies and methods to change how energy is produced, distributed, and consumed [9]. Currently, energy transition and energy ladder make technology adjustments in terms of energy use propensity shift and energy consumption scope, respectively [9]. China has been investing heavily in developing and deploying energy restructuring technologies to address its growing energy demand and reduce its dependence on fossil fuels. In terms of the energy transition, China has increased its exploration and use of renewable energy sources while also developing energy storage technologies to support grid integration of renewable energy sources [3]. According to Broadstock et al., the energy ladder theory changes the structure of energy consumption by households and society through energy resources [10]. China focuses on and develops emerging technologies such as smart grids, electric vehicles, and carbon capture and storage to expand people's choices in energy consumption and improve energy use structure [11].

Despite the Chinese government's tremendous efforts in energy restructuring, the following technical challenges to China's current energy restructuring remain. First, although China has been investing in such renewable energy sources as wind, among others, the country still relies heavily on coal for its energy consumption. The Fig. 1 shows the structure of China's energy consumption. Moreover, China's solar and wind power plants are not as efficient as those in other countries, which limits China's ability to transition to clean energy.

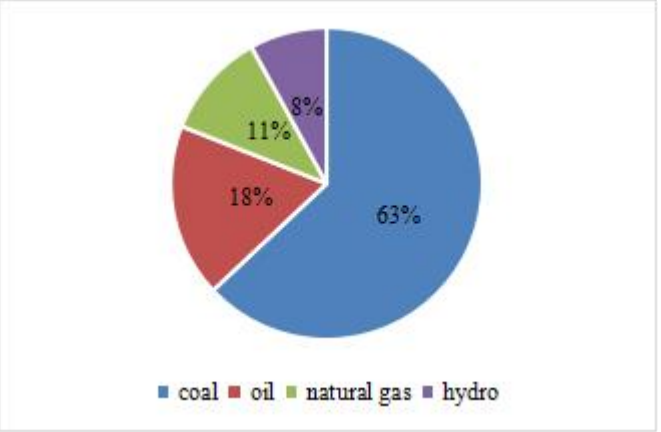

Figure 1: China's energy consumption in 2020.
(Source: https://www.iea.org/countries/china)

Second, China's energy grid is outdated and far from the urban centers where energy consumption is greatest [6]. The energy transmission infrastructure, in part, prevents electricity from being delivered from power plants to the cities that need it most. Third, China's energy storage technology is inadequate in terms of renewable energy storage [11]. Energy storage is crucial for renewable energy sources that depend on the weather, like wind and solar. China's current energy storage is mainly hydro energy, but this is an expensive and limited-capacity storage technology.

3.2. Unclear Direction of Energy Restructuring

Energy restructuring refers to transforming the energy sector from a traditional, centralized, fossil fuel-based system to a more decentralized, diversified, low-carbon system [11]. This energy restructuring strategy calls for switching to renewable energy sources, increasing energy efficiency, and investigating cutting-edge energy technologies like hydrogen energy.

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China's current energy mix reorientation includes significant investment in renewable energy, with lower wind and solar power generation capacity than other country [3] (shown in Fig. 2).

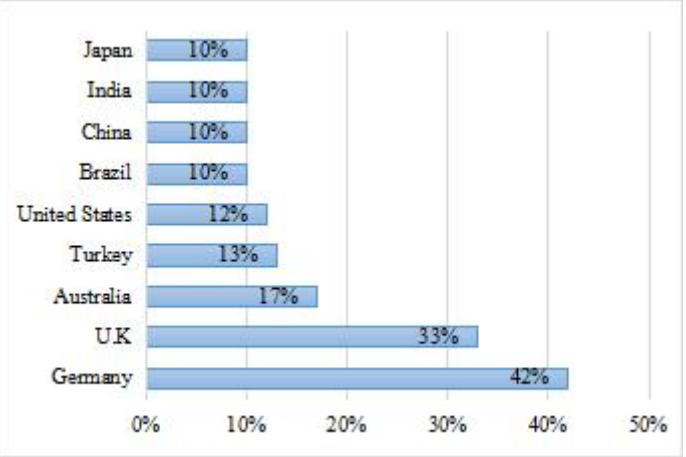

Figure 2: Share of solar and wind power generation in China and other countries in 2020. (Source: https://www.statista.com/chart/22558/wind-and-solar-generation-in-selected-countries/)

In addition, China has launched a national carbon trading program and is promoting the use of electric vehicles to reduce carbon emissions from the transportation sector [2]. In summary, China's current energy restructuring direction is transitioning toward a low-carbon and clean energy mix and scaling up stages by stage the share of clean energy under the energy use mix. Besides, this energy restructuring is in line with the demands of global warming on energy consumption. However, there are many realistic dilemmas regarding energy choices in China's energy restructuring process.

China's main problem in reorienting its energy mix is the limited availability of renewable energy sources [12]. Although China has great potential for renewable energy sources such as solar, wind, and hydro, their availability is limited in some regions. This makes it difficult for China to choose the direction of energy optimization. On the one hand, in terms of the cost of energy use, China currently has far more coal energy in terms of price and quantity than other clean energy sources [13]. Therefore, China's energy restructuring will be limited by the cost input, and China cannot choose alternative energy sources that can replace traditional coal energy sources in a short period. On the other hand, the distribution of new energy sources in China is uneven, with each province and region having its characteristics in terms of energy distribution [13]. This makes it very difficult to coordinate the new energy structure in China, which makes it impossible for the government to make a plan to adjust the energy structure according to the actual local situation, and thus to control the direction of the energy structure as a whole. In addition, the direction of China's energy restructuring is limited by the intermittent nature of new energy production and transmission distribution based on the choice of new energy sources in China. For instance, inconsistent weather makes it difficult for renewable energy sources like wind and solar to consistently provide electricity [11]. Geographically, renewable energy sources are often located far from energy demand areas, which can create pollution transmission and distribution constraints. Finally, China's current energy transportation structure is also not applicable to the goals of China's energy restructuring direction.

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3.3. Energy Restructuring Covers a Narrow Range of Society Elements

Fu and Min believed that a more holistic and diverse approach to energy production and consumption could be achieved when different sectors of society, including government, industry, communities, and individuals, are involved in the decision-making process [6]. This means that a wider range of energy sources can be explored and balanced to meet energy demand sustainably. Klemm and Vennemann also supported that different stakeholders have an important role in energy mix optimization, as this forms a closed loop of energy optimization from energy production to energy consumption [14].

The government and some energy-dependent industries are the two main players involved in China's current energy mix optimization. The government takes the main role in the process of an energy structure optimization, including the direction of optimization, energy production, consumption structure control, etc.; while energy-dependent industries generally plan the energy use structure and economic efficiency according to the government's relevant indicators. Therefore, it can be said that the above two main actors are the main actors in China's energy restructuring, while other industries, communities, and people play a very limited role in the process.

This has led to a disconnect and gap between the overall planning and the actual practice of energy restructuring in China. A major problem is the lack of transparency and accountability in decision-making. The Chinese government has largely determined the pace and direction of energy restructuring without meaningful consultation with the affected communities. This has resulted in a large portion of the population not being involved in the energy restructuring process moving forward, which has greatly hindered the process and coverage of energy restructuring. Another issue is the lack of public awareness and education on energy restructuring, which is detrimental to the long-term planning of energy restructuring. This has resulted in the potential benefits of energy restructuring not being spread to the larger community level and many industries and individuals being left out of this planning. This has led to a lack of popular support for renewable energy projects, resulting in an uneven distribution of energy transition costs and benefits. Poor communities often bear the brunt of the environmental degradation and health impacts associated with energy projects, while the benefits of the energy transition, such as job creation and reduced emissions, tend to be concentrated in wealthier areas.

4. Discussion

4.1. Traditional Energy Optimization Technologies Such as Net Coal Technology

Given that China's current energy consumption structure is still dominated by traditional energy sources such as coal in the foreseeable future, the net coal technology is necessary for China. The core principle of net coal technology is to reduce the harmful substances produced by burning charcoal [15]. Carbon capture and storage mainly involve storing carbon dioxide produced by coal combustion in underground geological formations, but the safety hazards and environmental risks associated with its generation are yet to be determined [11]. Therefore, China's future coal cleaning technology could shift toward integrated gasification combined cycle (IGCC), which combines coal gasification with a gas turbine system to reduce the pressure of energy optimization from coal energy use with lower carbon emission and higher electricity production efficiency. Also, this clean technology may, to some extent, adapt along with China's changing energy mix and can play a more significant part in China's energy mix optimization process [15].

On the issue of China's outdated power grid, to ensure the security of China's consumption of current energy and the demand for energy optimization in the future, China can optimize its circuits by upgrading its existing infrastructure and implementing smart grid technologies. On the one hand,

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China may upgrade its current infrastructure to modernize its energy grid, which entails replacing obsolete technology with newer, more effective equipment to increase the grid's total capacity and dependability. On the other side, smart grid technology may assist in streamlining energy consumption, lowering energy losses, and enhancing the system's dependability and efficiency. It may also make incorporating renewable energy sources into the system possible. This can also lower the expenses associated with energy restructuring while ensuring that China's energy mix is consistently applicable before and after improvements.

4.2. New Alternative Clean Energy Sources

In addition to the above-mentioned cleanup of China's traditional energy sources, the future direction of China should increase the consumption and use of new energy sources when optimizing the energy mix in the future. Therefore, the optimization of China's energy mix must fully explore and secure alternative energy sources. The availability of new energy sources in China has been hampered by energy prices and distribution, resulting in the low utilization of new energy sources. Therefore, China first needs to make concessions on new energy prices and develop reasonable new energy price advantages to promote the dominance of new energy in the broad consumption structure of society [15]. For example, to create a price differential between traditional energy use and new energy consumption, strike a balance between new energy production and price in terms of economic strategy, and subsidize new energy consumption with the performance of coal energy.

On the other hand, in response to the problem of uneven distribution of new energy sources, China can use clean energy in a localized manner. For example, wind and solar energy are Xinjiang's main clean energy sources but it also enjoys other traditional energy sources, including coal and oil [6]. The main way to optimize the energy mix in Xinjiang is to increase the use of local dominant clean energy sources, while places like Sichuan, China, are rich in hydro energy, which can be a dominant local clean alternative energy source [13]. The development of distinctive clean energy sources in different regions can achieve a diversified energy use structure and provide more directions to explore for energy mix optimization. More importantly, the exploration of multiple alternative clean energy sources can further alleviate the limitations of the intermittent nature of new energy production and transmission distribution. This ensures the overall energy consumption security and overall coherence of society.

As a result of this and taking into account China's energy reserves, the development, and exploitation of clean alternative energy sources like solar, wind, nuclear, biomass, and hydrogen fuel cells, in accordance with the characteristics of each region, will likely determine the future direction of clean energy alternatives in China. In addition, the use of new energy transmission technologies safeguards the supply and demand between energy production and consumption.

4.3. Energy-Saving Measures with Broad Social Participation

While the government and energy-dependent businesses now regulate China's energy structure optimization, which results in a delayed and ineffective energy restructuring, energy production and consumption cut across all facets of social life. Therefore, China's energy mix upgrade must include as many social elements as possible. Therefore, the government's new energy investment program needs to be more transparent and participatory at the workforce level, i.e., at the community level, to address the community's weak awareness and low activity level on new energy.

On the one hand, from a transparency perspective, China's energy restructuring needs to be publicized on a broad social level, and this can be done from a public health perspective. By emphasizing the actual health problems caused by traditional energy use, new energy sources can

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gain a huge advantage in public health, thus raising the public's awareness of the need for energy restructuring and building awareness of clean energy use.

On the other hand, increasing social and public participation is a way to get industries and people to join clean energy investment projects. For example, it is creating new jobs in the new energy sector and promoting the retraining of workers in coal-dependent areas. This will allow people to participate in producing and transporting new energy and experience the low-carbon structure of new energy in the process of production and consumption. The other is for the government to increase its support for companies and communities that consume new energy and to provide some assistance in terms of the policy. This will help the industry and communities to gain a proactive advantage in their development. Another, at the individual and household level, is to guide energy consumption behavior through prices. Since the general public is more sensitive to price in actual behavior, low prices can be an opportunity for the general public to consume new energy [6].

5. Conclusion

China has been seeking to transform its energy consumption towards clean and low-carbon in recent years, but this process faces some challenges, mainly in the lack of traditional clean energy technologies, uncertainty in the direction of alternative energy options, and narrow social coverage of energy optimization plans. In response to the above problems, IGCC can realize energy production optimization, while grid upgrade helps optimize energy transportation, which is conducive to developing clean energy technologies. In terms of new alternative energy options, it is necessary to establish a new energy consumption structure in line with the geographical characteristics of new energy distribution, taking a favorable market environment for clean energy development as a prerequisite. Finally, energy optimization should break through the restrictions of government and enterprises, include more social elements within the energy optimization scheme, and increase transparency and participation in energy structure optimization.

The research in this paper is a study of energy structure optimization in China; therefore, the conclusions of the solutions in this paper can provide some feasible suggestions on various aspects of energy optimization in China. This study emphasizes the key role of new energy sources in China's energy mix upgrade, which facilitates further calls for consumers to shift to new energy consumption and contributes to the further development of the new energy industry. In addition, this paper further calls for more social elements to be involved in the energy mix optimization process, which can help shift the population's awareness to some extent. Finally, the successful transformation of China's energy mix can further reduce global CO2 emissions and prevent global temperature rises.

However, this paper fails to avoid several limitations. First, the main data sources gathered are mainly secondary data, and the insufficient of primary data leads to the lack of practicality of the research basis and conclusions of this paper. Therefore, it may be necessary to increase the proportion of primary data in the article through research methods in future studies, which will help the practical operability of the article's recommendations. Second, the academic literature cited in this article is relatively new, which may mean that the article has not been peer-reviewed, which has an impact on the authority of this article. Therefore, the researcher needs to compensate for this deficiency by citing authoritative journals and reliable authors' conclusions. Third, literature research and case studies are the main research methods of this paper, and the difference in research background may make this paper fall short of the expected research findings when citing relevant data. Future research needs to follow the research background and objectives closely in terms of case selection and literature focus and do planning for research advancement.

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