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Research on the development status and path of clean energy industry

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Abstract: *The excessive use of fossil energy has brought about a series of problems, such as the ecological environment and climate change, which have become challenges and problems in front of the world. Clean energy, as an essential part of the energy supply system, drives the energy supply to become increasingly diversified, clean, green, and low-carbon. The development of new power technologies, such as wind power, hydro power, solar power, etc., marks that countries worldwide have begun to accelerate the transition to clean energy power. At present, clean energy power generation has achieved milestone results. However, there are still many problems in developing clean energy in China: insufficient propaganda, inadequate system protection, application technology to be broken through and so on. The relevant discussion on the current situation and problems of clean energy in China has both theoretical value and practical significance.*

Keywords: *Clean energy, Development status, Development suggestions*

1. Introduction

Due to the increasingly severe energy and environmental problems, the contradiction between the economy and the environment has gradually become prominent, and how to take into account the harmonious development of both has become an important topic. Clean energy is an energy source that emits no or very few pollutants during its development and utilization. Achieving clean energy instead of fossil energy generation is a critical way to achieve low carbon transformation in the power industry. In the clean energy industry, solar, wind, hydropower, and nuclear power are solar radiation, wind resources, hydro resources, etc., transformed by specific industrial procedures and equipment and are all natural resources. Changing the traditional economic development model and using clean energy to generate electricity in a low-carbon economy is gradually becoming the mainstream and meaningful direction in the future. Therefore, scholars are attracted to carry out relevant research on clean energy.

Li et al.[1]believed that due to the influence of resource endowment, coal-dominated fossil energy has dominated China's energy structure for a long time, with coal consumption accounting for 56.8% of total energy consumption in China in 2020. Jia [2] proposed to promote the development of the energy system in the clean and low-carbon direction, accelerate the development of solar power generation while maintaining the stable development of hydropower, promote the transformation of the power system to a high proportion of clean energy generation mode, replace traditional fossil energy with clean energy, and improve a series of environmental problems with energy restructuring. Tong[3]analyzed the difficulties and challenges of energy structure transformation under the double carbon target and proposed to build a new energy system, promote energy transformation to improve energy system efficiency, and achieve a "light carbon" energy structure. In China, hydropower construction work, small and medium-sized hydropower facilities account for a large proportion of the construction work, and Li Fernando et al. pointed out that there are specific problems in the construction of small and medium-sized hydropower facilities in China's rural areas, such as imperfect construction plans, strict quality control of engineering materials and insufficient management of organizational departments[4]. The unique location advantage of Qinghai province makes it rich in clean energy, and in recent years, the clean energy industry in Qinghai province has developed rapidly and has formed a certain scale, but a series of problems have emerged in the process of rapid development. Zhang et al. pointed out that in terms of energy storage facilities, due to the ecological environment, topography, and other restrictions, the investment in clean energy infrastructure construction in some areas is small, and the infrastructure

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conditions are backward[5]. Chen et al. pointed out that the inadequate construction of wind power transmission lines and infrastructure is the main constraint to the development of wind power in China, and as the proportion of clean energy in the energy system is increasing, the traditional obsolete grid system should keep pace with the development of clean energy infrastructure construction[6]. Guo et al. constructed a multi-regional model of electricity production and supply in China by constructing an objective function that enables the power generation industry 2013 to 2050 by maximizing the cumulative total profits obtained by the power generation industry from 2013 to 2050. The results suggest that energy subsidies and national targets are important for the development of clean energy in the short and long term[7]. Simone and Pulselli found that the premise of achieving sustainable economic development is that we should increase investment in and exploitation of clean energy, improve access to clean resources, and accelerate the electricity transition based on optimizing traditional energy generation technologies[8]. Scholars have measured the low carbon economy from different perspectives. Fragkos et al. used the carbon index to measure the level of the low carbon economy and explored the factors that have positively contributed to the development of low carbon economy in China using methods such as generalized moment estimation. The results show that energy substitution technologies can play a role by increasing the use of clean energy. In addition, corporate technologies have a greater role in driving the low-carbon economy than technologies such as research institutions and schools[9].

2. Analysis of the current situation of clean energy

From the perspective of total energy consumption, in 2020, China's total primary energy consumption reached 4.98 billion tons of standard coal. 2021 oil and coal consumption accounts for about 74.7% of the total energy consumption, natural gas, hydropower, nuclear power, wind power, solar power, and other clean energy consumption accounts for about 25.3% of the total energy consumption, from the perspective of power generation, 21 years of China's total power generation is From the perspective of power generation, in 21 years, the total power generation in China was 8,112.2 billion kilowatt hours, of which thermal power generation was 57,702-kilowatt hours, accounting for about 71%, occupying a dominant position, which shows that China still has great potential in clean energy development and utilization worth developing. China's energy structure is dominated by fossil energy, and with the rapid growth of energy consumption, pollutant emissions have risen sharply, causing tremendous pressure on the environment. In order to alleviate the contradiction between energy consumption and environmental pollution, it is essential to accelerate the development of environmentally friendly and clean energy. For China, a country with a large population, energy saving and emission reduction in the electric power industry plays an essential role in achieving energy saving and emission reduction in society. Accelerating the development process of clean energy and vigorously developing clean energy power generation is a critical way to save energy and reduce emissions in China.

2.1. Analysis of clean energy installed capacity in China

Table 1: 2012-2021 China's installed power capacity

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Thermal power	81968	87009	93232	100544	106094	110495	114408	119055	124517	129678
Wind power	6142	7716	9637	12934	14864	16367	18426	21005	28153	32848
Solar power	341	1589	2486	4318	7742	12942	17433	20468	25343	30656
Hydropower	24947	28044	30486	31954	33207	34359	35259	35640	37016	39092
Nuclear power	1257	1466	2008	2717	3364	3582	4466	4874	4988	5326

Data source: National Bureau of Statistics

Tab. 1 shows China's installed power capacity changes in the last decade. It is obvious to see that with the booming economy in China, thermal power maintains the dominant position in China's energy structure, but its growth rate is the slowest, and the limited regional development resources of hydropower, so the installed capacity of hydropower is growing slowly and will not grow rapidly in the future. In the past two years, the growth rate of installed capacity of clean energy has increased steeply, mainly benefiting from the new installed capacity of wind power and solar power to record highs, with wind power in 2020 adding about 71 million kilowatts of installed capacity, with a year-on-year growth rate of about 34%; with such an enormous growth in 2020, wind power installed in 2021 continues to soar, with a new installed capacity of about 47 million kilowatts, the total wind power Installed capacity exceeded 300 million kilowatts for the first time. Solar power is also up, with installed capacity increasing nearly ninety-fold over the decade from 2012 to 2021, with an average annual growth rate of about 65%.

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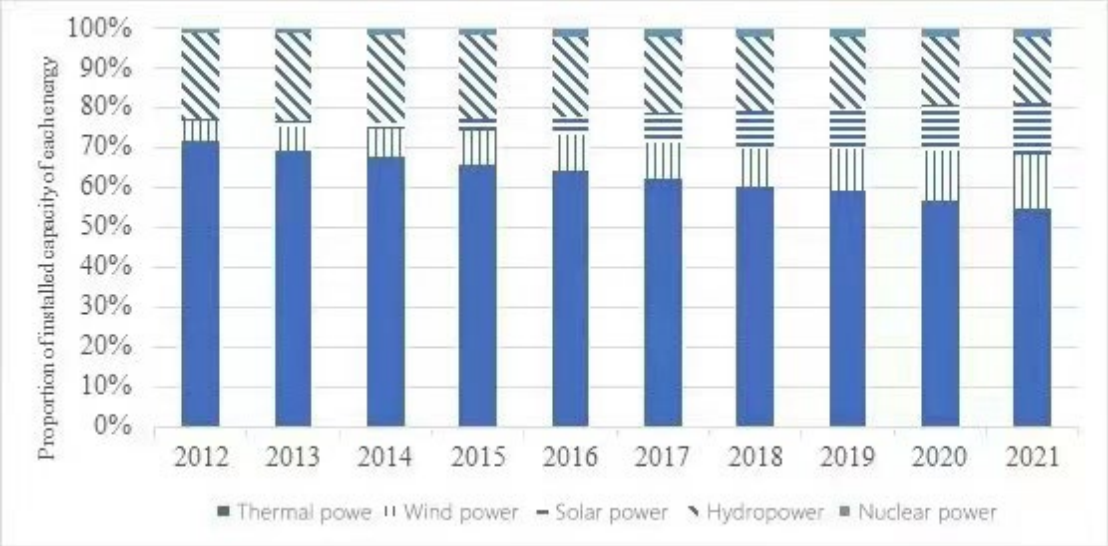
Wind power grid-connected installed capacity has been the world's first for 12 consecutive years, photovoltaic power generation grid-connected installed capacity for seven consecutive years, the world's first installed offshore wind power jumped.

2.2 Power Structure Analysis

As seen from Fig. 1, China's installed thermal power capacity has been declining to 46.7% over the past decade. On the other hand, the proportion of clean energy installed capacity has increased significantly, with clean energy installed capacity reaching 1.08 billion kilowatts, accounting for 46.5%. In terms of growth in installed capacity, in 2021, the installed capacity of solar power will grow by more than 20% year-on-year, wind power by more than 15%, and nuclear power and hydropower by 6.8% and 5.6%, respectively.



Data source: National Bureau of Statistics and Social Development Statistics Bulletin

Figure 1: 2012-2021 China's electricity installed power structure

3. Problems and challenges of clean energy development

3.1 The contradiction between development needs and resource constraints

In 2021, China's total primary energy consumption will exceed 5 billion tons of standard coal for the first time. However, there is still a great distance between per capita energy consumption and developed countries. In 2021, China's per capita electricity consumption will be about 5MWh /capita, the United States about 13MWh /capita, and Japan's about 8MWh /capita, which are 2.5 times and 1.6 times that of China, respectively. To achieve the two-hundred-year goal, China's energy demand will continue to grow for some time. However, China's per capita reserves of conventional fossil energy are far below the world average. Therefore, there is a certain pressure on energy supply and demand.

3.2 The contradiction between energy structure and green development

Although the proportion of clean energy in China's energy structure is increasing yearly due to the characteristics of China's resource endowment, the coal-based energy structure is difficult to change over time. The carbon emission coefficients of three fossil energy sources, namely coal, oil, and natural gas, are 2.66tCO^2/t standard coal, 2.02tCO^2/t standard coal, and 1.47tCO^2/t standard coal, respectively[10]. As a high-carbon energy source, coal has the most significant emission intensity in the country. China's coal-dominated energy pattern is complicated, and it urgently needs to shift to green power.

3.3 Lack of awareness of clean energy

The global transformation is accelerating, and it has been a globally recognized trend to develop a green economy, accelerate the transformation of low-carbon technologies and develop and use clean

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energy. The environmental problems caused by the over-exploitation and use of traditional energy sources are no longer a problem that can be solved by one country or region. However, people need to learn more about it, limiting it to solar and wind energy use. The public only knows a little about it, except for experts specializing in the clean energy industry.

3.4 The utilization technology of clean energy needs to be breakthrough

At present, China's clean energy industrialization process is accelerating, but compared with European and American countries; there are still apparent disadvantages in the use of energy, low industrialization, low technology level, low energy utilization, some energy development is in urgent need of technological breakthroughs, only the continuous progress of technology, it is possible to improve the level of industrialization rapidly, to change the structure of energy. For instance, carbon capture and storage (CCS) and CCUS technologies will be important technologies for net-zero carbon emissions in the coal industry in the future. At present, CCUS technology is still in the research and demonstration stage, and many factors limit the development of CCUS technology, such as high cost, high energy consumption, reliability, and safety of long-term storage. Considering the current technological development of China's coal industry, we should increase the research and application of CCS technology to find an optimal technology suitable for thermal power generation with zero emission.

4. Suggestions

(1) Deployment and implementation of clean energy policies

At the government level, relevant industrial policies should be formulated to attract and encourage more social capital to invest in the clean energy industry so as to give greater play to the positive role of clean energy investment in high-quality economic development.

(2) High-quality development of coal power.

First, we can start with the flexibility transformation of stock coal power units and the life extension transformation of stock coal power units. Second, accelerate the formation of a long-term mechanism to ensure the healthy development of coal power. Through the market mechanism to achieve reverse the situation of large losses of coal power enterprises, protect the confidence of power supply construction and improve the safety level of the power system.

(3) Optimize the development approach, increase investment in clean energy, and develop clean energy on a large scale.

Areas with better wind and solar resource endowments, such as northwest and north China, make full use of their superior construction conditions and the characteristics of sustainable large-scale development to attract governments and enterprises with strong economic strength to invest in clean energy on a larger scale and build onshore wind power bases and photovoltaic power generation bases.

(4) Strengthen open cooperation in the development of the clean energy industry, accelerate core technological innovation, and promote progress in the development of the clean energy industry.

Adhere to innovation-driven, sound protection mechanisms, high-quality development of clean energy, bringing down manufacturing costs, construction costs, operation and maintenance costs, and providing more assistance to the clean energy industry to compete for market share.

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