Energy applications under the dual carbon goal

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Abstract. The ninth meeting of the Central Finance and Economics Commission pointed out that "achieving carbon peaking and carbon neutrality is a broad and profound economic and social systemic change". Under the dual carbon goal, the deep decarbonization of the energy system is imperative. This paper analyzes the policy under the dual carbon goal and focuses on the current physical and chemical energy storage methods. The most fundamental way to realize the dual carbon goals as soon as possible and reduce carbon dioxide emissions so as to gradually replace coal and other fossil energy sources is to develop renewable energy.

Keywords: Energy; Carbon peaks; Carbon neutral; Energy storage; Energy application.

1 Introduction

Since the Industrial Revolution, the massive emission of greenhouse gases has led to an increasingly severe climate situation, and low-carbon development has become the only way for countries around the world to deal with climate change[1-2]. In the process of global low-carbon transition, developed countries and regions such as the United States, Japan, Canada, and the European Union have formulated climate strategies and pledged to achieve net zero CO_2 emissions by 2050. China continues to increase its nationally determined contribution. In September 2020, it announced that it will strive to achieve "carbon peak" by 2030 and "carbon neutrality" by 2060. The dual-carbon goal indicates that China will further accelerate on the road of low-carbon development.

In order to achieve low-carbon development, the energy industry, which accounts for a large proportion of carbon emissions, has become the main force in energy conservation and emission reduction. A comprehensive energy system with the advantages of multi-energy complementarity and energy cascade utilization is an important solution for the low-carbon transformation of the energy industry[3-4]. The "14th Five-Year Plan" for energy development emphasizes continuing to promote the active and orderly development of the integrated energy system, and promotes "intelligence and green enhancement of energy use scenarios"[5]. The low-carbon development strategies of many countries and regions, such as the "European Green Deal" proposed by the European Union in 2019 and the "Green Growth Strategy" proposed

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by Japan in 2020, have also clarified the important value of the integrated energy system[6-7]. In the context of increasing carbon reduction requirements, how to further promote the process of energy system emission reduction and achieve both economic goals and environmental goals has become an important topic at present. Therefore, in-depth research on low-carbon integrated energy systems is urgently needed.

The low-carbon integrated energy system has the following characteristics: (1) Improve the combustion efficiency of fossil energy through carbon capture technology, and capture the CO_2 released during the energy conversion process for storage or reuse, thereby directly reducing carbon emissions; (2) Using electricity/Gas/heat/cold multiple energy storage, demand side management, energy-information-transportation multi-system interconnection and interaction, etc., will deeply explore flexible resources, improve energy efficiency, promote renewable energy consumption, and indirectly reduce carbon emissions; (3) relying on The carbon market mechanism design, the coordinated interaction between the carbon market and the energy market, and other market adjustment methods, fully mobilize the enthusiasm of various entities to reduce carbon emissions and promote the carbon reduction of the energy system[8].

Achieving the "dual carbon" goal is not an easy task. It will be a major shift in economic structure, social cognition, energy reform and technological innovation. It can even be called a revolution in energy and a change in the times, because energy is both a The driving force of economic and social development is also the main source of carbon emissions[9].

2 Energy Storage Technology in the Context of Dual Carbon

Since the 1970s, energy storage technology has become a hot topic of research in countries around the world, especially the storage technology of secondary energy, which has achieved rapid development. To sum up, the significance of developing energy storage technology has four aspects: (1) saving primary energy resources, saving and effectively using fossil fuels. Through the energy storage technology, the load can be evenly distributed, the load can be adjusted, the utilization rate of the generator set, power transmission and transformation equipment, and air conditioning system can be improved, or the equipment capacity and investment cost can be reduced. (2) Recover and utilize the energy wasted in the process of energy production, transmission, distribution and use, the most prominent of which is the large amount of low-grade thermal energy emitted by industrial production. (3) In order to obtain intermittent energy such as solar energy, wind energy, tidal energy, and wave energy from nature and make effective use of it, it is necessary to be equipped with a corresponding energy storage system. (4) The development of energy storage technology provides various intermittent energy or special emergency energy for scientific and technological production. For example, hydrogen storage tanks for hydrogen energy vehicles and hydrogen energy aircraft, large battery packs for energy storage locomotives, cold storage pools in household air conditioning systems, high-efficiency batteries in space shuttles and artificial satellites, and even huge energy storage devices produced by super abnormal energy storage devices. Electric pulses to drive anti-missile lasers, railguns, particle beam weapons, and more.

Thermal energy storage methods can be divided into two areas: physical thermal storage and chemical thermal storage[10]. (1) Physical heat storage is to use the thermophysical properties of the heat storage medium. For example, when the temperature changes, a certain amount of heat (sensible heat) should be absorbed or released accordingly, and corresponding latent heat (phase heat) should be absorbed or released when a phase change occurs. heat), and the corresponding structural change heat of crystalline materials in the process of crystallization and melting. The earliest thermal energy storage technology utilizes the sensible heat of matter. Physical energy storage is an energy storage method that uses natural resources, so it is more environmentally friendly and green, and has the advantages of large scale, long cycle time and low operating costs. The disadvantage is that the construction is limited, and the geographical conditions and sites for the implementation of energy storage have special requirements[11]. Water and various crushed stones, refractory bricks, periclase blocks, etc. are ideal sensible heat storage media. The storage and release of sensible heat is a non-isothermal process without phase transition. The heat storage materials used for solid-liquid phase change heat storage are usually divided into two categories: low temperature and high temperature according to the working temperature.

The use temperature range of low-temperature heat storage materials is 0~20°C, which includes some salts, alkali hydrates and mixed salts, as well as organic substances such as paraffin, fatty acids and lipids. polyethylene material The working temperature of high temperature solid-liquid phase change heat storage material is about 120~850°C, which includes some salts, alkalis, metals and alloys. High temperature heat storage materials are mainly used in low temperature heat engine magnetic fluid generating systems, solar power plants, artificial satellites, wind power plants and home heating facilities[12].

Chemical heat storage is to use the thermal effect of reversible chemical reactions to store heat. When the reaction proceeds in the forward direction, heat is absorbed, and the heat energy is converted into chemical energy for storage; when the reaction proceeds in the reverse direction, the chemical energy is converted into heat energy and released. Among them, the heat can be stored by utilizing the heat absorption accompanying the chemical reaction, and the heat can also be stored by utilizing the thermal effect of the reversible adsorption or absorption process and the thermal effect accompanying the concentration change during the chemical reaction. The advantage of chemical heat storage is that it has high heat storage density and thermodynamic efficiency. At the same time, due to the wide variety of chemical reactions with thermal effects, it provides a wide range of choices for industrial and technological heat storage needs in various occasions. Chemical heat storage is especially suitable for the field of high temperature heat storage, and has a wide range of practical value in the technical fields of heat pipe technology, chemical heat pump, solar heat collector and other technical fields[10-11].

In recent years, chemical energy storage has become a leader in the field of energy storage in terms of newly installed capacity. According to relevant material statistics, from 2012 to 2020, the global installed capacity of chemical energy storage has increased from less than 1 GW to more than 13 GW, contributing to the main increase in the installed capacity of global electric energy storage. Among various chemical energy storage technologies, lithium battery energy storage has great advantages in terms of cycle times, energy density, response speed, etc., but the high cost previously restricted its large-scale application in the field of energy storage. In recent years, lithium battery technology for energy storage has made rapid progress. Compared with power batteries, energy storage batteries have relatively low requirements on energy density and relatively high requirements on cycle life and safety. In recent years, many domestic and foreign lithium battery companies have made great breakthroughs in the field of energy storage, and the lithium batteries produced for energy storage can achieve a cycle life of more than 5,000 times. For example, CATL has announced that it has developed a lithium iron phosphate battery for energy storage that can achieve "zero decay" within 1,500 cycles, and its single cycle life can reach 12,000 times. The State Grid Energy Research Institute predicts that China's new energy storage capacity will reach about 420 GW by 2060. As of 2019, the cumulative installed capacity of new energy storage in China was 2.1 GW. This means that in 2060, the installed scale of new energy storage capacity in China will soar nearly 200 times, and the energy storage industry will also usher in historical development opportunities. Among them, the "new energy + energy storage" fields such as off-grid grid energy storage, new energy networks and power grids will account for an increasing proportion. It is not difficult to see that the current conditions for the development of lithium battery energy storage in my country have become mature, and the continuous decline in the cost of lithium batteries and the continuous advancement of technology will facilitate its larger-scale application in the field of energy storage[13].

3 Energy Application

In the late 18th century, the first industrial revolution triggered technological innovation and the rise of industries in various fields. With the invention of the steam engine, coal was applied on a large scale and replaced fuelwood as the main energy source. Since then, the first transition from fuelwood to coal has been completed. A major energy conversion. At the end of the 19th century, the invention of the internal combustion engine promoted the development of the petrochemical industry. In 1965, oil replaced coal as the first energy source. Since then, the second major energy conversion from coal to oil and gas has been completed[14]. With the development of science and technology and the proposal of the "dual carbon" goal, driven by technology and policy, the world's energy has entered a low-carbon transition, and since then the third major energy transition from traditional fossil energy to new energy has begun[15].

At present, my country's energy structure is biased towards coal. From the perspective of my country's energy consumption structure in 2020 (Table 1), coal consumption accounts for 56.8%, oil accounts for 18.9%, and clean energy such as natural gas and non-fossil energy accounts for 24.3%[16].

Table 1. My country's total primary energy consumption and energy consumption structure from 2016 to 2020.

Years	Total energy consumption/100 million tons of standard coal	Energy consumption structure/%			
		Coal	Oil	Natural Gas	Non-fossil Energy
2016	43.6	62.2	18.7	6.1	13.0
2017	44.9	60.6	18.9	6.9	13.6
2018	47.1	59.0	18.9	7.6	14.5
2019	48.7	57.7	18.9	8.1	15.3
2020	49.8	56.8	18.9	8.2	16.1

Although the energy transition is a long-term and complex development process, the clean energy structure, the technologicalization of energy production, the electrification of energy consumption, and the intelligentization of energy management have become the "four major trends" of the world's energy development, which are described below.

(1) Clean energy structure. The above-mentioned three major energy transitions all have the characteristics of low carbonization and cleanliness, especially the ongoing third major energy transition, which replaces the carbon dioxide emission-intensive fossil energy with cleaner new energy, which more significantly reflects the clean energy structure. Characteristics[17].

(2) Technology of energy production. From the beginning, humans directly obtained fuelwood from the natural world for burning, and then developed to coal mining and utilization, and then to the exploration and development of oil and gas fields. Scientific innovation and technological progress have played an increasingly critical role in energy production[15].

(3) Electrification of energy consumption. The use of fuelwood and coal by humans is mainly based on direct combustion and utilization of thermal energy; with the invention of steam engines and internal combustion engines, energy utilization has been converted to kinetic energy; later, with the discovery of electromagnetic induction, energy utilization has opened the era of electrification. Under the carbon neutrality target, energy use will accelerate from primary direct utilization to electrified secondary utilization, and the direct use of fossil energy as an energy carrier will gradually decrease.

(4) Intelligent energy management. Information technology centered on big data, the Internet of Things, and artificial intelligence is reshaping the global competition landscape, and has also played a huge role in promoting energy transformation.

The most fundamental way to reduce carbon dioxide emissions and realize the gradual replacement of fossil energy such as coal is to develop renewable energy[18]. The replacement of traditional fuel vehicles by new energy vehicles is gradually becoming a trend. The strong growth in demand for power batteries will lead to a substantial increase in the demand for nickel, cobalt and lithium. As the cost of renewable energy power generation decreases and hydrogen production technology advances, its energy conversion efficiency and hydrogen production cost will be significantly improved. Considering the high calorific value, high energy density, storable, renewable, and zero carbon emissions of hydrogen energy, a series of advantages[19]. Hydrogen energy has the potential to become a new path for future energy development. In the future, we should continue to accelerate the development of electric energy substitution in the terminal energy consumption link, including electric heating, electric vehicles, and shore power for ships in port[20].

Make full use of changes in seawater potential energy and temperature difference in ocean space, and vigorously develop renewable energy resources such as tidal energy, wave energy, ocean current energy, and seawater temperature difference energy. Strengthen the space matching between the development of marine new energy and the development of coastal areas, alleviate the shortage of electricity in coastal areas and islands, and indirectly reduce carbon dioxide emissions. Coordinate the development of marine energy and marine industry, combine tidal energy with seawater desalination, chlor-alkali production and other industries, while developing marine resources industry, reduce the cost of power transmission space distance and space transmission loss. Combining environmental issues and economics, continuously improve the technical level and efficiency of comprehensive utilization of marine energy, and strengthen technical research support for multi-energy complementary network operation[21-22].

4 Conclusion

It is necessary to objectively understand the correlation between energy consumption and carbon emissions, accelerate the transformation and optimization of the energy structure, promote the clean and efficient utilization of high-emission fossil energy, continuously improve the supply of clean and low-carbon energy, and at the same time increase the support of technological innovation for energy consumption and carbon emission reduction , with the green and low-carbon development of energy leading the goal of carbon peaking and carbon neutrality, and injecting green new kinetic energy into the construction of a beautiful China.

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