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Exploration on Low-carbon Transformation Path of Power Industry under the Background of Carbon Trading.

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Abstract

With the aggravation of global climate change, carbon emission reduction has become the common goal of all countries in the world. Carbon trading is widely used as a policy tool for emission reduction, which promotes the development of low-carbon economy. As one of the industries with the largest carbon emissions in the world, low-carbon transformation is particularly important. This paper explores the low-carbon transformation path of power industry under the background of carbon trading, and analyzes the sources of carbon emissions and emission reduction technologies of power industry. Through the case study of low-carbon transformation of power industry at home and abroad, a variety of low-carbon transformation paths are put forward. This paper aims to provide reference for the low-carbon transformation of the power industry and promote the sustainable development of the power industry.

Keywords

Carbon Trading; Electric Power Industry; Low-carbon Transformation; Path Exploration.

1. Introduction

In September, 2020, General Secretary Xi Jinping delivered an important speech at the general debate of the 75th United Nations General Assembly, proposing that China will enhance its national independent contribution, adopt more effective policies and measures, and strive to achieve carbon neutrality by 2030 and 2060, and announced to the world the goal and vision of carbon neutrality in peak carbon dioxide emissions, China. After two years' development, the process of carbon neutrality in China has been promoted from concept to accelerated change in various industries.

2. Carbon Trading, Carbon Market and Trading Mechanism

2.1. Carbon Trading

The theoretical basis of carbon trading comes from Coase's property right theory. Enterprises do not consider the impact of pollution on the external environment when calculating the cost and benefit, and the ambiguity of environmental ownership will lead to "tragedy of the commons", resulting in excessive emissions and negative externalities[1]. According to Coase theorem, as long as the property right is clear, the externality problems arising in economic activities can be alleviated and the optimal allocation of resources can be realized. Therefore, the internalization of negative externalities is the key to emission reduction, and it is necessary to clarify the governance responsibility, let enterprises bear the cost of emission reduction, and internalize negative externalities into their own costs[2].

On the basis of Coase's property right theory, Dyers introduced the concept of "property right" into the field of pollution control, and further designed the theory of emission trading program. Carbon trading is a general term for greenhouse gas emissions trading, and carbon dioxide (CO2) is the largest among the six greenhouse gases required to be reduced by Kyoto Protocol.

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Therefore, greenhouse gas emissions trading is called "carbon trading" with the unit of calculation of CO2 equivalent per ton (tCO2e). On the premise of total emission control

At present, the greenhouse gas emission right including CO2 has become a scarce resource, which has the property of commodity, that is, the carbon emission right is traded as a commodity, and the buyer obtains a certain amount of CO2 emission right by paying a certain amount to the seller. The core of carbon trading is to bring the environment into the cost-benefit calculation and make it cost-effective. In the market, the environment, like labor, land, capital, data and other production factors, needs to spend costs in the process of use. As a scarce resource, carbon emission right is a valuable asset and can be traded as a commodity in the market[3-4].

Through the price transmission of market mechanism, carbon trading can realize the cost of buying carbon, the benefit of selling carbon and the return of investment, thus reducing greenhouse gas emissions, promoting the scale, technicalization and specialization of emission reduction, finally upgrading the industrial structure and promoting the transformation of low-carbon life in the whole society[5]. Carbon emission right is one of the important institutional innovations and main tools for countries to implement the vision of carbon neutrality. From the perspective of global development, carbon trading has gradually become an important international strategic resource after land, oil and minerals, and carbon emission right has become an important bargaining chip for realizing global competition in the process of carbon neutrality in peak carbon dioxide emissions.

2.2. Carbon Market

The carbon market generally refers to a national carbon emission trading market that is defined by law and established artificially for the purpose of controlling greenhouse gas emissions, and achieves emission reduction targets by trading greenhouse gas emission quotas or greenhouse gas emission reductions[6]. The core idea of carbon trading mechanism is that the government makes key emission units (also known as emission control enterprises) subject to carbon emission limits by introducing the total control and trading mechanism, that is, the principle of "cap and trade". If the carbon emissions of emission control enterprises exceed the prescribed limits, they need to buy corresponding quotas in the carbon trading market, otherwise they will be punished; On the other hand, emission control enterprises can also reduce carbon emissions through various measures to save energy and reduce emissions, and sell surplus quotas in the carbon trading market to make a profit[7]. Under the established goal of carbon emission, each emission control enterprise will consider its own interests and choose the most favorable way to carry out carbon emission, or reduce its own emissions or purchase quotas through the carbon market. Compared with administrative orders, carbon market can reduce the total cost of social emission reduction.

After more than ten years of development, China's carbon market has gradually moved from pilot to the whole country. Since the carbon emission trading began in October 2011, the national carbon market has been launched in July 2021 after publishing 24 industry calculation and reporting guides, historical data submission and verification, discussion drafts on quota allocation in power, cement and electrolytic aluminum industries, national carbon market start-up work plan, carbon market management measures and quota allocation plan. At the same time, the launching ceremony of the national carbon market was held in Beijing, Shanghai and Hubei. The trading center was located in Shanghai and the registration center was located in Wuhan. It took the lead in including 2,162 enterprises in the power industry, covering 4.5 billion tons of carbon emissions, ranking first in the world. On July 15, 2022, the first anniversary of the operation of the national carbon market, the cumulative turnover of carbon emission quota (CEA) in the carbon market was 194 million tons, and the cumulative turnover reached 8.492 billion yuan.

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2.3. Trading Mechanism

The United Nations Framework Convention on Climate Change, Kyoto Protocol and Paris Agreement are the three major international legal documents for global cooperation on climate change, and they have also established a carbon trading market mechanism based on CO2 emission rights, mainly including international emission trade (IET), Joint Implementation Mechanism (JI) and clean development mechanism,CDM). The common feature of these three carbon trading mechanisms is "overseas emission reduction", rather than implementing emission reduction actions at home.

In the international market, the above three trading mechanisms correspond to different trading targets, among which the international emissions trading mechanism is the mutual transfer of carbon quotas between developed countries, and the trading object is assigned amount units (AAU) or removal units (RMU); The mechanism of joint implementation is the transaction and transfer of emission reduction units (ERU)；) generated by projects between parties; The clean development mechanism (CDM) deals with certified emission reductions (CERs). In addition, there are EU emission quotas (EUA) in the EU carbon trading market and voluntary emission reductions (VER) designated by the United Nations and certified by third parties.

There are two carbon trading targets in the domestic market, namely quota and national certified voluntary emission reduction (CCER). Quota is the amount of carbon emission rights allocated by the government, which is characterized by: from free distribution to paid use, but not in full, the annual quota distribution ratio is about 90%, and the reduction ratio is required to be within 10%; Quota distribution is from top to bottom, from central to local, and then from local to enterprises, and finally decided by local governments; Quota allocation standards include historical emission method and industry benchmark value method.

CCER refers to the greenhouse gas emission reduction effect of renewable energy, forestry carbon sink, methane utilization and other projects in China, and is registered in the national voluntary greenhouse gas emission reduction transaction registration system. Enterprises with excessive emissions can offset the excess carbon emissions by purchasing CCER in the carbon trading market. The essence of CCER is a supplementary mechanism to encourage emission reduction. Under this mechanism, emission control enterprises can purchase a certain proportion of CCER equal to the quota to offset the excess carbon emissions (offset mechanism). From the perspective of market operation, due to the long effective period of carbon sink projects and the high cost of land resources and forest planting and maintenance, carbon market buyers are more inclined to obtain "performance-based" carbon quotas generated by industrial emission reduction projects, and pay insufficient attention to carbon sink voluntary offset projects. At present, the CCER of the eight pilot markets in China accounts for 5%~10% of the quota issued in that year.

3. Carbon Market to Promote High-carbon Industries to Achieve Carbon Neutrality Mechanism

On the macro level, China will realize peak carbon dioxide emissions through the adjustment and upgrading of industrial structure and the transformation of energy system, and finally achieve carbon neutrality by means of "negative carbon", the essence of which is the switching of development mode, industrial upgrading and infrastructure upgrading.

At the micro level, as "rational people", all high-carbon industrial entities will fully weigh the cost of purchasing carbon emission quotas, reducing the income of CCER voluntarily and investing in technological transformation, and make overall arrangements for specific transformation measures. For high-carbon industries, the carbon trading market works

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together from three directions: policy orientation, quota allocation and market price to promote high-carbon enterprises to accelerate technological innovation, carry out energy conservation and emission reduction, energy substitution and negative carbon development, so as to achieve carbon neutrality. Therefore, the carbon market has promoted the transformation of high-carbon industrial entities from passive acceptance of exogenous supervision to active transformation to create carbon economic dividends, which has become the driving force for high-carbon industrial entities to achieve carbon neutrality.

4. Power Industry Low-carbon Transformation Development Path

The electric power industry is the single industry with the largest proportion of carbon emissions in China, and it is the key to implement the carbon neutral strategy. The power industry bears the brunt of the low-carbon transformation and development of high-carbon industries. Combined with the mechanism of carbon market to promote carbon neutrality in high-carbon industries, while accelerating technological innovation, we should actively promote energy conservation and emission reduction, energy substitution and negative carbon development:

4.1. Energy Conservation and Emission Reduction

Energy conservation and emission reduction include efficiency improvement, power grid improvement and dispatching operation.

The first is the improvement of efficiency. While improving the utilization efficiency of energy consumption side, we will further optimize the utilization efficiency of energy supply side, accelerate the flexible transformation of coal-fired power and asset performance management throughout the life cycle. Actively promote the technical transformation of coal-fired power, mainly involving the development of clean coal conversion and efficient utilization technology and the improvement of coal-fired power generation efficiency to reduce coal consumption, including waste heat recovery, steam turbine circulation transformation, and promising integrated gasification combined cycle (IGCC), circulating fluidized bed combustion (CFBC) and other technologies.

The second is the power grid upgrade. Power grid companies can improve the acceptance of clean energy by improving the flexibility of power transmission, supporting the priority of new energy to be connected to the grid nearby; Actively explore smart microgrid and other technologies to meet the needs of distributed energy and multiple loads; Strengthen power grid planning and construction, and promote coordinated development of power grids at all levels.

The third is scheduling operation. Effective use of technologies such as "cloud-to-intelligence chain" will improve the operation control system of power system, promote the realization of "five-all", that is, full-service information perception, full-system collaborative control, full-process online decision-making, full-time optimal balance and all-round load dispatching, and further promote the coordinated and rapid response of multi-level dispatching of clean energy.

4.2. Energy Substitution

Energy substitution is mainly reflected in structural optimization, and new energy replaces traditional energy to generate electricity. Traditional energy sources, including coal and oil, have resource constraints, and clean energy sources such as wind power, hydropower, geothermal energy, nuclear energy, solar photovoltaic and hydrogen are the future exploration directions. Formulate more active new energy development goals, accelerate the construction of wind power and solar power generation, develop hydropower according to local conditions, effectively use geothermal power generation, and actively and orderly develop nuclear power; Change the orientation of coal-fired power in energy transformation, strictly control new installed capacity and eliminate backward production capacity; Improve the proportion of

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flexible power supply, promote the construction of pumped storage power stations and peak-shaving gas and electricity in the eastern and central regions, and popularize the application of large-scale energy storage devices to meet the rigid requirements of the power grid, smooth the output curve and provide auxiliary services.

Energy use is gradually developing from high carbon to low carbon or even no carbon, and the ultimate goal is to achieve terminal cleaning and source cleaning. Terminal cleaning requires that fossil energy should not enter the terminal energy market; Source cleaning requires that fossil energy is no longer used. At present, the proportion of coal in the energy consumption structure in China's power industry is too high, and it is difficult to absorb intermittent energy such as wind power and photovoltaic. Hydrogen is the only carbon-free terminal energy that can be used on a large scale, and hydrogen can be produced by electrolysis of water in a short time. In the future, as the cost of renewable energy power generation continues to decrease, hydrogen generators can be integrated into the power transmission line of the power grid, and they can cooperate with hydrogen production devices to electrolyze water to produce hydrogen in the low power consumption, and then generate electricity through hydrogen energy in the peak power consumption, thus improving energy utilization efficiency.

4.3. Negative Carbon Development

The development of negative carbon includes carbon capture, utilization and storage technology (CCUS) and CCER (national certified voluntary emission reduction). Power generation enterprises should strive to apply new technologies, reduce capital costs and operating costs, develop low-energy CO2 absorption and capture technology, optimize the coupling carbon capture system of supercritical coal-fired units, study and operate high-performance CO2 hydrogenation to methanol and new catalytic modes, and develop large-scale CO2 geological storage technology, so as to form a low-cost and low-energy CO2 absorption process and promote the development of CCUS technology. Actively promote technology research and development, improve capture capacity, improve generator efficiency and optimize CCUS operation scope and supply chain through modular construction; Reduce amine degradation; Optimize heat energy consumption and water consumption; Improve compression efficiency and digital technology, speed up the reuse of CO2 resources, and lock in future technology dividends.

In 2020, the global scale of carbon sequestration by CCUS is only 400 million tons, accounting for about 0.1% of the total carbon emissions. At present, due to the constraints of cost and technical applicability, the global CCUS scale is still relatively small, but it has great potential for future development. According to the Annual Report of Carbon Dioxide Capture, Utilization and Storage (CCUS) in China (2021), it is predicted that the emission reduction of coal-fired CCUS will reach 6 million tons/year in 2025, and reach the peak in 2040, ranging from 200 million tons/year to 500 million tons/year, and then it will remain unchanged. According to the prediction of the International Energy Agency (IEA), by 2060, the proportion of CCUS devices for coal-fired power generation will be close to 100%, that for gas-fired power generation will be close to 80%, and that for biomass power generation will be around 32%. Technical applicability standard and cost are the main factors affecting the application of this technology at present. If CCUS's technical maturity and economic development are less than expected, its carbon reduction effect will be reduced.

CCER in China is mainly produced in the fields of renewable energy (wind power, photovoltaic, hydropower, biomass energy, etc.), garbage (garbage incineration and landfill) and fuel transformation. In 2012, the National Development and Reform Commission issued the Interim Measures for the Management of Voluntary Emissions Reduction Trading of Greenhouse Gases, which proposed that the pilot carbon markets should be started gradually from 2013, and the emission control enterprises should be allowed to use CCER to fulfill their obligations. The

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"Measures for the Administration of Carbon Emission Trading (Trial)" issued by the state also clarifies that CCER can be used for offset. However, since March 2017, the state has suspended the approval of CCER projects and emission reduction filing. According to the China voluntary emission reduction trading information platform, before the suspension of examination and approval, there were 254 emission reduction projects completed nationwide, and the annual carbon reduction of CCER projects registered was about 130 million. According to the proportion of emission reduction types, hydropower and wind power are both around 25%, which are the two types of projects with the largest emission reduction, followed by biogas and natural gas, both of which are around 12%, while photovoltaic emission reduction accounts for a small proportion, only 5%. In the future, with the continuous promotion of carbon neutrality policy, CCER's filing application will also be put on the agenda after the carbon market construction is relatively complete.

To sum up, the development path of low-carbon transformation in power industry can be summarized as: improving the proportion of new energy power structure and fuel substitution at the front end, improving efficiency through technological transformation at the middle end, recycling waste heat and gas at the back end and implementing carbon capture.

5. Conclusion

Peak carbon dioxide emissions's carbon neutrality in the energy field is a complex long-term systematic project, which should be balanced and promoted steadily. In the process of low-carbon transformation, the power industry can follow up the "double carbon" top-level design of local governments and strive to participate in it; Pay attention to the industry data released by governments at all levels and their corresponding standard systems, and further support the realization of low-carbon goals on the basis of building a complete system and tapping the value of data, so as to fully meet the needs of government emission reduction and control and low-carbon industries.

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