The Impact of National Carbon Market on the Production and Operation and the Coping Strategy of Power Generation Enterprises

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Abstract: At present, the national carbon market is officially launched, and the power generation industry is first brought into in the national carbon market as a key industry. In order to analyze the impact of carbon market on the production and operation of power generation enterprises, this paper takes 30 units of 300 MW as an example to quantitatively analyze the carbon emission intensity and the surplus and deficit of quota, and the carbon benefits per unit electricity are quantitatively analyzed according to the different compensated quota allocation ratio and carbon price. Then, the cost and benefit per unit electricity are analyzed under different power production types, and it is shows that the power generation will be inclined to clean and efficient thermal power units and renewable energy sources with the increase of compensated quota allocation ratio and carbon price, which provides certain reference for carbon emission management of large domestic power generation groups.

1. Introduction

Carbon emission trading mechanism is a policy tool to optimize the allocation of carbon emission space, reduce the cost of carbon reduction, control greenhouse gas emission, and promote the transition of supply-side structure to green low-carbon by means of market trading under the premise of setting mandatory total carbon emission control objectives[1]. Compared with mandatory policy instruments (mandatory emission reduction targets) and fiscal policy instruments (carbon tax), carbon emission trading mechanism are more cost-effective, more flexible and more suitable for China's current situation.

At present, the national carbon emission trading system has been formally launched, and the total carbon emission quota setting and allocation scheme has been approved by the State Council. Undoubtedly, the start-up of the national carbon market is bound to have a significant impact on the internal management, business decision-making and investment tendency of power generation enterprises, and it will more directly affect the factors such as power generation cost, power generation behavior, energy structure and technological innovation. At the same time, it will promote enterprises to adopt flexible carbon reduction technologies, structural adjustment and management optimization methods to achieve low-cost carbon reduction [2, 3]. Simply put, the

carbon market will force large-scale power generation enterprises to optimize their installed power structure through carbon constraints, and further explore the potential of emission reduction, so as to promote the development of clean low-carbon transformation.

In view of the urgency and importance of carbon trading in China and the lack of experience in carbon emission and trading management in power generation enterprises, this paper quantitatively analyzes the affection of carbon market on production and operation of power generation enterprises and investment tendency of different energy structures according to the different compensated quota allocation ratio and carbon price, then the strategy of power generation enterprises to cope with carbon market is put forward, which provides certain reference for carbon emission management of large domestic power generation groups.

2. Current Situation of National Carbon Market

Since the 18th national congress of communist party of china, the ecological civilization construction has become one of the key tasks of the overall layout of "Five-point Strategy". Tackling climate change is an important part of the ecological civilization construction. As an effective market mechanism, carbon market can effectively reduce carbon emissions, and it has great significance for tackling climate change and the ecological civilization construction.

In order to realize the national commitment, the National Development and Reform Commission announced that the national carbon emission trading system was officially launched on December 19, 2017, and the National Carbon Emission Trading Market Construction Plan (Power Generation Industry) is issued, which fulfilled the relevant international commitments of the national action on climate reduction. The plan proposes:

(1) Take the power generation industry as the breakthrough point to start the carbon emission trading system, and define three stages of the carbon market construction: infrastructure construction period, simulation operation period and deepening improvement period. During the infrastructure construction period, national carbon market must complete the construction of national unified data transmission system, registration system and trading system, and carry out the construction of carbon market management institutional. During the simulated operation period, national carbon market will carry out power generation industry and quota simulation trading, and improve relevant mechanisms. During deepening the improvement period, national carbon market will carry out quota spot trading among the main trading entities in the power generation industry with the purpose of fulfilling the aggreement, the remaining quota can be transferred and traded across the performance period, then the market coverage is gradually expanded and the variety of transactions is enriched.

(2) Establish three basic systems for carbon emission monitoring, reporting and verification, quota management and market transaction, which can standardize the work of the carbon market.

(3) Built four supporting systems for carbon emission data reporting, registration of carbon emission rights, trading of carbon emission rights and settlement of carbon emission rights transactions to ensure, which can guarantee the normal operation of the national carbon emission trading system.

3. The Impact of National Carbon Market on the Production and Operation of Power Generation Enterprises

With the start of the national carbon emission trading system, the implementation of the quota allocation system has gradually moved from pilot to national coverage. Carbon emissions have changed from free to free within the prescribed limits, and in the future, it is likely to evolve into all

compensated quota. The introduction of carbon emission cost will have a significant impact on the production, operation and investment tendency of power generation enterprises.

3.1.National Carbon Market Quota Allocation Method

According to the National Quota Allocation Guidelines [4], the quota allocation in power generation industry is based on the benchmark method, and the quota which is free allocated by local authorities to units is the sum of power supply quota and heat supply quota.

The carbon quota of generating units can be expressed as:

$$A = A_e + A_h \quad (1)$$

Among that, A is total carbon quota of unit, tCO_2; A_e is power supply carbon quota of unit, tCO_2; A_h is heating supply carbon quota of unit, tCO_2.

The power supply carbon quota for unit can be expressed as:

$$A_e = Q_e \times B_e \times F_l \times F_r \quad (2)$$

Among that, Q_e is the unit power supply, MWh; B_e is carbon emission benchmark of unit power supply, tCO_2/MWh; F_l is Correction Coefficient of Unit Cooling Mode; F_r is correction coefficient of unit heat supply, which is equal to 1 - 0.25 × heating supply ratio.

The heating supply carbon quota of unit can be expressed as:

$$A_h = Q_h \times B_h \quad (3)$$

Among that, Q_h is the unit heat supply, GJ; B_h is carbon emission benchmark of unit heat supply, tCO_2/GJ.

3.2.Impact on Production and Management of Power Generation Enterprises

According to Carbon Emission Monitoring Report and Verification system (“MRV” for short), the unit carbon emissions are the sum of direct carbon emissions from fuel combustion and indirect carbon emissions from purchased electricity [5, 6, 7]. The carbon emission intensity of unit power supply is the quotient between carbon emission and power supply. In order to analyze the impact of quota allocation on unit in the carbon market, this paper takes 30 units of 300 MW as an example to calculate the carbon emission intensity of each unit’s power supply, and analyzes the quota surplus of each unit, as shown in Figure 1 and Figure 2.

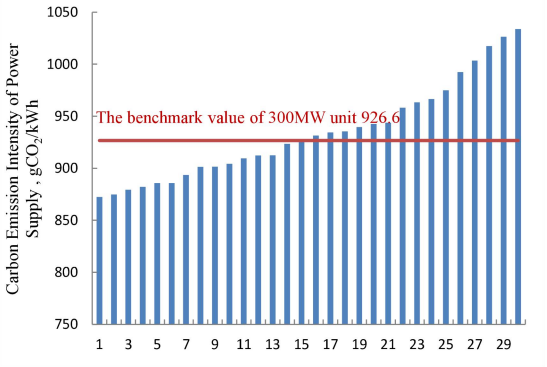

Figure 1: The contrast of power supply carbon emission intensity for 30 units of 300MW.

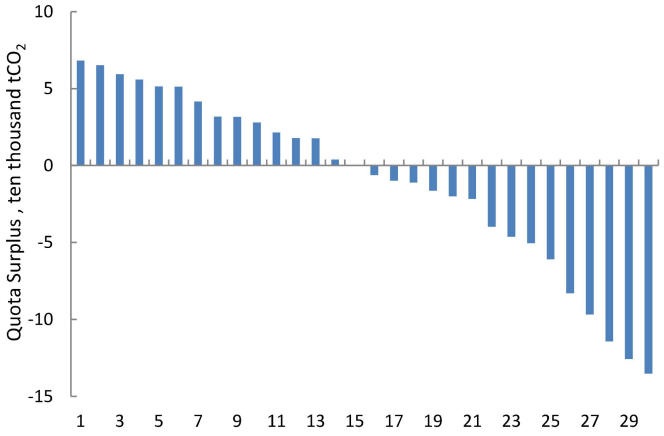

Figure 2: The analysis of quota surplus and loss for 30 Units of 300MW.

It shows that when the carbon emission intensity of unit power supply is lower than the the benchmark value, the higher the power supply of the unit, the more profits can be obtained from the carbon market. On the contrary, the unit quota loss can be bigger. According to the current quota allocation method, thermal power units are divided into 11 categories with different benchmark values. In order to achieve the surplus of carbon emission quota, the unit carbon emission intensity of power supply should strive to rank the forefront of the same type of units, and must be lower than the benchmark value.

The most direct decision index which can reflect the impact of quota allocation on power generation cost is the carbon benefits per unit electricity. According to the current carbon market policy and the possibility of future carbon market development, this paper analyzes the carbon benefits per unit electricity through three scenario models of carbon market based on the two major factors of carbon market, namely, the compensated quota allocation ratio and the carbon price. Scenario model one is set to free quota allocation, and carbon price is 30 yuan/tCO_2; scenario model two is set to 5% compensated quota allocation, and carbon is price 30 yuan/tCO_2; scenario model three is 15% compensated quota allocation, and carbon price is 60 yuan/tCO_2.

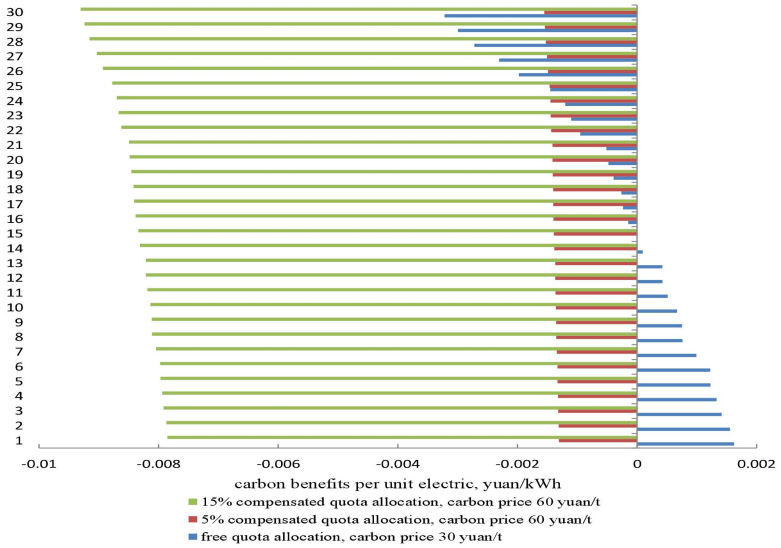

Figure 3: The carbon benefits per unit electricity for 30 Units of 300MW

through three scenario models.

According to the Figure 3, we can see that:

(1) Under scenario mode one, along with the increase of carbon emissions intensity of power supply, the carbon benefits per unit electricity in carbon market decreases from 0.0016 yuan to – 0.0032 yuan;

(2) Under Scenario mode two, the carbon benefits per unit electricity of all units is negative, which is between - 0.001.3 yuan and – 0.0015 yuan, indicating that when the future carbon market quota is allocated compensated, thermal power units will most likely face greater operating pressure;

(3) Under scenario three, the carbon benefits per unit electricity of all units will further expand, roughly between - 0.0079 yuan and - 0.0093 yuan, and the marginal cost of thermal power generation will increase, and it will probably face losses.

3.3.Impact on Investment Development of Power Production Type

In the current layout and development of power production structure, the carbon cost is less considered. However, with the further deepening of carbon market, the gradual increase of carbon price, and even the increase of compensated quota allocation ratio, carbon cost will have a practical impact on long-term investment in the future, which will not only promote the thermal power industry to the level of cleanliness and efficiency, but also likely lead the investment direction of enterprises from the traditional thermal power to renewable energy, which impels the optimization of power production structure. This paper will carry out the analysis of the cost and benefits per unit electricity for different power production type under the conditions of different compensated quota allocation ratio and different carbon price.

3.3.1. Economic Evaluation Index

Based on the traditional cost per unit electricity which includes investment cost, operation and maintenance cost, fuel cost, ect, carbon cost is introduced as the main economic evaluation index to analyze the economy of different power production, such as coal-fired power, gas-fired power, hydroelectric power, wind power, solar power and biomass power.

The traditional cost per unit electricity can be expressed as:

$$C_i = (I_i + OM_i + F_i) / P_i \quad (4)$$

Among that, C_i is traditional cost per unit electricity; I_i is annual investment; OM_i is operation and maintenance cost; F_i is annual fuel cost; P_i is annual output of the production; i is the power production type, which include coal-fired power, gas-fired power, hydroelectric power, wind power, solar power and biomass power.

Considering the influence of carbon cost, the total cost per unit electricity can be expressed as:

$$FC_i = C_i + A_l * CC \quad (5)$$

Among that, FC_i is total cost per unit electricity; A_l is unit power generation quota gap; CC is the carbon price of the carbon market.

The benefits per unit electricity can be expressed as:

$$B_i = G_i - FC_i \quad (6)$$

Among that, B_i is the benefits per unit electricity; G_i is the feed-in tariffs; FC_i is total cost per unit electricity.

3.3.2. Economy Analysis of Different Power Production Structures

To ensure the rationality of the analysis, this paper makes two assumptions as follows:

(1) Considering the uncontrollable factors such as fuel cost and renewable accommodation in electricity market for a certain period, the fluctuation range of coal, gas and biomass prices is set to ±10%, and the average utilization hours fluctuation range of hydroelectric power, wind power, solar power are set to ±5%;

(2) Considering the current carbon market policy and future development trend of carbon market, the compensated quota allocation ratio and the quota price are set to three scenario models: 1) the compensated quota allocation ratio is 5%, and carbon price is 30 yuan/tCO_2; 2) the compensated quota allocation ratio is 15%, and carbon price is 60 yuan/tCO_2; 3) the compensated quota allocation ratio is 100%, and carbon price is 60 yuan/t CO_2.

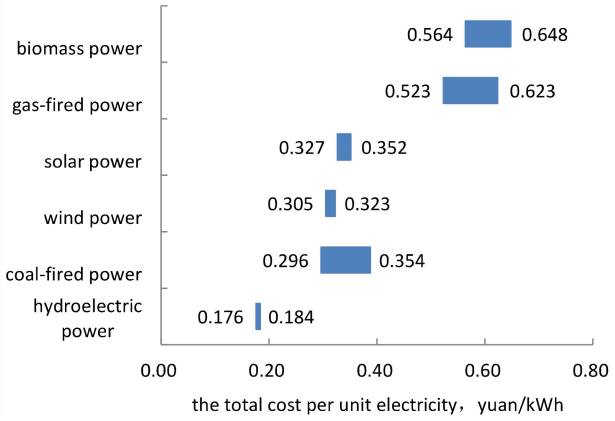

Figure 4: The total cost per unit electricity of power production type.

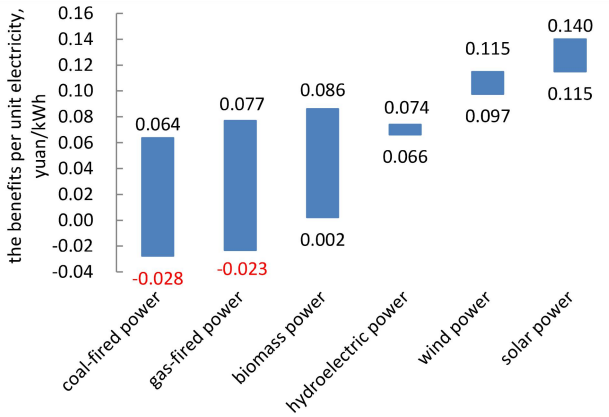

Figure 5: The benefits per unit electricity of power production type.

According to the Figure 4 and 5, we can see that:

(1) The total cost per unit electricity of wind power is broadly equal to solar power, and hydroelectric power may be the lowest. And the total cost of natural gas and biomass units stay at a relatively high level. With the increasing of the compensated quota allocation ratio and carbon price, the total cost per unit electricity of coal-fired power may be higher than wind power and solar power.

(2) Considering the carbon cost, the benefits per unit electricity of hydroelectric power and wind power are higher than coal-fired power. The benefits per unit electricity of conventional power

generation, such as coal-fired power and gas-fired power, are basically stable below 0.1 yuan/kWh, and the benefits is greatly affected by the fuel price.

(3) Only when all quotas need to be purchased for compensation, the benefits of coal-fired power and gas-fired power will be seriously damaged and may have deficit, otherwise there still has profit room for fossil fuel power generation.

However, it is worth pointing out that considering the enhanced action of global greenhouse gas emission reduction and the link of global carbon market, carbon prices may continue to rise. According to the forecast of European and American research institutes, the future carbon price will be $50 per ton (320 yuan per ton), and the carbon cost will more likely lead to the benefits of fossil fuel power generation (especially coal-fired power) losses. In this case, power generation enterprises will have to weigh the cost of carbon reduction technology and carbon trading costs to make investment decisions.

4. Conclusions

At present, the national carbon market is officially launched, and the power generation industry is first brought into in the national carbon market as a key industry. Considering the increasing of carbon price and compensated quota distribution ratio, this paper quantitatively analyzes the affection of carbon market on production and operation of power generation enterprises and investment tendency of different energy structures. For the same type of thermal power units, the unit carbon emission intensity of power supply is lower than the benchmark value, the more profit can be obtained from the carbon market, and power generation will be forced to be transferred from units with high power supply carbon emission intensity to units with low power supply carbon emission intensity. At the same time, carbon cost will have a practical impact on long-term investment in the future, which will likely lead the investment direction of enterprises from the traditional thermal power industry to renewable energy.

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