Study on carbon emission reduction mechanism of thermal power plants in medium and long term trade

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Abstract. Electricity market is gradually tending to be more energy-saving and environmental-friendly. In the context of medium and long-term electricity trading mechanisms, it is important to implement energy-saving and emission reduction with more reasonable and effective mechanism to solve the shortcomings in the overall environment and achieve energy conservation. The author finds that the core idea of energy conservation and emission reduction mechanism abroad to internalize the external cost. After in-depth study, the author summarizes the problems in realizing energy conservation and emission reduction in the medium and long-term electricity trading mechanism in the current market. The core design ideas and main development models of the mechanism are analyzed. Finally, the author analyses the design of market mechanism under the mode of trading volume restriction and power transfer in power plants. In the whole process, the author makes an auxiliary analysis with actual cases for peer exchange.

1. Introduction
With the gradual development of human civilization, the continuous progress of society and the rapid development of economy, the coordination between human beings and the environment has gradually presented problems, and the contradictions have intensified in various environments. Over-emission of global carbon dioxide has a direct impact on climate [1]. Since the 21st century, the most important problem facing mankind is the energy crisis. Under such circumstances, how to achieve better energy conservation and emission reduction has become the focus of scholars. The document No. 9 issued by China Development Corporation in 2015 is to deepen the reform of the electricity constitution, to carry out a comprehensive reform of the electricity system in China [2]. At present, the development of domestic power and trading institutions have been completed, market-oriented transactions have been formed, and diversification of market transactions have been formed. Most domestic provinces and cities have realized the power system for large users to purchase electricity directly. The market has gradually developed certain trading rules, and the medium and long-term electricity trading mechanism has gradually become more diverse. [3]-[5] The medium and long-term transactions in various provinces and cities across the country are presented by annual and monthly transactions. [6] After the reform of the electricity constitution, the electricity commodity market has presented a posture of blooming flowers, the cost of electricity in multiple industries has decreased, and the society has gradually transformed into a more friendly and efficient posture.

2. Problems in realizing medium and long-term electricity trading mechanism for energy conservation and emission reduction in the current market
The most important part of electricity reform is to form a system of electricity price market and establish a more effective mechanism to optimize the whole market resources. [7] The lower the cost of generating units, the greater the competitiveness of the whole market, the more advantageous and more power generation share in the whole market transaction to enhance the operation efficiency of the electricity system. Power plants will choose lower cost coal consumption to complete power generation, so when market costs are relatively stable, the level coal consumption and cost show a positive correlation, that is to say, the lower the level of coal consumption is, the lower the cost is. [8] However, if the fixed cost of generating units increases and the level of coal consumption varies, the overall competitiveness may be reversed. After that, market competition and energy-saving and emission reduction will go against each other. First of all, low coal consumption units generally have larger capacity, higher parameters, shorter operation time, higher cost and interest, so the whole bidding stage takes longer. In addition, the retrofit of small capacity units can reduce the level of coal consumption, but it needs higher retrofit cost, and the market bidding will decline in a short time. The existence of this contradiction is more remarkable at this stage because of the influence of the current transaction form. In the future, market reform will gradually infiltrate, various mechanisms of the spot market will be established and perfected, and the variable price cost will be controlled relatively well, which can well avoid the risk of such problems. [9] Therefore, it is one of the core tasks to solve the problems of energy-saving and emission reduction in medium and long-term electricity trading and to improve the market bidding contradiction.

3. Core design and main development modes of energy conservation and emission reduction mechanisms

The basic design idea of energy-saving and emission reduction is internalization of external cost. Under this concept, in order to ensure that the market bidding is within a reasonable range, it is necessary to reduce the overall development cost, so that the whole market subject can develop steadily under different competition, and truly realize the macro-control of market resources. The main operating modes of exterior cost internalization include four kinds, which are the most recognized mechanisms in the world. They are carbon tax mode, green certificate trading mode, quota trading mode and carbon emissions trading mode. [10]-[11]

3.1. Carbon tax model

According to the company's carbon emissions, the company imposes tariffs, and reverse management enables enterprises to reduce costs through energy conservation and emission reduction. The carbon tax model is gradually evolved according to Pigou's theory. The core idea of this model is to manage the environmental problems by taxation, so that the external costs are internalized, and the individual emissions are monitored macroscopically to improve the overall social benefits. At present, five Nordic countries including the Netherlands, Finland and Denmark have fully implemented the carbon tax model. [12]-[14] This new tax does not require an organization and is easier to implement. However, there will be information asymmetry in the carbon tax model from the actual situation analysis, and the implementation of the tax rate needs to combine the enterprise cost and the social cost. In different regions, the marginal cost difference is large, there is lack of practicality on how to calculate such costs. On the other hand, enterprises whose taxes exceed the emission reduction rate will choose to pay taxes to reduce costs, and the monitoring of total emissions will lose its own value; the effect of low taxation on the management of enterprises is not obvious. Therefore, in the power industry, the demand for electricity is just needed, and the carbon tax management mode has some limitations on the role of enterprise emission reduction.

3.2. Green certificate trading model

Under the market, the completion of the transaction with the issuance of green certificates has enabled the development of the entire renewable energy source. [15] Theoretically, this model can quantify energy conservation and emission reduction. Currently, this model can be completed in two forms, that is, voluntarily purchasing certificates or mandatory quotas. However, the current domestic power
market system is relatively imperfect, and there is still a lack of mechanisms to effectively transport renewable energy, so this trading model has not been carried out.

3.3. Quota trading model

Exhaust quotas or energy consumption quotas is implemented for enterprises and industries with certain standards. After enterprises exceed the rated quota, they need to accept the punishment of market supervision agencies or purchase quotas according to market transactions, so that the emissions and energy consumption of the entire province and city can be controlled within a certain range to achieve market management. [16]-[17] The entire quota is mainly distributed free of charge and distributed, and the quotas of different enterprises and industries are different. Free distribution can be assigned based on history and benchmarks. In historical distribution, enterprises are allocated in a fixed amount according to their historical emissions. The relative calculation is relatively simple and the supporting data is less, but the enterprises with poor development also need to bear high emissions and energy consumption, which will show problems on the quota. The benchmark allocation is based on the company's basic emissions, analyzing the average level of energy consumption, setting the minimum emissions and a reasonable performance management model, which will promote the energy-saving and emission reduction in the entire industry.

3.4. Carbon emissions trading model

This model essentially controls the entire market based on the total amount of carbon emissions. Under the carbon emission trading mechanism, enterprises with low emissions can sell shares to enterprises with excess emissions and obtain higher profits; enterprises with excess emissions need to pay high share fees, which promotes enterprises to increase energy conservation and emission reduction.[18] This model is relatively cheaper, it only needs to allocate the emission reduction targets and shares. However, the power industry is gradually developing, and the trend of big data is imperative. Under this model, it might be difficult to implement. [19]-[21] The comparison and analysis of four kinds of trading mechanisms are shown in Table 1.

**Table 1. Comparison and analysis of four kinds of trading mechanisms**

| Trading Mechanism               | Advantages & Disadvantages                                                                 |
|---------------------------------|-------------------------------------------------------------------------------------------|
| Carbon tax model                | Reduce costs, and the monitoring of total emissions will lose its own value, the effect of low taxation on the management of enterprises is not obvious |
| Green certificate trading model | Low-cost, but relatively general at carbon reduction effect and promoting the development of nonaqueous renewable energy effect. |
| Quota trading model             | Good at cost, carbon emission reduction effect, power industry installed structure and power generation structure optimization effect |
| Carbon emissions trading model  | Relatively limited at the adjustment effect of power industry structure optimization at a certain cost. |

4. Design of market mechanism under the limitation of trading volume and power transfer mode of power plants

The reform of electricity mechanism is advancing in an all-round way. The medium and long-term trading mechanism in months or years has gradually become the main body of domestic electricity transactions, and many provinces have been fully launched. If the goal of energy conservation and emission reduction is to be applied in the medium and long-term electricity trading mechanism, there are three principles to be followed: 1) to ensure that the emission of energy consumption can be controlled in the target; 2) to integrate closely with the market after linking up the current trading mechanism to avoid the significant changes in the market mechanism and the effect of the orderly conduct of the market; (3) higher execution, easier access to basic data and lower supporting investment. According to these requirements and background, a Capacity-and-Transfer (CAT) trading
mode can be selected for quota trading. C stands for capacity limitation; T refers to power plant power transfer. CAT takes the unit coal consumption as the quota object. According to the coal consumption and emission relationship table near the power plant, the comprehensive energy-saving side benefits and the emission reduction side benefits are realized. Integrating energy-saving and emission reduction into the current electricity constitution will have a significant role in promoting the construction of the entire electricity market. Market-oriented mechanism to achieve the allocation of power resources has a good role in promoting the research of renewable energy, and is conducive to the formation of a low-carbon energy structure in the whole market.

Under the medium-term and long-term bilateral trading mode, the basic electricity of power plant is allocated, and energy-saving and emission reduction is achieved according to the coal consumption level of the unit. The core factors include trading volume limitation of coal consumption level and power transfer in power plants. The level of coal consumption determines not only the amount of bilateral transactions to achieve the quota, but also the amount of electricity involved in bidding transactions for the whole annual cost of units. Under this mode, the contractual power transfer can be carried out again. Each power plant can transfer part or all of the electricity according to the situation. The seller can buy electricity and buyers can also conduct electricity sales transactions to achieve the role of energy saving and emission reduction. In this process, the core control point is that all contract transactions are completed under the concept of low carbon. CAT mechanism can promote the healthy development of the whole market according to the current situation of electricity market in China and the actual needs of the market and the timeliness and complexity of energy-saving and emission reduction. Therefore, the total emissions can be monitored and the competitiveness of the units with lower coal consumption is stronger, which is helpful for energy-saving and consumption reduction under the background of the whole medium-term and long-term power trading mechanism.

5. Conclusion
In summary, under the internalization mechanism of external costs, the author gradually develops the CAT mechanism, and carries out quota trading mechanism under the market mode of medium-term and long-term electricity trading, monitors the whole contract in the form of contract, realizes the optimal allocation of power resources, and the market scheme can closely link up all kinds of operation and adjustment. On the other hand, the current monitoring of power plants and market share can well encourage power plants to save energy and reduce consumption, develop new clean energy to obtain higher benefits. Moreover, it also can promote enterprises to think about how to better save energy and reduce emissions to reduce costs and to promote energy-saving and emission reduction policies in the medium-term and long-term electricity trading mechanism.

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