Research on thermal power new energy integration transaction model based on power reform system

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Abstract: Thermal power is the main power supply in China, but it brings serious environmental pollution; The introduction of renewable energy consumption responsibility weight system means that users need to increase the consumption of green power, which has a significant impact on the competitive strategy model of power producers. This paper also uses game model and cooperative game model to analyse the impact of thermal power new energy integration transaction model and market equilibrium point. The results show that the profit of generator under cooperative game is greater than that under competition.

1. Introduction

In order to reduce my country's traditional fossil energy consumption and promote the rapid development of the renewable clean energy industry, the Chinese government has formulated a series of policy tools such as fixed electricity price subsidies and renewable energy quotas. The quota policy urges traditional power producers to pay for their external environmental pollution, and they can also subscribe for green certificates to compensate for the cost of green power producers and reflect environmental values to guide green consumption. In a specific market environment, it is indispensable to consider the gaming role of power generators with different market power in the interactive decision-making of green certificate transactions and power production.

At present, some scholars' research on the green certificate system is focused on the macro policy of the green certificate, and they have not conducted in-depth research on the strategic behavior of power generators in the electricity market and the green certificate market regarding the change of assessment subjects. Therefore, on the basis of analyzing the competition factors of power companies, this article summarizes and analyzes the possible strategic behaviors of thermal power companies and green power companies, and uses Stackelberg game model and cooperative game model to explore the power companies' strategies and market equilibrium point change factors. Influence.

2. The quota system and the evolutionary mechanism of the strategic behavior of power generation companies

The implementation of the quota system requires a complementary system, namely the green certificate trading system. The implementation carrier of the green certificate trading system is the green certificate market. Generally, green certificates have a validity period and the changes in installed capacity of power plants have time lag. Therefore, the price of green certificates is determined by the short-term market supply and demand relationship. Therefore, a necessary condition for the success of the quota system is that a sufficient number of power generation companies believe that other manufacturers will abide by this rule, and it is more advantageous for them to also abide by the rules given that other manufacturers abide by the rules. The key to the success of the quota system is that the government has the ability to enforce its appropriate rules. Therefore, the government, as the supplier of the system, should make a scientific design to achieve the goal of the system and the goal of economic actors, and thus make it the common belief of all economic actors to achieve the long-term stability of the system. As far as power generation manufacturers are concerned, the quota system determines the feasible space for the green power manufacturers and thermal power manufacturers as participants (trade or not trade green certificates). If choosing to trade green certificates can achieve the goal of maximizing profits, then trading green certificates becomes a strategic equilibrium for manufacturers. If all manufacturers abide by the rules of trading green

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certificates, the quota system becomes the common belief of all manufacturers.

3. Analysis of the strategic behavior of power companies under the weight of renewable energy consumption responsibility

In recent years, the weight of responsibility for the consumption of renewable energy and the green certificate system have received widespread attention. The green certificate is the only certificate for the consumption of green electricity, and users can complete the assessment of the weight of consumption responsibility by purchasing the green certificate.

(1) Competitive factors analysis of power generation companies under the weight of consuming responsibility There are two main types of demand subjects for green certificates: one is power grid companies and power sales companies; the other is direct purchase users and companies with self-use power plants. The main body of green certificate supply is non-water renewable energy generators, and the two trade in the green certificate market. With the implementation of the consumption responsibility weight, emerging green certificate transaction entities represented by load aggregators and virtual power plants will also participate Green certificate trading is coming.

(2) Analysis of thermal power suppliers' strategic behavior under the weight of absorbing responsibility Thermal power has a certain price advantage for green power. The strategic focus of thermal power companies should be on competition for user quota power. Thermal power companies have the following options: First, through new green power plants or mergers and acquisitions The existing green power plants have completed their own strategic transformation and competed with other green electricity suppliers for quota electricity; second, thermal electricity suppliers do not participate in the competition of quota electricity; third, thermal electricity suppliers cooperate with green electricity suppliers to combine thermal power with Green electricity is sold in bundles according to a certain proportion; fourth, thermal power companies transfer part of the power generation rights to green electricity companies to obtain the proceeds from the transfer of power generation rights.

(3) Analysis of the strategic behavior of green e-commerce under the weight of consumption responsibility. The revenue of green e-commerce mainly comes from green electricity sales and green certificate sales. In green power sales, the cost of green power generation is the key, and the lower the power generation cost, the stronger the competitiveness. Green electricity sales revenue also depends on the expansion of business models. The rate of abandoning wind and light in some areas in China is still high, and green e-commerce can develop new business models. Electricity sales companies and large electric power users who did not complete the assessment indicators during the assessment of the weight of consumption responsibility can avoid deviation penalties by purchasing green certificates. The strategic actions of green e-commerce mainly include: reducing the cost of renewable energy power generation, opening up sales channels for abandoning wind and light, and increasing the trading volume of green certificates.

4. Game analysis of power companies' strategic behaviors under the weight of renewable energy consumption responsibility

4.1 Description of game problem

Assume that there are only thermal power suppliers and green power suppliers in the power market, and power generation companies compete for output. With reference to the strategic behaviors of thermal power companies mentioned above, considering that new green power plants and mergers and acquisitions are long-term investment, and trading green certificates is the original intention of the government to implement RPS, this article makes two assumptions. One is that thermal power companies and green power companies are competing for competition. Users, each adopting profit maximization strategies, can be analyzed by non-cooperative game equilibrium. This non-cooperative game equilibrium is analyzed from the perspective of Nash game and Stackelberg game. The second is that thermal power providers and green power providers cooperate to make joint decisions for the purpose of maximizing overall benefits, which can be analyzed by cooperation games.

Non-cooperative game equilibrium analysis

Assuming that there are only thermal power suppliers and green power suppliers in the power market, thermal power companies and green power companies jointly meet the electricity demand of the power market. In the Stackelberg model, green e-commerce and thermal e-commerce constitute the "leader-follower" Stackelberg model. This article considers a game analysis of a duopoly market consisting of a thermal electricity supplier and a green electricity supplier. In the Stackelberg model, green e-commerce is the leader and thermal e-commerce is the follower. The output response function of thermal e-commerce is changed with the response of green e-commerce.

When the weight of the consumption responsibility is fixed, the green certificate price, feed-in tariff, thermal power output and thermal power profit will all decrease with the increase of the marginal cost of thermal power; the number of green certificates Qr, green power output, and market electricity will increase with the increase of thermal power cost . This shows that the increase in the cost of thermal power will enable more green power to be successfully cleared in the electricity market, and the number of green certificates in the market will increase, and the price of green certificates will fall. Under this circumstance, a large number of green power can be successfully cleared out of the market, the output of green power has increased, and the amount of electricity on the grid has increased, realizing the substitution effect of green power for thermal power. Green certificate prices

and on-grid electricity prices will increase as the marginal cost of green electricity increases, and other variables will decrease as the marginal cost of green electricity increases. This shows that the increase in the cost of green power will reduce the amount of green power bids, reduce the output and profit of green power, and then reduce the number of on-grid electricity and green certificates, and raise the price of green certificates; when the green power quotation increases, the price is higher. Green electricity suppliers have become marginal generators, and the on-grid electricity prices have therefore increased. Therefore, thermal and green e-commerce companies have an incentive to reduce their power generation costs.

It would have been more profitable. By comparing the position of the equilibrium point of the Nash model and the Stackelberg model, it can be found that the partial monopoly caused by the merger of thermal power companies will increase the bargaining power of thermal power companies in the electricity market, thereby affecting the bidding of renewable energy in the electricity market.

4.2 Equilibrium analysis of cooperative game

In the scenario of thermal power supplier and green power supplier cooperation, thermal power supplier and green power supplier form an interest group to make decisions with the goal of maximizing collective interests.

In the cooperative game, the total revenue of thermal power and green power is greater than the total revenue of both parties in the non-cooperative game. The increased profits of the cooperation will help thermal power companies to get rid of their loss dilemma, and it can also help new energy power generation companies gain a foothold under the trend of "de-subsidy".

With the gradual increase of the quota ratio, the total power supply has a tendency to decrease. Through analysis, it can be seen that when the user side assumes more quota, only relying on the thermal power supplier to purchase the green certificate for the user cannot meet the user's quota assessment requirements, and the user will pass Other ways to complete the assessment, thermal power is less attractive to users, and the existence of a supply-demand balance mechanism leads to a reduction in thermal power output, which in turn leads to a reduction in the total power supply. The reduction in thermal power output also directly leads to a reduction in the profits of thermal power companies. Reasonable manufacturers will increase the declared price of electricity, which will lead to an increase in the feed-in tariff.

Since the profit of cooperative games is greater than that of non-cooperative games, manufacturers will spontaneously seek cooperation. (2) The cooperation between manufacturers will increase the profits of power generators, help thermal power companies to get rid of the dilemma of losses, and also help new energy power generation companies to gain a foothold under the trend of "de-subsidy". (3) Cooperation between manufacturers will raise the price of on-grid electricity and reduce the amount of electricity cleared from the market. The government should issue relevant policies to appropriately restrict cooperation between manufacturers.

5. Suggestions

By combining the renewable energy consumption guarantee mechanism with the power spot, the traceability and uniqueness of the green power certificate is used to ensure that the renewable energy consumption guarantee mechanism is implemented, and the scale of subsidies is reduced by stimulating the green certificate market.

In order to protect the enthusiasm of green power demand, the participation of the whole society, and the return and reflection of green value, it is recommended that renewable energy companies and users conduct bilateral direct green power transactions at the initial stage of the market; promote project progress at the government level and strengthen the relationship with the power grid. In order to promote the realization of green electricity trading, and as a powerful supplement to the quota system to be implemented, it will release the vitality of the market as the consumption of renewable energy is gradually improving.

The quota system assesses the electricity sales side, which increases the market's demand for electricity from renewable energy generation, thereby promoting the transformation of the country's energy structure. As traditional power sources such as thermal power bear the increased demand for ancillary services from renewable energy access, the prices of the electric energy market and the ancillary service market cannot truly reflect the actual value under the above-mentioned circumstances. It is recommended to add a flexible power supply layout to improve the peak and frequency modulation capabilities in the system.

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