

Design of User-side Settlement System based on High-proportion New Energy Electricity Spot Market

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Abstract. As the goal of “Carbon Emissions Peak and Carbon Neutrality” becomes a national strategy, new energy will gradually become the main power supply in the power system. Since Dec. 2018, the electricity spot market has completed several trial operations which work well. Based on the analysis of the problems exposed in the first phase operation of the unilateral market, the paper introduces the reasons for the user side to participate in the spot market and designs a users’ settlement system. Finally, the data of May 2021 is used to analyze the behavior of user side participation in the market, and compare the market performance before and after users participate in the market. The results show that after users participate in the spot market, users can promote the consumption of new energy, thereby helping to implement the goal of “Carbon Emissions Peak and Carbon Neutrality”.

Keywords: high proportion of new energy; spot market; bilateral market; user-side settlement

1. Introduction

In March 2020, the National Development and Reform Commission and the National Energy Administration jointly issued the "Notice on Doing a Good Job in Continuous Trial Settlement of Electricity Spot Market Pilots " Further clarify the requirements for the construction of the power spot market[1]. Up to now, eight spot pilot provinces in the South (starting with Guangdong), west inner Mongolia, Zhejiang, Shanxi, Shandong, Fujian, Sichuan, and Gansu have all been carried out continuous long-period settlement trial operations, and the construction of the power spot market has been progressing steadily. In the process of market operation, the unilateral bidding mode on the power generation side is considered to deviate from the essence of market competition, which is mainly reflected in the following aspects:

- 1) The distortion of the price signal generated by the unilateral spot market is difficult to reflect the user's price sensitivity[10]. In the first phase of the spot market construction process, users did not participate in the spot market competition, the electricity reform dividends failed to be transmitted to the user side[2], and the role of users to eliminate peaks and fill valleys based on market price signals was not brought into play.
- 2) The random matching degree between new energy medium and long-term electricity trading and new energy power generation output is poor. In the first stage of the spot market

construction plan[3], the medium and long-term trading power of new energy is decomposed by the market operating agency based on the short-term power generation forecast curve. Affected by the uncertainty of new energy power generation, it is necessary to further improve the medium and long-term trading mechanism and promote the participation of new energy in medium and long-term curve trading[5].

3) The demands of large users in the province for the electricity market cannot be met soon. Industrial loads are mainly high energy consumption and are more sensitive to electricity prices. High-energy-consuming industrial load accounts for about 40% of the entire society's electricity consumption, and industrial enterprises have a strong desire to obtain low electricity prices through the electricity market[7].

By building a bilateral market, the advantages of a market system with full interaction and competition between the two sides of the development and utilization can be brought into play. The time-of-use electricity price formed by bilateral market competition can accurately reflect the real market supply and demand situation at different times and the scarcity of power resources. When the new energy is booming, the real-time electricity price generated in the spot market is transmitted to the user side[6], and the user can adjust the electricity consumption behavior to create a larger consumption space for the new energy, and the user can also enjoy the electricity price dividend. In addition, spot market prices may fluctuate with changes in supply and demand[11], and users can respond to their electricity consumption behaviors based on price signals. Bilateral spot market electricity prices can not only reflect market supply and demand more accurately but also enable users to shift peaks and fill valleys, further ensuring the safe and stable operation of the power grid.

Therefore, this article comprehensively considers the issues exposed in the unilateral market, and combines the necessary conditions for the construction of the bilateral market to study the key mechanisms for users to participate in the electricity market, and then design the settlement rules for users to participate in the market, and finally take the bilateral market in May 2021. Take the results of the first settlement trial run as an example, and compare and analyze the market performance before and after the user side participates in the market. The results show that the user's spot market declaration behavior objectively reflects the changes in the market supply and demand situation, and is closely related to the output of new energy. The introduction of users to participate in the spot market The market has the function of reducing spot market prices, transmitting the welfare of spot market reforms, and stabilizing the volatility of electricity prices in the spot market[8].

This article aims to improve the electricity spot market transaction mechanism[4], expand its transaction scale, and form a spot market with bilateral interaction and bilateral centralized bidding. The gradual refinement of the unified settlement price mechanism on the user side reflects the relationship between power supply and demand[9], and guides users to use electricity through reasonable price signals to ensure the steady start and gradual progress of the electricity market.

2. User participation in electricity market settlement system design

2.1. Design of Settlement Mechanism

The electricity spot market adopts the settlement mode of "daily settlement and monthly settlement". The electricity bill calculation cycle is daily, with every 15 minutes as the basic calculation period, the temporary settlement result of the daily settlement is issued, and the official settlement basis is issued monthly to carry out electricity bill settlement. The electricity energy market is settled in the order of medium and long-term trading, day-ahead spot market, and real-time spot market.

The energy market adopts a double deviation settlement mode: medium and long-term contract full power settlement, the deviation between the day-ahead spot market and the medium- and the long-term market is settled at the day-ahead spot market price, and the deviation between the time-sharing power consumption and the day-ahead spot market is based on the real-time spot market price Settlement.

For spot market users and electricity sales companies, the deviation between the day-ahead spot market-clearing curve and the medium- and long-term transaction settlement curve will be settled at the user-side day-ahead spot market-clearing price.

2.2. Design of user electricity energy and electricity bill settlement system

The user's electricity fee includes the user's medium and long-term contract electricity fee, the day-a-day spot electricity fee, and the real-time spot electricity fee. The grid company calculates the electricity consumption information of the user at 96 points every day and settles the electrical energy and electricity bills according to the settlement day every month.

The medium and long-term transaction decomposition curve has a medium and long-term contract with multiple components. The user's medium and long-term contract transaction decomposition curve is the sum of the medium and long-term energy and electricity costs of each component.

The deviation between the current spot market clearing power and the mid- and long-term settlement curve contract power will be settled according to the weighted average power price of the zone nodes before the day.

The deviation between the actual electricity consumption of users in the real-time spot market and the amount of electricity cleared in the spot market before the day is settled according to the weighted average electricity price of the real-time zone nodes.

On the user side, the user side shall bear the unbalanced capital part of the regional spreads according to the user's spot power. The weighted average power price of the node in the spot market area is weighted and averaged according to the planned power of each node unit in the area; the weighted average power price of the node in the real-time spot market area is weighted and averaged according to the real-time planned power of each node unit in the area.

3. Operational practice and effectiveness

Take the first trial operation of the bilateral market in a high-proportion province in China in May 2021 as an example to analyze and study the behavior of the user side in the market and the market performance before and after the user side participates in the market.

3.1. Average price on the user side

In the early morning (3:00), the average user quoted price was 339.98 yuan/MWh; at noon (12:00), the average user quoted price was 187.1 yuan/MWh; in the evening (20:00), the average user quoted price was 345.01 yuan/MWh, average The quotation situation is shown in Figure 1. As can be seen from the figure, during the noon period when new energy is launched, the average price on the user side is generally low; in the early morning and evening hours, the output of new energy is low, and the average price on the user side is generally at a relatively high level.



Figure 1. Average user-side bidding price.

3.2. Bidding price distribution

In the spot market, with a total capacity of 184.8MW. In the early morning (3:00), the average daily declared capacity of users is 158.28MW; at noon (12:00), the average daily declared capacity of users is 158.35MW; in the evening (20:00), the average daily declared capacity of users is 157.61MW, The bidding price distribution is shown in the figure 2.

There are obvious differences in the user-side bidding price in different time periods. During the daily new energy generation period, the low-price declaration capacity is large. At 13:00, the quotation capacity of users 200 yuan/MWh and below accounts for about 50%, and the quotation is 300 yuan/MWh and below. Capacity accounts for about 70%; in the early morning and evening peaks, the capacity for low-priced declarations is significantly reduced, and the capacity for high-priced declarations increases. The capacity for declarations below 300 yuan/MWh for users at 3:00 and 20:00 accounts for about 30%, 300-500 yuan/ MWh capacity accounts for about 70%.

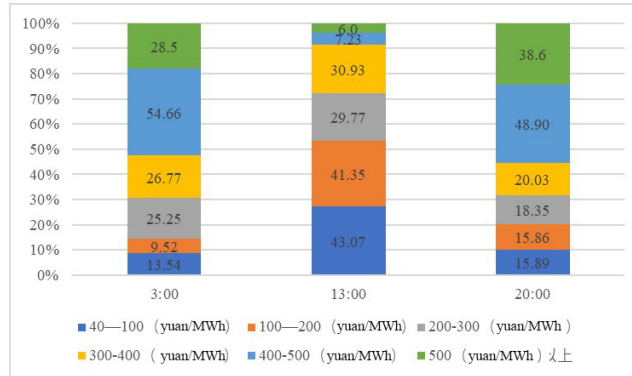


Figure 2. Overall distribution of user-side bidding price.

3.3. The relationship between the user-side bidding price and the market supply/demand ratio

During the trial run in May, the relationship between the average bidding price on the user side and the supply-demand ratio change is shown in the figure below.

On trading days with relatively low supply and demand (such as May 15th, 16th, and 17th), that is, the market supply is relatively tight, and the user-side declared price is higher; on trading days with relatively high supply and demand (such as May 12, 13th), that is, the market supply is relatively sufficient, and the user-side declared price is lower. The user-side quotation has an obvious correlation with the market supply and demand situation, and the user-side declaration objectively reflects the changes in the market supply and demand situation. The correlation between the user-side offer and the supply/demand ratio is shown in Figure 3.

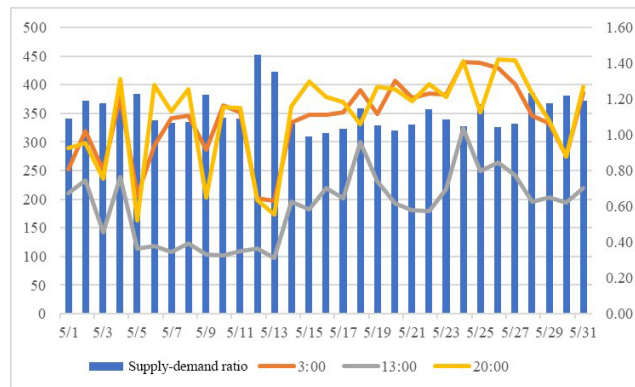


Figure 3. Correlation between user-side bidding price and supply/demand ratio.

During the trial operation cycle, the long-term and medium-term electricity consumption of users is linear, and it is impossible to judge the impact of the development of the spot market

on the historical electricity consumption behaviour of users. However, by comparing the spot electricity price with the actual electricity consumption of market users, it can be found that there is no obvious relationship between the spot market price and the actual electricity consumption of users. This is because the market user load is relatively small, many non-market users have raised the spot market transaction price, and market users have little effect on the market-clearing price.

4. Conclusion and outlook

Combining the actual operating results of the high-proportion new energy spot market, the following conclusions can be drawn: from the market behavior level, the user-side declared price has a large correlation with the new energy output. During the noon new energy period, the user-side average quotation is overall Low; in the early morning and evening hours, the output of new energy is low, and the average quotation on the user side is generally higher. In addition, the user-side declaration objectively reflects the changes in the market supply and demand situation. On a trading day when the supply and demand are relatively low, that is, the market supply is relatively tight, and the user-side declared price is higher; The side declared price is lower.

Finally, the overall reporting arbitrage behavior on the user side is relatively small, accounting for a relatively low percentage of user settlement fees. From the perspective of market performance, user-side quotations have the effect of lowering the spot market price, transmitting the benefits of spot market reforms, and at the same time stabilizing the spot market electricity price. Market users use less electricity during periods of high spot electricity prices and more use during periods of low spot electricity prices. To further optimize the trend of spot market price changes, avoid extreme price situations.

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