

Design of Multi-Time Scale Power Trading Platform in Regional Spot Market

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Abstract. In order to improve the reliability of power trading under the background of regional power spot market, a multi-time scale power trading platform is designed. The transaction status of foreign power spot markets, the general situation of China's power market construction and the particularity of China's market transactions are analyzed. A multi-time-scale trading platform in the spot market is constructed, the overall structure and technical architecture of the platform are established, the multi-time-scale transaction process is analyzed, and a clearing mechanism framework for cross-regional transactions is proposed. According to the needs of market connection, the basic plan for cross-regional transactions is proposed. Finally, the application effect analysis of the platform proposed in this paper is carried out, which shows the validity of the platform design.

Keywords: Regional spot market, spot trading, system design, multiple time scales.

1. Preface

The construction of China's electricity market started relatively late, and for a long time it was still dominated by mid- and long-term electricity transactions. At this stage, the construction of an electricity spot market and market transactions are gradually being explored. During the operation of the electricity market, the electricity market transaction mechanism and market supervision optimize the design of the mechanism and market transaction varieties, learn from the operation experience of foreign advanced power spot markets, and provide solutions for the spot price of China's future power market, new energy participation in power spot market transactions, and power spot market transactions that consider carbon trading.

At present, there are many trading mechanism designs for cross-regional spot trading platforms. Literature [1] studies the model space and influencing factors of the power spot trading market. Literature [2] analyzed the medium and long-term power market transaction settlement mode under the spot market. Literature [3] analyzed the construction of inter-provincial spot market under the tight power supply and demand. Literature [4] studied the analysis of the trial operation of the national power spot market and the countermeasures of new energy power generation enterprises. Literature [5] studied the development mechanism of electricity spot market at home and abroad to promote the consumption of renewable energy. Literature [6] analyzed the impact of power spot trading on market participants. Literature [7] proposed an inter-provincial power spot trading mechanism based on virtual traders. The above literatures explain the basic characteristics and trading mechanism of the electricity spot market, and provide a useful reference for the construction of China's electricity project market, but none of them are designed for the trading platform of the regional spot market under the background of multiple time scales and multiple trading varieties.

For this reason, this paper focuses on the basic situation and trading characteristics of China's electric power spot market on the basis of analyzing foreign power spot markets. The multi-time-scale trading platform system is designed, the overall platform architecture and platform technical architecture are given, and the multi-time-scale trading process is explained. It also analyzes the mechanism of inter-regional spot market connection.

2. General situation of electricity spot market transactions at home and abroad

There are many differences between European and American electricity market targets. The European Commission formulates the rules of the electricity market while promoting equality for all market participants, including traditional generators, renewable energy, distributed power, and more. The European Designated Electricity Market Operator works under the conditions proposed by the Commission and at the same time, designs different power products according to the technical conditions. This power product is suitable for various technical conditions. There is a difference between the sign of the demand target and the supply target in front of the bid. The market products provided by renewable energy generators and traditional generators are the same, the difference is that renewable energy generators need to balance the deviation between predicted output and actual output. The regional power transmission operator RTO can set corresponding power products according to different technical conditions. Traditional generators submit variable cost bids, and demand response bidders submit their range of changes in electricity consumption. Renewable energy units are different from traditional bidding methods, providing forecasted output in real-time electricity market and reducing its unbalanced deviation. In the US electricity market, the equality of different technical conditions is quite different, and it is more convenient for electricity market participants to participate in the market by setting specific electricity products. The above-mentioned areas are in the days before, and the bidding method in the market is similar, and the market clearing is generally set in the days before. The details are shown in Table 1.

Table 1. General situation of foreign power market

	Nordic electricity market	UK electricity market	PJM
Basis	The distribution of power load is uneven, and the proportion of new energy is large	Sufficient power supply, less grid congestion, and a large proportion of new energy	The power supply is tight and the power grid is seriously blocked
market	Day-Ahead Market, Intra-Day Market, Real-Time Balanced Market	Day-Ahead Market, Real-Time Balanced Market	Day-Ahead Market, Real-Time Balanced Market

There is a big difference between the intraday market and the real-time market. The European intraday market uses the continuous trading platform to provide targets that combine supply and demand, and the price is determined by bidding. The U.S. real-time market is the correction of the unit combination decision made in the day-ahead, and only the participants in the online market are dispatched to ensure that they match the actual power conditions. The European day-ahead market is more closely linked to the intraday market.

According to the classification of the electricity spot market in Europe and the United States, it is mainly divided into market transactions that take into account both market competition transactions and system balance dispatch, and market transactions that focus on system balance dispatch. The former mainly refers to the U.S. PJM market and the Australian electricity market, and the latter mainly refers to Including the European UK electricity market and the Nordic electricity pool, the real-time balancing market formed by it can also be attributed to ancillary services.

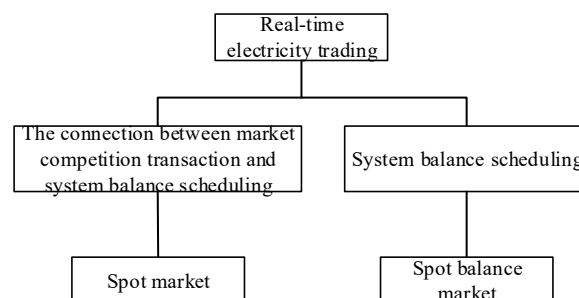


Figure 1. Classification of trading mechanisms

3. General Situation of China's Power Spot Market and Transaction

3.1. China's electricity spot market

The power spot market is a market form classified according to the transaction time scale. This time scale is shorter than the medium and long-term power market scale. It mainly includes time ranges such as day-ahead, intra-day and real-time balance. , power supply and market prices change with time, and in the spot market using regional or node marginal power prices, market prices in different regions will vary due to network congestion. In the electricity spot market, different time scales constitute different types of electricity transactions. The day-ahead market is mainly responsible for day-ahead electricity transactions, the intraday market is responsible for intraday electricity transactions, and the real-time balance market is responsible for real-time electricity transactions. The characteristics of the price mechanism are detailed in the table below.

Table 2. Overview of spot transactions in China

Place	Phase	Forms	Bidding	Pricing mechanism
Guangdong	Two stage	Day-Ahead Market, Real-Time Balanced Market	Electric energy, ancillary services	The power generation side is the node marginal electricity price, and the electricity sales side is the weighted average electricity price of the same node
Gansu	Two stage	Day-Ahead Market, Real-Time Balanced Market	Electric energy, ancillary services	The power generation side adopts regional electricity prices, and the electricity sales side adopts unified electricity prices
Shanxi	Two stage	Day-Ahead Market, Real-Time Balanced Market	Electric energy, ancillary services	The power generation side is the time-sharing node marginal electricity price, and the electricity sales side is the average weighted electricity price of the same node

3.2. Products traded in China's electricity spot market

According to the trading principles of the electricity market, a centralized trading method is generally adopted, as shown in the figure below. According to the day-ahead market, real-time market, and intraday market, it is divided into centralized bidding and continuous trading. From the perspective of electricity market transaction subjects, it can be divided into power generation competition mode and wholesale competition mode. The power generation competition model is also called the single buyer model. It only includes the power generation side quotation and the competitive power pool for transactions. The wholesale competition mode refers to the model in which both the power generation subject and the construction subject participate in the quotation.

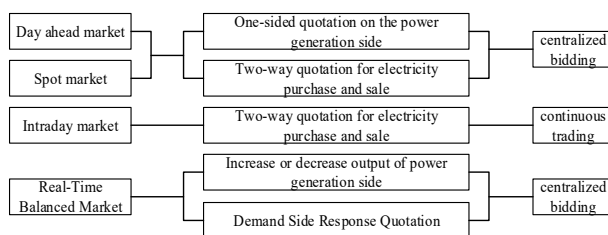


Figure 2. Classification of Spot Market Transactions

According to the different transaction modes of the electricity market, different transaction product combinations can be generated. For example, the day-ahead, pre-clearing and implementation markets can constitute corresponding power trading products; the day-ahead, the combination of the

market and the real-time market can constitute trading products; the day-ahead market, intraday market, and real-time balance market can constitute corresponding product transactions.

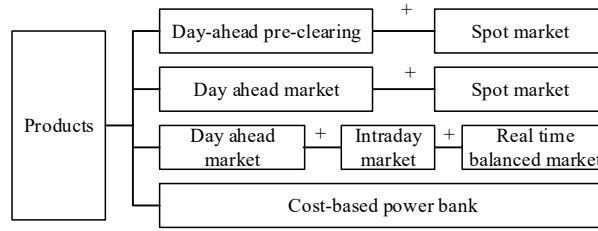


Figure 3. Spot trading varieties

3.3. The particularity of China's cross-regional electricity spot market

There are certain particularities in China's electric power system, which can be analyzed from the perspectives of national dispatching, regional dispatching, and provincial dispatching. Responsible for multiple provincial power supply units and transmission networks in the region within the same time scale, and provincial dispatching is responsible for the dispatching of units based on provincial internal demand and some new energy prefectures and cities. Therefore, China's power system has the particularity of multi-level and multi-management entities, and it is impossible to design trading varieties and trading methods in accordance with the existing foreign power spot market structure. At the current stage, China's power spot market is divided into initial goals, mid-term goals, long-term In the construction phase of the long-term goal, the initial goal of establishing a regional power spot market is realized on the basis of some provincial power spot market pilots in the form of three steps. Subsequently, with the continuous improvement of the multi-regional electricity spot market, a unified national electricity market will be formed, which is the medium-term goal. In the long run, it is necessary to form a unified national electricity market in accordance with the conditions of technological development.

4. System design of multi-time scale trading platform in spot market

4.1. The overall structure of the platform

The regional spot market multi-time-scale power trading platform proposed in this paper mainly uses trading as the main function to realize the in-depth application of different market participants in account management, transaction process management, contract management, credit information, and system settings.

The main function of the constructed platform is to realize multi-regional and multi-time scale power spot transactions. Among them, cross-regional, cross-provincial, and intra-provincial spot transactions are the main structure, and different time dimensions are used as the vertical structure to realize the power spot trading platform, which plays a role in transmission capacity calculation, market clearing, and transaction result backtracking.

This paper designs the coupling function of the regional power spot market model in terms of market subject maturity, ancillary service market conditions, power dispatching plans, and cross-regional congestion levels. Among them, according to the time scale of the day-ahead market, intraday market, and real-time market, involving trading platforms including different power trading entities, the corresponding interfaces are designed according to the system specifications, and at the same time, considering the application docking between the power trading platform and other systems, different docking system interfaces are designed. The main body of the power market includes traditional power generation companies, new energy power generation companies, power grid companies, dispatching agencies, trading centers, and power users.

The optimal clearing method is adopted, and the optimized clearing design is carried out based on the physical information model of the whole network, and the transaction input data is provided

according to the grid node information, section and tie line information, regional transmission price and network loss, transaction path information, and settlement path information. According to the confirmation of the declaration parameters provided by both parties to the transaction, the basic information of the transaction and the declared power information, a declaration curve is formed, and the curve is input as an optimized clearing model for spot cross-regional market transactions, and the rule configuration parameters are used as constraints for optimized clearing, get cleared power price information and settlement information, and display the results if errors or alarms occur. The platform uses a cloud operating system as the hardware infrastructure, and a variety of concurrent servers, storage structures, and network switches as the basic hardware facilities to form a platform operating system characterized by deep integration of resources, distributed file systems, and virtual networks. The transaction function section realizes the data transmission of various cloud platform middleware.

Pricing in the regional power spot market is closely related to the maturity of market players, system congestion level, and social fairness. In the power spot market environment, electricity prices change with time. According to the degree of market congestion, different pricing mechanisms can be adopted. The main points are: is node electricity price and regional electricity price. The former mainly refers to the marginal cost of a market, node class and all grid-connected generating units, and the latter refers to the marginal cost of the power system and congestion area within the geographical scope.

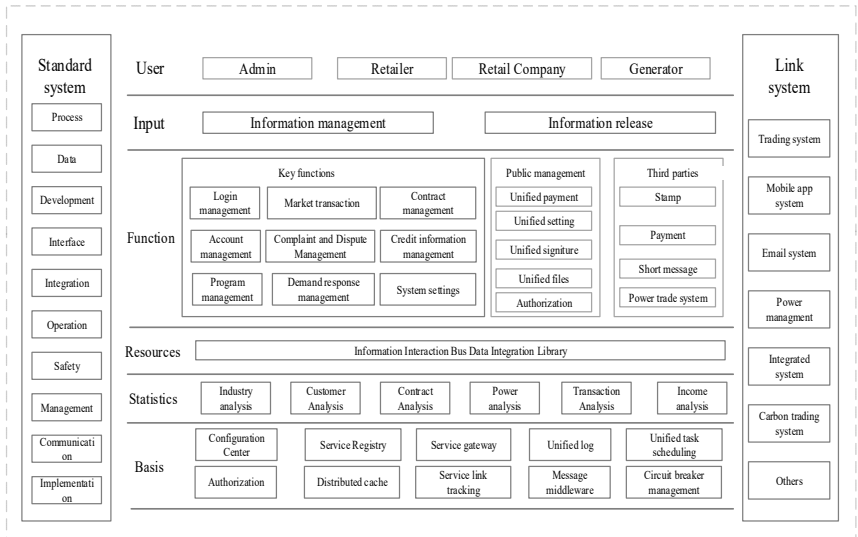


Figure 4. Power Spot Trading Platform Framework

4.2. Platform Technology Architecture

The platform architecture is divided into basic platform layer, data transmission layer, service layer, application layer and presentation layer.

The basic platform layer is a hardware architecture characterized by cloud infrastructure and cloud platform, forming the underlying logic of operating system, information integration, data processing and application construction. The data layer is responsible for the unified processing, unified access, unified analysis and unified management of cross-provincial, cross-regional and internal power spot transaction data. Form a full-service unified data center, including transaction data in different periods and scheduling information for transactions in different stages. The service layer takes the data provided by the full-service unified data center as the service object, and takes file service, model service, calculation service, data verification, alarm service, log management, etc. as the main service content to form diversified and multi-time dimension data processing result. The processed data further forms the main application of the application layer, which can provide diversified functional applications including market service, market clearing, market settlement, information release, market compliance, system management, etc., and integrates the needs of major market trading applications. Different time scales form annual, monthly, quarterly, daily, and real-time information

applications. The display of the application results is carried out at the display layer, which can be accessed and queried through the client, the large display screen, mobile applications and browsers. Present the results as a way of doing business on major trading platforms.

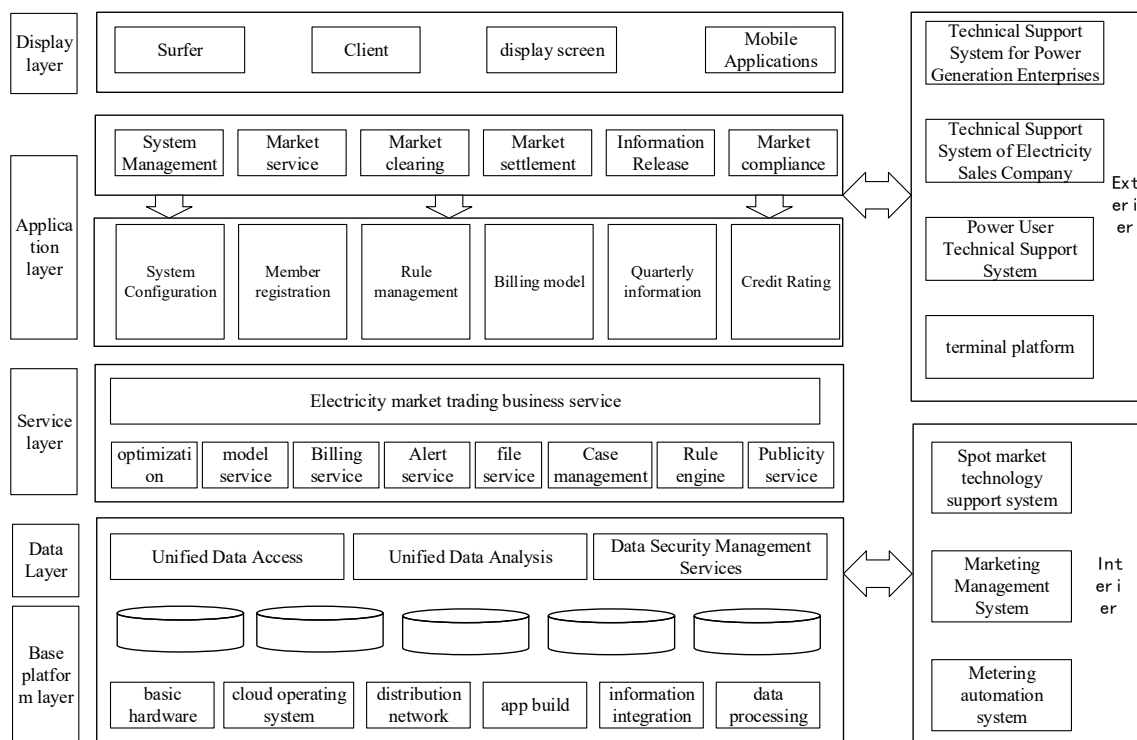


Figure 5. Power Spot Trading Technical Framework

4.3. Multi-time scale trading process

The multi-time scale transaction process is shown in the figure below. According to the different participants, a multi-time scale transaction process is formed.

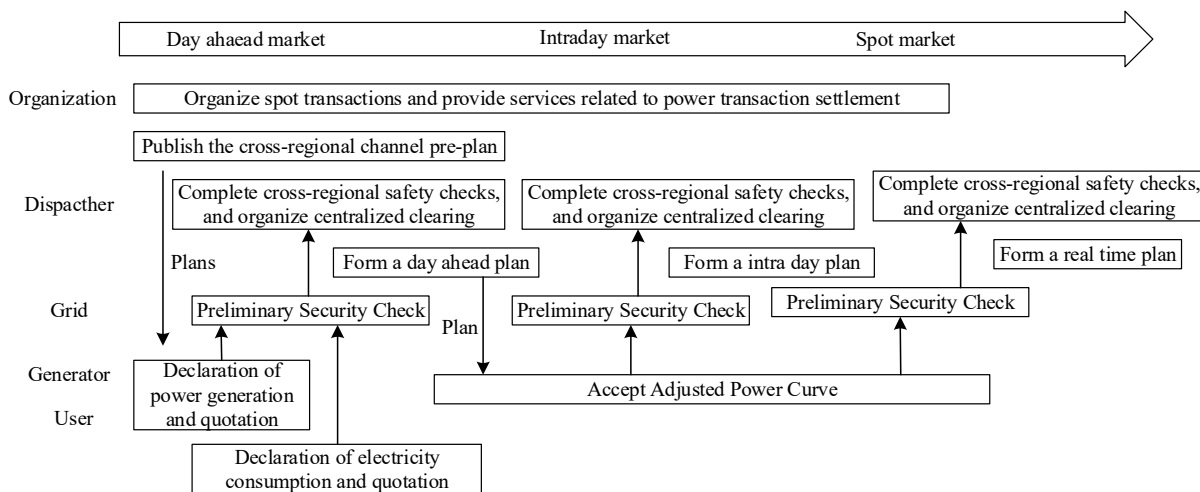


Figure 6. Multi-time scale transaction process

According to the time granularity, it is divided into day-ahead market, intraday market and real-time market. Market participants are composed of trading institutions, dispatching institutions, power grid enterprises, power generators and users. The corresponding market trading rules are shown by the arrows in the figure.

4.4. Cross-regional trading market framework

For cross-regional spot transactions, the National Power Dispatching and Control Center organizes market participants to participate in transactions through corresponding transaction transmission channels. Market participants mainly include multiple users such as the power supply side, grid side, load side, and energy storage mentioned in this article. Specifically, it includes the day-ahead market and the intraday market, which together constitute spot transactions.

The clearing mechanism is designed as follows:

1) Transaction declaration. Buyers and sellers participate voluntarily and declare the "power-price" curve by time period (15 minutes is a time period).

2) Clearing mechanism. Based on the network loss and transmission fee of the transaction path, considering the constraints of dynamic available transmission capacity, power balance, and ramping of multi-cascade channels, centralized bidding is carried out in accordance with the matching method of high and low price differences between buyers and sellers.

3) Price mechanism. The system marginal electricity price is adopted, and the average price quoted by the buyer and the seller of the last transaction in each sending province is taken as the system marginal electricity price, and the transaction electricity in the province is settled according to the marginal electricity price.

4.5. Cross-regional trading market connection

Cross-regional power spot trading needs to consider the connection between the medium and long-term market and intra-regional spot market transactions in terms of transaction timing, transaction varieties, transaction boundaries, and deviation handling.

In terms of transaction timing, medium and long-term transactions in the region have higher priority than transactions in the region. For spot trading, pre-clearance in the intra-regional spot market is carried out first, and then intra-regional day-ahead spot market transactions are carried out.

At the same time, cross-regional mid-to-long-term trading plans and cross-regional spot transaction results are used as input for intra-regional transactions.

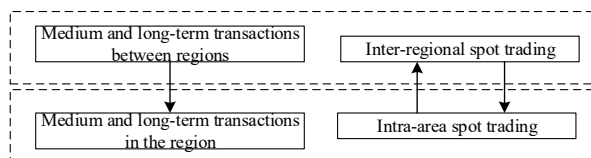


Figure 7. Transaction Connection Mechanism

4.6. Platform Application Effect Analysis

Using a province in southern China to carry out platform pilot application, compare the current platform system, and get the comparison results as shown in Table 3.

Table 3. What the system can achieve

Transaction Type	This system can realize	original system
Connect with the medium and long-term market	yes	part
Renewable Energy Trading	yes	yes
Balanced Market Mechanism	yes	part

According to the trading function designed by the platform, the organization will give priority to the pre-clearing or dispatching plan in the region to determine the internal balance of the region. The market entities within the region shall, according to the supply and demand situation, declare the power price curve for participating in cross-regional transactions. When there is a power gap within the region, it is necessary to declare power purchases to the cross-regional power trading center. When the power generation in the region is surplus, the remaining power cannot be consumed and sold to other regions. The transaction declaration curve for a typical day is shown in the figure below.

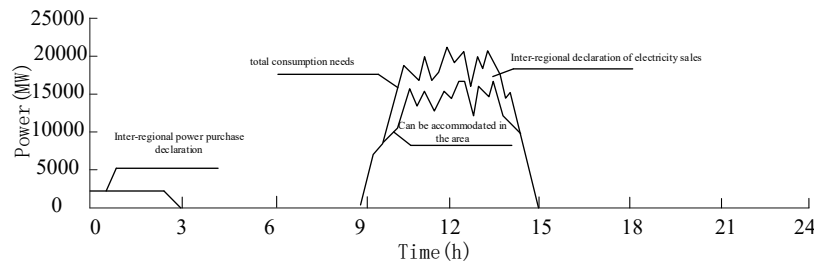


Figure 8. Market entities declare electricity

After the scheduling completes the clearing of spot transactions in the region, after safety checks, the clearing results are superimposed on the cross-regional channel power transmission plan, which serves as the operating boundary for clearing the market in the region or compiling the power generation plan in the region.

5. Conclusion

This paper proposes a multi-time scale electricity trading platform under the regional spot market. Designed a trading system featuring multiple time scales and multiple trading varieties. Through the design of the trading mechanism and trading model in this paper, combined with the actual project to carry out pilot projects, it shows that the proposed trading platform can effectively solve the problem of transaction fairness in the power spot market with multiple time scales and multiple trading varieties. The mechanism successfully completed the power spot transaction involving multiple market players, and achieved the connection between the power spot market and other markets.

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