



Research on the Participation Modes of User-Side Entities in China's Inter-Provincial Electricity Market

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Abstract. The establishment of a unified national electricity market is a crucial step in China's deepening reform of its energy management system. The inter-provincial market constitutes a significant component of this unified national electricity market. The key to building a unified national electricity market lies in how to better leverage the role of the inter-provincial market in optimizing resource allocation and facilitating the integration of intra-provincial and inter-provincial markets. This paper conducts a systematic analysis and research on user-side participation in inter-provincial transactions. Initially, it examines the general situation of China's inter-provincial market construction. Subsequently, it delves into the overall model of user-side participation in the inter-provincial market and analyzes existing issues. Based on this, it proposes a design for user-side participation in the market mode. Lastly, the study presents a design for a multi-channel centralized bidding mechanism for user-side participation in inter-provincial transactions.

Keywords: national unified electricity market, inter-provincial market, user-side entities, multi-channel centralized bidding transactions

1 Introduction

In recent years, China has gradually established an inter-provincial power supply guarantee system that prioritizes medium and long-term planning, utilizes spot market to balance supply and demand, and employs emergency dispatch for urgent needs. The market mechanisms primarily involve medium and long-term transactions and spot transactions. Through medium and long-term inter-provincial transactions, the national energy strategy is implemented, achieving wide-ranging optimization of energy resource allocation, promoting the consumption and development of clean energy, and solidifying the "fundamental foundation" of power supply guarantee. Spot market transactions between provinces respond to short-term demand for power and energy balance[1].

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Medium and long-term market positioning among Chinese provinces across different time periods. In terms of annual and monthly (multi-month) markets, based on ensuring the national planning of power flow direction and the basic pattern of inter-provincial power supply, the inter-provincial priority power generation plan is implemented to achieve a high proportion of medium and long-term contract signing. In terms of intra-month markets, on the basis of annual and monthly markets, intra-month markets are continuously open on working days (D-5). Under the premise of adhering to power supply guarantee and prioritizing new energy consumption, and coordinating resources across the entire grid, transactions are carried out with time priority, taking into account the planned power transmission directions of various channels and intergovernmental agreements[2]. The medium and long-term markets, together with the spot market and emergency dispatch, constitute an inter-provincial electric energy market system that meets the requirements of power resource allocation and power supply guarantee[3]. According to relevant national requirements for medium and long-term contract signing in the power sector, the transaction volume in the annual and monthly markets accounts for no less than 90% of the total, and the intra-month medium and long-term markets are organically linked with the spot market to meet the remaining 10% of electricity demand. Multi-channel centralized bidding transactions are regularly carried out in the monthly and intra-month (weekly) markets, expanding from bilateral and listing-based single-direction inter-provincial medium and long-term transactions to a multi-buyer and multi-seller market structure[4]. Operating entities across the entire grid can independently submit bids and quotes to express their market intentions. This further enhances market efficiency and promotes the optimization and allocation of resources on a larger scale[5].

Currently, the main buyers of electricity in the inter-provincial market are power grid enterprises. This is because inter-provincial transmission channels are scarce resources, and purchasing electricity through power grid enterprises can ensure fairness and secure supply in inter-provincial electricity purchases. After purchasing electricity, power grid enterprises distribute the electricity to residents and agricultural users in their respective provinces. However, with the gradual deepening of the construction of a unified national electricity market, it is necessary to promote the participation of electricity selling companies and wholesale users in inter-provincial transactions in the future. This paper focuses on the research of user-side entities participating in the inter-provincial market and analyzes the overall mode of user-side participation in the inter-provincial market. This paper establishes a design for a centralized bidding mechanism for user-side entities participating in multi-channel inter-provincial transactions, ensuring fair and efficient participation of user-side entities in inter-provincial transactions[6].

2 Overall Model of User-Side Entities Participating in Inter-Provincial Markets

2.1 Description and Analysis of Existing Problems

Currently, the cross-provincial and cross-regional power transmission in the operating areas of the State Grid Corporation of China mainly falls into three categories. The first

category is state-planned (including those historically formed during the era of the former regional power management bureaus). In this category, the government determines the transmission and reception of electricity, power, or distribution ratios through documents, and implements the nationally approved electricity price or a price mechanism established under national guidance. The second category is intergovernmental agreements. This category involves agreements between the governments of the transmission and reception ends or government-approved power transmission and reception agreements, which determine the transmission volume, power, and price through market-oriented negotiation and are adjusted periodically. The third category is market transactions. This category involves determining the volume, power, and price of electricity through centralized bidding, listing, and other methods.

In the cross-regional and cross-provincial power transmission conducted by the company, only the Yindong DC has carried out cross-regional and cross-provincial power transactions directly involving large users. Since 2016, the annual traded electricity volume has been 10 billion kWh, with the electricity price in Shandong Province being 374.9 yuan/MWh, which is about 20 yuan/MWh lower than the benchmark coal-fired electricity price in Shandong. The participating users are determined by the provincial energy authorities.

From the perspectives of various stakeholders, externally, some power generation enterprises and users hope to obtain corresponding price differences across regions and provinces. The National Development and Reform Commission (NDRC) has coordinated various factors and proposed to support orderly point-to-grid and point-to-point cross-regional and cross-provincial transactions. Some local governments, in order to support local economic development and enhance their leadership in electricity reform, also hold a supportive attitude towards users participating in cross-regional and cross-provincial transactions. For example, provinces such as Jiangxi, Jiangsu, and Shanghai have explicitly supported electricity users to directly purchase electricity across regions and provinces in their provincial electricity market trading schemes, with corresponding policy restrictions becoming increasingly less stringent. Internally, the construction of a unified national electricity market also requires addressing the issue of competition between users and power generation enterprises in participating in the cross-regional and cross-provincial electricity market on a theoretical framework.

At this stage, if the company fully opens up user participation in cross-regional and cross-provincial electricity markets, the following issues may arise:

Firstly, in terms of price differences, there is a price gap between the average landed price of electricity purchased from outside the company's main electricity-purchasing provinces (Hebei, Shandong, Shanghai, Jiangsu, Zhejiang, Hubei, Hunan, Henan, Jiangxi, Shaanxi, Chongqing, etc.) and the average price of electricity generated from domestic power sources. If all restrictions are lifted, this part of the revenue will inevitably be eroded. At the same time, the newly built thermal power units supporting the ultra-high voltage grid in the future will all be high-parameter and large-capacity units, and will mainly be coal-electricity joint ventures. If all restrictions are lifted and direct transactions with large users are allowed, it will be detrimental to the company's subsequent stable operation under the current situation where the corresponding price mechanism has not yet been straightened out.

Secondly, from the perspective of power supply guarantee, due to the large price difference among different price zones in various provinces, regions with high electricity prices will purchase electricity from regions with low electricity prices at a high price. Local users cannot compete with users from outside the province, resulting in power shortages in the sending areas, and the governments of the sending areas will inevitably oppose this. Taking the transmission of Sichuan hydropower to Zhejiang as an example, the price difference between the landing electricity price of Sichuan hydropower and the average electricity purchase price within the province is 90 yuan/MWh. If Zhejiang users are allowed to directly trade with Sichuan hydropower, it will inevitably drive up the on-grid electricity price of Sichuan hydropower, making Sichuan hydropower unwilling to trade with local users. This will not only affect the local power supply guarantee in Sichuan and the electricity purchase costs of Sichuan companies, but also form competition with existing provincial electricity purchasing companies on the three major UHV DC lines.

Thirdly, from a fairness perspective, when the transmission space is limited and mechanisms such as market access and transmission capacity allocation are not yet robust, it is inevitable to determine the participants, including cross-regional and cross-provincial users and power generation enterprises, through administrative means. It is understood that only 40 large users participate in cross-regional direct transactions on the Yindong DC, and the price difference they enjoy is significantly higher than that of direct transactions between large users within the same province. If this model is promoted nationwide, it will inevitably raise doubts among market participants and lead to greater and deeper levels of unfairness.

Fourthly, from the perspective of effectiveness, liberalizing electricity users' participation in cross-provincial and cross-regional markets has limited impact on increasing electricity transmission. Taking UHV transmission as an example, for DCs with small price differences such as Lugu DC and Yanhuai DC, the purchasing provinces have already set the average electricity purchasing price as the landing price. Even if users are liberalized to participate in transactions, it is expected that there will be no increase in electricity transmission. For DCs with large price difference margins such as Zhaoyi, Jiquan, Tianzhong, and Qishao, the external purchasing demand of the purchasing provincial companies has basically reached the upper limit of transmission capacity. Liberalizing users will only erode the price difference margins of the purchasing provinces and affect the overall electricity selling price in these provinces.

2.2 Design of Market Participation Mode for User-Side Entities

Firstly, multi-year long-term agreements and annual contracts serve as the "ballast" for cross-regional and cross-provincial power transmission. Among the three types of cross-regional and cross-provincial power transmission, after the issuance of Document No. 9, national ministries and commissions no longer specify the electricity quantity, electricity price, and distribution ratio for newly added external power sources, and the planned electricity quantity will gradually decrease. According to the utilization of transmission channels in recent years, relying solely on market transactions is prone to the situation where market entities "do not supply during peak periods and do not demand

during off-peak periods," which cannot guarantee stable power transmission through the channels. On the one hand, long-term power transmission agreements meet the needs of local governments for electricity reform and supply guarantee. On the other hand, they are also conducive to stabilizing the expectations of both the sending and receiving ends during the planning, preliminary, and operational stages of cross-regional and cross-provincial DC transmission channels, especially in leveraging the fundamental power transmission role of UHV (Ultra-High Voltage) channels. Furthermore, these agreements are market-negotiated actions that comply with national policies and are supported by relevant national authorities, local governments, and power generation enterprises. Therefore, we should actively support long-term power transmission and reception agreements and play a leading role in the signing and implementation of these agreements.

Secondly, we should promote the aggregation of users within the province to participate in inter-provincial green electricity trading through a platform aggregation approach, and explore the aggregation of users within the province to participate in other inter-provincial transactions through a platform aggregation approach. This will fully reflect users' trading willingness, effectively alleviate users' demands for "peer-to-peer" trading, and avoid the impact of "peer-to-peer" trading on power grid operations.

Thirdly, we should study and establish a mechanism for cross-regional and cross-provincial market access and transmission capacity allocation. Due to the limited capacity of cross-regional and cross-provincial power transmission, we should study and establish a mechanism for user and power generation enterprises to competitively participate in the access and transmission capacity allocation of the cross-regional and cross-provincial electricity market. On the basis of completing the national priority power generation plan, the remaining available transmission capacity should be publicly auctioned and traded among power generation enterprises and users at both the sending and receiving ends in the form of transmission rights. On the one hand, this can avoid unfair resource allocation, and on the other hand, it can also recover some price difference space.

Fourthly, refine the implementation path of the unified national electricity market. Considering the current system and mechanism where provinces are the pricing zones and the main entities responsible for electricity and energy balance, power generation enterprises and users are not yet equipped to fully liberalize on a nationwide scale. The liberalization of power generation enterprises and users participating in cross-regional and cross-provincial markets should be regarded as an advanced stage in the construction of the unified national electricity market. Public opinion propaganda and policy guidance should be strengthened, tackling easier issues before more difficult ones, and pilot projects should be carried out first. Initially, priority should be given to fully liberalizing and encouraging competition among power users and power generation enterprises outside of the priority purchase of electricity within the province. The cross-provincial and cross-regional market should still be led by provincial companies as the main entities responsible for purchasing electricity. Under the guidance of the National Development and Reform Commission, the corresponding price difference space should be coordinated and arranged by power grid enterprises and local governments in an open and transparent manner, avoiding a significant impact on the overall electricity selling price within the province. Meanwhile, pilot projects should be selected in provinces that have minimal impact on company operations and are well coordinated with the construction

of the spot market. Users should be allowed to participate in the cross-regional and cross-provincial electricity market on certain channels in a timely manner.

3 User-Side Entities Participate in the Design of Inter-Provincial Multi-Channel Centralized Bidding Trading Mechanism

3.1 Overall Mode Design

Establish a mechanism for user-side business entities to participate in inter-provincial transactions through platform aggregation. Under the premise of clearly implementing the responsibility of all parties for power supply guarantee and efficient utilization of channels, explore the participation of electricity selling companies, users, etc. in inter-provincial transactions through platform aggregation, supported by inter-provincial transmission rights, security supply guarantee, and benefit balancing mechanisms, to achieve flexible and fair participation of user-side entities in the inter-provincial market. Specifically, each province should summarize and aggregate users' inter-provincial electricity purchasing demands and participate in inter-provincial transactions, further enriching the new types of entities participating in the inter-provincial market model, steadily promoting user participation in inter-provincial spot transactions, and steadily expanding the scale of serving users' participation in inter-provincial transactions through platform aggregation.

Promote the establishment of an inter-provincial transmission rights trading mechanism. Collaborate with the government to ensure the orderly integration of inter-provincial transmission rights and transmission pricing mechanisms. For cross-regional transmission channels adopting a two-part or single capacity system, pilot transmission rights trading by combining explicit auctions with implicit allocation of physical transmission rights. The proceeds from transmission rights auctions will be used to offset the channel capacity electricity charges. Advance the implementation of transmission rights trading pilots, and in conjunction with subsequent developments related to channel construction and channel pricing mechanism reforms, explore a universal inter-provincial transmission rights trading mechanism.

3.2 Design of Inter-Provincial Multi-Channel Centralized Bidding Trading Mechanism

The buyer and seller respectively declare time-segmented electricity quantity (or power), price, and other information at the transaction gateways on the landing side and grid-connected side. The trading platform aims to maximize social welfare, taking into account market boundaries such as transmission channel ATC and transmission costs, and conducts multi-channel centralized optimization and clearing to form time-segmented transaction electricity quantity, electricity price, and curves for each market entity.

The objective function is:

$$\max \left\{ \sum_{l=1}^L \sum_{t=1}^T \left\{ \sum_{i=1}^I f(p_{buy,i,t,l}) - \sum_{g=1}^G f(p_{sell,g,t,l}) \right\} \right\} \quad (1)$$

The declared curve of units/stations with demand for increased output (electricity purchase) minus the declared curve of units with capacity for reduced output (electricity sales), where $f(p_{buy,i,t,l})$ is the increased output power of unit/station i with demand for increased output, $i=1 \dots I$, where I is the total number of units/stations with demand for increased output; $f(p_{sell,g,t,l})$ is the reduced output power of units with reduced output capacity/ g , $g=1 \dots G$, where G is the total number of units with reduced output capacity; $l=1 \dots L$, where L is the number of inter-provincial channels; $t=1 \dots T$, where T is the number of trading cycles.

The constraint conditions are:

$$\sum_{l=1}^L p_{buy,i,t,l} \leq p_{buy,i,t}^{bid} \quad (2)$$

Equation (2) is the constraint of purchasing electricity from provinces with successful bids. The sum of power flow in each time period on all transaction paths associated with the purchasing province is less than or equal to the sum of declared power in that time period by the purchasing province.

$$\sum_{l=1}^L p_{sell,g,t,l} \leq p_{sell,g,t}^{bid} \quad (3)$$

Equation (3) is the electricity sales province's bid-winning power constraint. The sum of electricity flow in each time period on all transaction paths associated with the electricity-selling province is less than or equal to the sum of declared electricity in that time period by the electricity-selling province.

$$\sum_{i=1}^I p_{buy,i,t,l} = \sum_{g=1}^G p_{sell,g,t,l} \leq p_{max,l} \quad (4)$$

Equation (4) is network constraint. The sum of the proportion factors of the transmitted power from multiple transaction paths associated with each channel is less than or equal to the available transfer capability (ATC) of the channel.

$$p_{buy,i,t}^{bid} = p_{buy,i,t}^{bid, grid} + p_{buy,i,t}^{bid, entity} \quad (5)$$

Equation (5) is aggregation constraint for electricity purchasing province users. The total declared electricity for the purchasing province during this period equals the declared electricity by the grid company in the purchasing province during this period plus the declared electricity by market entities in the purchasing province during this period.

Among them, the declared power by the provincial grid company for purchasing electricity refers to the power demand declared by the grid enterprise to meet the electricity purchasing needs of residents and agricultural users in the province. The declared power by the market entities in the purchasing province refers to the power demand declared by electricity selling companies and wholesale market users to meet their own electricity consumption needs.

The transmission fee for channels in multi-channel centralized bidding transactions is charged on a "one-line, one-price" basis. The transmission cost and line loss discount vary for electricity traded through different trading paths. In transaction clearing, marginal pricing is adopted based on the transmission path, with inter-provincial channel ATC serving as the constraint condition for centralized optimization clearing, ensuring that the traded electricity does not exceed the channel capacity. The results of inter-provincial multi-channel centralized bidding transactions are consistent with other medium- and long-term transaction forms, representing incremental additions based on existing contracts. Transaction clearing does not affect the executed contracts, and the organization, verification, and execution of transactions remain consistent with the current practices.

3.3 Case Study

Suppose there are two power-sending provinces, a and b, and two power-receiving provinces, c and d, in the power system. Among them, the power-sending provinces a and b are connected to the power-receiving provinces c and d through two channels, L1 and L2.

At a certain trading moment, the demand for electricity sold by power-sending province a is 3 million kWh at a price of 0.3 yuan/kWh. The demand for electricity sold by power-sending province b is 4 million kWh at a price of 0.35 yuan/kWh. The demand for electricity bought by power-receiving province c is 2 million kWh at a price of 0.6 yuan/kWh. The demand for electricity purchased by power-sending province d is 3 million kWh at a price of 0.5 yuan/kWh. Both L1 and L2 channels have a transmission capacity of 2 million kilowatts, and the transmission costs for L1 and L2 channels are 0.1 yuan/kWh and 0.15 yuan/kWh, respectively.

Based on the model proposed in this paper, the transaction demand of the receiving province is solved by superimposing the channel transmission cost onto the transmitting province. The electricity purchasing demand of 2 million kWh in the receiving province c is converted to the transmitting province through lines L1 and L2 at prices of 0.5 yuan/kWh and 0.45 yuan/kWh, respectively. The electricity purchasing demand of 3 million kWh in the receiving province d is converted to the transmitting province through lines L1 and L2 at prices of 0.4 yuan/kWh and 0.35 yuan/kWh, respectively. The model solution indicates that the transaction demand between the receiving province c and the transmitting province a is achieved through a 2 million kWh electricity transaction via line L1. The transaction demand between the receiving province d and the transmitting province a is achieved through a 1 million kWh electricity transaction via line L2. The transaction demand between the receiving province d and the transmitting

province b is achieved through a 1 million kWh electricity transaction via line L2. Through the aforementioned clearing method, social welfare is maximized.

4 Conclusion

This paper focuses on the research of user-side entities participating in the inter-provincial electricity market. Firstly, it provides an overview of the current status of China's inter-provincial electricity market construction, with a system dominated by medium and long-term transactions and supplemented by spot transactions. Currently, the main electricity purchasing entities are power grid enterprises. Subsequently, it analyzes the relevant issues of user-side participation in the inter-provincial market, including the impact of price differences, power supply guarantee, fairness, and actual effects. The paper proposes an overall model for user-side participation, which is based on long-term agreements. The model adopts a platform aggregation participation approach and establishes mechanisms for access and transmission capacity allocation. It promotes user-side participation in the inter-provincial market in stages. Finally, a multi-channel centralized bidding transaction mechanism is designed, which supports user-side participation in transactions through platform aggregation. The mechanism clarifies the objective function and constraints, aiming to ensure fair and efficient participation of user-side entities in inter-provincial transactions. Ultimately, it facilitates the construction of a unified national electricity market.

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References

1. Zhang, X., Li, Y., & Wang, Z. (2025). Research on cross-provincial power trading strategy considering the medium and long-term trading plan. *Plos One*, 20(7), e0386721. <https://doi.org/10.1371/journal.pone.0386721>
2. Sun, X., He, Y., Ding, T., Sun, J., Yuan, B., & Huang, Y. (2025). An elastic mechanism and its practice for inter-provincial mid- and long-term electricity transactions in the context of high renewable energy integration. *Proceedings of the CSEE*, 45(7), 2472–2485. <https://doi.org/10.13334/j.0258-8013.pcsee.241755>
3. Liu, Y., Chen, Q., Xia, X., & Kang, C. (2024). Inter- and intra-provincial electricity market clearing and pricing model under the evolution of national unified electricity market. *Transactions of China Electrotechnical Society*, 39(1), 215–228. <https://doi.org/10.19595/j.cnki.1000-6753.tces.231287>
4. Guo, S., Xu, H., & Zhang, L. (2025). The electricity purchasing and selling strategy of load aggregators participating in China's dual-tier electricity market considering inter-provincial subsidies. *Scientific Reports*, 15(1), 1–14. <https://doi.org/10.1038/s41598-025-13385-9>

5. Wei, W., & Mei, S. (2023). Pricing mechanism of China's trans-regional and trans-provincial electricity trading. *Energy Policy*, 178, 113675. <https://doi.org/10.1016/j.enpol.2023.113675>
6. Zhang, Y., Cheng, H., Yang, Z., & Li, G. (2022). Design of inter-provincial and intra-provincial two-level market transaction mode and clearing optimization under new power system. *Modern Electric Power*, 39(5), 1–9. <https://doi.org/10.19725/j.cnki.1007-2322.2022.0173>

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