Transaction analysis of multi market players based on global energy Internet

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Abstract. The deepening of the research on energy Internet will bring breakthroughs to the energy industry, and it will also promote more market participants. In this paper, the main body of the market trading under the global energy Internet is analyzed, and the various market entities are subdivided. On this basis, the variety and transaction form of the power market are analyzed in combination with the technical characteristics of the global energy Internet, and the power transaction mode in the global energy Internet is designed. Finally, according to the foregoing, the cost benefit analysis and the general market return analysis of various market participants are analyzed to provide reference for the development of the global energy Internet.

1. Introduction
With the development of the energy Internet theory and experimental work, and the continuous release of the new electric power reform to the selling side, the market subject in the energy Internet will be constantly enriched. Therefore, the design of the transaction mode under the background of the energy Internet and analysis of the cost and income of the main body in the market have some references to the development of the energy Internet.

Wu Jielong studied the current status and development trend of global energy Internet technology [1]. Sun Qiuye studied the optimal control and implementation path of energy Internet [2]. Wang Li looked forward to the future of China's power industry according to the global energy Internet technology [3]. Raghavan and Krause carry out cost-benefit analysis of each participant in the electricity market [4-5].

2. Type of market subject transaction in global energy Internet
In the background of energy Internet, the market environment will emerge more transaction subjects. In addition to the existing market, such as power generation enterprises and power grid enterprises, the future trading body and market structure will be more extensive. All kinds of electricity selling companies, parks, buildings and even individual users may uncover themselves. The network interface, to varying degrees, participates in the energy Internet trading market.

2.1 Power supply enterprise
The power supply enterprise is divided into two types of power supply enterprises, A and B, as shown in Table 1.
Table 1. Classification of power supply enterprises in electric power market.

| Classification | Characteristics |
|----------------|-----------------|
| Class A power supply enterprise | A regular coal-fired unit and a clean energy unit with a certain capacity of a single machine, a strong production capacity, a continuous power supply and a clean energy unit |
| Class B power supply enterprise | B1 Captive Power Plant |
| | B2 Fuel unit, gas turbine unit and cogeneration |
| | B3 Pumped storage hydropower, nuclear power and distributed power supply |

2.2 Power grid enterprise
The power grid enterprises are divided into regional power grid enterprises and domestic power grid enterprises.

2.3 Trading Center
The trading centre is divided into regional power trading centre and domestic power settlement centre. The functions of the power trading centre are as follows: organize regional power market monthly and daily electricity trading and auxiliary service transactions. Execute all kinds of technical standards, safety standards, quota standards and quality standards.

2.4 Sale of electricity
The sale of electricity providers is divided into selling electricity providers and ensuring the sale of electricity providers.

1. The responsibilities of the operating seller are as follows: signing and performing the contract for the purchase and sale of electricity, participating in the market transactions, providing relevant information according to the market rules, and responsible for the construction, operation, maintenance and management of the terminal technical support system, and the power purchase from the regional electricity market by the countries.

2. The safeguards are reorganized mainly by the Power Grid Corp's electricity sale center. The following duties are as follows: signing and performing the contract for purchase and sale of electricity, providing a unified purchase and selling service for power users without the market, and providing relevant information according to the market rules, responsible for the end of the market. The construction, operation, maintenance and management of the technical support system are carried out. Price declarations are made to relevant departments of the national government. At the same time, they can participate in market competition.

2.5 Power terminal users
The power end users include large power users and ordinary users.

1. The responsibilities of the large power users are as follows: comply with the scheduling rules, perform the system security obligations, sign and perform the purchase and sale contracts with the power supply enterprises, provide relevant information according to the market rules, and participate in the market transactions.

2. Ordinary user duties are as follows: comply with the scheduling rules, fulfill the system security obligations, sign and perform the purchase and sale contracts with the independent electric company, and provide relevant information to the independent sale company (retailer) according to the market rules.

To sum up, all kinds of market players have the right to participate in market transaction and market management and get corresponding interests protection. The market participants must abide by these rules, fulfill their duties and strive to maintain the normal operation of the market.
3. Global energy Internet electricity market transaction

3.1 Varieties of electricity trading

Cross-border electricity transactions generally involve only cross-border energy transactions (including electric power forward and electric spot transactions), transboundary transmission rights transactions (Transnational transmission capacity allocation mechanisms), spare capacity transactions in auxiliary services and some electricity and financial derivatives transactions.

1) Transboundary electricity and energy transaction

Cross-border electricity energy transactions include cross-border electricity forward contracts and cross-border electricity spot transactions. Among them, the spot trading of cross-border electricity is mainly involved in the daily and intraday transactions. The real time balance of the power system is usually realized by the local power and demand side resources.

There are two kinds of organizational forms for cross-border day transactions carried out through the trading platform. One is that the market subject of a country can bid for the other country's pre-day market and follow the market clearing rules of the bid market; the other is that the market subject still tends to the Japanese market in its own country.

2) Transboundary transmission rights transactions

Cross border transmission rights transactions are used to allocate the transmission capacity of transnational tie lines for market members. The distribution of the capacitance of the tie line can be divided into two types: explicit auction and implicit auction. Explicit auction refers to the sale of all or part of the cross-border transmission capacity through annual and monthly public auctions.

The implicit auction is based on the cross-boundary day market of the United States. According to the price selling quotations or buying quotations of each country (or each price zone), the unused transmission capacity between countries is taken as a transmission constraint.

In addition, MNCs can also be used exclusively by specific market members, without the need for transmission capacity auctions, or fixed transmission prices, and distribution of transmission capacity according to the principle of "first come first".

3) Cross border services transaction

FM, voltage regulation and black start in auxiliary services are generally provided by local resources and do not involve cross-border transactions. Standby services can provide a reserve capacity and relevant power and responsibility through bilateral consultations by the dispatching agencies of the two countries (regions) and purchase corresponding reserve capacity in the domestic auxiliary service market. When the trade coordination mechanism and the coordination mechanism between different countries are relatively perfect, the market players can also directly bid for the reserve market in other countries.

4) Cross-border electricity financial derivatives trade

Cross border electricity derivatives must be based on the mature cross-border electricity spot market. Cross border electricity derivatives include electricity price difference contracts, electricity futures, electricity options and so on. Power differential contracts are generally carried out through bilateral negotiation, and standardized differential contracts can also be concentrated on a trading
platform; electricity futures and options transactions require a centralized bidding transaction in the futures exchange.

3.2 Form of power transaction organization

(1) Categories of the form of transaction organization

From the point of view of trading venues, the main form of transaction organization can be divided into two types: field trading and OTC trading. Trading outside the exchange (OTC) refers to a bilateral transaction agreement between the two parties through consultation. In the bilaterally trading market of Nordic electric power, the supply and demand information is issued by the power exchange centre, and the purchase and sale contracts are signed by the two parties in the exchange.

(2) The combination of cross-regional electricity trading

The integration of electricity transactions in various countries is an important way to achieve convergence in the electricity market. The key to forming the global energy Internet power market is the need for unified market operation rules and trading support platform.

3.3 Global energy Internet market transaction model design

(1) Centralized power trading mode

The centralized trading market model refers to the completion of all transactions in the power market centre (MSO, Market System Operator) and the system operation and scheduling center (ISO, Independent System Operator). All power transactions are carried out in the power bank (POOL), usually based on electricity. The spot trading market (real time market + day market) and the financial contract trading market based on the difference contract. The centralized transaction mode is more efficient in allocation of resources, but the market rules are more complex and the market power is difficult to monitor.

(2) Decentralized power trading mode

The decentralized trading market mode refers to the separate operation of MSO and ISO, which usually includes real-time equilibrium and the market based on bilateral contracts. MSO is responsible for pre- and long-term transactions. All MSO power transactions can be organized by both parties to determine the contract as far as possible and submit the ISO to execute the scheduling plan according to the contract.

4. Global energy Internet cost and benefit analysis

4.1 Analysis of the cost and benefit of market subject

(1) Power supply enterprises

1) Cost analysis

The cost of power generation enterprises mainly includes fixed cost and variable cost. The cost of the fixed cost is the depreciation and the operation and maintenance cost of the unit mainly. The variable cost is mainly the cost of fuel and the cost of the start and stop of the unit. The cost of conventional units such as conventional coal-fired units, fuel units and gas sets is mainly the purchase and transportation cost of one energy source. The cost of new energy sources, such as distributed energy, is mainly the new wind, light and so on.
2) income analysis
The earnings of the power supply enterprises mainly include the gains involved in the medium and long-term transactions and the spot transactions. The medium and long-term transactions include contracts signed with the large users and the power grid enterprises and the sellers. The spot transaction mainly refers to the income obtained by the power supply enterprises participating in the real time electricity market.

(2) Power Grid Corp
In China, the development of the electric side reform has changed the profit model of the Power Grid Corp. The operation mode of the Power Grid Corp has changed from the original purchase and sale difference to the charge of the net, and the profit is determined by the product of the average distribution of electricity price and the product of the sale of electricity. The future global energy Internet mode will be the inevitable trend of the sale of electricity side, so setting the Power Grid Corp's profit is determined by the product of the average distribution of electricity price and the quantity of electricity to deduct the cost of distribution.

1) cost analysis
The cost of Power Grid Corp is mainly the cost of purchasing electricity, that is, the cost paid by Power Grid Corp from the power supply enterprises.

2) income analysis
The revenue of Power Grid Corp is mainly the transmission and distribution revenue, that is, the transmission and distribution price approved by the government is multiplied by electricity sales.

(3) electric power trading center
As a non-profit operating and dispatching organization, the electric power trading center is responsible for the construction and operation of the cross-district power market. It is responsible for the implementation of the national plan, the local government agreements, the marketing of cross-border transactions and the future transnational transactions, the promotion of clean energy, and the future development of electricity and financial transactions. So there is no analysis of his cost and benefit here.

(4) electricity selling company
1) cost analysis
The cost of electricity selling companies is mainly the cost of purchasing electricity, including the cost of electricity from the power supply enterprises and Power Grid Corp.

2) income analysis
The income of the selling company is the income from selling electricity, that is, the selling power is multiplied by the selling price. This includes the two part of the proceeds from the medium and long-term trading market and the spot market.

(5) power users
1) cost analysis
The cost of electricity consumers is mainly the cost of purchasing electricity from different channels, including the cost of purchasing electricity directly from the power supply companies, Power Grid Corp and power companies.

2) income analysis
As the energy Internet allows power users to become providers of electricity from consumers, this makes power users have access to revenue, mainly including the revenue from renewable energy such as photovoltaic to the grid.

4.2 Market cost income analysis
(1) cost analysis
From the perspective of generating cost, the energy Internet effectively improves the efficiency and stability of the power generation of renewable energy, reduces the unnecessary loss of voltage, power and so on, and reduces the power loss. In addition, the construction of the global energy Internet can also increase the utilization rate of renewable energy, save the cost of power generation, bring
considerable economic and environmental benefits. Renewable resources such as wind energy and bioenergy have a certain cost advantage compared with traditional energy, and these cost advantages will be transformed into economic advantage under the impetus of energy Internet construction.

2) import cost analysis
For our country, the significance of building the global energy Internet is far more than reducing energy costs and increasing economic output. "Nature" once wrote that China became a net importer of oil in 1993, a net importer of natural gas in 2007, and a net importer of coal in 2011. If China's planned targets for wind, water and solar power can be achieved in 2017 and integrate into the global energy Internet, China can save at least 45% of the costs of importing oil, coal and gas. It can be seen from these data that the development of UHV, smart grid technology and the improvement of the efficiency of renewable energy use can save the cost of energy import, reduce the dependence of fossil energy, strengthen the economic security and resist the risk of globalization. At the same time, the acquisition of energy trade surplus will expand domestic demand, promote national economic growth, and provide more room for development in many areas of our country.

5. Conclusion
With the development of industry, the implementation of policies and the promotion of reform, the "Internet + energy" model has been the trend of the times. All countries in the world are stepping up the research on the energy Internet. The energy Internet after industrialization will occupy a broad market and bring huge economic benefits, which is attributed to the energy industry itself. On the other hand, the huge scale is determined by the characteristics of decentralization and marketization of the Internet.

First of all, the energy enterprise itself, as a traditional enterprise with infrastructure, has great potential economic benefits. Secondly, the global platform owned by the Internet will further promote its development on the basis of the energy industry. Therefore, the combination of the energy industry and the Internet will provide a broad development platform for the related enterprises in China. If reasonable used, it will not only bring significant economic benefits for our country, but also promote the upgrading of China's industrial structure and the optimal allocation of resources.

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References
[1] Hu Jielong, Yang Jian. Research on the Status and Development Trend of Energy Internet Technology [J]. Power Grid and Clean Energy, 2016,32 (03): 8-12. (in Chinese)
[2] Sun Qiuye, Wang Bingyu, Huang Bonan, Ma Dazhong. A narrow framework for optimal control of energy Internet and its implementation [J].Journal of Electrical Engineering, China, 2015, 35 (18): 4571-4580. (in Chinese)
[3] Wang Li. Discuss the future of China's power industry with the global energy Internet [J]. Management and technology for small and medium-sized enterprises (later issue), 2016 (04): 82-83. (in Chinese)
[4] Krause T, Andersson G, Froehlich K, et al. Multiple-energy carriers: modeling of production, delivery, and consumption[J]. Proceedings of the IEEE, 2011, 99(1): 15-27.
[5] Raghavan B, Irwin D, Albrecht J, et al. An intermittent energy internet architecture[C]//Proceedings of the 3rd International Conference on Future Energy Systems: Where Energy, Computing and Communication Meet (e-Energy). Madrid: IEEE, 2012; 1-4.