Study on the risks and countermeasures after openness of the electricity market

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Abstract. With the deepening of the reform of the electric power system, more and more uncertainties in the competitive electricity market mean more risks. This paper focuses on the risks and countermeasures after openness of the electricity market. Firstly, deeply analysis on the two traditional types transaction of power market which is large concentrated transaction and micro-balance of park electricity market; Secondly, analysis on the risk of transaction participants from three aspects. Finally, based on technology of information and platform, putting forward countermeasures and suggestions based on early warning of big data transaction platform, information value-added service and risk control strategies after openness of the electricity market. Future research orientation upon this analysis is establishment of power market risk evaluation index system and study of risk quantification methods.

1. Introduction
Since the Central Committee of the Communist Party of China and the State Council issued the "Opinions on Further Deepening the Reform of the Power System (Zhongfa [2015] No. 9)" on March 15, 2015, the reform of the power system has continued to deepen, and related supporting documents have also been issued one after another [1]. The policies issued by the central government promote the development of the liberalization of the electricity market, which acts as a leader in the reform of the electricity market. For this reason, in-depth research must be conducted as early as possible in order to take necessary preventive measures as early as possible, and to reduce the various pressures and risks brought about by the interference of the trading market.

Research scholars at home and abroad have achieved certain results in power market risk research, mainly focusing on risk management, risk control and risk assessment [2]. On the basis of the literature [3], the literature [4] analyzes the operating risks of grid companies in the competitive power market and builds a risk assessment index system.

In summary, there are certain research foundations for the problems of power market risks at home and abroad, including the integrity of the evaluation index system and the selection of risk control methods. However, this risk study does not combine policy factors and the background of the times. After openness of the electricity market, the current risk issues faced by transaction participants have not yet been studied.

The main objective of this paper is to discuss the new risks faced by transaction participants after the current openness of the electricity market, and propose measures to avoid risks, in order to reduce the risks brought by fluctuations of the environmental market and ensure the healthy development of the trading market.
2. Characteristics of electricity market transactions after openness of the electricity market

The power market after openness of the electricity market is based on the introduction of market competition in the power generation sector, that is, further opening up the distribution network on the basis of the wholesale competition model, introducing market competition in the sales channel, and power users have power purchase options, that is, they can choose to purchase electricity from power retailers or distribution companies that also run the power retail business. They can also purchase electricity directly from power generation companies as large users.

Before and after openness of the electricity market, the comparison of the power trading mechanism is shown in Table 1.

| Transaction Participants | before Openness of the Electricity Market | after Openness of the Electricity Market |
|--------------------------|------------------------------------------|-----------------------------------------|
| Power generation enterprises, power grid companies, a small number of approved participants | Diversified transaction participants, intelligent buildings, parks, power sales companies, small and medium-sized users |

| Transaction Type | before Openness of the Electricity Market | after Openness of the Electricity Market |
|-----------------|------------------------------------------|-----------------------------------------|
| Single          | Auxiliary service transactions, green certificate transactions, power generation rights trading, and carbon emission trading markets are increasingly active |
| Opaque, inadequate | Transparent, timely, and paid |

| Transaction Management | before Openness of the Electricity Market | after Openness of the Electricity Market |
|------------------------|------------------------------------------|-----------------------------------------|
| Planned                | Marketized                               |

After openness of the electricity market, diversified transaction participants began to form, the market structure became more flexible, and higher requirements were placed on the credit construction of participants. The types of electricity market transactions are gradually diversified to meet the needs of different participants in the market. Long-term, futures and other power bilateral trade contracts are introduced into the electricity market as an effective risk management tool, which has certain control over the risks brought about by the liberalization of the electricity market. And the entry of private funds into the electricity market has greatly promoted the liberalization of the electricity market, stimulated market vitality and expanded market competitiveness [5].

3. Risk analysis of power market transactions after openness of the electricity market

3.1. Risk analysis of power generation companies

The main risks faced by power generation enterprises after openness of the electricity market are falling revenue, unbalanced interests, blocked sustainable development, settlement and so on. Before openness of the electricity market, the power generation enterprise was operated according to the nationally approved power generation plan and the on-grid electricity price, and the supply and demand relationship was stable for a long time. After openness of the electricity market, due to changes of the supply and demand situation, unfair competition among power generation companies, and the adjustment of China's energy industry structure, the planned power consumption was greatly reduced. Power generation companies want to generate more electricity, they must enter the market to compete, and the transaction price in the market is unpredictable. And in general, the transaction price in the market is lower than the government’s approved electricity price, so power generation companies will face the risk of falling income [6-7].

3.2. Risk analysis faced by power sales companies

The main risks faced by power sales companies after openness of the electricity market are contract
settlement risks, credit risks, external competition and so on. After openness of the electricity market, users have the right to choose the power, and the power demand can be submitted to multiple power sales companies. The contract signing needs to meet certain effective conditions, and the power sales companies may face the risk of the user running the order. After the contract is signed, the power sales companies also face the risk of charging electricity in the market. At the same time, social capital has established relatively independent power sales companies that only conduct purchases and sales transactions. Compared with power sales companies established by power generation companies or power grid companies, and power sales companies with distribution network management rights, they will face greater credit risk, because due to their business management and financial management level, users may be more reliant on a sales company with a foundation.

3.3. Risk analysis faced by power users
The main risks faced by power users after openness of the electricity market are unfair competition risks between users, actual power deviations and so on. After the implementation of direct power trade, due to policy regulations, some users of high-energy-consuming industries enjoy electricity price discount. Serious cross-subsidies between users before the reform are still being phased out. The electricity price discount of these users will lead to unfair competition among users and reduce market efficiency. At the same time, after openness of the electricity market, the proportion of competitive electricity is increasing, which make grid enterprises more difficult to maintain the electricity balance. The large users are affected by the industrial environment and other aspects. The risk of real deviations from the amount of contracted power is gradually increasing. Affected by the contract signed by the large user and the power producer, the electricity deviation needs to be borne by the contractual entity, and a certain amount of compensation must be paid. This leads easily to the situation where the buyer and the seller have different opinions on the compensation clause.

4. Study on the measures of trading risk in power market after openness of the electricity market

4.1. Risk prevention and control early warning design based on big data trading platform

4.1.1. Monitoring model of trading platform resource running state. The monitoring model of trading platform resource running state mainly includes three parts: state detection, state analysis and comprehensive processing, as shown in figure 1.
State detection includes detecting the operation of power generation resources, transmission resources, and demand resources. Through the analysis and evaluation of operational data, monitor the operation rules of each resource, and timely discover possible system anomalies, timely report early warning or alarm information, and simultaneously arrest detailed information about the abnormal point and record the system running status at that time.

State analysis refers to whether the current resource running status meets the requirements according to the monitored resource running status, combined with the trading platform's rule requirements and historical data for resource operation, and whether there is a possibility of breaking the constraint according to the current development trend.

Comprehensive processing is based on the results of the operational state analysis, comprehensively judge whether the status of various resource operations meets the requirements, and whether it is efficient; For the abnormality that occurred, after recording the abnormal information, according to the corresponding abnormal emergency handling mechanism, the system is properly restored to the state before problem occurred, immediately take corresponding measures to re-enter the system into stable operation.

4.1.2. Power market transaction early warning and evaluation. In the electricity market, there are behaviours in which participants violate market rules. There are also acts that do not violate market rules but are directly or potentially harmful. It is a problem that all parties very concerned about such as power producers, power purchasers, market operation centers, and regulatory authorities. The indicator system for early warning and evaluation of power market transactions is shown in table 2.

| Indicator Name                                      | Indicator Description                                                                 |
|-----------------------------------------------------|---------------------------------------------------------------------------------------|
| Beforehand Early Warning Indicators for Power Market Transactions | Declared Space Share = \frac{q_i}{\sum q_i}, among which \( q_i \) can be the declared capacity of the power plant. |
| Price Increase Rate                                 | Price Increase Rate = (\text{P} - \text{C}) / \text{C}, among which \( \text{P} \) is the average declared price, and \( \text{C} \) is the average power generation cost. |
| Report High Price Ratio                             | Report High Price Ratio is the proportion of times the market supplier reports the price near the highest in a certain period of time. |
| Report High Price Success Rate                      | Report High Price Success Rate = the number of applying high-price strategies and reporting successfully / the number of applying high-price strategies in a period of time. |
| Top-m Share Indicator                               | Top-m Share Indicator is the market share of the largest \( m \) suppliers in the market. |
| HHI Indicator                                       | \( HHI = \sum_{i=1}^{n} (100 \times s_i)^2 \), among which \( s_i \) is the market share of the i-th market supplier. |
| Supply and Demand Ratio                             | \( \Gamma = \frac{Q_S}{Q_D} \), among which \( Q_D \) is the predicted total demand of the market, \( Q_S \) is the total supply. |

Therefore, the annual contract power is reasonably allocated, and then decomposed into monthly according to factors such as load forecasting curve, unit maintenance plan and unit technical limit, and then the monthly plan is allocated reasonably to ensure the uniformity of the contract power in space and time, improve the market structure of the next level of trading and avoid the price of the next level of trading soaring.
4.2. Design of pricing model for information service of distributing and using electricity

The pricing model for information service of distributing and using electricity consists of a cost model for information service of distributing and using electricity and a benefit model for information service of distributing and using electricity. At the same time, the impact of opportunity costs should be weighed comprehensively.

4.2.1. A cost model for information service of distributing and using electricity. The information service of distributing and using electricity has a wide range of sources and complicated management. Whether the system operation is stable, the calculation efficiency is high, and the benefit depends largely on the fixed cost of the information product construction. Its fixed cost (FC) mainly comes from purchasing and establishing the corresponding communication system, computer hardware systems, programs, databases and other software systems during information production, transmission and acquisition, including expenses for maintaining the operating these devices. However, as an information product, the variable cost (VC) of information service of distributing and using electricity is very low, mainly due to the upgrade and re-development of the program and the attention purchase cost of the information. The allocation of electricity information cost model affects the determination of the lower price limit of information. It is assumed that within the service life of the equipment, estimating the market demand for the information product as Q, the average fixed cost of the information product is determined: AFC=FC/Q, and the average cost of the information product is: PL=AC=AVC+AFC, where AVC is the variable cost of the unit information product.

4.2.2. A benefit model for information service of distributing and using electricity. The benefit model for information service of distributing and using electricity can affect the upper price limit of information. Generally speaking: PH=VN-V, VN is the income after the information is used, and V is the income before the information is used. In the power market, the information utility measurement V can be divided into:

- Purchase and sales increase benefit
  A power equipment company, Distributing electrical production investment company, or a power sales company, etc., carry out the production and operation of the customer, and process the raw materials CM purchased from other companies to obtain new products and sell them, and obtain income RE. The company obtains value through sales. The increase in value is the added value V, which is the difference between the sales revenue and the expenditure on the purchase of raw materials: V=RE-CM.

- Power generation benefit
  Large-scale heavy industry enterprises, through information service of distributing and using electricity, will transmit the increase in demand-side power load rate to the optimized operation of the power-generating side units. The operating conditions of the generator units will be stable, which will bring about an increase in the power generation efficiency of the units.
  Power Generation Benefit, where is Thermal Efficiency, is economic running time, is on-grid electricity price.

4.2.3. Determination of the final price of information of distributing and using electricity. It is assumed here that the service objects of information of distributing and using electricity are all rational, and have the technical conditions and personnel quality requirements of information commitment.
  Therefore, when determining the final price of information of distributing and using electricity, the impact of opportunity cost and false information on the price of information of distributing and using electricity should also be considered.

4.3. Design of risk management mechanism in power market transaction

For the market organization member management mechanism, after the power generation enterprise, the sales company, the power user and other market participants apply for registration, the power
trading institution shall accept the application for registration and cancellation of the market members, and conduct the audit according to the relevant access conditions, and sign the relevant market entry agreement, and organize and maintain the information and materials of the market participants; Establish settlement measurement information specifications and set settlement checkpoints for electricity transactions.

For the management of the transaction organization, the dispatching agency shall be responsible for the spot transaction, effectively ensuring the smooth development and safe execution of the spot trading market; The implementation and price of each type of transaction should be established; Under the premise of meeting the safety check conditions of the power trading institution, the adjusted electricity in the medium and long term trading contract can be transferred by the market participants.

5. Results and discussion
Based on the above analysis of the risks faced by power generation enterprises, power sales companies and power users after openness of the electricity market, three technical means are proposed to deal with these risks: First, based on the risk prevention and control early warning design of big data trading platform, to analyse the method and process of early warning and evaluation of power market transactions; Secondly, the design of information value-added services in the power market, which design the pricing model for information service of distributing and using electricity; Thirdly, establish a risk management mechanism for power market transactions.

6. Conclusions
The document “Implementation Opinions on Promoting the Reform of the Electricity Market” is an overall planning and comprehensive deployment after openness of the electricity market. On the power generation side, the profit model will be changed: Power generation companies can enter the power-selling side and incremental distribution network to expand the new business sector. On the user side, the free option can be opened: Users can directly trade through the electricity market and optimize the energy-using price. The power selling side can provide users with energy-efficient management, help users to optimize their energy-using implementation and improve power efficiency. The openness of the electricity market is an institutional change that can alleviate the existing contradictions in the power system and reconstruct electricity market transactions. Due to the complexity of the reform of the electricity market, it needs to be gradual, and the trading entities in the market need to face up to the market risks, scientifically and rationally avoid it, and stimulate the market vitality. This paper is a useful discussion on the risk research of power market transactions after openness of the electricity market, and proposes solutions.

- Firstly, it summarizes the characteristics of the trading mechanism and the organization and operation mode of the competitive power market after openness of the electricity market. The literature review of the power market transaction risk research in this paper is made.
- Secondly, it studies the Trading characteristics of the power market after openness of the electricity market to help the market trading participants to understand and consider the market environment. It is the market of large-scale centralized trading and park micro-balanced power trading. At the same time, it introduces several key risk issues faced by various trading participants in the power market environment from the aspects of power generation enterprises, power sales enterprises and power users, and analyses the factors of risk generation in detail.
- Finally, the paper studies the countermeasures against the risk of trading in the power market after openness of the electricity market, and proposes three technical means.

References
[1] China Economic Herald 2016 Guizhou: Promoting transformation by electricity reform and steady growth (2016-09-13A02)
[2] Shawky H A, Marathe A and Barrett C L 2003 A first look at the empirical relation between
spot and futures electricity prices in the United States *J Futures Markets* **23** 931-55

[3] Woo C K, Lloyd D and Tishler A 2003 Electricity market reform failures: UK, Norway, Alberta and California *Energ. Policy* **31** 1103-15

[4] Collins R A 2002 The economics of electricity hedging and a proposed modification for the futures contract for electricity IEEE Transactions on Power Systems **22** 68

[5] Wolfram C D 1999 Electricity MARKETS: Should the rest of the world adopt the UK reforms? *Regulation* **22** 48-53

[6] Tishler A and Woo C K 2006 Likely failure of electricity deregulation: Explanation with application to Israel *Energy* **31** 845-56

[7] Xiao P and Zeng M 2015 What is the change of electric reform *J. Chongqing Uni. Technol. (Social Sciences)* **01** 19-24