Design and Implementation of Power Market Operation Analysis Tag Library

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Abstract. Responding to the continuous development of power reform and power market, referred to research of the power market operation, this paper designs operational analysis tag library, which is carried out in four dimensions: market supply and demand analysis, market structure analysis, market behaviour analysis and market operation analysis, to display and track the trend of power market operations more intuitively, and describes the operation status of the power market more comprehensively. Besides, Power Market Operation Analysis Tag Library is designed to deal with power trading management from a macro perspective with decision support.

1. Introduction

The rationality of electricity market operation analysis is directly related to the operation of electricity market. Operational analysis which meets the characteristics of the power market operation and market structure can ensure the reliability, stability, orderliness of the power market and the profitability of market participants, so that the power market can achieve long-term sustainable development.

However, it has not been established a set of effective analysis and evaluation methods in China for power market operations in a complete, scientific and reasonable way at present to reflect whether the design of the power market is reasonable, whether the operation is normal, and whether the function of resource optimization is effective.

To address this lack of analysis and evaluation methods, based on the actual demand of Chinese power market construction, combined with the characteristics of Chinese power industry and power market development, this paper studies and proposes operational analysis technology based on big data in Chinese power market, conducts power market operation analysis with multi-dimensional interactive analysis technology, and establishes a description of the power market with a tag library. This tag library of operation status proposes a set of key tags based on indicators, reflecting the operational characteristics of the power market, providing reference for analysing and researching the construction of Chinese power market, effective evaluation and operation of the power market.

2. Analysis of power market operations

According to the traditional SCP paradigm theory in the theory of industrial organization, a market can be divided into three parts: market structure (Market Structure), market behaviour (Market Conduct) and market performance (Market Operation). At home and abroad \cite{1-3}, we have done amounts of research and practical work in the design of the operation structure of power market, and have
achieved some results. For example, Liu Dunnan, et al [4] proposed the power market operation index system from five dimensions, including market supply and demand, market structure, bidding strategy, supplier status and transaction results, to achieve comprehensive evaluation of power market operation. Guo Lei et al. [5] combined with the development characteristics of Chinese power industry and the construction requirements of the power market system, and proposed a complete set of power market analysis and evaluation index system framework, including market supply and demand, market structure, market behaviour, market efficiency, etc. 11 aspects of the content.

However, by observing the predecessors' power market operation analysis dimensions and indicators, it is found that the relevant researches at home and abroad are inclined to design indicators, not to design tag library. Besides, these researches do not stand or rarely stand in the perspective of transaction management in the design of indicators, such as the design of market structure dimension indicators. Basically, only the power market concentration is considered, and the situation of energy allocation and power allocation is considered less.

In addition to drawing on the analysis perspective of domestic and foreign research, the design of the power market operation tag library needs to be combined with the power operation monitoring data from the perspective of transaction management business needs. Therefore, based on the above research, the analysis of power market operation will be carried out in four dimensions: market supply and demand analysis, market structure analysis, market behaviour analysis and market operation analysis.

(1) Market supply and demand analysis
By comparing and analysing the power supply capacity, supply willingness of supply side and demand capacity, and the willingness of demand side, this analysis could determine the overall supply and demand comparison in the electricity trading market, and judge whether the supply and demand of power trading is balanced.

(2) Market structure analysis
By measuring the participation of all types of power market members, transaction type structure, power allocation, etc., market structure analysis could reflect the degree of power trading concentration, energy structure optimization, resource allocation.

(3) Analysis of market behaviour
From the two dimensions which are trading power and trading price, we can analyse the behaviour characteristics, trading performance and risk types of electricity market members.

(4) Market operation analysis
This dimension is carried out in three dimensions which are transaction organization, transaction execution, and compliance operation, focusing on the national unified power market activity and compliance operations.

3. Power Market Operation Analysis Tag Library
Figure 1 shows the design flow of power market operation analysis tag library.
on the analysis of data source of power market, through data extraction, cleaning, conversion and operation, the corresponding tags are designed to facilitate the popularization, display and track the trend more intuitively of the electricity market operation, and describe the operation status more comprehensively of the power market. The attributes of the tag include tag name, tag definition, tag type, tag rules, tag recency, tag permissions.

Under the premise of following the basic principles and general ideas of the design of the evaluation system of electricity market operation rules, the tag library, which is shown in Table 1, is designed in this paper by analysing market supply and demand, market structure, market behaviour and market operation of power market. The tags in market supply and demand call for different time dimensions, so that the tag recency of these tags need to be defined in year, season and month for operational requirements, the rest tags can be defined with year only. Besides, market members can be only permitted to access tags in market supply and demand to help decision-making and matching transaction object. The other three dimensions of tag library are free to power exchange centre to supervise, investigate and manage the whole electricity market. In addition, the tag rules could be adjusted based on the practical experience by power exchange centre.

3.1. Tag design of market supply and demand

3.1.1. Market supply capability label. The total power generation reflects the system supply capacity of electricity market. The average utilization hours of power generation equipment are used as an indicator to reflect the utilization degree of power generation equipment of power plants. It reflects the utilization efficiency of power generation enterprises to a certain extent. The larger the value, the higher the utilization rate of equipment operation of power generation enterprises. Therefore, the design of the capacity labels of power generation enterprises should be considered from the "power generation capacity" and "power generation equipment utilization rate". The power generation side declaration power and power growth rate are used to reflect the degree of willingness of the power generation enterprise participation in the transaction. If the power generation side declares a positive growth, it indicates that the power generation side's willingness is stronger than before. Therefore, the "power generation side declaration willingness" can be added.

3.1.2. Market demand capability label. The design of the demand side label is consistent with the power generation side. After considering electricity consumption, total declared power and power growth rate reflect the degree of willingness of the power generation enterprise participation in the transaction. If the declared power is large or the rate is positive, it indicates that the demand side has a strong willing for electricity. Therefore, in the design of the label, it is necessary to consider the label reflecting the "demand side declaration intention" on the demand side.

3.1.3. Supply and demand balance label. The supply and demand balance labels contain supply and demand ratio of capacity and declaration, and the growth rate of transaction price. These labels can be reflected in the balance and change of supply and demand of electricity transactions. However, to fully reflect the supply and demand of electricity trading, we need to consider the three labels together. For example, when the ratio of supply and demand of capacity is much larger than 1, and the ratio of declared supply and demand approaches 1 or even less than 1, the negative growth of the average price of electricity transactions indicates that the shortage of supply in the market is formed by artificially controlling the declared electricity.

3.2. Tag design of market structure

3.2.1. Market concentration label. "Supply side concentration", which can be quantified by HHI, could reflect the market concentration of power transaction supply and the distribution of trading power, so it needs to be considered in the tag design. Independent power trading ltd is generally engaged in electricity purchase and sales of electricity. The higher the proportion of electricity is sold
by independent power trading ltd, the more adequate the competition is among power trading ltd, so that the “sales competition of power trading ltd” needs to be considered in the label design. Trading power by large consumers is generated between large consumers and power plants through direct sales. The higher the proportion of trading power by large consumers is, the greater the proportion of direct transactions is, and the more likely the power user can save costs. Therefore, the “proportion of Trading power by large consumers” needs to be considered in the design of label.

3.2.2. Power configuration label. Inter-provincial transactions can promote inter-province adjustments, power supply structure adjustments, and regional resource optimization configurations. The greater the value of these trading’s rate is, the more adequate the power resources are utilized in the process of power trading, and the more reasonable the power allocation. Hence, the "power configuration rate" is needed to be considered in the design of the electricity configuration label.

3.2.3. Transaction structure label. In terms of the form of power trading, higher proportion of centralized bidding transaction power and faster growth rate indicate that the power trading competition is more complete and the degree of marketization of power trading is higher, so that the degree of marketization of power trading needs to be considered.

3.2.4. Energy structure label. From the perspective of energy structure, power plants are divided into coal plants and clean energy power plants. When the proportion of thermal power transactions is low, the growth of thermal power transactions is slow, or the growth rate of clean energy is increasing, it shows that the energy structure is optimized and adjusted. Therefore, the “energy structure optimization degree” label which contains “main energy of trading”, “growth of thermal power in trading” and “growth of clean energy in trading”, is added to the design of the energy structure label. Besides, when the clean energy consumption ratio and growth rate increase, the utilization rate of clean energy in the market is indicated to be improved, and the “growth of clean energy utilization level” can be added to the design of the label.

3.3. Tag design of market behaviour

3.3.1. Market supply capability label. The reporting price and reporting volume can directly reflect the market behavior of members of electricity market. The declared retention rate, which is the power generation capacity of the power plants minus the actual reporting volume divided by the power generation capacity. The higher the declared retention rate is, the stronger the control degree of the power supply side is, and the more obvious the intention of the limited price increases. From the overall perspective of electricity market, if the reporting retention rate of the market increases, it will lead to tight supply and higher market prices. Therefore, “price control degree of supply side” is added. The high-price declaration rate of power plants is the ratio of declared electricity with a declared price higher than 95% of the price ceiling to the total declared electricity. When the rate is high, or the growth rate of high-priced declarations is positive, it indicates that power plants hold an optimistic attitude in power trading. In this process, power trading may be in the seller's market with less supply, so we add "supply-side market power" in the design of the label. On the demand side, when the low-cost ratio is high, and the growth rate in the demand-side low-price declaration is positive, it indicates that the demand-side enterprises are in a favorable market position in the whole power transaction. Therefore, the “demand-side market power” needs to be considered.

3.3.2. Bidding price strategy label. From the point of view of the bidding price strategy, the volatility of the quotation reflects the changing trend of the quotation of electricity market members. The convergence rate of the quotation reflects the consistency of the quotation. Therefore, "quote fluctuations" and "quote consistency" can be considered.
3.4. Tag design of market operation

In market operation, when the number of registered members or the number of enterprises participating in the transaction shows a positive growth, it indicates that the active participation of market members is high, the willingness to bid is strong. Hence the label design needs to consider “market member activity”, which contains “register activity” and “transaction activity”. In the two dimensions of transaction execution and compliance operation, when the settlement of electricity and the number of settlements increase, or the contract filing rate, the contract completion rate, and settlement completion rate grow, it indicates that the settlement of power transactions is better. Therefore, the “settlement quality”, which contains “growth of settlement”, “status of contract filing”, “status of contract completion” and “status of settlement completion”, needs to be considered in the label design.

**Table 1. Power Market Operation Analysis Tag Library**

| Dimension of Operation | Dimension of tags | tag name | tag definition | tag type | tag rules |
|------------------------|------------------|----------|----------------|----------|-----------|
| Market supply capability | power generation capacity | Range of power generation capacity | Numerical range | Based on the amount |
| Market supply capability | power generation equipment utilization rate | Range of average utilization hours of power generation equipment | Numerical range | Based on the amount |
| Market supply and demand | power generation side declaration willingness | Growth rate of power generation side declaration a | Tendency | a >5%, increase. -5% <a < 5%, invariant. a < -5%, decrease. |
| Market demand capability | electricity consumption | Range of electricity consumption | Numerical range | Based on the amount |
| Market demand capability | demand side declaration intention | Growth rate of demand side declaration b | Tendency | b >5%, increase. -5% <b < 5%, invariant. b < -5%, decrease. |
| Supply and demand balance | supply and demand ratio of declaration | Ratio between supply and demand declaration c | Tendency | c<0.8, demand exceeds supply. 0.8<= c <=1.2, Supply balance. 1.2< c <=2, oversupply. c >2, oversupply seriously |
| Market Structure | Market concentration | Supply side concentration | HHI | Numerical range | HHI>0.18, low.0.1<=HHI<0.18, medium. HHI<0.1, high |
| | Market concentration | sales competition of power trading ltd | proportion of independent power trading ltd d | proportion | d >20%, high. 5% <= d <20%, medium. d <5%, low |
| | Market concentration | proportion of | proportion of | proportion | e <5%, low,5% < |
| Category                        | Indicator                                                                 | Numerical Range               | Tendency                      |
|--------------------------------|---------------------------------------------------------------------------|--------------------------------|-------------------------------|
| **Trading power by large consumers** | e <= 20%, medium. e > 20%, high                                           |                                |                               |
| **Power configuration rate**   | Growth rate of inter-provincial transactions f                            | f > 5%, increase. -5% <= f <= 5%, invariant. f <= -5%, decrease |                               |
| **Degree of marketization of power trading** | Proportion of centralized bidding transaction power g                    | g > 50%, high. 20% <= g <= 50%, medium. g < 20%, low |                               |
| **Main energy of trading**     | Thermal power / clean energy transaction power ratio > 50%                | Thermal power transaction power ratio > 50%, Thermal power. clean energy transaction power ratio > 50%, clean energy |                               |
| **Growth of thermal power in trading** | Growth rate of thermal power in trading h                                | h <= 5%, slow. h > 5%, fast |                               |
| **Growth of clean energy in trading** | Growth rate of clean energy in trading k                                | k <= 5%, slow. k > 5%, fast |                               |
| **Growth of clean energy utilization level** | Growth rate of clean energy utilization l                                | l > 0%, increase. l < 0%, decrease |                               |
| **Price control degree of supply side** | The declared retention rate m                                           | m > 50%, obvious. 20% <= m <= 50%, ordinary. m < 20%, low |                               |
| **Supply-side market power**   | The growth rate of high-priced declarations n                            | n > 0%                        |                               |
| **Demand-side market power**   | The growth rate in the demand-side low-price declaration p               | p > 0%                        |                               |
| **The absolute volatility of the quotation q** | Tendency                                                               | q > 5%, big. q < 5%, small |                               |
| **The convergence rate of the quotation r** | Tendency                                                               | r = 0%, accordance. 0% < r < 5%, convergence. r > 5%, great difference |                               |
4. Conclusion
From the macro perspective of power trading, through multi-dimensional interactive analysis technology, the power market operation is analysed from the aspects of market supply and demand, market structure, market behaviour, market operation, and a tag library reflecting operational links, transaction execution, result analysis and other operational links is proposed. It helps power trading managers understand the market trading trends, such as market-oriented trading trends, energy trading and consumption structures, market trading concentration, direct power trading trends, market member activity, etc., so as to deal with power trading management from a macro perspective with decision support.

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