Research on Transaction Evaluation Model Based on Multi-region Interconnected Power System

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Abstract: Power market assessment has important significance for market construction and development, which can reveal development trend of market through and reflect the problems in market operation so that electricity market can healthily develop and market rules can be improved. Therefore, combined analysis of market evaluation index selection in multi-regional interconnected power system with quantitative principle of indicators, transaction evaluation model that meets the characteristics of power market is designed in this paper where analytic hierarchy process is adopted to scientifically determine the weight of transaction evaluation indicator and construct a complete set of electricity market evaluation index system.

1 Introduction

Comprehensive index, the earliest and most successful market application index, is an important method for market trading trend analysis, which can help market members understand the market trend by calculating daily market trading comprehensive index and displaying it through K-line chart. Besides, electricity market is an emerging market with electricity as commodity. In the context where rapid development occurs in current power market, it plays an important role in improving trading level of market members that comprehensive index analysis method is used to analyze the trend of power market transactions. First, under multi-regional market trading system, user's electricity purchase cost is analyzed in this paper to put forward multi-regional transaction benefit evaluation index[1-2]. Meanwhile, with reference to comprehensive index calculation method in stock market, power comprehensive index calculation method in the electricity market transaction whose visual design method is introduced based on the K-line diagram is proposed. Finally, according to actual data structure of certain province's electricity market in China, effectiveness of the method proposed in this paper is verified.

2 User Benefit Evaluation under Multi-regional Transactions

2.1 User Purchase Cost under Multi-regional Transactions

With the construction of electricity spot market, multi-regional electricity market transaction system of “medium and long-term electricity market including electricity transactions under timings of annual, quarterly and monthly+ electricity spot market including power trading at different timings, such as before and during the day” will be gradually formed on China [3]. Moreover, trading patterns and varieties of electricity markets in different regions are not the same. However, under any market structure, power load demand of power users can be expressed as the sum of standard power and deviation power in each regional power market, which is shown in Figure 1.

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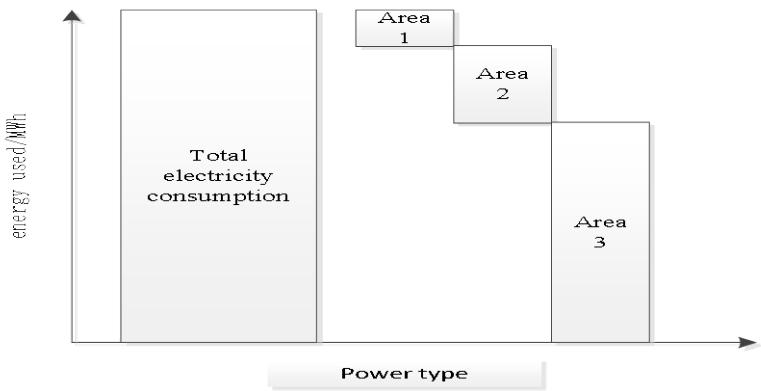

Figure 1 Multi-zone Power Meets Demand

The rightmost item in Figure 1 represents actual power consumption of user, and subsequent items are deviation power and winning power in each regional market transaction. Daily electricity consumption of power user can be expressed as follows.

$$W_i^{D,R} = \sum_{t=1}^{Ntype} W_{i,t}^{T/D} + W_i^{Dev} \tag{1}$$

In equation 1 $W_i^{D,R}$ is actual electricity consumption of power user for *i* day, NType refers to the number of trading varieties in different regions of electricity market, and $W_{i,t}^{T/D}$ indicates daily cumulative amount of registered electricity in transaction type *t* or daily decomposition amount. For medium and long-term power transaction types such as annual power transaction and monthly power transaction, A is the decomposition value of standard electricity on current day. However, for current spot transaction type such as spot transaction before the day, spot transaction within the day or real time spot transaction, B is the accumulated value of standard electricity on current day. What's more, W_i^{Dev} is deviation between actual electricity consumption and bidding power in electricity market transactions among different regions. Since clearing prices of electricity markets in different regions are different, cost of purchasing electricity can be expressed as follows in consideration of user's electricity consumption structure.

$$C_i^{D,R} = \sum_{t=1}^{NType} p_{i,t}^{T/D} W_{i,t}^{T/D} + p^{Dev} W_i^{Dev} \tag{2}$$

In equation 2 $C_i^{D,R}$ is current purchase cost of user *i*, $p_{i,t}^{T/D}$ represents clearing price of transaction type *t*, and p^{Dev} refers to penalty price of deviation power.

2.2 User Benefit Evaluation under Multi-Regional Transactions

Benefit of users is the difference between their revenue and cost. However, in the early stage of electricity market development, the revenue of user's production and operation has no direct relationship with electricity market, and its cost change is related to whether it participates in market-oriented transactions. Therefore, under the market environment, benefit of user market transactions is the difference among cost of electricity used in market transactions[4-5].

$$\mathrm{B}_{\mathrm{i}}^{\mathrm{D,R}} = C_i^{D,B} - C_i^{D,R} \tag{3}$$

In equation 3 $B_i^{D,R}$ is market transaction benefit index of user *i* on the day, and $C_i^{D,R}$ and $C_i^{D,B}$ respectively represent purchase cost whether it participates in multi-regional market transaction. If user does not participate in market transaction, purchasing electricity cost will be the product of electricity consumption and benchmark electricity price, which can be further decomposed according to winning power of each time series under multi-regional transaction. The expression is as follows.

$$C_i^{D,B} = p_i^B W_i^{D,R} = \sum_{t=1}^{NType} p_i^B W_{i,t}^{T/D} + p^B W_i^{Dev} \tag{4}$$

In equation 4 p_i^B is the benchmark price of user *i*, which is set by government price department. Moreover, compared with equations (2) and (4), multi-time transaction user benefit indicators can be expressed as follows.

$$B_i^{D,B} = \sum_{t=1}^{NType} (p_i^B - p_{i,t}^{T/D}) W_{i,t}^{T/D} + (p_i^B - p^{Dev}) W_i^{Dev} \tag{5}$$

In order to urge users to improve transaction levels, each power market often sets higher deviation penalty price. Therefore, there often exist following relationship.

$$p^{Dev} > p_i^B > p_{i,t}^{T/D} \tag{6}$$

3 Calculation and Demonstration of Power Comprehensive Index Based on Benefit Evaluation

3.1 Calculation Method for Power Comprehensive Index

Broad market composite index in stock market is obtained according to the ratio of the sum of product closing price and corrected weighting factor to the sum of product historical fixed date. What's more, depending on the choice of stocks, power composite index can be divided into large market index that assesses the entire stock market or industry/sector index for industry or sector. However, there are some differences in the purpose between power composite index and stock market composite index[6]. Users of stock market comprehensive index are mainly investors who use market comprehensive index to analyze the trend of stock price changes, and users of power comprehensive index are mainly electric power users who use power comprehensive index to analyze market trading trend and optimize trading strategy. Therefore, differences in evaluation lead to differences in their calculation methods.

Calculation method of power comprehensive index based on benefit evaluation, which is proposed in this paper, aims to select trading benefit index of all market users in certain industry or certain area according to the needs of evaluation purpose so that evaluation index can be comprehensively obtained with the help of power consumption which is treated as weight coefficient. According to above criteria, calculation formula of power comprehensive index can be expressed as follows.

$$In_{n,t} = \sum_{i \in n} B_i^{D,R} \mu_i \tag{7}$$

In equation 7 $In_{n,t}$ is power comprehensive index of industry or region *n* on the tth day, μ_i refers to the power consumption proportion of user *i* on *t* day, and i∈n indicates that user *i* belongs to industry or region *n*. The formula for calculating the ratio μ_i as follows.

$$\mu_i = \frac{W_i^{D,R}}{\sum_{j \in n} W_j^{D,R}} \times 100\% \tag{8}$$

In equation 8 $\sum_{j \in n} W_j^{D,R}$ is the sum of daily electricity consumption among all users belonging to industry or region *n*. Compared with stock market composite index, power comprehensive index is obtained by weighting power consumption of electricity user market in certain industry or region. Therefore, its numerical value actually reflects market-oriented transaction efficiency of the industry. On the contrary, for market users, compared with regional or industry power composite indices with the reference of performance indicators, transaction efficiency can be evaluated to improve transaction strategies.

3.2 Display Method for Power Comprehensive Index

Power comprehensive index can offer overall level of transaction benefit to market users in certain industry or region, but does not energize structural characteristics of its internal user transaction benefits, which is not conducive for market users to determine their location. Therefore, according to commonly used K-line diagram display method in stock market, K-line diagram display method in power comprehensive index is designed in this paper.

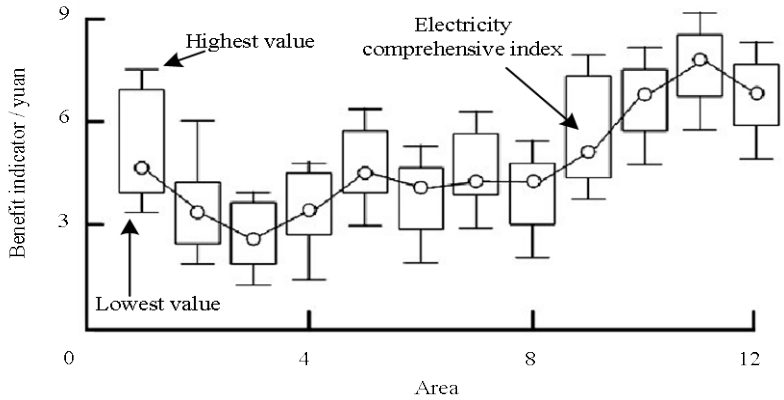

Figure 2 K Line Schematic Diagram of Power Comprehensive Index

Figure 2 shows the K-line diagram of multi-day continuous power comprehensive index proposed in this paper. Meaning of each specific eigenvalue in K-line diagram is shown in Figure 2. Moreover, for user benefit calculation result of certain day, the highest position in K-line chart corresponds to the maximum value of benefit calculation among all users, and the lowest position corresponds to the minimum value of benefit calculation among all users. In addition, upper limit in middle histogram is the location of user who is 80% of the top in benefit indicator, and the lower limit is the location of user after 20% in benefit indicator. Therefore, power comprehensive index should be within the histogram range. The closer upper limit of histogram is, the higher the number of users who show excellent transaction benefits will be. Otherwise, the majority of users' transaction benefits will need to be improved.

4 Conclusion

Calculation method of benefit indicators based on benefits of users participating in electricity market under multi-regional market transactions is proposed in this paper, according to which calculation method of power comprehensive index and comprehensive index display method based on K-line graph are proposed as well. Meanwhile, based on data practice from market transactions in certain province in China, method proposed in this paper can be effectively used to evaluate transaction level among different industries and users, which has a guiding effect on improving the efficiency of market transactions.

References

[1] [1] Hui H.W., Zhou C.C., Xu S.G., Lin, A Novel Secure Data Transmission Scheme in Industrial Internet of Things, China Communications, vol. 17, no. 1, pp. 73-88, 2020.

[2] Lin F.H., Zhou Y.T., An X.S., Ilsun You, Kim-Kwang Raymond Choo, Fair Resource Allocation in an Intrusion-Detection System for Edge Computing: Ensuring the Security of Internet of Things Devices, in IEEE Consumer Electronics Magazine, vol. 7, no. 6, pp. 45-50, 2018. doi: 10.1109/MCE.2018.2851723.

[3] Su J.T., Lin F.H., Zhou X.W., Lv X., Steiner tree based optimal resource caching scheme in fog computing, China Communications, vol. 12, no.8, pp. 161-168, 2015

[4] Guo Hengdong, Gao Qi, Gong Gaoqi. Research on the method of setting resource buffer buffer

based on improved [J]. Combined machine tools and automated processing technology. 2018(12)

[5] LIU Xiaowei, HAN Ying. Research on Risk Evaluation of PPP Project Based on Cov-AHP-Fuzzy Comprehensive Evaluation Method[J]. Journal of Liaoning University of Technology (Natural Science Edition). 2018(05)

[6] DI Fan, ZHOU Xia. Risk Assessment of PPP Projects in Private Enterprises Based on Fuzzy Comprehensive Evaluation[J]. Journal of Beijing Jianzhu University. 2018(03)