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Comprehensive Evaluation Model for the Implementation Effect of China's Transmission and Distribution Tariff Reform

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***Abstract*— *Building the comprehensive evaluation model for the implementation effect of the transmission and distribution tariff reforms is crucial to the improvement of the transmission and distribution pricing mechanism, the smooth progress of the power marketization reform, and the sustainable development of the industry in China. An index system for evaluating the implementation effect of transmission and distribution tariff reform was built in four dimensions, which are economic efficiency, safety and reliability, energy saving and environment protection, satisfaction, and this index system contains 12 detailed indicators. For comprehensively evaluate the implementation effect of China's transmission and distribution tariff reform, a hybrid MCDM model which combines the Matter-Element Extension Model with the Best-Worst Method was proposed. The Best-Worst Method was used for criteria weight determination, and the Matter-Element Extension Model was employed to rank the comprehensive performance of implementation effect of the transmission and distribution tariff reforms in China. This paper can provide references for policy-makers to improve the transmission and distribution tariff reform policy.*

***Keywords*— transmission and distribution tariff reform, comprehensive evaluation model, the matter-element extension model, the best-worst method.**

I. INTRODUCTION

In 2015, 'the Opinions on Further Deepening the Reform of the Power System' issued by the Central Committee of the Communist Party of China proposed the separate verification of power transmission and distribution price in the principle of permitted cost plus reasonable income, and the electric power transmission and distribution prices would be verified by the voltage class. Perfect the grid's constraint and incentive mechanism, promote grid enterprises to improve management, reduce costs and enhance efficiency. At the end of June 2017, all the provincial grids undertook the power transmission and distribution price reform, indicating that China's first round of power transmission and distribution price pilot reform has been fully completed. Since the pilot reform of the Shenzhen electric power grid, the power transmission and distribution price reform has been enduring more than two years, the effects and problems of the reform have gradually emerged. Therefore, it is necessary to establish a scientific and reasonable evaluation index system based on the actual situation of China's power transmission and distribution price reform to comprehensively assess the current work on the transmission and distribution price reform.

Regarding the study of policy effect evaluation model and method, Swedish scholar Even Vedung proposed three kinds of policy evaluation model, namely professional model, economic model and effect model, and established 10 models for different evaluating criteria [1]. Ref. [2] summarized several most commonly used policy effect assessment methods, which are Before-and-after comparison method, whether-or-not-a-policy comparison method, Practice-and -planning comparison method. Ref. [3] pointed out that the evaluation of regulatory effect offers a way to improve regulatory decision-making and practice, proposing the regulatory effect evaluation model that can be applied in low-income and middle-income countries.

For China's studies, they mainly focus on basic theoretical research such as assessment step, principle, standard, and evaluation index system, few empirical studies have been taken in the policy effect of power industry reform. Ref. [4] measures the market-oriented reform performance of the power industry from two aspects of total power generation and price level, and the result shows that the market-oriented reform has significantly reduced the price of electricity, but there is

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little impact on the total power supply. Ref. [5] used the DEA method to measure the efficiency of power generation enterprises, transmission and distribution enterprises, generation and transmission and distribution integration enterprises, and it also comprehensively evaluated the formulation, implementation and performance of power industry supervision policies based on the fuzzy comprehensive evaluation method. Ref. [6] evaluated the performance of electricity market from power generation side, power supply side, user side, market transaction and development coordination. Based on SCP analysis paradigm, the research has been taken in China's current electricity market structure, behavior and performance. Ref. [7] used the stochastic frontier model to measure the production efficiency of the power grid before and after the reform of China's power industry, indicating that the grid reform in 2002 was quite effective, but the efficiency of power transmission was low. Ref. [8] comprehensively evaluated the price subsidy, efficiency cost and welfare effect when introducing the peak valley electricity price after the ladder price, based on Ramsey pricing theory and cognitive price response hypothesis. Ref. [9] evaluated the power saving effect after implementing the residential ladder price plan, based on the utility function.

The research on the reform of power transmission and distribution price is mainly reflected on the effectiveness of the reform, its existing problems, and the experience of foreign power transmission and distribution price control. The effect study of this type of regulatory model is still blank. With the continuous advancement of power market reform, the central and local governments, enterprises, users and other parties are generally concerned about the implementation effect of power transmission and distribution prices in the cost plus income regulatory mode. Therefore, it is necessary to construct a scientific and reasonable comprehensive evaluation model to assess and analyze the implementation effect of China's power transmission and distribution price reform.

II. THE ESTABLISHMENT OF EVALUATION INDEX SYSTEM

This paper comprehensively evaluates the effectiveness and performance of the power transmission and distribution price reform policy. The government's regulation on the power transmission and distribution price not only includes economic supervision, but also the external issues, such as safety, reliability and environment, which belongs to the social supervision. Based on the objective principle of the power transmission and distribution price reform described above and the evaluation dimension in the UK RIIO regulatory model (revenue = incentive + innovation + output) [10], this paper develops an evaluation index system with 4 dimension, including economic efficiency, safety and reliability, energy saving and environmentally-friendly. The index system is shown in Figure 1.

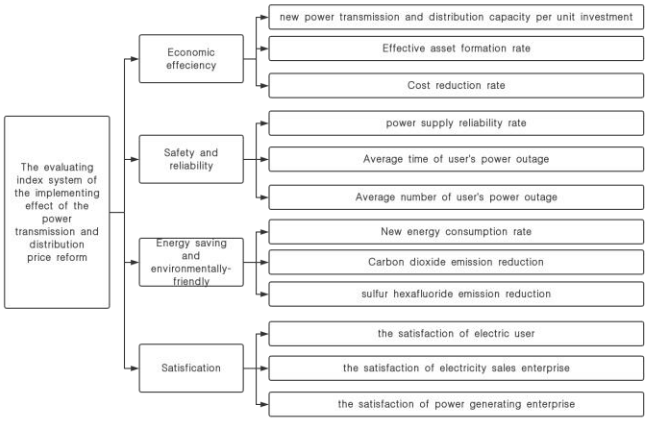

Fig. 1: Evaluation index system of the implementation effect of transmission and distribution tariff reform

1.1 Economic efficiency index

The regulation of transmission and distribution price includes total income supervision and price structure supervision, and the verification of total income is based on effective assets. The price structure is verified by the voltage class, based on the power transmission and distribution's effective assets, expenses and electricity of each voltage class. It can not only meet the normal and reasonable investment needs of the power grid, ensure the stable sources of the income level of the power grid enterprises, but also strengthen the cost constraints, strictly monitor the power transmission and distribution costs, facilitate the enterprises to improve the management, reduce costs and enhance efficiency. It includes the new power transmission and distribution capacity per unit investment, effective asset formation rate, cost reduction rate.

1.2 Safety and reliability index

The power transmission and distribution price reform has changed the main business of grid enterprises. The grid enterprises have been seen as network hubs, the main revenue of the grid will not only make up the related power transmission and distribution costs, but also promote the reliability of power grid security, safeguarding the main business [12]. China measures the reliability on the supply side by a number of indexes like the power supply reliability rate, average time of user's power outage and average number of user's power outage.

1.3 Energy saving and environmentally-friendly index

The traditional spread profit model is an insufficient incentive for grid enterprises to absorb new energy. After the power transmission and distribution price reform, the market-oriented trading mechanism of electricity is gradually improved, and the conventional thermal power generation plan is implemented in an orderly manner. The planning and dispatching of the generation can prioritize the new energy generation, thus decreasing the energy consumption and the emission of polluted gas. In addition, the grid enterprises have certain responsibilities in energy saving and emission reduction. The power transmission and distribution price reform makes the grid to set a goal to offer the high-efficiency power transmission and distribution services, reduce the emission of carbon dioxide by cutting down energy consumption, reduce the emission of sulfur hexafluoride by the recycling and purification treatment system. It includes the new energy generating consumption rate, carbon dioxide emission reduction, sulfur hexafluoride emission reduction.

1.4 Satisfaction index

The power transmission and distribution price reform is a systematic project involving different subjects. The power grid enterprises belong to the controlled object, and do not involve in satisfaction survey. Based on the impact of power transmission and distribution price reform, the satisfaction index layer includes three main subjects: power users, power sales enterprises, and power generation enterprises. The satisfaction index can be calculated by the corresponding satisfaction questionnaires of power users, power sales enterprises and power generation enterprises. The respondents score the satisfaction according to [0~10].

III. COMPREHENSIVE EVALUATION MODEL FOR THE IMPLEMENTATION EFFECT OF CHINA'S TRANSMISSION AND DISTRIBUTION TARIFF REFORM

Most comprehensive evaluation methods can only calculate a comprehensive value for the evaluating object, and compare the comprehensive values of multiple objects to judge the pros and cons. This paper evaluates the effect and performance of the power transmission and distribution price reform policy, and it is insignificant to simply calculate the comprehensive value of the evaluating object. The matter-element extension evaluation method can divide the evaluating object into multiple levels. Considering the complexity and the wide range of the power transmission and distribution price reform policy system and imitating the improved variable weight matter element extension model in the literature [18], this paper firstly uses the optimal and worst method to determine the weight of each index. Then, the improved matter element extension evaluation method is used to establish a comprehensive evaluation model for the implementation effect of the power transmission and distribution price reform.

2.1 The Best-Worst method

The Best-Worst method (BWM) fully considers the experts' opinions, experience and knowledge, which is based on the idea of pairwise. By sorting out the best and worst two special indexes, it simplifies the comparison process, reduces the risk of inconsistency, guarantees the accuracy of judgment, gets more reliable results, and considers the fuzzy problem decision in the absence of complete information and qualitative judgment. The specific steps are as follows:

Step 1: Select the optimal index c_B and the worst index c_W in the index set $\{c_1, c_2, \cdots, c_n\}$. The selection of the optimal index and the worst index do not consider the value of the index, but the importance among the indexes. The most significant and preferred one is the optimal index, and the relatively insignificant and less preferred one is the worst index.

Step 2: Use the 1~9 scale to score and determine the preference of the optimal index compared to all other indexes, and build a comparison vector $A_B = (a_{B1}, a_{B2}, \cdots, a_{Bn})$. Among them, a_{Bi} represents the degree of preference of the optimal index compared with the index i. The larger the value, the more significant is the optimal index than the index i. There is $a_{BB} = 1$.

Step 3: Use 1 to 9 scales to determine the preference of all other indexes compared to the worst indexes, and build a comparison vector $A_W = (a_{1W}, a_{2W}, \cdots, a_{nW})$. Among them, a_{iW} represents the degree of preference of index i compared to the worst index, and the greater the value, the more important is the index i better than the worst index. There is $a_{WW} = 1$.

Step 4: Construct the mathematical programming problems and solve them to get the optimal weight $(w_1^*, w_2^*, \cdots, w_n^*)$. To get the optimal weight for each index, it needs to minimize the largest value among all indexes' value $\{|w_B - a_{Bi} w_i|, |w_i - a_{iW} w_W|\}$, so the planning function can be written as:

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$$\min \max_i \{|w_B - a_{Bi} w_i|, |w_i - a_{iW} w_W|\}$$
$$s.t.$$
$$\sum_i w_i = 1,$$
$$w_i \geq 0, \text{for } i \qquad (1)$$

The planning function in Equation (1) can be converted into the following form to solve:

$$\min \xi$$
$$s.t.$$
$$|w_B - a_{Bi} w_i| \leq \xi, \text{for } i$$
$$|w_i - a_{iW} w_W| \leq \xi, \text{for } i$$
$$\sum_i w_i = 1,$$
$$w_i \geq 0, \text{for } i \qquad (2)$$

Equation (2) is a linear equation and has only one unique solution. By solving the model, the optimal weight can be obtained, namely $(w_1^*, w_2^*, \ldots, w_n^*)$.

Step 5: Conduct a consistency check. The consistency ratio can be calculated from the values ξ^* obtained from the planning model and consistency coefficients, which is as follows:

$$CR = \frac{\xi^*}{CI} \qquad (3)$$

where, CR represents the consistency ratio, CI represents the consistency coefficient. It can be seen that, the smaller the value of ξ^* is, the smaller is the consistency ratio, and the larger is the consistency coefficient, the higher is the reliability of the comparison.

2.2 Improved matter element extension evaluation method

The matter element extension evaluation method can be used to establish a quality assessment model that indicates the multifeature performance parameters of an object, and the evaluation results can be expressed in quantitative specific value.

Object P has the feature C, the value or range of C is V, the ordered triples $\boldsymbol{R} = (P, C, V)$ composed of P, C and V serve the basic element, short for matter element, which depicts the object. Object P, feature C and value V are the three factors of element $\boldsymbol{R}$. Provided that P has amount of n features, P can be described by the features $c_1, c_2, \ldots, c_n$ and values $v_1, v_2, \ldots, v_n$, that depicts $\boldsymbol{R}$ the N dimensions element as follows:

$$\boldsymbol{R} = (\boldsymbol{P}, \boldsymbol{C}, \boldsymbol{V}) = \begin{bmatrix} R_1 \\ R_2 \\ \ldots \\ R_n \end{bmatrix} = \begin{bmatrix} P & c_1 & v_1 \\ & c_2 & v_2 \\ & \ldots & \ldots \\ & c_n & v_n \end{bmatrix} \qquad (4)$$

where $\boldsymbol{R}_i = (\boldsymbol{P}, \boldsymbol{C}_i, \boldsymbol{V}_i)$ $i = 1, 2, \ldots, n$ is the Partition element of $\boldsymbol{R}$. $C = [c_1, c_2, \ldots, c_n]$ is n feature vector, $V = [v_1, v_2, \ldots, v_n]$ is the value of feature vector.

The basic steps of the matter element extension evaluation method are:

Step 1: Determining the classic domain, the joint domain, and the matter element to be evaluated.

$$\boldsymbol{R}_j = (\boldsymbol{P}_j, \boldsymbol{C}_i, \boldsymbol{V}_{ji}) = \begin{bmatrix} P_j & c_1 & v_{j1} \\ & c_2 & v_{j2} \\ & \ldots & \ldots \\ & c_n & v_{jn} \end{bmatrix} = \begin{bmatrix} P_j & c_1 & <a_{j1}, b_{j1}> \\ & c_2 & <a_{j2}, b_{j2}> \\ & \ldots & \ldots \\ & c_n & <a_{jn}, b_{jn}> \end{bmatrix} \qquad (5)$$

where $\boldsymbol{P}_j$ is the number j evaluation level, $c_1, c_2, \ldots, c_n$ is the different feature of $\boldsymbol{P}_j$, $v_{j1}, v_{j2}, \ldots, v_{jn}$ is $\boldsymbol{P}_j$'s range of value corresponding to $c_1, c_2, \ldots, c_n$, which is classic domain, a_{ji} and b_{ji} is the value boundary of $\boldsymbol{P}_j$.

$$\boldsymbol{R}_p = (\boldsymbol{P}, \boldsymbol{C}_i, \boldsymbol{V}_{ji}) = \begin{bmatrix} P & c_1 & v_{p1} \\ & c_2 & v_{p2} \\ & \ldots & \ldots \\ & c_n & v_{pn} \end{bmatrix} = \begin{bmatrix} P & c_1 & <a_{p1}, b_{p1}> \\ & c_2 & <a_{p2}, b_{p2}> \\ & \ldots & \ldots \\ & c_n & <a_{pn}, b_{pn}> \end{bmatrix} \qquad (6)$$

where $\boldsymbol{P}$ is the whole level of the object to be evaluated, $v_{p1}, v_{p2}, \ldots, v_{pn}$ is $\boldsymbol{P}$'s range of value corresponding to $c_1, c_2, \ldots, c_n$, that is joint domain.

$$\boldsymbol{R}_0 = (\boldsymbol{P}_0, \boldsymbol{C}_i, \boldsymbol{V}_i) = \begin{bmatrix} P_0 & c_1 & v_1 \\ & c_2 & v_2 \\ & \ldots & \ldots \\ & c_n & v_n \end{bmatrix} \qquad (7)$$

where $\boldsymbol{R}_0$ is the matter element to be evaluated, $v_1, v_2, \ldots, v_n$ is $\boldsymbol{P}_0$'s measured data corresponding to $c_1, c_2, \ldots, c_n$.

Step 2: Normalization

In the basis of the initial matter element extension method, normalize the magnitude of each classic domain and the matter element to be evaluated, that is, getting the normalized matter element's classic domain and matter

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element to be evaluated by divided the value of the right boundary of the domain.

$$R_j' = (P_j, C_i, V_{ji}') = \begin{bmatrix} P_j & c_1 & v_{j1}' \\ & c_2 & v_{j2}' \\ & \vdots & \vdots \\ & c_n & v_{jn}' \end{bmatrix} = \begin{bmatrix} P_j & c_1 & <\frac{a_{j1}}{b_{p1}}, \frac{b_{j1}}{b_{p1}}> \\ & c_2 & <\frac{a_{j2}}{b_{p2}}, \frac{b_{j2}}{b_{p2}}> \\ & \vdots & \vdots \\ & c_n & <\frac{a_{jn}}{b_{pn}}, \frac{b_{jn}}{b_{pn}}> \end{bmatrix} \quad (8)$$

$$R_0' = (P_0, C_i, V_i') = \begin{bmatrix} P_0 & c_1 & \frac{v_1}{b_{p1}} \\ & c_2 & \frac{v_2}{b_{p2}} \\ & \vdots & \vdots \\ & c_n & \frac{v_n}{b_{pn}} \end{bmatrix} \quad (9)$$

Step 3: Determine the weight

This paper determines the index weight by using BWM according to the evaluation object and index characteristics. The specific process refers to section 2.1.

Step 4: Calculate the comprehensive closeness

The value of the correlation function of each index of the matter element to be evaluated and the level of each grade is calculated according to the following formula:

$$K_j(v_i) = \begin{cases} \frac{-\rho(v_i, V_{ji})}{|V_{ji}|}, v_i \in V_{ji} \\ \frac{\rho(v_i, V_{ji})}{\rho(v_i, V_{pi}) - \rho(v_i, V_{ji})}, v_i \notin V_{ji} and\, \rho(v_i, V_{pi}) \neq 0 \\ -\rho(v_i, V_{ji}) - 1, v_i \notin V_{ji} and\, \rho(v_i, V_{pi}) = 0 \end{cases} \quad (10)$$

where $K_j(v_i)$ indicates the value of the correlation function of the number i index with respect to the number j level. $|V_{ji}|$ indicates the distance of the number i index with respect to the number j grade classical domain. $\rho(v_i, V_{ji})$ indicates the distance between the matter element to be evaluated of the number i index and its classical domain. $\rho(v_i, V_{pi})$ indicates the distance between the matter element to be evaluated and its section of the first index.

If the actual value of any index exceeds the range of the section, it is impossible to calculate the correlation function between the indexes of each matter element and the level of each grade according to the above formula. For the limitation of matter element extension, it needs to be improved.

The distance of the matter element to be evaluated about the normalized range of the classical domain is:

$$D(v') = \left| v' - \frac{a_{ji}' + b_{ji}'}{2} \right| - \frac{b_{ji}' - a_{ji}'}{2} \quad (11)$$

where v is a point value, a and b are values corresponding to the left end point and the right end point of the normalized classical domain interval, respectively. According to Ref. [10], two asymmetric closenesses are constructed, which solve the evaluation problem under the failure of the maximum membership criterion. The asymmetric closeness formula proposed in this paper ($\rho=1$). Improvements are available:

$$N = 1 - \frac{\sum_{i=1}^{n} D w_i}{n} \quad (12)$$

where N represents closeness, D represents distance, and w_i represents weight.

The matter-element to be evaluated R_0 and the closeness corresponding to each level is

$$N_j(p_0) = 1 - \frac{\sum_{i=1}^{n} D_j(v_i') w_i(X)}{n} \quad (13)$$

where $N_j(p_0)$ represents the matter-element to be evaluated R_0 corresponding to the closeness of level j, $D_j(v_i')$ represents the matter-element to be evaluated R_0 corresponding to the distance from the normalized classic domain, $w_i(X)$ represents the weight of the indicator; n represents the number of indicators.

Step 5: Rating

If $N_{j'}(p_0) = \max\{N_j(p_0)\}, (j = 1, 2, 3, \ldots, m)$, then the matter-element to be evaluated belongs to the jth grade. Let

$$\overline{N_j}(p_0) = \frac{N_j(p_0) - \min N_j(p_0)}{\max N_j(p_0) - \min N_j(p_0)} \quad (14)$$

$$j^* = \frac{\sum_{j=1}^{m} j \times \overline{N_j}(p_0)}{\sum_{j=1}^{m} \overline{N_j}(p_0)} \quad (15)$$

where j^* represents the grade value of a variable characteristic of matter-element to be evaluated R_0. The value of j^* can be judge the degree of bias of R_0 toward adjacent levels.

IV. CONCLUSION

With the deepening of China's transmission and distribution tariff reform, the effectiveness and problems of the transmission and distribution tariff reform have gradually emerged. The evaluation of the implementation effect of the transmission and distribution tariff reform has important practical significance. Based on the improved matter-element extension model and the Best-Worst Method, this paper constructs an evaluation model for the implementation effect of transmission and distribution tariff reform, and obtains the following research results and conclusions:

(1) Based on the objectives and principles of transmission and distribution tariff reform, index system is established to evaluate the implementation effect of the reform applies to electricity transmission and distribution, including economic efficiency, safety and reliability, energy saving and satisfaction four dimensions, and screen out 12 Evaluation indicators.

(2) The Best-Worst Method is used to determine the weight value for each evaluation index, which simplifies the comparison process. The reliability level can be measured by the calculation of the consistency ratio, and the weight coefficient of each evaluation index is accurately obtained.

(3) Using the improved matter-element extension model to establish an evaluation model for the implementation effect of transmission and distribution tariff reforms, the complex transmission and distribution tariff reform effect uncertainty problem can be transformed into an image model, through the classic domain and the matter-element to be evaluated. The normalization process uses the size of the comprehensive closeness to measure the coupling relationship between the object to be evaluated and the evaluation level, and overcomes the limitations and inadequacies of the traditional matter element extension model that cannot calculate the correlation coefficient in the index exceeding the section.

In the next research, we will select typical provinces and cities in China to evaluate the implementation effect of transmission and distribution tariff reform for empirical analysis.

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REFERENCES

[1] Vedung E. Public policy and program evaluation [M]. London, Transaction Publishers, 1997 Vedung E. Public policy and program evaluation[M]. London, Transaction Publishers, 1997

[2] Patton C, Sawicki D, Clark J. Basic methods of policy analysis and planning[M]. Routledge, 2015.

[3] Kirkpatrick C, Parker D. Regulatory impact assessment and regulatory governance in developing countries[J]. Public Administration and Development, 2004, 24(4): 333-344

[4] Ma Tian. An Empirical Study on the Effect of China's Power Industry Marketization Reform[J]. Lanzhou Academic Journal, 2009 (6): 83-86

[5] Zhang Song. Performance Evaluation of Power Industry Supervision Policy [D]. Dongbei University of Finance and Economics, 2007

[6] Li Hanfang. Research on Performance Evaluation Index System and Evaluation Model of China's Power Market[D]. Beijing: North China Electric Power University, 2008

[7] Zhou Lihua. Performance Evaluation of China's Power Industry Reform[D]. Shandong University, 2012

[8] Feng Yongzhen, Wang Junjie. Should Peak and Valley Electricity Prices Be Introduced after Ladder Price? ——Price Subsidy and Efficiency Cost Estimation for Chinese Residents' Electricity Price Policy[J]. Finance and Economy of China, 2016, 37(2): 145-158

[9] Zeng Ming, LI Na, LIU Chao. Evaluation of Power Saving Effect of Residential Ladder Price Based on Utility Function[J]. East China Electric Power, 2011, 39(8): 1215-1219

[10] RIIO-ET1 Annual Report 2015-2016. https://www.ofgem.gov.uk/

[11] Liu Shengli, Cao Yang, Feng Yueliang, et al. Research and Application of Investment Benefit Evaluation and Decision Model for Distribution Network[J]. Power System Protection and Control, 2015(2): 119-125.

[12] Liu Jianmin, Wang Dong, Li Shenwei, et al. Research on the Comprehensive Impact of Power Transmission and Distribution Price Reform on Power Grid Enterprises and Optimization Control[J]. Management Review, 2017(1): 23-25.

[13] Xiao Xiaoxin. Reliability Management of Distribution Network Power Supply and Its Application in Production Management[J]. City Construction Theory Research: Electronic Edition, 2016(6).

[14] Han Lei. Research on reliability algorithm of distribution network considering distributed power supply[D]. Shandong University, 2009.

[15] Yao Haiyan, Guo Jianfu. In-depth analysis and improvement measures on the average number of user power outages [C]// China Electrical Engineering Society Reliability Professional Committee, Urban Power Supply Professional Committee 2010 Academic Annual Meeting. 2010.

[16] Guan Dabo, Yuli Shan, Liu Zhu, et al. Performance Evaluation and Outlook of China Emissions Trading Scheme [J]. Engineering, 2016(4).

[17] JI Wei, ZHAI Xiangrong, ZHANG Zhongyuan, et al. Construction mode and implementation method of SF_6 gas recovery and purification treatment center in Gansu Power Grid[J]. Journal of Mechanical Research and Application, 2008, 21(6): 75-76.

[18] Li Hongze, Guo Sen, Tang Hui, et al. Comprehensive Evaluation of Power Quality Based on Improved Variable Weight Matter Element Extension Model[J]. Power System Technology, 2013, 37(3): 653-659.

[19] Rezaei J. Best-worst multi-criteria decision-making method[J]. Omega, 2015, 53: 49-57.

[20] Guo S, Zhao H. Fuzzy best-worst multi-criteria decision-making method and its applications[J]. Knowledge-Based Systems, 2017, 121: 23-31.