Demand-side response Resource Value Evaluation Method based on Entropy-weighted Close Value Method

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Abstract. The main benefits and social welfare of demand response resources participating in the market are mostly based on qualitative evaluation in previous studies, and no more mature evaluation methods have been seen. This paper uses the evaluation model of the entropy-weighted close value method to analyze the advantages and disadvantages of the evaluation units. Advantages, the standard of each evaluation index is used as the sample to participate in the composition of the original environmental matrix, the entropy weight method is used to determine the weight of each evaluation index, the "most advantages" and "the worst points" are determined in a limited sample, and the sum of each sample point is calculated. The Euclidean distance between the above two points is used to determine the close value of the sample point, determine the order of the merits of each evaluation unit according to the close value, and finally determine the optimal solution for the demand side response.

1. Introduction
Compared with the relatively mature foreign demand response resource participation market operation mechanism, domestic demand response resource trading system still lacks long-term stable operation. The income model of multiple market entities in multiple types of markets is not clear, which affects demand response resource participation in the market. At the same time, the main benefits and social welfare of demand response resources participating in the market are mostly based on qualitative evaluation in previous studies, and there is no more mature quantitative evaluation method. A combing and analysis of the factors that affect the cost-benefit of power market entities can increase revenue, reduce losses, and improve theoretical support for market entities. Under the reform of the power system, the power generation side competitive market has been established, and the power sales side market will be further liberalized in the future. The competitive system is gradually improving, and the establishment of a mature and open electricity market will be just around the corner. Studying the transaction issues between power generators and retail electricity suppliers has very important theoretical and practical value.

Reading domestic and foreign literature, it can be found that literature [1] believes that the respective cost and benefit information of the power generation company and the power user is relatively closed. Therefore, in order to achieve the purpose of successful bargaining between the two parties, the power generation company and the user are established based on the static Bayesian theory. The game model of bidding auctions is expected to obtain an equilibrium bidding strategy under the idealized return of both parties; Literature [2] adopts sequential game theory and introduces Bayesian learning model to improve the learning ability of generators and users, and improve the game process of both parties. The document [3] introduces the second-level sealed price auction system for the transaction forms of multiple generators and multiple users, and establishes an auction model based on transaction costs and...
transmission costs. The user side includes e-commerce sellers and large users. Type of electricity trading entity. Existing literature has more research on economies such as large users; literature [4] proposes a comprehensive fixed cost allocation method that considers three factors: time-of-use electricity price, power quality, and direct purchase electricity, and establishes time-of-use electricity price The index model and the power quality index model simulate and analyze the reasonable allocation of the transfer costs of large users; the literature [5] establishes the profit and loss model and the profit model under the point-to-point mode under the condition that the user's electricity demand remains unchanged, and directly trades electricity separately. Compare with self-built power plants and power grids to buy electricity; Literature [6] discusses the issue of electricity prices between generators and large users in direct transactions with large users. With reference to the characteristics of the direct transaction mode of large users, a two-party bidding strategy model is established based on the sequential game theory, and Bayesian learning theory is introduced here. Through Bayesian learning, the two parties can gradually improve their understanding of the other's bottom line during the negotiation process, and adjust their offer accordingly to improve the effectiveness of the game. Based on cost-benefit analysis and complementary relationship analysis, this paper intends to establish a quantitative index system for improving externalities such as the income and social welfare of demand response market entities in the spot market environment, and quantify the market value of demand response entities through the use of value networks and exergy economics theory. Characterize, construct a quantitative evaluation index system, and form a more complete quantitative evaluation method for the improvement of externalities such as demand response market entity income and social welfare under the spot market environment.

2. Exergy economics theory introduction

The essence of exergy economics is: on the basis of insisting on "pricing by exergy", the energy system is placed in a thermodynamic environment and an economic environment for comprehensive analysis. The main research methods include "algebraic" ex-economics represented by the "algebraic" model. This method analyzes the distribution of exergy and economic flows in various parts of the system through strict exergy cost statistics, so as to find out where there is improvement potential; "isolation" model exergy economics. This method optimizes the sub-systems locally by "isolating" each sub-system in exergy economics, thereby achieving global optimization. When analyzing and optimizing complex systems, this method is combined with "algebraic" model ex-economics. First, a large number of feasible solutions are screened and compared to find out the direction of improvement, and then optimize. In addition, the structural coefficient model ex-economics faithfully describes the relationship between the various components within the system to obtain the optimal layout between the various components, thereby giving the optimal economic cost of the system.

The exergy analysis method is based on the second law of thermodynamics, and combined with the analysis method of the first law of thermodynamics, reveals the utilization and loss of energy involved in the system or equipment in the process of transmission and conversion. The analysis and evaluation criteria of the exergy analysis method are the main technical indicators for the rationality of the energy use of the system or equipment, including: thermodynamic perfection, exergy efficiency, exergy loss coefficient and exergy loss rate. Through calculation and analysis of the above indicators, it is possible to clarify the exergy loss and its distribution of each equipment in the system, and find out the reasons for the large exergy loss and the weak links in energy utilization, and point out the direction for improving the energy consumption of the system. Based on ex-economics theory, this paper studies the complementary relationship and mechanism of multi-market participants' coordinated participation in the market, so as to analyze the advantages and disadvantages of demand response competitiveness and the complementary relationship among multi-market entities. The general process of exergy analysis includes: (1) determine the state parameters and flow direction of the energy flow of the analysis object; (2) analyze the energy transfer and conversion relationship in the system; (3) establish the exergy analysis model; (4) calculate the system (5) Calculate the exergy loss of each logistics exergy value or process; (6) Analyze the results of the index calculation and propose improvement measures.
The exergy analysis method takes into account the dual attributes of energy quantity and quality, and analyzes the energy consumption structure of the system more comprehensively and deeply. The exergy analysis method has been widely used in the engineering field and has formed many integrated thermodynamic analysis methods. The exergy analysis method is an analysis method that takes into account thermodynamic performance and economic factors. For engineering practice, the ultimate goal of energy consumption analysis of the system is to reduce production and operation costs, or to reduce the initial investment in the process of project decision-making cost. Exergy economics not only pursues the rationality of system energy use, but also considers the economic performance of system operation. The basic idea of economics is to put the analyzed system into two environments for investigation: one is the physical environment, such as temperature, pressure and other parameters that follow the laws of thermodynamics; the other is the economic environment, such as cost, profit, etc., which follow economic laws parameter. The material flow, energy flow and cash flow in the system follow strict laws in the process of inflow and out of the system. The mathematical expressions of these laws are the exergy cost equations. The content and scope of exergy economics research is wide, mainly including the following aspects: (1) The exergy economic optimization design of the energy system; (2) The exergy economic optimization operation of the energy system; (3) The reasonable calculation of the energy system products; (4) Analyze the feasibility of the energy system and plan decision-making.

3. Quantitative evaluation system construction

3.1. Power quality indicators
Whether it is a price-based demand-side response measure or an incentive-based demand-side response measure, in the specific implementation process, its role is mainly to reduce the peak load of the power grid on the basis of ensuring the reliability of the system operation, thereby improving the economy of the entire power system And to ensure its safety, so the value of demand-side resources can be fully reflected on the user side, power supply side, power generation side and the entire society. The overall evaluation system is shown in the figure:
3.2. Demand-side response resource value evaluation method based on entropy-weighted close value method

The osculating value method has the advantages of intuitiveness, easy quantification of the index matrix, and high accuracy of calculation results. It has been widely used in the fields of environmental quality evaluation, work quality evaluation, and enterprise capability evaluation. However, by default, the osculating value method considers the weights of all indicators to be equal, this feature may cause large errors in the evaluation results. The entropy method uses the amount of information passed to the decision maker by evaluation factors to determine the weight. The traditional entropy weight method has higher accuracy and stronger objectivity, and can better interpret the results obtained. At the same time, it can be fully combined with other methods, but this method is more used for weight determination and has limited application scope. In the evaluation process, the specific expectations of each indicator still need to be set subjectively, which will lead to a decrease in the credibility of the evaluation results. Therefore, this section combines the entropy weight method with the osculating value method, using the optimal reference point or the worst reference point of the osculating value method to replace the expected value in the entropy weight method, and using the entropy weight method to determine the weight of each index can well compensate the shortcomings of the two methods. This section establishes a demand-side resource value evaluation model based on the entropy-weighted close value method to make an overall evaluation of the demand-side resource value.

(1) Build indicator matrix
Suppose demand-side response plan set $A_i (i = 1, 2, \ldots, m)$ is set to $S_j (j = 1, 2, \ldots, m)$ under indicator $a_{ij}$ (Predict the effect of the program to get this value), and the index matrix $A = (a_{ij})_{m \times n}$ is obtained.

(2) Standard matrix normalization
Since there are many indicators in the scheme and the evaluation criteria of each indicator are different, for the convenience of comparison, the indicator matrix is standardized. When it is a positive index, that is, when the $j$-th index is larger, the specific index value is expressed by the following formula:

$$x_{ij} = \frac{a_{ij}}{\left(\sum_{i=1}^{m} (a_{ij})^2\right)^{\frac{1}{2}}}$$

When $j$ is a reverse index, that is, when the $j$-th index is as small as possible, such as the cost of response measures on the demand side of a grid company, the index value can be obtained by the following formula:

$$x_{ij} = -\frac{a_{ij}}{\left(\sum_{i=1}^{m} (a_{ij})^2\right)^{\frac{1}{2}}}$$

Get the normalized index matrix $X = (x_{ij})_{m \times n}$.

(3) Determine the weight of each evaluation index
According to the definition of entropy, the entropy of the evaluation index can be obtained by the following formula:

$$H_j = -k \cdot \left(\sum_{i=1}^{m} f_{ij} \ln f_{ij}\right) (j = 1, 2, \ldots, n)$$

Then the entropy weight of the $i$-th index can be obtained by the following formula:

$$w_i = \frac{1 - H_i}{n - \sum_{i=1}^{m} H_i}$$

The weight column vector can be obtained by the following formula $W = (w_1, w_2, \ldots w_n)^T$.

(4) Calculate the close value of each program
The close value of scheme $A_{ij}$ can be obtained by the following formula

$$c_j = \frac{d^+_j - d^-_j}{d^+_j + d^-_j}$$

$$d^+_j = \left[\sum_{i=1}^{m} \omega_i (x_{ij} - x_{ij}^+)^2\right]^{\frac{1}{2}}$$

$$d^-_j = \left[\sum_{i=1}^{m} \omega_i (x_{ij} - x_{ij}^-)^2\right]^{\frac{1}{2}}$$

$$d^+ = \min\{d^+_j\}$$

$$d^- = \max\{d^-_j\}$$

$d^+_j$、$d^-_j$ respectively represent the Euclidean distance between the demand-side response plan effect $A_i$ and the optimal effect $A^+$ and the worst effect $A^-$, $d^+$、$d^-$ respectively represent the minimum value of $m$ most point distances and the maximum value of $m$ worst point distances.

(5) Evaluation Analysis
The size of $c_j$ reflects the degree to which the plan set deviates from the best point. When $c_j > 0$, $A_i$ deviates from the best point. The larger the value, the farther the deviation is. When $c_j = 0$, it is closest to the best point. Taking the size of $c_j$ as the decision criterion, the solution with the smallest $c_j$ is the optimal demand-side response solution.
4. Conclusion

This paper adopts a combination of theoretical research and practice, based on the purpose of providing reference for the selection of demand-side response measures and implementation evaluation, proposes the evaluation index and evaluation system of demand-side response resources, and establishes a model to evaluate the value of demand-side response resources.

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