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Integrated Energy System Assessment Based on Improved Critic -Ahp Method under Energy Internet

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Abstract: In order to evaluate the integrated energy system under the background of energy Internet, the assessment index system is firstly constructed based on the energy consumption, economy, environment, availability, reliability, feasibility of the integrated energy system, and using the difference coefficient method to obtain the index of the information amount to improve the traditional CRITIC method. Then using the ratio of the index of the information amount to replace human subjective ratio of the importance degree, the empowerment method of the analytic hierarchy process (AHP) method is improved. The system assessment model of the integrated energy is established using the fuzzy comprehensive assessment method. A university integrated energy system is analyzed using the model and the scientific nature of the model is verified.

1. Introduction

With the development of energy Internet, energy enterprises transition from production type to service type. The energy planning of the 14th Five-Year Plan will vigorously promote the construction of comprehensive energy services, or make it the top priority of energy development. Improving energy efficiency has become an important field of comprehensive energy service development in China in recent years. Therefore, the evaluation of China's integrated energy system is an essential work to ensure integrated energy services.

In the traditional index weighting method, the subjective weighting method lacks the objective basis for the index weight, the objective weighting method lacks the subjective importance of the index weight, and the subjective and objective combination weighting can not find the appropriate subjective and objective weight proportional coefficient.A CRITIC-AHP comprehensive weighting method based on improvement is proposed. Firstly, the CRITIC method of improving the difference coefficient is used to determine the information quantity of adjacent indexes, the ratio of information quantity is used to replace the hierarchy to analyze the importance of legal person as subjective index, and the final weight of each evaluation index is determined. This method takes into account the subjective and objective weight of the index and the horizontal and vertical influence degree of the index[1]Finally, the fuzzy comprehensive evaluation method is used to evaluate the integrated energy system engineering project under the background of energy Internet.

2. Evaluation System

2.1 Construction of an Indicator System

Based on the characteristics of integrated energy system under the background of energy Internet, this paper summarizes and puts forward its evaluation index, which can be used for reference[2]This paper takes the integrated energy system as the first class index under the background of energy Internet, and takes the system reliability, environment, economy, feasibility and energy consumption as the second class index.In order to fully reflect the systematic and hierarchical nature of the integrated energy system project under the background of energy Internet, this paper continues to subdivide more low-level indicators. This paper uses three layers and twenty evaluation indexes to evaluate the integrated energy system under the background of energy Internet, as shown in figure 1.

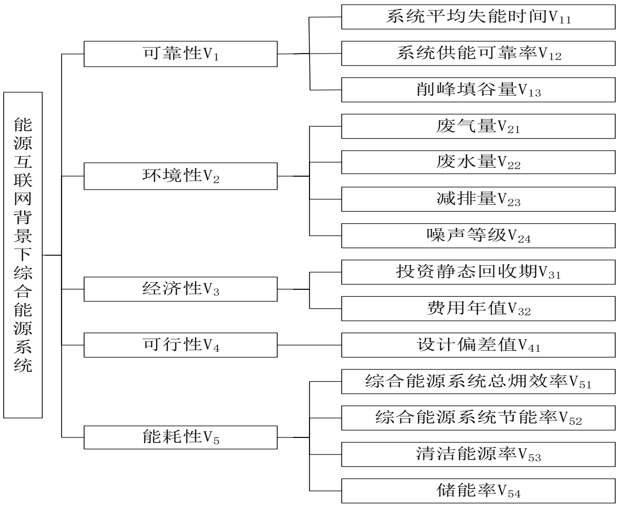

Fig.1 Evaluation Indicator System

. 1 F ig assessment index system

3. System Evaluation Model

3.1 System Weight Calculation

In this paper, we try to use the difference coefficient because of the many factors and interaction of the integrated energy system under the background of energy Internet[13]An improved CRITIC method is used to construct the discriminant matrix of AHP and to solve the weight of the index by AHP. The comprehensive weighting method makes the weight more in line with the actual situation.

3.1.1 Critic Act

CRITIC method is an objective weighting method to determine the weight by comparing the two basic concepts of strength and conflict between evaluation indexes. The calculation steps of CRITIC method are referred to[3].

3.1.2 Entropy Weight Method

Entropy weight method is an objective weighting method to express the degree of uncertainty of information by entropy. The greater the amount of information, the greater the entropy. Entropy weight method calculation steps reference[12].

3.1.3 Hierarchical Analysis Method

Analytic hierarchy process (AHP) is a subjective weighting method that decomposes the index with decision into target layer, criterion layer, scheme layer and carries on qualitative and quantitative analysis. A reference to the computational steps of AHP[4].

3.2 Improved Critic-Ahp Empowerment Approach

The difference coefficient method is used to improve the information quantity of the traditional CRITIC calculation evaluation index, and the ratio of the information quantity of the index is used to replace the ratio of the importance of the expert's subjective determination index into the subjective weighting AHP method. The improved weighting method is a new weighting method that embodies both subjective and objective information.

The calculation steps are as follows:

1). Construction of Evaluation Matrix of Index Importance by Expert Grading Method

$$A=\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{21} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mm} \end{bmatrix} \quad (1)$$

2). This paper adopts the positive index scoring formula

$$x_{ij}^{'}=\frac{v_{ij}-\min v_{ij}}{\max v_{ij}-\min v_{ij}} \quad (2)$$

3).Calculation of information

R_j j The conflict coefficient of the calculation index is as follows:

$$R_j=\sum_{i=1}^{m}(1-r_{ij}) \quad (3)$$

r_{ij} i, j The correlation coefficient between the indicators.

Difference coefficient of calculation index

$g_j=1-e_j$ (4)

g_j e_j The difference coefficient is the entropy value of the index in the entropy weight method. j

Amount of information to be calculated C_j

$C_j=g_j\times R_j$ (5)

4).A AHP judgment matrix is constructed by information ratio

$$B=\begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ y_{n1} & y_{n2} & \cdots & y_{nn} \end{bmatrix} \quad (6)$$

5). w_j By using hierarchical analysis method AHP the weight of evaluation index is calculated and consistency test is carried out.

3.3 Systematic Evaluation Based on Fuzzy Comprehensive Evaluation Model

Fuzzy Comprehensive Evaluation Method[5]It is a kind of evaluation method based on fuzzy mathematics to deal with the indexes which are not easy to quantify, so as to make the overall evaluation of the multi-factor restricted system.

The calculation steps are as follows:

1).Determining Factor Set

Level I indicators:

$U=\{U_1,U_2,\ldots U_n\}$ (7)

Secondary indicators:

$U=\{U_{i1},U_{i2},\ldots U_{in}\}$ (8)

U_{ij} It represents the index of the index layer of membership degree. i j

2).Establishment of evaluation sets

The evaluation of integrated energy systems is generally divided into five levels, namely

$V=\{v_1,v_2,v_3,v_4,v_5\}$ (9)

in turn corresponds to excellent, good, medium, qualified and poor.

3).Establishment of weight sets

The weight of the index system is divided into two levels: the first class index weight set

$W=\{w_1,w_2,w_3,\ldots,w_i\}$ (10)

and the secondary index weight corresponding to the primary index

$W_i=\{w_{i1},w_{i2},w_{i3},\ldots,w_{in}\}$ (11)

4).Model building, evaluation

First class fuzzy comprehensive evaluation. Fuzzy Comprehensive Evaluation of Category Factors i

$B_i=W_i\times R_i$ (12)

R_i Among them, it is a single factor evaluation matrix.

Secondary Fuzzy Comprehensive Evaluation

$R=[B_1,B_2\ldots B_s]$ (13)

5).Evaluation findings

Final evaluation results

$Z=W\cdot R$ (14)

Z Represents a comprehensive main score for integrated energy system indicators. The higher the score, the better the integrated energy system.

4. Example Analysis

4.1 Building the Initial Evaluation Matrix of Indicators

The integrated energy system index was scored by 10 experts in the context of energy Internet.An integer multiple of 0.5 is required in this paper, and the scoring interval is set to [0,10]. V_5 Taking the energy consumption dimension as an example, the initial evaluation matrix is constructed according to the new sequence obtained by experts, and the initial evaluation matrix is dimensionless according to formula (2). The scoring results are shown in Table 1.

Table 1 Expert Score Sheet

Indicators	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Experts 6	Expert 7	Experts 8	Experts 9	Experts 10
V_{51}	1.000	0.909	0.896	0.680	0.734	0.721	0.563	0.394	0.260	0.000
V_{52}	0.000	0.136	0.276	0.321	0.510	0.720	0.816	0.910	0.991	1.000
V_{53}	0.000	0.314	0.392	0.510	0.686	0.843	1.000	0.961	0.922	0.804
V_{54}	0.000	0.119	0.279	0.305	0.489	0.689	0.749	0.860	0.956	1.000

4.2 Measuring the Amount of Information

The conflict coefficient of the calculated index according to formula (3) is listed in column 2 of Table 2. According to formula (4), the difference coefficient of the index is obtained and listed in column 3 of Table 2. According to formula (5), the amount of information of the index is obtained and listed in column 4 of Table 2.

4.3 Index Weights Calculated

Judging Matrix by Information Ratio of Indexes

$$B = \begin{bmatrix} 1.942 & 1.000 & 2.993 & 1.897 \\ 1.000 & 0.515 & 1.541 & 0.977 \\ 0.649 & 0.334 & 1.000 & 0.634 \\ 1.024 & 0.527 & 1.578 & 1.000 \end{bmatrix} \quad (15)$$

By matlab programming, the index weight is obtained and the consistency test of the index weight is carried out. The weight results are shown in Table 2.

Table 2 Results of The Weight Table of Indicators Based on Matlab

Tab le.2Results of indexes weight table based on matlab

Indicators	Conflict coefficient	Difference coefficient	Information	Indicator weights
V_{51}	5.533	0.073	0.404	0.421
V_{52}	1.958	0.106	0.208	0.217
V_{53}	1.870	0.072	0.135	0.140
V_{54}	1.987	0.107	0.213	0.222

Similarly, information on the weights of indicators at all levels is available in table 3. Table 3

From the weight results, we can see that the largest weight of the secondary index is the energy consumption of the integrated energy system, the second is the environment of the integrated energy system, the third is the reliability of the integrated energy system, and the fourth is the economy of the integrated energy system. Among the three-level indexes, the total energy efficiency of the integrated energy system is the largest, and the minimum weight is the annual cost of the integrated energy system.

Table 3 Indicator Weight Information At All Levels

Level I indicators	Secondary indicators	Secondary indicator weights	Level 3 indicators	Level 3 indicator weights
Integrated energy systems in the context of the energy Internet	Reliability	0.209	Average system disablement time	0.034
			Reliability of system availability	0.054
			Peak filling	0.111
	Environmental	0.213	Waste gas	0.034
			Waste water	0.050
			Emission reductions	0.037
			Noise level	0.092
	Economy	0.070	Investment static payback	0.041
			Annual cost	0.029
	Feasibility	0.046	Design Deviation Value	0.046
	Energy consumption	0.462	Integrated Energy System Total Efficiency	0.195
			Energy efficiency in integrated energy systems	0.100
			Clean energy rates	0.064
			Energy storage rate	0.103

4.4 Assessment Calculations

In this paper, the evaluation grade of integrated energy system is divided into

$V=$(excellent, good, medium, qualified, poor)$=(100,80,60,40,20)$ (16)

Using the expert scoring method, five experts related to the integrated energy system are used to score the actual situation of the integrated energy system. Taking energy consumption as an example, the scoring is normalized, and the scoring situation is shown in Table 4.

Table 4 Comprehensive Energy Consumption Score in the Context of Energy Internet

Indicators	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
V_{51}	0.190	0.095	0.285	0.190	0.381
V_{52}	0.095	0.190	0.285	0.190	0.285
V_{53}	0.285	0.095	0.190	0.285	0.285
V_{54}	0.190	0.095	0.190	0.190	0.285

Based on formula (12), the fuzzy comprehensive evaluation matrix of energy consumption of comprehensive energy is obtained

$B_5=(0.164,0.135,0.251,0.204,0.306)$ (17)

In the same way, a fuzzy comprehensive evaluation matrix of energy reliability, environment, economy and feasibility can be obtained

Construct the second-level evaluation matrix and conduct comprehensive evaluation

Integrated Fuzzy Matrix

$$R=\begin{bmatrix}0.483 & 0.232 & 0.141 & 0.061 & 0.073\\ 0.152 & 0.232 & 0.342 & 0.131 & 0.143\\ 0.141 & 0.211 & 0.303 & 0.212 & 0.133\\ 0.501 & 0.243 & 0.110 & 0.084 & 0.052\\ 0.164 & 0.135 & 0.251 & 0.204 & 0.306\end{bmatrix} \quad (18)$$

From formula 14

$$Z=(0.209,0.186,0.265,0.161,0.206) \quad (19)$$

Finally, the general evaluation of integrated energy system under the background of energy Internet can be obtained

$$E=Z\cdot[100 \quad 80 \quad 60 \quad 40 \quad 20]^{T}=60.22 \quad (20)$$

It can be seen that the evaluation of the integrated energy system of a university campus in this paper shows that the grade is “medium “.Basically in line with national laws and regulations and industry standards, but also room for improvement and promotion.

5. Conclusion

This paper first constructs the index system of integrated energy system under the background of energy Internet, and then puts forward an improved CRITIC correction AHP comprehensive empowerment method to obtain the index weight. The comprehensive weighting method proposed in this paper takes into account the advantages of subjective and objective empowerment, and the index weight of the integrated energy system is more accurate. In this paper, the fuzzy comprehensive evaluation method is used to evaluate and calculate the comprehensive energy system of a university campus, and the grade of the system is determined. It provides the basis for system optimization and other integrated energy system service construction.

There are still shortcomings in the theoretical research and practical project experience of integrated energy system evaluation. The integrated energy system project is a key project in China and plays an important role in China's economic development and global environmental problems.It is of great significance to use scientific methods to evaluate the integrated energy system.

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