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Comprehensive Evaluation of the Sustainable Development of Power Grid Enterprises Based on the Model of Fuzzy Group Ideal Point Method and Combination Weighting Method with Improved Group Order Relation Method and Entropy Weight Method

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Received: 15 August 2017; Accepted: 19 October 2017; Published: 21 October 2017

Abstract: As an important implementing body of the national energy strategy, grid enterprises bear the important responsibility of optimizing the allocation of energy resources and serving the economic and social development, and their levels of sustainable development have a direct impact on the national economy and social life. In this paper, the model of fuzzy group ideal point method and combination weighting method with improved group order relation method and entropy weight method is proposed to evaluate the sustainable development of power grid enterprises. Firstly, on the basis of consulting a large amount of literature, the important criteria of the comprehensive evaluation of the sustainable development of power grid enterprises are preliminarily selected. The opinions of the industry experts are consulted and fed back for many rounds through the Delphi method and the evaluation criteria system for sustainable development of power grid enterprises is determined, then doing the consistent and non dimensional processing of the evaluation criteria. After that, based on the basic order relation method, the weights of each expert judgment matrix are synthesized to construct the compound matter elements. By using matter element analysis, the subjective weights of the criteria are obtained. And entropy weight method is used to determine the objective weights of the preprocessed criteria. Then, combining the subjective and objective information with the combination weighting method based on the subjective and objective weighted attribute value consistency, a more comprehensive, reasonable and accurate combination weight is calculated. Finally, based on the traditional TOPSIS method, the triangular fuzzy numbers are introduced to better realize the scientific processing of the data information which is difficult to quantify, and the queuing indication value of each object and the ranking result are obtained. A numerical example is taken to prove that the model of fuzzy group ideal point method and combination weighting method with improved group order relation method and entropy weight method is feasible and effective for evaluating the sustainable development of power grid enterprises.

Keywords: the sustainable development of power grid enterprises; comprehensive evaluation; group order relation method improved by matter element analysis; entropy weight method; combination weighting method; group ideal point method improved by triangular fuzzy numbers

1. Introduction

In the process of pursuing interests and development, enterprises should not only consider the business objectives of enterprises, but also ensure the competitive advantages and social influence of enterprises, and achieve sustained profitability and sustainable development in the future expansion. That is the sustainable development of enterprises. With the rapid development of economy in the world, the demand for electricity is increasing day by day, and grid enterprises play a more and more important role in the social and economic development. As an important implementing body of the national energy strategy, grid enterprises bear the important responsibility of optimizing the allocation of energy resources and serving the economic and social development, and their levels of sustainable development have a direct impact on the national economy and social life.

The comprehensive evaluation of the sustainable development of power grid enterprises is a complex process, involving many aspects, such as economic development, production operation, management level, coordinated development and so on. When evaluating the sustainable development of power grid enterprises, we should construct the evaluation criteria system from different aspects, angles and levels for comprehensive evaluation. According to the evaluation results, enterprise managers can find out the problems existing in the operation of power grid enterprises and solve them in a timely manner, which plays a very important guiding role for the future development planning of power grid enterprises. Therefore, constructing a simple, efficient and clear evaluation criteria system for sustainable development of power grid enterprises and evaluating the sustainable development of power grid enterprises effectively with scientific and normative evaluation methods are valuable researches.

In recent years, researchers have carried out comprehensive evaluation from all aspects of power grid enterprises, such as safe operation [1–5], power quality [6–8], investment and operation [9,10], facilities construction [11,12], management development [13–15] and so on. A variety of targeted and innovative comprehensive evaluation methods have been proposed and a large number of practical problems have been solved.

For safe operation of power grid enterprises, Mu Y et al. [1] built the new criteria system and the novel model based on multi-operator fuzzy AHP for comprehensive evaluation of power grid security and benefit. Shi Z et al. [2] put forward a risk assessment system of power grid operation evaluated by matter-element extensible model for building the dynamic management system. Long Y, Li X and Pan K [3] put forward a new criteria system for comprehensive evaluation on annual operation mode of the smart distribution network. Deng C et al. [4] established a fuzzy comprehensive evaluation model for the metropolitan city power grid system risk assessing. Gong J et al. [5] introduced grey relational degree to the TOPSIS for comprehensive evaluation on operation risk management of power grid enterprises.

For power quality of power grid enterprises, Ding Z [6] proposed two comprehensive evaluation models of continuous power quality on the basis of mathematical statistic and fuzzy method. Ouyang S et al. [7] established the criteria system of comprehensive power quality according to six national standards and proposed the evaluation model with weighting the subsystems and large-scale systems by scatter degree method and improved analytic hierarchy process-G1 method. Wang W et al. [8] constructed the integrated assessment system of power grid for metropolitan cities and implemented the evaluation based on AHP and entropy method.

For investment and operation of power grid enterprises, Wang Y et al. [9] put forward the comprehensive evaluation criteria system of the projects investment benefits for power grid under the background of the power system reform in China. Jia Z et al. [10] adopted the information entropy theory to determine the weights of the evaluation criteria of operation capacity for regional power grid corporation and proposed the comprehensive evaluation model with the fuzzy evaluation method.

For facilities construction of power grid enterprises, Du Z et al. [11] proposed the comprehensive evaluation methods of the power grid infrastructure projects by linear weighting method, ideal method and Romanian method on the basis of determining the criteria weights by set-valued iteration method. Chen H et al. [12] constructed the evaluation criteria system of power grid considering technology, security and economy and put forward the evaluation method according to the theory of moment estimation.

For management development of power grid enterprises, Wei J et al. [13] constructed the criteria system of power grid emergency management capability and implemented evaluation with AHP and fuzzy comprehensive evaluation. He L and Zhao J N [14] put forward a efficient and reasonable comprehensive evaluation method for power grid enterprise material bidding assessment considering technology, business and offer of bidders. Xu X et al. [15] proposed the evaluation model with improved TOPSIS using the idea of matter element extension for the development of renewable energy and traditional power grid, considering power generation, transmission, distribution and scheduling.

However, at present, there are relatively few research achievements on the comprehensive evaluation of the sustainable development of power grid enterprises. Only a few scholars have done relevant research in this area. Li L I et al. [16] proposed the sustainable development criteria system of the power grid company and the evaluation model with an improved weighting method and the TOPSIS method. Chen Y H et al. [17] put forward the evaluation criteria system after analyzing the status of sustainable development of regional electricity enterprises and proposed the comprehensive evaluation model with rough sets and support vector machine. Zhang J L and Jing-Jing L I [18] constructed the comprehensive evaluation criteria systems for power enterprises by analyzing the characters of power enterprises and their subsystems and put forward the AHP-ELECTRE evaluating model for comprehensive evaluation.

As for comprehensive evaluation methods, analytic hierarchy process, order relation method, Entropy weight method, fuzzy evaluation method, matter element extension method and TOPSIS method are commonly used in comprehensive evaluation. Chen T et al. [19] proposed an index system of food safety supervision information transparency and used the fuzzy-ANP comprehensive evaluation model to evaluate the food safety supervision information transparency in China. Ji M A and Liu X [20] put forward an evaluation method of health status of low-voltage distribution network, where the optimal Lagrange multiplier method is used to obtain comprehensive index weight based on order relation-entropy method. Wang X et al. [21] constructed an evaluation index system through the qualitative and quantitative analysis of external and internal factors affecting the efficiency of water usage and put forward a matter-element model based on game theory weight to evaluate the effects of the implementation of efficiency control measures for regional water usage. Li C et al. [22] constructed a land-use performance evaluation framework and evaluated the land-use performance in the Shunyi District from 1996 to 2010 based on TOPSIS method and entropy-weighted method.

According to the research above, we find that the current design of sustainable development evaluation criteria system for power grid enterprises has not yet formed a unified standard and the practicability and scientific nature of the existing evaluation criteria system need further study. In addition, the evaluation methods adopted by the researchers above are relatively simple, which need to be improved and integrated.

In this paper, the model of fuzzy group ideal point method and combination weighting method with improved group order relation method and entropy weight method is proposed to evaluate the sustainable development of power grid enterprises. The main content and structure of this paper are as follows: the second section constructs the evaluation criteria system for sustainable development of power grid enterprises from the four dimensions of economic development, production operation, management level and coordinated development, and introduces the preprocessing method of the evaluation criteria; The third section describes the comprehensive evaluation model. Firstly, based on the basic order relation method, the weights of each expert judgment matrix are synthesized to construct the compound matter elements. By using matter element analysis, the subjective weights of the criteria are obtained. And entropy weight method is used to determine the objective weights of the preprocessed criteria. Then, the combination weighting method based on the subjective and objective weighted attribute value consistency is adopted to calculate combination weight. Finally, based on the traditional TOPSIS method, the triangular fuzzy numbers are introduced to obtain the queuing indication value of each evaluated object for determining the ranking result; The fourth section takes a numerical example to prove that the model of fuzzy group ideal point method and combination weighting method with improved group order relation method and entropy weight method is feasible and effective for evaluating the sustainable development of power grid enterprises. The fifth section summarizes the text.

The innovations of this paper are as follows:

(1) The construction of the evaluation criteria system

In order to realize the sustainable development, the power grid enterprises should not only ensure their own economic benefits, but also provide safe and reliable power services. While improving the level of science and technology, management ability and enterprise culture, the power grid enterprises should ensure the coordinated development of society and environment. Taking into account the above factors, in this paper, the evaluation criteria system for sustainable development of power grid enterprises is constructed from the four dimensions of economic development, production operation, management level and coordinated development, which is more comprehensive and effective for evaluation.

(2) The construction of the comprehensive evaluation model

For the determination of evaluation criteria weights, the combination weighting method based on the subjective and objective weighted attribute value consistency is used in this paper, which combines the subjective and objective information to calculate more comprehensive, reasonable and accurate combination weights for comprehensive evaluation. Entropy weight method is adopted for determining the objective weights. As for the subjective weights, the group order relation method improved by matter element analysis is used, which gives full consideration to each expert's understanding of different things and makes the subjective weights more comprehensive compared with traditional order relation method.

For evaluation method, the group ideal point method improved by triangular fuzzy numbers is used in this paper. Compared with the traditional TOPSIS method, this improved method introduces the triangular fuzzy numbers to better realize the scientific processing of the data information which is difficult to quantify and integrates the opinions of experts group effectively.

In summary, this paper not only puts forward a comprehensive and effective evaluation criteria system for sustainable development of power grid enterprises, but also creatively combines various evaluation theories to construct the comprehensive evaluation model.

2. The Evaluation Criteria System for Sustainable Development of Power Grid Enterprises

2.1. Construction of the Evaluation Criteria System

In order to realize the sustainable development, the power grid enterprises should not only ensure their own economic benefits, but also provide safe and reliable power services. While improving the level of science and technology, management ability and enterprise culture, the power grid enterprises should ensure the coordinated development of society and environment. In this paper, in order to evaluate the sustainable development of power grid enterprises comprehensively, objectively and scientifically, on the basis of consulting a large amount of literature, the important criteria of the comprehensive evaluation of the sustainable development of power grid enterprises are preliminarily selected. The opinions of the industry experts are consulted and fed back for many rounds through the Delphi method and the evaluation criteria system for sustainable development of power grid enterprises is determined.

In this paper, the evaluation criteria system for sustainable development of power grid enterprises is constructed from the four dimensions of economic development, production operation, management level and coordinated development, containing 4 first-level criteria, 11 second-level criteria and 32 third-level criteria. As shown in Figure 1:

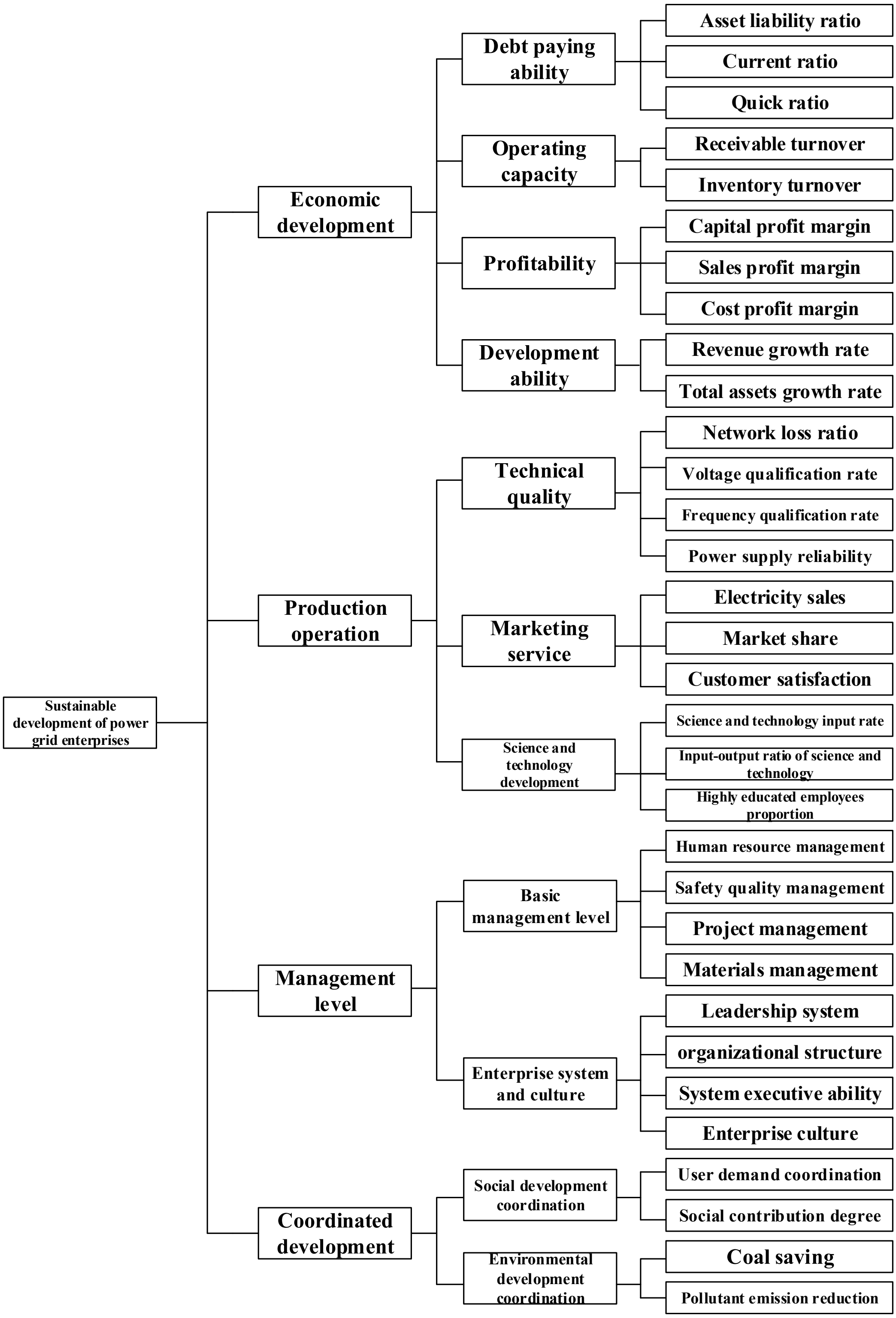

Figure 1. The evaluation criteria system for sustainable development of power grid enterprises.

(1) Economic development

Economic development is the foundation of the sustainable development of power grid enterprises, and also the core embodiment of power grid enterprise performance. In this paper, we evaluate the economic development of power grid enterprises from four dimensions: debt paying ability, operating capacity, profitability and development ability, and determine 10 third-level criteria: asset liability ratio, current ratio, quick ratio, receivable turnover, inventory turnover, capital profit margin, sales profit margin, cost, profit margin, revenue growth rate and total assets growth rate.

(2) Production operation

Production operation is the driving force for the sustainable development of power grid enterprises, and the key to improve the core competitiveness of power grid enterprises. In this paper, we evaluate the production operation of power grid enterprises from three dimensions: technical quality, marketing service and science and technology development, and determine 10 third-level criteria: network loss rate, voltage qualification rate, frequency qualification rate, power supply reliability, electricity sales, market share, customer satisfaction, science and technology input rate, input-output ratio of science and technology and highly educated employees proportion.

(3) Management level

Management level is the guarantee for the sustainable development of power grid enterprises, and is the important support of the strategic transformation of the power grid enterprises under the background of China's electric power system reform. In this paper, we evaluate the management level of power grid enterprises from two dimensions: basic management level and the enterprise system and the culture, and determine 8 third-level criteria: human resource management, safety quality management, project management, materials management, leadership system, organizational structure, system executive ability and enterprise culture.

(4) Coordinated development

Coordinated development is a necessary condition for the sustainable development of power grid enterprises, and an important factor to enhance the overall image and social influence of power grid enterprises. In this paper, we evaluate the coordinated development of power grid enterprises from two dimensions: social development coordination and environmental development coordination, and determine 4 third-level criteria: user demand coordination, social contribution degree, coal saving and pollutant emission reduction.

For convenience, we use $M_1 - M_{32}$ to represent third-level criteria, and the correspondence between the criteria and the symbols is shown in Table 1:

Table 1. The correspondence between the criteria and the symbols.

Criteria	Symbol	Criteria	Symbol
Asset liability ratio	M_1	Customer satisfaction	M_{17}
Current ratio	M_2	Science and technology input rate	M_{18}
Quick ratio	M_3	Input-output ratio of science and technology	M_{19}
Receivable turnover	M_4	Highly educated employees proportion	M_{20}
Inventory turnover	M_5	Human resource management	M_{21}
Capital profit margin	M_6	Safety quality management	M_{22}
Sales profit margin	M_7	Project management	M_{23}
Cost profit margin	M_8	Materials management	M_{24}
Revenue growth rate	M_9	Leadership system	M_{25}
Total assets growth rate	M_{10}	organizational structure	M_{26}
Network loss ratio	M_{11}	System executive ability	M_{27}
Voltage qualification rate	M_{12}	Enterprise culture	M_{28}
Frequency qualification rate	M_{13}	User demand coordination	M_{29}
Power supply reliability	M_{14}	Social contribution degree	M_{30}
Electricity sales	M_{15}	Coal saving	M_{31}
Market share	M_{16}	Pollutant emission reduction	M_{32}

2.2. The Consistent Processing of the Evaluation Criteria

Before making a comprehensive evaluation, the consistent processing of the criteria must be done. In the third-level criteria, except that the asset liability ratio is the interval type criteria and the network loss rate is the cost type criteria, other criteria are benefit type criteria. In this paper, we convert all types of criteria into benefit type criteria.

For the cost type criteria, the consistent processing of the network loss rate criterion is shown in Equation (1):

$$x^* = \frac{1}{x}, (x > 0 \ \ or \ \ x < 0) \tag{1}$$

For the interval type criteria, it is generally believed that the best stable range of the asset liability ratio criterion is $[0.4, 0.5]$. The consistent processing of the asset liability ratio criterion is shown in Equation (2):

$$x* = \begin{cases} 1 - \frac{q_1 - x}{\max\{q_1 - m, M - q_2\}} \ x < q_1 \\ 1 \ x \in [q_1, q_2] \\ 1 - \frac{x - q_2}{\max\{q_1 - m, M - q_2\}} \ x > q_2 \end{cases} \tag{2}$$

where $[q_1, q_2]$ is the best stable range of the criteria. M and m are the upper and lower bound of the criteria respectively.

2.3. The Non Dimensional Processing of the Evaluation Criteria

The evaluation criteria system of sustainable development of power grid enterprises is a very complex system. The unit of measurement, the form of expression and the economic meaning of each evaluation criteria are different, so the original criteria data don't have comparability. In order to ensure the authenticity and reliability of the comprehensive evaluation results, we must do the non dimensional processing to eliminate the influence of the dimension of the evaluation criteria.

The non dimensional processing of the evaluation criteria is a mathematical transformation to eliminate the influence of the dimension of the original criteria.

In this paper, the normalization method is adopted to do the non dimensional processing of the evaluation criteria, as shown in Equation (3):

$$x_{ij}^* = \frac{x_{ij}}{\sum\limits_{i=1}^{m} x_{ij}} \tag{3}$$

where x_{ij} is the criterion value of the i evaluated object to the j criterion. x_{ij}^* is the criterion value after the non dimensional processing.

3. The Evaluation Model

3.1. Combination Weighting Method with Improved Group Order Relation Method and Entropy Weight Method

In order to evaluate the sustainable development of power grid enterprises comprehensively and accurately, based on the basic order relation method, the weights of each expert judgment matrix are synthesized to construct the compound matter elements. By using matter element analysis, the subjective weights of the criteria are obtained. The group order relation method improved by matter element analysis gives full consideration to each expert's understanding of different things, which makes the subjective weight more comprehensive. And entropy weight method is used to determine the objective weights of the preprocessed criteria. Then, combining the subjective and objective information with the combination weighting method based on the subjective and objective weighted attribute value consistency, a more comprehensive, reasonable and accurate combination weight is calculated to better realize the comprehensive evaluation of the sustainable development of power grid enterprises.

3.1.1. The Group Order Relation Method Improved by Matter Element Analysis

(1) The Order Relation Method

The order relation method is a subjective weighting method with simple calculation and good rank preservation [23]. Firstly, the experts sort the evaluation criteria qualitatively, and then compare the importance of the adjacent indicators. Finally, the weights are determined by mathematical methods [24,25]. The concrete calculation process of the order relation method is as follows:

(1) Determine the order relation.

For evaluation criteria, if the importance of the evaluation criterion x_i is greater than criterion x_j, it is denoted as $x_i > x_j$.

For the evaluation criteria set $\{x_1, x_2, \cdots, x_n\}$, the concrete steps for establishing order relations are as follows:

First of all, in the criteria set $\{x_1, x_2, \cdots, x_n\}$, choose the most important criterion, marked as x_1^*. Then, in the remaining $n-1$ criteria, choose the most important criterion, marked as x_2^*. Next, repeat the above steps until mark to x_n^*. Finally, determine the unique order relation $x_1 > x_2 > \cdots > x_n$.

(2) Give the judgment of the relative importance between x_{k-1} and x_k.

According to the experts research, it is estimated that the ratio of the importance of the evaluation criterion x_{k-1} and the evaluation criterion x_k is w_{k-1}/w_k, valued as r_k. That is $w_{k-1}/w_k = r_k$ $(k = n, n-1, \cdots, 2)$. The value of r_k is shown in Table 2:

Table 2. The value of r_k .

r_k	Explanation
1.0	Criterion x_{k-1} is as important as criterion x_k
1.2	Criterion x_{k-1} is a little more important than criterion x_k
1.4	Criterion x_{k-1} is obviously more important than criterion x_k
1.6	Criterion x_{k-1} is strongly more important than criterion x_k
1.8	Criterion x_{k-1} is extremely more important than criterion x_k

(3) Calculate the weight coefficient w_k

Suppose that r_k satisfies the relation $r_{k-1} > 1/r_k$, $k = n, n-1, \cdots, 2$, then the weight of evaluation criteria can be determined according to Equation (4):

$$\begin{gathered} w_n = \left(1 + \sum_{k=2}^{n} \prod_{i=k}^{n} r_i\right)^{-1} \\ w_{k-1} = r_k w_k, k = n, n-1, \cdots, 2 \end{gathered} \tag{4}$$

(2) The group order relation method improved by matter element analysis [26–29]

Suppose that the evaluated object has n evaluation criteria and there are m experts participating in the evaluation. The weight of the i expert to the j criterion can be obtained by order relation method as θ_{ij} and the compound matter element R can be constructed as Equation (5):

$$R = \begin{bmatrix} & M_1 & M_2 & \cdots & M_n \\ c_1 & \theta_{11} & \theta_{12} & \cdots & \theta_{1n} \\ c_2 & \theta_{21} & \theta_{22} & \cdots & \theta_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ c_m & \theta_{m1} & \theta_{m2} & \cdots & \theta_{mn} \end{bmatrix} \tag{5}$$

According to compound matter element, the classical domain matter element R_{oj}, the joint domain matter element R_{pj} and the matter element R_j^x to be measured are determined as follows:

$$R_{oj} = \begin{vmatrix} c_1 & V_j \\ c_2 & V_j \\ \vdots & \vdots \\ c_m & V_j \end{vmatrix} \tag{6}$$

$$R_{pj} = \begin{vmatrix} c_1 & \langle a_j, b_j \rangle \\ c_2 & \langle a_j, b_j \rangle \\ \vdots & \vdots \\ c_m & \langle a_j, b_j \rangle \end{vmatrix} \tag{7}$$

$$R_j^x = \begin{vmatrix} c_1 & \theta_{1j} \\ c_2 & \theta_{2j} \\ \vdots & \vdots \\ c_m & \theta_{mj} \end{vmatrix} \tag{8}$$

where $V_j = \sqrt[m]{\prod_{i=1}^{m} \theta_{ij}}$, $a_j = \min(\theta_{ij})$, $b_j = \max(\theta_{ij})$, $i = 1, 2, \cdots, m$, $j = 1, 2, \cdots, n$.

The correlation function matter element R_0 is as follows:

$$R_0 = \begin{vmatrix} & M_1 & M_2 & \cdots & M_n \\ c_1 & K(x_{11}) & K(x_{12}) & \cdots & K(x_{1n}) \\ c_2 & K(x_{21}) & K(x_{22}) & \cdots & K(x_{2n}) \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ c_m & K(x_{m1}) & K(x_{m2}) & \cdots & K(x_{mn}) \end{vmatrix} \tag{9}$$

$$K(x_{ij}) = \begin{cases} (\theta_{ij} - V_j)/(b_j - V_j) & (\theta_{ij} \geq V_j) \\ (V_j - \theta_{ij})/(V_j - a_j) & (\theta_{ij} < V_j) \end{cases} \tag{10}$$

where $K(x_{ij})$ is the correlation function value of the i expert to the j criterion.

The expert validity matter element R_η is as follows:

$$R_\eta = \begin{vmatrix} & c_1 & c_2 & \cdots & c_m \\ \eta & \gamma_1 & \gamma_2 & \cdots & \gamma_m \end{vmatrix}$$
$$\gamma_i = \frac{1}{k_i} / \sum_{i=1}^{m} \frac{1}{k_i}, k_i = \sum_{j=1}^{n} K(x_{ij}) \tag{11}$$

Suppose:

$$R_T = R_\eta \cdot R = \begin{vmatrix} & M_1 & M_2 & \cdots & M_n \\ \widetilde{w} & \widetilde{w}_1 & \widetilde{w}_2 & \cdots & \widetilde{w}_n \end{vmatrix} \tag{12}$$

Then, the weighted matter element R_w can be determined as Equation (13):

$$R_w = \begin{vmatrix} & M_1 & M_2 & \cdots & M_n \\ w' & w'_1 & w'_2 & \cdots & w'_n \end{vmatrix} \tag{13}$$

where $w'_j = \widetilde{w}_j / \sum_{j=1}^{n} \widetilde{w}_j$, $j = 1, 2, \cdots, n$.

Thus, the subjective weights of the evaluation criteria determined by the group order relation method improved by matter element analysis can be obtained as $w' = (w'_1, w'_2, \cdots, w'_n)$.

3.1.2. Entropy Weight Method

Entropy weight method is the method of determining criteria weight according to the magnitude of information load of each criterion [30–33].

Set the decision matrix as $D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$, where x_{ij} is the criterion value of the i evaluated object to the j criterion. The procedure of determining the weight coefficients of the criteria by entropy weight method are as follows:

(1) Calculate the contribution of the i evaluated object to the j criterion.

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{14}$$

(2) Calculate the entropy value of the j criterion.

The entropy value e_j represents the total contribution of all the evaluated objects to the j criterion.

$$e_j = -k \sum_{i=1}^{m} p_{ij} \ln p_{ij} \tag{15}$$

where $k = 1/\ln m$.

(3) Calculate the otherness coefficient g_j of the x_j criterion.

The otherness coefficient g_j indicates the inconsistency degree of the contribution of each evaluated object under the j criterion, which is determined by Equation (16):

$$g_j = 1 - e_j \tag{16}$$

Obviously, the greater g_j is, the greater the role of the criterion is.

(4) Determine the weight coefficient.

The normalized weight coefficient w_j is determined by Equation (17):

$$w_j = \frac{g_j}{\sum_{j=1}^{n} g_j} \tag{17}$$

Thus, the objective weights of the evaluation criteria determined by entropy weight method can be obtained as $w'' = (w''_1, w''_2, \cdots, w''_n)$.

3.1.3. The Combination Weighting Method Based on the Subjective and Objective Weighted Attribute Value Consistency

From the above analysis, the weight vector obtained by the subjective weighting method is $w' = (w'_1, w'_2, \cdots, w'_n)^T$, and satisfies the condition $0 \leq w'_j \leq 1$, $\sum_{j=1}^{n} w'_j = 1$. The weight vector obtained by the objective weighting method is $w'' = (w''_1, w''_2, \cdots, w''_n)^T$, and satisfies the condition $0 \leq w''_j \leq 1$, $\sum_{j=1}^{n} w''_j = 1$.

In order to evaluate the sustainable development of power grid enterprises more systematically, scientifically, comprehensively and accurately, the combination weighting method is adopted to synthesize the information of subjective and objective weights. And the combination weight vector is determined by Equation (18):

$$w = \alpha w' + \beta w'' \tag{18}$$

where α, β satisfies the condition $\alpha, \beta > 0, \alpha + \beta = 1$.

α and β are the combination coefficients of subjective and objective weights, which determine the final result of the combination weighting directly. In order to fully embody the subjective and objective information in the evaluation of the sustainable development of grid enterprises, the consistency of subjective and objective information should be ensured. According to the weighted attribute value, a mathematical model is established for the subjective and objective weighted attribute value consistency. Calculate the optimal solution of combination coefficients α and β, and then determine the combination weights of the evaluation criteria [34–36].

The concrete calculation process for solving α and β is as follows:

Firstly, the decision matrix is set as $R = (r_{ij})_{m \times n}$. According to the principle of the consistency of subjective and objective information, a single objective programming model is set up as Equation (19):

$$\begin{gathered} \min Z = \sum_{i=1}^{m} d_i = \sum_{i=1}^{m} \sum_{j=1}^{n} (r_{ij} \alpha w'_j - r_{ij} \beta w'')^2 \\ s.t. \alpha + \beta = 1 (\alpha, \beta \geq 0) \end{gathered} \tag{19}$$

Then, calculated the combination coefficient α and β.

$$\alpha = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} r_{ij}^2 w''_j (w'_j + w''_j)}{\sum_{i=1}^{m} \sum_{j=1}^{n} r_{ij}^2 (w'_j + w''_j)^2} \tag{20}$$

$$\beta = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} r_{ij}^2 w'_j (w'_j + w''_j)}{\sum_{i=1}^{m} \sum_{j=1}^{n} r_{ij}^2 (w'_j + w''_j)^2} \tag{21}$$

Finally, according to the above steps, the combination weights of the evaluation criteria can be obtained as $w = (w_1, w_2, \cdots, w_n)$.

3.2. The Group Ideal Point Method Improved by Triangular Fuzzy Numbers Based on Combination Weighting Method

3.2.1. The Determination of Triangular Fuzzy Numbers Evaluation Matrix

Suppose an evaluation problem has m objects to be evaluated $(i = 1, 2, \cdots, m)$, n evaluation criteria $(j = 1, 2, \cdots, n)$, which is evaluated by k experts $(l = 1, 2, \cdots, k)$. And the initial fuzzy evaluation matrix of the expert group is obtained as $X = (\widetilde{X}_{ij})_{m \times n}$.

For qualitative criteria, experts use linguistic variables to score the criteria of the evaluated objects, and transform the scoring results into triangular fuzzy numbers [37–39]. The correspondence between evaluation linguistic variables and triangular fuzzy numbers is shown in Table 3:

Table 3. The correspondence between evaluation linguistic variables and triangular fuzzy numbers.

Linguistic Variables	Triangular Fuzzy Numbers
Very poor	(0, 0, 0.25)
Poor	(0, 0.25, 0.5)
Average	(0.25, 0.5, 0.75)
Good	(0.5, 0.75, 1)
Very good	(0.75, 1, 1)

The triangular fuzzy numbers $\widetilde{X}_{ij}^k = (x_{ij1}^k, x_{ij2}^k, x_{ij3}^k)$ represents the evaluation value of the j qualitative criterion of the k expert to the i evaluated object. λ_k represents the evaluation weight of the k expert. $\widetilde{X}_{ij} = (x_{ij1}, x_{ij2}, x_{ij3})$ represents the comprehensive criteria value of the expert group for evaluation. Then we can obtain that:

$$\begin{cases} x_{ij1} = \sum\limits_{l=1}^{k} \lambda_k x_{ij1}^k \\ x_{ij2} = \sum\limits_{l=1}^{k} \lambda_k x_{ij2}^k \\ x_{ij3} = \sum\limits_{l=1}^{k} \lambda_k x_{ij3}^k \end{cases} \tag{22}$$

For quantitative criteria, the pretreated quantitative data need to be transformed into triangular fuzzy numbers by fuzzy processing [40]. As shown in Equation (23):

$$\begin{cases} x_{ij1} = d_{ij}(1-\alpha_j) \\ x_{ij2} = d_{ij} \\ x_{ij3} = d_{ij}(1+\beta_j) \end{cases} \tag{23}$$

where d_{ij} represents the numerical value after the consistent and non dimensional processing of the j quantitative criterion of the i evaluated object.

α and β are the downward fluctuation coefficient and upward fluctuation coefficient of the data respectively, which are determined by the expert group.

According to the above procedure, the initial fuzzy evaluation matrix of the expert group can be obtained.

Standardize the initial fuzzy evaluation matrix to obtain the standardized matrix $U = (\widetilde{U}_{ij})_{m\times n}$ by Equation (24):

$$\begin{gathered} \widetilde{U}_{ij} = (u_{ij1}, u_{ij2}, u_{ij3}) \\ u_{ij1} = \frac{x_{ij1}}{x_{j3}^+}, u_{ij2} = \frac{x_{ij2}}{x_{j3}^+}, u_{ij3} = \frac{x_{ij3}}{x_{j3}^+} \end{gathered} \tag{24}$$

where $x_{j3}^+ = \max_i\{x_{ij3}\}$.

3.2.2. The Fuzzy Group Ideal Point Method

(1) Determine the positive and negative fuzzy ideal solutions according to the standardized matrix [41,42].

Positive fuzzy ideal solution:

$$f_j^+ = (u_{j1}^+, u_{j2}^+, u_{j3}^+) \tag{25}$$

where $u_{j1}^+ = \max_i\{u_{ij1}\}$, $u_{j2}^+ = \max_i\{u_{ij2}\}$, $u_{j3}^+ = \max_i\{u_{ij3}\}$.

Negative fuzzy ideal solution:

$$f_j^- = (u_{j1}^-, u_{j2}^-, u_{j3}^-) \tag{26}$$

where $u_{j1}^- = \min_i\{u_{ij1}\}$, $u_{j2}^- = \min_i\{u_{ij2}\}$, $u_{j3}^- = \min_i\{u_{ij3}\}$.

(2) Calculate fuzzy distance [43,44].

Calculate the Euclidean distance of each triangular fuzzy number in the normalized matrix to the positive and negative fuzzy ideal solution:

$$d_{ij}^+ = \sqrt{\frac{1}{3}\left[(u_{j1}^+ - u_{ij1})^2 + (u_{j2}^+ - u_{ij2})^2 + (u_{j3}^+ - u_{ij3})^2\right]} \tag{27}$$

$$d_{ij}^- = \sqrt{\frac{1}{3}\left[(u_{j1}^- - u_{ij1})^2 + (u_{j2}^- - u_{ij2})^2 + (u_{j3}^- - u_{ij3})^2\right]} \tag{28}$$

The weighted judgment matrix T is constructed according to the combination weights determined by group order relation method improved by matter element analysis and entropy weight method:

$$T = \begin{bmatrix} w_1 t_{11} & w_2 t_{12} & \cdots & w_n t_{1n} \\ w_1 t_{21} & w_2 t_{22} & \cdots & w_n t_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ w_1 t_{m1} & w_2 t_{m2} & \cdots & w_n t_{mn} \end{bmatrix} \tag{29}$$

where $t_{ij} = \frac{d_{ij}^-}{d_{ij}^+ + d_{ij}^-}$.

The queuing indication value of each evaluated object is calculated as follows:

$$y_i^+ = \sqrt{\sum_{j=1}^{n}\left[w_j t_{ij} - \max_{1\le i\le m}(w_j t_{ij})\right]^2} \tag{30}$$

$$y_i^- = \sqrt{\sum_{j=1}^{n}\left[w_j t_{ij} - \min_{1\le i\le m}(w_j t_{ij})\right]^2} \tag{31}$$

$$C_i = \frac{y_i^-}{y_i^+ + y_i^-} \tag{32}$$

Using queuing indication value to evaluate the system comprehensively, the greater the queuing indication value is, the stronger the sustainable development capacity of power grid enterprise is. On the contrary, the smaller the queuing indication value is, the weaker the sustainable development capacity of power grid enterprise is.

3.3. Construction of the Comprehensive Evaluation Model

The basic steps of constructing the comprehensive evaluation model of fuzzy group ideal point method and combination weighting method with improved group order relation method and entropy weight method are as follows:

(1) Construct the evaluation criteria system and preprocess the data.
(2) Experts rank the evaluation criteria qualitatively and compare the importance of adjacent criteria. The weight of each expert is determined by the basic order relation method to construct the compound matter elements, and the subjective weights of evaluation criteria are obtained by matter element analysis.
(3) Entropy weight method is used to determine the objective weights of the preprocessed criteria.

(4) Calculate the combination weights by the combination weighting method based on the subjective and objective weighted attribute value consistency.

(5) Using the linguistic variables and fuzzy processing method to transform the evaluation value of the qualitative criteria and quantitative criteria for the evaluated object into triangular fuzzy numbers, construct and standardize the initial fuzzy evaluation matrix.

(6) Determine the positive and negative fuzzy ideal solutions according to the normalized fuzzy evaluation matrix and calculate the Euclidean distance of each triangular fuzzy number to the positive and negative fuzzy ideal solution. And transform the fuzzy evaluation matrix into the weighted judgment matrix based on the combination weights.

(7) According to the weighted judgment matrix, use the traditional TOPSIS method to determine the positive and negative ideal solutions, and calculate the Euclidean distance of each evaluated object to the positive and negative ideal solution. Then the queuing indication value of each object and the ranking result are obtained for comprehensive evaluation and analysis.

The process of constructing the comprehensive evaluation model is shown in Figure 2:

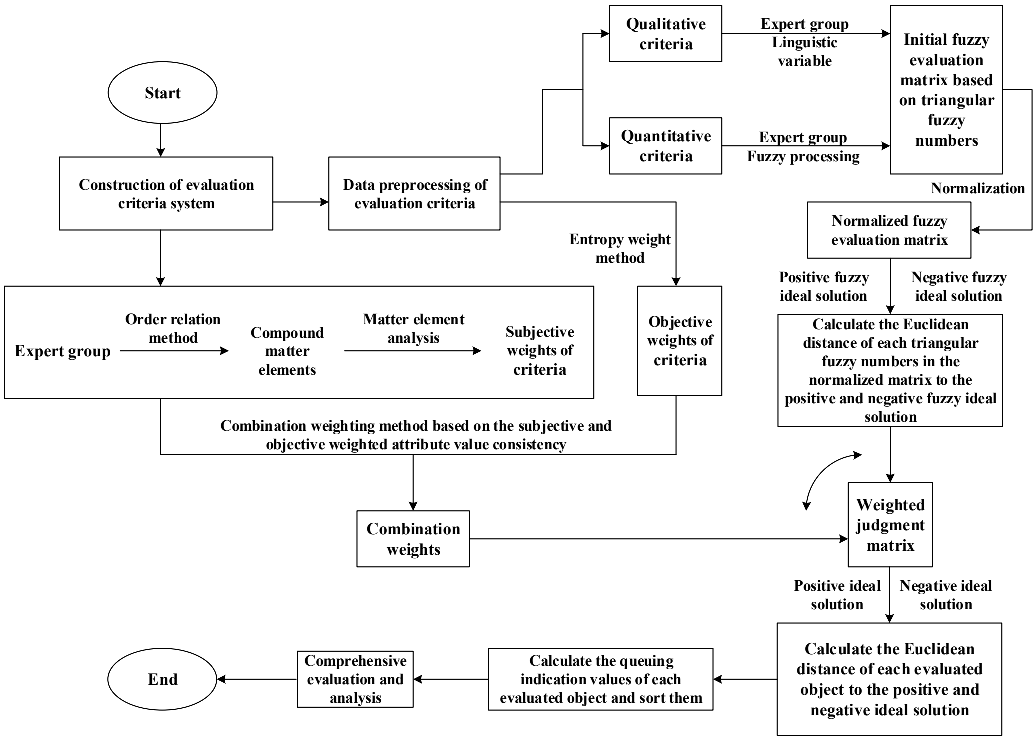

Figure 2. The flow chart of the comprehensive evaluation model construction.

4. Example Analysis

4.1. Data Collecting and Preprocessing

In this paper, the criteria data of four power grid enterprises A, B, C and D were collected, and five industry experts were invited to make a comprehensive evaluation of the sustainable development of the four power grid enterprises. According to Equations (1)–(3), do the consistent and non dimensional processing of the raw data, and the data preprocessing results are shown in Table 4:

Table 4. The data preprocessing results.

Enterprise	A	B	C	D
M_1	0.2252	0.1712	0.2883	0.3153
M_2	0.2357	0.1929	0.3143	0.2571
M_3	0.1944	0.2315	0.3148	0.2593
M_4	0.2594	0.2008	0.3082	0.2316
M_5	0.2772	0.1715	0.3156	0.2357
M_6	0.2545	0.2737	0.2413	0.2305
M_7	0.2598	0.2451	0.2639	0.2312
M_8	0.2633	0.2678	0.2419	0.2271
M_9	0.2567	0.2171	0.2445	0.2816
M_{10}	0.3119	0.1890	0.2644	0.2347
M_{11}	0.2814	0.2223	0.2446	0.2517
M_{12}	0.2497	0.2477	0.2520	0.2507
M_{13}	0.2497	0.2473	0.2521	0.2509
M_{14}	0.2501	0.2476	0.2519	0.2504
M_{15}	0.2434	0.2577	0.2655	0.2333
M_{16}	0.2423	0.2484	0.2577	0.2515
M_{17}	0.2485	0.2339	0.2632	0.2544
M_{18}	0.2247	0.2806	0.2628	0.2319
M_{19}	0.2548	0.2395	0.2490	0.2568
M_{20}	0.2222	0.2534	0.2882	0.2362
M_{21}	0.2395	0.2695	0.2575	0.2335
M_{22}	0.2264	0.2436	0.2693	0.2607
M_{23}	0.2543	0.2457	0.2601	0.2399
M_{24}	0.2639	0.2346	0.2493	0.2522
M_{25}	0.2414	0.2241	0.2759	0.2586
M_{26}	0.2617	0.2349	0.2819	0.2215
M_{27}	0.2424	0.2515	0.2576	0.2485
M_{28}	0.2737	0.2518	0.2409	0.2336
M_{29}	0.2387	0.2447	0.2598	0.2568
M_{30}	0.2570	0.2353	0.2446	0.2632
M_{31}	0.1896	0.2827	0.2740	0.2537
M_{32}	0.2225	0.2572	0.2837	0.2366

4.2. Determination of the Weights of Evaluation Criteria

(1) Determination of the subjective weights

The five experts rank the importance of the third-level criteria, and give the ratio of importance to form five order relations. Calculate the weights under each order relation according to Equation (4) and construct the compound matter element R, the classical domain matter element R_{oj}, the joint domain matter element R_{pj} and the matter element R_j^x to be measured according to Equations (5)–(8).

$$R = \begin{bmatrix} & M_1 & M_2 & \cdots & M_{32} \\ c_1 & 0.0359 & 0.0299 & \cdots & 0.0423 \\ c_2 & 0.0176 & 0.0212 & \cdots & 0.0508 \\ c_3 & 0.0285 & 0.0238 & \cdots & 0.0385 \\ c_4 & 0.0176 & 0.0212 & \cdots & 0.0466 \\ c_5 & 0.0175 & 0.0245 & \cdots & 0.0543 \end{bmatrix}$$

$$R_{o1} = \begin{vmatrix} c_1 & 0.0223 \\ c_2 & 0.0223 \\ c_3 & 0.0223 \\ c_4 & 0.0223 \\ c_5 & 0.0223 \end{vmatrix} \quad R_{o2} = \begin{vmatrix} c_1 & 0.0239 \\ c_2 & 0.0239 \\ c_3 & 0.0239 \\ c_4 & 0.0239 \\ c_5 & 0.0239 \end{vmatrix} \quad \cdots \quad R_{o32} = \begin{vmatrix} c_1 & 0.0462 \\ c_2 & 0.0462 \\ c_3 & 0.0462 \\ c_4 & 0.0462 \\ c_5 & 0.0462 \end{vmatrix}$$

$$R_{p1} = \begin{vmatrix} c_1 & \langle 0.0175, 0.0359 \rangle \\ c_2 & \langle 0.0175, 0.0359 \rangle \\ c_3 & \langle 0.0175, 0.0359 \rangle \\ c_4 & \langle 0.0175, 0.0359 \rangle \\ c_5 & \langle 0.0175, 0.0359 \rangle \end{vmatrix} R_{p2} = \begin{vmatrix} c_1 & \langle 0.0212, 0.0299 \rangle \\ c_2 & \langle 0.0212, 0.0299 \rangle \\ c_3 & \langle 0.0212, 0.0299 \rangle \\ c_4 & \langle 0.0212, 0.0299 \rangle \\ c_5 & \langle 0.0212, 0.0299 \rangle \end{vmatrix} \cdots R_{p32} = \begin{vmatrix} c_1 & \langle 0.0385, 0.0543 \rangle \\ c_2 & \langle 0.0385, 0.0543 \rangle \\ c_3 & \langle 0.0385, 0.0543 \rangle \\ c_4 & \langle 0.0385, 0.0543 \rangle \\ c_5 & \langle 0.0385, 0.0543 \rangle \end{vmatrix}$$

$$R_1^x = \begin{vmatrix} c_1 & 0.0359 \\ c_2 & 0.0176 \\ c_3 & 0.0285 \\ c_4 & 0.0176 \\ c_5 & 0.0175 \end{vmatrix} R_2^x = \begin{vmatrix} c_1 & 0.0299 \\ c_2 & 0.0212 \\ c_3 & 0.0238 \\ c_4 & 0.0212 \\ c_5 & 0.0245 \end{vmatrix} \cdots R_{32}^x = \begin{vmatrix} c_1 & 0.0423 \\ c_2 & 0.0508 \\ c_3 & 0.0385 \\ c_4 & 0.0466 \\ c_5 & 0.0543 \end{vmatrix}$$

Determine the correlation function matter element R_0 according to Equations (9) and (10).

$$R_0 = \begin{vmatrix} & M_1 & M_2 & \cdots & M_n \\ c_1 & 1 & 1 & \cdots & 0.4980 \\ c_2 & 0.9721 & 1 & \cdots & 0.5685 \\ c_3 & 0.4545 & 0.0520 & \cdots & 1 \\ c_4 & 0.9721 & 1 & \cdots & 0.0508 \\ c_5 & 1 & 0.0933 & \cdots & 1 \end{vmatrix}$$

The subjective weights of the evaluation criteria determined by the group order relation method improved by matter element analysis can be obtained according to Equations (11)–(13). As shown in Table 5:

Table 5. Subjective weights of evaluation criteria.

Criteria	Weight
M_1	0.0236
M_2	0.0244
M_3	0.0244
M_4	0.0477
M_5	0.0341
M_6	0.0360
M_7	0.0287
M_8	0.0254
M_9	0.0405
M_{10}	0.0289
M_{11}	0.0239
M_{12}	0.0287
M_{13}	0.0287
M_{14}	0.0344
M_{15}	0.0312
M_{16}	0.0238
M_{17}	0.0242
M_{18}	0.0302
M_{19}	0.0301
M_{20}	0.0215
M_{21}	0.0283
M_{22}	0.0429
M_{23}	0.0349
M_{24}	0.0243
M_{25}	0.0257
M_{26}	0.0229
M_{27}	0.0255
M_{28}	0.0191
M_{29}	0.0526
M_{30}	0.0439
M_{31}	0.0431
M_{32}	0.0467

(2) Determination of the objective weights

On the basis of data preprocessing, the objective weights of the evaluation criteria determined by entropy weight method can be obtained according to Equations (15)–(17). As shown in Table 6:

Table 6. Objective weights of evaluation criteria.

Criteria	Weight
M_1	0.1568
M_2	0.0922
M_3	0.0926
M_4	0.0747
M_5	0.1429
M_6	0.0124
M_7	0.0081
M_8	0.0132
M_9	0.0262
M_{10}	0.0975
M_{11}	0.0215
M_{12}	0.0001
M_{13}	0.0002
M_{14}	0.0001
M_{15}	0.0076
M_{16}	0.0015
M_{17}	0.0055
M_{18}	0.0249
M_{19}	0.0022
M_{20}	0.0291
M_{21}	0.0098
M_{22}	0.0133
M_{23}	0.0029
M_{24}	0.0053
M_{25}	0.0180
M_{26}	0.0265
M_{27}	0.0014
M_{28}	0.0110
M_{29}	0.0036
M_{30}	0.0057
M_{31}	0.0675
M_{32}	0.0255

(3) Determination of the combination weights

By calculation according to Equations (20) and (21), obtain the combination coefficients $\alpha = 0.6502$, $\beta = 0.3498$. Substitute the combination coefficients into Equation (18), and then the combination weights of the evaluation criteria based on the subjective and objective weighted attribute value consistency can be obtained. As shown in Table 7:

Table 7. Combination weights of evaluation criteria.

Criteria	Weight
M_1	0.0702
M_2	0.0481
M_3	0.0483
M_4	0.0572
M_5	0.0722
M_6	0.0277

Table 7. *Cont.*

Criteria	Weight
M_7	0.0215
M_8	0.0211
M_9	0.0355
M_{10}	0.0529
M_{11}	0.0231
M_{12}	0.0187
M_{13}	0.0187
M_{14}	0.0224
M_{15}	0.0229
M_{16}	0.0160
M_{17}	0.0176
M_{18}	0.0283
M_{19}	0.0203
M_{20}	0.0242
M_{21}	0.0218
M_{22}	0.0325
M_{23}	0.0237
M_{24}	0.0177
M_{25}	0.0230
M_{26}	0.0242
M_{27}	0.0171
M_{28}	0.0163
M_{29}	0.0355
M_{30}	0.0305
M_{31}	0.0516
M_{32}	0.0393

4.3. Comprehensive Evaluation Based on the Fuzzy Group Ideal Point Method

(1) The determination of triangular fuzzy numbers evaluation matrix

Under the condition that the evaluation weights of the five experts are equal, according to the experts scoring, the triangular fuzzy numbers of qualitative criteria are determined by Equation (22). For quantitative criteria, the expert group determines the downward fluctuation coefficient $\alpha = 0.4$ and upward fluctuation coefficient $\beta = 0.3$ of the data. Then the triangular fuzzy numbers of quantitative criteria can be determined according to Equation (23). After that, the initial fuzzy evaluation matrix of the expert group can be obtained according to Equation (24). And standardize the initial fuzzy evaluation matrix to obtain the standardized matrix U:

$$U = \begin{bmatrix} & A & B & C & D \\ M_1 & (0.1351, 0.2252, 0.2928) & (0.1027, 0.1712, 0.2225) & (0.1730, 0.2883, 0.3748) & (0.1892, 0.3153, 0.4099) \\ M_2 & (0.1414, 0.2357, 0.3064) & (0.1157, 0.1929, 0.2507) & (0.1886, 0.3143, 0.4086) & (0.1543, 0.2571, 0.3343) \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ M_{32} & (0.1335, 0.2225, 0.2892) & (0.1543, 0.2572, 0.3344) & (0.1702, 0.2837, 0.3688) & (0.1420, 0.2366, 0.3076) \end{bmatrix}$$

(2) Comprehensive evaluation

According to Equations (25) and (26), determine the positive fuzzy ideal solution $f_j^+ = (0.75, 1, 1)$ and the negative fuzzy ideal solution $f_j^- = (0, 0.05, 0.22)$. And according to Equations (27)–(29), obtain the weighted judgment matrix T.

$$T = \begin{bmatrix} & A & B & C & D \\ M_1 & 0.0113 & 0.0076 & 0.0162 & 0.0183 \\ M_2 & 0.0083 & 0.0061 & 0.0125 & 0.0094 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ M_{32} & 0.0062 & 0.0077 & 0.0088 & 0.0068 \end{bmatrix}$$

According to Equations (30)–(32), calculate the queuing indication values of the power grid enterprises A, B, C and D. As shown in Table 8:

Table 8. The queuing indication values.

Power Grid Enterprise	Queuing Indication Value
A	0.3991
B	0.3679
C	0.7242
D	0.5736

According to the queuing indication values, the sorting result of the sustainable development of the four power grid enterprises can be obtained: C > D > A > B, and the best power grid enterprise for sustainable development is C.

4.4. Innovations of Evaluation Model

On the basis of using traditional order relation method to determine the criteria weights, adopt the traditional TOPSIS method to evaluate the same case above. And the queuing indication values of the four power grid enterprises are shown in Table 9.

Table 9. The queuing indication values.

Power Grid Enterprise	Queuing Indication Value
A	0.3748
B	0.3622
C	0.5465
D	0.4839

As can be seen from Table 9, the sorting result based on traditional order relation method and traditional TOPSIS method of the sustainable development of the four power grid enterprises is: C > D > A > B, which is the same as the sorting result based on the evaluation model of fuzzy group ideal point method and combination weighting method with improved group order relation method and entropy weight method. However, compared with the evaluation model of single weighting method and single evaluation method, the comprehensive evaluation model proposed in this paper obviously integrates more evaluation information of experts and more objective information of power grid enterprises development.

For the determination of evaluation criteria weights, the combination weighting method based on the subjective and objective weighted attribute value consistency is used in this paper, which combines the subjective and objective information to calculate more comprehensive, reasonable and accurate combination weights for comprehensive evaluation. Entropy weight method is adopted for determining the objective weights. As for the subjective weights, the group order relation method improved by matter element analysis is used, which gives full consideration to each expert's understanding of different things and makes the subjective weights more comprehensive compared with traditional order relation method.

For evaluation method, the group ideal point method improved by triangular fuzzy numbers is used in this paper. Compared with the traditional TOPSIS method, this improved method introduces the triangular fuzzy numbers to better realize the scientific processing of the data information which is difficult to quantify and integrates the opinions of experts group effectively.

To sum up, the evaluation model of fuzzy group ideal point method and combination weighting method with improved group order relation method and entropy weight method proposed in this paper creatively combines various evaluation theories to integrate more evaluation information of experts and more objective information of power grid enterprises development, which makes the comprehensive evaluation results more credible and effective.

5. Conclusions

In this paper, the model of fuzzy group ideal point method and combination weighting method with improved group order relation method and entropy weight method is proposed to evaluate the sustainable development of power grid enterprises. Firstly, on the basis of consulting a large amount of literature, the important criteria of the comprehensive evaluation of the sustainable development of power grid enterprises are preliminarily selected. The opinions of the industry experts are consulted and fed back for many rounds through the Delphi method and the evaluation criteria system for sustainable development of power grid enterprises is determined, then doing the consistent and non dimensional processing of the evaluation criteria. After that, based on the basic order relation method, the weights of each expert judgment matrix are synthesized to construct the compound matter elements. By using matter element analysis, the subjective weights of the criteria are obtained. And entropy weight method is used to determine the objective weights of the preprocessed criteria. Then, combining the subjective and objective information with the combination weighting method based on the subjective and objective weighted attribute value consistency, a more comprehensive, reasonable and accurate combination weight is calculated. Finally, based on the traditional TOPSIS method, the triangular fuzzy numbers are introduced to better realize the scientific processing of the data information which is difficult to quantify, and the queuing indication value of each object and the ranking result are obtained. A numerical example is taken to prove that the model of fuzzy group ideal point method and combination weighting method with improved group order relation method and entropy weight method is feasible and effective for evaluating the sustainable development of power grid enterprises. Compared with the evaluation model of single weighting method and single evaluation method, the evaluation model proposed in this paper creatively combines various evaluation theories to integrate more evaluation information of experts and more objective information of power grid enterprises development, which makes the comprehensive evaluation results more credible and effective. However, there is still some room for further research in this paper. In the following study, intelligent algorithms can be combined with traditional comprehensive evaluation methods to realize the innovation of the comprehensive evaluation model.

Acknowledgments: This work was supported by Natural Science Foundation of China (Project No. 71471059).

Author Contributions: In this research activity, all the authors were involved in the data collection and preprocessing phase, model constructing, empirical research, results analysis and discussion, and manuscript preparation. All authors have approved the submitted manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

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