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Using a Novel FCE Model to Evaluate the Industry Competitiveness of Biomass Power Generation

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Abstract. Biomass energy is a kind of clean renewable energy, and the resources are abundant. With the rapid development in recent years, the biomass power generation has become one of the electric power new energy with the large-scale commercialization development prospects. The industry competitiveness evaluation of biomass power generation in China is the basis to explore the biomass power generation industry development strategy, which also can indicate the direction for the rapid and sound development of biomass power generation industry in China. To evaluate the industry competitiveness of biomass power generation scientifically and accurately, we defined the subordinate function and weight proportion and constructed the multi-level fuzzy comprehensive evaluation (FCE) model. The biomass competitiveness evaluation of biomass power generation showed that the results given by this model are reliable and precise.

Introduction

Energy is one of the important material bases of economic development and social progress, and which is the important factors that affect the human survival environment. At present, the energy structure that the coal is taken as the key energy is not reasonable in China, has restricted the sustainable development severely. So it is the important way of achieving the low carbon economy, optimizing the energy structure and ensuring the sustainable development of the energy to develop the new energy sources such as biomass power generation vigorously. Due to the emerging characteristics of biomass power generation industry, although the domestic and foreign scholars has conducted some research in related fields, but most are only limited to the surface or a point of research. To go on deeply study on the biomass power generation industry in China, and then put forward the systemic strategic suggestion is very little. At present, large-scale blind investment contributed to the appearance of prosperity, but the blindness of investment behavior is widespread within the biomass power generation industry, the existence of many problems such as technology and market price mechanism, the cost of raw materials, make the industry into development bottleneck in China [1-5].

So it is very important to analyze and evaluate the industry competitiveness of biomass power generation, and which is a systematic evaluating process, and a scientific and quantitative argumentation. There are some methods have been widely applied, such as: diamond model, principal component analysis, analytic hierarchy process, gray systematic evaluation, etc. However, these methods are subject to stochastic factors in the evaluating process, and the evaluating results are influenced by subjective experience and knowledge limitations easily, which often with personal bias and one-sidedness. We used a novel fuzzy comprehensive evaluation (FCE) model to evaluate the competitiveness evaluation of wind energy industry synthetically in this paper.

Methodology

Determine the Index Weight (θ_t) based on Entropy Value.

$$\theta_t = \frac{1}{n - E_e}[1 - e(d_i)] \tag{1}$$

Make $0 \le \theta_t \le 1$, $\sum_{i=1}^{n} \theta_t = 1$

In formula (1):

$$e(d_i) = -\frac{1}{\ln m} \sum_{k=1}^{m} \frac{d_i k}{\sum_{k=1}^{m} d_i k} \ln \frac{d_i k}{\sum_{k=1}^{m} d_i k}$$

Make $0 \le e(d_i) \le 1$

Construct the remark set. The remark set is the set of the probable results about the various indices. We can invite the related field experts to assess the outcomes. We establish the remark set about the evaluation indices:

V={(V_1 (strong competition), V_2 (relative strong competition), V_3 (general competition), V_4 (weak competition)}.

Ascertain the Weight Set. The weight set of the first level indices are $W = \{W_1, W_2, W_3, W_4, W_5\}$, the weight set of the second level indices are $W_i = \{W_{i1}, W_{i2} \cdots W_{ij}\}$.

Establish the evaluation matrix.

$$R = \begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_m \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{2}$$

In formula (2), R_i denotes the evaluation structure to the factors i; r_{ij} denotes the subject degree of evaluation factor i to the evaluation degree j, and it denotes the fuzzy relation between the evaluation factor and the evaluation degree. N denotes the amount of evaluation degree in remark set; m denotes the amount of the evaluated factors.

The multilevel fuzzy comprehensive evaluation. Firstly, we go along the first level fuzzy comprehensive evaluation, and calculate the indices weight (W) and the evaluation matrix (R) on the basis of entropy weight evaluation method, then we use the fuzzy algorithm to carry through the integrated operations and unitary treatment, and we gain the subject vector (S_i) of factor U_i to the remark set V.

$$S_i = W_i \cdot R_i = (W_{i1}, W_{i2,} \cdots, W_{ij}) \cdot \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{3}$$

Then, we go along the second level fuzzy comprehensive evaluation, gain the total evaluation vector A and the comprehensive evaluation conclusion [6-8].

$$A = W \cdot S \tag{4}$$

Evaluation Results based on FCE Model

The Evaluating Indices System Construction. "Diamond model" pointed out that a country's specific industry whether to have the competitive power to be decided by four fundamental factors: resources and elements, demand condition, related and auxiliary industrial condition and enterprise

competitors. Based on the fundamental idea of the diamond model, we constructed the evaluating index system for the competitiveness evaluation, which was as shown in Table 1.

Table 1 The Evaluating Index System Construction and Parameter Assignment

First Level Index (U)	Weight (W)	Second Level Index (U_i)	Weight (W_i)	Remark Set			
				Strong	Relative Strong	General	Weak
Total reserves of biomass energy (U_1)	0.16	(U_{11})	0.32	0.41	0.49	0.10	0
		(U_{12})	0.16	0.25	0.30	0.30	0.15
		(U_{13})	0.28	0.30	0.27	0.28	0.15
		(U_{14})	0.10	0.42	0.43	0.15	0
		(U_{15})	0.14	0.50	0.50	0	0
Industry Innovation Ability (U_2)	0.18	(U_{21})	0.12	0.45	0.50	0.05	0
		(U_{22})	0.28	0.30	0.30	0.30	0.10
		(U_{23})	0.24	0.42	0.42	0.16	0
		(U_{24})	0.16	0.25	0.30	0.25	0.20
		(U_{25})	0.20	0.58	0.42	0	0
Industry Policy (U_3)	0.33	(U_{31})	0.14	0.37	0.37	0.20	0.06
		(U_{32})	0.20	0.20	0.59	0.19	0.02
		(U_{33})	0.10	0.44	0.42	0.09	0.05
		(U_{34})	0.12	0.25	0.39	0.30	0.06
		(U_{35})	0.10	0.48	0.38	0.14	0
		(U_{36})	0.22	0.30	0.54	0.08	0.08
		(U_{37})	0.12	0.36	0.44	0.15	0.05
Industry Chain (U_4)	0.14	(U_{41})	0.14	0.50	0.40	0.10	0
		(U_{42})	0.42	0.33	0.47	0.10	0.10
		(U_{43})	0.12	0.35	0.35	0.20	0.10
		(U_{44})	0.32	0.25	0.30	0.25	0.20
Market Factor (U_5)	0.19	(U_{51})	0.22	0.16	0.50	0.30	0.04
		(U_{52})	0.14	0.25	0.65	0.10	0
		(U_{53})	0.18	0.21	0.29	0.46	0.04
		(U_{54})	0.30	0.26	0.62	0.10	0.02
		(U_{55})	0.16	0.25	0.39	0.32	0.04

Evaluating Results. According to Table 1 and formula (3), we carried on the fuzzy comprehensive evaluation:

$$S_1 = W_1 \cdot R_1 = \begin{bmatrix} 0.32 \\ 0.16 \\ 0.28 \\ 0.10 \\ 0.14 \end{bmatrix}^T \cdot \begin{bmatrix} 0.41 & 0.49 & 0.10 & 0 \\ 0.25 & 0.30 & 0.30 & 0.15 \\ 0.30 & 0.27 & 0.28 & 0.15 \\ 0.42 & 0.43 & 0.15 & 0 \\ 0.50 & 0.50 & 0.15 & 0 \end{bmatrix} = \begin{bmatrix} 0.37 \\ 0.39 \\ 0.19 \\ 0.07 \end{bmatrix}^T$$

Similarly, we could gain:

$S_2 = W_2 \cdot R_2 = [0.39 \quad 0.38 \quad 0.17 \quad 0.06]$

$S_3 = W_3 \cdot R_3 = [0.32 \quad 0.47 \quad 0.16 \quad 0.05]$

$S_4 = W_4 \cdot R_4 = [0.33 \quad 0.39 \quad 0.16 \quad 0.12]$

$S_5 = W_5 \cdot R_5 = [0.23 \quad 0.50 \quad 0.24 \quad 0.03]$

Carry on the second fuzzy evaluation using the formula (4); the final evaluation results were available:

$$A = W \cdot S = \begin{bmatrix} 0.16 \\ 0.18 \\ 0.33 \\ 0.14 \\ 0.19 \end{bmatrix}^T \cdot \begin{bmatrix} 0.37 & 0.39 & 0.19 & 0.07 \\ 0.39 & 0.38 & 0.17 & 0.06 \\ 0.32 & 0.47 & 0.16 & 0.05 \\ 0.33 & 0.39 & 0.16 & 0.12 \\ 0.23 & 0.50 & 0.24 & 0.03 \end{bmatrix} = \begin{bmatrix} 0.32 \\ 0.44 \\ 0.18 \\ 0.06 \end{bmatrix}^T$$

To facilitate comparison, we translate the comprehensive evaluation results into the score, and we adopt the evaluation degree is V = {strong, relative strong, general, weak}={90, 80, 70, 60}.

$U_1 = S_1 \cdot V = 80.39$

$U_2 = S_2 \cdot V = 81.00$

$U_3 = S_3 \cdot V = 80.60$

$U_4 = S_4 \cdot V = 79.30$

$U_5 = S_5 \cdot V = 79.30$

The score of the first level evaluation result was:

$U = A \cdot V = 80.20$

So we can find that the industry competitiveness of biomass power generation was “relative strong”.

Conclusions

The industry competitiveness evaluation of biomass power generation is associated with many factors, it need large numbers of statistical calculation, and the factitious factors can be mixed into easily, which make the evaluating work is difficult. On the basis of analyzing the influencing factors of biomass power generation industry based on the diamond model, this paper designed the reasonable and comprehensive evaluating index system, and proposed the multi-level fuzzy comprehensive evaluating model, and obtained a reliable competitiveness evaluation results.

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