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New energy industry competitiveness evaluation method based on analytic hierarchy process

Ji Wenju, Wang Jianwen
Inner Mongolia University of Technology, Hohhot 010051, (CHINA)

ABSTRACT

In this paper, we focus on the problem of new energy industry competitiveness evaluation, which is of great importance in modern society development, and governments have paid more and more attentions on this problem. The analytic hierarchy process algorithm can compute a priority of the importance of each alternative. Hence, an overall object is located at the top level, and the criteria in the middle level can represent the overall object. In order to evaluate competitiveness of the new energy industry, we set up an index system. Particularly, the proposed index system consists of three levels, and the top level contains "Technical efficiency evaluation", and "Comprehensive environmental assessment". To testify effectiveness of the proposed method, we collect the new energy industry information from eight provinces of China. For each province, the data for eighteen indexes are obtained, and index weights are calculated by the analytic hierarchy process algorithm. Experimental results demonstrate that the proposed method can effectively evaluate new energy industry competitiveness for a given region.

KEYWORDS

New energy industry; Competitiveness evaluation; Analytic hierarchy process; Ranking score.

INTRODUCTION

As is well known that in the 12th Five-Year national strategic emerging industries development plan, Chinese government aims to greatly develop several strategic emerging industries, in which the new energy industry is included[1,2]. Currently, the new energy industry development in China has been a certain scale of the industry with the industrial base[3].

Furthermore, because the energy crisis and environmental pollution significantly influence our daily life, many governments are planning to find new methods to tackle these problems. Particularly, we need to find new energy to replace the traditional energy to solve the problem of energy crisis and environmental pollution[4,5]. Hence, some new energy are paid more attentions by the world, such as wind, solar, hydro, geothermal, ocean energy and so on. We can see that new energy has the characteristics of clean, renewable, reusable, and less pollution.

On the other hand, energy industry is of great importance in modern economic restructuring. However, different regions implement different plans and policies on new energy industry development, and then these policies can modify regional energy structure and enhance the economic growth speed[6,7]. Moreover, there are some difficulties in the development of new energy industry, such as low-level redundant construction, and part of the new energy industry overcapacity[8,9].

Therefore, it is important to combine all the influencing factors to tackle the new energy industry evaluation problem. Particularly, in this paper the analytic hierarchy process technology is utilized, which is a powerful computing tool in many applications[10-12].

OVERVIEW OF THE ANALYTIC HIERARCHY PROCESS

In this section, some basic knowledge about analytic hierarchy process are illustrated. In recent years, applications of analytic hierarchy process are introduced in detail. Many researchers have successfully exploited in many different domains, such as Organ Transplantation[13], safety assessment of food-waste feed[14], Customer satisfaction evaluation[15], fuzzy-linguistic preference structures[16], Selecting stratospheric airship energy storage system[17], Dependability Benchmarking[18], Acceptability of energy sources[19].

Analytic hierarchy process has the ability to gain a priority of the importance of each alternative. It means that an overall object is positioned at the top level, and the criteria in the middle level represents to the overall object. Furthermore, elements located at a given level can be recorded as $X_1, X_2, \cdots, X_n$. Exploiting the relative evaluations computed by a decision maker, a pairwise comparison matrix can be defined by the following equation.

$$A = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix} \quad \textbf{(1)}$$

where the above equation should satisfy the condition that the reciprocal property $a_{ij} \cdot a_{ji}$ is equal to one. Then, the derivation of priorities at the specific levels is implemented by the pairwise matrix in Equation (1). Afterwards, the perfectly consistent case where the pairwise comparisons matrix is defined using vector $w = (w_1, \cdots, w_n)$.

$$A = \begin{pmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & \vdots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & \frac{w_n}{w_n} \end{pmatrix} \quad \textbf{(2)}$$

Therefore, using A, the priority vector is computed via Equation (3) and Equation (4).

$$Aw = nw \quad (3)$$

$$Aw = \lambda_{max} w \quad (4)$$

where λ_{max} denotes the largest eigenvalue of matrix A and w refers to the weight vector which is the eigenvector solution of Equation (4). Using the parameter λ_{max}, the consistency index is defined as follows.

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (5)$$

In order to compute the priority vector, the EV algorithm is used to tackle the eigenvector problem, and then the structure analytic hierarchy process is illustrated in Figure 1.

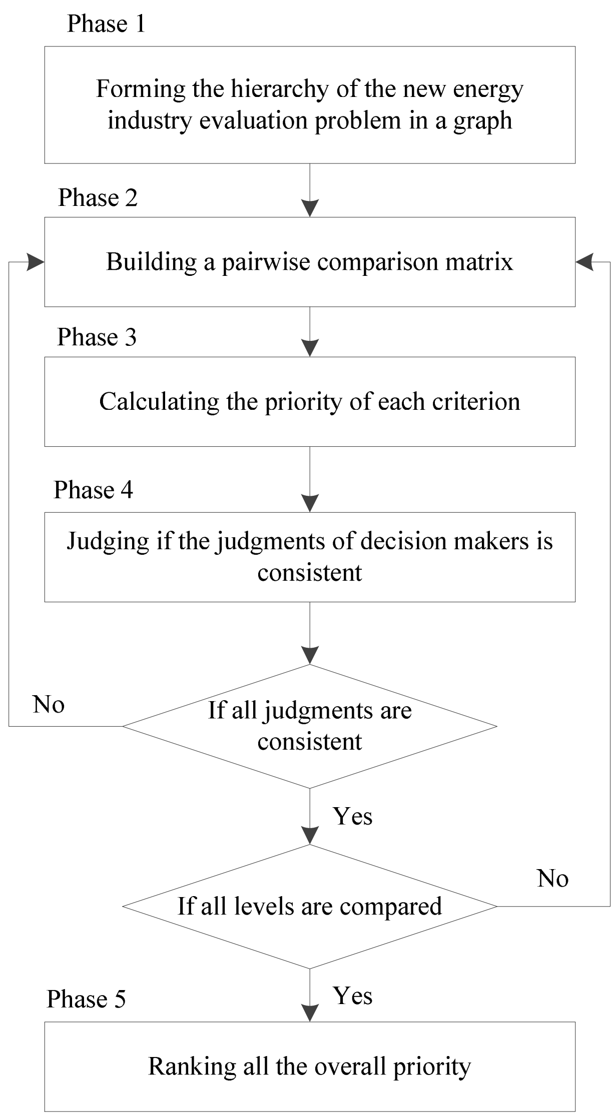

Figure 1 : Process of the analytic hierarchy process

INDEX SYSTEM FOR NEW ENERGY INDUSTRY COMPETITIVENESS EVALUATION

To evaluate the problem of new energy industry evaluation, the index system should be determined in advance. Particularly, the proposed index system is made up of three levels. For the first level, 1) Technical efficiency evaluation, and 2) Comprehensive environmental assessment are included. For the second level, six parts are designed, such as 1) the technical economic benefit, 2) technology of social benefit, 3) the ecological benefit of technology, 4) technology economic environment, 5) technology and social environment and 6) ecological and environmental technology. Afterwards, the layer of the third level is made up 18 factors, the main work of this paper is to determine the weight of these 18 factors by analytic hierarchy process. Particularly, the proposed index system is shown in TABLE 1.

TABLE 1 : Index system for the problem of new energy industry evaluation.

The first level	The second level	The third level
Technical efficiency evaluation	The technical economic benefit	I1: R & D investment
		I2: The cost of operation and maintenance
		I3: The contribution of technology innovation ability
		I4: The contribution to industrial production capacity
		I5: Contribution of industrial competitiveness
		I6: The contribution to the economic growth
	Technology of social benefit	I7: The number of jobs in the industry
		I8: Other industries driven situation
	The ecological benefit of Technology	I9: Energy savings
		I10: Emission reductions (C02, S02, and so on)
Comprehensive environmental assessment	Technology economic environment	I11: R&D technology based on strength
		I12: R&D funds guarantee
		I13: Development of supporting industries
	Technology and social environment	I14: Policy supporting
		I15: Talent supply
	Ecological and environmental technology	I16: Resource conditions
		I17: Climatic conditions
		I18: Geographical conditions

EXPERIMENTS

In this section, experiments are conducted based on the dataset which is collected from the new energy industry in eight different provinces of China. For each province, the data we collected contain all the indexes in TABLE 1. Furthermore, to let the problem easier to be solved, all the values are normalized to one, and the experiment data after normalizing are listed in TABLE 2 as follows.

TABLE 2 : Index values for new energy industry competitiveness evaluation of ten regions.

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
P1	.59	.70	.30	.66	.36	.67	.70	.87	.81	.84	.50	.45	.52	.90	.79	.53	.79	.24
P2	.61	.60	.43	.62	.30	.61	.60	.89	.71	.52	.47	.43	.53	.91	.65	.70	.89	.29
P3	.67	.69	.41	.66	.50	.60	.58	.87	.85	.84	.65	.53	.51	.97	.68	.83	.84	.22
P4	.62	.68	.44	.69	.48	.64	.64	.88	.84	.63	.50	.68	.55	.94	.65	.61	.85	.21
P5	.63	.64	.31	.51	.32	.59	.59	.82	.81	.52	.42	.64	.50	.80	.64	.51	.79	.28
P6	.55	.63	.44	.52	.47	.57	.61	.81	.82	.83	.74	.43	.55	.82	.62	.74	.78	.34
P7	.57	.68	.41	.53	.51	.60	.85	.83	.81	.63	.63	.67	.54	.85	.80	.50	.86	.23
P8	.62	.69	.42	.54	.46	.51	.57	.84	.90	.51	.53	.62	.51	.95	.75	.80	.72	.34

In TABLE 2, Pi denotes the i^{th} province. Afterwards, we execute the analytic hierarchy process algorithm to make sure the weights of all the indexes in TABLE 1, and the experimental results are shown in Figure. 2 as follows.

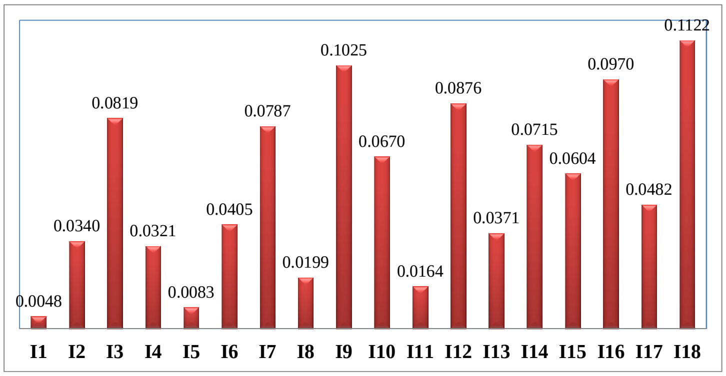

Figure 2 : Index weight for the proposed index system

Next, the new energy industry competitiveness score for each province is illustrated in TABLE 3 as follows.

TABLE 3 : Ranking scores for the eight provinces

ID	Ranking score
P3	0.6855
P8	0.6641
P7	0.6588
P4	0.6587
P1	0.6476
P6	0.6444
P2	0.6175
P5	0.5973

As is shown in TABLE 3, all the eight provinces are ranked according to their competitiveness scores by considering all the influencing factors in TABLE 1. Therefore, we can know that the proposed new energy industry competitiveness evaluation approach can effectively compute the competitiveness scores for all the provinces in the dataset.

CONCLUSIONS

This paper presents a novel new energy industry competitiveness evaluation method using the analytic hierarchy process. Firstly, we set up an index system to evaluate competitiveness of the new energy industry. Secondly, the analytic hierarchy process is utilized to compute weights of the given index system. Thirdly, experiments are conducted based on the dataset which is collected from eight provinces in China. In the future, we collect the experiment data from foreign countries to make the experiment analysis more accurately.

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