

# Application of AHP and TOPSIS Analysis in Performance Evaluation of Power Enterprise in China

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**Abstract.** With the development of economy, China has come to the deep reform period, the resulting electricity reform is inevitable, which makes our country electric power industry increasingly fierce competition, the performance level of enterprises are the main basis of the electric power enterprise competitiveness in the fierce competition. This article compiled economic, social, security, and resource use of five aspects of the data in five power industry and accorded to the analytic hierarchy process (ahp) and TOPSIS method for the five power generation companies has carried on the comprehensive evaluation, and explains the evaluation result.

**Keywords:** power generation enterprise; the performance evaluation; Hierarchical analysis; TOPSIS.

## 1. Introduction

Electric power industry is the national monopoly industry, which is directly related to the development of the national economy, and plays an important role in social development in China [1]. It is not only related to people's daily life, but also related to the stability of the society, the country's development. For the electric power enterprise, how to improve the competitiveness, to strive for in the market economy, how to adapt to the needs of the state and society has become a focus of the thinking of enterprise. Therefore, through continuous technological innovation and management innovation, the production and management objectives of the enterprise is perfect or even exceeded, what's more, for the comparison of different enterprises in the same industry, it is needed to construct a set of scientific evaluation system.

## 2. Construction of performance evaluation index system

Enterprise performance evaluation is an objective, fair and accurate comprehensive evaluation on the operating efficiency and performance of the enterprise during a certain period of operation, which uses a certain method and a specific index system, the evaluation of the unified standard, according to a certain procedure.<sup>[3]</sup>

Through the comprehensive analysis of several power enterprise performance evaluation index system, combined with power generation enterprises in the economic, environmental, social, security and resource use the input level of five aspects, this paper determines the power enterprise performance evaluation index system, as shown in Table 3-1.

## 3. Performance evaluation using model method

AHP depend too much relay the decision maker subjective experience to be formed directly for the reference information for decision-making. TOPSIS under multi factor index weight determination is difficult. The ahp-topsis method is based on the basic principle and characteristics of AHP and TOPSIS method, it perfectly overcomes the disadvantages of the two methods, and the operation is simple, intuitive result. Steps are as follows:

(1) According to the evaluation index system, the maximum eigenvalues of the matrix  $W_i$  and the positive characteristic vector of the judgment matrix are obtained  $\lambda_{\max} = \sum_{i=1}^n \frac{(BW)_i}{nW_i}$ ,  $n$  is the

judgment matrix order number,  $w_i$  is the same layer index weight value; Calculated consistency ratio  $CR = \frac{CI}{RI}$ , and  $CI = \frac{(\lambda_{\max} - n)}{(n-1)}$ ,  $RI$  See table two, when  $CR < 0.1$ , meet the conformance test.

(2) According to the evaluation index of the original data set up the decision-making matrix  $A$ , According to the decision-making matrix  $A$  set up the normalized decision-making matrix  $Z$ , which element is  $Z_{ij}$ . And

$$Z_{ij} = \frac{f_{ij}}{\sqrt{\sum_{i=1}^n f_{ij}^2}}, i=1,2,3\dots n; j=1,2,3\dots m \quad (1)$$

$f_{ij}$  is the element in the matrix  $A$ .

(3) Constructing the normalized decision-making weighted matrix  $X = [x_{ij}]$ . And

$$x_{ij} = w_j z_{ij}, i=1,2,3\dots n; j=1,2,3\dots m \quad (2)$$

(4) Determine the optimal solution  $x^+$  by

$$x^+ = (x_1^+, x_2^+ \dots x_m^+) = \left\{ \max_i x_{ij} \mid j = 1, 2, 3, \dots, m \right\} \quad (3)$$

and the worst solution  $x^-$  by

$$x^- = (x_1^-, x_2^- \dots x_m^-) = \left\{ \min_i x_{ij} \mid j = 1, 2, 3, \dots, m \right\} \quad (4)$$

(5) Calculate the distance of the optimal solution for each power enterprise's performance  $S^+$  by

$$S_i^+ = \sqrt{\sum_{j=1}^m (x_{ij} - x_j^+)^2}, i=1,2,3\dots n \quad (5)$$

and the worst solution  $S^-$  by

$$S_i^- = \sqrt{\sum_{j=1}^m (x_{ij} - x_j^-)^2}, i=1,2,3\dots n \quad (6)$$

(6) Calculating relative closeness degree  $C_i$  by

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-} \quad (7)$$

and sort,  $C_i$  is the largest, enterprise performance effect is the best.

## 4. Research on the performance evaluation of power enterprises

### 4.1 Collation of raw data.

According to several large-scale power generation enterprise social responsibility report published performance data, the paper sorts selected performance data of the five major power generation enterprises (Datang, Huaneng, Huadian, the CPI, the country's electricity) for the year 2013, the time span of the report for the whole year, with certain reliability. According to the overall situation of the key performance index system in front of the design of the original data is shown in table 3-1.

### 4.2 Structure judgement matrix.

According to the index system of Table 1 - 1, the judgment matrix is constructed. The judgment matrix of the target layer and the criterion layer is as follows:

A	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>
B <sub>1</sub>	1	7	6	3	5
B <sub>2</sub>	1/7	1	1/2	1/5	1/3
B <sub>3</sub>	1/6	2	1	1/4	1/2
B <sub>4</sub>	1/3	5	4	1	3
B <sub>5</sub>	1/5	3	2	1/3	1

The judgment matrix of the criteria layer and the index layer is as follows:

B <sub>2</sub>	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	B <sub>1</sub>	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>
C <sub>1</sub>	1	1/5	1/5	1/3	C <sub>1</sub>	1	1/2	1/3	1/5	1/5
C <sub>2</sub>	5	1	2	3	C <sub>2</sub>	2	1	1/3	1/3	1/5
C <sub>3</sub>	5	1/2	1	3	C <sub>3</sub>	3	3	1	1/3	1/3
C <sub>4</sub>	3	1/3	1/3	1	C <sub>4</sub>	5	3	3	1	1/2
					C <sub>5</sub>	5	5	3	2	1

B <sub>3</sub>	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	B <sub>4</sub>	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	B <sub>5</sub>	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>
C <sub>1</sub>	1	5	5	3	C <sub>1</sub>	1	3	5	C <sub>1</sub>	1	5	3	3
C <sub>2</sub>	1/5	1	1/3	1/5	C <sub>2</sub>	1/3	1	3	C <sub>2</sub>	1/5	1	1/3	1/3
C <sub>3</sub>	1/5	3	1	1/3	C <sub>3</sub>	1/5	1/3	1	C <sub>3</sub>	1/3	3	1	1/2
C <sub>4</sub>	1/3	5	3	1					C <sub>4</sub>	1/3	3	2	1

Table 3-1 The original data of five major power generation enterprises

Target layer	Standard layer	Performance index (Index layer)	Datang	Huadian	Huaneng	the CPI	State Grid
Performance effect of electric enterprises	Economics	Installed capacity	11543	11276	14224	8967.78	12279
		Generating capacity	4940	4612	6493	3678.12	5332.5
		Total assets	6980	6534	8552	6180.47	7860
		Business income	1903	2118	2932	1910.10	2327.6
		Total profit	109.61	151.7	236	111.76	159.9
	Environment	Clean energy and renewable energy proportion	25.70	24.49	24.64	34.19	24.98
		NO <sub>x</sub> emission rate	2.41	2.6	2.27	2.41	2.41
		SO <sub>2</sub> emission rate	1.57	2.0	1.28	1.91	1.61
		Soot emission rate	0.3	0.2	0.18	0.24	0.2
	society	Staff number	105288	110907	137779	124049	138614
		Collective contract coverage	100	100	100	90.4	100
		Number of female employees	25891	26348	32696	27710	33545
		Total donation	1588	4852	11425	2178	2447.6
	safety	Personal injury accident	2	0	2	4	4
		Equipment accident	0	0	3	3	0
		Equivalent availability factor for power generation equipment	92.61	93.75	92.87	94.31	94.22
	Resource utilization	The power supply coal consumption	316.59	313.3	312.89	313.5	316.40
		Comprehensive utilization of fly ash	80.2	88.4	78.14	83.6	81.5
		Water consumption per unit	1.16	1.18	1.22	1.23	1.22
		Power consumption rate for a composite plant	5.19	5.18	4.59	5.91	4.92

### 4.3 Processing of AHP.

Respective characteristic vector and the maximum characteristic value should be calculated according to the established judgment matrix, and the uniform examination should be made as follows:

Table 3-2 RI values of the 1 order -8 order matrix

Matrix order (n)	1	2	3	4	5	6	7	8
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41

After the inspection above 6 matrix are  $CR < 0.1$ , They are all passed through the consistency test, then the final determination of the 20 indicators in the total target weight is  $W = (0.0284, 0.0421, 0.0781, 0.1455, 0.2129, 0.0032, 0.0220, 0.0156, 0.0072, 0.0436, 0.0050, 0.0099, 0.0221, 0.1618, 0.0724, 0.0267, 0.0600, 0.0089, 0.0195, 0.0395)$ . [2,3]

### 4.4 Processing of TOPSIS.

Before using the TOPSIS method [4, 5, 6], the first of all the data is non dimensional. In the original data index, the eight indexes of numerical is the lower the better, including NOx emission rate, SO2 emission rate, smoke emission rate, casualty accident, the accident of the equipment, power supply coal consumption, power generation unit water consumption, integrated plant electricity rate. The eight indicators known as low priority index; other values are, the higher the better, known for high quality index. In order to transform the low priority index into high quality index, the method is to use the reciprocal method, but the personal injury accident, equipment accident has zero data, cannot directly use the reciprocal method  $f_{ij} = \frac{1}{f'_{ij}}$ , For these two indicators, this paper uses the modified

inverse method [7]  $f_{ij} = \frac{1}{k + \max_{1 \leq i \leq n} |f'_{ij}| + f'_{ij}}$ ,  $i=1, 2, 3, \dots, n$ .  $k$  is constant, and  $K > 0$ .

According to the formula (1) to get the normalized matrix, according to the formula (2) to construct the weighted normalized matrix, finally according to the formula (3), (4) to get the optimal solution and the worst solution. The following:

$x^+ = \{ 0.0153, 0.0240, 0.0411, 0.0841, 0.1447, 0.0018, 0.0105, 0.0088, 0.0038, 0.0218, 0.0023, 0.0050, 0.0195, 0.0997, 0.0379, 0.0120, 0.0270, 0.0043, 0.0090, 0.0196 \}$

$x^- = \{ 0.0097, 0.0136, 0.0297, 0.0313, 0.0649, 0.0013, 0.0091, 0.0056, 0.0023, 0.0166, 0.0021, 0.0039, 0.0027, 0.0553, 0.0216, 0.0118, 0.0266, 0.0038, 0.0081, 0.0152 \}$

According to equation (5) and (6) to calculate the electric power enterprise performance and the optimal solution and the worst solution distance, then according to the formula [7] calculated the electric power enterprise performance relative closeness and sorting. Results are shown in table 3-5 shows:

Table 3-5 Relative closeness degree value and ranking

Enterprise name	$S_i^+$	$S_i^-$	$C_i^+$	Sort results
Datang	0.106	0.024	0.185	5
Huadian	0.064	0.059	0.480	2
Huaneng	0.033	0.100	0.752	1
The CPI	0.098	0.029	0.228	4
State Grid	0.071	0.051	0.418	3

The table can clear intuitively see, five major power generation enterprises performance ranking for Huaneng, Huadian, State Grid, The CPI, Datang. Through further comparison of various power generation business relative closeness can be seen, Huaneng Company's performance is significantly better than other companies, indicating high level of management of the company, it is worth to learn for other enterprises. Huadian performance slightly better in State Grid, indicating that the two company's management level should be in about the same. The CPI and the Datang, the CPI's performance is better in Datang, but compared to the other three enterprises or slightly worse in some

shows that in some places need to be improved. Datang, its performance is compared with the first four it, especially the top three, there is a big gap, indicating that the level of management and the other four enterprises compared to the existence of certain defects and need further improvement.

## 5. Concluding remarks

In this paper, the aspect of economic, environmental, social, security and resource utilization as a target, the use of AHP-TOPSIS method to analyze the five major power generation companies' performance level. The method is compared with the traditional AHP method, which solves the shortcomings of its over reliance on the decision maker's supervisor's experience. Compared to the traditional TOPSIS method, it solves the problem of the difficulty of determining weights. This method combines the advantages of AHP and TOPSIS, which makes it clear that the performance level of the five major power generation companies is analyzed, and the results are clear[8]. This is the five major power generation companies to provide a good basis for positioning, but also for the development of the five major power generation companies to provide a certain reference. At the same time, it also provides a reasonable and scientific method for the research of the performance evaluation of the electric power industry and other industries.

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