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The Building and Application of Environmental Performance Evaluation System of Y Electricity Generation Enterprise Based on Balanced Scorecard

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***Abstract*—Power generation enterprises are the pillar industry in energy field with thermal power bringing about surge economic development at the expense of resources and environment for its high-energy consumption and high pollution. Y Electricity Generation Enterprise's core industry is thermal power; it should adhere to the sustainable development strategy and continue to improve the level of environmental management. This paper introduces the basic situation of Y Electricity Generation Enterprise. At the same time, Based on the four-dimensional theory of Balanced Scorecard, this paper divides the environmental performance evaluation system of Y Electricity Generation Enterprise into financial dimension, stakeholder dimension, internal business process dimension, learning and growth dimension. Then, Analytic Hierarchy Process combined with experts' investigation method is employed in this paper to decide the weight of index. There is reference significance for electricity generation enterprises on environmental performance evaluation and analysis.**

Keywords—Environmental performance evaluation; Balanced scorecard; Analysis hierarchy process; Power generation enterprises

I. THE BASIC SITUATION OF Y ELECTRICITY GENERATION ENTERPRISE

Y Electricity Generation Enterprise was established in August 2001. It is a power generation enterprise born as a result of power system reform. The registered capital of Y Electricity Generation Enterprise is 23 billion RMB, It is the largest power generation enterprise in province G.Y Electricity Generation Enterprises have been awarded the title of "A Class Enterprise" for 14 consecutive years in the performance appraisal of province G. The power supply structure of Y Electricity Generation Enterprise is dominated by thermal power, among which the primary energy of thermal power mainly comes from coal resources. The installed capacity of coal and electricity is 83%, and the other new energy generation capacity is about 17%. The power generation enterprises are committed to optimizing the power supply structure. At present, Y Electricity Generation Enterprises do not have systematic Environmental performance evaluation system.

II. THE BUILDING OF ENVIRONMENTAL PERFORMANCE EVALUATION SYSTEM OF Y ELECTRICITY GENERATION ENTERPRISE BASED ON BALANCED SCORECARD

A. The objective of constructing Y Electricity Generation Enterprise environment evaluation system

Y Electricity Generation Enterprises have the characteristics of production and management. Based on the four-dimensional theory of Balanced Scorecard, this paper divides the environmental performance evaluation system of Y Electricity Generation Enterprise into financial dimension, stakeholder dimension, internal business process dimension, learning and growth dimension[1]. At the same time, Y Electricity Generation Enterprise decomposes the environmental strategy into specific goals based on these four dimensions. These objectives are broken down into key performance indicators, which are then evaluated and managed[2].the Strategic objectives of Environmental performance and Goals in each dimension in Y Electricity Generation Enterprises. Setting up Financial Dimension is helpful to the harmonious Development of Economic benefit and Environmental Protection benefit of Enterprise.

B. The building of environmental performance evaluation of Y Electricity Generation Enterprise

The index of financial dimension is divided into environmental benefit index and profitability index. The indicators of stakeholder dimension are divided into environmental standard degree and external communication ability .Indicators of the internal business process dimension includes resource utilization, emission reduction capacity, assembling ratio of Environmental protection equipment. The dimension of learning and growth can be divided into two categories: environmental protection consciousness, environmental protection innovation ability[3].The specific indicators of each dimension are shown in the table I.

III. INTRODUCTION TO THE ANALYTIC HIERARCHY PROCESS

There are many indicators of environmental performance evaluation, and their influence degree is different. In order to

make a comprehensive and reasonable analysis of the environmental performance indicators of Y Electricity Generation Enterprises, it is necessary to classify all the impact indicators scientifically. This paper carries on the reasonable analysis according to its influence degree. The Analytic hierarchy process (AHP) adds the weight to the analysis process, which is scientific and concise, and can meet the needs of enterprises. In the analysis of many influential factors, Analytic hierarchy process (AHP) can be classified according to the nature of each influencing factor and the correlation degree between each other[4].First of all, the judgment matrix is obtained by comparing the importance of the influencing factors. Then the weight of each index is determined by transformation and calculation. Finally, it provides scientific basis for environmental management decision-making.

Because of the diversity of environmental information, some quantitative and qualitative indicators are involved. AHP can determine the weight of the index by comparing the importance of the index. According to the characteristics of each index and the relationship between each other, it can be divided into target layer (strategic level), criterion layer (dimension layer), and alternative layer (index layer).

IV. STEPS TO DETERMINE WEIGHTS

A. Constructing a picture of hierarchical analysis structure

When using AHP to determine the weight, the key is to define the hierarchy structure. The hierarchy reflects the causal and driving relationships between the levels. This paper classifies the indexes according to their commonness and difference. According to the objective and index characteristics of environmental performance evaluation of Y Electricity Generation Enterprises, this paper divides the system into "strategic level, dimension layer, primary index layer and secondary index layer" The hierarchical structure of the environmental performance evaluation indicator system in this paper is shown in TABLE I.

TABLE I. HIERARCHICAL ANALYSIS STRUCTURE

dimension	Primary indicator	Secondary index
A1Financial dimension	A11 profitability	a1All capital earnings rate
		a2 Ratio of income as a percentage of sales
		a3Cost profit rate
	A12 Environmental benefit	a4 Environmental protection investment rate
		a5Environmental cost rate
		a6Environmental income rate
B1Stakeholder dimension	B11 The degree of Environmental standard	b1 The legality of Emission Licensing right
		b2 Status of sewage charges
		b3Environmental penalties
	B12 External communication skills	b4 Environmental related reports
		b5Environmental information disclosure
C1Internal business process dimension	C11 Resource utilization rate	c1Comprehensive utilization ratio of ash and slag
		c2net coal consumption rate
		c3Integrated auxiliary power consumption rate
	C12 Emission reduction capacity	c4Smoke emission rate
		c5Nitrogen oxide emission rate
		c6Sulfur dioxide emission rate
	C13 Ratio of environmental equipment	c7Denitrification equipment rate
		c8Desulfurization equipment rate
		c9New energy unit ratio
D1Learning and growth dimension	D11 Environmental awareness	d1Environmental training coverage
		d2Higher education ratio
	D12Innovation ability	d3Winning rate of environmental protection
		d4R & D investment rate

B. Constructing judgment matrix

This paper uses analytic hierarchy process to determine weight. First, we need to know the judgment scale. In this paper, the scale method of 1-9 is used to judge the importance of the comparison of each index. In general, Analytic hierarchy process (AHP) gives different quantitative scales for different cases. In this paper, we use odd number 1, 3, 5, 7 to express the degree of influence of I factor relative to j factor. An even number of 2, 4, 6, 8 is used to indicate the importance of the judgment between the two neighbors. $b_{ij}=1$; $b_{ij}=1/b_{ij}$ [5].The specific interpretation is as shown in table Ⅱ :

TABLE II. MEASUREMENT OF JUDGMENT MATRIX FOR ANALYTIC HIERARCHY PROCESS

Scale values	Interpretation
1	For B, bi and bj are equally important
3	For B, bi is slightly more important than bj
5	For B, bi is more important than bj
7	For B, Bi is much more important than bj
9	For B, Bi is absolutely more important than bj
2, 4, 6, 8	The degree of importance between two adjacent scales
reciprocal	For B, the importance of comparing bj with bi

The Analytical hierarchy process (AHP) judgment Matrix is obtained by comparing each index with each other. As shown in table Ⅲ:

TABLE III. JUDGMENT MATRIX OF ANALYTIC HIERARCHY PROCESS

B	Judgment matrix				
B1	b11	b12	b13	...	b1n
B2	b21	b22	b23	...	b2n
B3	b31	b32	b33	...	b3n
...	...	...	...	...	...
Bn	bn1	bn2	bn3	...	bnn

C. Determination of relative Vector weights

Firstly, the judgment matrix is constructed, then the sum product method, the power method and the root method can be used to calculate the coefficients of the weight vector[6].In this paper, the coefficient of weight vector is obtained by rooting method., In this paper, the judgment matrix is constructed according to the results of investigation, and the weight vector coefficients are obtained by the method of seeking roots. The specific formulas are as follows:

$$w_i = \frac{\sqrt[n]{\prod_{j=1}^{n} b_{ij}}}{\sum_{k=1}^{n} \sqrt[n]{\prod_{j=1}^{n} b_{kj}}} (i = 1, 2, ..., n) \quad (1)$$

According to formula (1), the weight vector coefficient can be obtained. In the first step is to multiply the element of B and getting the new vector .The second step is to open every component of the new vector to the nth power. The third step is to normalize all the vectors and obtain the weight vectors.

D. Consistency check

The calculation of weight vector coefficient can't be carried out for the model with inconsistent judgment matrix. If there is a large deviation between the influential factors of weight vector and the judgment of the whole, it means that the weight distribution is unreasonable. Therefore, the consistency of judgment matrix must be checked, and the formula of consistency checking is as follows:

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(Bw)_i}{nw_i} \quad (2)$$

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (3)$$

$$CR = \frac{CI}{RI} \quad (4)$$

RI values are shown in Table 5.If the value of CR is less than 0.1, it is proved that the judgment matrix passes the consistency test, and it is shown that the weights of each index at the same level are allocated reasonably. When the value of CR is greater than or equal to 0.1, the judgment matrix will need to be readjusted until a satisfactory CR value is obtained. As shown in table Ⅳ:

TABLE IV. RI VALUE

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.9	1.12	1.24	1.34	1.41	1.45

V. DETERMINATION OF INDEX WEIGHT OF Y ELECTRICITY GENERATION ENTERPRISES

In order to make the weight of the environmental performance evaluation system of Y Electricity Generation Enterprises scientific, this paper designs a questionnaire on determining the index weight according to the hierarchy structure of the environmental performance evaluation system. A total of 50 questionnaires were sent out, and 46 valid questionnaires were collected from experts in the field of environmental accounting, Y Electricity Generation Enterprises and the same industry.

TABLE V. JUDGEMENT MATRIX OF DIMENSION LEVEL

T	A1	B1	C1	D1	Wi
A1	1	3	1/2	3	0.3107
B1	1/3	1	1/3	2	0.1464
C1	2	3	1	3	0.4393
D1	1/3	1/2	1/3	1	0.1036

Based on the judgment matrix in Table Ⅴ, the formula (2), (3), (4) shows that: CR=0.0454<0.1, It can be judged that the matrix has passed the consistency test. Therefore, the weight of dimension layer can be expressed as W_i = (0.3107,0.1464,0.4393,0.1036) .The next step is to determine the weight of the primary indicator layer, A judgment matrix for determining the first level of indicators according to the above, If each judgment matrix passes the consistency test, the weight of each index is also obtained by root seeking method. The judgment matrix is shown in Table Ⅵ:

TABLE VI. FIRST-ORDER INDEX LAYER JUDGMENT MATRIX TABLE

financial dimension			
A1	A11	A12	Wij
A11	1	5	0.8333
A12	1/5	1	0.1667
stakeholder dimension			
B1	B11	B12	Wij
B11	1	2	0.6667
B12	1/2	1	0.3333
learning and growth dimension			

Cont. to TABLE VI			
D	D11	D12	Wij
D11	1	3	0.75
D12	1/3	1	0.25

Internal business process dimension				
C1	C11	C12	C	Wij
C11	1	1/5	1/4	0.0936
C12	5	1	3	0.6267
C13	4	1/3	1	0.2797

It is found that the judgment matrix of the first order index level has passed the consistency test, and it is proved that it meets the requirements. Similarly, According to the steps of determining the index weight above, Finally, the index weights of environmental performance evaluation system are obtained. As shown in table Ⅶ:

TABLE VII. WEIGHT OF INDEX EVALUATION SYSTEM

A1	0.3107	A11	0.1667	a1	0.1021
				a2	0.7258
				a3	0.1721
		A12	0.8333	a4	0.7049
				a5	0.2109
				a6	0.0842
B1	0.1464	B11	0.6667	b1	0.2176
				b2	0.0914
				b3	0.6910
		B12	0.3333	b4	0.25
				b5	0.75
C1	0.4393	C11	0.0936	c1	0.1293
				c2	0.7855
				c3	0.0852
		C12	0.6267	c4	0.0989
				c5	0.5368
				c6	0.3643
		C13	0.2797	c7	0.4667
				c8	0.4667
				c9	0.0666
D1	0.1036	D11	0.75	d1	0.8333
				d2	0.1667
		D12	0.25	d3	0.8
				d4	0.2

VI. CONCLUSION

Low-carbon environmental protection is the inevitable trend of the development of power generation enterprises. The scientific and applicable index system of environmental performance evaluation is the key to the research of environmental performance evaluation.. At present, the research on environmental performance evaluation in China is increasing gradually. Due to the lack of a scientific, comprehensive and feasible evaluation system for large thermal power generation enterprises, Y Electricity Generation Enterprises are selected as the research object. It is of great theoretical and practical significance for the development and improvement of the research on environmental performance evaluation.

There are some flaws in this thesis. I hope to do more in-depth research on Y Electricity Generation Enterprises. Accessing to more environmental information related to Y Electricity Generation Enterprises. In order to make up for the shortcomings of the environmental performance evaluation system, the author will add new evaluation indicators in the future.

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