

Comprehensive Benefit Evaluation Model and Analysis Considering Multi - Energy Supply

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Abstract. In the context of low-carbon economy, using environment-friendly and energy-friendly energies is an important measure to achieve sustainable development. In view of the various forms of energy supply, in addition to the most basic economic factors, the paper introduces environmental and social impact, and together constitute the comprehensive benefit evaluation indicator system of energy supply mode. Taking Zhejiang province as an example, the analytic hierarchy process (AHP) is used to evaluate the energy supply in Zhejiang province and analyze the weak link of energy supply in accordance with the evaluation results.

Introduction

Electricity as a secondary energy comes from the conversion of primary energy. Thermal power is the most important power generation method in China [1], which has a great cost competitiveness, but it is also often criticized for its pollution. Since China's energy consumption has long been dominated by coal, its CO₂ emission accounts for about 80% of the total domestic emissions of various greenhouse gases [2]. A large amount of coal has become the main cause of air pollution and acid deposition [3].

To achieve the emission reduction target of 2020 [4], in addition to vigorously adopting various energy-saving measures, also need to take actions to reduce emissions. Adjust the energy structure and develop non-fossil energy sources, especially to develop nuclear power and renewable energy power generation [5]. To comprehensively weigh multiple energy supply modes, environmental impacts and social impacts are also important considerations [6,7], and the economic, environmental and social aspects of each energy supply mode need to understand for assessing the impact of different energy supply modes overall benefit.

This paper sets up a comprehensive evaluation indicator system of energy supply mode, make a comprehensive evaluation of different energy supply modes, compare the advantages and disadvantages of different energy supply modes through horizontal and vertical comparison of indicator scores, and weigh the economic benefits, environmental benefits and Social benefits.

Comprehensive Evaluation Indicator System of Energy Supply Mode

This paper constructs the indicator system of comprehensive benefit evaluation of energy supply from three aspects of economy, environment and society. Economic indicators reflect the cost of energy supply; with the goal of building a resource-saving society put forward, environmental costs have become an important cost of generating enterprises, environmental impact cannot be ignored [8]; different modes of energy supply will cause to society and residents of the impact of the proposed social indicators, and quantify the indicators, as assessable indicators.

Table 1 Comprehensive Evaluation Indicator System of Energy Supply Mode

Target Layer	Criterion Layer	Indicator Layer
Comprehensive Benefits of Energy Supply Mode	Economic Investment (C_1)	Energy Supply Costs (C_{11})
		Reliability of Energy Supply (C_{12})
		Resource Consumption (C_{13})
	Environmental Protection (C_2)	Carbon Emission (C_{21})
		Emission of Air Pollutants (Particulate Matter of Gas and Dust) (C_{22})
		Pollution Levels of Soil and Water Resources (C_{23})
	Social Influence (C_3)	GDP Driven Performance (C_{31})
		Impact on The Surrounding Residents (C_{32})
		Impact on The Ecological Environment (C_{33})

Comprehensive Benefit Evaluation of Energy Supply Modes Based on AHP

AHP. AHP is a multi-objective decision analysis method combining qualitative analysis with quantitative analysis [9]. It decomposes complex system as a whole and makes multi-objective and multi-criteria decision-making into multi-level and one-goal pairwise comparison, and then carries on the simple mathematical operation.

Using AHP modeling to solve problems can be divided into four steps:

Step 1: establish a hierarchical model of substructure.

Step 2: construct all the judgment matrix in each level.

A comparison of the significance of the two factors is made by using the numbers 1 to 9 and their reciprocals as the scale to judge the matrix $A = (a_{ij})_{n \times n}$, a_{ij} means that for a certain factor in the upper level, the i th factor Relative to the j th factor of importance, as shown in Table 2.

Table 2 The significance of indicators

Significance	Meaning	Explanation
1	The two factors are equal in important	The two factors contribute equally to the goal
3	One factor is more important than another	There is a slight difference between the two
5	One factor is obviously more important than another	The difference between the two is obvious
7	One factor is more important than another strongly	There is a strong difference between the two
9	One factor is definitely more important than the other	The difference between the two is extreme
2, 4, 6, 8	The intermediate values of the above two judgments	Coordinated judgment value

Step 3: Hierarchical order and consistency test.

(1) Calculate the consistency indicator.

Then the hierarchical order is sorted to obtain the eigenvectors of the judgment matrix. By $AW = \lambda W$, the largest eigenvalue λ_{\max} of the matrix A can be obtained.

$$CI = \frac{\lambda_{\max} - n}{n - 1}$$

(1)

(2) Find consistency indicator RI .

Look up the table to get the average random consistency indicator RI , then calculate the random consistency ratio CR .

Table 3 Average random consistent indicator

n	3	4	5	6	7	8	9	10	11	12	13	14
RI	0.52	0.89	1.12	1.24	1.36	1.41	1.46	1.49	1.52	1.54	1.56	1.58

(3) Calculate the proportion of consistency.

$$A = CR = \frac{CI}{RI}$$

(2)

When $CR < 0.10$, that the consistency of the judgment matrix is acceptable, otherwise the judgment matrix should be properly amended.

Step 4: Overall ranking and consistency test.

The overall ranking also need to make a consistency test, calculate the composition of the various elements of the total weight of the system of synthetic goals, and the various options sorted. According to this procedure, comprehensive evaluation of energy supply methods and comparative analysis of advantages and disadvantages of different energy supply methods.

Determine the Weight of the Indicators. The weight of indicators is determined by expert scoring method [10]. Taking Zhejiang Province of China as an example, 20 experts in Zhejiang-related energy-related fields are invited to score each index according to the scale of 1 to 9, and the weight calculation results of each index are obtained, as shown in Table 4.

Table 4 Weight calculation result

Target Layer	Criterion Layer	Weighs of Criterion Layer	Indicator Layer	Weighs of Indicator Layer
Comprehensive Benefits of Energy Supply Mode	Economic Investment (C_1)	0.6	C_{11}	0.62
			C_{12}	0.24
			C_{13}	0.14
	Environmental Protection (C_2)	0.2	C_{21}	0.11
			C_{22}	0.44
			C_{23}	0.44
	Social Influence (C_3)	0.2	C_{31}	0.08
			C_{32}	0.34
			C_{33}	0.58

Based on the index weight value, the judgment matrix was constructed and the consistency test was performed. After calculation, the indicators passed the consistency test.

Comprehensive Benefit Evaluation of Energy Supply Modes. Invited Energy 20 experts in the field of energy-related indicators of scoring in Zhejiang, the questionnaire on the evaluation of energy

supply indicators of the issue of using 10 points for scoring, for economic indicators, 10 points that the economic costs of the smallest, 8 points smaller, 6 points indicate normal, 4 points indicate poor, and 2 points indicate poor; for environmental protection indicators, 10 points indicate environment-friendly energy supply, 8 points indicate environmental protection, 6 points indicate normal, 4 points indicate more serious pollution, and 2 The points indicate the highest degree of pollution. The social impact assessment rules are similar to environmental protection, with 10 points indicating that the society is friendly and 2 points are poor.

Table 5 Experts scoring results

Target Layer	Criterion Layer	Indicator Layer	Thermal power	Nuclear power	Hydropower	Wind Power	Photovoltaic Power Generation
Comprehensive Benefits of Energy Supply Mode	C_1	C_{11}	10	8	6	5	3
		C_{12}	10	10	8	4	4
		C_{13}	6	4	10	10	9
	C_2	C_{21}	4	10	10	10	10
		C_{22}	4	10	10	10	10
		C_{23}	6	6	10	10	10
	C_3	C_{31}	10	6	6	6	6
		C_{32}	7	4	6	6	10
		C_{33}	6	8	6	10	10

According to the above indicators to determine the weight, calculate the price of different energy supply comprehensive evaluation results, as shown in Table 6.

Table 6 Comprehensive evaluation of energy supply modes score

Energy Supply Modes	Thermal power	Nuclear power	Hydropower	Wind Power	Photovoltaic Power Generation
Economic Investment	9.44	7.92	7.04	5.46	4.08
Environmental Protection	4.84	8.14	9.9	9.9	9.9
Social Influence	6.66	6.48	6	8.32	9.68
Comprehensive evaluation of energy supply modes	7.964	7.676	7.404	6.92	6.364

Conclusions

This paper combines the environmental impact and social impact of energy supply with the cost of energy supply, establishes a comprehensive evaluation indicators system of energy supply mode and applies AHP to evaluate it comprehensively. With the proposed goal of reducing carbon emissions and the implementation of energy conservation and emission reduction policies, the environmental costs of power generation enterprises will further increase. It is imperative to speed up the development of clean energy. Hydropower installed capacity is second only to thermal power. Wind power has great potential in our country. However, wind power resources in China are mainly distributed in the western and northern regions with low electricity load and long-distance wind power transmission. Solar energy is the most abundant renewable energy that can be fully utilized to meet all of country's energy needs.

However, solar energy development is still in its infancy. With the development of advanced manufacturing technology, the cost of photovoltaic power generation will be further reduced. At this time, the environmental protection advantages of photovoltaic power generation will be further highlighted.

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