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Research on the Comparison of Solar Power Generation with Different Technology Paths

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Abstract. To effectively cope with global climate change and the environment pollution problem, all countries are promoting low-carbon development actively. China is rich in solar energy resources, which has important influence on the sustainable development. Photovoltaic and thermal power generation were compared by constructing the comprehensive comparison model which is based on the interval weight and set pair analysis method. Then, their superiorities can be judged. The results of the study can provide strategic advice for investors in the solar-thermal and photovoltaic power generation to make decisions, which has far-reaching significance for them.

1 Introduction

Chinese Academy of Social Sciences, China Meterological Administration jointly issued the "Green book of climate change: climate change report (2013)" that pointed out in recent 50 years, haze weather days in China generally showed an increasing trend. The number of fog days is significantly reduced, whereas the number of haze days increased significantly. Persistent haze process has been greatly increased [1], [2]. China has officially proposed that carbon dioxide emissions will reach the peak in 2030. To reduce carbon emissions, Chinese government plans to make non fossil energy consumption account for about 20% in energy consumption in 2030. According to estimates, in order to achieve this goal, China needs to increase 800-1000GW nuclear energy, wind, solar and other zero emission power generation capacity. The potential of China's solar power generation installed capacity is about 16000GW, and power generation potential is about 42000TWh/year [3]. This means that even in the future, after all the fossil energy depletion, China still has a wealth of stable solar power resources far greater than self-sufficiency [4]-[6].

Solar power generation mainly has solar photovoltaic power generation and solar thermal power generation two types. According to the research of domestic and foreign scholars, though solar thermal power generation is now behind the photovoltaic power generation, it will catch up from behind and become the direction of the future development of solar energy [7]-[11]. Based on the comparison and evaluation index system of the solar power generation technology, a comprehensive comparison model based on the interval weight and set pair analysis method is established. After fitting the estimates to index into the model, we got some results that can provide both strategic advice for enterprises and theoretical guidance for the development of China's solar energy industry.

2 Composition of evaluation index system

Through detailed analysis of solar power technology, this paper selects the three aspects of technical feasibility, economic rationality and social friendly index to establish a comparative solar power evaluation index system of different technical paths, as shown in Table 1.

2.1 Evaluation of solar power generation with different technology paths

The research framework of solar photovoltaic power generation and thermal power generation is shown in Figure 1.

2.1.1 Determine the weight set

The importance of photovoltaic power generation and photovoltaic power generation is not consistent with the two main body of the enterprise investors and the state, therefore, from the point of view of the two main body of the enterprise investor and the state to determine the weight.

(1) Establish interval number complementary judgment matrix. According to the index, the experts use the 0.1-0.9 nine scale method to compare the index, and establish the interval number complementary judgment matrix. The enterprise comprehensive comparison matrix

is BC, and the national comprehensive comparison matrix is BN, which are expressed as follows.

$$B_C = \begin{bmatrix} 0.500, 0.500 & 0.385, 0.455 & 0.522, 0.582 \\ 0.545, 0.615 & 0.500, 0.500 & 0.625, 0.665 \\ 0.418, 0.478 & 0.335, 0.375 & 0.500, 0.500 \end{bmatrix}$$

$$B_N = \begin{bmatrix} 0.500, 0.500 & 0.515, 0.558 & 0.415, 0.458 \\ 0.442, 0.485 & 0.500, 0.500 & 0.325, 0.355 \\ 0.542, 0.585 & 0.645, 0.675 & 0.500, 0.500 \end{bmatrix}$$

Calculate the weight vector in the form of interval numbers. After the interval number complementary judgment matrix is obtained, the weight vector expressed in the form of interval numbers is calculated. The weight vector of the index of comprehensive comparison is respectively calculated as follows:

$$\omega_C = ([0.301,0.355],[0.358,0.411],[0.268,0.312])^T$$

$$\omega_N = ([0.310,0.346],[0.274,0.306],[0.365,0.401])^T$$

Establish the possibility degree matrix. Using the weight vector represented in the form of interval numbers, the possibility degree matrix can be calculated. The possibility degree matrix of the comprehensive comparison PC, PN are as follows:

$$P_C = \begin{bmatrix} 0.500 & 0.000 & 0.886 \\ 1.000 & 0.500 & 1.000 \\ 0.114 & 0.000 & 0.500 \end{bmatrix}$$

$$P_N = \begin{bmatrix} 0.500 & 1.000 & 0.000 \\ 0.000 & 0.500 & 0.000 \\ 1.000 & 1.000 & 0.500 \end{bmatrix}$$

Table 1. Comparative evaluation index system of solar energy power generation.

Target layer	Criterion layer	Sub criterion layer
Comparative evaluation index of solar energy power generation	technical feasibility	Light intensity coincidence rate
		Land use efficiency
		Energy conversion rate
		Grid connected stability
		Industrialization level
	Economic rationality	Original total investment
		Average cost of power generation
		Internet Pricing
		Project construction period
		Support policy
	Social friendliness	environmental effect
		Energy saving effect
		Employment opportunities
		Desertification control
		Popularization of electric

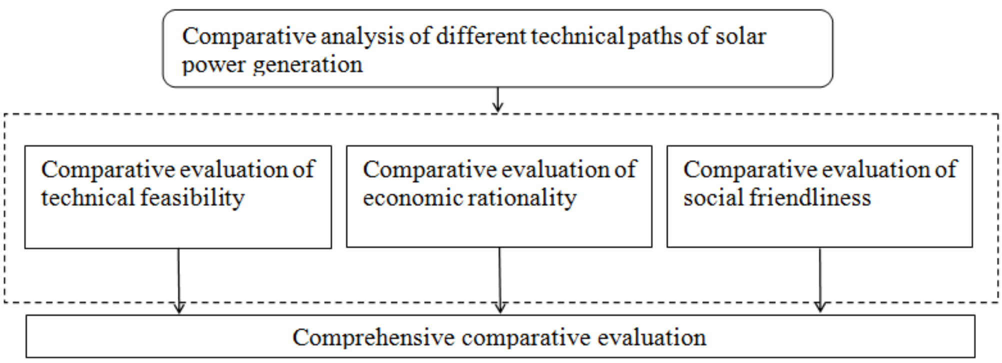

Figure 1. Research framework.

(2) Determine the weight vector. After obtaining the possibility degree matrix, the weight vector is obtained. The weight vector of the index of comprehensive comparison ω_C, ω_N are as follows:

$$\omega_C = (0.308,0.555,137)^T$$

$$\omega_N = (0.333,0.111,556)^T$$

Calculate the connection degree and result. According to the formula (1) (2), the connection of the comprehensive evaluation index is calculated, and the results are shown in Table 2.

Table 2. The connection degree of comprehensive comparative evaluation index

	a	b1	b2	b3	c
μ1	0.373	0.343	0.067	0.184	0.032
μ2	0.077	0.166	0	0.087	0.670
μ3	0.308	0.0385	0.071	0.394	0.189
ωC1μ1	0.115	0.106	0.021	0.057	0.010
ωC2μ2	0.043	0.092	0	0.048	0.372
ωC3μ3	0.042	0.005	0.010	0.054	0.026
ωN1μ1	0.124	0.114	0.022	0.061	0.011
ωN2μ2	0.009	0.018	0	0.010	0.074
ωN3μ3	0.171	0.021	0.040	0.219	0.105

$$\mu_{ij} = \begin{cases} 1 + 0i_1 + 0i_2 + 0i_3 + 0j & x > s_1 \\ \frac{x-s_2}{s_1-s_2} + \frac{s_1-x}{s_1-s_2} i_1 + 0i_2 + 0i_3 + 0j & s_2 \le x < s_1 \\ 0 + \frac{x-s_3}{s_2-s_3} i_1 + \frac{s_2-x}{s_2-s_3} i_2 + 0i_3 + 0j & s_3 \le x < s_2 \\ 0 + 0i_1 + \frac{x-s_4}{s_3-s_4} i_2 + \frac{s_3-x}{s_3-s_4} i_3 + 0j & s_4 \le x < s_3 \\ 0 + 0i_1 + 0i_2 + \frac{x-s_5}{s_4-s_5} i_3 + \frac{s_4-x}{s_4-s_5} j & s_5 \le x < s_4 \\ 0 + 0i_1 + 0i_2 + 0i_3 + 1j & x < s_5 \end{cases} \quad (1)$$

$$\mu_{ij} = \begin{cases} 1 + 0i_1 + 0i_2 + 0i_3 + 0j & x < s_1 \\ \frac{s_2-x}{s_2-s_1} + \frac{x-s_1}{s_2-s_1} i_1 + 0i_2 + 0i_3 + 0j & s_1 \le x < s_2 \\ 0 + \frac{s_3-x}{s_3-s_2} i_1 + \frac{x-s_2}{s_3-s_2} i_2 + 0i_3 + 0j & s_2 \le x < s_3 \\ 0 + 0i_1 + \frac{s_4-x}{s_4-s_3} i_2 + \frac{x-s_3}{s_4-s_3} i_3 + 0j & s_3 \le x < s_4 \\ 0 + 0i_1 + 0i_2 + \frac{s_5-x}{s_5-s_4} i_3 + \frac{x-s_4}{s_5-s_4} j & s_4 \le x < s_5 \\ 0 + 0i_1 + 0i_2 + 0i_3 + 1j & x > s_5 \end{cases} \quad (2)$$

The result is obtained according to the formula (3).

$$\mu = \sum_{i=1}^{3} \omega_i \mu_i = \sum_{i=1}^{3} \omega_i a_i + \sum_{i=1}^{3} \omega_i b_{i,1} i_1 + \sum_{i=1}^{3} \omega_i b_{i,2} i_2 + \sum_{i=1}^{3} \omega_i b_{i,3} i_3 + \sum_{i=1}^{3} \omega_i c_i j \quad (3)$$

μ_C＝0.199+0.203 i1+0.030 i2+0.159 i3+0.408j

Comprehensive comparison result in the perspective of corporate investors is $\triangle_C$=－0.119<0

μ_N＝0.304+0.154 i1+0.062 i2+0.290i3+0.190j

Comprehensive comparison result in the perspective of nation is $\triangle_N$=0.027>0

Through the above results, we can see that for investors in the enterprise, the comprehensive benefit of investment in photovoltaic power generation is better than that of investment in thermal power generation; however, from the national point of view, investment in solar thermal power generation comprehensive benefit is better than that of the photovoltaic power generation, though the advantage is not obvious.

From the current comparison results, compared to photovoltaic power generation, thermal power generation does not have the advantage for investors in the enterprise, but has weak advantage for the nation. Although the solar thermal power generation started late, there is a larger space for further development. With the national attention to the development of new energy and investment volume increased, the technical level of solar thermal power generation and application promotion will achieve a great leap forward. So, we can predict the future of the solar thermal power generation will be bright.

3 Conclusion

By comparing the results of the comparative evaluation model, the paper obtains the results of the comprehensive comparison of the feasibility, economic rationality and social friendly indexes of the photovoltaic power generation and thermal power generation technology. Results show that under the current situation, solar thermal power generation is greatly superior to solar thermal power generation in the technical feasibility, but slightly weaker in terms of social friendliness and greatly weaker in the economic rationality. The results of the comprehensive comparison show that for corporate investors, photovoltaic power generation is better than the thermal power generation, whereas for the nation, thermal power generation has a slight advantage. This paper make comparisions from the aspects of technical feasibility, economic rationality and social friendly, and calculated from different angles. The results both for the enterprises or to the nation can play a guiding role.

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