The study on the development countermeasure of renewable energy in provincial power grid based on SWOT

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Abstract. The SWOT method is applied to analyze the strengths, weaknesses, opportunities, Threats of the development of renewable energy in provincial power grid, and Delphi method is used for its quantitative evaluation and this conclusion has important research value and practical significance for the development of provincial power grid. Taking some provincial power grid as an example, the development strategy of renewable energy is analyzed. The results show that the method is simple and effective, which can support the decision-making of renewable energy development strategy.

1. Prefaces

During the "13th Five-Year Plan", the situation of China's energy development is complex. The acceleration of industrialization and urbanization and the economic development is at a critical stage of dynamic transformation and structural optimization. All these factors have placed higher demands on energy development. The task of ensuring energy supply and accelerating the transformation of energy development is still arduous. A provincial power grid, as the principal part undertaking the various requirements of the state-owned enterprises, is the backbone to promote energy restructuring and the development of renewable energy. At present, the research on energy development strategy mainly focuses on the whole energy system [1]-[3], but the content of renewable energy such as the landscape of renewable energy, the policy environment and the level of economic development varies greatly every province. Therefore, the study of renewable energy development strategy of the provincial grid is necessary.

2. The Overview of SWOT and Fuzzy Comprehensive Evaluation Method

SWOT analysis, also known as situational analysis, is an important analytical model in strategic management. It can be used to analyze and study the reality of a unit accurately and objectively. A series of decision-making conclusions are promoted through surveying and listing all the major strengths, Weakness, Opportunity and Threat which are closely related to the research object, then arranging them according to the matrix form.

Overall, SWOT can be divided into two parts: SW mainly used to analyze the internal conditions; OT mainly used to analyze external conditions. The strengths, weaknesses, opportunities and Threats are determined through the combination of internal and external environment analysis. Then the resources and methods can be adjusted both strategically and tactically to ensure that the established aims are achieved.

Fuzzy comprehensive evaluation is a comprehensive evaluation method to make an effective and comprehensive evaluation of many factors. This method is used to determine the uncertain factors through accurate mathematical language description .the fuzzy attributes of the factors are

emphasized, which can effectively solve the problem involving quantitative and qualitative analysis. It is widely used in social life, engineering technology and economic management.

3. The SWOT Analysis of Renewable Energy Development

The SWOT analysis matrix of renewable energy development in provincial power grids is given qualitatively using Delphi method, including four dimensions of strengths, weaknesses, opportunities and Threats as shown in the following table.

Table 1. Renewable energy development SWOT analysis module matrix of provincial grid

Strengths (S)	S1:... S2:... ...
Weaknesses(W)	W1:... W2:... ...
Opportunities(O)	O1:... O2:... ...
Threats (T)	T1:... T2:... ...

According to the "very unimportant, unimportant, general, more important and very important" categories and the probability of occurrence of various types of evaluation, the various factors of the SWOT analysis module matrix are evaluated and a normalized comprehensive evaluation matrix of each module is formed. Take the Strength module as an example, the evaluation matrix is as shown in equation (1), where the sum from v_{11} to v_{15} must equal to 1.

$$S = \begin{bmatrix} S_1 \\ S_2 \\ ... \\ S_i \end{bmatrix} = \begin{bmatrix} v_{11} & v_{12} & v_{13} & v_{14} & v_{15} \\ v_{21} & v_{22} & v_{23} & v_{24} & v_{25} \\ & & ... & & \\ v_{i1} & v_{i2} & v_{i3} & v_{i4} & v_{i5} \end{bmatrix} \tag{1}$$

SWOT analysis matrix elements of Henan Province renewable energy development are weighted Using fuzzy comprehensive evaluation method. Taking the weaknesses module as an example, the weight matrix is as follows:

$$W_s = \begin{bmatrix} W_{s1} & ... & W_{si} \end{bmatrix} \tag{2}$$

Five categories of "very important, not important, general, important and important" are assigned to F = (1, 2, 3, 4, 5), and the strengths module is calculated according to the formula of $G_S = S \times F^{'} \times W_S$ .The final evaluation result of opportunity module, strength module and threat module are calculated in the same way:

$$G_w = W \times F^{'} \times W_W \text{ '} G_O = O \times F^{'} \times W_O \text{'} G_T = T \times F^{'} \times W_T \tag{3}$$

The area covered by growth strategy ($G_s \times G_o$), diversification strategy ($G_s \times G_T$), reverse strategy ($G_s \times G_o$) and defensive strategy ($G_T \times G_w$) are compared and the highest area is selected as the strategy.

4. Instance Verification

Comprehensive analysis of renewable energy development environment and the development status, a provincial grid SWOT analysis results are reached as follows.

4.1. SWOT matrix construction

4.1.1. Strengths (1) Significant geographical advantages. With its unique geographical advantages, it is not only an important channel for sending electricity from the west to the east but also for mutual supply of north and south and optimal allocation of large-scale energy sources. There is also a huge market for implementing the energy policy and absorbing clean energy in the future.

(2) The huge market space for energy. The total economic output ranks the top five in the country. It is estimated that the GDP in the "13th Five-Year Plan" will increase by about 8% annually, more than 1% of the national average. Per capita energy consumption is only about 80% of the national average now. The urbanization rate is lower than the national average of nearly 10 percentage points. this province's energy demand will remain a rigid growth in future market considering the rapid economic growth, the   urban and rural development, the integrated use of rural energy efficiency and other integrated factors.

(3) Gradual deepening of energy system reform. The planning, policies, rules, regulatory "four in one" project management mechanism is established initially, and the market can play a decisive role in the allocation of resources. The policy of the coal and electricity price linkage, refined oil taxes, residential lifestyles electricity prices and gas prices, renewable energy electricity generation tariffs, clean coal charges, coal resource tax levy and other energy price reforms have made positive progress.

4.1.2. Weaknesses (1) The arduous task of energy restructuring. The coal-based energy production and consumption structure will remain for a long time constrained by the distribution of resources, and renewable energy will only be used as supplementary energy for a longer period of time. At present, non-fossil energy only accounts for 5.8% of the province's energy consumption, 6.2 percentage points lower than the national average. Coal consumption accounts for about 76% of the total energy consumption, 10 percentage points higher than the national average.

(2) The unbalanced energy distribution and consumption. The growth of energy demand in traditional industrial areas has slowed down. Areas with population advantages and weaker traditional industries will maintain medium-high-speed growth in the near future, but their resources are relatively scarce. Renewable energy-rich renewable energy in six cities has installed capacity of the province's total installed capacity of 68% of renewable energy.

4.1.3. Opportunities (1) Many policies to support renewable energy development introduced by government. The country proposes that carbon emissions will peak and the proportion of non-fossil fuels will increase to about 20% by 2030. The proportion of coal consumption in the province is 10% higher than the national average and the proportion of non-fossil fuels is 6.2% lower than the national average. By 2015, the sulfur dioxide and nitrogen oxide emissions are among the highest in the country, and the air pollution control has a long way to go. The province's "13th Five-Year Plan" requires that the proportion of fossil fuels in total energy consumption will reach over 7%, and that of non-fossil energy power generation projects will exceed 14 million kilowatts by 2020, which will the good opportunity of the development of renewable energy.

(2) The declining cost of renewable energy development. With the rapid development of renewable energy technologies, its development costs are constantly declining. At the same time, due to limitations of fossil fuels, marginal development costs gradually increase. This situation determines that the renewable energy has broad prospects for development. The "Roadmap for Renewable Energy Development in China 2050" predicts that the photovoltaic by 2020 and wind power by 2025will basically reach parity and renewable energy can compete fully with fossil fuels.

(3) The accelerating transformation of energy development promoted by technological Innovation. The rapid development and transformation of clean energy is the fundamental

direction of future energy development. The pace of energy science and technology innovation has accelerated noticeably. The rapid development of distributed energy and the rise of new-generation information technologies such as cloud computing and big data have provided a new impetus for the sustainable and healthy development of renewable energy. The province earnestly implemented the national energy strategy of "saving first, based on domestic, green, low-carbon, and innovation-driven" and formulated the energy guideline to promote the large-scale development of clean energy, wide deployment and efficient utilization and energy development and transformation.

4.1.4. Threats (1) Power grid planning and operation affected by large-scale renewable energy access. There is a lack of overall coordination between the overall planning and layout of renewable energy sources and the development planning of power grids. There is a phenomenon of looting of resources and disorderly development of power generation enterprises, resulting in the passive adjustment of power grid planning and the waste of grid resources. At present, renewable energy has little effect on grid power quality, peak regulation and frequency modulation, and there is no abandonment of water. However, t is estimated that abandonment of wind and PV may occur in 2018.

(2) Direct purchase of electricity policy squeeze renewable energy power generation space. According to the requirements of the General Office of the State Council, the National Energy Administration will no longer issue administrative examination and approval for direct power trading pilot projects. After the abolition of administrative examination and approval, the scale of direct purchase of electricity has rapidly increased, and the squeeze on the power generating space of renewable energy was more and more notable

Thus, the SWOT analysis matrix of this province's renewable energy development is shown in Table 1.

Table 2. The SWOT Analysis Module Matrix of the renewable energy development

Strengths (S)	S1:Significant geographical advantages. S2:The huge market space for energy. S3:Gradual deepening of energy system reform
Weaknesses(W)	W1:The arduous task of energy restructuring W2:The unbalanced energy distribution and consumption
Opportunities(O)	O1:Many policies to support renewable energy development introduced by government O2:The declining cost of renewable energy development O3:The accelerating transformation of energy development promoted by technological Innovation
Threats (T)	T1:Power grid planning and operation affected by large-scale renewable energy access T2:Direct purchase of electricity policy squeeze renewable energy power generation space

The fuzzy comprehensive evaluation method is adopted to weight each element of SWOT analysis module matrix of the renewable energy development, and the weight coefficients of each element are shown in the last column of Table 2, the weight matrix is as follows:

$$Ws= [0.32\ 0.45\ 0.23] \tag{4}$$

$$Ww= [0.45\ 0.55] \tag{5}$$

$$Wo = [0.45\ 0.25\ 0.3] \tag{6}$$

$$Wt = [0.6\ 0.4] \tag{7}$$

Reference to fuzzy comprehensive evaluation of the rating methods, the value of F = (1, 2, 3, 4, 5) is assigned to "very unimportant, unimportant, general, more important and very important" categories. The ratings are evaluated based on the Delphi method according to the probability distribution and the normalized comprehensive evaluation matrix of each module in the SWOT analysis matrix is obtained as follows:

$$S = \begin{bmatrix} S_1 \\ S_2 \\ S_3 \end{bmatrix} = \begin{bmatrix} 0.1 & 0.12 & 0.23 & 0.25 & 0.3 \\ 0.05 & 0.1 & 0.18 & 0.42 & 0.25 \\ 0.04 & 0.19 & 0.37 & 0.26 & 0.14 \end{bmatrix} \tag{8}$$

$$W = \begin{bmatrix} W_1 \\ W_2 \end{bmatrix} = \begin{bmatrix} 0.1 & 0.13 & 0.3 & 0.23 & 0.24 \\ 0.2 & 0.35 & 0.17 & 0.19 & 0.09 \end{bmatrix} \tag{9}$$

$$O = \begin{bmatrix} O_1 \\ O_2 \\ O_3 \end{bmatrix} = \begin{bmatrix} 0.05 & 0.07 & 0.25 & 0.28 & 0.35 \\ 10.08 & 0.12 & 0.18 & 0.34 & 0.28 \\ 0.1 & 0.11 & 0.24 & 0.25 & 0.3 \end{bmatrix} \tag{10}$$

$$T = \begin{bmatrix} T_1 \\ T_2 \end{bmatrix} = \begin{bmatrix} 0.07 & 0.15 & 0.25 & 0.23 & 0.3 \\ 0.2 & 0.2 & 0.3 & 0.17 & 0.13 \end{bmatrix} \tag{11}$$

Each module factor evaluation and weight coefficient of SWOT is shown in table 3.

Table 3. The SWOT modules evaluation and weighting coefficient of Renewable Energy Development

SWOT		evaluation					weight
		very unimportant	unimportant	general	more important	very important	
S	S1	0.1	0.12	0.23	0.25	0.3	0.32
	S2	0.05	0.1	0.18	0.42	0.25	0.45
	S3	0.04	0.19	0.37	0.26	0.14	0.23
W	W1	0.1	0.13	0.3	0.23	0.24	0.45
	W2	0.2	0.35	0.17	0.19	0.09	0.55
O	O1	0.05	0.07	0.25	0.28	0.35	0.45
	O2	0.08	0.12	0.18	0.34	0.28	0.25
	O3	0.1	0.11	0.24	0.25	0.3	0.3
T	T1	0.07	0.15	0.25	0.23	0.3	0.6
	T2	0.2	0.2	0.3	0.17	0.13	0.4

The final evaluation result of province's advantage module through the formula is calculated as following:

$$G_S = S \times F' \times W_S = 3.56 \tag{12}$$

Similarly, the evaluation results of the remaining three modules can be calculated. According to the calculation, the evaluation results of the four modules of strengths, weaknesses, opportunities and threats are 3.56, 2.96, 3.68 and 3.26 respectively. The analysis chart is represented in Figure 1. There are a total of four alternative strategies in the axis.
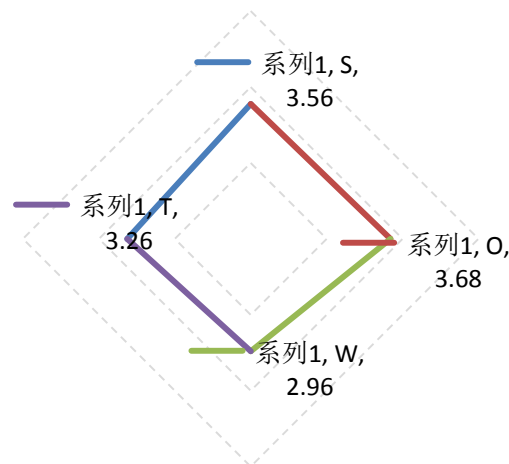
Figure 1. Renewable energy development strategy of a provincial grid

It can be seen from the figure that renewable energy development has a very favorable position. The weight of opportunity shows that the development of renewable energy is very attractive and has a great potential market. According to the data in the graph, it can be calculated that the combined area of advantages and opportunities is 13.11, which is the largest of all combined areas. Therefore, the first quadrant -growth strategy-is selected as strategic goal.

5. Conclusion

The strengths, weaknesses, opportunities, threats are analyzed based on SWOT method. The Delphi method is used to construct the SWOT matrix module and analyze quantitatively. The next step will study the renewable energy installed capacity based on the status of renewable energy development policies, technologies, management, power grid and other factors.

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