Research Article
Study on the Development Capability of New Energy Industry in China
-A Case Study of New Energy Industry Development in Tianjin

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Abstract: This study first introduces the development history of new energy industry. In order to evaluate the development capability of new energy industry, the study set up an evaluation model for development capability of new energy industry. Using this model the study evaluates the development capability of new energy industry in Tianjin.

Keywords: Development capability, new energy industry, Tianjin

INTRODUCTION

Evaluation of the development of new energy industry is mainly carried out based on the industrial competitiveness and technological aspects. Liu (2008a) and other scholars carried out research on the competitiveness of new energy industry in Baoding from four aspects, including market influence, economic benefit, scale competitiveness and scientific and technological ability for innovation. Liu (2008b) believed that there are three types of potential external benefits generated by using new energy sources, including energy security benefit, environmental benefit and social benefit. External benefits would lead to low a locative efficiency of resources while taxation policies and financial expenditure policies can expedite the development of new energy industry. Wu and Feng (2001) set up four objectives, including market orientation and environmental friendliness, to evaluate the competitiveness of new energy industry in West China for sustainable development. On the other hand, research on the development of new energy industry that is based on technological aspects mainly analyzes the key role of technology innovation during the development of new energy industry and its influence mechanism from the technological perspective. Li and Zhang (2004) believed that the key issues of new energy industry development are technology R&D and technology innovation. Gu and Zhou (1999) established an evaluation system for renewable energy sources after studying the characteristics of renewable energy sources and their relations with technologies and market. Zeng et al. (2006) studied renewable energy technologies within the EU by applying the simulated market model. The results indicated that wind power and biomass energy would be greatly promoted and estimated the unit price of Renewable Energy Sources (RES-E) would drop by USD 1 to 8 cents/degree. Zeng et al. (2006) analyzed and evaluated utilization of renewable energy sources in Guangdong and clearly pointed out that technology innovation can expedite development of. renewable energy sources in the region. Xiao (2007) worked on market and technology problems caused by lack of key technology and their solutions.

This study believes the competitiveness of new energy industry is not only a key strength in industrial development but also the foundation for strategy making of regional industrial development. Technology innovation, the catalyze agent for vigorous development of new energy industry, will continuously expedite the development of new energy industry. Competitiveness of new energy industry and its industrial development are under the influence and constraints of social and economic aspects, resource endowment, R&D and innovation and policies.

COMPREHENSIVE INTEGRATED MODELING APPROACH

New energy industry in Tianjin is generally witnessing a fast development. Wind power is undergoing a large-scale and all-around development. Solar energy PV industry is expecting a favorable development impetus and close cooperation along the

industry chain has been established for agglomeration development. Industries relating to geothermal & biomass energy are highly territorial and are distributed in different areas within the region. New energy industry in Tianjin presents a development pattern featured with a clear hierarchy, multi-levels and wide coverage. In view of the development foundation of new energy industry in Tianjin, this study has quantitative evaluations on industries of wind power, solar energy PV, geothermal & biomass energy with the Analytic Hierarchy Process (AHP) and the Experts Grading Method.

Metasynthesis: Design ideas for the model are as below:

- **Defining the target layer:** Target layer is a key issue needs to be solved in AHP. Moreover, it defines the ultimate target of the entire evaluation model. In this case, the target is to give comprehensive consideration to various key factors affecting new energy industry and have a comprehensive evaluation of the development capability of new energy industry.
- **Finalizing the criterion layer:** Among various factors affecting the development of new energy industry, this study selects four factors to be the criterion of the evaluation system. They include social and economic aspects, resource endowment, R&D and innovation and policy support.
- **Determining the index layer:** With factors in the criterion layer, determine specific evaluation indices to evaluate the development capability of new energy industry.

- **Comprehensive evaluation of the development capability of new energy industry:** Evaluate the development capability of new energy industry with calculation results and reach the conclusion.

Basic model: The development capability of new energy industry in Tianjin. The development capability of new energy industry is defined as the target layer. The criterion layer is made up of social and economic aspects, resource endowment, R&D and innovation and policy support. The criterion layer is further divided as below when defining the indices:

- **Social and economic aspects:**
- The ability to guide economic development
- The ability to promote market growth
- Market share
- The ability to allocate resources
- **Resource endowment:**
- Abundance level of resources
- Utilization level of resources
- Input of resources
- The ability to maintain environmental friendliness
- **R&D and innovation:**
- Technology R&D input
- The level of technology industrialization
- **Policy support:**
- The ability to have policy support
- Economic incentive effect

The scheme layer consists of wind power industry, solar energy PV industry, geothermal & biomass energy industry.

Table 1: Paired comparison matrix of layers

Development capability of new energy industry	Social and economic aspects B_1	Resources endowment B_2	R&D and innovation B_3	Policy support B_4
Social and economic aspects of B_1	1.0000	2.0000	3.0000	3.0000
Resources endowment of B_2	0.5000	1.0000	2.0000	2.0000
R&D and innovation B_3	0.3333	0.5000	1.0000	0.1411
Policy support of B_4	0.3333	0.5000	1.0000	0.1411
Social and economic aspects	Ability to guide eco. dev. C_1	Ability to promote mkt. growth C_2	Market share C_3	Ability to allocate resources C_4
Ability to guide eco. dev. C_1	1.0000	1.0000	3.0000	3.0000
Ability to promote mkt. growth C_2	1.0000	1.0000	1.0000	2.0000
Market share C_3	0.3333	1.0000	1.0000	3.0000
Ability to allocate resources C_4	0.3333	0.5000	0.3333	1.0000
Resources endowment	Abundance level of resources C_5	Utilization level of resources C_6	Input of resources C_7	Ability to maintain environmental friendliness C_8
Abundance level of resources C_5	1.0000	2.0000	3.0000	0.5000
Utilization level of resources C_6	0.5000	1.0000	5.0000	0.5000
Input resources of C_7	0.3333	0.2000	1.0000	0.3333
Ability to maintain environmental friendliness C_8	2.0000	2.0000	3.0000	1.0000
R&D and innovation	Technology R&D input C_9		Level of technology industrialization C_{10}	
Technology R&D input C_9	1.0000		2.0000	
Level of technology industrialization C_{10}	0.5000		1.0000	
Policy support	Ability to have policy support C_{11}		Economic incentive effect C_{12}	
Ability to have policy support C_{11}	1.0000		2.0000	
Economic incentive effect C_{12}	0.5000		1.0000	

Table 2: Weight sequencing of indices and layers of the development capability evaluation system for new energy industry

Influencing factors	Layer B Layer C	Social and economic aspects B₁	Resource endowment B₂	R&D and innovation B₃	Policy support B₄	C.R. ratio for matrix consistency
		0.4550	0.2627	0.1411	0.1411	0.0039
B₁	Ability to guide economic development C₁	0.3930	-	-	-	0.0653
	Ability to promote mkt. growth C₂	0.2699	-	-	-	
	Market share C₃	0.2269	-	-	-	
	Ability to allocate resources C₄	0.1102	-	-	-	
B₂	Abundance level of resources C₅	-	0.2848	-	-	0.0923
	Utilization level of resources C₆	-	0.2288	-	-	
	Input of resources of C₇	-	0.0836	-	-	
	Ability to maintain environmental friendliness C₈	-	0.4028	-	-	
B₃	Technology R&D input C₉	-	-	0.6667	-	0.0000
	Level of technology industrialization C₁₀	-	-	0.3333	-	
B₄	Ability to have policy support C₁₁	-	-	-	0.6667	0.0000
	Economic incentive effect C₁₂	-	-	-	0.3333	

CASE STUDY

Evaluation model calculation for the development capability of new energy industry in Tianjin: According to basic principles and decision making process of the AHP, the paired comparison method is first adopted. The ratio scale from 1 to 9 is used to form the paired comparison matrix according to the importance level. Table 1 shows the comparison matrix of Layer A, Layer B and Layer C.

With the established paired comparison matrix, a relative weight ω is given to each layer in comparison to its upper layer and the Consistency Ratio (C.R.) is calculated and examined. The result of C.R.<0.1 indicates that factors in the matrix are basically consistent to the estimation, which is acceptable and the consistency test is passed, Table 2 for calculation results.

It can be seen from Table 2 that the C.R. of all factors in the matrix is lower than 0.1, showing a high level of consistency. In Layer B, weights of Social and Economic Aspects B1 and Resource Endowment B2 are 0.4550 and 0.2627, respectively. These two indices present significant impacts on the development capability of new energy industry, which are also important criterion and dimensions for reference in the evaluation system. Driving forces generated from social and economic aspects and foundation established by resource endowment are key factors influencing the vigorous development of new energy industry. Figure 1 for weights of Layer C against Layer B.

Altogether there are 12 indices in Layer C. Table 3 for weights of industries in Tianjin including wind power, solar energy PV, geothermal and biomass energy.

Calculation results show that, to a certain extent, the development of wind power is under the influence and constraints of social and economic aspects, R&D and
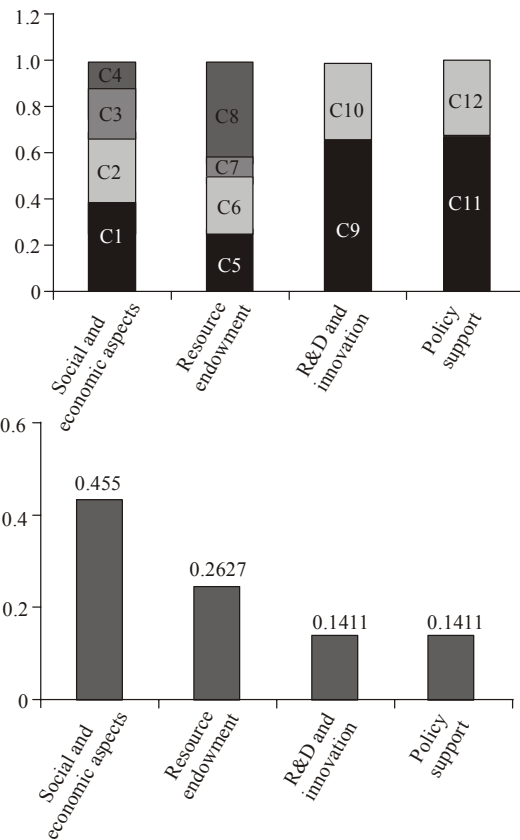

Fig. 1: Weights of layer C against layer B

innovation and technical support. Four indices under the wind power industry, including C1 (ability to guide economic development), C3 (market share), C10 (level of technology industrialization) and C12 (economic incentive effect), all have a weight of 0.6250, which directly reflect the higher development demands of wind power industry on social and economic aspects as well as R&D and innovation. As for Layer C, indices such as C5 (abundance level of resources), C6 (utilization level of resources) and C7 (input of resources) have a bigger

Table 3: Weights of indices for the development capability of new energy industry

Scheme layer D index layer C	Wind power	Solar energy PV	Geothermal and biomass energy	C.R.
Ability to guide economic development C_1	0.6250	0.2385	0.1365	0.0176
Ability to promote mkt. growth C_2	0.5936	0.2493	0.1571	0.1228
Market share C_3	0.6250	0.1365	0.2385	0.0176
Ability to allocate resources C_4	0.5396	0.1634	0.2970	0.0088
Abundance level of resources C_5	0.1220	0.2297	0.6483	0.0036
Utilization level of resources C_6	0.1007	0.2255	0.6738	0.0825
Input resources of C_7	0.2098	0.2402	0.5499	0.0176
Ability to maintain environmental friendliness C_8	0.5584	0.1220	0.3196	0.0176
Technology R&D input C_9	0.5396	0.2970	0.1634	0.0088
Level of technology industrialization C_{10}	0.6250	0.2385	0.1365	0.0176
Ability to have policy support C_{11}	0.5499	0.2098	0.2402	0.0176
Economic incentive effect C_{12}	0.6250	0.2385	0.1365	0.0176

Table 4: Evaluation results for the development capability of new energy industry

Scheme D layer C	Wind power industry		Solar energy PV industry		Geotherma and biomass energy industry	
	Sequencing of layer C	Mean value of experts grading	Sequencing of layer C	Mean value of experts grading	Sequencing of layer C	Mean value of experts grading
Ability to guide economic development C_1	0.2003	83.6364	0.1237	80.0124	0.0536	76.9083
Ability to promote mkt. growth C_2	0.1411	82.2727	0.0672	79.3901	0.0424	81.0909
Market share C_3	0.1290	68.6364	0.0507	74.8182	0.0957	72.0909
Ability to allocate resources C_4	0.0541	73.2727	0.0380	70.3124	0.0427	72.0000
Abundance level of resources C_5	0.0182	78.0909	0.0654	80.1926	0.0846	85.8124
Utilization level of resources C_6	0.0121	84.0909	0.0516	77.0000	0.1049	83.0898
Input resources of C_7	0.0092	77.1818	0.0503	70.0000	0.0460	76.2727
Ability to maintain environmental friendliness C_8	0.1212	89.3636	0.1057	80.6772	0.1192	85.0578
Technology R&D input C_9	0.1015	79.4545	0.1217	70.2311	0.1089	77.0909
Level of technology industrialization C_{10}	0.0858	75.4545	0.1061	69.0175	0.1135	68.2342
Ability to have policy support C_{11}	0.0634	78.1818	0.1399	72.1110	0.1136	70.3481
Economic incentive effect C_{12}	0.0641	75.8182	0.0797	70.6688	0.0749	71.5379
Total	79.5142		74.5546		76.6468	

influence on the industry of geothermal and biomass energy with their weights being 0.6483, 0.6738 and 0.5499, respectively. It shows a strong reliance of geothermal & biomass energy industry on resource endowment. Factors including the abundance level of resources, utilization level of resources and input of resources directly affect the development and flourishing of geothermal & biomass energy industry. On the other hand, weights of indices under the solar energy PV industry are rather close, which does not show any preference. Therefore, it is necessary to give overall consideration to all indices so as to promote the sound development of the industry.

This study, based on the Layer and Structural Evaluation Model for the Development Capability of New Energy Industry, evaluates the development capability of wind power industry, solar energy PV industry, as well as geothermal and biomass energy industry respectively by following the basic steps of the AHP. Grades given by experts are also taken into account in final evaluation results for the development capability of new energy industry in Tianjin, Table 4 for the results.

First, wind power industry in Tianjin has a total score of 79.5142 for its development capability which indicates a fair average level. Currently, it has formed an industrial agglomeration for wind power industry in Tianjin which is led by manufacturing enterprises of complete appliance, backed up by supporting enterprises, linked by work specialization and supported by technology innovation and talented personnel. However, high value added links such as key parts of equipment and core technology still rely on foreign market and import, which remains a serious problem. As far as manufacturing of wind power equipment, it is necessary to increase input in technology R&D and technical and industrial transformation, promote the vigorous development of existing enterprises and make efforts to key links of the industrial chain. It is urgent to enhance technology R&D and innovation and industrialization. As for wind power operations, there are four farms in Tianjin respectively in Mapengkou, Dashentang, Shajingzi and the estuary of Ji Canal for wind power generation. It is important to steadily push forward the construction of wind farms following planning targets on the basis of existing development, carefully review up-coming projects in approval process and make long-term planning. We should not blindly go for the quantity of wind farms in development. On-grid price and integration of power grids will remain difficult

Table 5: Comprehensive scores of the development capability of new energy industry in Tianjin

Optional schemes	Weight	Scores	Comprehensive score
Wind power industry	0.5165	79.5142	77.6788
Solar energy PV industry	0.2146	74.5546	
Geothermal and biomass energy industry	0.2689	76.6468	

problems for a long time that should be solved in future development. Wind power industry in Tianjin is gradually becoming more vigorous. It is important to seize the favorable opportunity for development, which is brought by policy support, to give a full play to the great potential of wind power industry and its development capability, so as to make Binhai New Area of Tianjin the biggest export base for wind power related products and the biggest manufacturing center for wind power equipment and establish wind power brands that are internationally influential.

Second, solar energy PV industry in Tianjin has a total score of 74.5546 for its development capability which indicates a medium-to-low level. CIGS Solar energy PV industry in Tianjin, which shows strengths in guiding economic development, maintaining environmental friendliness and having policy support and policy protection, has basically formed an entire industrial chain including a-Si/μc-Si tandem solar cells, CIGS thin film cells and CPV cells. However, technology industrialization level should be further enhanced and breakthroughs should be made to key and core technology. Improvements should be made in terms of raw material procurement, whole process management of manufacturing and cost control. At the same time, technology R&D, demonstration and promotion relating to utilization of solar energy[are still on trial and being improved and solar energy PV industry in Tianjin does not have a good development capability. With the release of <Notice on Improving On-Grid Price Policy for Solar Energy PV Industry> by the National Development and Reform Commission, all links of the solar energy PV industry must greet a whole new development opportunity. Solar energy PV industry in Tianjin should seize the opportunity to expedite its development and realize the flourishing of the entire industry.

Third, geothermal and biomass energy industry in Tianjin has a total score of 76.6468 for its development capability which indicates a medium level. As for geothermal energy, its development is limited by resource quality, geographic distribution and development cost, hence, it experiences a slower development pace than other renewable energy such as wind energy, solar energy and biomass energy. A comprehensive utilization system for geothermal energy sources, such as shallow Ground Source Heat Pump (GSHP), shallow water source heat pump, waste water source heat pump, tail water source heat pump and geothermal wells, are established in Tianjin to realize cascade development of energy and complete recharge of tail water, make the best use of its favourable geothermal energy source and dramatically improve utilization efficiency of energy. Geothermal energy in Tianjin is yet to be developed into a large scale industry and its existing market share is low.

As far as biomass energy industry is concerned, it is important to strengthen the construction of methane tanks, promote the use of energy-saving biomass boilers and encourage production and R&D of bio fuels. Existing development of geothermal and biomass energy industry shows that Tianjin has made achievements in terms of new rural construction, increasing peasants' income and implementation of policies benefiting peasants and citizens. However, R&D of core technology for geothermal energy utilization has fallen behind and biomass energy sources are widely distributed which makes it difficult for R&D, demonstration and promotion. Moreover, industrialization level is still low, policy support is insufficient and incentives are ineffective. In one word, the industry of geothermal energy and biomass energy in Tianjin still needs to put more efforts on technology R&D and innovation, provide more policy support, establish a management system, make the best use of its resource strengths, enhance industrial linkage and promote large scale development.

CONCLUSION

This study has quantitative evaluations on industries of wind power, solar energy PV, geothermal & biomass energy in Tianjin with the Analytic Hierarchy Process (AHP) and the Experts Grading Method. Also, all judgment matrixes have passed the consistency test, indicating a high level of consistency. In other words, evaluation of the development capability of new energy industry in Tianjin satisfies the requirements in feasibility study, Table 5 for evaluation results.

New energy industry in Tianjin has a comprehensive score of 77.6788 for its development capability, indicating a medium level of development capability. The result is basically in line with the overall development level of new energy industry in China. With its abilities to guide economic development and promote market growth, new energy industry in Tianjin will eventually be further developed at a faster pace when it exerts its strengths in resource endowment, improves technology R&D and industrialization level and enjoys more policy supports and incentives. With the foundation built following the guideline of "industrial integration, cascade development and mutual promotion", gradually form a pattern that is "green, low-

carbon and sustainable" for new energy industry in Tianjin, so as to make significant contributions to the structural adjustment of energy industry in Tianjin.

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