Analysis on the industrial performance of wind power in China

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Abstract. In recent years, the growth rate of wind power in China installed capacity has tended to be sta-ble, and the competition among wind power equipment manufacturers has become increasingly fierce. In order to analyze the industrial performance of wind power in China, the paper summarized the status quo of China's wind power, and then used the Data Envelopment Analysis (DEA) model to analyze the industrial performance of China's wind power from 2010 to 2014. We found that: during the analysis period, the industrial performance of wind power equipment manufacturing was best in 2010. Due to fierce competition between wind turbines manufacturers, the industrial performance was in the declining trend in the next three years. By 2014, the performance increased again, but did not reach the best state. Besides, the technical efficiency has been better than scale efficiency.

1 INSTRUCTION

With the adjustment of energy structure, the renewable energy, especially the wind power, was facing a historic opportunity for development in China. In recent years, wind power industry itself has been also in the state of constant adjustment. The scale of projects approval, equipment tendering and projects construction of the wind power all has bigger growth. Besides, the grid-connected and integration issues of China's wind power were also alleviated, due to the construction of UHV grid and the implementation of interconnection policy and subsidies policy. Therefore, the installed capacity of wind power in China maintained a rapid growth. At present, the market concentration degree of wind power manufacturing industry in China has been in a downward trend, but it is still higher [Yuanxin Liu, 2015]. According to the new installed capacity situation, the domestic market shares of the top 20 wind turbine manufacturers were about 90%. Although the market demand of domestic wind power grew steadily, the competition between wind power manufacturers was still fierce, and the overcapacity problem of wind power industry was stall serious. Both fierce competition and overcapacity have important influence on the industrial efficiency, so it is significant to research on the industrial performance of China's wind power.

In recent years, large numbers of scholars researched the China's wind power industry from different aspects, such as wind power price and policy [Ping Lu, 2013] [Ting-Ting Mi, 2012], development bottleneck [Zhao Dong, 2009] [Hua BAI, 2012], sustainable development [Zheng-ming WANG, 2008] [Weidong Shi, 2011]and wind power industry innovation [Yuanying CHI, 2008] [Jorrit Gosens, 2013]. The research literatures of China's wind Power industry have been comprehensive. Based on the exiting research literatures, the paper adopted the DEA model to analyze the industrial performance of China's wind power.

2 STATUS QUO

2.1 Market

The wind power in China has experienced rapid development since 2005, especially the period of 2006-2009. However, the growth rate began to slow down in 2010, and then tended to be stable in the last three years (See Fig.1). In 2014, the newly installed capacity of wind power was 23196MW

and set a new record; the cumulative capacity reached 114609MW, an increase of 25.4% over the same period of last year.

Determined by the distribution of wind energy resources, the wind power installed capacity mainly concentrated in the North China, Northwest, Northeast and East China. However, the growth of installed capacity of wind power in the Northeast has been slow down since 2010. Compared to 2013, the new installations of wind power in Northeast China declined in 2014, and the main reason was that the new capacity of wind power of Jilin and Liaoning fell by 28.76% and 44.8% respectively. Besides, the new installed capacity of wind power in other regions was increased in 2014. Thereinto, the new installations in the Southwest, Northwest, North China and East China increased by 72.26%, 67.84%, 45.44% and 41.26% respectively.

There were 26 wind power equipment manufacturers to provide wind turbines for China's wind farms in 2014. Thereinto, the new installed capacity in the top 5 of wind turbine manufacturers were Goldwind, United Power, Ming Yang, Vision Energy and XEMC Wind power, and their new installations were 12828MW, account for 55.26% of the new total installed capacity of China's wind power (See Table 1). The Goldwind has ranked the first in view of the new and cumulative installed capacity of wind power in recent years. By contrast, the market share of Sinovel was declining significantly. Although the cumulative installed capacity of Sinovel reached 15805 MW, second only to the Goldwind, its new wind turbines installed capacity was only 729MW and ranked the tenth in 2014(See Table 2). It indicated that the competition of China's wind turbine market has become increasingly fierce in recent years.

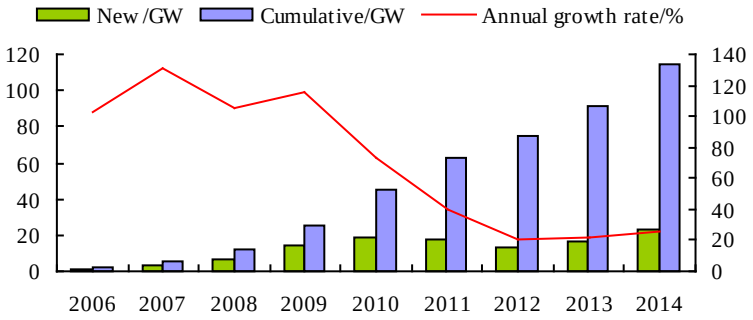

Figure 1. Installed capacity of wind power in China (2006-2014).

Table 1. Newly installed capacity in the top 10 of wind turbine manufacturers in China (2014).

Manufacturer	New capacity (MW)	Ratio (%)
Goldwind	4434	19.12
United Power	2582.5	11.13
Ming Yang	2058	8.87
Vision Energy	1962.5	8.46
XEMC Wind power	1781	7.68
Shanghai Electric	1735.6	7.48
Dongfang Electric	1298	5.60
Chongqing Haizhuang	1144	4.93
Zhejiang Windey	898	3.87
Sinovel	729	3.14
others	4573.4	19.72
total	23196	100

Table 2. Cumulative installed capacity in the top 10 of wind turbine manufacturers in China (2014).

Manufacturer	New capacity (MW)	Ratio (%)
Goldwind	23384.6	20.40
Sinovel	15805	13.79
United Power	11381	9.93
Dongfang Electric	9236	8.06
Ming Yang	7600.5	6.63
XEMC Wind power	5527.5	4.82
Shanghai Electric	5405	4.72
Vestas	4749.6	4.14
Vision Energy	4383.2	3.82
Gamesa	3597.6	3.14
others	23538.9	20.55
total	114608.9	100

2.2 Price

The fierce competition can promote decline in prices. As shown in Fig.2, the price of wind turbines in China was in decline trend between 2008 and 2010, and then became stable. It illustrated that the variation trends between wind turbines price and wind power installed capacity were similar. Besides, the price of imports wind turbines was higher than that of domestic wind turbine. The main reason was that the competition of wind turbine market in China was fiercer.

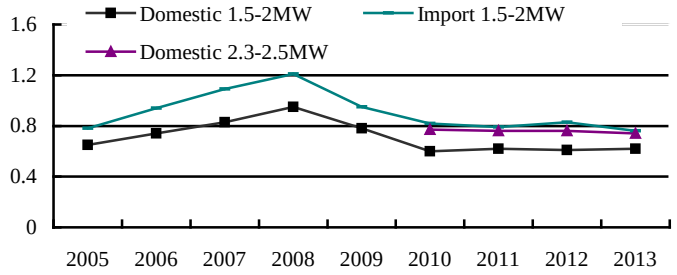

Figure 2. The price of wind turbines in China from 2005 to 2013 (Million$/MW).

2.3 Technology

The development of wind power in China heavily relied on foreign technology, especially in the early stage. Over the period of 2000 to 2007, large numbers of China's equipment manufacturers began to enter wind power market, and then grabbed domestic market share quickly. The rapid growth of China's wind power installed capacity provided strongly support for the technology research and development of domestic wind turbines manufacturers. From 2007 onwards, most of domestic turbine manufacturers were able to develop and design high-power wind turbines independently. At present, many domestic manufacturers has mastered the technology of manufacturing 2MW, 2.5MW, 3MW and even 5MW scale wind turbines.

With the rapid rise of domestic wind power equipment manufacturing industry, the China's wind turbine manufacturers occupied most of the domestic wind power equipment market. The average size of installed wind turbines in China kept increasing with the development of wind power industry. By the end of 2014, the average size of new installed and cumulative installed wind turbines in China reached 1.77MW and 1.5MW respectively. As seen in the Fig. 3 and 4, the 1.5MW and 2MW wind turbines has become the mainstream models of China, and their proportions in the new installed and cumulative installed wind turbines were 87% and 83% respectively in 2014. Besides, the development and design of large-scale wind turbines has become a main technology development tendency. At present, many domestic wind turbine manufacturers are able to design and produce the

3MW, 5W and even 6MW wind turbines. The high-power wind turbines were mainly installed in the offshore wind power projects [Zhao Xin-gang, 2015]. What's more, many competent wind turbine manufacturers in China planned to research and design higher-power wind turbines for the offshore wind power.

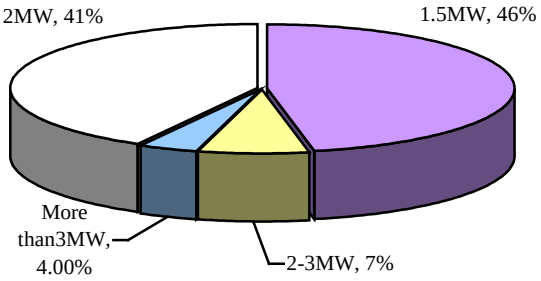

Figure 3. The type of newly installed wind turbines in China (2014)

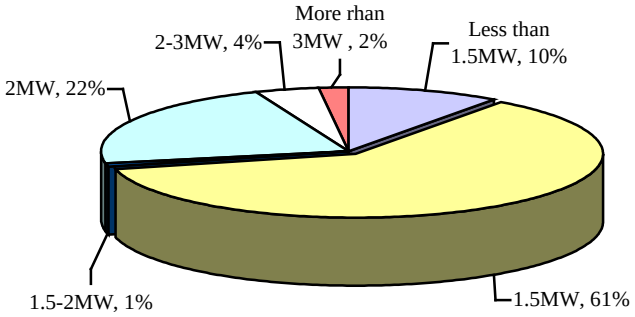

Figure 4. The type of cumulative installed wind turbines in China (2014)

3 INDUSTRY PERFORMANCE ANALYSIS

The Data Envelopment Analysis (DEA) is a kind of relative effectiveness of nonparametric method, and it can be used to evaluate the relative performance of decision making units based on the analysis on the data of input and output. Because it does not need to consider the unit of input variables and output variables in the process of the use of DEA, the use of DEA model is convenient, the analysis results of DEA are more objective and its economic significance is clear. Besides, the investigators can use DEA model to provide the comprehensive efficiency, technical efficiency, scale efficiency and much other information for the competent authorities. Therefore, the DEA model is widely applied in many industry fields. Due the advantage of the DEA analysis, the paper would use the DEA model to analyze the industrial performance of China's wind power in the section.

3.1 Variable selection and data processing

The paper chose the operating income as the output variable of DEA model, and selected the capital investment and operating cost as the input variables of DEA, to analyze the efficiency of wind power industry [Yu-hua WU, 2008] [Yunfei PENG, 2011].

In order to analyzed the overall performance of China's wind power industry, we selected the eight wind turbine manufacturers① (Sinovel, Goldwind, Dongfang Electric, Ming Yang Wind Power, Shanghai Electric, XEMC Wind power, Silver Star Energy and Huayi Electric), which listed the data of wind power business in their annual reports. And then the paper used their primal data to analyze the performance of wind power equipment manufacturing industry. Besides, the paper took 2008 as the base period, and chose the producer price index for industrial products, purchasing price

index for industrial products and price index for investment in fixed assets as the parity index of the operating income, operating costs and capital investment respectively, in order to eliminate the impact of price movements on the statistical data of China's wind power industry. Finally, the adjusted data of the wind power equipment manufacturing industry was shown in the Table 3.

Table 3. The data of wind power industry in China from 2010 to 2014. (Unit: Million$)

Year	Operating income	Operating costs	Capital input
2010	10099.419	8566.734	21299.990
2011	7030.629	6186.800	22264.384
2012	5032.848	4723.885	20699.601
2013	5279.404	5218.080	20239.914
2014	6944.374	6250.719	21643.556

3.2 Empirical analysis

The paper used the DEA-xp1 software to analyze the data of wind power equipment manufacturing industry, and the results were shown in the Table 4. According to the analysis results, the paper found that: China's wind power industry in 2010 was in the optimally effective size, that is, the industrial performance was best. And then the industrial performance of wind power in China was in the declining trend between 2011 and 2013. By 2014, the industrial performance increased again, but did not achieve the best state.

On the further analysis, the paper found that: the technical efficiency of wind power in China has been in best state during the period of 2010-2013. Unlike the technical efficiency, the scale efficiency of wind power industry in China has been in declining trend from 2010 to 2013. In the analysis period, the technical efficiency of wind power industry has been better than the scale efficiency. It indicated that the technology of wind power equipment manufacturing industry in China has been improved dramatically in recent years. Besides, the scale merit of wind power industry was in the state of increasing economies of scale between 2011 and 2014, and it indicated that the scale of wind power equipment manufacturers was too small.

Table 4.The efficiency of wind power industry in China (2010-2014).

year	crste	vrste	scale	Scale merit
2010	1.000	1.000	1.000	-
2011	0.964	1.000	0.964	irs
2012	0.904	1.000	0.904	irs
2013	0.858	1.000	0.858	irs
2014	0.942	0.981	0.942	irs
mean	0.934	0.996	0.961	

Note: Crste = comprehensive efficiency CRS DEA; Vrste = technical efficiency from VRS DEA; Scale = scale efficiency = crste/vrste.

4 CONCLUSION

The wind power industry in China has achieved a stable growth in recent years. The rapid growth of installed capacity has promoted the domestic wind power equipment manufacturing industry to rise rapidly in China, and the wind turbine manufacturers also commenced gradually to research and design the wind turbines independently. Due to the fierce competition, the market structure of wind power equipment in China changed a lot, and the price of wind turbines become stable in domestic wind power market. Besides, the paper adapted the DEA model to analyze the industrial performance of wind power in China, and found that the decline in growth rate of installed capacity and the fierce competition had an important effect on the performance of China's wind power industry, and the performance did not achieve the best state in the period of 2011 to 2014.

Based on the status quo of wind power and the analysis on the industrial performance of wind power in recent years, the paper held that Chinese government should continue to adjust the structure and scale of wind power industry, in order to improve the comprehensive efficiency of wind power industry, especially the technical efficiency. Besides, China's wind power equipment manufacturers should develop and design the high-power wind turbines independently, and master the core techniques of high-power wind turbines, in order to break the restrictions of the wind turbines manufacturing technology in the developed countries.

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In view of the availability of data, the paper chose the wind power equipment manufacturing industry as the object of study to analyze the industry performance of China's wind power. Besides, the market shares of the eight wind turbine manufacturers were almost 60%, and their wind power business could reflect the performance of China's wind power industry.

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