Chinese Wind Power Development Experience and Future Expectations

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Abstract. With the rapid development of renewable energy technology in the world, the upgrading of the energy system in China with new renewable energy techniques is necessary, the government has taken more measures in order to seek better future development. Wind power plants are a promising way of solving the electricity shortage in eastern China. However, several problems exist with the fast development and extensive expansion of wind power plants in the past decade. Also, there is a lack of systematical understanding in measures of solving the currently existing issues with the fast development. Thus, in this paper, China's wind power technology development will be explored in the following sections as the epitome of the whole new energy technology. The distribution of wind reserves in China is discussed, and the development of wind power in China is furtherly explored. Take it as a reference, constructive suggestions have been made for future development, and the possible ways to develop wind energy sustainably might be verified in the future.

Keywords: Wind power, Sustainable development, Wind power prospect.

1. Introduction

Though China has giant fossil energy reserves, the per capita possession is still lower than the average world level because of the massive population base. In the current Chinese energy and electric power structures, coal-based parts take up the major part. Also, considering the environmental problems (global warming, air pollution) caused by fossil fuels and their limited domestic reserves, which is not likely to meet the growing requirements soon in the future, especially the price of petroleum and its by-product keeps a stubbornly high trend, paying more attention on developing alternative and renewable energy sources is an effective method for government to solve or relieve the energy problem. As alternative energy technology only reduce the emission of pollutant instead of reducing the consumption of fossil fuels, other emissions like greenhouse gases and the major energy problem are not solved. While using renewable energy directly reduces fossil fuel consumption, thus reducing the total emission (including greenhouse gases and harmful gases). With its renewability, environmental friendliness, and an infinite amount of energy reserves, renewable energy is far more of a potential choice in long-term consideration than alternative energy or other schemes.

The wind power generation technology, which belongs to renewable energy, get more favor because of the flexibility, low construction cost, and short construction period. However, technology has not just caught attention in China; the international society has valued it greatly since the 1990s. In 1994, the installed wind turbine capacity of the total world was about 350 million kilowatts, while the number jumped to 1750,19439 million watts in 2000 and 2010, respectively, representing a dramatic increasing trend. In 2021, the total generating capacity of wind power and photovoltaic power generation set a new record with 10.3 percent of the world's total, and it was the first time it surpassed 10 percent of the whole world. With the fast-developing wind technology, many countries have already made great models, which can be seen as references to the others. As the place where the world's first wind power plant, Denmark has always had advanced wind power technology and an adequate amount of installed wind turbines compared to less than 6 million population. Its capacity had already reached 2.3 million kilowatts in 2000. After 20 years of development, the wind power capacity of only the offshore part had a reserve of about 2 million watts, and the wind power

generation supported 50 percent of electricity consumption in Denmark in 20201[1,2]. For developing countries, India has huge potential and a relatively fast rate of developing wind power generations. In 2016, 5400 million watts were produced by the wind turbine, far more than the expected amount(4000 million watts) made before. India also especially set up a department of unconventional energy to make long-term plans for renewable energy technology including wind power generations, and to achieve its enormous potential on offshore wind turbines. Though examples have already been made by several countries, as the national conditions vary in numerous aspects in different countries, their methods can not be used directly in China. For example, Denmark, with a far smaller population and 3 or 4 times higher electric charge compared to China, can make the wind power generations take up a large percent of the total ones, which China can never imitate because of the enormous costs and resistance from the mass. Thus, to find a better forward direction, it is necessary to analyze wind power generations in China from different aspects, thus providing some expectations for the future [1].

2. Influence factors of wind power distribution in China

China has a giant national territorial area covering a long coastline of about 18000 kilometers in total. According to the figure from more than 900 meteorological stations located in the nation, the Chinese average wind power density is 100 watts per square meter, and the total wind energy content is about 3.226 billion kilowatts, about 3 times bigger than that of available ones. The exploitable onshore and offshore wind energy content is 0.253 billion kilowatts and 0.75 billion kilowatts, respectively, which is about 1 billion kilowatts in total. As the above data presents, China is rich in wind energy resources and has great potential to develop wind power technology [2].

Regionally, the wind energy distribution in China can be divided into 3 major areas. One is the particular area called "the three months" starting from Xinjiang(northwest China), going through Inner Mongolia(north China), to the Northeast three provinces, wind energy in this region is much richer than the other ones. Based on information from the local meteorological station, the average wind power density of these individual provinces always varies from 200 to 300 watts per square meter, and some can even reach 500 watts per square meter, far exceeding the Chinese average level. And the available wind energy reserves in the region take up about 79 percent of the total Chinese amount. Also, most of these regions are plat terrains with convenient transport facilities, and the wind speed seldom appears devastating for infrastructure. With all these favorable geographical conditions, it is appropriate to construct a wind power plant on a large scale. However, different natural factors must be considered before building in different areas. For example, the effect of the sand storm or low temperatures should be considered in northwest China, like Xinjiang province. Also, though the three northern regions have an excellent environment for wind power construction, this region is reversed to the load center. Thus, the consumption problems should be considered before building large wind power plants [3].

Another one is the southeastern coastal areas, including about 18000 kilometers long coastline and more than 5000 islands, which can be seen as the best wind energy zone. When cold air south into the strait is affected by Taiwan Strait, the Funnelling effect causes the acceleration of wind speed, thus enriching the wind energy reserves in the southeast coastal area and islands. The average wind power density here is about 200 watts per square meter. For the islands, including Pratas, Matus, and so forth, the figure increase to above 500watts per square meter and above 4000 running hours per year. While the great wind energy sources still get limited geographically because of the hilly land nearby the coastline, only 50kilometres from the coast have abundant wind energy reserves. Based on these features, offshore wind power development better fits local conditions instead of impracticable large-scale construction. Though the zone has great natural factors and appropriate methods to use it, difficulties are still caused by social or technical reasons. Considering the high cost and long-term payback period, many local governments are unwilling or unable to carry out policies supporting wind power generation. Some areas where local wind sources are unable to be fully

explored must take the risk of choosing a relatively worse place for wind power generation if they intend to. Also, the Chinese offshore wind power industry is still not perfect, which increases the risk of investment and construction [3].

The last part is out of the two huge zones, combined with several regions of the interior, with an average wind power density of below 100 watts per meter under normal conditions, where wind power reserves in this part are much poorer than the first two, thus lowering its importance. But some regions in this part also have relatively rich energy reserves by the influence of special terrain, like the area surrounding Poyang Lake, Songshan mountain, etc. Scattering wind power generators at low wind speeds can be a good choice for these places [4].

3. Evolution of Wind power resources in China in the past two decades

Currently, China's cumulative installed capacity reached above 0.3 billion kilowatts, which continues to be the largest in the world and has countless wind power generation farms in the whole nation, while China did not formally develop or apply wind power generation on wind power on a large scale until 2006. Besides natural advantages, Chinese policies play an important role in that great progress. The total time period can be divided into 3 parts according to the 3 "five-year plans" (the 11th, 12th, and 13th ） carried out by China. At the beginning of the 11th five-year plan in 2006, the Chinese government carried out the "Renewable energy law", starting to attach importance to wind power officially. As the large-scale development(mainly in regions with rich wind energy sources), serious technical problems were discovered, major ones like low technical level of complete machines, lack of independent and sustainable development capability, and incomplete industry. To solve problems, the relative department set up a major scientific project about developing high-power wind generators, including 23 Chinese research units. The government also gradually carried out supportive policies to promote wind power development and attract foreign companies to bring in various technology. By the end of 2010, the cumulative installed number of wind turbine generators reached 34485 with 44733.29 megawatts installed capacity; during years of technical import and industrialization, though further development is still required, technical problems became no more urgent in China. By the end of the 11th Five-year plan, more specific policies are made to push regional wind power development, which is mainly about enhancing quality, restricting the standard of the wind power project, and adjusting the management approach based on local wind power traits. In these five years, the big picture began with the publishment of the "Renewable energy law", China started to accelerate the energy system revolution from fossil fuels to renewable energy. For wind power technology, China's wind power overcame the most urgent technical problems of wind power caused by later start time in wind power development and laid a foundation for the rapid follow-up development. Also, China's efforts during the five years let wind power and other renewable energy get into public sight [5].

After 5-year rapid growth, wind power generation formed sizeable wind power plants and laid the foundation for further development, while the side-effect appeared following it. As most of China's wind energy reserves are distributed reversely from the load center in The Three Norths, plus the enormous amount of wind generators equipped in the 11th five-year plan, wind power consumption problems were becoming increasingly important. According to information from the China Longyuan power group, from January to April 2011, the power rationing amount took up 16percents of the total, while 40 percent of power rationing came from inner Mongolia. During the 12th Five-year plan, the Chinese energy department made adjustments in priorities based on national conditions at that time. Following the large-scale wind power plant integrating with the grid equipped during the 11th five-year plan, the government decided to support places with poor wind power reserves like Chongqing by building Low wind velocity wind farms, slowing down the rapidly growing trend of wind power in the three northern regions. At the same time, the energy department also paid close attention to the prospect of wind power techniques and started vigorously promoting offshore wind power. The Yellow Sea was the key experiment zone, especially the 2 offshore wind plants in Jiangsu and

Shandong provinces, due to their high but nondestructive wind velocity. During the 12th five-year plan, Chinese research units successfully manufactured the first Chinese self-developed 5MW offshore wind turbine generator, and completed the first national demonstration project about offshore wind power, which integrated 34 3MW offshore wind turbine generators in the grids, broke the foreign monopoly of manufacturing skills about advanced wind turbine generators. But there was a pity that the installed capacity failed to reach the expectation of 5 million kilowatts in 2015 with a number of 1 million kilowatts. Among the 12th five-year plan, research and development of wind power entered a time period for stable and sustainable progression, no longer eagerly pursuing the rapid development in wind turbines as 11th five-year plan but seeking a sustainable development pattern for balancing resources utilization between regions with rich or poor wind energy reserves, and subsequent problems caused by suddenly boom in the renewable energy industry [6,7].

For the 13th five-year plan, the policies from the 12th five-year plan continued to be used but became more specific and practical, making much further progress in both technique(especially offshore wind power generation)and practical construction. The principal barrier to offshore wind power development was the high building cost, and operational and maintenance cost since the environment for construction is complex and fickle, thus making it relatively difficult to build. As the inevitable building difficulties, measures from other aspects were made to reduce the cost or increase the profits. As the offshore wind power generator takes up a small percent of the total cost, China accelerates the development of high-capacity and powerful wind turbines to earn more profits. For the social aspect, China completed the wind power industrial system, including prices and market size, and strengthened the cooperation between upstream and downstream industries, clearing construction standards. By the end of the 13th five-year plan, Chinese wind power installed capacity went beyond 0.1 billion kilowatts, and the offshore cumulative wind power installed capacity reached 9898 megawatts. The work about transforming the priority of wind power development from resource concentration area to the load center also got remarkable improvement, the pattern of centralized and decentralized development had formed, the wind power capacity in middle-east and the south region took up 31.2 percents of the total in 2020, and from 2018 to 2020 only Henan, Hebei, Shanxi three provinces have more than 7 gigawatts distributed wind power capacity [8].

4. Suggestions for further development of wind power in China

In recent years, the government has constantly carried out supportive policies for renewable energy development to keep a relatively fast developing trend of wind power. The Chinese wind power industry ranks high today and has kept the world's largest cumulative installed capacity of wind power since 2010. In contrast, there are still some problems to be solved and great room for future development. In the author's opinion, the most basic but useful development pattern is to keep a stable and well-organized developing trend in the future. Keep pushing the policy that changes wind power's priority to the load area since the consumption problem in the north three is still serious. There is still some phenomenon of the limited construction period, short supply of equipment, and price fluctuation. Companies and enterprises should consider the situation of local wind turbines and the output capability of the power grid and comply with governmental regulations according to their abilities. To avoid unnecessary potential risks, the government should also reinforce supervision of local executive conditions to keep the wind power industry's stability and avoid big rises and falls.

The second one is to innovate the system and mechanism of wind power and implement grid parity among the whole country. Governmental and public services relative to wind power should be optimized, including providing one-step services and setting a better bidding model for distributed generation. The grid parity policy local should also be checked regularly, provide some help if necessary, reduce the non-technology costs and push the fair price of electricity among every region of the country, thus creating conditions for improving the whole competitiveness improvement [9].

The next one is about technological innovation. Technology is the core competitiveness of an industry, especially an emerging industry like wind power. Innovation in wind power technology is

the main impetus for industrial advancement. However, it can be seen as 2 aspects. One is the breakthrough in key technology; another is to combine information technology and intellectualized systems to keep promoting generating efficiency, declining the cost of generating electricity, thus improving the quality of products and product competitiveness [10].

Last but not least, insisting on international cooperation. Energy problems are always a worldwide problem; renewable energy has also been a hot topic in recent years. Not a single nation on earth can catch up with the latest technique without international communication, and especially the Chinese wind power technology still can not compare to the world's top level in Northern Europe. Decades ago, Chinese wind power development was fallen behind others and had to catch up with the average world level in a hurry. Currently, facing the international energy pattern and boom in the wind energy technique, insisting on international cooperation and expanding the range of communication so that China can learn experiences or lessons from the international community and improve domestic wind power technique and application scale.

5. Conclusion

Energy is the foundation of the national economy, Rapid economic development in China requires more energy resources. Chinese energy industry structure has changed a lot during the efforts made during the last decade, but still can not compare to the reliance on fossil fuels, while there are problems of high energy consumption, environmental pollution, and supply-demand imbalance that will harm the sustainable development of China's economy. It is necessary to further explore the potential of renewable energy. Wind power as its lower costs, mature technique, and safety, has already become a strategic option for Chinese renewable energy developments. During decades of development, Chinese wind power installed capacity has become the largest in the world, the fan blade, and generator unit basically achieved localized production, but some components still need to import from aboard. Currently, limitations still exist for the developing Chinese wind power. The power grid access problems are still serious, and the capability of independent innovation and the wind power industry service system has a certain gap with advanced countries. Besides these, there are plenty of social problems like trade friction, the benefits of wind power enterprises, etc. The paper reviews and analyses the development history of wind power in China, and offers proposals for the future based on past experiences.

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