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Development of Wind Renewable Energy in Different Regions of China

Li Li[1,*]

[1]*Changsha Nanya Middle School, Changsha, Hunan, 410006, China*
**Corresponding author: yifang@qingta.com*

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Abstract: Wind energy, characterized by its renewable, clean, and non-emissive nature, is progressively securing global interest. As the globe's preeminent energy consumer, China's appetite for wind energy exhibits a consistent rise, marked by substantial advancements in this domain. This research presents a comprehensive exposition of China's journey in wind energy, addressing its milestones in areas such as installed capacity, technological breakthroughs, spatial distribution, ecological repercussions, and economic dividends. The article further delves into the spatial distribution of wind resources across China, spotlighting the resource richness and developmental prospects in the eastern, central, and western sectors. Moreover, the research probes into advancements in wind power generation methodologies, encompassing improvements in turbine design, dependability, strategic planning, and schematic arrangement. Concludingly, the narrative elucidates the prospective trajectory and ramifications of wind energy in the Chinese context, encapsulating technological evolution, magnitudinal growth, ecological and societal ramifications, policy-driven scaffolding, and beyond. In summation, this analysis accentuates the pivotal role and latent potential of wind energy in China's energy matrix, proffering crucial perspectives and suggestions for its enduring progression. With unwavering policy backing and technological strides, China is aptly positioned to maintain its ascendancy in wind energy, thereby fortifying global ecological sustainability.

1. Introduction

Wind energy, harnessed from the kinetic energy of wind, stands as a paramount renewable electricity source. Its prevalence in the global energy matrix underscores its pivotal role in diminishing greenhouse gas emissions, thereby aiding the fight against climate change. The methodology of converting wind energy into electricity employs wind turbines, which are predominantly composed of expansive rotating blades, a drive mechanism, and a generator. China, as a dominant global energy consumer, is witnessing an escalating demand for renewable energy solutions. Given its expansive geographical expanse coupled with a rich repository of wind resources, the prospects for wind energy evolution in China are considerable. Data from the National Energy Administration reveals a meteoric rise in China's wind power installed capacity over recent years, underscoring its integral role in the nation's energy framework [1]. Concurrently, the Chinese governmental apparatus has instituted myriad policies and incentives to bolster wind energy adoption,

encompassing financial incentives and preferential electricity pricing structures.

The objective of this research endeavor is to delve into the spatial distribution and progression of wind energy utilization across various Chinese regions. Primarily, this dissertation endeavors to evaluate the wind resource potential dispersed across China, followed by a meticulous examination of the region-wise installed capacities and their respective developmental trajectories. Subsequently, this academic discourse will elucidate the primary catalysts and impediments shaping the wind energy landscape across different Chinese precincts. Conclusively, this manuscript will proffer strategic recommendations to facilitate the enduring and sustainable augmentation of wind energy within China's borders.

2. Overview of wind energy development in China

Wind energy encompasses the conversion of aerodynamic forces into electrical power via wind turbines. This form of energy generation arises from solar radiation heating the earth's surface unevenly. Influenced by the planet's rotation and geographical topography, this differential heating leads to air movement, instigating turbine rotation and subsequent electricity generation. Renowned for its renewable, pollutant-free, emission-less nature, and independence from fuel procurement constraints, wind energy is heralded as a green and sustainable energy alternative.

The trajectory of wind energy development in China can be demarcated into distinct phases. Initial ventures in the 1970s marked the inception, characterized by the introduction of wind turbine technologies. Nevertheless, constrained by technological and economic hurdles, the early endeavors yielded limited traction. Fast-forward to the dawn of the 21st century, and technological maturation combined with robust policy backing ushered in a period of brisk development for China's wind sector. By 2005, the nation emerged as the global leader in terms of newly added wind power capacities. Currently, China boasts the world's most expansive wind energy installed capacity [2]. This ascendancy transcends mere installation numbers, with notable advancements materializing in technology, spatial distribution, ecological implications, and economic dividends. Transitioning from a phase of dependency on imported technologies, China now thrives on indigenously developed wind turbine innovations, with operational terrains diversifying to encompass inland and montane regions. State-driven initiatives, encompassing fiscal incentives, tax rebates, and a renewable energy quota framework, have provided impetus to the sector's growth. Concurrently, a marked reduction in the cost metrics of wind energy has rendered it an economically viable contender in the energy arena. While the sector grapples with challenges—ranging from grid integration, temporal variability of wind, to ecological considerations—persistent technological strides, fortified policy architecture, and international synergies ensure that China's wind energy sector remains a testament to the latent potential of renewables within holistic sustainability blueprints. This growth trajectory is anticipated to sustain and amplify in forthcoming decades.

3. Wind energy distribution in China

China's eastern provinces represent some of the pioneering and most developed regions in wind energy deployment. Endowed with substantial wind resources, this region is conducive to wind power projects. Provinces such as Shandong, Liaoning, and Henan have considerable installed wind power capacities. Notably, Shandong stands out as one of the nation's top provinces in terms of wind power capacity. In contrast, China's central regions, while being replete with wind energy potential, embarked on the wind power trajectory relatively later. Provinces including Hunan, Hubei, and Jiangxi are progressively emerging as crucial hubs for wind power in this region. Aided by policy and technological frameworks, these provinces are witnessing annual increments in their wind power installations. Western China, despite its abundant wind resources, has faced a more staggered

development in wind energy, primarily due to its intricate topography and constraints in electrical grid infrastructural development. Nonetheless, as the western provinces undergo economic acceleration and grid enhancements, the prospects for wind energy expansion in this region seem promising, indicating substantial growth potential in the near future. According to the National Energy Administration of China, the geographical distribution of wind energy in China is as follows:

1) Inner Mongolia and northern Gansu have a large share of China's wind energy. This area is under the control of the westerly belt all year round, and it is also the place where the cold air invades first. The wind energy density is 200-300 W/m^2, the effective wind force occurs for about 70% of the time, and the wind speed is greater than or equal to 3 m/s. There are more than 5000 h in a year, and the wind speed greater than or equal to 6m/s is above 2000 h, gradually decreasing from north to south, but not as large as the gradient in the southeast coast. In the Hulegai area with the largest wind energy resources, the cumulative hours of wind speeds greater than or equal to 3 m/s and greater than or equal to 6m/s can reach 7659 h and 4095 h, respectively[3]. Although the wind energy density in this area is smaller than that on the southeast coast, its distribution range is wider, and it is the largest wind energy resource area in China.

2) Heilongjiang, the eastern part of Jilin and the coast of Liaodong Peninsula also have relatively large wind energy. The wind energy density is above 200 W/m^2, and the annual cumulative hours of wind speed greater than or equal to 3 m/s and 6 m/s are 5000-7000h and 3000h, respectively [4].

3) The Plateau, the northern part of the Three-North region and the coastal areas are areas with relatively large wind energy. In this area (excluding the above range), the wind energy density is between 150 and 200W/m^2, the wind speed greater than or equal to 3 m/s is accumulated for 4000 to 5000h throughout the year, and the wind speed greater than or equal to 6 m/s is accumulated for more than 3000h throughout the year. The annual cumulative wind speed of 3 m/s or higher on the Plateau can reach 6500 hours. However, due to the high altitude of the Plateau and the low air density, the wind energy density is relatively small. At a height of 4000m, the air density is roughly 67% of that of the ground. In other words, the same wind speed of 8m/s is 313.6 W/m^2 on flat ground but only 209.3 W/m^2 at a height of 4000m[5]. Therefore, if we only count the occurrence hours of wind violations greater than or equal to 3 m/s and greater than or equal to 6m/s, the Plateau should belong to the largest area, but in fact, the wind energy here is much smaller than that of the southeastern coastal islands. From the northern part of the Three Norths to the coast, they are almost connected into one piece, surrounding the mainland of our country. The availability of wind energy on the mainland is also basically consistent with the boundaries of this region.

4) Yunnan, Guizhou, Sichuan, southern Gansu and Shaanxi, western Henan and Hunan, mountainous areas of Fujian, Guangdong and Guangxi, and the Tarim Basin are the smallest wind energy regions in China. The effective wind energy density is below 50 W/m^2, the available wind power is only about 20%, the annual cumulative hours of wind speed greater than or equal to 3 m/s are below 2000 h, and the wind speed of greater than or equal to 6m/s is below 150h. In this area, the wind energy is the smallest in the Sichuan Basin and Xishuangbanna, where the annual static wind frequency is over 60%, such as 67% in Mianyang, 60% in Bazhong, 67% in Aba, 75% in Enshi, and 75% in Germany. Ge is 63%, Gengma Mengding is 72%, and Jinghong is 79% [6]. The wind speed greater than or equal to 3m/s is only accumulated for 300 hours throughout the year, and the wind speed greater than or equal to 6m/s is only 20 hours. Therefore, except for special terrains such as high mountain tops and canyons, the wind energy potential in this area is very low and has no utilization value.

5) In the vast areas other than 4 and 5 areas, it is the seasonal utilization area of wind energy. Some can be used in winter and spring, and some can be used in summer and autumn. In this area, the wind energy density is between 50 and 100 W/m^2, and the available wind power is 30 to 40%. About[7].

Generally speaking, the geographical distribution of China's wind energy is relatively balanced,

and different regions have certain wind energy resources.

4. Research progress of wind power technology in China

The advancement of wind power technology is the key to the development of wind energy. China's wind power technology has made remarkable progress after years of development. On the one hand, the design and manufacturing technology of wind turbines has been continuously improved, the power has been increased, and the cost has been reduced. At present, China has built a number of large-scale wind farms, and the installed capacity of wind turbines has continuously set new records. On the other hand, the reliability of wind power generation has been improved. Through the automatic control and monitoring system of wind power generators, the failure rate has been effectively reduced, and the power generation efficiency has been improved. In addition, the planning and layout of wind farms have also been optimized [8]. Through scientific and reasonable layout, wind energy resources can be fully utilized, and power generation efficiency can be improved. However, the storage and transmission of wind energy remains a challenge. Wind energy is unstable, and it is necessary to solve the fluctuation and instability of wind power generation. On the one hand, it is necessary to develop energy storage technology for wind energy to store excess electric energy to meet the problem of unstable wind power generation.

China is fervently advancing its endeavors in wind power generation and related energy storage technologies, such as wind battery storage and wind water pump storage systems. A concurrent focus is on fortifying the transmission capabilities to effectively channel the generated electricity from remote wind farms to demand centers. To this end, China has established multiple power transmission corridors that seamlessly integrate wind energy into the national grid. Moreover, there's an emphasis on enhancing wind power forecasting methodologies to ensure its optimal dispatch and utilization. Economically, wind energy stands out not only for its ecological credentials but also for its promising financial returns. The declining costs, driven by technological breakthroughs and economies of scale, position wind energy as a viable competitor to conventional energy sources. Furthermore, with longer operational lifespans and minimal running costs, wind energy promises attractive return on investments. This green energy sector also acts as an economic catalyst by spurring ancillary industries, generating employment, and fostering regional economic growth. Nevertheless, considering the substantial capital outlays required for wind infrastructure and its ensuing operational expenses, comprehensive financial analysis becomes imperative. Recognizing this, the Chinese authorities are augmenting their support mechanisms, urging societal investments, mitigating associated financial risks, and championing the broader proliferation of wind energy.

5. Future development and influence of wind energy in China

The future development of wind energy's future is underscored by several anticipated advancements. Researchers are venturing into designing wind turbines adept for loftier altitudes and profound aquatic depths, potentially diversifying the wind energy landscape. Simultaneously, innovations like bladeless turbines are on the horizon, promising both enhanced efficiency and diminished maintenance overhead. Modern digital tools, rooted in artificial intelligence and the Internet of Things, are now equipping wind farms with real-time operational insights, facilitating predictive maintenance and thereby elevating overall productivity. A significant shift is the envisaged integration of wind power with alternative energy modalities, notably solar photovoltaics and contemporary energy storage mechanisms, such as lithium batteries, ensuring uninterrupted power delivery even during wind lulls [9]. Of particular note is the burgeoning interest in distributed wind energy, wherein compact turbines are envisioned to populate urban skylines, local communities, or isolated terrains, serving proximate energy demands and curtailing transmission inefficiencies.

Policymakers are urged to foster this paradigm through fiscal incentives, propelling both research and grassroots adoption. This encourages individuals and businesses to not only adopt but also contribute excess energy back to the grid, epitomizing the "produce-store-use" energy model. The continued evolution of distributed wind systems necessitates their seamless integration with conventional energy infrastructures, accentuating both reliability and economic viability. Crucially, the inception of a comprehensive smart grid becomes indispensable, poised to mitigate the inherent unpredictability of wind, thereby safeguarding a stable energy supply.

Further, the impact of wind energy on the environment and society will be positive. Wind power is a clean energy that does not produce greenhouse gases and pollutants such as carbon dioxide and is of great significance to reducing carbon emissions and improving air quality. At the same time, wind power will not seriously impact water and land resources, and is relatively environmentally friendly. In addition, the construction and operation of wind power generation can also create employment opportunities and promote local economic development. Wind power can also improve energy security, reduce dependence on imported energy, and improve the country's energy independence. Finally, the development of wind energy needs the support and guidance of policies and regulations [10]. The Chinese government has formulated a series of policies and regulations to promote the development of wind energy. These include the "Wind Power Industry Development Plan" and "Wind Power Development Guidance" issued by the National Energy Administration and wind power development plans and preferential policies formulated by various regions. The government also encourages social capital to participate in wind energy investment and construction, provides financial and tax support, and reduces investment risks and costs. At the same time, the government has also strengthened the supervision and management of wind power generation to ensure the safe and reliable operation of wind power generation.

6. Conclusion

China's ascendancy in wind energy, with its leading global stance in installed capacity, underscores its pivotal role in the renewable sector. Predominantly harnessed in the eastern coastlines and western terrains owing to their wind-rich topographies, the nation's wind energy deployment is poised for a broader geographical distribution, extending to plains and urban locales, fueled by technological strides and policy advocacy. Key research vectors encompass enhancing turbine efficiencies, pioneering in material science for robust wind resistance, and fortifying energy storage solutions to address the intermittency associated with wind power. Concurrently, an integrative approach that amalgamates wind energy with solar photovoltaics, state-of-the-art energy storage, and intelligent grid systems aims to establish a resilient energy matrix. While the prospect of wind energy in China is undeniably vast, it is not without its quandaries [11-12]. Economic concerns persist with the relatively elevated costs of wind energy, and ecological considerations, like avian migrations and habitat conservation, necessitate vigilant stewardship. The intricate dynamics of integrating wind energy into the power grid, ensuring consistent supply and seamless turbine operations, warrant meticulous attention. In summation, China's wind energy future plan, marked by immense potential and innovation, is juxtaposed with inherent challenges. Yet, through persistent policy bolstering and tech-driven solutions, it remains a linchpin in the nation's sustainable future.

References

[1] Bootorabi F., Haapasalo J., Smith E., Haapasalo H. and Parkkila S. (2011) Carbonic Anhydrase VII—A Potential Prognostic Marker in Gliomas. Health, 3, 6-12.

[2] Li D. F. Development of off-grid wind power industry in my country (2018). Renewable Energy, 27, 4-6.

[3] Jiang X., Qiao Jx, Zhang X. J. Current status and development suggestions of renewable energy power generation (2018). Gas and Heat, 38, 6-11

[4] Yan Y. Q. Exploration of development ideas of new energy wind power generation (2019). Power System Equipment, 6, 76-77.
[5] Wang Z. X., Zhang H. Q. New progress in wind power generation and its control technology (2009). Low Voltage Electrical Appliances, 19, 2-9.
[6] Fu Z. Y. Discussion on new energy power generation and wind power technology (2020), Science and Technology Innovation, 36, 145-146.
[7] Liu B., He Z. J, Jin H. Current status and development trends of wind power (2016). Journal Of Northeast Dianli University
[8] Zhang M. Discussion on wind power generation and its technology development (2022). China Equipment Engineering, 4, 200-201.
[9] Guan W. Exploration of development ideas of new energy wind power generation (2019). Power System Equipment, 8, 27-28.
[10] Wang Y. P. Analysis of current situation and development trends of wind power generation (2020). Electric Power Equipment Management, 11, 21-22.
[11] Liu C, Wang H, Li T, et al. Research on the impact of distributed new energy generation on distribution network voltage (2019). Renewable Energy, 37, 1465-1471.
[12] Guo X. T, Cai J. C, Han G. Y, et al. Distributed energy technology and development status (2019). Distributed Energy, 4, 52-59.