Research on Wind Power Generation Technology in New Energy Power Generation

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Abstract. With the continuous development of the social economy and the continuous increase of the population, earth resources' storage is becoming less and less, and the non-renewable resources are gradually depleted. People's survival will be seriously threatened. Therefore, the development and utilization of renewable resources and clean energy have become our country's primary task to solve the shortage of resources. The development and utilization of new wind power energy can effectively alleviate the human survival crisis caused by the shortage of coal resources. The article adopts the development status of wind power new energy, and the current development status of grid-connected technology is explored, hoping to help our country's sustainable development.

Key words: Wind power generation, environment, real-time detection, adaptive control, efficiency.

1. Introduction
Continuous power generation through wind power is mainly the most important way to use wind energy. This power generation method has been highly valued by various countries, mainly using a natural energy source for power generation. This technology has many advantages in the actual application process and has a relatively important role in energy-saving and renewable and important ecological protection. Because my country's current energy situation is relatively short, it has become an inevitable choice for the sustainable development of my country's economy through wind power generation's continuous development. Therefore, in this article, based on the world-wide situation of new energy power generation, a comprehensive analysis is mainly made on the technology of wind power generation [1]. On this basis, the following content is proposed, hoping to provide corresponding reference value to the workers in the same industry.

2. The development background and current situation of wind power generation
In order to realize the strategic transformation of energy and take the path of sustainable development, countries have formulated clear renewable energy development plans. The European Union has put forward a development goal of reaching 20% of the EU's total energy consumption by renewable energy by 2020. My country has set a goal of reducing carbon dioxide emissions per unit of GDP by 40% to 45% compared to 2005, and that non-fossil energy sources account for about 15% of primary energy
consumption. Obviously, wind power generation, as a vitally important part in new energy power generation, makes extraordinary contributions to creating a sustainable energy structure.

China's "Renewable Energy Law" was formally promulgated and implemented in 2006. The law clearly stipulated the legal status of wind energy and other renewable energy sources, and made renewable energy a priority for energy development. The Chinese government promised to reduce carbon emissions per unit of GDP by 40% to 45% by 2020 compared to 2005, and non-fossil energy to account for about 15% of primary energy consumption. During the "Thirteenth Five-Year Plan" period, China's wind power technology has achieved steady and rapid development. As of the end of 2019, China has built more than 4,000 wind farms with 120,000 wind turbines. The total installed wind power in China is 210 million kW. (The cumulative installed capacity of wind power is 204 million kW, and the cumulative installed capacity of offshore wind power is 5.93 million kW. Wind power installed capacity accounts for 10.4% of the total installed capacity. In 2019, wind power generated 405.7 billion kWh, exceeding 400 billion kWh for the first time. It accounts for 5.5% of all power generation. Wind power has become one of China's important energy sources. [2]

3. The development trend of wind power technology

3.1. Development from small capacity to large capacity
The single-unit capacity of wind turbines is increasing. At present, mainstream models are above 1MW, and the maximum single-unit capacity is 5MW. The United States has successfully developed 7MW wind turbines, while the UK is developing giant 10MW wind turbines. It is predicted that by 2020, there will be 20MW, 30MW, and even 40MW wind turbines available, and the manufacturing of wind turbines will be transformed from manufacturing machines to building power stations.

3.2. Development of onshore wind power to offshore wind power
My country has become the world's largest installed wind power generation market. In 2018, my country's new installed capacity reached 21,143MW. At the end of 2018, the cumulative installed capacity of wind power reached 209,533MW. My country's cumulative installed capacity of wind power increased from 2.0% in 2000 to 2018. Of 35.4%. Please refer to Table 1 for the newly installed capacity and proportion of wind power in my country's different regions in 2018.

| Area               | New installed capacity/MW | The proportion of new domestic installed capacity in the same period/% |
|--------------------|---------------------------|----------------------------------------------------------------------|
| North-east area    | 678                       | 3.2                                                                  |
| Huadong Region     | 4861                      | 23                                                                  |
| Central China      | 4086                      | 19.3                                                                |
| South China        | 1901                      | 9                                                                   |
| Southwest Region   | 1172                      | 5.5                                                                 |
| North-west region  | 3001                      | 14.2                                                                |

Offshore wind power is roughly the same as wind turbines on land. However, building wind farms on the sea solves the problem of occupying land resources, but at the same time, it uses the vast space and abundant wind resources that are blessed by nature on the sea, which can be produced in batches and scales, thereby reducing wind power generation cost. Many countries have formulated plans for large-scale development and utilization of offshore wind energy. For example, in 2002, the European Union's goal was: by 2010, the installed capacity of wind power will reach $4.0 \times 10^{10}$W, of which offshore wind power will reach $5.0 \times 10^{9}$W; in 2020, the installed capacity of wind power will reach $1.5 \times 10^{11}$W,
of which offshore wind power will reach $5.0 \times 10^{10}$ W; requirements The installed capacity of wind power accounts for more than 15% of the total installed capacity of the EU. The development of offshore wind power in China is taking off. The $1.0 \times 10^8$ W offshore wind farm project of the Donghai Bridge under construction in Shanghai is the first large-scale offshore wind farm in China. The whole project is planned to be completed in 2010 (25 months), using 3MW wind turbines. By 2020, Shanghai plans to build 5 offshore wind farms with an installed capacity of $1.1 \times 10^9$ W. Besides, my country also plans to build offshore wind farms in Cixi, Linhai, Daishan, Zhejiang, Yancheng, Jiangsu, and Qingdao, Shandong, with cumulative installed capacity exceeding $2.0 \times 10^9$ W.

3.3. **The development of constant pitch to pitch, variable speed, and constant frequency**

Compared with a wind turbine operating at a constant speed, a variable-speed operation can adjust the wind turbine speed in real-time under the condition of wind speed changes following the requirements of capturing the maximum wind energy, so that it always runs at the optimal speed, which can reduce the mechanical stress of the unit. Increased wind energy capture, good adaptability to changes in wind speed, low production cost, and high efficiency [3]. The number of variable-speed wind turbines produced by Germany's Enercon and Denmark's Vestas is in the world's leading position. The variable pitch is better than the fixed pitch because it has good starting performance, stable output power, and small mechanical load on the unit structure. Besides, when the wind speed is higher than the cut-out wind speed, the blades can also be feathered to protect the wind turbine from damage. Increase the service life of the fan. But the disadvantage is that due to the increase of the pitching device, the probability of failure is increased, and the control program is more complicated.

4. **Wind power generation system structure**

4.1. **Constant speed wind power generation system**

The fixed-speed wind power generation system uses two-speed induction generators, in which low-power low-speed induction generators work in low wind speed areas, and high-power high-speed induction generators work in high wind speed areas. When the wind speed exceeds the rated wind speed, the wind energy utilization coefficient is reduced by the blades' stall to maintain a constant power [4]. Because wind turbine speed cannot frequently change with wind speed, its wind energy utilization coefficient often deviates from the maximum value, and the utilization rate of wind energy is not high. Wind turbines often run in a low-efficiency state.

4.2. **Variable speed wind power generation system of the double-fed generator**

The grid-connected control strategy of doubly-fed wind turbines is shown in Figure 1. Before the generator is connected to the grid, the stator is open, and the grid voltage and rotor current are taken as control information and provided to the control system. According to this, the generator's excitation is adjusted, and the generator stator no-load voltage is controlled according to the grid connection conditions. When the generator stator output voltage and the grid voltage are precisely the same in amplitude, frequency, and phase, the grid operation is performed. After the grid connection is successful, the system automatically switches from grid connection control to power generation control.
The doubly-fed induction generator works in a limited variable speed range, which is related to the converter's design. The converter capacity is 20% to 30% of the generator's rated power. It has a considerable price advantage. The variable speed range is relative to the external resistance of the rotor. The Opti Slip is bigger. However, wind turbines require low voltage ride-through when the power grid fails, and the doubly-fed induction generator system will produce a sizeable current peak [5]. To ensure the safe operation of the system, advanced protection systems are required. As shown in Fig. 2, the voltage equation and flux linkage equation of the doubly-fed generator with the conventional motor in the two-phase rotating d-q coordinate system are shown in equations (1) and (2).

\[
\begin{align*}
\frac{du_d}{dt} &= -\omega_L i_{q_d} + R_j i_{d_d} \\
\frac{du_q}{dt} &= -\omega_L i_{d_q} + R_j i_{q_d} \\
\frac{du_{d'}}{dt} &= -\omega_L i_{q_{d'}} + R_j i_{d_{d'}} \\
\frac{du_{q'}}{dt} &= -\omega_L i_{d_{q'}} + R_j i_{q_{d'}} \\
\end{align*}
\]
\[
\begin{align*}
\psi_{ds} &= L_s i_{ds} + L_m i_{dr} \\
\psi_{dq} &= L_s i_{qs} + L_m i_{qr} \\
\psi_{q} &= L_s i_{q} + L_m i_{q} \\
\psi_{d} &= L_s i_{d} + L_m i_{d}
\end{align*}
\]  

(2)

Where: \( R_r \) is the equivalent resistance of the rotor winding; \( L_s, L_r, L_m \) is the self-inductance and mutual inductance of the stator and rotor windings respectively; \( i_{ds}, i_{qs}, i_{dr}, i_{qr} \) is the stator and rotor currents of the d and q axes respectively; \( u_{ds}, u_{qs}, u_{dr}, u_{qr} \) is the stator and rotor voltages of the d and q axes respectively; \( \psi_{ds}, \psi_{dq}, \psi_{d}, \psi_{q} \) is respectively d and q axis stator flux linkage and rotor flux linkage; \( \omega_s, \omega_r \) is the synchronous angular frequency and slip angular frequency respectively.

5. Wind power technology analysis

5.1. Control technology of electronic converter

For wind power generation technology, a more critical component is the controller of the power electronic converter. In the process of wind power generation, there is a more critical promotion effect. At the same time, this technology is characterized by an extensive range of applications. In some large-scale wind power generation systems, this technology is widely used. The efficiency of energy conversion can be effectively improved through the practical application, and the transmission efficiency can be fully improved after the conversion is completed. The application of this technology can effectively complete reactive power, and it is also very safe and reliable during the actual application of the technology.

5.2. Windwheel control technology

In the actual application of wind power technology, the wind wheel's control technology is very critical. When this technology is actually applied, it can comprehensively improve the power generation system's stability, and the application of this technology is mainly through the power signal feedback can grasp the signal of the wind turbine power in time. After continuously analyzing the relationship between the powers, the relevant graphs can be drawn on this basis. Therefore, when the actual operation is performed, the maximum power and system. The actual output power is analysed to obtain the relevant difference. At this time, by adjusting the blade angle of the wind wheel, it is ensured that the overall operating power of the wind wheel can be maximized [6]. However, the cost of the whole process is relatively high. At the same time, during the wind turbine's actual operation, obtaining the maximum power curve has corresponding difficulties, so this content must be paid attention to by the staff. Besides, in the actual application of wind wheel control technology, the control of blade tip speed ratio is an essential component because, under the interaction of wind, the blade tip rotation has a linear speed, which is called Tip speed, so in the process of actual control of this value, the actual operating system of its wind speed must be continuously improved and optimized.

5.3. Reactive power compensation and harmonic elimination technology

In the actual implementation of new energy wind power generation, through the practical application of reactive power compensation and harmonic elimination technology, it has a positive effect and is also the key to ensuring the system's stable operation. This technology is actually applied. At that time, under the mutual influence of its sensing elements, the actual consumption of reactive power in the system can be discovered in time, and the voltage is also through the entire process of induction [7]. If the high voltage is relatively high, the inductive element's current will have a certain degree of damage to other elements, so through the appropriate application of reactive power compensation technology, it can effectively deal with its harmonics. Besides, in the actual application of harmonic elimination
technology, because the whole process of wind power generation will have harmonic problems, if there are harmonic problems, it will inevitably lead to more inferior power quality, so this time it is necessary to apply Harmonic elimination technology uses power converters and related equipment to effectively eliminate its harmonics. Either by adjusting the capacitor bank in time to effectively improve the reactive power so that it can reasonably control the influence of harmonics or by using a triangle to make mutual connections so that the entry of harmonics is effectively reduced to ensure that the overall technical level of its wind power generation is comprehensively improved.

6. Conclusion
Wind power is a new type of power generation using clean and renewable energy. My country ranks among the top in the world in terms of energy consumption every year, and the efficient use of clean energy is of great significance in terms of energy-saving, emission reduction, and low-carbon environmental protection. Adding an adaptive control strategy to the wind power system is a type of intelligent technology that can significantly reduce the randomness of the output power, control the intermittent and volatility, and suppress disturbances. The addition of intelligent solutions to the control system is a reliable guarantee for promoting clean and multiple power generation energy and is also the smart grid's core force that enhances system self-healing and efficient emergency response.

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