

# Contemporary Development and Trend of Jiangsu Province Wind Power Generation Technology

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## Abstract

In this paper, we have mainly introduced the contemporary development of the global wind power generation technology. And we have discussed the constant-speed & constant-frequency power generation system and pitch-controlled adjusting model. We also have introduced the power generation technology development in our country and in Jiangsu province from 2010 to 2015.

**Index Terms:** Development of wind power generation; Constant-speed & constant frequency; Pitch-controlled adjusting; Jiangsu wind power

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## 1. INTRODUCTION

Wind power has been applied for thousands of years. Wind power was always used to mill corn, pump water and drive ship before the invention of steam engine. In these days, wind power can be used to generate power without any pollution. And the power can be transmitted to central power grid. Because wind power resource is very plentiful, and the wind power generation technology is very advanced, so the wind power price has great competitive power, and wind power has been used widely and rapidly in this world. In recent years, wind power generation equipment's average manufacture has been increased 30%. At the same time, wind power equipment's production has been realized industrialization and commercialization. [1]

## 2. Contemporary development of wind power generation technology

Wind power generation machine usually consists of vane, generator with transmission gear, phase modulator, tower, speed-restriction device and power storage equipment. Wind power generation has three operating models: The first model is independent operation, which consists of wind power generator and converter, storage battery. The generator is used to provide electrical power for one user or several users; the storage battery is used store

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power, which used when there is no wind. The second model is combined wind power operation. Expect the wind power generator, it has been equipped a set of spare generating system, such as diesel engine. The spare diesel engine is always used to provide electrical power when wind power is not strong enough to provide electrical power. The third model is that power grid operation. The electrical power from wind power generation system is transmitted by means of common power grid. Usually we use hundreds of wind power generators to realize it, and this kind of model is the main model of wind power generation.

In wind power generation system, generator is the core part of energy conversion. When generator is connected into power grid, we require that the wind power frequency should be same with power grid frequency, and this means that the wind power frequency should be constant. So, we can classify wind power generation system into Constant-speed & Constant-frequency generator system (CSCF system) and Variable-speed & Constant-frequency system (VSCF system) in accordance with the operation model of generator. CSCF system means that we can get the electrical power whose frequency is same with power grid frequency by maintaining the generator's constant speed during the process of wind power generating. CSCF system is usually very easy, and the accepted generator is always the synchronous generator or squirrel-cage generator.[2] The former generator is always dependant on motor's number of poles and frequency, and the latter is always operated at a higher rate than synchronous rotational speed. VSCF system means that the generator's rotational speed varies with wind speed during the process of wind power generating, and we should use other measures to get a constant-frequency electrical power whose frequency is same with power grid. We have mainly introduced these two kinds of generator systems in this paper.

#### A. CSCF generation system

At present, wind turbine whose power per unit is from 600 KW to 750KW always use CSCF system. This kind of turbine is easy to control, and it has good reliability. The turbine always accepts squirrel-cage asynchronous generator which is easy to produce and the excitation power can be acquired from power grid directly. Constant-speed wind power turbine usually has two kinds of types: stall-regulated generator and pitch-controlled generator.[3] The former type generator restricts vanes to absorb the redundant wind power by using the characteristics of aerodynamic performance. And the power adjusting is executed by means of vanes. This kind of generator is easy to control, but its vane structure is very complex and hard to produce. The latter type generator controls the output power by means of vane's pitch-controlled adjusting equipment. The squirrel-cage asynchronous generator has been used in these two types' systems, so the generator's rotational speed is dependant on power grid frequency. The rotational speed range of synchronous generator's rotor is very narrow, and the slip ratio is from 3% to 5%, so it belongs to CSCF wind power generator. CSCF generation system usually has three kinds of adjusting types.

- Stall-regulated model: The main characteristic of stall-regulated wind power generation turbine is that its vanes are connected with wheel boss. When the wind speed changes, the vane's windward angle is constant. Because of vanes' stalling characteristics, when the wind speed is higher than normal speed, the load angle of airflow will reduce efficiency, which restricts power. This kind of wind power generation system is easy to control. But its vanes are heavy, and it is very complex, and the whole efficiency is low. On the other hand, it must stop when wind speed reaches certain value.[4]
- Pitch-controlled model: In present, CSCF wind power generation system has been applied more. In order to maintain the constant rotational speed, the CSCF can be realized by means of electrical control when the wind variation is in normal range. But when wind speed is strong too much, the output power may cause electrical system and mechanical system to be worse, so we should control the output power. At this time, we should change airflow load angle by changing vanes' pitch, so the air turning effort of wind power generator can be changed. Because this kind of type turbine can make vane have better load angle when wind speed is low, so it is fit used in the areas whose average wind speed is low.[5]
- Initiative stalling adjusting: Initiative stalling adjusting is the combination of the former two kinds of power adjusting types. It combines those two kinds of types' advantages. In this system, the system output power can be optimized by using stalling characteristics and pitch-controlled adjusting. When the system meets the strong wind, the vane pitch angle adjusts toward stalling direction automatically, so the

output power will be restricted under the normal value. With the wind speed's variation continuously, the vanes only need to adjust a little. On the other hand, we can realize aerodynamic brake by adjusting vanes. This kind of system not only has aerodynamic performance, but also pitch-controlled adjusting. It has increased the whole system efficiency greatly. And it is easy to control, and the side effect which caused by mechanical brake is weak more. So the output power is very constant, and the power of executing equipment is relative small.

#### *B. VSCS generation system*

Depends on VSCS generation system, wind power turbine can operate at various speed. So the rotational speed of wind wheel can vary with wind speed, which makes it a constant. So we can get a constant and best tip speed ratio. This can make wind power coefficient be biggest in the whole operation range at the rate of normal speed. And we can acquire much more power than constant speed. On the other hand, this kind of conversion equipment can meet all kinds of areas, which widens the using area of wind power generation. Usually, there three kinds of control designs about wind power generation's various-speed & constant-frequency: VSCS wind power generation system with squirrel-cage sense generator, double-feed VSCS wind power generation system and direct-driving type VSCS wind power generation system.[6]

### **3. Development trend of wind power generation technology**

With the development of science & technology, more and more countries are paying attention to the new-type power technology. So, wind power generation has been gotten a rapid development, and it has been shown on broad prospects. In the future several years, the development trends of world wind power generation technology are mainly shown the following aspects:

#### *A. Large scale of wind power generation equipments*

Before 21 century, the main wind power turbine type in international wind power generation market had been increased from 50KW to 1500KW. With the development of wind power generation technology, wind power generation turbine is developing into large scale. At present, wind power turbine with power per-unit has been from 1MW to 3MW, and this has been the common wind power generation turbine. On the other hand, wind power generation turbine with 5MW turbine is being tested. The wind power generation turbine with 1MW has accounted for 74.9% of the total since 2004. Large scale wind power generation turbine has two kinds of types: land-type and ocean-type. Land-type wind power generation is mainly restricted in low-speed wind power generation. And the main turbine is the large scale turbine with 3MW, and it can provide electrical power for power grid. Offshore wind power generation is mainly used the ocean which is near from continent. And usually the large scale wind turbines whose powers are higher than 3MW are fixed here. This is convenient to construct large scale wind power generation factory. Now, this kind of wind power generation is playing more and more important role in wind power's development.

#### *B. The length of vanes can be adjusted*

With the increasing of wind wheel's diameter, wind power turbine can acquire more wind power. Usually, the wind wheel whose diameter is 40 meters is fit for the wind power turbine with 500 KW, while the wind wheel whose diameter is 80 meters is fit for the wind power turbine with 2.5MW. The wind wheel whose vane's length is longer than 80 meters has been applied successfully. And the longer the vane is, the more wind power can be acquired. Just like vane length, the design of vane is also very important to increase the usage of wind power. Now, many countries such as Denmark, America and Germany, many famous wind power equipment corporations are studying the technology about variable vane length by means of advanced equipments and technology conditions. This kind of technology can adjust the length of vane in accordance with wind conditions. When the wind speed is weak, the vane can be extended fully. This can produce electrical power farthest. With

the increasing of wind speed, the output electrical power will reach the normal power of wind power turbine. Once the wind speed is stronger than the normal value, the length of vane will be reduced. This can restrict the output electrical power efficiently. If the wind speed increases too much, the length of vane will be reduced the shortest. So the length of vane can varies with the wind speed contrarily. [7]

### C. Improvement of wind power turbine control technology

With the development of electrical power electronics technology, scientists have developed a kind of various-speed wind power turbine which has no heavy speed-increasing gearbox in recent years. It is connected with wind power turbine axis. The speed of rotor varies with wind speed, and its AC frequency also varies with wind speed. It converts AC with constant frequency into DC by means of high-power electrical converter which in on the ground. And then the DC will be converted AC whose frequency is same with power grid. Because it has been designed to acquire better aerodynamic performance at any wind conditions, its efficiency is very high. The test has shown that various-speed wind power turbine can acquire 15% more wind power than constant-speed wind turbine when the average wind speed is 6.7m/s. At the same time, because the whole weight has been reduced and the all parts of comments in transmission system has been improved, we can reduce the weight of wind power turbine's base, and the cost can be reduced, too. This kind of technology has wide application prospect.

### D. From land to ocean

Usually, ocean has plentiful wind power resources and wide and flat area, where the wind speeds is very strong. To a same wind power turbine, it can get 50% more electrical power when it is used on the ocean. With the development of wind power generation, the wind power turbines on the land have been saturated. So the wind power generation on ocean will be the emphasis in the future. Although the prophase capital in ocean wind power generation and operating & maintaining cost are very high, the scale of ocean wind power generation is very large. In order to build bigger wind power turbine on ocean, many large-scale wind power turbine factories are developing the turbine from 3MW to 5MW. Large-power wind power turbine is the trend in the future. Wind power generation in Europe

## 4. Wind power generation development in our country

The development of wind power generation in our country has started from small-scale wind power turbine since 1980s. In the past, we had mainly studied the turbines from 100W to 10KW. In the ninth five-year plan period, China had mainly studied the turbines about 600KW three-vane turbine, stalling-type turbine and double-speed-type turbine. And China had known the technology about vane, electrical control, generator and their equipments. At that time, China had grasped the whole design technology about wind power turbine. In the tenth five-year plan period, Science and Technology Department has mainly studied the stalling-speed wind power generation turbine, and it has succeeded. At present, the fixed pitch stalling-speed turbines with 600KW and 750KW have been applied widely in China. On the basis of these studies, 863 Program in China has sustained the studies about MW-level wind power generator and its key components. On the other hand, China also cooperates with many foreign advanced countries. The first sample wind power turbine with 1.2MW was tested in 2005, and about 25% of total technologies were developed by China itself. The second sample wind power turbine has been applied in 2006. Now, China has the technology about 1.2MW direct-driving permanent magnet wind turbine. China also can design the large-scale vane, electrical system, generator and some key comments.

Wind power equipment manufactures in China have studied the technology about MW-level wind power turbine since 2004. They also cooperate with many foreign advanced countries to develop wind power turbines. And China also imports some advanced and proven techniques from some advanced countries. After some years, many imported wind power turbine components have been designed and manufactured depend on us.[8]

Generally speaking, many corporations in China have owed the wind power turbine technologies including stalling-speed type, direct-driving permanent magnetic type and double-feedback type. All kinds of MW-level

wind power turbines have been applied since 2007. But, the control system about MW-level wind power turbine is still dependant on import.

In recent years, the development of wind power generation has driven some other equipment's development. With the support of national policy and plentiful wind power resources, China has been the active place about wind power industrial investment.[9] Many international wind power equipment manufactures have invested in China, such as Gamesa and Vestas Corporations.

With the development of wind power technology, China has been formed a large-scale wind power equipment manufacture. Many technologies and components can be produced by us. In those corporations, there are some large-scale corporations, such as Jinfeng, Huarui and Xiangdian.

In the past many years, the government of China always pays attention to the development of wind power generation. With the study ability's increasing, China no longer requires that some technologies about wind power generation must be produced by us. So, many wind power equipments corporations' production structure can be optimized. And it strengthens these corporations to develop orderly.

China is being in a good environment which developing wind power generation. This requires that we need plenty of equipments. Except for the whole wind power turbines, the components such as vanes, peed-increasing gearbox, electrical-control, and so on are still not sustain the increasing requirements. So, the manufacture of China wind power equipments has good application prospect.

## **5. Wind power technology development in Jiangsu from 2010 to 2015**

Jiangsu province is the earliest area which using wind power in China. Jiangsu province has plentiful wind power resources which is about 2380 thousand KW. Jiangsu province has long beach, which is the ideal place to build large-scale ocean wind power generation factory.

Jiangsu province has been paid attention to the development of wind power resource since 21 century. They have studied the wind power resources' storage, distribution and development, and have programmed a set of subjects about wind power generation. In 2006, the wind turbine with 150 thousand KW wind power generation factory has been built in Rudong county Jiangsu province. From that time, many counties in Jiangsu province have built other wind power factories. And now, ocean wind power factory corridor has been the infant industry in Jiangsu province.[10]

In 2010, China started an invite public bidding about ocean wind power generation. And there are four areas in Jiangsu province were chosen to build wind power generation factory. The wind power industry in Jiangsu province is facing new opportunities for development and new challenges.

## **6. Conclusions**

Many power factories in Jiangsu province are coal-fired power plants, whose structure is single. But the ability of producing coal is very limited, and the power plants need 80% of total coal from other provinces. So the cost is very high. On the other hand, Jiangsu province almost hasn't any water resources to generate power, and the nuclear power is much cost. So, it is important to develop wind power generation in Jiangsu province, which is helpful to adjust energy structure in Jiangsu province. And this is convenient to develop many other industrial productions, such as making wind turbines, wind power generation, salt chemical industry, metallurgy industry and metal processing industry. And this will forms particular green energy using in Yangtze River Delta Area.

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