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# Kickoff of Offshore Wind Power in China: Playoffs for China Wind Power Development

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**Abstract**

Year 2010 is the significant year of offshore wind power development in China. The first national offshore wind power project is connected to the grid, and the first round of concession projects marks the strong support from central government. It is foreseeable that offshore wind power capacity in China will expand rapidly in the future, and the understanding pattern of it is crucial for analyzing the overall wind market in China and global offshore wind power development. This paper firstly provides an overview of global offshore wind power development, then in China, including historical installation, potential of resources, demonstration and concession projects, and target of development. Based on this, analysis on current policies related to offshore wind power and their implementation, current wind farm developers and turbine manufacturers of China's offshore wind industry is done. All the previous analysis generates complete evaluation of current status and some issues and trends of China offshore wind power development, based on which some policy recommendations for sustainable development of offshore wind power are made.



*Keywords* :Offshore wind power; China; policy

## 1. Introduction

After dramatic growth of onshore wind power from first round of concession in 2003, China has also initiated the first round of national-level offshore wind farm concession projects in 2010. Taking incredible increase from 567 MW in 2003 to nearly 13,803 MW in 2009 after concession as a benchmark [1], it is foreseeable that offshore wind power development in China will boom dramatically in the future. This kickoff of offshore wind power is based on the strong support on wind power development from China government in order to cope with the increasing concern of energy security and climate change.

China has become the world second largest energy consumer, and IEA predicted that its primary energy demand will double from 2005 to 2030 [2], while the energy resources per capita in China is much smaller than the world average level [3]. Therefore, import dependence of energy keeps increasing. With regard to crude oil, proportion of import has grown from 42.9% in 2005 to 48.3% in 2008 [4], which has severely influenced the sustainable growth of China's economy.

Also, China has made strong commitment of emission reduction, which forces carbon intensity in 2020 a 40%-45% decline with baseline of 2005 [5]. President Hu Jintao has clearly stated that stimulating non-fossil energy to 15% of primary energy consumption in 2020 is a key pathway of achieving the reduction objectives [6].

Since wind power is one of the most mature and economical renewable energy technologies, China has successfully encouraged onshore wind power development in recent years. Considering premium space is becoming scarce for the installation of onshore wind turbines, offshore wind energy is getting more and more attractive due to the several advantages – vast deploying area, higher speed and more stable wind, closing to load center, and so on. Besides, Chinese wind power manufacturers have developed their capabilities rapidly in recent years with onshore wind development, and have significantly narrowed the gap between these capabilities and those of leading international suppliers, which also makes China ready for offshore wind power leap.

This paper is structured as follows: in Section 2, we first provide a brief overview of the development of the global offshore wind power. Section 3 continues with an overview of current offshore wind power status in China from

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perspectives of potential for offshore wind energy, existing projects. Section 4 details planning and policies for China's offshore wind power. Section 5 focuses on the situation of the manufacturers of China wind power industry. In section 6, we discuss several issues and trends of offshore wind development in China, such as size and quality of offshore turbine. Section 7 concludes the paper

## 2. Global status of offshore wind energy

The first offshore wind turbine of the world was installed in 1990 in Sweden Nogersund. In the following 20 years, Denmark, Sweden, the Netherlands and the UK have built a number of demonstration offshore wind power projects which were mainly funded by the Government and research institutions. The complete of Horns Rev 160MW offshore wind power project in 2002 in Denmark marks the offshore wind power has stepped to a new stage. The project greatly enlarged the size of the project, before when, the largest offshore wind power project scale was only 40MW. After that, Denmark, the UK, and other European countries have developed a number of projects. At the end of 2006, Europe had the operating wind farms in Denmark (398 MW), UK (304 MW), Ireland (25 MW), Sweden (23.3 MW) and the Netherlands (136 MW). It accounted 1.8% of the installed wind energy, but 3.3% of the wind energy production [7]. In last few years, there was about 150MW increase of global offshore wind power installations annually, and the average growth rate is 58% from 2000 to 2007 [8]. By Jan 2009, the world had got 1,470MW wind power installed, all of which is in Europe. Figure 1 shows the growth trend of world offshore wind installation in the new century.

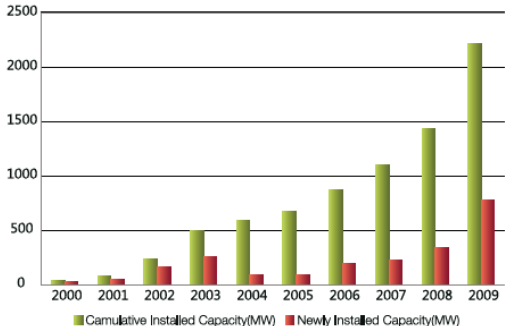


Figure 1. Global offshore wind installation growth from 2000 to 2009 [1].

In February 2007, European member states made a commitment to increase the total share of renewables in primary energy consumption to 20% by 2020 [9]. It has been estimated that the cumulative installed offshore wind power will reach 4,000MW by the end of 2011 [10]. However, offshore wind energy development is taken stably and steadily in Europe, mainly because the cost of offshore wind does not show an obvious decline, which is shown in Figure 2.

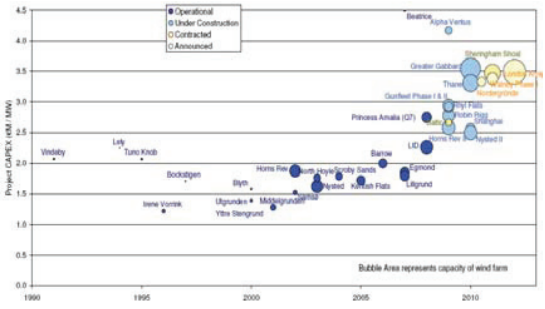


Figure 2. Historical CAPEX of Offshore wind projects in Europe [11].

Beside Europe, North America is still at the planning stage by the year 2008, despite the great potential of 907 GW within a 50 nautical miles limit.

## 3. Overview of china offshore wind energy

### *3.1. Potential for offshore wind energy*

China has relative abundant wind energy resources because of its location at the monsoon zone. With the advantage of long and winding coastal line, regions in the south-east coast and nearby islands including Shanghai and the provinces of Shandong, Jiangsu, Zhejiang, Fujian, Guangdong, Guangxi and Hainan have great potential to develop offshore wind power. The annual wind power density reaches above 200 W/m$^2$ within the areas 10 km from the coast, and over 500 W/m$^2$ on the adjacent islands, such as Tai Mountain, Pingtan, Dongshan, Nanlu, Dachen, Shengsi, Nanao, Mazu, Magong and Dongsha [12].

There are several analysis assessing the potential of China offshore wind energy. A long-standing 'preliminary' assessment carried out by China Meteorological Administration at the beginning of 21st century indicates that offshore (water depths less than 20 meters) wind power had 750 GW which is as large as 3 times of the onshore (250GW). However, at the end of 2009, China Meteorological Administration released a new wind assessment, based on measurements at 50m height. This showed that China has a potential to develop 2,380 GW of class 3 wind power (avg. wind power density >300 W/m2) and 1,130 GW for class 4 (average wind power density >400W/m2), while the offshore potential (water depth 5-25m) reaches 200 GW for class 3 [13]. Another research carried out by the UNEP in cooperation with the US National Renewable Energy Laboratory (NREL), calculated the exploitable onshore wind resource of 1400GW (at 50m height) and 600 GW of the offshore [14].

Although with downgraded expectations for China's offshore wind market, and the less cost to develop onshore wind farm, there is still a major opportunity for the country to power up its coastal regions from turbines at sea. As AMSC's Poor says, there is a "tremendous opportunity"-- "What we see from our perspective is that they are pursuing the offshore market very strongly. Whether (the potential) is 750GW, 600GW or 250GW, it's going to be a very significant part of the overall wind market in China going forward. [15]"

### *3.2. Existing offshore wind power projects*

The first pilot offshore wind power project in China is one 1.5MW wind turbine installed upon jacket at the Suizhong 36-1 oil field in Bohai Bay, being linked to the national grid in November 2007 [16]. However, the first commercial offshore wind project -- the 102 MW Shanghai Donghai Bridge wind farm, which is consisted of 34 Sinovel (3 MW) turbines off Shanghai's coast, has not been operated until 2010. This project is specially designed for World Expo 2010 in Shanghai with strong political objective, and all the 34 turbines are connected to the grid in June [17]. Three months later, the world first inter-tidal wind farm – Rudong offshore wind project is accomplished by Longyuan Group. This project is an important trial for inter-tidal wind turbine installation. Longyuan Group has successfully installed 16 turbines from 9 domestic manufacturers with total capacity of 32MW. There are six 1.5 MW turbines, two 2.5 MW turbines, and two 3.0 MW turbines, all of which have been connected to grid by the end of September [18].

More importantly, in May 2010, the first round of concession projects was started. There are four projects with total capacity of 1GW in this round, and all of them are located in Jiangsu Province -- two offshore projects in Binhai and Sheyang with 300MW capacity respectively and two inter tidal projects in Dafeng and Dongtai with 200 MW capacity respectively. In October, the concession result was revealed. All the developers and manufacturers are domestic players. Another notable phenomenon is that all the bidding prices for these projects offered by the successful bidder – about 0.7 RMB - are much lower than expected –0.9 RMB at least, which is estimated by China Hydro Consultant Group [19].

## 4. Planning and policies for offshore wind development in China

### *4.1. Planning*

Mainland China has 11 provinces and municipal cities with coastal lines, which is shown in Figure 3.


Figure 3. Coastal provinces and municipal cities of China

In April 2009, the National Energy Administration (NEA) required each coastal province to formulate a provincial offshore wind development plan which clarifies potential offshore wind farm with the scale about 1000MW, and divided China's potential offshore wind sites into three categories, according to the depth of water: an 'inter-tidal' zone for water depth of less than 5 m; an 'offshore' zone for water depth of 5-50 m; and a 'deep sea' zone deeper than 50 m. The provincial governments were required to draft offshore development plans for 'inter-tidal' and 'offshore' wind development up to 2020 [20]. Before 2009, some provinces already formulated planning for offshore wind farms, shown in Table I.

TABLE I. PLANNING OF OFFSHORE WIND POWER OF COASTAL PROVINCES IN CHINA IN 2008 [21]

| [illegible] | | [illegible] | [illegible] |
|---|---|---|---|
| Hebei | Cangzhou | 50,000 KW | 100 |
| Shandong | Weihai | | 110 |
| | Qingdao | | 150 |
| Jiangsu | Xiangshui | | 100 |
| | Lianyungang | | 200 |
| | Rudong | | 250 |
| Shanghai | Donghai Bridge | 100,000 KW | |
| | Fengxian | | 40 |
| | Nanhui | | 40 |
| | Hengsha | | 20 |
| Zhejiang | Cixi | | 150 |
| | Daishan | | 50 |
| | Linhai | | 20 |
| Fujian | Hu'ao | | 20 |
| | Nan'ao | | 30 |
| Guangdong | Jiahua Bay of Lufeng | | 125 |
| | Dongshan Sea | | 268 |
| Hainan | Floating Wind Farm | 20,000 KW | 100 |
| Total | | 170,000 KW | 1710 |

However, planning in China has always been surpassed, and the growth of wind power is often beyond expectation, forcing Chinese authorities to conduct a series of revisions of their medium-term targets for total installed wind power capacity. In the early of 2010, there even exists study doubting whether the 100 GW for 2020 target can be achieved [22], however, after then, among various perditions in China, even the most conservative one for 2020 has total installed wind power capacity prediction more than 150 GW [23,24,25]. Analogous to this, there is also great possibility that the offshore power planning surpasses the planned capacity in the future.

### *4.2. Policies*

*1) General wind power policies*

The Renewable Energy Law in 2005 is the first national renewable energy law. It gave huge momentum to the development of renewable energy and the wind power has grown at a frantic pace since then. In 2007, the first implementation rules for the Renewable Energy Law emerged, offering further impetus to wind energy development [20].

An amendment to China's Renewable Energy Law was introduced in 2009. Reiterating priority grid access for wind farms, it was a stipulation which had previously not been enforced. The amendment raised the Renewable Energy Premium in November 2009 to 0.004RMB/kWh, and established Renewable Energy Fund to cover the extra cost for integrating renewable energy. Also, feed-in-tariff regulation took places of two parallel systems, with a concession process on the one hand, and the project-by-project "government approval" process on the other. There are four

different categories of tariff depending on a region's wind resources, ranging from 0.51RMB/kWh to 0.61RMB/kWh, which gave investors a much more clear idea of the long-term framework for the sector [20].

Relevant Provisions for the Administration of the Generation of Electricity Using Renewable Energy Resources issued by National Development and Reform Commission (NDRC) in 2006 has clarified approval right of central and provincial government. Wind projects larger than 50 MW are authorized under a concession process managed by the NDRC, while smaller projects are managed by Provincial Development and Reform Commission. Concessions are allocated typically for a 25-year period in regions preselected. Provincial grid companies are required to sign a power purchase agreement (PPA) with successful bidders. The price at which electricity is delivered to the grid is fixed during an initial period, typically about 10 years, at a level set during the initial bidding process. The price in subsequent years is expected to adjust to the prevailing electricity market price in the region served by the grid [26].

Investments in renewable energy benefit from favorable treatment both in terms of obligations for value added tax (VAT) and enterprise income tax (EIT). Before 2009, to promote wind energy projects in China, VAT for wind power has been reduced from 17% to 8.5% and the income tax has been reduced from 33% to 15% [27].

*2) Specific policies for offshore wind power*

Issued in February 2010, by National Energy Bureau and National Marine Bureau, Interim Measure of Development and Construction of Offshore Wind Power is considered as guidelines for offshore wind power development. This measure has made clear regulations for overall planning of offshore wind power and construction of specific wind power project. Every coastal province should formulate planning for the development of offshore wind power under the guidance of National Energy Bureau and National Marine Bureau. For one specific wind power project, provincial government is responsible for drafting the application materials. When approved by National Energy Bureau and National Marine Bureau, concession process starts to select company. Company which has rights to invest and develop the project should be local or joint-owned that China holds the controlling share. Moreover, the construction and operation of the project should be also under the guidance of these two authorities.

To improve the efficient competition of wind power equipment manufacturing industry, Ministry of Industry and Information Technology (MITT) drafted Access Standard of Wind Power Equipment Manufacturing Industry for the integration of this industry. This draft was issued in March, 2010, and key regulations for manufacturers are listed as follows:

For the initial investment, this standard requires that equity proportion of initial investment of wind power project should be no less than 30%. This is considered as a solution for the "overcapacity" situation of wind power investment;

For the location, this standard requires manufacturers locate their factories near the "wind base" and upstream suppliers to reduce the logistics cost;

For production capacity, this standard requires that manufacturer must have the production capacity of 2.5 MW or more independently, and annual production more than 1 million kilowatts;

For R&D, the standard requires that manufacturer should give priority to development of independent intellectual property rights of wind turbine with unit capacity of 2.5 megawatts or more and development of offshore wind power equipments.

If issued formally, this standard will greatly influence the offshore wind power industry.

## 5. Manufacturers of wind power industry in China

Offshore wind power equipments have more strict requirements. Therefore, there is few player which masters mature products in this area now. In the world market, Vestas and Siemens are leading companies, and they take the major share of the offshore wind power equipment market shown in Figure 4.

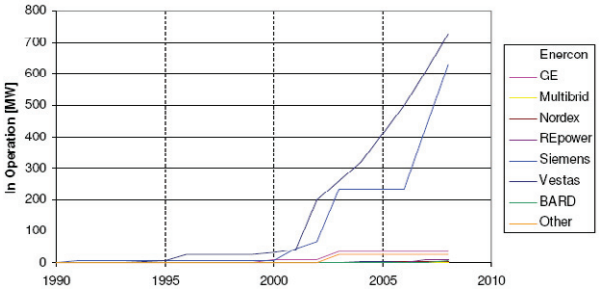


Figure 4. World offshore wind power market shares [11]

Since offshore wind power market in China has just been initiated, here we just take a brief review of Chinese manufacturers and qualified players in the future according to the standard drafted by MITT.

Chinese manufacturers have developed quite fast in recent years. In 2007, the market share held by Chinese manufacturers was 56% of the total new installations in 2007 [27]. By the end of 2009, there were almost 80 wind turbine manufacturers, 30 of which had actually already sold wind turbines. Already now, the three largest domestic manufacturers (Sinovel, Goldwind and Dongfang) have a combined production capacity of 8.2 GW for an annual market of 13.8 GW. Table II shows main types and production capacity of top 10 manufacturers in China by the end of 2009.

TABLE II. MAIN TYPES AND PRODUCTION CAPACITY OF TOP 10 MANUFACTURERS IN CHINA [28]

| Manufacturer | Turbine Type (MW) | Annual Production(MW) | Technology Source |
|---|---|---|---|
| Sinovel | 1.5/3/5 | 3000 | 1.5 MW: Introduced from Fuhrlander<br>3.0/5.0 MW: Introduced from Windtec |
| Goldwind | 0.6/0.75/ 1.5/2.5 | 2200 | 0.6MW: Introduced from REPower<br>0.75MW: Introduced from Jacobs<br>1.5/2.5MW: Introduced from Vensys |
| XEMC | 1.5/2/5 | 2100 | 1.5/2MW: Introduced from TMPA<br>5MW: Introduced from Darwind |
| Dongfang | 1.5/2.5/3 | 2000 | 3MW: Introduced from Moventas |
| Guodian | 1.5/3 | 1000 | 1.5MW: Co-designed with Aerodyn |
| Zhongchuan | 0.85/2 | 1000 | 0.85MW: Introduced from Frisia<br>2MW: Co-designed with Aerodyn |
| Mingyang | 1.5/3 | 1000 | 1.5MW: Co-designed with Aerodyn |
| Suzlon | 1.25/1.5 | 900 | Independent R&D |
| Vestas | 0.85/2.0 | 800 | Independent R&D |
| Huayi | 0.75/1.5 | 800 | 0.78MW: Independent R&D<br>1.5MW: Co-designed with Aerodyn |

Since the drafted standard by MITT requires manufacturers for offshore wind power have production capacity of 2.5 MW or more independently, and annual production more than 1 million kilowatts. Only less than 10 manufactures in China are qualified according to the access standard. This standard will diminish the opportunity to enter the offshore wind market for small manufacturers, and qualified manufacturers will be selected from the top 10 manufacturers mentioned above. By the end of 2009, manufacturers that can produce wind turbine with capacity larger than 2 MW are Goldwind, Sinovel, Dongfang, Shanghai, Zhongchuan, Mingyang, and Vestas in China. Some other manufacturers, such as Siemens, Shanghai Electric and Shenhua Group, XEMC, CSIC, United Power, and Yinhe Avantis Corporation, are busy developing prototypes of large-scale wind turbine. It is foreseeable that the competence of offshore wind power equipment market is intensive although players are much fewer than onshore.

## 6. Issues and trends of offshore wind development in china

### *6.1. Bigger turbine?*

Due to the higher cost of installation and smaller importance of visual impact, most manufacturers in China are interested in developing bigger turbine for offshore wind. Goldwind is developing 6 MW direct-drive offshore turbine. Sinovel and Dongfang, are also working on designs for 5 MW offshore units, and it is certain they also have plans for larger machines further down the line.

However, bigger is not necessarily better. From turbine perspective, as was recently discussed by Moe, increasing mass of turbine, higher cost of gearbox, and other reasons such as learning effect have made bigger turbine not as efficient as designed [29]. From grid connection perspective, due to lack of offshore power management, larger size of turbine may increase the difficulty for grid connection [15].

### *6.2. Turbine quality*

Comparing with onshore wind turbine, offshore wind turbine should have better quality and reliability to avoid repair and maintenance. That is why European countries are very careful to develop offshore wind, and the cost of offshore turbine has not been reduced in recent years [11]. In China, the installation capacity is sky-rocketing, and it is rather fast to develop offshore wind energy just not long after large-scale installation of onshore wind. Therefore, higher risk may exist. In 2010, several accidents caused by wind turbine have already warned the fast growing industry [30, 31, 32, 33].

## 7. Conclusion

Offshore wind energy is booming in China together with steady growth around the world. Unlike European countries which have almost already finished onshore wind development, and have to accelerate offshore wind

development, there is still huge potential for China to develop onshore wind. Also, China has some unique advantages and challenges for offshore wind energy development. Therefore, more caution is needed when talking about offshore development in China.

Offshore wind is now at the initial stage. The coming years are playoffs for the China wind power development which is still far from the vision of significant supplement to energy mix. Such a market currently shows no commercial capacity. China needs to carefully formulate planning, summarize experience of demonstration projects, and see how the four pilot projects go before it makes any further decisions about further concession.

With the pace of offshore energy development, capacities of China's wind power industry have been greatly enhanced. Utilizing multiple mechanisms of technology transfer and development, Chinese manufacturers have preliminarily mastered offshore wind power technologies. To narrow the gap between the most advanced turbine, upgraded capacity of material processing is still needed. Moreover, China should pay more efforts in the size and quality of turbine.

Generally, the development of China offshore wind power will follow a more expedient mode, based on the onshore experiences, which will pave the way for the offshore market to rapidly unlock the massive offshore wind resources existing around the county.

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