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CHINA WIND POWER REPORT

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China Wind Power Report · 2007

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Preface

Wind power is sustainable and clean energy. Compared with conventional energy, generating electricity from the wind does not need fuel; hence there is no risk of a fuel price rise. There are no environmental costs, such as carbon emissions, in the generation process. Wind power has the added advantage that it is widely available worldwide.

In many countries wind power has become a major part of their plans for sustainable development. According to the Global Wind Energy Council, the wind industry has been expanding at an annual growth rate of 28% over the past ten years. Global cumulative installed capacity has reached 74GW and the level of annual investment about €18 billion. In 2006, wind power investment in China was RMB 16.27 billion yuan, accounting for 9% of the global total. If its growth rate is maintained, China could become the largest wind market in the world.

China is rich in wind resources. The technically exploitable resource is 1,000GW, distributed across the southeast coastal areas, adjacent islands, Inner Mongolia, Xinjiang, the Gansu Hexi Corridor, Huabei and the Qinghai-Tibetan Plateau.

China has chosen wind power as an important alternative source in order to rebalance the energy mix, combat global warming and ensure energy security. Supportive measures have been introduced. In order to encourage technical innovation, market expansion and commercialisation, development targets have been established for 2010 and 2020, concession projects offered and policies introduced to encourage domestic production.

By the end of 2006, cumulative installed wind capacity had reached 2.6GW; the average annual growth rate over the past ten years has been 46%. Between 2004 and 2006, China's ranking in the world wind energy league moved up from the top 10 to the top 6, and the country is planning to host some of the biggest wind farms in the world. At the present growth rate, the 2010 target will be reached two years earlier. Wind power has not just contributed to supplying electricity but has lowered supply costs, reduced carbon emissions and helped to limit air pollution.

The growing wind power market has encouraged domestic production of wind turbines. By the end of 2006 there were more than 40 companies involved in manufacture. Domestic products accounted for 41.3% of the annual market in 2006, an increase of ten percentage points. During the construction of more than 100 wind farms, a lot of experience and expertise has been gained in construction and operation. This is fundamental for the future development of wind power. Although grid-connected wind power is the current area of development in China, the off-grid market is the largest in the world, particularly for rural electrification.

The year 2007 is a key point in the growth of the wind industry in China. After one year's operation of the Renewable Energy Law, a number of problems for wind development need to be solved urgently. This report analyses the development of China's wind industry and the implementation of national policies, points out the challenges to be met and makes a realistic prediction of the wind market in the future. It therefore provides valuable information for both policy makers and the business community.

The report has been compiled by the Chinese Renewable Energy Industry Association with the support of Greenpeace and the Global Wind Energy Council. Sincere thanks go to the following experts, companies and institutions for their contributions: the Energy Research Institute, the China Hydropower Engineering Consulting Group, the Chinese Wind Energy Association and the Solar and Wind Energy Resource Assessment Programme.

Contents

1 Resources and Development Potential

1.1 China's wind energy resource

Throughout China's vast land mass and long coastline there is a rich resource of wind energy with great development potential. In the late 1980s and during 2004–2005, the National Meteorological Bureau conducted the second and third general investigations of the resource, concluding that at 10 metres height above ground, the theoretically exploitable wind resource was 3,226GW and 4,350GW respectively, and the technically exploitable wind resource 253GW and 297GW. In addition, the United Nations Environment Programme (UNEP) organised an evaluation of the wind energy resource in China by using a data modeling method. This concluded that at 50m above ground level the technically exploitable wind energy resource would reach 1,400GW. In 2006, the National Climate Center also applied a data modeling method to assess the wind energy resource in China, concluding that at 10 m height above ground level, and without taking into account the Qinghai–Tibet Plateau, the technically exploitable wind energy resource is about 2,548GW. This is much larger than the outcome of the third general investigation①.

According to the results of the third general investigation, the technically exploitable land area (with a wind power intensity of over 150W/m^2) is approximately 200,000km^2. Taking a ratio of 3–5MW/km^2, the resulting exploitable wind power capacity would be 600–1,000GW. According to the Report on Coastal Resources, there is a further 157,000 km^2 of coastal areas round China where the water depth is 0–20m. In 2002, a National Plan on Ocean Usage was published, which designated areas suitable for shipping, fishing, entertainment and industrial uses. Taking this into account, if wind power can be realised at a density of 5MW/km^2 over 10%–20% of the ocean area, then the installed capacity of offshore wind power could reach 100–200GW. In summary, there is a huge wind power potential in China, of around 700–1,200GW, which could play a significant role in the country's future energy supply.

The richest wind energy resources are distributed along the south–eastern coastal areas and its adjacent islands as well as in the north (north–east, north and north–west China). There are also some parts of inland China that are rich in wind resources, as well as off–shore.

1. The most abundant wind resources along the coast and islands include the provinces of Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Guangxi and Hainan. Areas within 10 km of the coast have an annual wind power density above 200W/m^2.

2. The most abundant wind resources in the north include Heilongjiang,Jilin,Liaoning, Hebei, Inner Mongolia, Gansu, Ningxia and Xinjiang; this area is about 200km wide. The wind power density ranges from 200W/m^2 up to 300 W/m^2 and sometimes even reaches above 500W/m^2, for example in the Ala mountains, Dabancheng, Huitengxile, Huitengliang of Xilinhaote and the Chengde hunting grounds.

3. In inland regions outside the two areas described above, the general wind power density is below 100W/m^2. In some areas located influenced by lakes or other special geographic conditions, the wind resources can also be considerable.

4. The most abundant wind resources off–shore can be found in vast areas along the eastern coast with a water depth of 5–20 metres. Because it is limited by other factors, the technically exploitable potential in off–shore areas is still less than on land. In some areas, however, such as Jiangsu, Fujian, Shandong and Guangdong, there is a large off–shore resource located close to centres of power demand. With the development of off–shore wind

① China Meteorology Bureau. China Wind Resource Assessment Report. December 2006.

technology and improvements in its economic viability, these areas will play an important role in the future.

1.2 Supply and demand

China's wind and hydro resources complement each other in their seasonal variation. The wind resource is abundant in the spring, autumn and winter but poor in summer. The hydro resource is abundant in the summer. In south China, the rainy season is from March to June or April to July, during which time the rainfall accounts for 50%–60% of the annual total. In north China, the average rainfall is much less than in the south, with winter as the dry and summer as the rainy season. This perfect match between the wind and hydro resources will enable large scale wind power development to compensate for the lack of electricity generation from hydro–power in the spring and winter.

However, the geographical distribution of the wind resource does not fit well with the country's power load profile. Coastal regions with a large power load have fewer areas with rich wind resources than the northern areas with abundant wind resources but relatively smaller demand. This creates difficulties for the economic development of wind power. As most of the areas with abundant wind resources are far away from the power load centres, and the grid network is relatively weak, grid reinforcement is needed to support the development of large scale wind power.

2 Present Status of Development

2.1 Development of grid–connected wind farms

Grid–connected wind power started to develop in the 1980s, but grew rapidly during the 10th Five–year Plan, with total installed capacity increasing from 350MW in 2000 to 2,600MW in 2006. The average growth rate during this period was nearly 40%. In 2006 alone, the growth rate was 105%. The installed capacity of wind power in China enabled the country to move from No.10 in the world to No.6 by the end of 2006①.

There have been three stages in the development of grid–connected wind farms②:

In the initial demonstration period (1986–1993), the main activity was to build small–scale demonstration wind farms by utilising grants from foreign donor countries and loans. Support from the government was mainly in terms of financial backing, such as investment in wind farm projects or in the development of wind turbines.

In the industrialisation period (1994–2003), the former Ministry of Electric Power proposed a wind power industrialisation programme, including the early stages of wind farm construction, at a "National Wind Power Work Meeting" in 1993. The following year it was decided that the grid utility should facilitate the connection of wind farms to the nearest grid and all the electricity generated by wind farms should be purchased. The grid tariff would be calculated as the sum of power generation costs, loan payments and a reasonable profit. The difference between the wind electricity price and the average electricity price would be shared across the whole grid, with the power company responsible for purchase of the electricity. As the security of investors was guaranteed, development of wind farms started through loans. Later, the State Planning Commission laid down that the average electricity price for wind power should be calculated according to the operational period of the turbines and the loan payment period extended over 15 years. In addition, value–added tax was reduced by half to 8.5% for wind power projects. However, with the reform of the electricity supply system and its transformation into a competitive market, the wind power industry developed slowly due to its high cost and vague policy support.

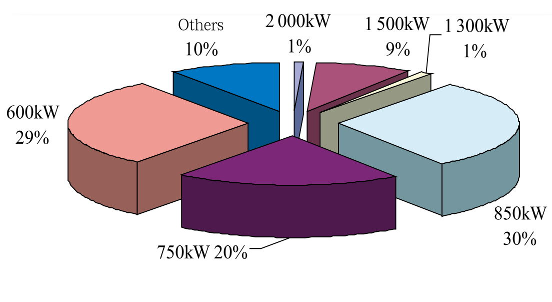
In the scaling–up and domestic production period (2003–2007), the National Development & Reform Commission aimed to commercialise the wind industry by initiating a wind power concession programme in 2003, since when it has been held annually. Under this the investors and developers of wind power projects are selected through bidding, with the aim to expand the rate of development and improve the manufacturing capacity of domestically made parts on the one hand, and to lower power generation costs and reduce electricity prices on the other. A Renewable Energy Law was introduced in 2006 which, together with other measures such as a pricing policy, obligation on grid companies to purchase renewable electricity, and cost distribution, has boosted the development of renewable energy in China. As a result the wind industry has move into a rapid growth phase.

2.2 Installed capacity of wind power③

By the end of 2006, the number of wind turbines installed in China amounted to 3,311 units, of which 366 were of 1MW capacity or above, accounting for 11% (Figure 1). With a total installed capacity of 2,600MW. There were 100 wind farms distributed across 16 provinces (Table 1). Compared to the cumulative capacity of 1,260MW at the end of 2005, the growth rate in 2006 was 105% (see Figure 2). The estimated output of grid–connected wind power in 2006 was 3,860GWh (calculated as the cumulative

① Global Wind Energy Council. Global Wind Energy Development Report. 2006.
② Li Junfeng, et al. Study of China Wind Power Price Policy. 2006.
③ Shi Pengfei. Statistics of Installed Capacity of Wind Power in China. May 2007.

Figure 1 Turbine capacity types installed at end of 2006



installed capacity at the end of the previous year plus 50% of the installed capacity of the current year and the average equivalent full load hours of 2,000), an increase of 2,200GWh[①] in a single year.

In 2006, without taking into account the regions of Hong Kong, Macao and Taiwan, there were 1,454 newly installed wind turbines with a capacity of 1,337MW in 2006, which is more than the total commissioned over the past 20 years. Among these, 263 were MW or larger capacity wind turbines, accounting for 18% of the new installations. Compared to the newly installed capacity of 503MW in 2005, the year–on–year growth rate reached 166% in 2006.

Although the majority of turbines in China are still 600kW, 750kW and 850kW capacity (see Figure 1), accounting for 80% of installed units and 75% of installed capacity, the trend in the future will be towards MW models.

There were no major changes in the installed capacity distribution by province, but the gap between them was enlarged. The installed capacity in Inner Mongolia exceeded 500MW, accounting for one fifth of the total, followed by Hebei, Jilin, Liaoning, Guangdong and Xinjiang with installed capacities over 200MW. The number of provinces with over 100MW increased from 7 in 2005 to 11 in 2006. Heilongjiang, Shandong, Gansu and Jiangsu are among those with a cumulative installed capacity of 100MW.

In terms of turbine manufacture, the market share for domestic manufacturers increased in 2006 to 45% (including joint ventures), among which Jinjiang Gold Wind had the biggest share, with 33% of the total newly installed capacity and 80% domestic output. Foreign manufacturers shared 55%, among which Vestas of Denmark, Gamesa of Spain and GE of the US took the biggest share, with together 50% of the total newly installed capacity and over 90% of the foreign share.

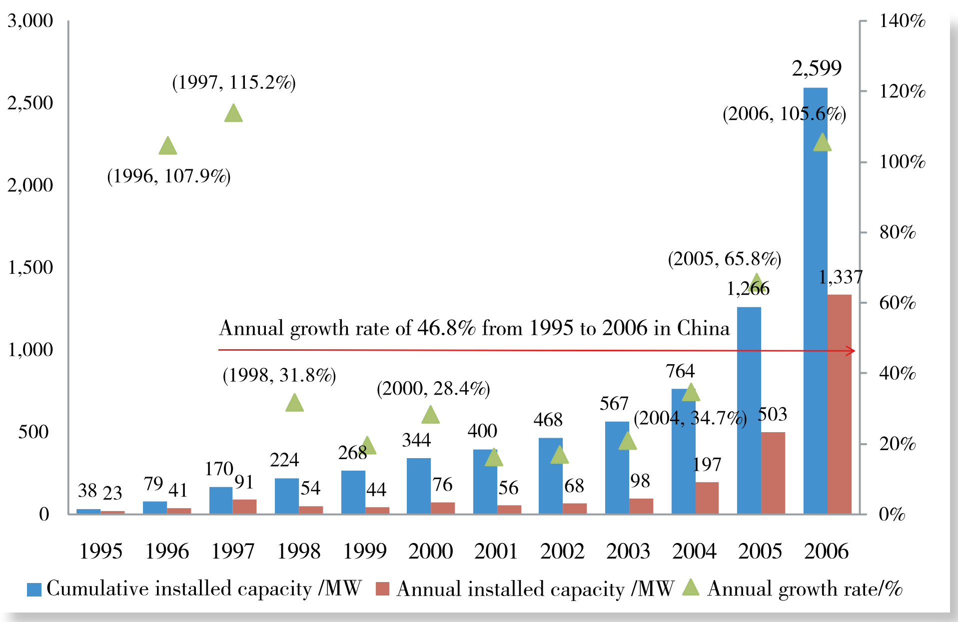
Table 1 Installed capacity of wind power by province in 2006

No.	Province	Units	Installed capacity /kW	No.	Province	Units	Installed capacity /kW
1	Hebei	343	325,750	9	Fujian	90	88,750
2	Inner Mongolia	668	508,890	10	Shandong	161	144,600
3	Liaoning	334	232,260	11	Guangdong	377	211,140
4	Jilin	303	252,710	12	Hainan	18	8,700
5	Heilongjiang	186	165,750	13	Gansu	163	127,750
6	Shanghai	18	24,400	14	Ningxia	195	159,450
7	Jiangsu	68	108,000	15	Xinjiang	329	206,610
8	Zhejiang	57	33,250	16	Hongkong	1	800
China (without Taiwan)						3,311	2,598,810

Source: Shi Pengfei, Statistics of wind power installed capacity in China, May, 2007.

① Calculated as the sum of cumulative installed capacity of last year and 50% of the increased this year; full–loaded operation period is 2000 hours.

Figure 2 Cumulative and annual installed capacity of wind power 1995–2006



2.3 Wind power development and the Concession Programme

In order to increase the scale of development of the wind power industry, the Chinese government conducted four rounds of wind concession tendering programmes during the period of 2003–2006. Eleven projects were approved, with an installed capacity of 2.45GW. All the projects have started construction, while only 650MW have been completed, accounting for 25%. It is expected that they will be fully completed by 2009.

The four rounds of concession tendering solved some of the major problems that had hindered the development of wind power before 2002. The programme clearly regulated that wind power does not participate in power market competition; the government promised a fixed price for a specific amount of electricity generated (30,000 full load hours); the grid company is obliged to purchase all the electricity generated by wind power; the difference between the wind power price and the conventional power price is shared among the provincial grids; the grid company is responsible for investment in the construction of transmission lines and the connection between wind farms and the nearest network; and local government is responsible for construction of road access to the wind farms as well as coordination of some preparation work. As for the enforcement of these conditions and measures to differentiate wind concession projects from regular wind power projects, the provincial governments and grid companies are responsible for signing concession agreements and power purchase agreements with the investors that win the bids. Some of these principles form part of the Renewable Energy Law and are therefore legally binding. In the fourth round of the wind concession tendering programme in 2006, it was further decided to bundle the bidding between developers and their chosen wind turbine suppliers. The wind concession programme has therefore played a significant role in the promotion of wind power development as well as domestic production of wind turbines.

The main features of the wind concessions are as follows:

1. Investors are selected through public tendering by the government. The bidder who offers the lowest price wins the bid. In 2005 the criteria were revised so that the electricity price was given 40% of the total weight in deciding the winning bids. This was further reduced to 25% in 2006, and then in 2007 the winning criterion was set as the bid closest to the average bidding price, excluding the highest and lowest bids.

2. The concession period is set at 25 years.

3. The provincial grid company must sign a power purchase agreement with the bid winners and purchase all the electricity generated by the wind projects.

4. The difference between the wind power price and that of conventional power must be shared across the provincial grid users. From 2006, the price difference is shared across the national grid.

5. The electricity price paid is divided into two stages across the project's lifetime. In the first period, the price is the bidding price proposed by the bidders up to an electricity generation level of 30,000 equivalent full load hours. In the second period, the price is set as the average electricity price in the power market.

On 5 January 2006, the National Development & Reform Commission released "NDRC [2006] No. 13 document-Related Regulations regarding Renewable Energy Power Generation". This clearly stipulates that "power enterprises should actively invest in renewable energy power generation projects and accept the obligation of a renewable energy power generation quota. The quota allocation will be stipulated in other documents". Since this document mentions the future implementation of quota obligations, the stated-owned power companies have proposed very low bidding prices in order to win the wind power projects and therefore reserve a quota of renewable energy against the likelihood of these obligations.

Between 2003 and 2006 a total of 11 wind power concession projects were agreed, with the highest bidding price of 0.519 0Yuan/kWh and the lowest of 0.382 0Yuan/kWh. The total tendered capacity was 1,650MW and the total capacity eventually bid was 2,450MW. Table 2 shows the bidding prices and the initial prices set after various feasibility studies.

The calculation of the price is based on the normal operation of mature turbine models. Since domestically made parts for MW size turbines are still at a "running in" stage, many problems are likely to be discovered and parts will need to be improved after testing and operational experience. Taking into account various risks, such as the difference between the wind resource assessment and practical conditions when the wind farms come into actual operation, the potential lower efficiency of wind turbine operation and the difficulty of grid connection, the electricity prices calculated in the feasibility studies were set on the low side.

The actual bidding price is then based on the business strategy of the bidders and the final contract price is the choice of the government decision makers after comprehensive consideration of multiple factors. The actual contract prices of wind concession projects are therefore low, and are favourable neither for the encouragement of equipment manufacture nor for local economic development. It has therefore been suggested that some key parameters of the process should be recalculated, after two years' operation of the projects, taking into account financial conditions, investment capital, annual electricity sales and turbine performance, when their real operating status can be judged.

Table 2 Comparison of contract prices for wind concession projects with feasibility and bidding prices

Project	Tendering capacity /MW	Bidding capacity /MW	Grid connected power production in feasibility study /equivalent full load hours	Average price of feasibility studies (Yuan/ kWh)	Contract price (Yuan/ kWh)	Difference of contract price and average price in feasibility studies (Yuan/ kWh)	Difference of contract price and the lowest bidding price (Yuan/ kWh)	Lowest bidding price (Yuan/ kWh)	Highest bidding price (Yuan/ kWh)
2003 Rudong Phase I	100	100	2,180	0.6374	0.4365	−0.2009	0	0.4365	0.7191
2003 Huilai	100	100	1,990	0.5740	0.5013	−0.0727	0	0.5013	0.7179
2004 Rudong Phase II	100	150	2,273	0.5425	0.5190	−0.0235	0	0.5190	0.5660
2004 Huiteng xile	100	100	2,588	0.4091	0.3820	−0.0271	0	0.3820	0.4260
2004 Tongyu	100	2×200	2,309	0.5093	0.5090	−0.0003	0	0.5090	0.5096
2005 Dongtai Dafeng	200	2×200	2,126	0.5042	0.4877	−0.0165	0.0277	0.4600	0.5460
2005 Anxi	100	100	2,358	0.514	0.4616	−0.0524	0	0.4616	0.5560
2005 Jimo①	150	100	1,686	0.7261	0.6000	−0.1260	−0.126	0.7261	0.7261
2006 Bayin	200	200	2,383	0.5143	0.4656	−0.0487	0.009	0.4566	0.5550
2006 Danjinghe	200	200	2,369	0.5361	0.5006	−0.0355	0	0.5006	0.6010
2006 Huiteng liang	300	2×300	2,726	0.4803	0.4200	−0.0603	0.0142	0.4058	0.5651

2.4 Off–grid wind power generation

Off–grid wind power is mainly used to provide electricity to herdsmen, fishermen and peasants in areas not covered by the grid. With an improvement in living standards and the use of more household appliances, there is a greater demand than the capacity of a single turbine. This has phased out production of turbines of 50W capacity and the production of 100W and 150W turbines has decreased as well. Turbines in the 200W, 300W, 500W and 1kW range are increasingly popular, accounting for 80%② of annual production of off–grid turbines.

At present there are 70 companies involved in the business of off–grid wind power generation, among which

① It is changed to provincial level project rather than a national concession project afterwards.

② Li Junfeng, et al. China Renewable Energy Develop Annual Report. 2007.

35 are universities, colleges and research institutes, 23 are turbine manufacturers and 12 are parts and accessories manufacturers, including batteries, blades and inverters. Among companies with a large annual production are Jiangsu Shenzhou Wind Power Development Co. Ltd., Inner Mongolia Longxinbo Wind Power Equipment Company (previously Inner Mongolia Shangdu Agricultural & Pasturage Device Factory), Inner Mongolia Tianli Mechnics Co. Ltd. (previously Inner Mongolia Power Machine Factory) and Guangzhou Hongying Energy Science and Technology Co. Ltd.

In 2006, over 30,000 turbines below 30kW capacity were produced, an increase of 34.4% over 2005, and among which turbines of 200W, 300W and 500W accounted for 72.5% of the total. The average capacity per unit was 361W. Total production was valued at about 100 million yuan and the average value was 7,000yuan/kW, with a profit tax of about 10 million yuan.

After 20 years' research, development and manufacture there has been a great improvement in the technical standard and production quality of off-grid wind turbines made in China. In 2005, 5,884 off-grid wind turbines were exported, producing foreign currency income of 2.83 million US $ and accounting for 18% of the annual production and 27% of the production value. The turbines were exported to 24 countries and regions in both the developing and developed world, including the Philippines, Pakistan, Argentina, Britain, the US and Australia.

3 Development of Wind Turbine Manufacture in China

The introduction of the Renewable Energy Law and its accompanying implementation regulations provided solid legal guarantees and clear policy direction for the development of a wind industry in China. Although foreign manufacturers still take the major share of the market, there has been a positive trend towards domestic manufacture. Currently there are more than 40 manufacturers supplying the Chinese market, including domestic owners, joint ventures and foreign companies.

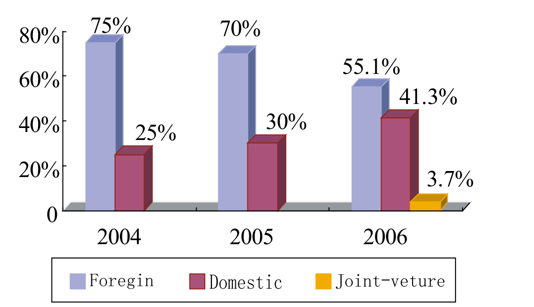
Domestic manufacturers include Sinovel Windtec, Goldwind and Dongfeng Eletrical Machinery. Joint ventures include Nantong CASC Wanyuan Wind Acciona Wind Turbine Manufacture, REpower North, Nordex (Yinchuan) and Hunan Hara XEMC Windpower. Foreign companies include GE (US), Gamesa (Spain), Vestas (Denmark) and Suzlon (India). The wind manufacturing industry in China is booming.

3.1 Wind turbine production

Investment in the wind turbine accounts for 70% of total investment in a project. Reducing the cost through domestic production is a necessary pre–condition of large–scale development. In the 1980s, China conducted a number of scientific research projects involving grid–connected wind power units with a rated power of 18kW, 30kW, 55kW and 200kW. However, most of these experimental turbines had no potential to be improved and transformed into commercial products both because of the long research cycle required and the fact that they could not meet the market demand for units with larger capacity. The Chinese government has financed two types of 200kW turbine prototypes, for example, but 600kW units became the dominant international products before the 200kW units could be commercialised. The current strategy is to gradually improve domestically made turbines by adopting mature foreign technologies, in the meantime making efforts to produce major parts and accessories domestically. This could lower the price by 10%–20% compared to imported units. In order to improve domestically made equipment, the National Development & Reform Commission has organised four rounds of wind concession tendering specifically designed to provide market opportunities for domestic enterprises.

In 2006, the total capacity of wind turbines produced by domestic manufacturers was about 540MW, accounting for 41.3% of the market. This was an increase of 11% on the previous year. Domestic manufacturers have played a significant role in reducing wind power costs and boosting wind development, especially with their advantage of lower product prices.

Figure 3 Market share of domestic and foreign wind turbines, 2004–2006



Foreign enterprises and joint ventures together account for 60% of the wind turbine market in China. Technically the market is dominated by the established international technology – adjustable pitch and variable speed turbines. Some companies have started up assembly in China, for example the US manufacturer GE (Shenyang), the Danish manufacturer Vestas, the Spanish Gamesa (Tianjin) and the Indian Suzlon (Tianjin). The largest single unit – Vestas' 2MW turbines – were installed in Jiangsu and Fujian for the first time in 2006. In future there is expected to be a fall in the market share of foreign enterprises to below 50% by 2007.

In April 2005, the 1.2MW direct drive turbine developed by the Gold Wind Company has completed its installation and commissioning, and tests made of its power curve by an international assessment agency. A significant step in product development, the turbine was scheduled to be released on the market in the first half of 2007. Under the 863 Programme of the Ministry of Science and Technology, the Energy Department of Shenyang Industry University has also succeeded in the development of an adjustable pitch and variable speed double fed turbine of 1MW capacity. This was commissioned in July 2005. In 2006, a 1.5MW version of the same turbine was developed and released on the market. Dongfeng Electrical Machinery and Sinovel have both meanwhile also introduced adjustable pitch and viable speed technology, produced large scale turbines and operating them in wind farms. Sinovel achieved production of 75MW of capacity in 2006, with a turnover of over 100 units. The company is now planning to complete production of 500 1.5MW capacity turbines and become a substantial competitor in the wind manufacturing industry.

In addition, foreign companies and joint ventures such as Nantong CASC Wanyuan Wind Acciona Wind Turbine Manufacture, Nordex (Yinchuan), Suzlon, GE and Vestas have started batch production ofMW grade turbines during 2006 and 2007. Table 3 shows the main wind turbine producers.

Table 3 Major wind turbine manufacturers

Manufacturer	Type (specification)	Technical source	Stage
Xinjiang Gold Wind Science & Technology Co. Ltd.	Gold Wind 50/750 (Ø50–P750–SR)	Repower of Germany Production license	Batch production
	Gold Wind 70/1,500 (Ø70–P1,500–DD)	Gold Wind and Vensys of Germany joint development	Batch production abroad Sample turbine production in China
	Gold Wind 77/1,500 (Ø77–P1,500–DD)	Gold Wind and Vensys of Germany joint development	Batch production abroad Sample turbine production in China
Dongfang Steam Turbine	FD70B/1,500kW (Ø70–P1,500–VV)	Repower of Germany Production license	Batch production abroad Sample turbine production in China
	FD77B/1,500 (Ø77–P1,500–VV)	Repower of Germany Production license	Batch production abroad Sample turbine production in China
Sinovel Windtech Co. Ltd.	70/FL1,500 (Ø70–P1,500–VV)	Fühländer of Germany Production license	Batch production abroad Sample turbine production in China
	77/FL1,500 (Ø77–P1,500–VV)	Fühländer of Germany Production license	Batch production abroad Sample turbine production in China

Zhejiang Windey Wind Generating Engineering Co. Ltd.	WD49/750 (Ø49–P750–SR)	Repower of Germany Production license	Batch production
	WD54/800 (Ø54–P800–AS)	Developed by Zhejiang Windey	Sample trial production
	WD77/1,500 (Ø77–P1,500–VV)	Developed by Zhejiang Windey	Design
Baoding Huide Wind Power Energy Engineering Co. Ltd. (state–owned)	55/FL1,000 (Ø55–P1,000–SR)	Fuhrländer of Germany Production license	Batch production abroad Sample turbine production in China
Beijing Beizhong Steam Turbine Generator Co. Ltd. (state–owned)	80/D8–2,000–80 (Ø80–P2,000–VV)	EU Group DeWind of Great Britain Production license	Batch production abroad Sample turbine production in China
Shanghai Electric Group Wind Power Equipments Co. Ltd. (state–owned)	SEC64–1,250 (Ø64–1,250–VV)	British EU Group with DeWind Production license	Batch production abroad Sample trial production
	SEC82–2,000kW (Ø82–2,000–VV)	Shanghai Electric Group and Aerodyn Design Company Jointly development	Design
Nordex (Yinchuan)	S70/1,500kW (Ø70–P1,500–VV)	Nordex of Germany Production license	Batch production abroad Sample trial production
Guangdong Mingyang Wind Technology Co. Ltd. (private owned)	83/MY1.5se (Ø83–P1,500–VV)	Mingyang and Germany Aerodyn Joint development	Sample trial production
Hunan Hara XEMC Wind Power Co., Ltd. (joint venture)	Z72–2,000kW (Ø72–2,000–DD)	Harakosan of Japan has the technology from Lagerway of the Netherlands Joint development with Hunan Hara XEMC	Batch production abroad Sample trial production
Nantong CASC Wanyuan Wind Acciona Wind Turbine Manufacture Co. Ltd (joint venture)	AW77/1,500 (Ø77–P1,500–VV)	Acciona of Spain and Wanyuan Joint venture	Batch production
REpower North	Variable pitch and variable speed (2,000kW/82m)	Repower (Germany)	Sample turbine production in China

Vestas	Variable pitch and variable speed (2,000kW/80m/90m)	Vestas	Batch production abroad Sample turbine production in China
Gamesa Wind Power	G52–850kW (Ø52–P850–VV)	Gamesa of Spain	Batch production abroad Sample turbine production in China
	G58–850KW (Ø58–P850–VV)	Gamesa of Spain	Batch production abroad Sample turbine production in China
GE Energy (Shenyang)	Variable pitch and variable speed (1,500kW/70m/77m)	GE of US	Batch production abroad Sample turbine production in China
Suzlon Energy (Tianjin) Co. Ltd. (Soleproprietor–ship corporation of India)	S64/1,250kW (Ø64–1,250–VF)	Suzlon of India	Batch production

Turbine specifications: Ø = rotor diameter; P = rated power; AS = active stall; DD = direct drive; SR = stall regulation; VV = variable pitch and speed; VF = variable pitch and constant speed.

In summary, China's wind industry has already mastered the manufacturing technologies of MW capacity wind turbines and started preliminary batch production. There is also ongoing improvement in the quality of the main parts and accessory production. China is now one of only a few countries capable of mass production of wind turbines, becoming more competitive. 39 of 1–2MW wind turbines are installed and running. Although they still need to be tested for operation in exposed conditions so as to discover any problems and make improvement, there are several Chinese businesses with the capability to produce this size of machine, the three major ones of which are Goldwind, Dongfang Steam Turbine and Sinover Windtech. This provides a strong basis for the large scale development of wind power. As the production capacity of both domestic and foreign manufacturers continues to increase, and with more than 20 enterprises investing in R&D, it is expected that there will be a major increase in wind turbine production and capacity, and the gap between supply and demand will be solved.

3.2 Components and accessory production

Parts and accessory companies in China have developed the key components required by domestic wind turbine manufacturers (see Table 4)[①].

Blades:

China has mastered the technology of blade manufacturing and is able to mass produce blades for turbines up to 1.5MW capacity. Manufacturers include Huiteng Windpower Equipment, Zhongfu Lianzhong and Shanghai FRP Research Institute. LM of Denmark, the internationally renowned blade manufacturer, set up a factory in Tianjin

① Information from enterprises.

Table 4 Main component manufacturers in China

No.	Component	Name of enterprise	Technical resource	Stage
1	Gearbox	Nanjing High-speed & Accurate Gear Group Co. Ltd	Own research & development	Batch production
2		Chongqing Gearbox Co. Ltd	Own research & development	Batch production
3		Hangzhou Advance Gearbox Group Co. Ltd	Own research & development	Batch production
4	Generator	Lanzhou Electric Corporation	Own research & development	Batch production
5		Haerbin Hadian Wind Power Equipment Co. Ltd	Own research & development	Batch production
6		Beiche Group Yongji Electric Motor Factory	Own research & development	Batch production
7		Shanghai Electric Group Shanghai Electric Motor Co., Ltd	Own research & development	Trial production: batch production started in the first quarter of 2007
8		Shangxi Fengxi Heavy Industry Co. Ltd	Own research & development (1.5MW) Technology introduced (transferred from Germany for 2MW by license)	Design phase, trial production in March 2007
9	Blades	Shanghai FRP Research Institute	Joint design (Germany Company)	Batch production
10		China Composites Group Corporation Ltd	Technology transfer (purchase the technology from NOI)	Batch production
11		LM Glasfiber (Tianjin) Co. Ltd	Sole foreign proprietorship Own research & development	Batch production
12		ZhongHang (Baoding) Huiteng Windpower Equipment Co. Ltd	Own research & development	Batch production
13	Electrical control	Beijing Corona Science & Technology Co. Ltd (Institute of Electrical Engineering Chinese Academy of Sciences)	Own research & development	Trial production
14		Hefei Sunlight Power Co. Ltd	Own research & development (joint development with Hefei Industry University)	Trial production Batch production will start in 2008
15		Nanjing Automation Research Institute (Nanrui Group)	Own research & development	Trial production

16	Tower	Shanghai Taisheng Power Engineering Machinery Co. Ltd	Technology introduction (learn and simulate processing according to the design)	Batch production
17		Qingdao Wuxiao Pipe Co. Ltd	Technology introduction (design provided by client)	Batch production
18		South China Pipe Industry Company (Guangzhou)	Joint design with Gold Wind	Batch production

in 2002. Vestas, Gamesa and Suzlon also have their own blade manufacturers in China. Others are carrying out research into blades, including Huayi (Baoding), Tianjin Dongqi and Beijing FRP Research Institute.

Gearboxes:

Major gearbox manufacturers include Chongqing Gearbox, Nanjing High-speed & Accurate Gear Group and Hangzhou Advance Gearbox Group. The latest companies to enter the market are Dalian Heavy Industry and Sichuan Erzhong.

Generators:

There are more generator than gearbox manufacturers. These include Lanzhou Electric Corporation, Yongji Electric Motor Company, Shanghai Electronics, Dalian Tianyuan, Dongfeng Electric Motor, Nanyang Electronics and Zhuzhou Time Group Company.

Bearings:

For the main bearings China is almost entirely dependent on imports. SKF and FAG are the major manufacturers. Xuzhou Rothe Erde produces yaw and variable pitch bearings. Wangfangdian Bearings and Luoyang Bearings have production capacity for variable pitch bearings.

Electrical control:

This is the weakest sector in domestic accessory production and is entirely imported. Enterprises currently in the research process include the Institute of Electrical Engineering Chinese Academy of Sciences, Hefei Sunlight, Xuji Electric Company and Nanjing Automatic Research Institute. There are also other companies and research institutes doing research into electrical control systems for MW capacity variable speed and permanent frequency turbines.

Other parts manufacturers include FAW Jiefang Automotive Co. Ltd. Wuxi Diesel Engine Works (Wuxi, Jiangsu, hub and gearbox body casting), Dongfang Steam Turbine Factory (Deyang and Sichuan, hub and gearbox body casting), Qinchuan Machine Tool (Baoji and Shaanxi, hub and gearbox body casting), Wuxiao Group (Tsingdao, towers), Wuxi Dachang (Wuxi, towers), Tianshun (Suzhou, towers) and Shanghai Taisheng (towers).

Currently, domestically made components could meet 90% of the demand for 600kW and 750kW models, whilst the output for 1.5MW units exceeds 70%. However, with the expansion of wind power development there is still a lack of capacity in parts and accessory production, especially blades and gearboxes. Present production capacity of blades can meet an annual demand of about 1,500–1,700MW. For gearboxes, production capacity is about 1,600 units, which represents about 2,000MW. Compared to the growing demand for up to 4,000MW of capacity, there is still a gap of 2,000MW. In addition, most of the bearings for wind turbines are still reliant on imports. SKF and FAG, the two major bearings producers have supplied as much as they can to China but they still could not meet the demands of gearbox production. In terms of electrical control systems, China has little experience and many enterprises are still doing research on the road to producing mature products. Lack of production capacity of key components is an issue to which attention needs to be paid.

3.3 Profiles of major wind power companies

Gold Wind Science and Technology Co. Ltd.

Xinjiang Gold Wind Science and Technology Co. Ltd. was founded in 1998 with a registration capital of 32 million RMB. The business includes: production and sale of large wind turbines; technology transfer and the application of wind turbine technology; manufacture and sale of wind turbine components; technical consultancy in the manufacture of wind turbines and operation of wind farms; construction and operation of pilot wind farms.

The company has been dedicated to organisational improvement, technical innovation and creative management since first establishing the R&D work on 600kW wind turbines, one of the key scientific and technological achievements during China's ninth five year national development programme. The company also completed R&D for a 750kW wind turbine during the tenth five year programme and later for a pioneering 1.2MW direct drive turbine.

The main products of the company include 600kW, 750kW, 800kW and 1.5MW direct drive wind turbines. More recently, 2MW and 2.5MW turbines have been under development, aiming at future offshore applications. The company has built three factories in Hebei, Zhejiang and Guangdong, and two production bases in Beijing and Baotou, establishing a production capacity for thousands of wind turbines per year.

By the end of 2006, the installed capacity of wind turbines produced by Gold Wind was 667MW, representing 83.4% of the domestic market, and 25.7% of the cumulative installed capacity in China. In 2006, Gold Wind achieved tenth position among global manufacturers of wind turbines.

Sinovel Wind Co. Ltd.

Sinovel Wind Co. Ltd. specialises in R&D, design, manufacture and sale of wind turbines. The company is financed by Dalian Heavey Industry-Dalian CraneWork Group Co. Ltd with the aim of industrial restructuring by entering the wind market. It has set up headquarters in Beijing and a production factory in Dalian with a total area of 30,000m^2. Sinovel is the first company to transferMW capacity technology by importing the complete system of the German Führlander FL1,500 turbines. The company developed and updated the technology, and also completed the production chain for manufacturing FL1,500 turbines. 85.7% of the components can be made locally. The production capacity is now 300 units per year, with a plan to increase to 1,000 units by the end of 2010. The company is also undertaking R&D on 2MW, 3MW and 5MW turbines, to be used both inland and offshore. In 2006, Sinovel was the second manufacturer in China in terms of installations. It is estimated that the company's sales will reach 750MW in 2007, covering 40% of the domestic production.

Dongfang Steam Turbine Factory

Dongfang Steam Turbine Co. Ltd., part of the China Dongfang Steam Electric Group Co. Ltd., was created from the restructuring of the former Dongfang Steam Turbine Factory in December 2006. The latter was a large state-owned company engaged in R&D, design and manufacture of power generation equipment. In 2004 the company imported the advanced technology and production permits for the 1.5MW MD70/77 wind turbines produced by German company REpower. Developing on this technology, the company is now able to provide services from wind farm design through to after-sales service. Nowadays, 70% of the 1.5MW wind turbine's components can be made locally. The annual production capacity of this company is 300 units, with a target for over 500 units from 2008.

Based on the knowledge gained in designing, manufacturing and servicing the 1.5MW model, the company is now cooperating with established wind turbine design companies in Europe to develop 2.5MW turbines with its own patent. The company has also established a blade factory and a wind power technology research institute. In 2005, the largest 1.5MW wind turbines produced by the Dongfang Company were installed in Rongcheng, Shandong. In 2006, the self-developed duplicate feeder asynchronous wind turbines aimed at low temperature operation were installed in Hulunbeier, Inner Mongolia, indicating the mass production of high capacity wind turbines.

4 Prices for Wind Power Generation

4.1 History of wind power pricing systems

China has gone through four stages in its pricing system for wind power generation.

Free competition stage

In the first stage, from 1990 to 1998, the price paid for electricity from wind power was very low because the equipment was purchased using foreign grants and the income only had to cover the maintenance of the wind farms. For the Dabancheng wind farm, for example, built in the early 1990s, for example, the price was less than 0.3Yuan/kWh. This was almost the same as that for thermal power stations.

Government approved prices

The price for wind powered electricity varied between 1998 and 2003. The price was approved by local government, which then reported it to central government. During this period, various prices were adopted. The lowest was the same as for thermal power. This was the case for Zhangbei wind farm, built by the China Energy Conservation Investment Company, for example. The highest price, on the other hand, could be more than 1Yuan/kWh. The Kuocangshan wind farm in Zhengjiang, for example, received 1.2Yuan/kWh.

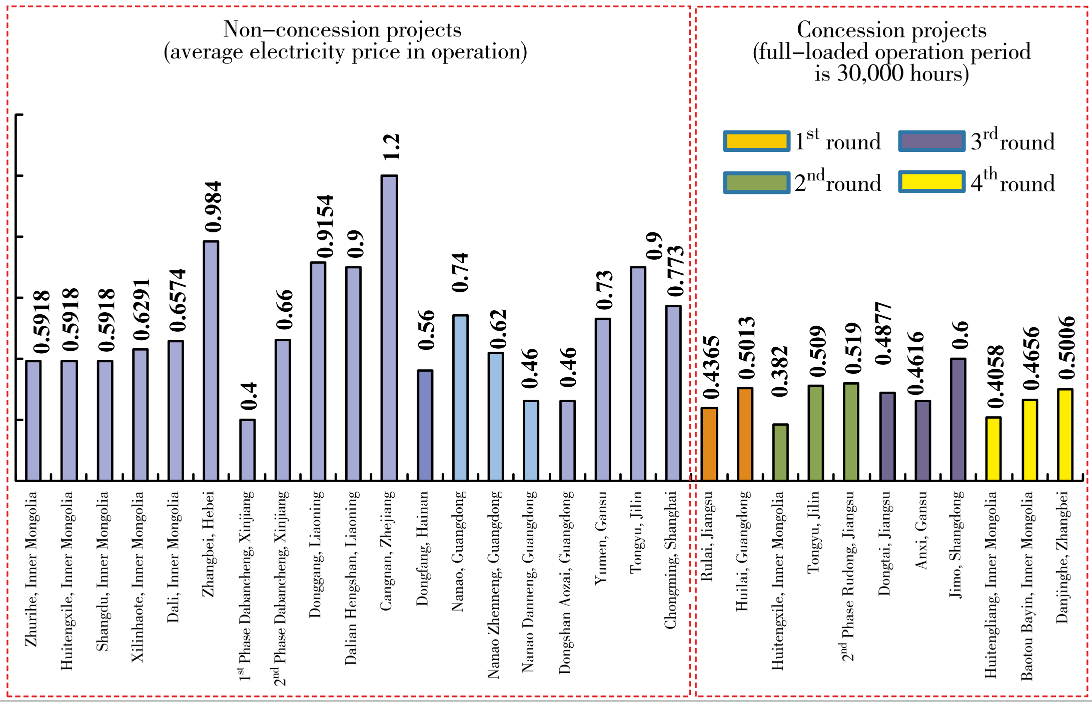
Tender prices or approved prices

From 2003 to 2005 there were two ways in which the price for wind power was decided, either through a bidding or taken as an approved price. This stage started as the first batch of wind concession projects was organized. By the end of 2006, the government organized four batches of wind concession projects. The projects for 2007 are still under consideration. At a local level, the price was still determined by the local government.

Bidding price plus approved price

After 2006, China introduced a fourth system for setting the price of wind power, coinciding with the inauguration of the Renewable Energy Law and its implementation regulations. This states that "the price for wind power should be determined through tender". This means that the price

Figure 4 Average electricity price for current wind power projects at the end of 2006 (yuan/kW·h,tax not included)



is determined through a tender and then approved by the government.

Figure 4 shows the electricity price for some wind projects at the end of 2006, reflecting the variations in the price in the past years. The prices approved by the government are similar to those in foreign countries, indicating that the price (except for some projects) for non–concession projects is reasonable. The difference in the price also reflects the difference in wind resource between different areas. In some cases, however, pricing systems and policies interfere with fairness. A price difference implemented because of varying wind resources is acceptable, but becomes controversial when brought about by government policies. In some cases the result is that different prices have been adopted in the same geographical location. For example, for three wind farms built at the same time the price ranges from 0.74Yuan/kWh down to 0.46Yuan/kWh. The gap between the highest and lowest price is 0.28Yuan/kWh, which cannot be considered fair.

4.2 Current pricing policy for wind power

On 1 January 2006 the Renewable Energy Law became effective, providing a legislative framework for developing renewable energy. The law states that "the grid power price of renewable energy power generation projects shall be determined by the pricing authorities of the State Council on the basis of being beneficial to the development and utilisation of renewable energy and being economic and reasonable". Three days later the NDRC issued "Temporary Implementation Rules for Establishing a Feed–in Tariff for Renewable Energy Power and the

Sharing of Expenses in Purchasing Electricity from Renewable Energy", encompassing the principle that "the wind power price should follow the government determined price. This price should be approved by the relevant department of the State Council based on the price of the tender".

This pricing policy for wind power is based on the fact that China has now obtained some experience through national wind concession projects. The tendering system is aiming at finding the proper price standard, but it is not necessarily for every project. The implementations could be as the follows. Prices are determined by means of tender for wind projects. After a while, the government then decides the local price based on the result of the tenders. Because of the limited number of the tenders, however, the price cannot reflect the accurate cost and profit of a wind project. But as the number is growing, the price is close to reasonable. At that time, it is wise to use the tendering price as local standard.

Apart from that, the regulations also state that "the price for wind power should be confirmed by the government after 2006 and the excess between the price for wind power and the price for thermal power should be compensated for by adding an additional charge to the selling price of electricity to all electricity consumers". Since 30 June 2006 an additional 0.001Yuan/kWh has been charged to electricity consumers in order to compensate for the additional cost of renewable electricity.

4.3 Effects of wind power pricing policy

1. The implementation of pricing policies has encouraged a booming wind market

The government's pricing systems and other supporting policies have accelerated growth of the wind power market in China. By the end of 2005 a total of 1,864 wind turbines had been installed, with a combined capacity of 1.265GW. During 2006 a further 1,454 turbines were installed, with a capacity of 1.33GW, increasing the cumulative capacity by more than 100%. This total has pushed China up to number 6 in the international wind market.

However, of the capacity newly installed in 2006, only 328.6MW was approved in that year. The remaining 1GW was approved before 2005. According to government regulations, those projects cannot be compensated through the renewable energy fund. In order to promote wind power, the government should consider enlarging the subsidy system to include projects approved before 2005 and implemented in 2006.

2. There is a wide variation in prices paid through tenders ①

After the implementation of the wind pricing polices, some local government authorities also made plans for wind projects outside the 4th national wind concession projects. The result is that the price paid varies between projects being built in the same place. Sometimes the price is too low, sometimes too high. For example, the prices resulting from the 4th round national wind concession project are 0.4058, 0.4566, 0.4656 and 0.5006Yuan/kWh respectively. The price for wind projects lower than 50MW initiated by local governments, on the other hand, is more than 0.50Yuan/kWh, and mostly 0.55-0.65Yuan/kWh. In a few cases it is as high as 0.8Yuan/kWh. Generally speaking, the price gap between national concession projects and projects initiated by local government is about 0.1Yuan/kWh. According to some experts, this gap is far wider than that justified by the difference in size of projects. Furthermore, these prices must be verified by the pricing bureau within NDRC before the projects can receive their

①Li Junfeng, et.al. Study of Wind Power Price Formulation in China. 2006.

subsidy from the renewable energy fund.

3. Unclear pricing policies impact on foreign and private investment

Since the price is determined on a project by project basis, both foreign and private investors are not sure about the investment signal being given and are reluctant to invest in wind power. After the implementation of the recent pricing policies, no foreign or private companies won concession projects, which makes them to doubt the Chinese system. At present, in both the national wind concession projects and projects initiated by local government, the developers are all state–owned companies.

4. Latest progress on wind power pricing policy

There has been some progress on wind power pricing policy during 2007. In June 2007, the NDRC verified and approved 23 wind projects in Hebei, Inner Mongolia, Jilin, Gansu, Xinjiang and Fujian. The prices ranged from 0.51 to 0.61Yuan/kWh. During the verification process, some prices were slightly adjusted, although they still basically reflected the local wind resources. In Jilin, the verified price was exactly the same as the contracted price, 0.61Yuan/kWh. The same was true in other provinces (see Table 5).

Table 5 Approved price for some non–concession wind projects in 2007

Province	Installed capacity /MW	Price (Yuan/kWh)
Hebei (7 projects)	300	0.54–0.61
Inner Mongolia (8 projects)	350	0.51–0.54
Jilin (6 projects)	300	0.61
Gansu (4 projects)	110	0.54
Xinjiang (1 project)	30	0.51
Fujian (1 project)	30	0.585

4.4 Trend of wind power pricing policy

The new pricing policies for wind power have been in operation for a year, resulting in some successes but also some problems. Although the policies have been improved during their implementation, some of the regulations still need adjusting. These are the most important questions:

1. How should the price be determined through tenders?

As mentioned above, the government aims to determine the price for wind power in different regions through a number of tenders. However, how many tender projects are enough to determine the price for a particular region? If the prices in tenders vary widely, how should this be dealt with? There are no existing answers to these questions, but the problems need to be dealt with through practical experience. At present, there are more than 40 wind tender projects nationwide, of which 23 have been submitted to the NDRC for approval. Although the approved price for each region is almost the same, this is not the confirmed price for this region. The price is only for a particular project, not for the province. But the results of the tenders, the approved price and the price verifying method have established the basis for determining the price for the region in the future.

2. How can an attractive price level be ensured?

The four national wind concession projects have give some idea of the price level of wind power in China, while it is time now to move to the feed–in–tariff system. One method would be to divide the nation into three regions – areas with a rich wind resource (more than 2,500 hours at full operation per year), those with a good wind resource (between 2,000 and 2,500 hours) and those with an ordinary wind resource (below 2,000 hours). Relevant prices should be set for the three regions using the following approach.

For tenders in Jiangsu, Guangdong and Jilin provinces we could take the price for coastal regions, using the average price of the contracted prices, excluding the highest and lowest figure. This would give a reference price of about 0.6Yuan/kWh. For tenders in Inner Mongolia, Hebei and Xinjiang provinces we could take the price for the regions with a rich wind resource. This would give a reference price of about 0.5Yuan/kWh. For other regions, we could adopt a maximum price, for example no more than 0.65Yuan/kWh.

3. How should the price be adjusted?

The wind power industry is developing very fast and the cost of manufacture is decreasing. We should therefore reduce the electricity price according to the falling cost of manufacture. In order to protect the industry, however, we should set a minimum price. At the moment, we should consider setting the minimum price at 0.5Yuan/kWh up to 2020. This would protect the interests of investors, developers and manufacturers.

5 Wind Power Concession Projects

Wind power projects with an installed capacity of or above 50MW are approved by the national government and can go through the concession bidding process. Projects with an installed capacity below 50MW are approved by the relevant provincial government agencies. In that case, there is no regulation or policy requiring projects to go through the concession bidding process.

5.1 Concession bidding and evaluation procedure for wind power

Concession project bidding is organized by the NDRC. The Commission is responsible for the initial evaluation of projects submitted by local authorities, for deciding which bidding projects are successful and for granting project approval.

The practical bidding work is carried out by the Zhongshe International Bidding Co. Ltd. and the China Hydro Power Project Consulting Group. These two companies write the bidding documents and publish the bidding invitation letter in major domestic and international newspapers and on the internet. According to the bidding documents, the relevant provincial DRC and the bidding company organize an on site inspection and hold a pre–bidding meeting. Each bidding project must open its bids at an agreed time in Beijing.

The organization and procedures for the project bidding evaluation runs as follows:

Organization of the evaluation

The director of the evaluation committee comes from the Division of Renewable Energy and Rural Electrification of NDRC. The members are from provincial DRCs, the State Grid Company, provincial power companies, bidding agencies and technical experts.

Within the evaluation committee there is a Business Group and a Technical Group.

The Business Group is responsible for initial evaluation, evaluation of the concession agreement with notes, supporting the Technical Group in finishing the evaluation, ranking and clarification and collecting relevant documents and finishing the report.

The Technical Group is responsible for delivering detailed evaluation of the bidding documents (technical plan, financing plan, financing proposal and experience), evaluation of the electricity purchase contract with notes and completing the ranking, clarifying and evaluation report with the Business Group.

The evaluation procedure

a) Initial evaluation: The Business and Technical Groups decide whether the proposals respond to the bidding requirements and whether there are mistakes or reservations. The Business Group will finish the initial evaluation report on the noted concession agreement and submit it to the evaluation committee. The Technical Group will evaluate the technical plan and noted electricity purchase contract and submit them to the evaluation committee.

b) Detailed evaluation: The Technical Group evaluates the technical plan, financial plan, financing proposal, experience etc. to decide whether they meet the requirements. It will finish the evaluation on the noted concession agreement and electricity purchase contract and determine the list of candidates.

c) Ranking of candidates: The evaluation committee ranks the candidates based on the detailed evaluation report. The companies ranked second and third are recommended as candidates for negotiation.

d) Clarification: In order to evaluate and compare the proposals, the bidders might be requested to give written clarification on unclear statements in their proposals. However, requests, proposals, permission or acceptance of a change related to the price or other important contents are not acceptable. All clarification requests must be issued and collected in writing. They need signatures from both parties and can form part of the eventual contract with legal force.

e) Negotiation: The evaluation committee negotiates with the candidates on the bidding documents and suggestions or modifications according to the bidding requirements. The negotiation begins with the candidate who has the highest ranking and continues until the committee is satisfied. Negotiation involves both price terms as well as any other non–price items.

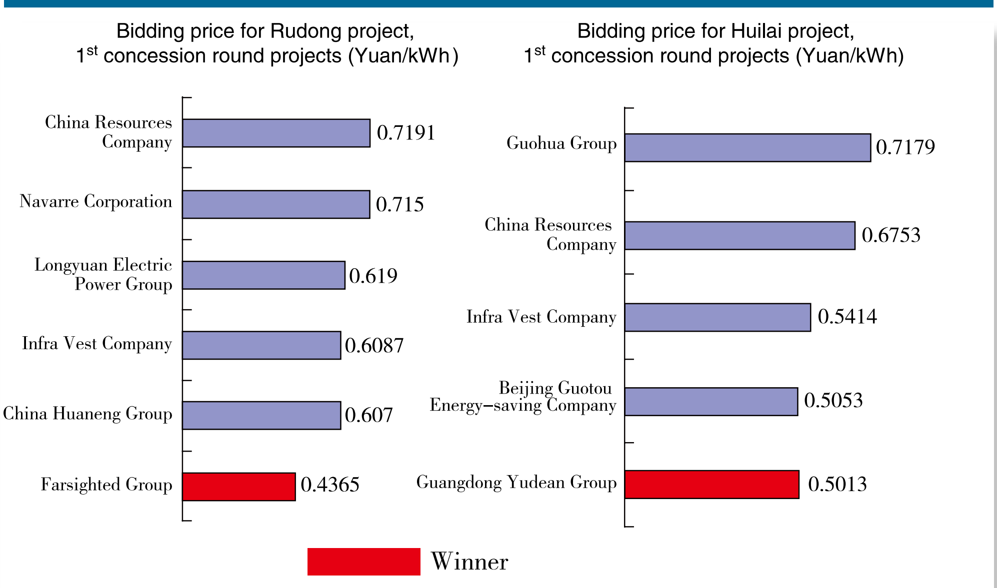
After negotiation, the committee decides the winning bidder and reports the results, with the evaluation report, to the NDRC.

5.2 Outline of the concession bidding procedure for wind power

The first concession round projects were for Rudong wind farm (100MW) in Jiangsu province and Huilai Shibeishan wind farm (100MW) in Guangdong province.

On 1 September 2003, the first wind concession bidding process opened in Beijing. Huarui Company won the bidding for Rudong wind farm with a price of 0.4365Yuan/kWh. Guangdong Yuedian Group won the bidding for Shibeishan wind farm with a price of 0.513Yuan/kWh (see Figure 5).

Figure 5 First round of wind power concession projects

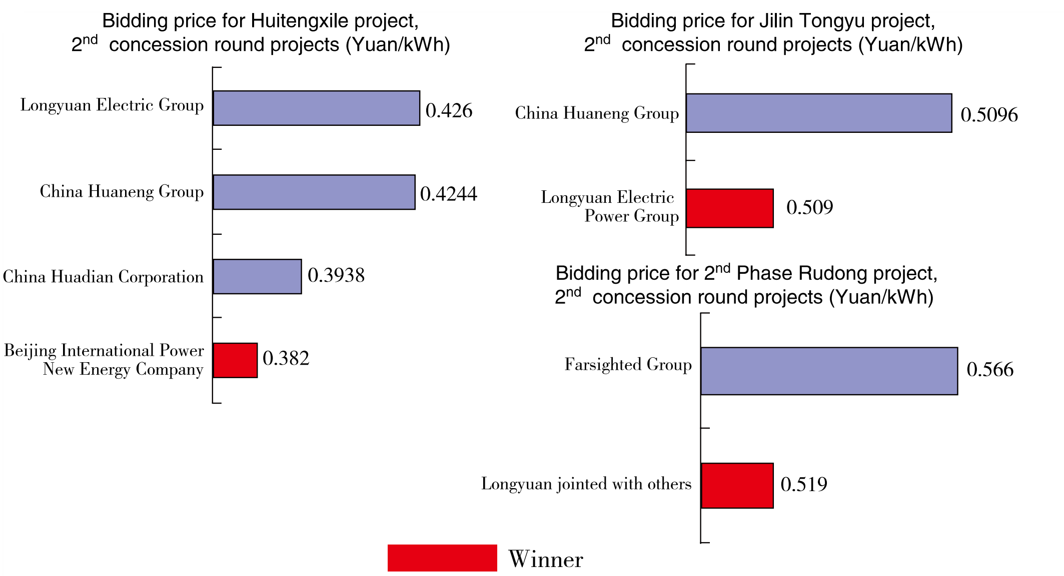


The prices in Figure 5 include value added tax (VAT). Some adjustment are made to turn orgianal prices (without VAT) into real ones (with VAT).

The second round of concession projects was for the second phase of Rudong wind farm (100MW) in Jiangsu province, Huitengxile (100MW) in Inner Mongolia, Shibeishan wind farm (100MW) in Guangdong province and Tongyu Unity wind farm (100MW) in Jilin province.

On 1 September 2004, the second round of wind power concession projects bidding opened in Beijing. The results are shown in Figure 6.

Figure 6 Second round of wind power concession projects



Note 1: Beijing International Power New Energy Co. Ltd .and its partners won the bid for Huitengxile wind farm in Inner Mongolia. Because the area near the wind farm also has a rich wind power resource, NDRC decided that a wind farm of the same scale, conditions and bidding price could be built if other bidders agree. China Huadian Co. Ltd. agreed to build another 100MW wind farm nearby after negotiation.

Note 2: Longyuan Power Group with its partners and Hua'neng New Energy Environmental Protection Industry Co. Ltd. won Yutong Unity wind farm in Jilin province with a bidding price of 0.5090Yuan/kWh. Because the scale of the development area was enough to justify 400MW of capacity, both sides agreed to develop an additional 200MW wind farm with the same bidding price.

Note 3: Longyuan Power Group with its partners won the bid for the second phase of the Rudong wind farm project in Jiangsu province with a price of 0.5190Yuan/kWh. The development scale was adjusted upwards to 150MW.

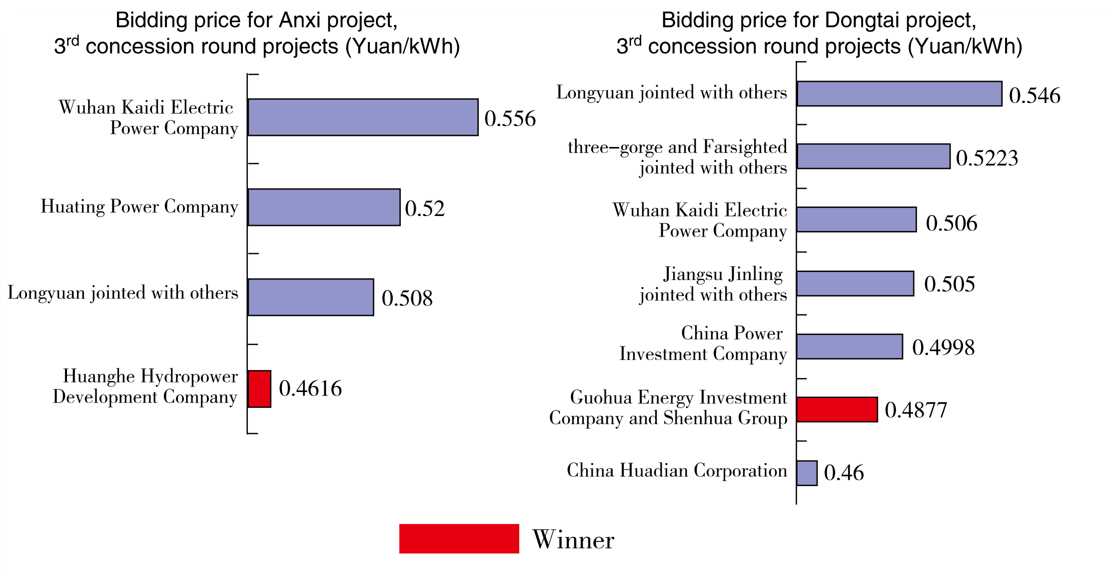
The third round of concession projects covered Dongtai wind farm (200MW) in Jiangsu, Anxi wind farm (100MW) in Ganxu province and Jimo Wangcun wind farm (150MW) in Shandong province.

On 16 August 2005 bidding for the third round of wind power concession projects opened in Beijing. The bidding results are shown in Figure 7.

Note 1: Guohua Energy Investment Company won the bid for Dongtai wind farm in Jiangsu province with a bidding price of 0.4877Yuan/kWh. China Power Investment Group agreed to develop an additional 200MW project in the nearby Dafeng county after negotiation.

Note 2: Huadian International Co. Ltd. was the only bidder for the Jimo Wangcun wind farm in Shandong province, with a bidding price of 0.7261Yuan/kWh. Due to the concentration of farmland in the project site, the installed capacity was limited. The project was therefore adjusted to 100MW with a bidding price of 0.60Yuan/kWh approved by the NDRC.

Figure 7 Third round of wind power concession projects



The fourth round of concession projects covered Huitengliang wind farm (300MW) in Inner Mongolia, Baotou Bayin wind farm (200MW) in Inner Mongolia and Zhangbei Shanjinghe wind farm (200MW) in Hebei province.

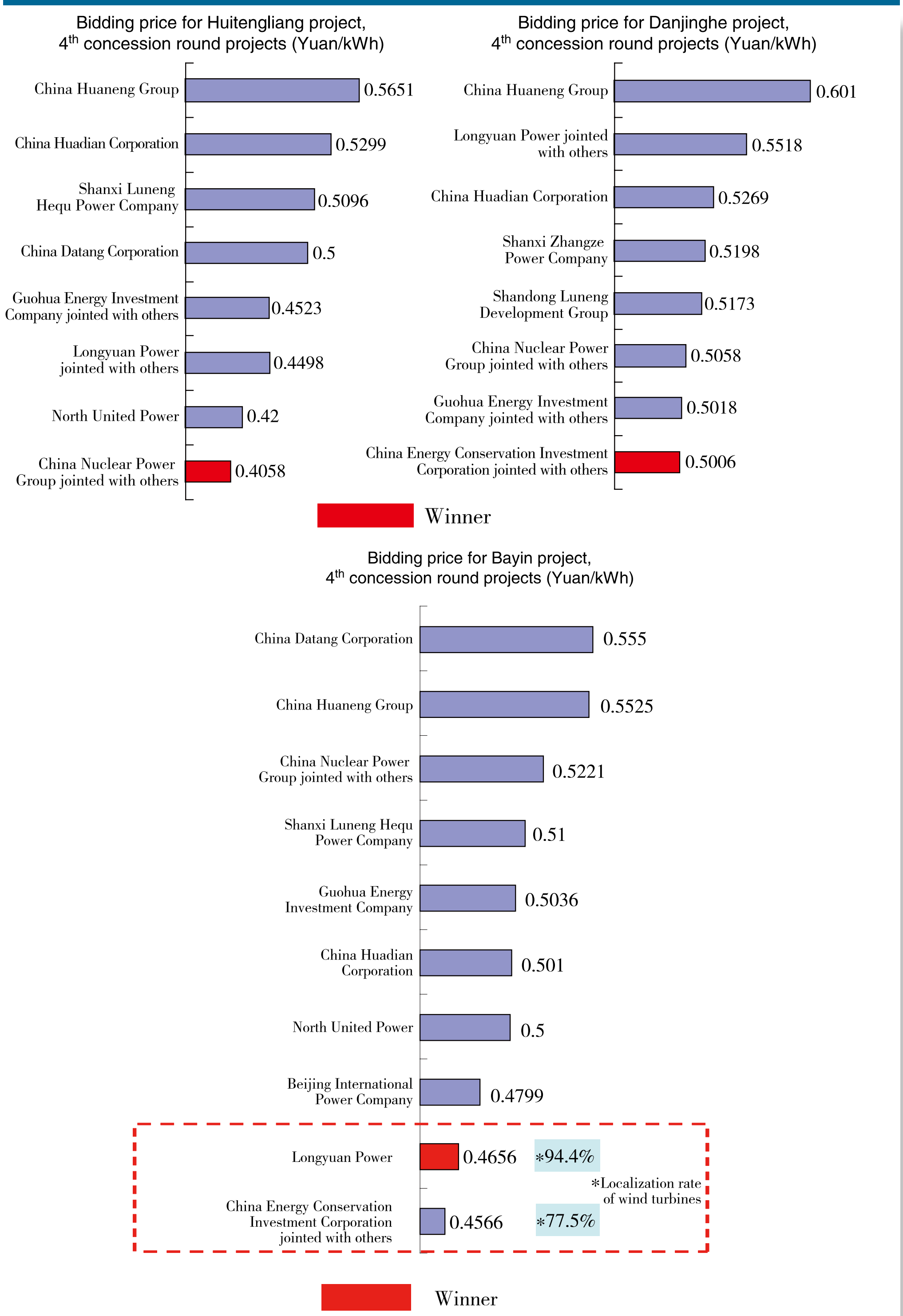
There were 17 bidders in the fourth round, all of them state-owned companies. Five of the companies established joint bidding bodies with companies registered abroad in order to benefit from preferential policies for foreign companies. There was also a major adjustment to the evaluation procedure and a requirement for increased localisation of equipment. This further reduced the range of prices in the bidding.

The bidding prices for Huitengliang wind farm (300MW) in Inner Mongolia ranged from 0.4058Yuan/kWh to 0.5651Yuan/kWh, with an average of 0.4788Yuan/kWh. The bidding prices for Baotou wind farm (200MW) in Inner Mongolia ranged from 0.4566Yuan/kWh to 0.5550Yuan/kWh, with an average of 0.5041Yuan/kWh. The bidding prices for Zhangbei Shanjinghe wind farm (200MW) in Hebei province ranged from 0.5006Yuan/kWh to 0.6010Yuan/kWh, with an average of 0.5281Yuan/kWh. These prices generally reflected the construction conditions for each project and an expected income mostly meeting the standard investment return for the industry.

Due to the requirement for an agreement between investors and manufacturers in the bidding process, 12 turbine manufacturers joined the fourth round. There was one foreign owned company, three Chinese and foreign joint ventures, one private company, two stock companies and five state-owned companies. Altogether 20 types of wind turbine were involved in the bidding. Blade diameters ranged from 49m to 83m and the rated power from 750kW to 2,000kW. Six of the turbines were domestically produced. The bidders had all signed contracts with major equipment suppliers and made plans for the 70% localisation requirement.

In August 2006, the fourth round of wind power concession project bidding opened in Beijing, with the results shown in Figure 8.

Figure 8 Fourth round of wind power concession projects



Note 1: The bidding consortium of Zhongguang Nuclear Development Co. Ltd. and Zhongguang Nuclear International Co. Ltd., together with Beifang United Power Co. Ltd. won the bid for Huitengliang wind farm project in Inner Mongolia with a bidding price of 0.4056Yuan/kWh. Each partner can develop a 300MW wind farm.

Note 2: In the Bayin project, Jie'neng Investment company had the lowest bidding price, but Longyuan Power won the bid with the advantage of a high level of localisation of wind turbine supply, even though the bidding price was slightly higher.

The fifth round of concession projects covered Beiqinghe wind farm (300MW) near Tongliang in Inner Mongolia, Wulanyiligeng wind farm (300MW) near Bayanzhuoer in Inner Mongolia, Weichang Yudaokou wind farm (150MW) near Chengde in Hebei province and Changma wind farm (200MW) near Yumen in Gansu province.

In April 2007, the evaluation meeting for the feasibility study reports of the four projects was held. In May, the evaluation findings were reported to the NDRC. At the end of August, the opening meeting of the fifth round of wind power concession projects was held and the bidding documents submitted. There were relatively major adjustments to the conditions of the bidding, based on previous experience, and these are expected to have a positive influence on the prices eventually agreed.

5.3 Analysis of the results and impacts of concession project bidding

1. The role of concession projects in improving the acceptance of wind power to the national grid

Four rounds of wind farm concession projects from 2003 to 2006 have been important steps in the context of Chinese power sector reform, which has resulted in the separation of power generating companies from the supply utilities. This reform process exempts wind power from market competition by offering a fixed price and a long–term contract. The utilities invest in the construction of transmission lines and transformers from wind farms to the grid. The monopoly over wind power by the former Ministry of Power has been broken, helping to draw in investors from both home and abroad and encourage competition. Requirements for the extent of localisation in turbine manufacture have been set. When there was no fixed price for wind power and the local government authorities and utilities were not supportive of wind farm development, the concession projects organised by central government have played a significant role in promoting acceptance of large scale wind power to the grid.

2. The impact of concession projects on wind power development in China

A. The bidding system has resulted in very low wind power price

The negative impact of the first and second rounds of concession projects was caused by the promise of the former National Planning Commission that the bidders proposing the lowest price would win the bids. As a result, the bidding price was lower than reasonable to make the project effective. The most notable example was the bidding in consecutive years for the Rudong wind farm. The wind resources and other conditions were the same, but the bidding price by the Huarui company was 0.3979Yuan/kWh in 2003 and 0.56Yuan/kWh in 2004. The price rose 40% within one year.

Even though the third and fourth rounds took non–price criteria into consideration, in almost all cases the company with the lowest bidding price won the bid. This suggests that despite the fact that other factors were considered, the bidding price was still the determining factor.

In order to reduce the bidding price, bidders have either over–estimated the wind resource and expected electricity generation or underestimated the cost of the wind turbines and maintenance. Some of the bidders have established joint ventures with companies registered abroad, a method by which they can avoid VAT and reduce income tax. This is being used as a means of unfair competition, and will mean a rise in normal tax for the country.

B. Bidding is not conducive to the development of multi–investment sources for wind power

Ultra low bidding price can also be seen as an indication that wind power companies are enthusiastic about investing in the technology. This competition is welcomed by the government. However, careful analysis suggests that the wining bidders only intend to win the concession projects in order to enter the wind power field for its future prospects. Their purpose is to occupy good resources for the future, instead of considering the investment return on their current projects. Under this unreasonable investment drive, some privately owned companies ventured into the price competition in the first few rounds. Some of them were even successful. However, in the latest round of bidding all the private companies retreated due to the high investment risk. Foreign companies also decided to wait and see. In the fourth round, all the bidders were large state–owned energy groups.

Why do the state–owned companies have the ability to shoulder this price cutting? In practice, most of them belong to large national and local energy groups with some kind of monopoly and strong financial backing supported by profitable coal fired or hydro power stations. They are therefore able to shoulder a small profit or even a loss from several hundreds of MW of wind power projects. In other words, the state–owned companies can afford to lose money at present, so long as they can control the resources and make profits in five or even ten years. Meanwhile, investing in wind power will win their company a good image for developing clean energy. For private companies, on the other hand, the risk is big enough to keep them out.

Another reason why the state–owned companies are willing to bid low prices for wind power may have something to do with the binding quota policy for renewable energy currently under discussion. In order to increase investment in renewable energy, the central government has been considering setting a minimum percentage share of renewable energy within the generation output of large power companies. This has made the companies willing to bid for wind power projects with low prices in order to achieve their renewable energy quota.

This quota policy was originally designed to encourage large state–owned power companies to invest more in renewable energy at a time when investment in renewables was generally limited. Since the Renewable Energy Law was passed, however, and the key issues about grid connection, tariff and cost distribution were solved, investment in renewable energies such as wind and solar power has soared. Competition between private and state–owned companies has become fierce, an unexpected situation making the quota policy less relevant. Meanwhile, it has been used as an excuse for the big five power groups to compete with low prices for wind power projects.

It is safe to say, nonetheless, that the large state–owned power companies and the big five power groups in particular will invest in wind power to investment in renewables even without the government's quota policy. The problem is how to build a suitable system to attract investment from a range of sources. Meanwhile, a reasonable competition mechanism and optimised regulations need to be introduced to ensure the long-term healthy development of wind power.

However, with the unwritten rule that the lowest bidding price wins the bid and the participation of multiple investors, the winning bidding price is so low that a reasonable profit cannot be guaranteed. This has become an investment barrier for both private and foreign companies. It is far removed from the original intention of attracting multiple sources of investment and avoiding a cartel situation in power industry.

In addition, a bidding price lower than a reasonable level makes it harder for the investor to make profits, thus not generating any income tax. The project cannot therefore promote the development of the local economy. This in turn will seriously lessen the enthusiasm of poorer regions to develop wind power.

C. A lower than reasonable wind power tariff will ultimately destroy the newly developed wind turbine manufacturing industry in China

Apart from marginalising serious investors, the other major problem of a lower than reasonable grid tariff for wind power is that it will shift the pressure on costs to the wind turbine manufacturers. The turbine manufacturing industry is still in its early stage of development in China. Although China has rich wind resources and a large potential wind power market, large scale development of the manufacturing industry still relies on foreign technologies and products, including building wind turbines through joint ventures, obtaining the technology through a permit or even importing complete turbines. This is why the fourth round of concession projects introduced a regulation binding the bidding to Chinese production in order to protect domestic manufacturers.

Even so, if nothing is changed, the bidding will ultimately return to a price war, as seen in the first four rounds of concession projects. The abilities of developers to build wind farm projects are at basically the same starting point, and the price war will ultimately be reflected by the prices for equipment and services. After winning a wind power project at a low price, developers will try their best to squeeze the profits of the suppliers. It is well known that when an industry has made no major technology breakthrough, has no complete industrial chain and before it is given government preferential support such as through tax cuts, personnel training or public research and development, it is quite exposed to risks and might die young. The wind power equipment manufacturers currently have no leeway to reduce the price of their equipment or services dramatically in order to drastically reduce the wind power price. Even though the government set a 70% localisation rate to ensure a market share for wind power equipment manufacturers, the wind power industry at the manufacturing end makes little or no profits, or even loses money. This situation will not ensure the development of competitive high tech businesses and a mature industrial supply chain. It will also limit the research and development enthusiasm of the enterprises and push them into being only concerned for their short term survival. They will have no ability to invest in improvements to their technology. This is contradictory to the original intention of developing a national wind power industry and increasing the overall installed capacity of wind power. Without opening up more potential for profits at the lower end of the supply chain, this vicious cycle will not change.

3. The bidding process needs to be further modified

A. The preparatory work for wind projects needs to be further strengthened. Some of the previous bidding projects encountered problems due to lack of preparatory work. In the first round, for example, the Huilai wind farm had only one set of wind measurement data and the location of the wind measurement mast was not marked on the bidding proposal. As a result, the wind measurement was unrealistic. At Tongyu wind farm, the winning bidder Huaneng New Energy Company found that the actual site was not the same as that described in the bidding documents. The local government had not conducted a preparatory investigation, causing uncertainty about both the potential installed capacity and power output of the project. There was also insufficient wind measurement or land data for the 2005 Jimo wind farm in Shandong, and the technical feasibility study required by the NDRC was missing. During the construction period, the scale of the project was reduced.

These contradictions over land use also occurred for other projects. In the end, some projects had to be cancelled. During implementation, the winning developers found that many problems which should have been solved in the preparatory period had not been dealt with, and the developer had to start again from scratch.

B. The phase II price, the so-called "average market price at that time", has been estimated by bidders. The purpose of phase II is to make sure that the price is fixed during the period of the loan, normally 15 years. Once the period of electricity generation has exceeded 30,000 hours, the operating cost is greatly reduced due to the payback of the loan. At that time, the company can operate well, even when the average market power price is adopted. In practice, however, some bidders have reduced their phase I bidding price by increasing their phase II price. The difference is in a range from 0.3038Yuan/kWh to 0.5425Yuan/kWh. If the winning price is low, however, the operation of the company during the loan period will be strongly affected, making it difficult to repay the investment.

C. There is a need for clear regulation over the checking of completion of a project. In the first three rounds of bidding, localised products is only a preliminary criteria in the project design. After winning the bid, the developers could therefore accept other offers of equipment. So it is very likely that the equipment will end up being different from the bidding plan. In the fourth round, the investors and equipment suppliers bid jointly and provide an equipment localisation plan. Because the regulations on the checking of the completion of the project are not fully published, there is no clear sanction on the investors if they cannot meet the standard promised in the bidding.

4. Change of conditions for concession bidding in the fifth round

The fifth concession project bidding introduced some major adjustments to the bidding documents based on the previous four rounds. The most important one was a change to the evaluation plan for the bidding power price. In the first four rounds, the bidder with the lowest bidding price had the most advantages. In the fifth round, a completely new power price evaluation method is used, the formula being as follows:

$$\text{Score} = \left(1 - \frac{|X_n - A|}{A}\right) \times 25$$

In this formula, $A = \dfrac{X_1 + X_2 + X_3 + \cdots + X_n - X_{\max} - X_{\min}}{n-2}$

$X_1, X_2, X_3 \cdots, X_n$: represents the bidding prices of bidders passing the initial evaluation

$X_{\max}, X_{\min}$: represent the highest and lowest prices of bidders passing the initial evaluation

n : represents the number of bidders passing the initial evaluation.

The weight of the bidding price is still 25% and those bidders with the bidding price closest to the average bidding price score the highest, but the purpose of the new formula is to discourage some bidders from using an unreasonably low bidding price to win the bid.

Another major adjustment relates to the specific regulation for wind power equipment manufacturers. As a supplier joining the bidding, one manufacturer can sign supply contracts for a single type of wind turbine with up to three developers. In the first four rounds, a supplier contract had to be exclusively with one developer. This adjustment means that developers have more choice of turbines, making the technical plan more scientific and reasonable.

Meanwhile, some adjustment has been made to the bidding papers according to the changes of national policies and relevant technical regulations and different requirements of the bidders. At this point in time it is difficult to evaluate the fifth round of bidding since the results have not yet come out. However, the adjustments are good news in terms of optimising the wind power grid–connected pricing mechanism.

6 Wind Power and the Environment

Renewable energy is clean and sustainable. Wind is one of the most competitive and promising renewable energies. But every coin has two sides. Wind energy brings great environmental benefits but also negative side effects. These effects include noise, visual intrusion, bird mortality and electromagnetic radiation. Compared with conventional power generation, however, wind power has few environmental effects and these are avoidable.

6.1 Environmental Benefits of Wind Power

According to the Fourth Assessment Report released by the Intergovernmental Panel on Climate Change (IPCC), the warming of the earth over the past half century has been caused by human activities (greater than 90% certainty). The main culprits are the greenhouse gases emitted by burning of fossil fuels, in particular carbon dioxide (CO_2). Wind power can provide energy whilst reducing the emission of CO_2. According to the World Energy Commission, using one million kWh of wind power will save 600 tons of CO_2 emission. Therefore massive use of wind power will help mitigate climate change.

The use of wind power can also avoid regional environmental problems brought about by the burning of coal. According to the NDRC, SO_2 and smoke emitted by the burning of coal account for 70%–80% of the total. Acid rain caused by SO_2 already covers one third of the land in China. Pollution has serious impacts on socio-economic development and the health of the people. The World Bank estimates that the environmental and health losses caused by air pollution will reach 13% of GDP by 2020.

6.2 Environmental Impacts of Wind Power

6.2.1 Noise

The noise of wind farms come from two sources: mechanical noise and airflow noise. The mechanical noise is made by the generator, gearbox and blades whereas the airflow noise occurs when the air flows across the blades and the turbines. With the increasing sophistication of manufacturing technology, the noise from wind turbines is generally decreasing. Compared with other noise sources such as transportation, construction and industry, the noise from wind turbines is also very low. Wind farms are generally constructed far away from the residential areas and have little impact on the lives of people.

Table 6 Comparison of noise sources

Noise source	Noise density /dB
Jet plane engine 250 metres away	105
Electric drill 7 metres away	95
48 km/h truck 100 metres away	65
64 km/h car 100 metres away	55
Wind farms 350 metres away	35–45
Bedroom	35
Village at midnight	20–40

6.2.2 Visual impact

China is rich in wind resources in remote or coastal areas. The population density near wind farms is generally very low and they are mostly built on hills with poor soil, seldom in places with fertile land or plenty of water resources. Even in agricultural or coastal areas, grazing or drying seafood can still be carried out where wind farms are located. Most people treat white wind turbines as a beautiful sight and symbolic of a clean environment and sustainability. Relativity applies to everything, but wind farms bring much less visual damage than fossil fuel or nuclear plants, regardless of other environmental pollution.

Currently, wind farms are used as a tourist attraction in many places in China. For example, from June to September, a number of tourists visit the Huitengxile wind farms in Inner Mongolia – riding horses, looking at flowers, eating barbecued lamb or having a fire party. The income to the local herdsmen from tourism could represent half of their total income.

6.2.3 Impact on birds

The construction of wind farms can result in impacts for the habitat, breeding and feeding of birds. The turning blades can also kill flying birds. According to Chinese regulations an environment assessment should be made before a construction project is started. This report must include the impact on birds. The assessment must also address the issue of whether the location of the wind farm is on a bird migration route.

In general, birds are familiar with their surrounding location and when they find a newly built wind farm, they will select other places to fly. Improving technology has also reduced the speed of the blades compared to older designs of the same capacity, thus reducing the harm to birds. According to a study in the United States, the level of accidents to birds caused by wind turbines represents just 0.01%–0.02% of all bird accidents. A 2003 study in Spain indicated that the 692 wind turbines in 18 wind farms caused the death of 89 birds, 0.13 birds per wind turbine.

A report produced by the UK's Royal Society for the Protection of Birds confirmed that the greatest long term threat to birds comes from climate change. Changes in plants and the lifecycles of insects will make some places unsuitable for birds. According to the latest research, climate change will cause the extinction of one third of animals and plants, including birds, by the middle of the 21st century. Compared to such an outcome, the harm caused by wind turbines is insignificant.

6.2.4 Electromagnetic radiation

Electromagnetic radiation is line–frequency radiation generated when electronic equipment is operating. In a wind farm the radiation is created by the generator, electric motor, electricity substation and transmission line. The radiation generated by the generator and electric motor is comparatively weak. If the capacity of the electricity substation and transmission line is over 100kV, the radiation generated must be taken into account. At below 100 kV, the radiation is much less strong.

6.2.5 Environmental impacts of offshore wind farms

There are presently no commercial offshore wind farms in China, although pilot projects are ongoing. Europe has the largest number of offshore wind farms in operation. Offshore wind farms can bring two side effects. One is electromagnetic disturbance, the other is noise. The magnetic field generated by the transmission line could have an impact on both sea animals and plants. To avoid this electromagnetic field, multi–conducting cables are used. With regard to noise, some research indicates that the noise made by wind turbines is at the same level as that of fishing boats and waves, thus having little impact on sea animals or plants. Practical experience shows that some sea creatures enjoy living around the foundations of wind turbines in Europe's North Sea, and even lay their eggs there.

To summarise, wind power has little negative impact on the environment. On the other hand it plays a very important role in terms of improving the energy structure, reducing environmental pollution and greenhouse gas emissions and slowing down climate change. According to a rough estimate, if 30GW of wind power was installed in China by 2020 and the annual power generation reached 60 billion kWh, the emission reduction of SO_2 and CO_2 would be 900 million tons and 36 million tons respectively. At the same time, 420 million tons of solid pollutants would be also reduced. Looked at another way, if we don't use clean and renewable energy but rely on fossil fuels, the resource will eventually be exhausted and the pollution and climate change brought about by using fossil energy will prove fatally damaging to the human environment.

7 Key Regions for Wind Power Development

The wind resource is distributed unevenly in China. The northern part and coastal areas are rich in wind, and it also varies from province to province. The places with the richest wind resource include Inner Mongolia, Xinjiang, Hebei, Jilin, Liaoning and Guangdong[1]. The details are described below.

7.1 Inner Mongolia Autonomous Region

7.1.1 Wind Resource

The area with a wind density higher than 150W/m^2 at a height of 10 metres covers about 105,000km^2. The technically exploitable capacity is 150GW. The areas with a rich wind resource range from east Hulunbeierxi rangeland to Bayanzhaer.

The first wind farm was built at Zhurihe in Suniteyouqi in 1989, where 100kW wind turbines with variable pitch from the United States were installed. In the 1990s, the focus was on the development of Huitengxile wind farm of Chayouzhongqi, using turbines made in Denmark and the US. By the end of 2004, the total installed capacity was 69MW. After 2004, the development of wind farms in the eastern part of Inner Mongolia was accelerated. Several 100MW wind farms were built, such as Saihanba wind farm in Keshiketengqi and Sunjiaying in Wengniuteqi.

By the end of 2006, the total installed capacity in Inner Mongolia reached 509MW, of which 182MW was installed in the western part of Inner Mongolia and 327MW in the east.

7.1.2 Electricity Price

In 2005, the grid–connected electricity price for desulphurised coal–fired electricity was 0.257 yuan/kWh. By comparison, in the 200MW concession project at Damaoqibayin, with estimated working hours at full operation of about 2,380 hours,the bidding price was 0.4656Yuan/kWh. In the 300MW concession project at Huitengliang in Xilinhaote, with estimated working hours at full operation of about 2,730 hours, the bidding price was 0.4200Yuan/kWh. The electricity price for non–bidding projects is about 0.5Yuan/kWh (without tax) or 0.55Yuan/kWh (with tax). The grid–connected electricity price for wind power approved by the central government is about 0.54Yuan/kWh (with tax). The grid–connected electricity price for wind power in Inner Mongolia is therefore around 0.54Yuan/kWh.

7.1.3 Grid

The west part beyond Xilinhaote belongs to the West Inner Mongolia Grid whilst Chifeng in the east is connected to the North–east Grid. A transmission line is needed if the wind farms are to be developed at a large scale. By the end of 2005, the total of grid–connected power generation in full operation was 9.31GW, with 8.95GW on the West Inner Mongolia grid, 465MW on the Chifeng grid and 378MW on the Tongliao grid.

7.1.4 Manufacturing Industry

A wind turbine assembly factory has been established by the Xinjiang Gold Wind Technology Company and the German–Sino Ruineng North Wind Corporation.

7.2 Hebei Province

7.2.1 Wind Resource

The area with a wind density higher than 150W/m^2 at a height of 10 metre high covers about 7,378km^2. The technically exploitable wind capacity is 8.69GW. The areas with a rich wind resource are Bashang in Zhangjiakou, Weichang and Fengning in Chengde and Huangye harbour.

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① The main contents of this chapter is provided by Mr. Shi Pengfei.

In 1996, the first wind farm was built near Huicai in Zhangbei. The installed capacity was 10MW, using wind turbines from Denmark, Germany and the US. After 2001, new wind farms began to use national wind turbines made by the Golden Wind Company. Some turbines have been installed in Longhua. By 2006, the total installed capacity of Hongsongwa wind farm in Weichang was 106MW.

By the end of 2006 the total installed capacity in Hebei was about 326MW. Of this, 218MW was installed in Zhangjiakou and 108MW in Chengde.

7.2.2 Electricity Price

In 2005, the grid–connected electricity price for desulphurised coal–fired electricity was 0.345Yuan/kWh. In the southern part of Hebei the price was 0.339Yuan/kWh. By comparison, in the 200MW concession project at Shanhe in Zhangbei, with estimated working hours at full operation of about 2,370hours, the price was 0.5006Yuan/kWh (without tax). Electricity prices for non–bidding projects were about 0.55–0.60Yuan/kWh (without tax) or 0.60–0.65Yuan/kWh (with tax). The grid–connected electricity price approved by the central government is 0.54 Yuan/kWh (without tax) and 0.61Yuan/kWh (with tax). The grid–connected electricity price for wind power in Northern Hebei is therefore 0.54Yuan/kWh and 0.61Yuan/kWh in other parts of the province.

7.2.3 Grid

The northern part of Hebei belongs to the Jingjintang Grid. The total installed capacity in 2005 was 29GW, expected to increase to 36GW by 2010 and 57GW by 2020. The wind sites at Bashang in Zhangjiakou and the northern part of Chengde are located at the end of the grid. A transmission line is needed if the wind farms are to be developed on a large scale.

7.2.4 Manufacturing Industry

There are many power companies and new energy companies in the national high–tech development zone of Hebei. The blade manufacturer Zhonghang Huiteng Wind Power Company, controller manufacturer Kenuo Weiye Company and wind turbine manufacturers Huide Wind Engineer Company and Boding Tianwei Wind Technology Company are all located in the established wind power section. At Longhua in Chengde, Golden Wind has also set up an assembly plant producing 750kW turbines.

7.3 Liaoning Province

7.3.1 Wind Resource

The area with a wind density higher than 150W/m^2 at a height of 10 metres covers about 2,100km^2. The technically exploitable wind capacity is 2.52GW. The areas with a rich wind resource are along the coastal areas and islands of Liaodong peninsula as well as in the north–west part of Liaoning near Inner Mongolia.

The first wind farm was built at Donggang in Wafangdian in 1994, using wind turbines from Denmark and the US. The first MW–level wind turbines were installed at Jiulongdi in Bayuquna in 2001. Between 2000 and 2006 more wind turbines made in China were installed there, as well as a small number of turbines made by the joint venture between Xi'an Weide Company and Tuomeide Company, Shenxin Company and Huide Company. Shenyang Industry University has recently carried out some tests at this wind farm, which contributed to the localisation of the wind turbines. Before 2002, wind farms were installed in coastal areas or islands of the Liaodong peninsula, but development has recently accelerated in the north–west part of Liaoning, including a 50MW wind farm installed at Zhangjia in Changtu.

By the end of 2006, the total installed capacity in Liaoning was 232MW, of which 94MW was installed in the coastal area of Liaodong Peninsula and 138MW in the north-west.

7.3.2 Electricity Price

In 2005, the grid-connected electricity price for desulphurised coal-fired electricity was 0.347Yuan/kWh. The price for wind power approved by the local government ranges from 0.65Yuan/kWh to 0.70Yuan/kWh (with tax). There is no grid-connected electricity price approved by the central government.

7.3.3 Grid

By the end of 2005, the total installed capacity of the province was 17.36GW, and is expected to reach 27GW by 2010 and 50GW by 2050. Liaoning is the load centre of the North-east Grid. The grid has no limitation for the development of wind power.

7.3.4 Manufacture Industry

There are gearbox and generator manufacturers in Dalian. Huarui Wind Technology Company, part of the Dalian Heavy Industry Group, Huachuang Wind Energy Company and GE (Shenyang) Wind Energy Company are all wind turbine manufacturers.

7.4 Jilin Province

7.4.1 Wind Resource

The area with a wind density greater than 150W/m^2 at a height of 10 metres covers about 511km^2. The technically exploitable wind capacity is 600MW. The areas with rich wind resources are Baicheng, Tongyu, Changling and Shuangliao in the west.

The first wind farm was built at Gengsheng in Tongyu in 1999, using wind turbines from Spain and Germany. Five years later a second wind farm was installed in Baicheng. Wind power developed very fast after that. In 2004, Longyuan Power Group and Huaneng New Energy Company won the tender for the Tongyu Wind Concession Project. The total installed capacity will be 400MW, which will make it the largest wind farm in China. Longyuan and Huaneng will install 200MW respectively and share a single transformer station at Dongxinrong. By the end of 2006, the total installed capacity was 253MW.

7.4.2 Electricity Price

In 2005, the grid-connected electricity price for desulphurised coal-fired electricity was 0.339Yuan/kWh. By comparison, for the 200MW concession project at Dongxinrong in Tongyu, with estimated working hours at full operation of about 2,310 hours, the price was 0.5090Yuan/kWh. The electricity price for non-bidding projects was about 0.5-0.6Yuan/kWh (without tax) or 0.55 -0.65Yuan/kWh (with tax). The grid-connected electricity price approved by the central government is 0.61Yuan/kWh (with tax). The grid-connected electricity price for wind power in the province is 0.61Yuan/kWh.

7.4.3 Grid

The western part of Jilin is far away from the load centre. Driven by the wind concession projects and coordinated by state and provincial governments, the State Grid, North East Grid and Jilin Grid have together set up transmission lines and transformer stations to address the issue of developing large scale wind power.

7.4.4 Manufacturing Industry

At present there are no wind turbine or components manufacturers.

7.5 Guangdong Province

7.5.1 Wind Resource

The area with a wind density greater than 150W/m^2 at a height of 10 metres covers about 2,024km^2. The technically exploitable wind capacity is 2.46GW. The areas with a rich wind resource are the coastal areas and islands. Typhoons are common in these areas, on the one hand contributing to increased power generation, on the other threatening to damage the wind turbines.

Guangdong has a long history of developing wind power. The first wind farm was built on Nan'ao Island in 1989, using Swedish wind turbines, and later extended with turbines from Denmark and the US. Some local wind turbines were also demonstrated there. Niutouling wind farm was the first to use foreign investment whilst Shipeishan wind farm at Huilai was one of the first batch wind concession projects. The total 100MW capacity was supplied by Gold Wind. Honghaiwan wind farm was hit by the "Dujuan" typhoon in September 2003 and nine turbines were damaged, with a broken blade each. This is the first accident in which wind farms have been affected by a typhoon.

By the end of 2006, the total capacity of Guangdong was 211MW, of which 152MW was installed in the coastal area and 59MW on Nan'ao Island.

7.5.2 Electricity Price

In 2005, the grid-connected electricity price for desulphurised coal-fired electricity was 0.439Yuan/kWh. By comparison, for the 100MW concession project in Huilai, with estimated working hours at full operation of about 1,990 hours, the price was 0.5013Yuan/kWh. Referring to the price of the wind concession projects, the Gongdong government set the grid-connected electricity price for wind power at 0.528Yuan/KWh.

7.5.3 Grid

At the end of 2005, apart from 10.88GWh from the "transmitting electricity from the West to the East Project", the total installed capacity of power in the province had reached 48.08GW. Of this 19.18GW came from units an installed capacity over 300MW, accounting for 40% of the total. Guangdong is the load centre of the North-east Grid. The grid has no limitation for the development of wind power.

7.5.4 Manufacturing Industry

Zhongshan Mingyang Wind Power Company is developing 1.5MW wind turbines designed by a German company but self-patented. Test models are under demonstration now.

7.6 Xinjiang Uighur Autonomous Region

7.6.1 Wind Resource

The area with a wind density greater than 150W/m^2 at a height of 10 metres is about 80,000km^2. The technically exploitable capacity is 120GW. Areas with a rich wind resource are Dabancheng, Xiaochaohu and the "wind gate" of Ala Mountain, which has the geographic advantage of increasing the wind speed.

Xinjiang was the first province to develop wind power on a large scale. Some Danish turbines were installed around Dabancheng for testing in 1986. The first wind farm was established in 1989, using a Danish grant. Altogether 13 wind turbines with a capacity of 150kW each were installed, reaching a total of 1.95MW. The wind farm was the biggest at that time, and provided much experience of linking wind power to the grid. Xinjiang led the wind market up to 2001, but due to the limited capacity of the grid development subsequently slowed down.

By the end of 2006, the total installed capacity was 207MW, concentrated in Dabancheng, and with 2MW located in Buerjin and the wind gate of Ala Mountain.

7.6.2 Electricity Price

In 2005, the grid–connected electricity price for desulphurised coal–fired electricity was 0.235Yuan/kWh. The Xinjiang government set the grid–connected electricity price for wind power at 0.51Yuan/kWh and 0.47Yuan/kWh.

7.6.3 Grid

By the end of 2006, the total installed capacity in Xinjiang had reached 7.52GW, with 1.57GW from hydro power (20.9%), 5.29GW from coal (70.3%), 470MW from natural gas (6.3%) and 190MW from wind power (2.5%). Xinjiang has a large area but small power demand. The major bottleneck for developing wind power is limited grid and transmission capacity.

7.6.4 Manufacturing Industry

Xinjiang was the first province to promote localisation of wind turbine manufacture. In 1997 Xinjiang Wind Energy Company signed a contract with the German Jacobs business to manufacture gearboxes and generators in China. They replaced all the components from Jacobs with their own products, testing and improving their product quality based on lessons learned and eventually bringing their own version of Jacobs turbines to the market, establishing the Xinfeng Tech and Industry Company. The name was later changed to Xinjiang Golden Wind Company, which is a stock holding company rather than a state–owned company. Over the next ten years Golden Wind gained the largest share of the national wind turbine market.

Golden Wind has two manufacturing factories in the Economic and Technology development zone of Wulumuqi and one national wind engineering centre. Apart from R&D and the production of wind turbines, they have also assigned one workshop to LM of Denmark for blade manufacture. Outside Xinjiang, Golden Wind has established the Chengde Longhua Factory and two assembly workshops in Beijing and Baotou. Finally, they have set up a German Golden Wind Company to carry out R&D and develop an international market.

7.7 Jiangsu Province

7.7.1 Wind Resource

The total wind resource amounts to 34.69GW. The technically exploitable area covers about 1,505km^2, with a capacity of 1.77GW. The wind resource decreases steadily as you move away from the coast. The coastal and Taihu Lake areas are rich in wind resources whilst the inland resource is relatively poor. There is a sharp contrast in wind resources between the east and the west.

Jiangsu has witnessed a rapid development of wind power in recent years. From 2003 to 2005, Jiangsu joined the national concession projects bidding for three consecutive years. The total bidding was for 450MW. Four further wind farms with an installed capacity of 200MW each will be developed following the conditions of the concession projects. By the end of 2006, the total installed capacity in Jiangsu had reached 108MW, with all 68 turbines installed in Rudong County.

7.7.2 Electricity Price

In 2005, the grid–connected electricity price for desulphurised coal–fired electricity was 0.371Yuan/kWh.

The bidding price for wind power was 0.4365Yuan/kWh, 0.4877Yuan/kWh and 0.519Yuan/kWh (with no tax). The grid-connected electricity price for wind power in Jiangsu is relatively low.

7.7.3 Grid

Jiangsu is part of the Huadong Grid and composed mainly of coal-fired power stations. There is a great demand for coal, 80% of which comes from other provinces. Wind power will help improve the power structure of the province, help solve power shortages and promote economic development and environmental protection.

7.7.4 Manufacturing Industry

A joint venture Nantong A Wanyuan Wind Equipment Manufacturing Company has been set up by the Beijing Wanyuan Industrial Company, Spain Acciona Energy Group and Inceisa Industrial and Trading Co. Ltd in the city of Nantong. The company has started producing 1.5MW turbines. Nangaochi Company also produces gearboxes whilst other companies manufacture parts such as towers.

7.8 Shandong Province

7.8.1 Wind Resource

The total wind resource amounts to 61.50GW. The technically exploitable area is about 619km^2, with a capacity of 950MW. The wind resource is concentrated in islands, peninsulas and high mountains. The average wind speed at a height of 70 metres is about 5.4–8.0 metres/second, giving an annual average wind power density of about 220–580W/m^2. The period during which wind speed is over 3m/s is between 7,000 and 8,000 hours.

Wind power development in Shandong started in the 1980s. In 1983, three wind turbines with an installed capacity of 55kW were imported from Denmark, three of which were installed at Malan Bay in Chenshantou, part of Rongchen City. One of the turbines was used as a test unit. Two turbines produced locally were installed in October 1989. By the end of 2006, the total installed capacity of wind power in Shandong had reached 148.5MW, ranking it the 10th province in China.

7.8.2 Electricity Price

In 2005, the grid-connected electricity price for desulphurised coal-fired electricity was 0.33Yuan/kWh. There has been no successful bidding project in Shandong so far. The non-bidding electricity price is around 0.5–0.7Yuan/kWh (without tax) or 0.55–0.78Yuan/kWh (with tax).

7.8.3 Grid

The grid is dominated by fossil fuel-fired power stations, with 99% of the power coming from coal. 40% of this is imported from other provinces. During the 11th five year plan, Shandong will speed up the construction of a 500kV main grid.

7.8.4 Manufacturing Industry

There are no wind power equipment manufacturing companis in Shandong.

8 Development Outlook and Policy Recommendations

8.1 Lessons Learned

The current development trend convinces us that we will meet the 2010 target of 5 million kW of installations by the end of 2008, two years ahead of schedule. This means that it will be easily achievable to reach 30 million kW of installations by 2020. The long term target is to make wind power competitive with conventional power technology by 2020 and become the third major source of electricity following hydro and fossil fuels.

Once the installed capacity has reached at least 30 million kW, the government should make every effort to increase wind power to 100 million kW, when it will contribute 10% of total power capacity. The aim should then be to increase the installed capacity of wind power to 500 million or 1 billion kW by around 2040 or 2050, representing 20% of total installed capacity. In order to meet this target, we need to spend five to ten years (2010 to 2015) on establishing a strong technical and industrial foundation for the wind power industry. The following measures should be considered.

1. We should clarify the short term and long term targets for wind power. Strategically, the main goal up to 2020 should be to encourage the localisation of wind equipment manufacturers, reducing the cost of wind turbines, which normally account for 70% of total wind project costs. Another important goal should be to promote the economic development of poor areas with rich wind resources.

2. We should learn the lessons from the wind concession projects and develop dozens of large wind farms with a capacity of 100 or 300MW each. At the same time we should adopt feed-in-tariff policies so as to encourage the development of small scale wind projects and establish a stable wind power market.

3. The wind turbine manufacturers should grasp the opportunity of increasing their market by scaling up their production capacity, importing international advanced technology and producing new generation wind turbines, especially MW-rated products. They should learn the lessons from experience so far, improve their R&D capacity and reduce manufacturing cost. Even though wind turbine and component manufacturers are not obliged to meet the renewable energy quota, they should ensure the quality of their products and receive a reasonable profit.

4. The development of wind power depends on the status of the local economy and the grid capacity. In coastal areas where the economy is well developed but there is a shortage of energy, wind power should be rapidly expanded. In western China, rich in wind resources, wind power should be promoted by increasing the grid capacity.

5. Full use should be made of the various mechanisms under the international climate change agreements. Records show that 90% of non-concession wind projects in China have applied to be registered under the Kyoto Protocol's Clean Development Mechanisms since 2005. Additional funding generated through the CDM credits could further stimulate the growth of wind power. The international carbon market will continue to provide additional incentives for the Chinese wind market in terms of money and technology.

6. The development of large-scale wind projects should be combined with decentralised projects. Decentralised energy systems will become an important form of future development. In Germany, for example, there is no single wind farm exceeding 100MW yet the total installed capacity has surpassed 18GW. It is therefore important to develop small to medium sized wind farms, depending on the local resource. When the rural grid connection has been strengthened, single turbines can also be connected to the grid.

7. Preparations should be made for the development of near-shore wind power. Near-shore areas of the sea have

higher and more predictable wind speeds, which helps increase the efficiency of the wind turbines. Moreover, the best near-shore wind resources are close to the eastern coast, where the grid load is centered and therefore have a regional advantage. Lessons should be learned from foreign examples so as to start resource assessment and prepare for large scale offshore wind farms in the future.

8. More investment should be made in R&D at the early development stage of the industry. The focus should be on quality rather than quantity. We should remind ourselves that wind power is an investment for power generation over more than 20 years in an exposed situation. The sustainable and fast development of wind power in the future depends on the serious lessons we are learning now.

8.2 Issues for wind power development

Wind power is a complex system, depending on wind resources, wind equipment manufacture, wind farm operation and grid construction. Although the Renewable Energy Law was passed in 2006, and the development of wind power in China offers good opportunities, there are still some issues to be addressed.

1. Wind resource assessments, the foundation for wind development planning, grid construction and wind resource management, are not accurate enough. It is therefore necessary to re-examine assessments of the wind resource in both inland and offshore areas, combining wind measurement data and modeling simulations. The research into short range weather forecast and relevant safety measures is also very important.

2. Innovation capacity is weak and a fully functioning wind industry is not yet in operation. At present, China is short of the technology to design and produce MW-scale wind turbines and their key components. We have to take action to support and promote technical innovation by the companies, accelerate technology transfer and knowledge and complete the manufacturing chain for turbine components.

3. Grid construction and management has not kept pace with the development of wind power. The variability of wind power will impact on the projection of grid loads and management of the grid. Wind power is not part of the grid construction plan. There are no regulations and instructions on how to connect wind power into the grid. We should formulate management regulations and technical specifications in order to bring wind power into the grid planning system. We should also clarify the relationship between wind power development and grid extension, ensuring both the safe operation of the grid and the reliable transmission of wind power.

4. The pricing system needs to be improved. The profit for a wind project relies on the grid-connected price. A wind project currently depends on the support of the central government regardless of how the price is initially decided. The current price for wind concession projects is too low, leading to many non-profitable projects. At the same time, low prices encourage a low manufacturing cost for components, which leads to poor quality. This will do harm to the wind power industry in a long run.

5. The public service system for supporting wind power is inadequate. A national public service for wind power could take advantage of existing technologies nationwide and carry out basic R&D. Public service systems in great demand at present include the State Wind Energy Technology Centre, the State Demonstration Wind Farms, the State Wind Turbine Testing and Demonstration Platform, the State Wind Power Information Centre, the State Wind Resource Assessment Centre and the State Wind Power Testing and Certification Centre.

6. A standards and certification system for wind power has been established, but yet to be improved. It is

important to accelerate the creation of technical supportive systems for standards, guidelines, testing and certificates.

8.3 Risks involved in investing in wind power

Investors face a number of potential risks through their involvement in wind power projects. These include:

1. Tariff risks. According to the No.7 Regulation released by the NDRC in 2006, the wind tariff should be decided through bidding. However, in reality the bidding tariff coexists with an approved tariff. The electric price varies a lot among different projects, many of which cannot guarantee proper profit. Investors therefore have to make a careful judgment as to whether a project will make a profit.

2. Wind resource risks. It is still difficult to calculate the expected wind power generation over a 20 year lifespan based on the current wind resource and micro location assessments. It is quite common that the actual wind generation is lower than the results from feasibility studies before the construction.

3. Wind equipment risks. If the actual output of the wind turbines is lower than that predicted by the turbine manufacturer then the maintenance fees will increase proportionately whilst the power generation will decrease.

4. Grid connection risks. The Renewable Energy Law states that "grid enterprises shall enter into grid connection agreements with renewable power generation enterprises that have legally obtained an administrative license or for which filing has been made, and buy the grid-connected power produced by renewable energy within the coverage of their power grid, and provide grid-connection services for the generation of power with renewable energy." However, these regulations have not been well implemented in practice. The grid company should not be an obstacle to wind development; instead it should try to improve its own capacity and strengthen the grid connection in order to support wind power.

8.4 Development Perspectives

Table 7 sums up three development scenarios for the Chinese wind market. The "low-speed development goal" refers to a conservative scenario, the accomplishment of which should be guaranteed by the existing policies. The "mid-speed development goal" refers to a highly likely scenario, where some more policy measures would be required. The "high-speed development goal" is an optimistic estimate which requires more investment in areas such as the feed-in-tariff system, grid connection, decentralised systems and R&D for offshore wind. The main difference among the three scenarios lies in the judgment made about the rate of development up to 2020, whilst the annual growth would remain more or less the same after 2020.

Judging from the fact that newly installed capacity reached 1.33GW in 2006, representing a 105% increase, it is forecast that the governmental wind target of 5GW by 2010 will be achieved by late 2007 or early 2008. By then, a domestic wind turbine manufacturing industry should have been established. The quality of the products should be further improved and matured, and the manufacturing capacity should also be expanded. From 2007 onwards, therefore, the annual increase in capacity should reach 50% and by 2010 the cumulative installed capacity should be 12-13GW. If by 2010 the total installed capacity of wind power could reach 12 GW, wind power electricity generation would amount to 24TWh, which means that wind would become an effective and important form of alternative power.

Table 7 Projection of wind power development in China

Year	Development Scenario (Low)			Development Scenario (Mid)			Development Scenario (High)			Global Annual Growth estimated byGWEC /%
	Installed Capacity /GW	Yearly Average Newly Installed /GW	Yearly Average Growth Rate /%	Installed Capacity /GW	Yearly Average Newly Installed /GW	Yearly Average Growth Rate /%	Installed Capacity /GW	Yearly Average Newly Installed /GW	Yearly Average Growth Rate /%	
2006	2.6			2.6			2.6			
2010	8	1.35	32.4	10	1.85	40.0	13.16	2.64	55.0	18.0
2015	20	2.4	20.1	30	4	24.6	48.87	7.14	30.0	18.0
2020	40	6.4	14.9	70	8	18.5	122.12	14.65	20.1	14.0
2030	120	8	11.6	180	11	9.9	268.56	14.65	8.2	7.0
2040	250	13	7.6	300	12	5.2	429.20	16.06	4.8	2.0
2050	400	15	4.8	450	15	4.1	611.30	18.21	3.6	0.5

It should not be a problem to achieve the "low target" of 40 GW by 2020. Based on the global annual wind power growth rate of 28.3% over the past ten years, this target could be achieved five years ahead. Based on the current European annual wind growth rate of 19% , the level of annual newly installed capacity could reach 8GW. By 2020, therefore, the total installed capacity could reach 70GW. By then, wind could account for 6% of the total installed power capacity in China and 2.8% of total power generation. If the policy environment could be further improved, then the installed capacity could reach 120GW, requiring an average of 24% growth between 2010 and 2020.

From 2020 onwards, wind should already be competitive with traditional power generation. According to the "low-speed development goal" , with the annual newly installed capacity set according to the European level of 8GW, by 2030 total installed capacity could reach 120GW. According to the "mid-speed development goal" , with annual newly installed capacity at over 11GW, which means a 30% growth rate (the same percentage level as in the EU over the last five years), then by 2030 total installed capacity could reach 180GW. Under this scenario, wind would account for 11% of the total installed power capacity and 5.7% of total electricity generation. According to the "high-speed development goal" , after 2020 the wind market will maintain an annual installed capacity of 14GW, reaching an installed capacity of 270 GW by 2030. Under this scenario, wind would account for 16% of the total installed power capacity and nearly 8.6 % of total electricity generation.

After 2030, most of the exploitable hydro resources would have been developed. Wind power would become the major form of power industry construction, with its important social and environmental benefits, mature technology and decreasing costs. By 2050, the installed capacity of wind power could reach 400-600GW. By that time, wind power would be the third largest power source after fossil fuels and hydro power.

8.5 Policy recommendations

In order to implement the Renewable Energy Law, address the problems mentioned above and obtain sustainable, rapid and regulated development of the wind power industry, the following actions are recommended.

8.5.1 Further improve the support systems

Improve the pricing system for renewable energy. The Renewable Energy Law states that "the grid-connected price for renewable energy should be decided on the principle of being beneficial to the development and utilisation of renewable energy and being economic and reasonable, with timely adjustment being made on the basis of the development of the technology and the utilisation of renewable energy." It is essential to set a reasonable and economic price for wind power in order to promote its development and utilisation.

So far, the government has introduced the "Temporary Implementation Rules for Setting up Feed-in Tariffs for Renewable Energy Power and the Sharing of Expenses in Purchasing Electricity from Renewable Energy", which means that an additional charge for renewable electricity is shared nationwide, balancing out the provinces through their utilities. However, we should further develop these rules and make the system work efficiently. Wind power is in its infancy and only a stable wind power market will be attractive to investors.

Finally, we should strengthen the financial investment and taxation policies. It is recommended that favourable VAT and income tax policies for wind farms and wind equipment manufacture should be introduced. We should conduct research and studies into a combination of policies, such as low interest loans for R&D on wind turbines and purchase of local wind turbines and wind projects, with an extended loan period. These measures will contribute to reducing the costs and accelerating the development of wind power.

8.5.2 Increase investment

The key period for the wind power industry is from now to 2010. Both basic R&D and a growing wind industry depend on investment from the government. Special funds are needed to carry out wind resource diversity assessments, grid construction to connect large scale wind farms, R&D for MW-scale wind turbines with their own patent, draft standards and regulations, the construction of demonstration wind farms and a public testing platform, wind resource assessments, professional training and capacity building. Only a complete financial programme can guarantee the rapid and healthy development of the wind power industry.

8.5.3 Further improve the regulatory system

The wind power industry is still small at present and it is easily coordinated by the government. Besides, it is not possible to set up a special department for managing the wind power industry. However, the industry involves the interests of many departments and has a very large manufacturing chain. Although the obligations of different departments towards the grid, power generation, meteorology, technical R&D, regulations and standards, equipment manufacturers and industrialisation are clearly described in the Renewable Energy Law, each department has its own plan, investment arrangement, cooperation units and priority projects. The Ministry of Science and Technology, for example, has listed R&D for wind power technology in its research and development guidelines and the investment is increased annually. Quite separately, the State Fund for Nature Science has also planned funding for basic R&D in wind power technology. It is not clearly described in the Renewable Energy Law how to combine these interests and take advantage of different departments to develop wind power in a healthy and rapid way. We should therefore set up an efficient coordination system which creates a good environment for wind power, a clearly important and promising energy source for the future.

The first step should be to establish a unique and powerful management system, taking advantage of national resources such as the State Wind Energy Technology Centre, the State Wind Energy Resource Assessment Centre and the State Wind Power Testing and Certification Centre. We should make good use of both finance and technology, carry out technical R&D and implement large wind power projects.

Figures & Tables

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