2010
CHINA WIND POWER OUTLOOK
中国风电发展报告

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October 2010

Foreword

The Chinese Renewable Energy Industries Association (CREIA) published *Wind Force 12 – China*, *China Wind Power Report 2007* and *China Wind Power Report 2008* with the support of Greenpeace, the Global Wind Energy Council (GWEC) etc. in 2005, 2007 and 2008 respectively. These reports were well received by readers both at home and abroad, and we have similar expectations for the publication of China Wind Power Outlook 2010. As a new wind power report was expected by people in the industry, CREIA organised experts from both China and overseas to edit and publish China Wind Power Outlook 2010 with the support of Greenpeace and GWEC. Our aim is to satisfy readers' desire to understand the latest situation on wind power development in China.

China Wind Power Outlook 2010 includes the main features of previous reports and some elements from GWEC's analysis of global wind energy, and tries to reflect the situation, characteristics and prospects for both global and Chinese wind power. The report covers strategic energy demand and resources, market capacity and equipment, market environment and policy, environmental issues and climate change, a historical perspective and prospects for the future. To provide a comprehensive overview for readers, we have tried to analyze and interpret all the main issues for wind power development in China in terms of both the global context and the country's broader energy development strategy. Our analysis also combines wind power development with energy saving and emissions reduction and the strategic objective that the consumption proportion of non-fossil energy will reach 15% by 2020.

Due to the need for haste and the limitations of the main authors' knowledge, the discussion of many issues raised in this report will be improved at the time of republication. It is hoped that readers will make comments and propose constructive suggestions for modifications that will make this an authoritative publication. During preparation of this report, both support and financial assistance were received from Greenpeace and the Global Wind Energy Council, and strong support from the Chinese Wind Energy Association and the Industry Association of Chinese Renewable Energy Societies, the China Hydropower Engineering Consulting Group Corporation, the Energy Research Institute of the National Development and Reform Commission, the SWERA Project of the United Nations Environment Programme, the National Climate Centre and the National Energy Bureau, to which we hereby express our gratitude.

Authors

1st October 2010

Foreword by Zhu Junsheng

Four or five years ago, when many were discussing how Spain had succeeded in taking the lead in wind power, China's wind power industry and its market remained at an early stage which was full of difficulties. It was difficult to imagine at that time that China would eventually take a leading position itself in the developing pattern of global wind power. Looking back to the preparation, commencement and development of Chinese wind power, we have succeeded, failed and explored unknown areas. This has been a process full of experiences and lessons learned from failures. It also indicates that China's wind power industry, although moving towards maturity, still has a long road to travel and needs to make persistent efforts.

We should firstly recognize the current international status of China's wind power development. China has now joined the front ranks of the world in terms of both the industrial and market scale of its wind power industry. However, in some respects China's international position as a large manufacturing country has not been changed. China remains dependent on Europe and America for the key design technology of wind turbine generator systems; the detection and certification systems for wind turbine generator systems are not sound; the developers of Chinese wind power lack experience in the long-term operation and maintenance of wind power plants; China's own technology for evaluation of wind resources is still at an early stage; and the cultivation and maintenance of Chinese skills in wind power remains insufficient.

China has therefore just taken the first and easy step in the development of wind power, owning the biggest market and output in the world. To face and address the long-term problems, China needs to learn constantly, create opportunities for international cooperation and communication, and establish a cooperative mechanism of win-win and multilateral wins with wind power corporations and research institutes all over the world in order to learn other countries' strong points, compensate for her own weak points, and develop together.

The second point is that the rapid development of China's wind power should be regarded calmly and objectively. As a rising high-tech industry, its technological reliability needs to be examined through a long-term operating cycle. With less than 10 years experience in wind power development and no more than 5 years experience in the installation and operation of large-scale wind turbine generator systems, China is still unable to guarantee the reliability of the systems or declare that the development speed of its wind power market is definitely impressive. Investors need to consider its development in the long run and regard wind power as a practical option for future energy substitution. The development of wind power needs cooperation and efforts from all types of stakeholders over a long period, and it should not be merely regarded as a tool to pursue short-term benefits.

Thirdly, it would be prudent to develop an offshore wind power industry. Offshore wind power has become a hot topic recently. However, this is only limited to media reports and discussions on policy. Compared with the operation of land-based wind power, the conditions for the operation of offshore wind power are more complicated; it is more demanding in terms of technology and it is more expensive to address problems. Therefore, rational investors will give priority to land-based wind power for quite a long time and test offshore systems against onshore ones rather than investing in deep-sea wind power blindly. To be objective, offshore wind power will attract new investment soon but it will not become a focus for large-scale investment.

Fourthly, it is most important that both technological progress and quality control should be made consistent. From development to maturity, the wind power industry has to pass the test of both technology and quality, which is also the basis for measuring the strength of a wind power enterprise. We therefore believe that an enterprise with consistent technological improvement and quality control will be the final winner.

Finally, I wish that the practitioners of wind power in China bear more social responsibility, contribute more passion and wisdom to the great movement of energy reform, find a healthy, sustainable and steady development road through the intense market competition, and thereby contribute to the common future of humanity.

Zhu Junsheng

President of Chinese Renewable Energy Industries Association

Foreword by Kumi Naidoo

I recently visited the Guanting wind farm near Beijing, and what an inspirational experience it was. Located in farmland, this quiet and clean wind farm will soon generate enough electricity to supply 200,000 households in Beijing. It will save 200,000 tons of CO_2 every year – and that is just one wind farm.

Imagine wind farms such as the one I visited dotted across China, replacing dirty, dangerous coal-fired power stations and mines. Imagine the improvement in the quality of life of millions of Chinese people – and imagine the contribution the country could make in the global struggle against catastrophic climate change.

This is not an empty dream. Over the last four years, the wind power market in China has grown annually by more than 100%. We are expecting another significant jump in 2010. Five years ago, the Chinese government announced plans to install 30 GW of wind power by 2020. In fact, things have gone so well that, right now, two wind turbines are being built in China every hour. This report predicts that wind capacity could reach over 230 GW by 2020 in the most ambitious scenario. Wind is becoming a Chinese success story.

There are still major hurdles to overcome. China remains the world's biggest producer and consumer of coal. This dirty, old-fashioned form of energy is not only the single biggest contributor to climate change, its pollution also poses a daily health hazard for people across China. But, here too, things are progressing: over the last three years, more coal-fired power stations have been shut down in China than the total electricity capacity of Australia.

By choosing to cut their dependence on dirty energy sources, and by focusing on renewable energy instead, China can equip itself with a clean, secure and independent means of energy that is guaranteed for generations to come. The wind doesn't stop blowing. Government investment in this sector would also provide the country with thousands of new jobs.

What inspires me most in all of this is that by choosing to go down the road of renewable energy, China could pride itself on having had both the foresight and the courage to become the country that led the world in the struggle against catastrophic climate change. It could pride itself on having contributed massively to guaranteeing a safe and secure future for all of our children and grandchildren.

China has all the potential to become the world's clean energy superpower, the world reference for low carbon development – to me, that is very exciting to witness.

Kumi Naidoo

Executive Director, Greenpeace International

Foreword by Steve Sawyer

GWEC is very pleased to support and contribute to the 2010 version of the China Wind Power Report. It is the definitive work on this subject and a source of much useful information for those interested in the world's most dynamic wind power market.

The story of the Chinese wind industry is remarkable indeed. From a small series of demonstration projects in the early part of the last decade, the Chinese market has grown in a few short years into the world's largest, and passed Germany to become No.2 in cumulative installed capacity at the end of 2009. From a near complete reliance on imported equipment, a domestic industry has undergone explosive growth and now boasts three manufacturers in the global top 10 and five in the top 15, supplying more than 80% of the domestic market; and a number of China's domestic manufacturers are developing serious export strategies. Another 2009 milestone was the construction start on China's first offshore wind farm near Shanghai, with construction completed in the first half of 2010.

China's success has been driven by a unique combination of a rapidly growing economy and electricity demand, combined with a clear and unambiguous commitment on the part of the government to develop wind power in order to diversify the electricity supply, make the overall economy more energy efficient, create a domestic industry with global leadership potential and at the same time reduce carbon emissions. International political leaders talk much about capturing the energy markets of the future; China's leadership is walking the talk, providing clear signals and direction to the marketplace. The results speak for themselves. Clear medium term targets, the ambitious wind base programme and the new push for offshore development set the industry on a clear path for continued growth and expansion.

Of course, this rapid growth has not been without its problems. Grid connection remains a problem, and only government action can open up the bottlenecks that delay grid connection for new projects, or cause production curtailment for existing projects in some grid-congested areas. In addition, there is a universally recognised need to change the focus from 'quantity' to 'quality' which is already underway.

One of the best ways to facilitate this is further opening the market to international players with more experience in such areas as certification, standards, grid management, resource assessment, forecasting and other consulting services, which are necessary to improve the quality and performance of the industry. As major Chinese players begin to establish themselves abroad, we believe that this will facilitate this 'knowledge exchange'. However, the government could do more by providing guidance and setting standards and requirements in this area.

Having said this, the Chinese government and industry has been very willing to listen to and learn from international experience, from the early days of the first demonstration projects through to the formulation of the landmark Renewable Energy Law. Now, in addition to learning the lessons from elsewhere on quality control and grid management, the Chinese industry has something to teach about low cost manufacturing and rapid deployment, where they are the clear leaders. We look forward to working with our Chinese partners to continue to facilitate this exchange to the benefit of the Chinese market, and the global market as a whole.

Given the rapidity and scale of development in China, no doubt this report will need to be updated soon!

Steve Sawyer

Secretary General, Global Wind Energy Council

Executive Summary

1. Current Status of Global Wind Power

In 2009, despite the ongoing international financial crisis, the global wind power industry continued to expand rapidly, achieving an annual growth rate of 41%. The European Union, the USA and Asia dominate global wind power development. China ranked first in the world for newly installed capacity.

According to statistics compiled by the Global Wind Energy Council (GWEC), total installed capacity of global wind power reached 158 GW, a cumulative growth rate of 31.9%.

The global wind power industry has not only become an important part of the world energy market but is also playing an increasingly important role in stimulating economic growth and creating employment opportunities. According to GWEC, the total output value of the installed capacity of global wind power has already reached 45 billion euros and the number of people employed in the industry was approximately 500,000 in 2009.

By the end of 2009 more than 100 counties around the world had started developing wind power, and more than 17 countries each had over 1 GW of cumulative installed capacity. The top ten countries for cumulative installed capacity were the USA, China, Germany, Spain, India, Italy, France, Britain, Portugal and Denmark.

Asia became an important new market in 2009, exceeding the levels in both America and Europe and mainly stimulated by China and India. Newly installed capacity in China was 13.8 GW and the cumulative installed capacity reached 25.8 GW.

2. Status of Wind Power in China

1) Wind resources

China has a vast land mass and long coastline and is rich in wind energy resources. Studies show that the potential for exploiting wind energy in China is enormous, with a total exploitable capacity for both land-based and offshore wind energy of around 700-1,200 GW. Other assessments suggest even higher figures up to over 2,500 GW. Wind power therefore has the resource basis to become a major part of the country's future energy structure. Compared with the current five major countries for wind power, the extent of wind resources in China is close to the USA and greatly exceeds India, Germany and Spain.

Wind energy resources are particularly abundant in the southeast coastal regions, the islands off the coast and in the northern part (northeast, north and northwest) of the country. There are also some places rich in wind energy in the inland regions. Offshore wind energy resources are also plentiful.

The geographical distribution of wind energy resources is mismatched with the electrical load, however. The coastal areas of China have a large electrical load but are poor in wind energy resources. Wind energy resources are plentiful in the north, on the other hand, but the electrical load is small. This brings difficulties for the economic development of wind power.

2) Market overview

In 2009, the Chinese wind power industry was a global leader, increasing its capacity by over 100%. Its cumulative installed capacity now ranks second in the world. Its newly installed capacity was the largest in the world. The country's equipment manufacturing capability also took first place in the world. Both the newly installed capacity in the country and China's wind turbine output accounted for roughly a third of the global total.

The total number of newly installed wind turbines in China in 2009, excluding Taiwan Province, was 10,129, with an installed capacity of 13.8 GW. China thus overtook the USA for new installations. The cumulative installed capacity reached 25.8 GW, in the fourth consecutive year that had seen a doubling in capacity

3) Industry and Supply Chain

China's wind turbine equipment manufacturing industry has developed rapidly and its industrial concentration has further intensified. Domestic manufacturers now account for about 70% of China's supply market and are beginning to export their products.

The manufacturing industry for wind power equipment is clearly divided into three levels, with Sinovel, Goldwind and Dongfang Electric (all among the world's top ten suppliers) in the first ranking and Mingyang, United Power and XEMC in the second. These are followed by a range of smaller manufacturers.

Driven by the development trends in international wind power, the larger Chinese wind turbine manufacturers have also begun to enter the competition for large-scale wind power equipment. Sinovel, Goldwind, XEMC, Shanghai Electric Group and Mingyang are all developing 5 MW or larger turbines and can be expected to produce competitive and technically mature machines. One concern for the industry, however, is the quality of its products. The general view is that China's domestic wind power equipment will receive its supreme test in 2011 and 2012. If it passes this test successfully, it will mean a qualitative leap forward.

Although China now has an established wind turbine manufacturing supply chain, including producers of all the main parts, it is still lacking a fully developed network of ancillary services, such as certification bodies and background research and development.

4) Offshore prospects

Serious investigation effort is being committed to the prospects for offshore wind development around China's long coastline. In 2010 the first offshore project was completed – 100 MW at Shanghai's Donghai Bridge, with 34 Sinovel 3 MW turbines. According to plans prepared by the coastal provinces, the installed capacity of offshore wind power is planned to reach 32,800 MW by 2020.

5) Developers

The top three developers of wind parks in China are Guodian (Longyuan Electric Group), Datang and Huaneng. All three are large state-owned power supply companies. Most investment and project development work is undertaken by power supply companies who have a commitment under national law to steadily increase their proportion of renewable energy.

6) Geographical Distribution

By the end of 2009 a total of 24 provinces and autonomous regions in China had their own wind farms. There were over nine provinces with a cumulative installed capacity of more than 1,000 MW, including four provinces exceeding 2,000 MW. The Inner Mongolia Autonomous Region is the lead region, with newly installed capacity of 5,545 MW and a cumulative installed capacity of 9,196 MW.

3. National Energy Policy

At the end of 2009, the Chinese government made a political commitment to the international community at the Copenhagen Conference on climate change that non-fossil energy would satisfy 15% of the country's energy demand by 2020. This will require an unprecedented boost to the scale and pace of future clean energy development, including a new orientation towards wind power development. Wind energy is encouraged by a range of laws and regulations, the most important being the Renewable Energy Law, originally introduced in 2005. This report includes details of the latest changes to this and other statutes affecting wind power development.

1) Wind Power Bases

A major part of the Chinese government's commitment to wind power involves the creation of seven "GW-scale wind power bases". The seven bases, each with a potential for at least 10 GW of installed capacity, are located in the east and west of Inner Mongolia, Kumul in Xinjiang, Jiuquan in Gansu, Hebei, the western part of Jilin, and the shallow seas off Jiangsu.

Planning the development of these bases started in 2008 under the leadership of the National Energy Bureau and is progressing fast. According to the plan, they will contain a total installed capacity of 138 GW by 2020, but only if the supporting grid network is established. A significant problem is that many of these bases are located in remote areas with a weak transmission grid and at a long distance from China's main electricity load centers. There is also the issue of how large quantities of variable wind power are integrated into a grid network dominated by inflexible coal-fired power stations.

2) Price Support Mechanisms

Pricing policy is a key factor affecting the level of active investment by developers and market growth. China's support mechanism for wind power has evolved from a price based on return on capital and the average price of electricity through a competitive bidding system for wind park development contracts to a feed-in tariff with variations based on differences in wind energy resources.

Introduced in 2009, the feed-in tariff system establishes a benchmark price for land-based wind power based on dividing the country into four categories of wind energy resource areas. There is no doubt that the introduction of the regional feed-in tariff policy has been a positive step in the development of wind power in China and is stimulating stronger growth.

4. Wind Power and Sustainable Development

As the most economically competitive new energy source, wind power plays an essential role not only in energy security and the diversification of energy supplies but also in economic growth, poverty alleviation, atmospheric pollution control and the reduction of greenhouse gas emissions. In 2009 China produced wind turbines with a capacity of over 15 GW and an output value totalling RMB 150 billion, and with taxes and fees paid to the national finances valued at over RMB 30 billion. The industry also offered nearly 150,000 jobs in employment areas directly related to wind power. Assuming that the Chinese wind power industry has an installed capacity of 200 GW by 2020, and a power generation output of 440,000 GWh, if not considering energy efficiency improvement, then it will reduce the emission of greenhouse gases by 440 million tons as well as limiting air pollution by reducing coal consumption, at the same time generating over RMB 400 billion in industrial-added value and 500,000 jobs.

Compared with these benefits the potential negative effects of developing wind energy, such as the risk of bird collisions, are minor. If we do not 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 result in fatal damage to the human environment.

5. Issues for China's Wind Power Development

Despite the clear success of wind power in China, a number of issues are raised in this report about its ongoing operation and regulation.

1) Clean Development Mechanism

The Clean Development Mechanism (CDM) is one of the methods devised under the Kyoto Protocol to enable clean energy projects to be financed in relatively poorer developing countries with the support of richer nations. China has taken great advantage of this.

A total of 869 Chinese projects have been approved by the United Nations, accounting for 38.71% of the total number of CDM projects registered, and income from the CDM has made an important contribution to investors' return from wind farm development. This has now been threatened, however, by challenges to the way in which Chinese projects have interpreted the rule that any CDM project must be "additional" to what would have happened otherwise. This issue needs to be resolved for the health of the Chinese wind industry. There is also uncertainty about whether the CDM will continue in the same form after the expiry of the current Kyoto Protocol emissions reduction period in 2012.

2) Grid Integration

As a variable supply, large-scale wind power development is bound to result in challenges in terms of its easy integration into the electricity grid network. Wind farms in China are mainly located in areas far from load centers, and where the grid network is relatively weak, so the present design of the grid places constraints on the development of wind power. This has become the biggest problem for the future development of wind power in the country.

Four issues need to be addressed in relation to grid integration. The first is that of the weak grid itself. The specialized construction of long-distance transmission lines to meet the needs of large-scale wind and solar power development is now a vitally necessary part of the country's energy infrastructure.

The second issue is the reluctance of grid companies to accept wind power in their network. On paper, China's Renewable Energy Law requires grid companies to acquire increasing volumes of renewable energy generation, with the aim of achieving an 8% proportion of renewable energy generation in their output by 2020. These provisions are not practical, however. There is no punishment if the grid does not accept renewable energy generation and there is no compensation for the loss of wind power business, so the grid enterprises have no pressure to accept this input, including wind power.

The third issue is the compatibility of wind power with the requirements of the grid. China needs to follow the lead of other countries with a large quantity of renewable energy, which have implemented technical standards and regulations for the integration of renewable power into the electricity grid system. Wind power forecasting, energy storage such as Pumped Storage Power Station and electric vehicles also all need to be developed in order to make best use of the resource.

The pricing policy for wind power does not fairly reflect the difficulties it currently encounters in terms of grid connection, often resulting in less power being accepted than agreed. Current rules for the determination of the power price and power scheduling also do not fully reflect the part that electricity generators can play in the process of safe operation of the power grid, such as peak regulation and standby operation. Wind power development has also been negatively affected both by recent changes in the national VAT regime and by reduced income from the CDM.

The role of government in price leverage should therefore be given full play to mobilize the enthusiasm of market participants. Differential power prices should be used to guide and encourage enterprises to construct power generation capacity with a flexible adjustment capacity and to increase the scheduling flexibility of the grid companies. At the same time, peak-trough prices should be used to guide the power use of electricity consumers, encourage off-peak power use and reduce the pressure on power grid enterprises for peak shaving.

6. Proposals for reforms in wind power development policy

Although on the whole the policy of encouraging wind power has been successful, the report makes specific suggestions for reform in wind power development policy. These are:

1) Present a clear national development target which local governments, power companies, power generation companies and manufacturing industry can all work towards. The installed wind power capacities for 2015 and 2020 (including offshore) should not be less than 110 and 200 GW; 130 and 230 GW would be better.

2) Develop economic incentive policies to coordinate the interests of all parties and protect local economic benefits, such as an increase of 3-5 fens in the price of electricity through the economic development fund. Western regions should enjoy more favorable policies.

3) Work out an effective economic policy to encourage integration into the power grid, including introducing wind power grid connection standards and specific rules to guarantee acceptance by the grid companies.

4) Work out better management of the nationally agreed "renewable energy funds".

5) Improve the various incentives and penalties to meet the requirements of the proportion of installed capacity of non-hydropower renewable energy to achieve 8% by 2020, a target in the Mid-long Term Plan.

7. Projections of Future Growth

Experts from the Chinese Academy of Engineering and the National Development and Reform Commission have projected in 2008 that under low, medium and high growth outcomes Chinese wind power capacity will reach either 100, 150 or 200 GW by 2020. This would see the proportion of wind power in total energy consumption reach 1.6%, 2.5% and 3.3% respectively. If wind power is looking to account for 5% of total energy consumption, then a figure of 300 GW would be required.

The authors of this report have produced a more ambitious "forecasts" up to 2050. Under a "conservative" version, these would see wind power grow to 150 GW by 2020, 250 GW by 2030 and 450 GW by 2050. An "optimistic" version sees this figures increase to 200 GW by 2020, 300 GW by 2030 and 500 GW by 2050, as a result of bottleneck issues primarily addressed, such as grid integration. Finally, a "positive" scenario assumes that there will be intense pressure for the reduction of greenhouse gas emissions, that the government will introduce policies to actively support wind power, and that by 2050 those resources developable in terms of technology will have been basically exploited. This version shows wind power increasing to 230 GW by 2020, 380 GW by 2030 and 680 GW by 2050.

These forecasts are more in line with an advanced scenario produced by the Global Wind Energy Council. It projects that China's wind power capacity could reach 129 GW by 2015, 253 GW by 2020 and 509 GW by 2030. Wind power would account for 10% of total electricity supply by 2020 and reach 16.7% in 2030. This assumes, however, that overall consumption is reduced by major energy efficiency measures.

CONTENTS

1.Current Development Status and Outlook of World Wind Power

1.1. Summary

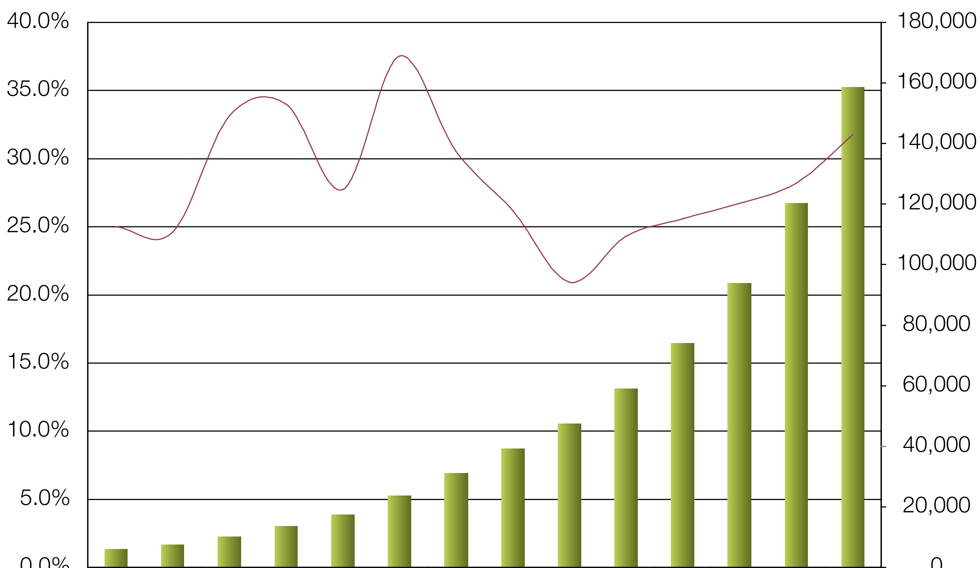
In 2009, despite the ongoing international financial crisis, the global wind power industry continued to expand rapidly, growing even faster than in 2008, when the growth rate was 32%. The growth rate in 2009 was 10% higher than the average over the previous ten years, reaching 41%. The European Union, the USA and Asia still dominate global wind power development. Although there have been changes in the respective positions of the USA, China, Germany, Spain and India, these are still the top five countries for wind power. In 2009, China ranked first for newly installed capacity. However, it will take longer for it to catch up with the USA to become the largest country in the world for cumulative wind power.

Although the development of offshore wind power has accelerated, land-based wind power still takes priority, accounting for over 98% of total installed capacity, with offshore wind only representing around 1.3%. The trend towards large-scale wind turbines is continuing. Many of the leading enterprises in wind turbine manufacturing have developed models with a capacity of over 5 MW, and it's expected that a 7.5 MW turbine will be developed successfully before 2012. In terms of the wind turbine drive train, the trend towards large-scale turbines has encouraged the development of direct drive and fully synchronous permanent magnet technology.

1.1.1. Development status in 2009

According to statistics compiled by the Global Wind Energy Council (GWEC), the average growth rate of cumulative installed world wind power capacity was 28.6% for the period from 1996 to 2009, which shows the momentum of rapid and continuous growth. In 2009, the total installed capacity of global wind power reached 158 GW, a cumulative growth rate of 31.9%, 3.3% higher than the average over the previous 13 years (see Figure 1).

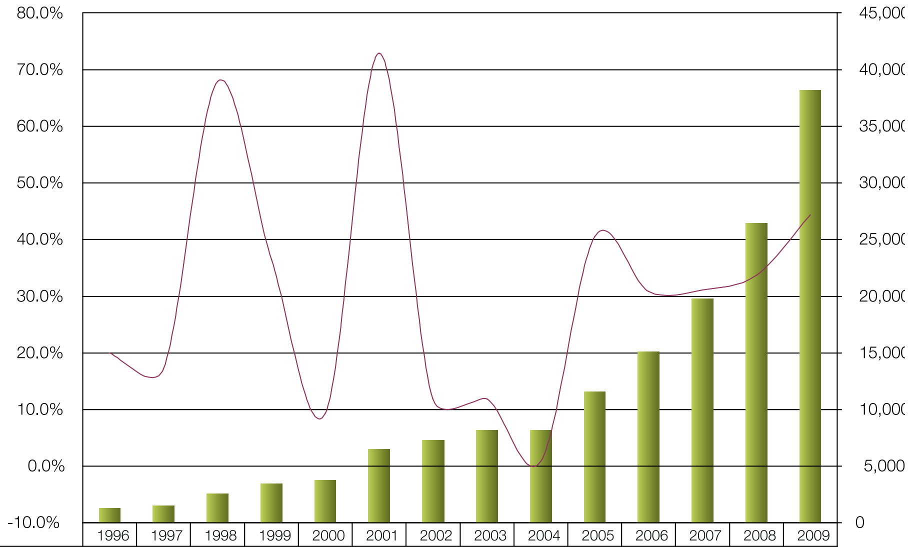
In 2009, newly installed capacity of global wind power reached 38.35 GW, a year-on-year growth rate of 41.7%, 10% higher than the average during the previous 13 years (see Figure 2). In the context of the international financial crisis, the fact that the wind power industry still kept increasing rapidly proved yet again that the industry has not only become an important part of the world energy market but is also playing an increasingly important role in stimulating economic growth and creating employment opportunities. According to GWEC calculations, the total output value of the installed capacity of global wind power



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cumulative Installed Capacity (MW)	6,100	7,600	10,120	13,560	17,320	23,820	31,090	39,223	47,430	58,961	74,052	93,835	120,296	158,505
growth rate (%)	25.0%	24.6%	33.2%	34.0%	27.7%	37.5%	30.5%	26.2%	20.9%	24.3%	25.6%	26.7%	28.2%	31.8%

Figure 1 Growth of Global Wind Power Cumulative Installed Capacity

Source: GWEC, Global Wind Report 2009



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Newly Installed Capacity (MW)	1,280	1,500	2,520	3,440	3,760	6,500	7,270	8,133	8,207	11,531	15,091	19,783	26,461	38,209
Growth Rate (%)	20.0%	17.2%	68.0%	36.5%	9.3%	72.9%	11.8%	11.9%	0.9%	40.5%	30.9%	31.1%	33.8%	44.4%

Figure 2 Growth of Global Wind Power Newly Installed Capacity

Source: GWEC, Global Wind Report 2009

has already reached 45 billion euros, and the number of people employed in the industry was approximately 500,000 in 2009.

1.1.2. International status of wind power

By the end of 2009, more than 100 countries around the world had started developing wind power, and more than 17 countries each had over 1 GW of cumulative installed capacity. The total installed capacity of the top ten countries for wind power was each over 3 GW and the total installed capacity of the top five countries was over 10 GW. The top three countries each had over 20 GW (see Figure 3).

The top ten countries for cumulative installed capacity of wind power at the end of 2009 were the USA, China, Germany, Spain, India, Italy, France, Britain, Portugal and Denmark. The top ten countries for newly installed capacity were China, the USA, Spain, Germany, India, Italy, France, Britain, Canada and Portugal.

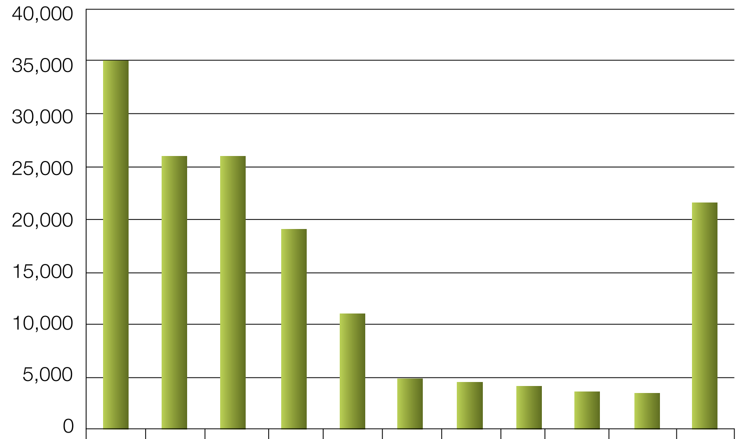
Apart from China, the USA and India, the other seven countries in the top-ten list for newly installed capacity in 2009 were all European. In the rankings for cumulative installed capacity China overtook Germany by a nose to occupy second place, but there was still a margin of nearly 10 GW between China and the USA, which still ranks No.1. Germany ranked third and Spain fourth.

Europe, America and Asia are still the mainstay regions for wind power, and in the newly installed capacity of 38.35 GW during 2009, Asia, North America and Europe all contributed more than 10 GW. As the largest markets, the growth of installed capacity in Asia, America and Europe powerfully advanced the development of the global wind power industry (see Figure 5).

Asia, mainly stimulated by China and India, became an important new market in 2009, exceeding the levels in both America and Europe. Newly installed capacity in China was 13.8 GW and the cumulative installed capacity reached 25.8 GW; newly installed capacity in India was 1.3 GW and its cumulative capacity reached 10.9 GW. Although these two countries are the mainstays of wind power development in the Asian market, they are followed by both Japan and, more recently, Korea. Newly installed capacity in Japan was 178 MW and the cumulative capacity reached 2.1 GW; newly installed capacity in Korea was 112 MW and its cumulative capacity reached 348 MW.

In the North American market, the USA's newly installed capacity reached 10,010 MW and the cumulative capacity 35 GW, which kept the country ranked as No.1 in the world. Newly installed capacity in Canada reached 950 MW, a record for annual additions, while total installed capacity is now 3.3 GW, 11th largest in the world. In Latin America, Mexico showed a good momentum for development, with newly installed capacity in 2009 reaching 117 MW and the cumulative capacity 202 MW.

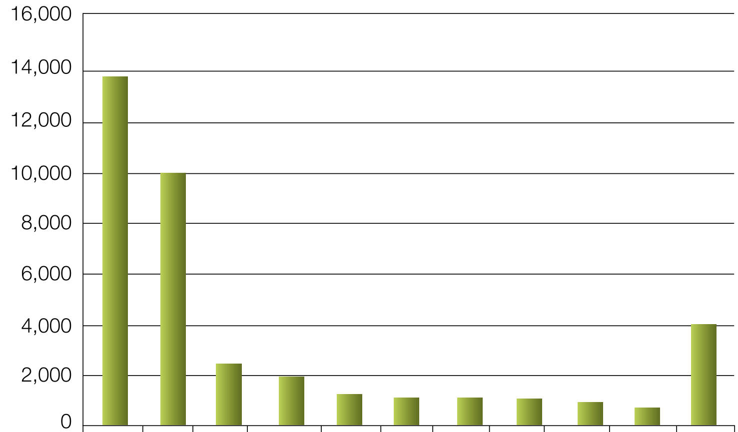
In the European market Germany still held the lead, with newly installed capacity of 1.9 GW and a cumulative total of 25.8 GW, third in the global rankings. With newly installed capacity



	USA	China	Germany	Spain	India	Italy	France	UK	Portugal	Denmark	Others
Camulative Installed Capacity(MW)	35,064	25,805	25,777	19,149	10,926	4,850	4,492	4,051	3,535	3,465	21,391

Figure 3 Top 10 countries for Wind Power Cumulative Capacity

Source: GWEC, Global Wind Report 2009



	China	USA	Spain	Germany	India	Italy	France	UK	Canada	Portugal	Others
Newly Installed Capacity(MW)	13,803	9,996	2,459	1,917	1,271	1,114	1,088	1,077	950	673	3,994

Figure 4 Top 10 countries for Newly Installed Capacity

Source: GWEC, Global Wind Power Report 2009

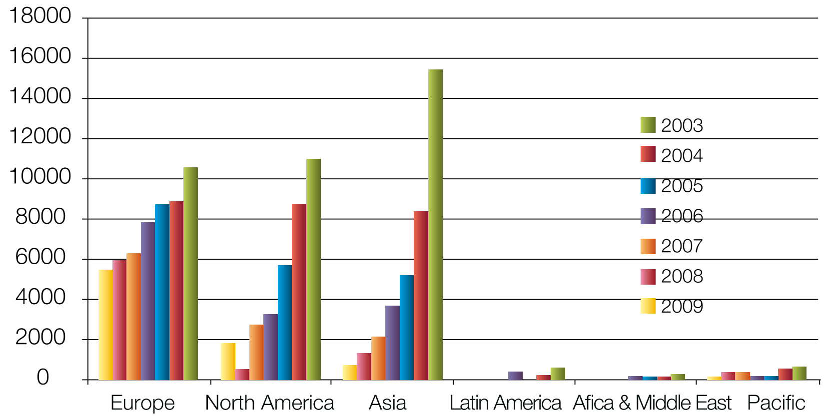


Figure 5 Regional Distribution of World Wind Power Development

Source: GWEC, Global Wind Power Report 2009 of 2.5 GW, Spain was the most active country in Europe in 2009; its cumulative capacity reached 19.1 GW, fourth in the global rankings. Italy achieved newly installed capacity of 1.1 GW and a cumulative capacity of 4.9 GW; France installed 1.1 GW of new capacity, with a cumulative total of 4.5 GW; Britain was not far behind, with newly installed capacity of 1.1 GW and a cumulative total of 4.1 GW.

Some less-developed regions for wind power experienced positive development in 2009. Newly installed capacity in Latin America reached 622 MW and its cumulative capacity exceeded 1 GW for the first time, reaching 1.27 GW. Brazil was a particularly bright spot in Latin America, with newly installed capacity of 264 MW and a cumulative total of 606 MW at the end of 2009. The country entered a new development stage for wind power at the end of 2009, when the Brazilian government held the first bidding round for wind power development concessions. It was expected that 71 wind power projects would be launched in the coming two years, with a total capacity of 1.8 GW. During 2010 there will be more bidding initiated, an indication that the activities of the Brazilian government are enabling the wind power market to enter a rapid development stage.

The scale of development in the Oceania region remained at the same level as the previous year, with newly installed capacity of 500 MW. Of that, Australia realised the highest level in its history, with newly installed capacity of 406 MW and a cumulative total of 1.7 GW. Newly installed capacity in New Zealand was 171 MW and the accumulated figure around 500 MW.

Africa and the Middle East are still the slowest areas in the world for the development of wind power, and newly installed capacity in 2009 was 230 MW. Many African countries have launched plans to develop wind power, however, including Kenya, Ethiopia and Tanzania. Together they are expected to complete projects of approximately 1 GW over the coming three to four years.

The cumulative installed capacities of the EU, the USA and China at the end of 2009 were respectively 76.20, 35.06 and 25.80 GW; the newly installed capacities that year were respectively 10.50, 9.99 and 13.80 GW. These accounted for 88.1% of the global cumulative total and 88.5% of newly installed capacity. To summarise, although developing wind power now involves a large number of countries around the world, the EU, the USA and China are the three crucial markets, which together influence the overall pattern of world wind power development.

1.1.3. Regional characteristics of the wind power industry

In 2009 the pattern of innovation in the design and manufacturing of wind turbines was further strengthened. The top ten manufacturing companies of complete wind turbine generator systems (WTGS) accounted for 81% of the annual, and 84% of the cumulative, value of the global wind power market. Established companies such as Vestas, GE, Gamesa, Enercon and Siemens were the leaders, accounting for 67% of cumulative world market share. In 2009, however, their percentage of the newly installed market fell to just 47%. Emerging enterprises such as Suzlon, Sinovel, Goldwind and Dongfang Turbine came to the forefront in the competition for the wind turbine supply market. Although they account for only 14.5% of the cumulative world market share, they established a 30% share of the newly installed market in 2009 (see Table 1).

In 2009 the development of the wind power manufacturing industry was increasingly internationalised, although the strength of companies located in particular country markets was still noticeable. German enterprises accounted for 74% of the market in Germany, for example. If the market share of European brands, such as Vestas, is included, the share of 'local companies' in Germany rises to 94.5%. In Spain, the market share of Spanish companies reached 51%. Again, when European companies are included, the market share rises to 91%. The US and Indian markets were strongest in terms of internationalisation, although the market shares of US companies GE and Clipper also rose to 44.7%. In India, the market share of Indian companies such as Suzlon increased to 59.5%. In the competition for the Chinese wind power market, the number of local companies and the proportion of domestic manufacturing both increased substantially, with the market share of local enterprises reaching 87%, 40% higher than in 2005.

1.1.4. Development trends in wind turbine manufacturing

Only the German companies REpower and Enercon had achieved the commercial development of very large capacity wind turbines before 2008. REpower produced its first 5 MW model in 2004. At present, the company has 17 of these turbines operating on land and offshore. The diameter of the second generation wind turbine with direct drive and a capacity of 6 MW, developed by Enercon, has increased from 112 metres (for the 4.5 MW model) to 127 metres. Other companies are now starting to follow this lead. Vestas in Denmark is developing a 4 MW offshore wind turbine and the Spanish Gamesa company is developing a 4.5-5 MW wind turbine system. BARD in Germany has also developed a 5 MW design and installed three of these machines on land and offshore; in 2009 the company announced that it would research and manufacture 6.5 MW WTGS. Two other companies have also developed large direct drive turbines. Siemens has completed tests on its 3.6 MW direct drive conceptual system while Darwind from the Netherlands is developing a 5 MW direct drive generator system.

Looking ahead, the US manufacturer Clipper plans to develop a 7.5 MW generator system through a cooperation agreement with the British government, with the ultimate objective in a second stage of developing a 10 MW system. AMSC has also reached an agreement with the United States Department of Energy to use a superconductive generator in the manufacturing of a 10 MW generator system. It is therefore clear that 4-10 MW capacity wind turbines will be mainstream in the development of offshore wind turbines in the future. In light of ongoing research and development activities, the design of offshore wind turbines is also likely to be diversified. Table 2 gives a brief overview of large-scale generator systems being developed by European companies.

The trend towards larger scale turbines is not only taking place in the development of offshore wind power but on land as well. Wind turbine generator systems have continued to increase in power in recent years. In 2008, the average power of newly installed wind turbine generator systems around the world reached 1.560 MW, 66,000 W higher than in 2007. Wind turbines in the power range from 1.5 MW up to 2.5 MW accounted for 62.2% of the global newly-installed market in 2006, but this increased to 63.7% in 2007 and 80.4% in 2008, consolidating the mainstream position of this power range. In turn, the market share of wind turbine generator systems with a capacity of less than 1.499 MW obviously decreased. The 3 MW wind turbine manufactured by Vestas and the 3.6 MW model manufactured by Siemens dominated the multi-MW share of the market (above 2.5 MW). Only a small number of 5-6 MW wind turbines manufactured by Enercon, REpower, Multibrid and Bard were released on the market, as shown in Tables 3 and 4.

Table 1 Breakdown of Global Wind Turbine Manufacturing Industry

No.	Company	Newly installed in 2009 (MW)	%	Cumulative (MW)	%
1	Vestas	4,766	12.9%	39,705	23.6%
2	GE Wind	4,741	12.8%	22,931	13.6%
3	Sinovel	3,510	9.5%	5,658	3.4%
4	Enercon	3,221	8.7%	19,738	11.7%
5	Goldwind	2,727	7.4%	5,315	3.2%
6	Gamesa	2,546	6.9%	19,225	11.4%
7	Dongfang	2,475	6.7%	3,765	2.2%
8	Suzlon	2,421	6.5%	9,671	5.7%
9	Siemens	2,265	6.1%	11,213	6.7%
10	REpower	1,297	3.5%	4,894	2.9%
Total for other companies		7,034	19.0%	26,331	15.6%
Total		37,003	100.0%	168,446	100.0%
Top ten companies		29,969	81.0%	142,115	84.4%

Source: Wind Power (March 2010) and BTM Consult.

Table 2 Large-scale Wind Turbines Newly Developed in Europe

			
Manufacturer and product model	Enercon E-112	REpower 5M	Multibrid M5000
Single turbine capacity (MW)	4.5-6	5	5
Hub height (m)	124	120	102.6
Rotor diameter (m)	114	126	116
Swept area of rotor (m^2)	10,207	12,469	10,568

Source: German Wind Energy Institute

Table 3 Power Range of Global Wind Turbine Generator Systems, 2006-2008

Power range	2006	2007	2008
<0.75 MW	2.4%	1.3%	0.5%
0.75MW-1.499 MW	31.0%	29.8%	13.1%
1.500MW-2.500 MW	62.2%	63.7%	80.4%
>2.5 MW	4.3%	5.3%	6.0%
Total	100%	100%	100%

Source: BTM Consult

Table 4 Power Range of Global Newly-installed Wind Turbines in 2008

Power range	Number of turbines	Installed capacity (MW)	Average Power (MW)	Market share
<0.75 MW	454	153	0.337	0.5%
0.75 MW - 0.999 MW	3,691	2,926	0.793	9.4%
1 MW - 1.499 MW	1,061	1,188	1.119	3.8%
1.5 MW - 2.5 MW	14,241	25,149	1.766	80.4%
>2.5 MW	603	1,866	3.094	6.0%
Total	20,050	31,281	1.560	100%

Source: BTM Consult

1.2. Development of offshore wind power

Since Denmark's building of the first wind park in the sea in 1991, the development of offshore wind power has not proceeded as quickly as anticipated. The main reasons for this are the complex technology required and the high costs of installation, operation and maintenance. It has therefore not been readily taken up by prospective developers. However, the research and development of offshore wind power technology in Europe and the USA has continued, and many difficult technical problems have been solved. At the same time, as the land-based wind power resources in Europe, especially in Denmark and Germany, are almost reaching the limits of their potential - and in order to minimise the emission of greenhouse gases and improve the contribution of renewable energy - the development of offshore wind power has returned to the agenda. From 2008 onwards there has been a new leap forward, and the newly installed capacity of offshore wind power reached more than 500 MW in two consecutive years (2008 and 2009), exceeding the total installed historically (see Figure 6).

1.2.1. Features of offshore wind power development

The EU plays a leading role in offshore wind power development, accounting for 90% of global installed capacity. In 2009 the EU invested 1.5 billion euros in offshore projects, and installed 199 sets of offshore turbines with a capacity of 577 MW. This was over 200 MW higher than in 2008 (373 MW), a 54% increase. By the end of 2009, Europe had completed the construction of 38 offshore wind farms and installed 328 turbines with a cumulative installed capacity of 2,110 MW (see Figure 7).

Both of the best countries for the development of offshore wind power - Britain and Denmark - are in Europe, and they account for 44% and 30% of the global market share respectively. In 2009, newly built offshore wind power projects were all located in Britain (283 MW), Denmark (230 MW), Sweden (30 MW), Germany (30 MW) and Norway (2.3 MW). Meanwhile, the first German deep-sea wind park was established and put into production with an installed capacity of 60 MW in May 2010. This is located 50 km from the coast, the farthest from land of any offshore wind farm.

In light of the accelerated development of offshore wind power in Europe, other countries and regions are following suit. In China, a 100 MW offshore wind project at Shanghai's Donghai Bridge was due to be completed in April 2010, with 34 turbines each with a capacity of 3 MW. By the end of 2009, 20 of these had been installed with a capacity of 60 MW. Moreover, after many years of preparation, the first US offshore wind power project was approved by the government in May 2010, and is expected to start preparation soon.

1.2.2. Current plans for offshore wind power

It is estimated by the EU that European investment in offshore wind power will double during 2010, compared to 2009, and reach a level of 3 billion euros. In 2010, 17 offshore wind power projects with a total installed capacity of 3,500 MW will be under construction in Europe, and it is expected that an installed capacity of 1 GW will be completed by the end of the year, 70% higher than the

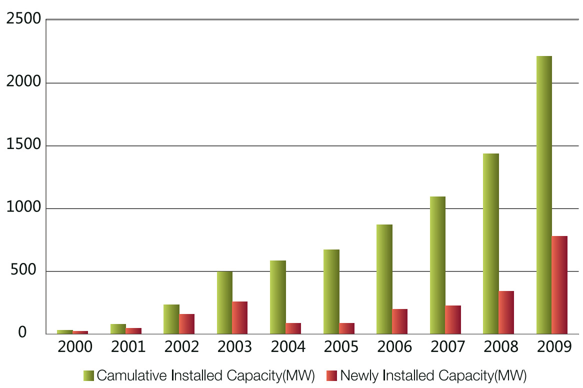


Figure 6 Growth of Global Offshore Wind Power (MW)

Source: BTM Consult

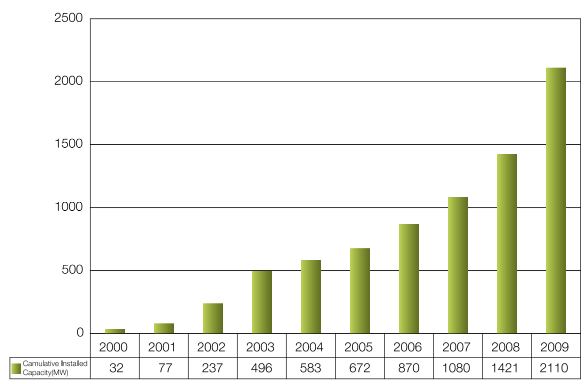


Figure 7 Cumulative Installed Capacity of EU Offshore Wind Power, 2000-2009

Source: BTM Consult

level in 2009. This greatly exceeds the growth rate of land-based wind power. The EU issued a comprehensive plan for offshore wind power in November 2009. This envisaged a total of 100 GW of offshore projects with an annual power generation output meeting 10% of current electricity demand in the EU. The offshore wind power plans extensively discussed over a long period in the US will also move forward in 2010, encouraged by the successful experiences in the EU. It is expected that one or two offshore wind power projects will be launched and constructed with a total installed capacity of over 1 GW.

1.2.3. Offshore technology

Offshore wind turbines have developed for installation in marine environments based on existing land-based machines. The developers and manufacturers of turbines have now accumulated more than ten years' experience in offshore wind power development. Turbines and parts used for offshore turbines have constantly improved, and knowledge about the special operating conditions in the sea has steadily deepened. Reducing the development cost of offshore wind power is a major challenge, but the power output obtainable from an offshore machine is much higher than on land. The capacity of offshore turbines put into commercial operation mainly ranges from 1.5 MW up to 3.6 MW, with 65-104 metres as the diameter of the rotor blades.

Among the main turbine manufacturers, the E-122 6 MW wind turbine was developed successfully by the German company Enercon and tested at the trial locations of Cuxhaven and Emden. The company has not yet, however, committed to using this design in offshore wind parks. In the USA, GE is busy with the design, development and research of a 7 MW wind turbine. The 5 MW design developed by German manufacturer REpower has been successfully installed in a demonstration offshore wind power plant off Scotland in a water depth of 40-44 metres and with a 126-metre diameter rotor blade. Apart from the offshore wind power equipment produced by Vestas, Siemens, REpower, Multibrid, GE and Enercon, the Chinese manufacturers Sinovel, Goldwind, Shanghai Electric, Mingyang, XEMC and United Power are all also developing offshore wind turbine generator systems, some of which are currently under research and evaluation. In conclusion, all the large turbine manufacturers are starting to aim at the offshore wind power market, making large-scale investments in the design and development of offshore technology and manufacturing, ready for a new round of competition in the supply market.

1.2.4. Installation and construction technologies for offshore wind power

To resist the strong wind loads, marine corrosion and wave impact found out at sea, the foundations for offshore wind turbines have to be more complex structures, involving greater technical challenges and higher costs than land-based systems. Generally speaking, the foundation structure – tower and seabed foundation – accounts for around one third of the total cost for offshore wind power development. The different types of offshore foundation structures are generally classified as single pile structures, gravity structures and multi-pile structures, all of which have been used in practice. Prototype floating support structures are also under research and development. The factors which need to be considered in the selection of the foundation type include water depth, soil and seabed conditions, environmental load, construction methods, installation and costs.

At present, most of the offshore wind turbines installed around the world have either used a design involving a gravity concrete structure or a steel monopile structure. The most widely used type of single pile structure involves inserting steel tubes with a diameter of 3-5 metres into the seabed to a depth of 15-30 metres using drilling bores. The merit of this foundation is that a seabed base is not required and its manufacturing is relatively simple, but the installation can be relatively difficult and flexibility is greater when the sea is deeper.

The gravity type foundation is usually made of steel or concrete, depending on the need to guard against capsizing. The cleaning preparation of the seabed is very important for this structure, because it is very sensitive to sea wave sweeping and is only suitable for a site where the water is not deep and is unsuitable for drilling. Gravity foundations can also be difficult to handle during transportation and installation, and there are potential downsides for the marine environment.

Multi-pile foundation structures are still largely at the testing stage and have still not been applied to commercial wind power plants. This foundation generally has a tripod structure, mainly using small diameter steel tubes, and is suitable for deep water areas. The downsides to these structures are that vessels find it difficult to get close to the foundations and they also increase the possibility of the water freezing.

A caisson foundation structure involves inserting a steel box into the seabed through gravity and pumping seawater into the box to produce pressure so that it can then be fixed using an anchor chain. This type of structure is at the stage of feasibility research.

In terms of floating structures there are many optional concepts, with the cost being nearly equal to the seabed fixing type. There is much flexibility in the construction and installation stages, and they are easy to move or disassemble. Although there are plans to deploy this system in Norway, it is still at the test stage at present.

As far as the installation of offshore wind power equipment is concerned, there is a range of lifting and anchoring systems, some dependent on the seawater depth as well as the capacity of cranes and vessels. Currently, there are four technical choices available. Table 5 gives the merits and demerits of each type.

Table 5 Four Optional Installation Systems for Offshore Wind Power

Scheme	Merits	Demerits
Self-elevating installation	This is the first-used hoisting method for offshore wind power plants. A stable foundation can be provided for the installation, and it is also preferred for piling.	Lack of internal stability and flexibility. Can cause difficulties in the installation of towers.
Semi-submersible installation	A semi-submersible hoisting vessel is one of the most stable floating platforms.	The current design of vessel is only suitable for offshore operation at a greater distance from the shore, and is difficult to operate in shallow areas.
Installation of carrying vessel, flat bottom barges and land-based cranes	As long as it is fine weather, the land-based crane can show its two advantages – use of a rotary crane and low costs.	The stability of the carrying vessel and flat bottom barges during construction are not good, and they are influenced easily by the weather.
Floating installation	It can be built in shallow waters, towed into deep sea and can carry out integral hoisting.	It is more difficult technically.

2. Present Status and Prospects of China's Wind Power Industry

2.1. Resource Conditions

2.1.1. Characteristics of wind energy resources in China

China has a vast land mass and long coastline and is rich in wind energy resources. The China Meteorological Administration organised the second and the third national wind energy resources censuses in the late 1980s and during the period 2004-2005. From these it drew the conclusion that China's theoretically exploitable reserve of wind energy resources at a height of 10 metres above ground level was respectively 3,226 GW and 4,350 GW and the technically exploitable capacity was 253 GW and 297 GW. In addition, the United Nations Environment Programme commissioned international research institutes to carry out research and assessment of China's wind energy resources by numerical simulation during the period 2003-2005. This research concluded that the technically exploitable capacity at a height of 50 metres above ground level could reach 1,400 GW.[1] In 2006, the National Climate Center also applied numerical simulation to evaluate wind energy resources in China, and obtained the result that the technically exploitable capacity at a height of 10 metres above ground level across the whole country was 2,548 GW. This was without taking into account the Qinghai-Tibet Plateau, and therefore greatly exceeded the conclusion of the national wind energy resources census. [2]

According to the third national wind energy resources census, the technically exploitable land area (with a wind power density of 150 W/m^2 or more) is roughly 200,000 km^2 (see Figure 8). Taking into account the actual layout of wind turbines in wind farms, the technically exploitable capacity is around 600-1,000 GW on land, calculated on the basis of a lower limit of 3 MW/km^2 and an upper limit of 5 MW/km^2. For offshore wind power, the conclusion of the Comprehensive Survey of China's Coastal Zones and Tideland Resources was that the sea area with a water depth of 0-20 metres was 157, 000 km^2 in the shallow seas along the Chinese mainland coast. In 2002, the Marine Function Divisions across the whole of China specified those maritime zones, which should be reserved for harbours, shipping, fishing development, tourism and engineering. Excluding these zones, the potential installed capacity of inshore wind power is roughly 100-200 GW, calculated on the basis of 5 MW/km^2, taking into account the actual layout of offshore wind parks and assuming that 10-20% of the sea area can be utilised.

Overall, these studies show that the potential for exploiting wind energy in China is enormous. The total exploitable capacity for both land-based and offshore wind energy is around 700-1,200 GW. Wind power therefore has the resource basis to become a major part of the country's future energy structure. Compared with the current five major countries for wind power, the extent of wind resources in China is close to the USA and greatly exceeds India, Germany and Spain.

2.1.2. Detailed survey of wind energy resources at a planning level

With the wind energy resources assessment system developed by the China Meteorological Administration, the Center for Wind and Solar Energy Resources Assessment, the numerical simulation of wind energy resources at various levels less than 150 metres above the ground is done at a 5 km × 5 km resolution for the whole country. For some areas, including the seven 10 GW-scale wind-base areas, it is done at a resolution of 1 km × 1 km. Depending on the terrain, gradient, land usage and other factors, the area which cannot be used for building wind power

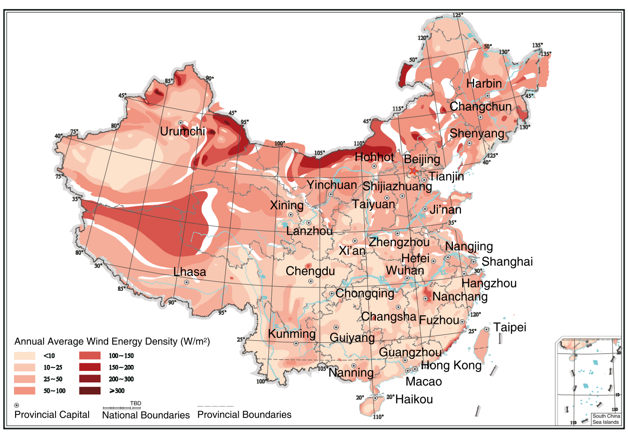


Figure 8 Distribution Map of China's Average Wind Energy Density at 10m Above Ground Level

Source: The Third National Wind Energy Resources Census

1 Data for Solar and Wind Renewable Energy, UNEP, http://swera.unep.net/

2 China Meteorological Administration, China Wind Energy Assessment Report, December 2006

plants (within the regions that are abundant in wind energy resources) is initially deducted. The installed capacity density is then defined and the potential installed capacity in regions with different wind energy resource classes are specified utilising GIS technology. It should be particularly noted that the 10 GW wind power base in the west of Jilin Province is a potentially exploitable region with above Class 2.5 level of wind energy resources, while the regions with Class 3 or greater are also technically exploitable regions with potential wind energy resources.

1) The potential exploitable capacity of land-based wind energy resources in China is roughly 2,380 GW at a height of 50 metres above ground level.

2) According to a preliminary estimate, the potential installed capacity is around 200 GW at a height of 50 metres above sea level in the shallow seas with a 5- to 25-metre water depth around the Chinese coast.

3) The seven 10 GW-scale wind power bases located in the east and west of Inner Mongolia, Kumul in Xinjiang, Jiuquan in Gansu, Bashang in Hebei, the western part of Jilin and the shallow seas off Jiangsu, contain roughly 1850 GW of potential exploitable capacity with above Grade 3 level wind energy resources at at height of 50 metres above ground level.

4) The total installed capacity of the seven 10 GW-scale wind power bases is 570 GW.

2.1.3. Wind energy resources in the northeast, north and northwest of China and the coastal regions

Wind energy resources are particularly abundant in China in the southeast coastal regions, the islands off the coast and in the northern part (northeast, north and northwest) of the country. There are also some places rich in wind energy in the inland regions. The offshore wind energy resources are also plentiful.

1) The coastal and island zones are rich in wind energy. Across 10-km-broad zones in the coastal regions of Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Guangxi and Hainan, the annual wind power density is above 200 W/m^2 and the wind power density contour is parallel with the coastline.

2) The zones with plentiful wind energy in the north include 200-km-wide zones in the three northeast provinces of Hebei, Inner Mongolia, Gansu, Ningxia and Xinjiang, where the wind power density reaches more than 200-300 W/m^2 and sometimes more than 500 W/m^2. Examples of this are found in the Ala Mountain Pass, Daban Town, Huiteng Xile, Huitengliang in Xilin Haote and Chengde Yard.

3) The inland regions have a wind power density usually below 100 W/m^2 outside the two abundant zones. However, there are rich wind energy resources in some regions due to the influence of lakes and special terrain.

4) Abundant zones near the coast include the vast 5 to 20-metre deep sea area in the eastern coastal area, although the actual exploitable capacity of coastal wind energy resources is much less than on land. However, the provinces of Jiangsu, Fujian, Shandong and Guangdong are all rich in inshore wind energy resources. Since they are close to major electricity demand centers, inshore wind energy may well be developed and supply significant clean energy to these areas in the future.

2.1.4. Seasonal and geographical distribution of wind energy resources in China

The wind energy resources of China have two characteristics. Firstly, their seasonal distribution is complementary to the country's hydro-energy resources. Generally, winds are plentiful in spring, autumn and winter but lower in summer. For China's hydro-energy resources, on the other hand, the rainy season is roughly from March/April to June/July in the south, during which precipitation accounts for 50% to 60% of the whole year's rainfall. In the north, the precipitation is less than in the south, and its distribution is also more unbalanced. Winter is a relatively dry season. As a result, the best wind energy resources are complementary to the hydro-energy resources according to their seasonal distribution. To a certain extent the large-scale development of wind power can therefore compensate for the deficiency of hydroelectricity in the dry seasons of spring and winter.

Secondly, the geographical distribution of wind energy resources is mismatched with the electrical load. The coastal areas of China have a large electrical load but are poor in wind energy resources. Wind energy resources are plentiful in the north, on the other hand, but the electrical load is small. This poses difficulties for the economic development of wind power. Since most of the regions with abundant wind energy resources are distant from the electrical load centers and the present electricity grid network is a weak, large-scale development of wind power requires extension and strengthening of the electricity grid.

2.1.5. The exploitation of wind energy resources in China

The exploitation of wind energy resources is still at a low level in China. By the end of 2009, less than 26 GW of installed capacity had been developed and utilised (less than 2% of the exploitable capacity). Even after the level of expansion currently anticipated, the capacity would be no more than about 200 GW, accounting for 20% of the lower limit of the resource potential. From this we can see that the potential for exploiting the undeveloped resources is huge.

2.2. Present Status of Development

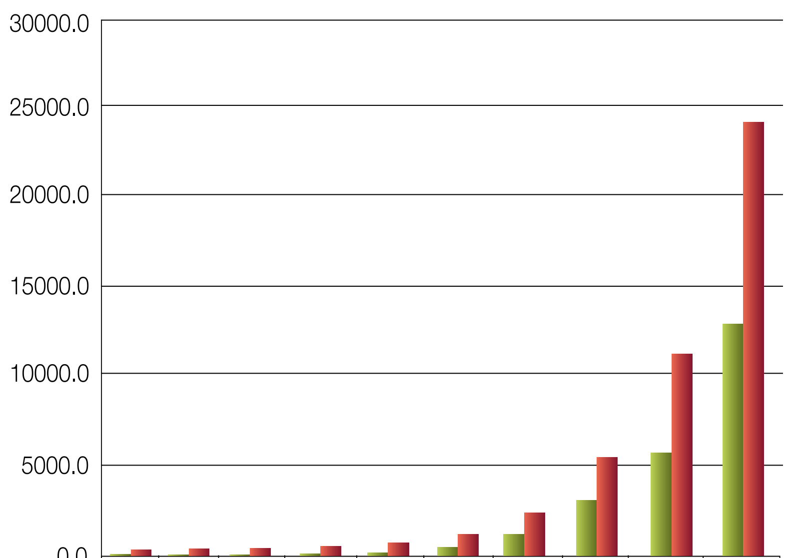
In 2009, the Chinese wind power industry was a global leader, increasing its capacity by over 100%. The cumulative installed capacity now ranks second in the world. Newly installed capacity was the largest in the world. The country's equipment manufacturing capability also took first place in the world. Both the newly installed capacity in the country and China's wind turbine output accounted for roughly a third of the global total.

The development distribution of wind power within China saw no significant changes, and Inner Mongolia remained the No.1 province. The leading developers were still large-scale government-owned enterprises, notably Longyuan (Guodian), Datang and Huaneng, the top three corporations in China. The highlight in 2009 was that offshore wind power started to develop, and more than 30 sets of 3 MW wind turbines were installed and commissioned. Meanwhile, the prominent problems of grid connection for wind power compelled all concerned parties to pay close attention to the issue.

The manufacturing industry for wind power equipment is now clearly divided into three levels, with Sinovel, Goldwind and Dongfang Electric (DEC) in the first ranking and Mingyang, United Power and XEMC in the second. These second-ranked companies have started to make efforts with the intention of competing with enterprises at the first level. Driven by the development trends in international wind power, the larger Chinese wind turbine manufacturers have also begun to enter the competition for large-scale wind power equipment. Sinovel, Goldwind, XEMC, Shanghai Electric Group and Mingyang are all developing 5 MW or larger turbines and can be expected to produce competitive and technically mature machines. One concern for the industry, however, is the quality of its products. The general view is that China's domestic wind power equipment will receive its supreme test in 2011 and 2012. If it passes this test successfully, it will mean a qualitative leap forward.

2.2.1. Development of wind power in China in 2009

China maintained its rapid and strong growth in both wind turbine equipment manufacture and the exploitation of wind power during 2009. According to statistics compiled by the Chinese Renewable Energy Society and the China Hydropower Engineering Consulting Group Corporation, the total number of newly installed wind turbines in China in 2009, excluding Taiwan Province, was 10,129, with an installed capacity of 13.8 GW. China thus overtook the



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cumulative Installed Capacity (MW)	341.6	403.5	469.8	568.1	764.9	1271.8	2559.4	5870.7	12024.4	25827.7
Newly Installed Capacity (MW)	73.3	52.7	66.3	98.3	196.8	506.9	1287.6	3311.3	6153.7	13803.3

Figure 9 Growth of Wind Power in China

Source: Global Wind Power Report 2009

USA and became the country with the most newly installed capacity in a single year. The cumulative installed capacity in China (excluding Taiwan Province) reached 25.8 GW at the end of 2009, moving up from fourth place in 2008, placing it second in the rankings of global cumulative installed capacity. Compared with 6.15 GW newly installed capacity and 12 GW cumulative installed capacity in 2008, the growth rate of newly installed capacity reached 124.3% in 2009 and the growth rate of cumulative installed capacity was 114.8%. This was the fourth consecutive year of a doubling in capacity (see Figure 9).

Table 6 Installed Wind Capacity by Province

Unit: MW

Province (Autonomous region or municipality)	Cumulative installed capacity in 2008	Newly installed capacity in 2009	Cumulative installed capacity in 2009
Inner Mongolia	3,650.99	5,545.17	9,196.16
Hebei	1,107.7	1,680.4	2,788.1
Liaoning	1,224.26	1,201.05	2,425.31
Jilin	1,066.46	997.4	2,063.86
Heilongjiang	836.3	823.45	1,659.75
Shandong	562.25	656.85	1,219.1
Gansu	639.95	548	1,187.95
Jiangsu	645.25	451.5	1096.75
Xinjiang[1]	576.81	443.25	1002.56
Ningxia	393.2	289	682.2
Guangdong	366.89	202.45	569.34
Fujian	283.75	283.5	567.25
Shanxi	127.5	193	320.5
Zhejiang	190.63	43.54	234.17
Hainan	58.2	138	196.2
Beijing	64.5	88	152.5
Shanghai	39.4	102.5	141.9
Yunnan	78.75	42	120.75
Jiangxi	42	42	84
Henan	48.75		48.75
Hubei	13.6	12.75	26.35
Chongqing		13.6	13.6
Hunan	1.65	3.3	4.95
Guangxi		2.5	2.5
Hong Kong	0.8		0.8
Subtotal	12,019.6	13,803.2	25,805.3
Taiwan[2]	358.15	77.9	436.05
Total	12,019.6	13,881.1	26,341.4

Notes: 1. 35 Nedwind turbines in Daban Town, Xinjiang, with a capacity of 17.5 MW, were taken down.
2. The installed capacity of Taiwan Province is only included in these statistics and not calculated in the market shares of manufacturers and developers.

2.2.2. Regional characteristics of wind power development

By the end of 2009 a total of 24 provinces and autonomous regions (excluding Hong Kong, Macao and Taiwan) had their own wind farms in China. There were over nine provinces with a cumulative installed capacity of more than 1,000 MW, including four provinces exceeding 2,000 MW. The Inner Mongolia Autonomous Region took the lead, with newly installed capacity of 5,545 MW and a cumulative installed capacity of 9,196 MW by the end of the year, both representing substantial increases of 150%. The cumulative and newly installed capacity in Inner Mongolia in 2009 accounted for 36% and 40% respectively of the whole capacity in China. The province was closely followed by Hebei with a cumulative capacity of 2,788.1 MW, Liaoning with 2,425.3 MW and Jilin with 2,063.8 MW (see Table 6).

2.2.3. Status of wind power developers

There were no significant changes in the status of the ten largest wind power developers during 2009. Guodian (Longyuan Electric Group), Huaneng and Datang remained the top three in terms of their installed capacity during the year, as well as cumulative and grid-connected capacity. Huadian edged its way into fourth place. Guohua and China Guangdong Nuclear Power, fourth and fifth in 2008, fell backwards to fifth and sixth position. Those developers with a cumulative installed capacity of 1,000 MW or more increased from three to seven (see Table 7).

In 2009, energy investors became actively involved in wind power, most of which were large electricity supply companies. The installed capacity of these investors reached 90% among the overall installed capacity, of which central government owned enterprises accounted for more than 80%, the five major power supply groups (Huaneng, Datang, Huadian, Guodian, and CPI) for 50% and other state-owned investors, foreign-owned and private enterprises for less than 10%. Most of the local state-owned non-energy enterprises, foreign-owned and private enterprises retreated from the market. Only a minority of enterprises, such as China Wind Power and Tianrun, were struggling in terms of their finances. Their shares of new and cumulative installed capacity were very small, however.

The five major power groups accelerated their development of wind power in 2009. Their proportion of the total new and cumulative installed capacity was respectively 54.8% and 54.4%. The growth rates of these five companies were over 113.4%, two percentage points more than the national average of 111.4%. Huadian grew most among the five power groups, expanding by 279.9% and ranking first among the country's wind power developers. Although Guodian and Datang maintained their first and second places, their growth rates decreased. CPI grew least among the five big groups and just managed to keep eighth place.

2.2.4. Status of equipment manufacturing industry

In recent years China's wind turbine equipment manufacturing industry has developed rapidly and its industrial concentration has further intensified. In terms of new and cumulative installed capacity, the top three, five and ten companies respectively accounted for 55.5% and 59.7%, 70.7% and 70.4%, and 85.3% and 84.8% in 2009. Following the planning of the national 10 GW–scale wind power bases, domestic manufacturers of complete turbines have accelerated their industrial expansion for two years in succession. The complete turbine manufacturers, including Goldwind, Sinovel Wind Power, Guodian United Power and Guangdong Mingyang, have all established manufacturing plants close to the wind power bases. Because they are close to the point of installation, this decision effectively minimises transportation costs and ensures the timing of deliveries, which in turn has a positive influence on the development of the enterprise. Some regional governments have introduced policies to encourage the machine manufacturers to build plants in order to speed up the development of a local manufacturing industry and increase their tax revenue. Without taking local industrial support systems and the availability of human resources into account, however, such administrative intervention is bound to result in scattered distribution of manufacturing bases, which has caused considerable concern. Table 8 shows the location of manufacturing plants for the main enterprises.

2.2.5.Development trends in equipment technology

In 2005, MW-scale wind turbine generator systems (≥ 1 MW) newly installed in China's wind power plants only accounted for 21.5% of newly installed capacity during the year. With the increase in the manufacturing of these turbines by domestic enterprises, however, the proportion of MW-scale machines reached 51% in 2007, 72.8% in 2008 and 86.8% in 2009. MW sized wind turbines have now become mainstream in the

Table 7 Growth of Wind Capacity Installed by Major Developers in 2009

No.	Investor	Newly installed capacity (MW)	Cumulative installed capacity (MW)	Annual growth rate (%)
1	Guodian	2,600.4	5,098.3	104.10%
2	Datang	1,739.85	3,805.8	84.20%
3	Huaneng	1,644.75	2,874.35	133.80%
4	Huadian	1,239.95	1,682.95	279.90%
5	Guohua	590.25	1,475.65	66.70%
6	China Guangdong Nuclear Power	854.45	1,360.25	168.90%
7	Jingneng	757.5	1,200.3	171.10%
8	China Power Investment Corporation (CPI)	386.13	860.63	81.40%
9	China Energy Conservation and Environmental Protection Group (CECEP)	400.25	774.75	106.90%
10	Jointo	260.4	493.85	111.50%
11	Other investors	3,407.17	6,714.52	103.00%
Total		13,881.1	26,341.35	111.40%

Table 8 Industrial Location of Domestic Turbine Manufacturers

Enterprise	Location
Sinovel	Dalian, Yancheng, Jiuquan, Baotou, Dongying and Baicheng
Goldwind	Urumchi, Baotou, Yinchuan, Jiuquan, Chengde, the second phase in Urumchi, Beijing, Xi'an and Dafeng
United Power	Baoding, Lianyungang, Chifeng and Jiuquan
Dongfang Steam Turbine Co., Ltd.	Deyang and Tianjin
XEMC	Xiangtan, Zhangzhou and Laizhou
Yunda	Hangzhou and Zhangjiakou
Mingyang	Tianjin, Jilin, Zhongshan, Xi'an and Nantong
Vestas	Tianjin and Huhhot

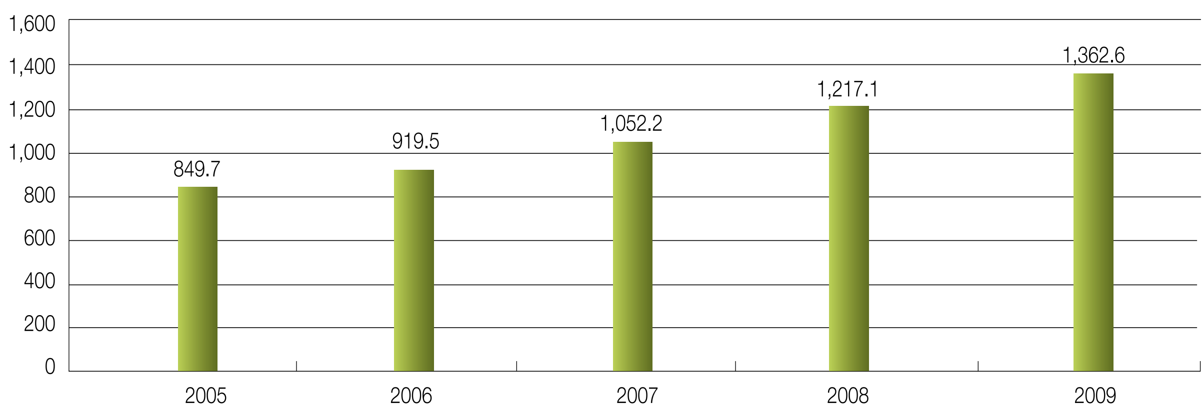


Figure 10 Increase in Capacity of Domestic Installed Wind Turbines Unit: kW

Chinese wind power market (see Figure 10).

Meanwhile, the larger wind turbine manufacturers in China have started to enter the competition for large-scale wind power equipment, encouraged by the international trend towards greater capacity machines. In 2009, China realised a new achievement in the research and manufacturing of MW (≥2 MW) wind turbine generator systems. The 2.5 and 3 MW wind turbines manufactured by Goldwind Science & Technology Co. Ltd., for example, were both put into commission in wind farms. The 3 MW offshore wind turbine produced by Sinovel Wind Co. Ltd. was connected to the grid and began to generate power in the Donghai Bridge offshore wind park. The 3 MW wind turbine developed by the Shenyang University of Technology was also commissioned successfully. In addition, Sinovel, Goldwind, Dongfang Steam Turbine, Haizhuang and XEMC all started to research the manufacturing of wind turbines with a single capacity of 5 MW. China has therefore successfully entered in the field of multi-MW wind turbine generators.

2.2.6. Price of wind turbines

From 2004 to 2008, the price of wind turbines kept rising due to a number of factors. The average price increased from RMB 4.8 per MW in April 2004 to RMB 6.2 at the beginning of 2008. However, prices began to fall again during the second half of 2008, and in 2009 they fell rapidly (see Figure 11). By the end of 2009, the market price of domestic wind turbines had decreased from RMB 6.2 per MW at the beginning of 2008 to below RMB 5 per MW. The reasons for this dramatic fall in market price included an increase in the localisation of manufacturing within China, a reduction in raw material prices and transportation costs, and an improvement in economies of scale. In addition, it cannot be ruled out that some enterprises broke market discipline and reduced their prices in order to win the bidding rounds for new projects, which in turn resulted in other enterprises blindly following suit.

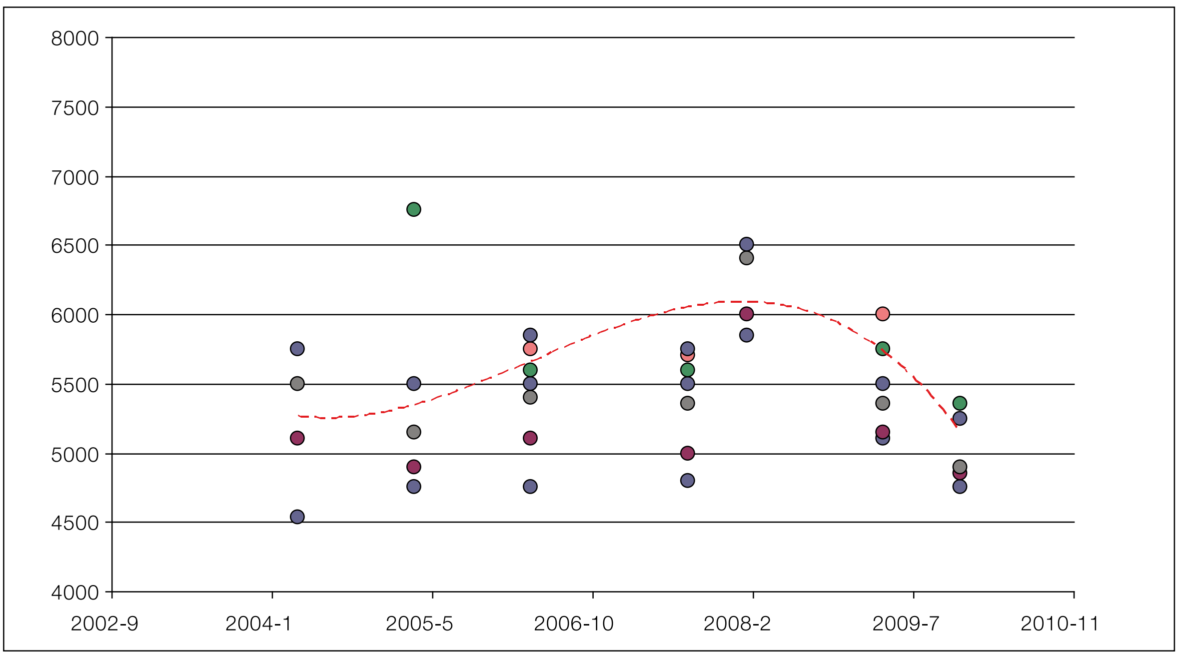


Figure 11 Market Price Trends of Domestic Wind Turbine Generator Systems, 2004-2009 Unit: Yuan

Source: Chinese Wind Energy Association. This data refers to the offer (excluding the tower) of 1.5 MW wind turbines in concession and large-scale wind power project bids.

2.3. Offshore Wind Power

The development of offshore wind power has made some progress in China but it remains at an early stage compared with Europe. The main developments are as follows:

2.3.1. Research and development of offshore wind power technology

Although China has much experience in the development of wind power, this is limited to land. Offshore wind power is a new departure. Before large-scale exploitation, there are major challenges to address in terms of the basic design of the technology, as well as construction, equipment supply and operation. For this reason, the Ministry of Science and Technology has allocated special funds to support the relevant organisations in the development and research of key technologies for offshore wind power during the period of the Eleventh Five-Year Plan (see Table 9).

2.3.2. Demonstration offshore wind projects

Shanghai's Donghai Bridge offshore wind power project, the first offshore wind park in China, is located along a line 1,000 metres away from both sides of Donghai Bridge, which connects Lingang New City with the Yangshan deep-water port. Its northernmost end is approximately 6 km from the coastline of Nanhuizui and the southernmost end is 13 km away from the coast. It is within the border of Shanghai City. The project developers, Shanghai Donghai Wind Power Co. Ltd., a company formed by China Power International Development Ltd., Datang, China Guangdong Nuclear Power Group and Shanghai Green Energy, are carrying out the construction, management, operation and maintenance of the plant. The first set of offshore wind turbines, researched and developed entirely by Sinovel Wind Co. Ltd., completed their installation at Shanghai's Donghai Bridge on 20 March, 2009 (see Figure 12 for details). By February 2010, 27 sets had been erected, of which three have been connected to the grid. The whole project is due to be completely installed, commissioned and put into operation before the beginning of the Shanghai EXPO in 2010.

The total investment value of the Donghai Bridge offshore project is RMB 3 billion. Thirty-four 3 MW Sinovel turbines will eventually be installed, with a total capacity of 102 MW and an expected electrical output of 258.51 GWh. This will meet the annual demand of 200,000 average families. In addition, United Power, Shanghai Electric Group, Mingyang and XEMC have also carried out experiments in offshore

Table 9 Topics for Inshore Wind Power Research in the National Science & Technology Programme

Topic	Responsible corporation
Research of key technology in the construction of inshore wind power plant	Shanghai Electric (Group) Corporation
	China Three Gorges Project Corporation
Installation and maintenance of inshore wind turbine generator system, and manufacture of special equipment	CNOOC Oil Base Group Co. Ltd.
	China Three Gorges Project Corporation
Inshore wind power plant technology, economic analysis and assessment of effect on the environment	CNOOC Oil Base Group Co. Ltd.
Construction technology handbook for inshore wind power plant	CNOOC Oil Base Group Co. Ltd.
Research and development of 3.0 MW with proprietary intellectual property rights	Baoding Tianwei Group Co. Ltd.
	Beijing Corona Science & Technology Co. Ltd.
	Sino-Wind Energy Group Ltd.

Source: Ministry of Science and Technology (www.most.gov.cn)

Figure 12 Panorama of the Donghai Bridge Wind Power Project

wind power projects in different regions.

2.3.3. Relevant policies for offshore wind power

The National Development and Reform Commission listed R&D projects covering inshore wind power technology, which were supported by the Chinese government in the 2005 Directory of Renewable Energy Industry Development. The commencement of the Shanghai Donghai Bridge offshore wind project at the end of 2006 marked the start of demonstration work for offshore wind power in China. In 2007, China issued its Eleventh Five-Year Energy Development Plan and proposed to explore the potential for inshore wind power along the coast of Jiangsu and Shanghai, reinforce research into development technology for inshore wind power, carry out an investigation and assessment of inshore wind energy resources and the initial preparation for pilot and demonstration projects, and establish one or two pilot projects of 100 MW-scale parks in order to accumulate experience in large-scale development.

The "Seminar for Offshore Wind Power Development and Construction of Large-scale Coastal Wind Power Bases", hosted by the National Energy Bureau and attended by all relevant departments of central and local government, related scientific research institutions and other organisations and companies in January 2009, was a milestone in the Chinese government's implementation of its strategy for offshore wind power development. This seminar established technological standards, including issuing Regulations for Preparing Engineering Planning Reports on Inshore Wind Power Plants (Trial) and Preparation Rules of Inshore Wind Power Project Pre-feasibility Study Report.

The National Energy Bureau subsequently issued the Outline Measures for the Administration of Offshore Wind Power Development (Guo Neng Xin Neng [2010] No. 29) in January 2010, and required all related facilities to implement it. This document, which was designed to promote the standardised construction and management of offshore wind power projects and their orderly development, covered the administrative organisation and technological quality management in procedures such as the development and planning of offshore wind power, project grants, project approval, use of sea areas and protection of the marine environment, construction, completion, acceptance and management of operational data. It stipulated that a competent national energy department should take charge of the development, construction and management of offshore wind power across the whole country. The relevant departments of coastal provinces (cities or districts), under the guidance of the national energy department, were placed in charge of the development, construction and management of local offshore wind power, and the central management institution of national wind power construction technology was authorised to be responsible for offshore wind power technology. These administrative measures indicated that the Chinese government had decided to manage and supervise the large-scale development of offshore wind power at a national level.

2.3.4. Regional planning and project preparation

To accelerate the implementation of large-scale wind power bases in the coastal regions, and boost the rapid development of wind power nationally, the National Energy Bureau has taken responsibility for carrying out preparatory work for their construction. Taking the 10 GW-scale wind power bases in the coastal region of Jiangsu as an example, the preparation for large-scale coastal wind power has already started. It has been defined that the wind power plants will be divided into two categories: land-based and offshore plants. The offshore plants include those in intertidal zones and subtidal mudflats, inshore locations as well as deep-sea projects. These are further defined as follows:

1) Land-based wind power plant: This refers to a wind power plant developed and constructed in the supratidal mudflat area above the average high tide line on land and in coastal regions, including plants established on islands with permanent residences.

2) Intertidal zone and subtidal mudflat wind power plant: This refers to a wind power plant established in a sea area below the average high tide line in a water depth of up to 5 metres at the theoretically lowest water level.

3) Offshore wind power plant: This refers to a wind power plant established in a sea area with a water depth of 5-50 metres below the theoretically lowest water level, including ones on islands without permanent residences and reefs within the corresponding sea area.

4) Deep offshore wind power plant: This refers to a wind power plant in a sea area with a water depth of 50 metres or more below the lowest water level, including ones constructed on islands without permanent residences and reefs within the corresponding sea area.

Subject to the principles of unified planning and construction by stages, several locations for inshore wind power plants with a total installed capacity of more than 1,000 MW have been selected. A programme of construction in phases has been proposed and initial preparation, such as a survey of wind energy resources and marine hydrological observation, carried out. The preparation work has included studying the pre-feasibility of the first-phase construction, geological reconnaissance of the project location, topographic surveys, assessment of the wind energy resources, geological assessment of construction, construction scale and deployment, estimation of the construction investment and an initial economic assessment. In addition, the construction programme for the wind power plants has been determined in outline.

If the location of the wind power plant is different, the land and sea areas for construction and installation are also different. Depending on the development level of wind power technology, the scope of planning covers land-based wind power plants, intertidal zone and subtidal mudflat wind power plants and inshore wind power plants in Jiangsu Province. Deep-sea wind power plants are not included at present.

According to these deployment plans, the provinces of Jiangsu, Shanghai, Shandong, Zhejiang, Fujiang, Guangdong and Liaoning have all planned to construct offshore wind power plants. Jiangsu, Shandong, Shanghai and Guangdong have completed the planning stage, although this still remains on hold due to lack of support from the assessment and analysis of offshore wind energy resources. Table 10 shows progress in offshore wind power planning in different areas.

Without considering the ability of the power market to handle the electricity, according to statistics[4] from the preliminary results of provincial planning, by 2015 the installed capacity of offshore wind power in Shanghai, Jiangsu, Zhejiang, Shandong and Fujian is planned to reach 10,100 MW, of which inshore wind power will make up 5,900 MW and intertidal zone wind power 4,200 MW. By 2020, the installed capacity of offshore wind power is planned to reach 22,800 MW, of which inshore wind power will make up 17,700 MW and the intertidal zone 5,100 MW (see Table 11).

2.3.5. Concession bidding for offshore wind power projects

The concession bidding for national offshore wind power projects, which was first advertised in May 2010, included four projects. These were Binhai Offshore Wind Power Plant (300 MW), Sheyang Offshore Wind Power Plant (300 MW), Dafeng Offshore Wind Power Plant (200 MW) and Dongtai Offshore Wind Power Plant (200 MW), all in Jiangsu Province. The total installed capacity was 1,000 MW. This concession bidding is the first of its kind for demonstration projects of offshore wind power plants. The requirements in terms of bidders' qualifications and performance included:

1) The bidders must be an independent legal entity.

2) The bidders may be a single or joint entity. In the case of a single entity they should be a China-funded enterprise or a Sino-foreign joint venture held and controlled in China (shareholding over 50% and absolutely holding). In the case of a joint entity the initiators should meet the requirements stated above.

3) By September 2010 the capacity of wind power plant under construction or finished by the bidders should be no less than the scale of the bid project. In the case of a joint entity, the initiators should meet the requirement on performance.

According to the schedule of bidding, site inspections

Table 10 Progress in Offshore Wind Power Development Planning by Province[3]

Province or city	Progress
Shanghai	Passed the examination
Jiangsu	Finish the examination and enter the phase of modification and improvement
Zhejiang	Finish the application for examination and wait for examination
Shandong	First draft is completed and it is in the phase of further improvement
Fujian	First draft is completed and it is in the phase of further improvement
Hebei, Liaoning, Guangdong, Guangxi and Hainan	Planning report in preparation

Table 11 Development Planning for Offshore Wind Power in Coastal Provinces

Region	Planning capacity (MW)	
	Year 2015	Year 2020
Shanghai	700	1,550
Jiangsu	4,600	9,450
Zhejiang	1,500	3,700
Shandong	3,000	7,000
Fujian	300	1,100
Other (tentative)	5,000	10,000
Total	15,100	32,800

3 The data is selected from the articles related to the second Shanghai Offshore Wind Power and Industrial Chain during Jun.7-9, 2010.
4 The data is selected from the articles related to the second Shanghai Offshore Wind Power and Industrial Chain during Jun.7-9, 2010.

would be carried out in mid-June, a pre-bid conference would be held in early August and the formal bidding would be commenced on 10 October. The organisations that won the bidding were notified in mid-June 2010. They have three years to finish the project.

2.4. National Energy Policy

At the end of 2009, the Chinese government made a political commitment to the international community at the Copenhagen Conference on climate change that non-fossil energy would satisfy 15% of the country's energy demand by 2020. This goal became a binding target for short-term and medium-term national social and economic planning, together with a subsequently formulated target that CO_2 emissions per GDP would be 40-45% lower in 2020 than in 2005. This will require an unprecedented boost to the scale and pace of future clean energy development, including a new orientation towards wind power development.

Since the Renewable Energy Law was first promulgated, China's renewable energy industry has maintained a rapid momentum of development which has attracted global attention. In 2009, China overtook the EU and the USA for the first time and became a major location for global renewable energy investment and the largest country for newly installed wind power capacity in the world. China also ranked first in the output of solar photovoltaic panels for the third consecutive year, accounting for approximately 40% of the global market. Meanwhile, the total energy consumption in China broke through the barrier of three billion tons of standard coal eqivalent (tce) and greatly exceeded expectations. At the start of establishing its goals for renewable energy, China estimated its expected energy demand in 2020. It is now generally estimated that energy consumption will reach 4.6 billion tons of standard coal equivalent in 2020 (see Figure 13). On the basis of a 15% contribution, this means that non-fossil energy supplies will need to reach the equivalent of 690 million tons of coal equivalent, 240 million tons more than anticipated in 2004. Even if the development of nuclear power is taken into account, the pressure on the demand for wind power and other renewable energy sources is still great.

In 2007 the Chinese Academy of Engineering asked experts to estimate China's expected wind power development in the short and medium-term.[5] The most optimistic estimate was that the installed capacity of wind power would reach 120 GW in 2020, 270 GW in 2030 and 500 GW in 2050. Since it was expected that non-fossil energy should account for 15% of demand, the renewables industry enhanced the expectation for wind power and projected that its installed capacity should reach at least 150 GW in 2020. It would be even better if it could reach 200 GW, at which point it would account for 3-5% of the total renewable energy supply of 15%.

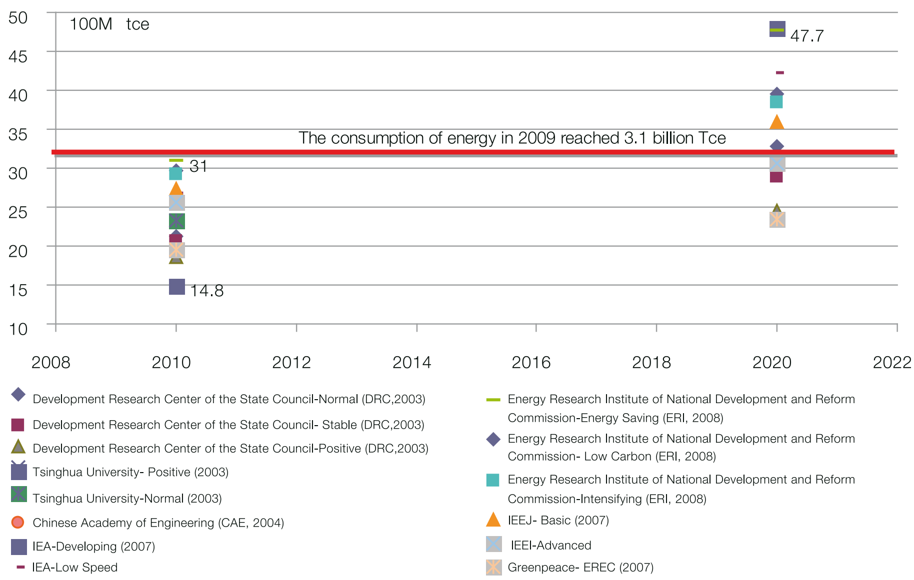


Figure 13 Range of Energy Demand Estimates for 2020

Source: Chinese Academy of Engineering, Research Report on Problems of China's Renewable Energy Development, China Science Press, October 2008

5 Du Xiangwan, etc. Research on the Development Strategy of China Renewable Energy, China Science Press, October in 2008

3. Seven Major Wind Power Bases

3.1. Outline Proposal

The overall wind energy resources are very plentiful in China. However, they are mainly concentrated in the northwest, north and northeast, the "three northern areas in China". After discussion of this issue, the Chinese government's concept of wind power development was gradually shifted towards the idea of establishing large bases and connecting with a new larger grid. It was therefore required that all planning and construction should be carried out in accordance with this concept. Since 2008, under the leadership of the National Energy Bureau, the planning of 10 GW-scale wind power bases in Gansu, Xinjiang, Hebei, the eastern and western part of Inner Mongolia, Jilin and the coastal area in Jiangsu has all been completed to the extent of an assessment of the wind energy resources and preparation for construction. According to the plan, all these wind power bases will contain a total installed capacity of 138 GW by 2020, and on the assumption that a supporting grid network is established.

3.1.1. Hebei wind power base

Hebei Province is rich in wind energy resources, which are mainly distributed in Zhangjiakou, Chengde Bashang and in the coastal areas of Qinhuangdao, Tangshan and Cangzhou. The Bashang area of Zhangjiangkou is abundant in wind energy resources, with an annual average wind speed of 5.4-8 metres per second and a mainly northwesterly wind. The resources are mainly distributed in the low mountain, hill and plateau areas of Kangbao County, Guyuan County, Shangyi County and Zhangbei County. Transport routes in the area are convenient and there are good conditions for the construction of large-scale wind power plants. A part of the mountain areas in Chongli County and Wei County are also rich in wind energy resources. The annual average wind speed in Chengde area reaches 5-7.96 m/s, with the wind mainly blowing from a northwesterly direction. The resources are mainly distributed in the northern and western parts of Weichang County, the northern and northwestern parts of Fengning County and the western part of Pingquan County. The wind energy resources in the coastal areas are mainly distributed in the coastal mudflats of Qinhuangdao, Tangshan and Cangzhou. The annual average wind speed there is around 5 m/s.

According to the overall distribution characteristics of wind energy resources in Hebei Province, wind power plants planned in the 10 GW-scale Hebei wind power base are mainly located in Zhangjiakou, Chengde and the coastal area of the province. After analysis of wind energy resources, engineering geology, transportation and grid planning capacity, 59 sub-wind power plants are planned in total. Of these, 39 have been selected in Zhangjiakou City, with an estimated total installed capacity of 9.55 GW, 16 sites selected in Chengde City, with an estimated total installed capacity of 3.98 GW, and four sites selected in the coastal area, with an estimated total installed capacity of 600 MW (see Table 12). The total capacity will reach 14,130 MW and the base is expected to be established in Hebei by 2020.

At present, the national government has replied officially on the first-stage and second-stage construction proposals for the GW-scale wind power base in Bashang and the first-stage construction proposals for Chengde. These include 30 projects with a capacity of 3.85 GW, of which 11 have already been approved. These are for the first-stage construction of the GW-scale wind power base in Bashang, Zhangjiakou and the Yudaokou national concession tendering projects for the GW-scale wind power base in Chengde. The total approved capacity is 1.5 GW. At the end of 2009, the supporting grid network for the first-stage construction in Bashang was completed successively or under construction, and a 240 MW wind park had been connected to the grid and put into production. It was predicted that all the other projects would be completed and generate electricity in 2010. Furthermore, with respect to the second-stage construction in Bashang and the 19 further projects in Chengde, the supporting documents for project approval are currently being considered. It is estimated that these will be constructed during 2010.

Table 12 Summary of Installed Capacity Planned for Hebei Wind Power Base Unit: MW

Key area	Cumulative capacity by 2010	Newly installed capacity by 2015	Newly installed capacity by 2020	Cumulative installed capacity by 2020
Zhangjiakou City	2,760	2,420	4,370	9,550
Chengde City	1,150	2,300	530	3,980
Coastal areas	250	100	250	600
Total	4,160	4,820	5,150	14,130

3.1.2. Eastern Inner Mongolia wind power base

The planning investigation of the eastern part of Inner Mongolia includes the areas round Chifeng City, Tongliao City, Xingan League, Hulunbuir City and Manzhouli City. This region is rich in wind energy resources. The border region between Ongniud Banner and Hexigten Banner of Chifeng City and Songshan District has flat terrain, high altitude and good wind energy resources, with the average wind speed reaching 8.0-9.3 m/s at a height of 70 metres and the power density 700-1,200 W/m^2. It is a superb site for large-scale wind power plants. The wind energy resources in Tongliao and Xingan League are average. Hulunbuir, located in the Greater Khingan area, has a large forest-covered area, great unevenness in the ground and relatively poor wind energy resources. By October 2008, the installed capacity put into production by the four cities and one league in Inner Mongolia had reached more than 1 GW.

56 wind power plants have been planned to start production in eastern Inner Mongolia before 2020. Of these, 24 are located in Chifeng City, with an installed capacity of 6.75 GW and with the sites concentrated in the border region between Ongniud Banner and Hexigten Banner of Chifeng City and Songshan District, which is even in terrain and high in altitude; 16 wind power plants are located in Tongliao City, with an installed capacity of 7.45 GW and the sites concentrated in the border region between Kailu County and Horqin Banner; 11 plants are situated in Xingan League, with an installed capacity of 3.85 GW and the sites concentrated in the southwest; four plants are located in Hulunbuir City, with an installed capacity of 1.6 GW; one plant is located in Manzhouli City, with an installed capacity of 150 MW. By 2020, the newly installed capacity in the four cities and one league in the eastern part of Inner Mongolia will have reached 19.80 GW, and ten centralised GW-scale wind power bases will have been established. These are the Chifeng Million Wind Power Base, Hanshan Wind Power Plant, Dalihu Wind Power Base, Kailu Wind Power Base, Zhurihe Wind Power Base, Dalijifeng Wind Power Base, Zhalute North Wind Power Base, Eergetu Wind Power Base, Taohemu Wind Power Plant and Hulunbuir Wind Power Base.

According to the plans, the newly installed capacity in the eastern area of Inner Mongolia will reach 3.2 GW and the total installed capacity will reach 4.211 GW by the end of 2010. Newly installed capacity will then increase by 9 GW between 2011 and 2015 and reach a total of 13.211 GW by the end of 2015. A further 7.6 GW of new capacity will be installed during the years from 2016 to 2020, with the total exceeding 20 GW by the end of 2020.

Presently, the Chinese government has replied officially on the construction of GW-scale wind power bases in the Tongliao and Kailu areas of eastern Inner Mongolia. There are five projects there with a total capacity of 1.5 GW. One project has already been approved, the Kailu Beiqinghe national concession tendering project, with a capacity of 300 MW. At the end of 2009, the wind turbines had been completely installed and the supporting grid network is under construction. It should be connected to the grid and generate electricity in 2010. The supporting documents related to project approval for the other projects are being considered. It is predicted that they will be approved and launched in 2010.

3.1.3. Western Inner Mongolia wind power base

According to the initial analysis of wind energy resources, engineering geology, transportation, construction and installation, environmental effects and other conditions, as well as the power market in the western part of Inner Mongolia, 14 GW-scale wind power bases are initially planned in the region. It has plentiful wind energy resources, uncomplicated terrain with a flat and broad relief, good conditions for engineering geology, convenient transportation, favourable conditions for installation and no significant negative factors affecting construction, combined with good progress in preparation, the development requirement of the local social economy and the opinions of local government. Meanwhile, some small-scale wind power plants are planned in western Inner Mongolia. The proposals for these plants have been approved by the Inner Mongolia Autonomous Region or (mostly) by the national government. Some projects have already been constructed and put into production.

The planning area includes Ulaanchab City, Xilin Gol League, Baotou City, Bayan Naoer City, Hohhot City, Ordos City, Alxa League and Erlianhaote City in the west of Inner Mongolia.

Based on the wind energy resources in western Inner Mongolia and the present status and development plans for the necessary connecting grid, the planned installed capacity of wind power in the western area of Inner Mongolia is for it to reach 3.46 GW by 2010, 17.95 GW in 2015 and 38.30 GW in 2020.

In terms of wind power planning for the western part of Inner Mongolia, the development and construction of wind power plant in this area is determined in accordance with the principles of “overall planning, reasonable layout, scientific construction and step-by-step implementation”. The process for developing wind power plants is decided in accordance with previous wind measurements in the location of the plants, an assessment of the wind energy resource, geological conditions, transportation, installation, grid connection and the conditions of the local social economy.

Subject to these principles, the plans initially include projects for wind power development approved prior to 2010, including the two GW-scale wind power bases in Urad Middle Banner of Bayan Naoer City and Damao Banner of Baotou City. During the period from 2011-2015, small-scale wind power projects will be increased appropriately in some places and the development and construction of the two planned GW-scale wind power bases in Urad Middle Banner of Bayan Naoer City and Damao Banner of Baotou City will be completed. In this period, the development of GW-scale wind power bases will be given priority - mainly the seven large-scale wind power bases which include Jiqing, Dabanliang in Ulanqab City as well as Zhurihe wind in Xilin Gol League, Xianghuang Banner, Taibai, Duolan and Huitengliang. Between 2016 and 2020 smaller scale wind power projects will also be installed in some places, together with continuing work on the large-scale wind power bases. The 12 large-scale wind power bases which will dominate activity during this period are Jiqing, Dabanliang, Honggeer and Wulan in Ulanqab City, Zhurihe, Xianghuang Banner, Taibai, Duolan, Huitengliang in Xilin Gol League, Wuchuan in Hohhot City and Guyang in Baotou City.

At present, the government has replied officially on the construction of the two GW-scale wind power bases in Damaobayin and Bayannaoer, Baotou and in Bayannaoer, western Inner Mongolia. The Damaobayin base consists of eight projects with a total capacity of 1.6 GW, of which one, the Baotou Bayin national concession tendering project, has been approved. The agreed capacity is 200 MW. The project has completed grid connection and was generating electricity at the end of 2009. The supporting documents related to the approval of the other projects are under consideration. It is predicted that they will be built in 2010. The Bayannaoer base covers ten projects with a total capacity of 2.1 GW, of which one, the Wulan Yiligeng national concession-tendering project, has been approved with a capacity of 300 MW. At the end of 2009 the project had already completed its grid connection and been put into production. The supporting documents related to the approval of the other projects are being considered. It is expected that these will be approved and built in 2010.

3.1.4. Jilin wind power base

Jilin Province is abundant in wind energy resources and the wind power plants in the province were developed early on. By the end of 2008 the total installed capacity of wind power in Jilin had reached 1,157 MW, accounting for 9.51% of the total capacity in the whole country and ranking third of all the regions. The wind power resources of Jilin Province are mainly distributed in the western part of Jilin. The site of the 10 GW-scale wind power base is also in western Jilin. The area is flat and open terrain, with degenerated grassland and saline-alkali land dominating the vegetation. The land resources that wind power can utilise are relatively plentiful. The wind energy resources in this area are the best in Jilin Province, with the annual average wind speed ranging between 6.0 m/s and 7.1 m/

s at a height of 70 metres and the annual average power density ranging from 255 W/m^2 – 385 W/m^2.

For the 10 GW-scale wind power base in Jilin Province the total area of the planned wind power plant sites covers roughly 12,900 km^2 and the total proposed installed capacity is 27,290 MW. By the end of 2008, the finished and approved capacity had reached 2,015 MW. The newly installed capacity is expected to reach 19,00 MW in 2010, 6,200 MW during the period from 2011 to 2015, and with a further 11,200 MW to be installed during the period 2016-2020.

The planning sequence for the exploitation of wind power plants is initially determined in accordance with the conditions of the wind energy resources, the geological conditions, the conditions for construction and installation, grid connection availability, economic indicators and other contributing factors.

It is initially proposed that the development of wind power up to 2010 gives priority to projects that have already been approved, including the Tongyu Zhanyu GW-scale wind power base, which has finished planning. During the period from 2011-2015 the focus will be placed on the development of further GW-scale wind power bases, including Daan Haituo, Yaonanxiang (Longma and Xiangyang wind power plants) and Bahong (Bamian wind power plant in Tongyu and Hongxing wind power plant in Changling). Meanwhile, the development and construction of the Shanshui wind power base in Shuangliao will be started. The electrical output from these GW-scale wind power bases will be connected into the 500 kV grid. Depending on the local conditions for grid connection, other wind power plants in Fuyu and Ningjian, Songyuan City, Chaganhaote, Baicheng City, will be linked to the local 220 kV grid. The total new installed capacity over this period will reach 6,200 MW.

During the period from 2016 to 2020, the development and establishment of GW-scale wind power bases will continue, including Hongrang (Hongxing wind power plant, Qianguo and Rangzi wind power plant, Qianan), Shuangxing (Yaobei Shuanglong and Xingfu in Zhenlai and Wanbaoshan), Daan Xinpingan, Tongyu Taipingshan and Changling Longwang. Over this period, the planned new capacity will reach 11,200 MW in total. The 10 GW-scale wind power base in Jilin Province will therefore be basically completed by 2020. To reinforce the ongoing development of renewable energy, China will continue to develop large wind power plants, with a planned capacity of 5,975 MW in total in western Jilin Province, depending on social and economic factors and the development potential of the power grid.

3.1.5. Jiangsu coastal area wind power base

This wind power base covers mudflats, an intertidal zone and inshore parts of the coastal area of Jiangsu province. The proposed wind parks can be divided into land-based wind power plants (including the coastal mudflats), intertidal zone and subtidal mudflat wind power plants (generally called “intertidal-zone wind power plants”), inshore wind power plants and deep-sea wind power plants. These are defined as follows:

Land-based wind power plant: This refers to wind turbines developed and constructed in the supratidal mudflat area above the average high tide line on land and in coastal regions, including those established on islands with permanent residences.

Intertidal zone and subtidal mudflat wind power plant: This refers to wind turbines developed and established in the sea area from below the average high tide line to a depth of 5 metres below the theoretically lowest water level.

Inshore wind power plant: This refers to wind turbines established in the sea at a depth of 5– 50 metres below the theoretically lowest water level, including turbines on islands without permanent residences and reefs within the corresponding sea area.

Deep-sea wind power plant: This refers to wind turbines located in the sea at a depth of 50 metres or more below the lowest water level, including those constructed on islands without permanent residences and reefs within the corresponding sea area.

According to development level of wind power technology, the plans for the wind power base in coastal Jiangsu province are mainly land-based, intertidal zone and inshore wind power plants, with consideration of deep-sea wind power plants temporarily shelved. The intertidal zone and inshore wind power plants will be less than 100 km away from the coastline and in a water depth of less than 25 metres below the lowest water level, all subject to development goals, transmission distance, difficulty of construction and investment. Considering the current construction technology, power distribution level, investment cost and other factors, the projects which are within 40 km from the coast and in water less than 15 metres deep will be those mainly developed before 2020.

According to the reports Development Planning in the

Coastal Area of Jiangsu and Development Planning of Wind Power in Jiangsu Province (2006-2020), and in the light of the potential layout and construction conditions for wind power plants, the proposed target is for 1.8 GW by 2010, including 1.5 GW on land and 300 MW in the intertidal zone, 5.8 GW by 2015, including 2.4 GW on land, 2 GW in the intertidal zone and 1.4 GW in the inshore area, 10 GW by 2020, including 3 GW on land, 2.5 GW in the intertidal zone and 4.5 GW in the inshore area, and 21 GW by 2030, including 3 GW on land, 2.5 GW in the intertidal zone and 15.5 GW inshore (see Table 13).

At present, the government has confirmed or made an official response to ten land-based wind power plant projects in Yancheng and Nantong with a total capacity of 1.43 GW. Apart from two projects in Yancheng, Sheyang and Binhai affected by environmental protection issues, the other eight projects have been approved. These are Rudong and Dongtai national concession tendering and bidding projects, of which the total approved capacity was 1.15 GW. By the end of 2009, six projects had been completed and a total of 750 MW had achieved grid connection and been put into production. It is expected that other two projects will be brought into production in 2010.

3.1.6. Gansu Jiuquan wind power base

The Jiuquan area of Gansu Province is located at the western end of Hexi Corridor in Gansu Province at 92°04’-100°20’E longitude and 37°51’- 42°50’N latitude, covering a total area of 194, 000 km^2. The total capacity of the available and exploitable wind energy resources is approximately 40 GW. The Qilian Range in southern Jiuquan, the Mazongshan Mountain in the north, part of the northern mountain system, and the flat Gobi Desert in the middle together constitute a favourable landform of two mountains and a valley and make Jiuquan a passage for the west and east winds. It is therefore rich in wind energy resources and suitable for large-scale wind power plants. By the end of January 2008 the total installed capacity had reached 410 MW in the Jiuquan area, including 210 MW within Yumen City and 200 MW within Guazhou County.

According to the proposals for the 10 GW-scale wind power base in Jiuquan, newly installed capacity in the Jiuquan area will be 4,750 MW and the total capacity will reach 5,160 MW by the end of 2010. Newly installed capacity will reach 7,550 MW between 2011 and 2020. By the end of 2020 the total installed capacity will reach 12,710 MW and Jiuquan 10 GW-scale wind power base will have been established. Table 14 shows the plans for installed capacity in the Jiuquan wind power base.

The wind energy resources of Gansu Province are mainly concentrated in the Jiuquan area. The 10 GW-scale wind power base in Jiuquan was the first to be decided. Its construction will therefore provide significant experience for others in China. The first-stage projects of the Jiuquan GW-scale wind power base, to which the government has already officially responded, are made up of 20 projects with a total capacity of 3.8 GW. All these projects have now been approved and started construction in August 2009. It is estimated that the various parts of the base will be put into production one by one in 2010.

3.1.7. Kumul, Xinjiang wind power base

The Kumul area of Xinjiang is adjacent to the 10 GW-scale wind power base in Jiuquan, Gansu, both of which belong to the same wind field. This is a vast territory with sparse population. Its landform is the Gobi Desert. Kumul, abundant in wind energy resources and with flat terrain, also possesses the conditions to build a large-scale wind power base.

The total wind energy resources of Xinjiang are calculated to be 872 GW, according to the Technological Regulations on Assessment of National Wind Energy Resources, making it one of the richest provinces for wind power potential in the whole country. There are nine regions with an annual wind power density of over 150 W/m^2, including Dabancheng in Urumchi, Ala Mountain Pass, Shisanjianfang, Xiaocaohu in Turpan, the valley of the Ertix River, Tacheng Laofengkou, Santang and Naomao Lakes and southeastern Kumul and Luobupo. The total area is roughly 77,800 km^2 and the technically exploitable capacity reaches 120 GW. The development prospects for wind energy resources are therefore considerable.

According to the Assessment Report on Xinjiang Wind Energy Resources, the Kumul area mainly consists of the wind field in southeastern Kumul, Santang Lake - Naomao Lake wind field, and Shisanjianfang wind field. There are three wind power plants planned in Kumul's 10 GW-scale wind power base. The projects will be carried out in different stages. Newly installed capacity will reach 2,000 MW during the period from 2008-2010 and the total installed capacity will reach 2,000 MW in 2010. Newly installed capacity will reach 5,000 MW between 2011 and 2015 and the total will reach 7,000 MW

Table 13 Cumulative Development Objectives for Jiangsu Wind Power Base Unit: MW

	2010	2015	2020	2030
Land-based wind power plant	1,500	2,400	3,000	3,000
Intertidal zone wind power plant	300	2,000	2,500	2,500
Inshore wind power plant		1,400	4,500	15,500
Total	1,800	5,800	10,000	21,000

Table 14 Installed Capacity Planned for the 10 GW-Scale Wind Power Base in Jiuquan, Gansu Unit: MW

No.	Wind power plant		2007	2010	2015/2020
1	Guazhou Beidaqiao Wind Power Plant	Newly installed capacity		1,500	3,900
		Cumulative installed capacity	100	1,600	5,500
2	Guazhou Ganhekou Wind Power Plant	Newly installed capacity		1,700	
		Cumulative installed capacity	100	1,800	1,800
3	Guazhou Qiaowan Wind Power Plant	Newly installed capacity		600	
		Cumulative installed capacity		600	600
4	Guazhou Liuyuan Wind Power Plant	Newly installed capacity		50	50
		Cumulative installed capacity		50	100
5	Yumen 30 Li Jing Zi	Newly installed capacity			
		Cumulative installed capacity	110	110	110
6	Yumen Diwopu Wind Power Plant	Newly installed capacity		100	
		Cumulative installed capacity	100	200	200
7	Yumen Changma Wind Power Plant	Newly installed capacity		800	
		Cumulative installed capacity		800	800
8	Yumen Mahuangtan Wind Power Plant	Newly installed capacity			1,200
		Cumulative installed capacity			1,200
9	Mazongshan Wind Power Plant	Newly installed capacity			2,400
		Cumulative installed capacity			2,400
Total			410	5,160	12,710

Table 15 Installed Capacity Planned for the 10 GW-Scale Wind Power Base in Kumul, Xinjiang Unit: MW

No.	Wind Power Plant		Year 2010	Year 2015	Year 2020
1	Kumul Southeastern Wind Power Plant	Newly installed capacity	1,000	1,400	1,200
		Cumulative installed capacity	1,000	2,400	3,600
2	Naomaohu Wind Power Plant	Newly installed capacity		1,200	1,200
		Cumulative installed capacity		1,200	2,400
3	Santanghu Wind Power Plant	Newly installed capacity	1,000	2,400	1,400
		Cumulative installed capacity	1,000	3,400	4,800
Total			2,000	7,000	10,800

by 2015. During the years from 2016 to 2020, newly installed capacity will be 3,800 MW and the total capacity will reach 10,800 MW in 2020 (see Table 15).

The wind energy resources in Xinjiang are very plentiful but since the grid is weak and very distant it is unable to absorb more wind power. By the end of 2009, wind power capacity was just 870 MW. However, the wind energy resources in Kumul are plentiful and close to the northwestern grid. To make best use of the wind energy resources in Xinjiang it is therefore considered sensible to connect Kumul's wind power capacity with the northwestern grid. The first-stage projects of the wind power base in southeastern Kumul, which involves the construction of a total of 2 GW of capacity, are planned to include ten projects, each of which will be 200 MW. It has been one year since the measurement of wind energy resources for all the sites was carried out by developers. Considering the official response to the first batch of projects, all of the total capacity of 2 GW is expected to be put into production in 2011. The completion and operation of the Kumul base will be a breakthrough in the process of large-scale bases being connected to the grid in China. Santang Lake and Naomao Lake GW-scale wind power bases will be developed and built after 2010.

3.2. Construction Progress

The 10 GW-scale wind power bases described above will be constructed in phases. Based on comprehensive analysis of the wind energy resources, planning capacity, construction conditions and engineering investment for all the wind power bases, the government has made an official response or confirmed eight GW-scale wind power bases so far. These are the first and second-stage projects of the GW-scale wind power base in Bashang area, Zhangjiakou in Hebei province, the first-stage projects of the GW-scale wind power bases in Chengde, Hebei, Bayannaoer in Inner Mongolia, Damaobayin, Tongliao Kailu, and the first-stage projects of Gansu Jiuquan and the coastal Jiangsu. This amounts to 83 projects in total with an installed capacity of 14.28 GW. Table 16 shows progress on the construction of the wind power bases by the end of 2009.

3.3. Grid Connection and Wind Power Delivery

The 10 GW-scale wind power bases planned in Hebei, Jiangsu, Inner Mongolia, Gansu and Xinjiang are mostly located at the end of the power grid. The grid structure is not strong enough and the power system is basic. The connection of wind power therefore places great pressure on the stable operation of the grid. In addition, most of the wind turbines use asynchronous generator technology, which has an influence on the security and stability of the grid unlike the the more typical synchronous generator systems. The variation in the wind also makes the output power of a wind park fluctuate. As a result, it is difficult to formulate and implement accurate electricity supply plans from wind turbines in the same way as from ordinary power. With the expansion of wind power plants, the proportion of wind power in the grid is steadily increasing, and its influence on the network growing in parallel. The transmission distance from remote wind power sites is great and the transmission power is relatively large. There are therefore problems with the stability of the voltage. At the same time, the variability of wind power causes changes to the power flow, with great uncertainties, alters the distribution of the power flow, the transmission power of the circuit and the inertia of the whole system, and influences the transient and frequency stability.

To enhance the transmission capability of wind parks and improve the quality of grid-connected wind power, advanced technology must be applied. This includes, for instance, dynamic var-compensation equipment (SVC, STATCOM, etc.), series compensation/thyristor controlled series compensation, controllable shunt reactors and automatic voltage control (AVC). The dynamic var-compensation equipment is used to raise the var-compensation and voltage regulation capability of wind power plants and improve the quality of power. Series compensation/thyristor controlled series compensation is used to minimise the electric distance of the transmission system and enhance the level of security and stability, and the controllable shunt reactor is applied to stabilise the voltage of the regulating system and maintain the voltage level of the transmission passage when the active power fluctuates. At Gansu Jiuquan 10 GW-scale base, for example, which transmits its output to the northwestern main grid through a 750 kV AC connection, the wind power plant is fitted with SVC, which accounts for 15% of the installed capacity. 30-50% series compensations are installed in the 750 kV circuit and a controllable shunt reactor is installed in the circuit and busbar.

In short, both the national and local grid companies are making positive efforts to solve the problems of power transmission from wind power bases. The power generated

Table 16 Progress of 10 GW-Scale Wind Power Base Development

Province	GW-scale wind power base	Number of projects	Total installed capacity (MW)	Number of approved projects	Approved capacity (MW)	Installed capacity (MW)
Hebei	Chengde first-stage	6	1,000	1	150	0
	Zhangjiakou Bashang first-stage	10	1,350	10	1,350	864
	Zhangjiakou Bashang second-stage	14	1,500	0	0	0
	Total	30	3,850	11	1,500	864
Inner Mongolia	Tongliao Kailu	5	1,500	1	300	300
	Bayan Naoer	10	2,100	1	300	300
	Damao Bayin	8	1,600	1	200	200
	Total	23	5,200	3	800	800
Gansu	First-stage of Jiuquan Base	20	3,800	20	3,800	304.5
	Total	20	3,800	20	3,800	304.5
Jiangsu	Costal and land-based	10	1,430	8	1,150	825
	Total	10	1,430	8	1,150	825
Grand total		83	14,280	42	7,250	2,793.5

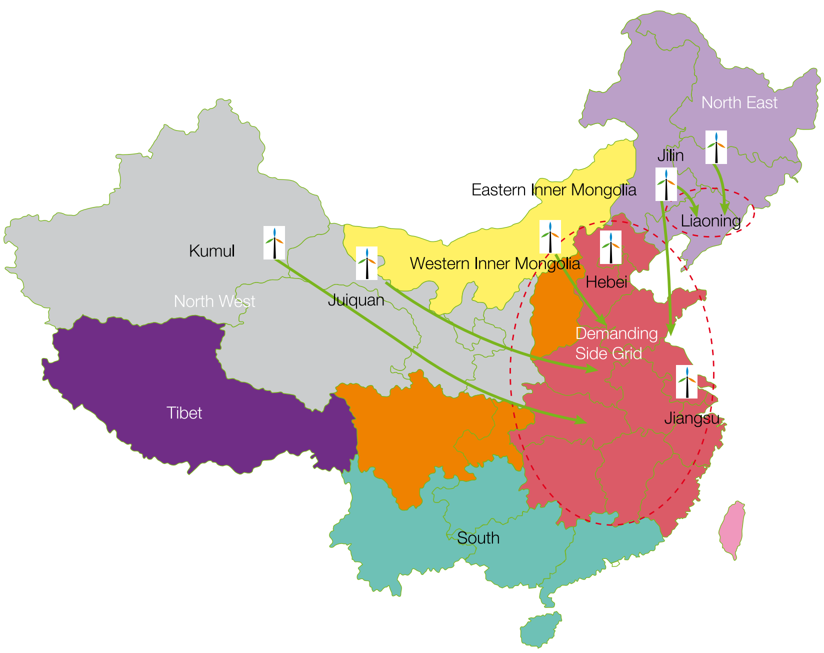


Figure 14 Schematic of Electricity Delivery from the Main Wind Power Bases

in the northeastern wind power base is absorbed by the northeastern grid completely and the power from the inshore and offshore wind power bases in the coastal Jiangsu region is mainly absorbed locally. The plan for distribution of the power generated by the other large wind power bases, excluding the part consumed locally, is as follows:

The Hebei wind power base and the wind power base in western Inner Mongolia are mainly connected into the North China Grid. The Shandong grid needs to absorb part of this power from around 2020. The wind power base in eastern Inner Mongolia will be connected to the northeastern grid and the North China Grid in the near future. Gansu Jiuquan and Xinjiang Kumul wind power bases have recently been connected to the northwestern grid and will be connected to the central China grid in the future (see Figure 14).

3.4. National Support Policies

To support the construction of large-scale wind power bases, the government has made a number of arrangements in terms of industrial policy, standards setting, information administration and grid connection. These are summarised here.

1) Industrial policy: The National Development and Reform Commission issued A Notice Regarding the Price Policy on Wind Power into the Electricity Grid (Fa Gai Jia Ge [2009] No. 1906) in July 2009 and established a benchmark price mechanism formed in accordance with the status of wind energy resources and the conditions of construction. This benchmark grid tariff compliments and improves the previous Tentative Regulations on Price of Renewable Energy Generated Electricity and Fee Sharing Management. By clearly setting a price level, this policy provides a clear expectation of return on their investment for investors and encourages them to exploit high quality resources and to guarantee the orderly progress of wind power development.

2) Standards setting: The National Energy Bureau produced the Tentative Regulations for Administration of Offshore Wind Power Development and Construction, which were issued in January 2010. As a result of studying the latest technology and the experience of foreign offshore wind power development and construction, China has been able to summarise the best practice for domestic offshore wind power construction and also stipulate technological standards suitable for the characteristics of Chinese offshore wind power. These standards cover the whole process, including planning, pre-feasibility and feasibility studies, operation and maintenance. So far, the guideline documents Regulations for Preparing Engineering Planning Report on Inshore Wind Power Plant, Preparation Rules of Inshore Wind Power Project Pre-feasibility Study Report, Preparation Rules of Offshore Wind Power Project Feasibility Study Report and Preparation Regulations on Construction and Designing of Offshore Wind Power Plant have all been published.

3) Construction information: The National Energy Bureau responded to the Hydropower and Water Resources Planning and Design General Institute by establishing a National Wind Power Information Administration Center which took charge of all information about construction of wind power all over the country in February 2009. This center has already built an information submission system. From June 2010, the wind power information submission system and information officers' training began. The center should formally come into operation during 2010.

4) Grid construction: To boost the secure and rapid development of wind power in China, according to principles laid down by the State Council, the National Energy Bureau has contacted all the relevant players in wind power and held a number of forums on the development of the technology, including investigating and studying the main problems which have emerged in the development of wind power in China since August 2009. From November 2009 the national grid corporation and relevant technology institutions have begun to carry out investigations and studies in the major wind power regions, such as Inner Mongolia, Gansu, the northeastern part of China and North China, with the aim of finding solutions to the current problems over planning and grid connection. In June 2008 the northwestern grid conducted an appraisal study of the large-scale development of wind power, a study of the wind energy resources in the 10 GW-scale wind power bases, and wind power development planning was carried out in May 2009. A plan for the study of wind power grid connection and market absorption was formulated in April 2010. Through these various studies it is intended to better understand the relationship of the power system to the large-scale development and grid connection of wind power, to understand the absorption scale of wind power, the conditions and cost of this absorption in combination with the existing power supply structure, the load and output characteristics of wind power and to further analyse the technical feasibility of wind power development planning in relation to grid operation, including the corresponding output cost and congestion management. These studies will provide an important decision-making reference for the technical development of wind power in China.

4. Development Status of China's Wind Power Industrial Supply Chain

Ever since the first wind turbine generator system was connected to the grid and put into production in 1985, China's wind power industry has experienced progress from slow to very rapid development and the corresponding market environment has been gradually established. To summarise, the market environment of Chinese wind power development has the following characteristics: the manufacturing industry is intensely competitive but relatively mature; the developers are concentrated among large-scale energy enterprises; and the pricing policy tends to be stable. In brief, the market for China's wind power development is expanding on a sound basis.

4.1. Present Status of the Equipment Manufacturing Industry

4.1.1. Development of domestic manufacturers

Domestic manufacturers of wind power equipment were virtually unknown in the Chinese domestic market before 2000, holding a market share of less than 10%. Since 2003 the country has organised five successive invitations to bid for national wind power concessions, allocating the right to construct wind power projects of more than 3 GW capacity. From 2005 onwards, the planning of 1 GW-scale wind power bases began to be carried out, and the planning and construction of 10 GW-scale wind power bases was started in 2008. This strongly boosted the scale development of the wind power industry in China, created good market conditions for the domestic manufacture of wind turbines, stimulated the rapid development of a turbine manufacturing industry and advanced the formation of independent companies.

Just one Chinese enterprise featured among the top 15 manufacturers in the world before 2005. By 2009 three companies had entered the ranks of the top 10 and five were listed among the top 15 in the world. Sinovel, Goldwind and Dongfang have become famous brands in the global wind power industry, one indication that the manufacturing industry of wind power equipment has begun to mature in China. In 2009, there were six domestic companies ranked among the top 10 in terms of both new and cumulative installed capacities. The other four were all foreign businesses. The market share of new and cumulative installed capacities attributable to domestic companies was 74.1% and 73.8% respectively, while the market share attributable to the four foreign companies was 10.8% and 11.4% (see Table 17).

4.1.2. Equipment and technology

Before 2005, MW-scale wind turbine generator systems (≥1MW) were rarely installed in China. With the increased production of MW-scale wind turbines by domestic companies, however, the installed capacity accounted for by MW-scale machines has risen from 51% in 2007 to 72.8% in 2008 and 86.8% in 2009. The MW-scale wind turbine generator system has now become the main product in the Chinese wind power market. Following the international trend for scaling up wind turbine generator systems, domestic companies have also started to research and develop multi-MW scale equipment.

In 2009, China realised a series of new achievements in the research and manufacture of multi-MW scale wind turbines. The 2.5 MW and 3 MW wind turbines manufactured by Goldwind Science & Technology Co. Ltd. were put into commission; the 3 MW offshore wind turbine manufactured by Sinovel Wind Power Co. Ltd. was connected to the grid and generated power at the Donghai Bridge offshore wind power plant; and the 3 MW wind turbine developed by Shenyang University of Technology was also released successfully. In addition, Sinovel, Goldwind, Dongfang, Haizhuang and XEMC have all started to research the manufacture of wind turbines with a capacity of 5 MW. China has definitely entered the market for multi-MW scale wind turbine generator systems.

In order to satisfy the market demand for offshore wind power both at home and abroad, Chinese manufacturers have also started to develop and trial-manufacture offshore wind turbine generator systems, making positive progress. Table 18 summarises the research, development and pilot manufacturing of offshore designs by the various domestic companies.

4.1.3. Technology level

With the enhancement of the companies' strength, domestic brands have increased their efforts in research and development. All the top 10 enterprises have established their own R&D centers. The emphasis originally placed on purchasing a production license has changed to the manufacture of complete turbines. Licensed designs, joint designs and independent designs have become the main methods for Chinese companies to obtain their own independent technology.

At present, the seven enterprises - Sinovel, Goldwind, Dongfang, Zhejiang Windey, XEMC, Guodian United Power and Guangdong Mingyang - essentially possess the design capability and key manufacturing technology for MW-scale wind turbines, and are in an excellent position to carry out independent research and development through introducing or developing advanced design software and control strategies, establishing high level laboratories and other R&D platforms and cultivating professional technical personnel.

In 2009, the installed capacity of the seven enterprises

Table 17 Newly Installed and Cumulative Market Share of Top 10 Equipment Manufacturers in 2009

Market share distribution of newly installed capacity			Market share distribution of cumulative installed capacity		
Name of enterprise	Installed capacity (MW)	Market share	Name of enterprise	Installed capacity (MW)	Market share
Sinovel	3495	25.32%	Sinovel	5,652	21.90%
Goldwind	2722	19.72%	Goldwind	5,343.85	20.70%
Dongfang	2035.5	14.75%	Dongfang	3,328.5	12.90%
United Power	768	5.56%	Vestas	2,011.5	7.80%
Mingyang	748.5	5.42%	Gamesa	1,828.75	7.10%
Vestas	608.75	4.41%	GE	957	3.70%
XEMC Wind Power	454	3.29%	Mingyang	895.5	3.50%
GE	322.5	2.34%	United Power	792	3.10%
Suzlon	293	2.12%	Suzlon	605.25	2.30%
Gamesa	276.25	2.00%	Windey	594	2.30%
Others	2079.71	15.07%	Others	3,814.45	14.80%
Total	13803.21	100.00%	Total	25,805.3	100.00%

Table 18 Offshore Wind Turbine Research and Manufacture by Domestic Manufacturers

Company	Research, development and trial product
Sinovel	23 sets of 3 MW wind turbines installed; it is predicted that a 5 MW wind turbine will be launched at the end of 2010.
Goldwind	In 2007 the first 1.5 MW offshore wind turbine was manufactured. 2.5 MW, 3 MW and 5 MW designs are under research.
Dongfang	5 MW offshore wind turbine under research.
United Power	It is predicted that a 3 MW system will be launched in 2010.
Mingyang	It is predicted that a 3 MW offshore wind turbine will be launched in 2010
XEMC	5 MW offshore wind turbine under research (XEMC Darwind)
Sewind	It was predicted that a 3.6 MW offshore wind turbine would be launched in June 2010.
Haizhuang	5 MW offshore wind turbine under research.
Nanche	3 MW system under research, with expectation that a trial product will be launched in 2010.
Yinhe Avantis	2.5 MW offshore wind turbine has been tested.

Table 19 Export of Chinese Wind Turbines

Company	Model	Number of sets	Capacity	Exporting country
Sinovel	SL1500/82	10	15	India
Goldwind	GW77/1500	3	4.5	USA
Sewind	W1250/64	5	6.25	Britain (3 sets); Thailand (2 sets)
New United (Changqian Xinyu)	SD77/1500	2	3	USA (1 set); Thailand (1 set)
Total		20	28.75	

listed above accounted for 69% of the newly installed capacity in the whole country, providing strong support for the stable and rapid development of wind power in China. In addition, the domestic complete turbine manufacturing industry represented by these enterprises has started to research and develop new products autonomously and has made some progress towards establishing independent research and development.

4.1.4. Status of the export of complete turbines

In 2009, China started to export complete wind turbines, with a total of 20 sets with a capacity of 28.75 MW going to four countries. The main exporters were Sinovel, Sewind and Goldwind (see Table 19).

4.1.5. Development status of the manufacturing industry

Preliminary statistics show that there were 86 enterprises engaged in manufacturing complete grid-connected wind turbines at the end of 2009. These domestic manufacturing enterprises have introduced technology from foreign countries either through production licenses or by joint designing. Some companies have exploited domestic scientific and technical achievements and autonomously researched and developed the technology to make complete turbines. According to their manufacturing capability and equipment, these enterprises can be roughly divided into five categories:

Category I: These companies already possess the capability to manufacture MW-scale wind turbines in large quantities. They include Sinovel Wind Power Co. Ltd., Xinjiang Goldwind Science & Technology Co. Ltd. and Dongfang Turbine Co. Ltd. In 2009 their supply capacity exceeded 1 GW. The total installed capacity of the wind turbine generator systems produced by Sinovel, Goldwind and Dongfang were respectively 5.57 GW, 5.36 GW and 3.19 GW at the end of 2009.

Category II: These companies already have the capability for mass production of MW-scale wind turbines. They include Guangdong Mingyang Wind Power Technology Co. Ltd., Guodian United Power Technology Co. Ltd., Shanghai Electric Corporation, Hunan XEMC Wind Power Co. Ltd., Nantong CASC Wanyuan Acciona Wind Turbine Manufacture Co. Ltd., Beijing Beizhong Steam Turbine Generator Co. Ltd., New United (Changqian Xinyu/ Jiangsu Xinyu Wind Power Equipment Co. Ltd.), Shenyang Huachuang Wind Energy Co. Ltd., Zhejiang Windey Wind Power Engineering Co. Ltd., Envision Energy Ltd. and Ningxia Yinxing Energy Co. Ltd. By the end of 2009 these enterprises had all installed a cumulative capacity of more than 40 sets of MW wind turbine generator systems.

Category III: These companies possess the capability to manufacture MW-scale wind turbines in small quantities. They include Harbin Wind Power Equipment Co. Ltd., Baoding Tianwei Wind Power Technology Co. Ltd., Sany Electric Co. Ltd., Heilongjiang Province Rehao Energy Group, Baoding

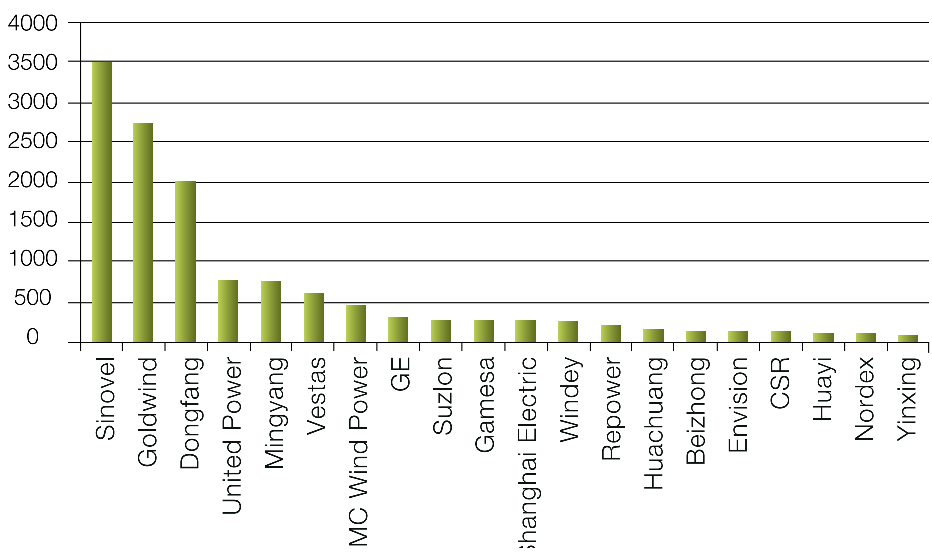


Figure 15 Output of Complete Turbine Manufacturing Enterprises with Mass Production Capability Unit: MW

Huide Wind Power Engineering Co. Ltd., CSIC (Chongqing) Haizhuang Wind Power Equipment Co. Ltd., CSR Zhuzhou Institute Co. Ltd. and Zhejiang Huayi Wind Power Co. Ltd. By the end of 2009 these enterprises had all installed more than 10 sets of wind turbine generator systems.

Category IV: These companies have put sample turbines into operation and produce less than 10 sets of wind generator systems. They include Wuhan Guoce Nordic New Energy Co. Ltd.

Category V: Other companies that are designing and manufacturing machines or bringing in technology.

Figure 15 shows those companies manufacturing complete turbines in mass production.

4.1.6. Advantages of domestic companies in market competition

Before 2005, foreign companies dominated the wind power market in China, accounting for more than 70% of the market. By 2009 this had decreased to about 13%. The market share of domestic manufacturers had therefore increased from 25% in 2004 to 87% in 2009.

By the end of 2009 the wind power plants established across China had installed wind turbines produced by 49 enterprises from both home and abroad, of which 24 were foreign enterprises with a capacity of 6.34 GW, accounting for 24.6% of the cumulative market share, and 25 were domestic enterprises with a capacity of 19.46 GW, accounting for 75.4% of the market.

Although international companies have faced unfavourable conditions in market competition because of the Chinese government's commitment to a high percentage of wind turbine equipment being manufactured by domestic businesses, some have still been successful. At the end of 2009, Sinovel, Goldwind, Dongfang, Vestas and Gamesa were the top five ranking suppliers in the cumulative market share of complete wind turbine generator systems, two of which are international brands. GE, Mingyang, United Power, Suzlon, Windey, XEMC and Sewind ranked respectively from the sixth to the twelfth. In 2009, however, most of the 24 foreign enterprises which at some stage had been involved in the Chinese market decided to retreat, leaving less than ten still active. There are still four foreign enterprises ranked in the top 10 suppliers to the Chinese wind power market, however,

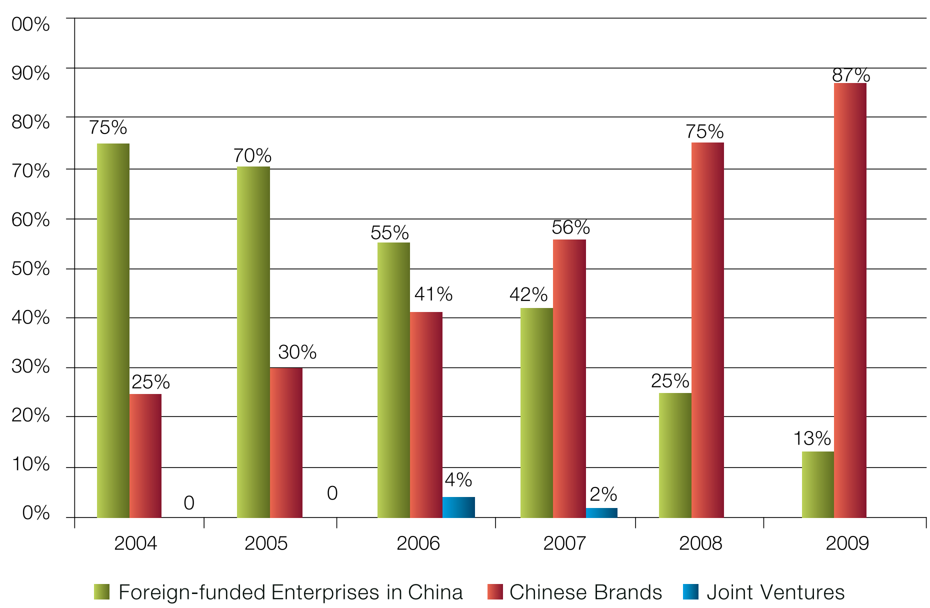


Figure 16 Comparison of Newly Installed Capacity Market Share between Domestic and Foreign Companies in the Chinese Wind Power Market

Source: BTM; Global Statistics Reports of 2004-2009; Shi Pengfei, Chinese Wind Power Installed Capacity Statistics which indicates that the strongest international brands are still competitive (see Figure 16).

4.1.7. Localised development by foreign manufacturers

Many of the manufacturers of foreign wind turbine generator systems have registered solely-funded subsidiaries in China, such as Denmark's Vestas (Vestas Wind Power Equipment (China) Co. Ltd.), Spain's Gamesa (Gamesa Wind Power (Tianjin) Co. Ltd.), India's Suzlon (Suzlon Energy (Tianjin) Co. Ltd.), Germany's Nordex (NORDEX (Beijing) Wind Power Technology & Engineering Co. Ltd.) and the USA's GE Energy (GE Energy (Shenyang) Co. Ltd.). Some have established joint ventures, as for example Germany's REpower (REpower North (China) Co. Ltd.). All of these enterprises have built assembly lines for complete turbines and parts production facilities. The proportion of turbine parts made in China has steadily increased.

4.1.8. Competition among companies

The three domestic manufacturers - Sinovel, Goldwind and Dongfang - who have taken the lead in the manufacture of domestic wind turbines, can now produce 1.5 MW machines in large quantities and dominate the market. In 2009, these three enterprises installed 5,611 sets of wind turbines all over the country with an installed capacity respectively of 3.3 GW, 2.54 GW and 1.91 GW. In addition, Sinovel achieved the capability for mass production of 3 MW turbines, installing 23 sets in 2009.

The newly installed capacity of those enterprises ranking from fourth place onwards is less than 800 MW. This is a big margin from the three top companies. In terms of market share, the manufacturers ranked from fourth place down are, in turn, Guodian United Power, Guangdong Mingyang, Vestas, XEMC, GE, Suzlon, Gamesa, Sewind and Zhejiang Windey. Altogether there are 16 enterprises with a newly installed capacity of 100–800 MW, amounting to 5 GW in total and accounting for 36% of the Chinese market.

The top 3 enterprises accounted for 59% of the newly installed capacity in China in 2009 and the top 10 enterprises accounted for 84%. These figures indicate the intensity of market competition. There were also more than 20 enterprises with a newly installed capacity of less than 100 MW, most of which have just entered the phase of sample commissioning. The total installed capacity (550 MW) of these enterprises accounted for just 4% of the market.

4.1.9. Component suppliers

The rapid development of the complete turbine manufacturing industry since 2005 has encouraged the establishment of enterprises manufacturing gearboxes, blades, electric motors, hubs, main shafts, bearings and other parts. In particular, more than ten companies produce gearboxes, blades, electric motors and bearings. These include NGC and Chongqing Gearbox Co. Ltd. manufacturing gearboxes, Huiteng, Zhongfu Lianzhong and Sinoma producing blades, Yongji, XEMC and CSR manufacturing electric motors, and LYC and ZWZ manufacturing bearings. The situation of insufficient component supply has improved significantly. The production of gearboxes, blades, electric motors and hubs is now basically able to meet the market demand. The shortage of bearings has also been improved. Control systems and inverters remain in insufficient supply.

The uneven division of enterprises between the upstream and downstream parts of the markets has resulted in component enterprises being engaged in the manufacturing of complete turbines and those companies producing complete turbines also developing the production of components. Some wind power developers are even engaged in the production of complete turbines and components. It is still too early to tell whether such a mix is good for the sound and sustainable development of the wind power industry supply chain.

4.2. Status of Wind Power Developers

4.2.1. Distribution of developers

By the end of December 2009, more than 50 enterprises had invested in the development of wind power and established approximately 330 project companies to participate in the development and construction of wind parks in China. A total of 20 enterprises had newly installed capacity of more than 100 MW in 2009, including ten central government-owned enterprises, six state-owned local energy enterprises and four private and foreign-funded enterprises (Tianrun, China Wind Power, Zhonghong and Hongteng). The top 10 enterprises are all energy investment enterprises owned by central and local governments. It is clear, therefore, that the development of wind power is concentrated among energy investment enterprises.

For these large-scale energy companies, especially those involved in power supply, one of the main incentives for developing wind power is the Eleventh Five-Year Plan for Renewable Energy agreed to by the National Development and Reform Commission in 2008. This requires those enterprises with a capacity of more than 5 GW of thermal power electricity generation to introduce an installed capacity of non-hydropower renewable energy that reaches 3% of their capacity in 2010 and 8% in 2020. According to statistics from the Energy Research Institute, there are roughly 25 enterprises in conformity with this condition, all of which are large-scale state-owned energy enterprises. Currently, however, no more than half of the large-scale energy enterprises are expected to reach the target of 3%. The five major enterprises in power supply (apart from CPI) have already reached the target for developing 3% of non-hydropower renewable energy one year ahead of schedule.

4.2.2.Large-scale central government owned energy companies

The top 10 companies in terms of cumulative installed capacity accounted for 71% of the market at the end of 2009, of which eight were central government-owned enterprises. The top five were all energy investment enterprises owned by central government, accounting for 54% of the market. The Guodian Group ranked first, with a capacity of 4.43 GW; Datang, Huaneng and Huadian Group ranked second, third and fourth respectively. Apart from CPI, which was listed in eighth place, the five major power groups were all in the top five (see Table 21). Encouraged by the initial involvement of the Longyuan Group, these large central government owned enterprises, especially the five power groups, have all steadily acquired wind power assets, prepared stock market listings at home or abroad, and raised funds to develop them.

4.2.3.Advance planning reserves for wind power development projects

Wind power developers throughout the country have a major incentive to ensure that they acquire reserves of projects ready to develop in future. According to calculations by Azure, a leading wind energy consultancy, the total capacity of projects reserved by developers will reach about 45 GW in total in 2012, roughly 100 GW in 2015 and approximately 210 GW in 2020 (see Figure 17). The five major power groups in particular, as well as large-scale central government owned enterprises such as Guohua, CGNP, China Res Power and CECIC, all have project reserves of dozens of GW.

Figure 17 Reserves and Distribution of Major Companies' Wind Power Development Projects

Source: Azure

Table 20 Newly Installed Capacity of Wind Power Developers in 2009

Unit: MW

	Name of Enterprise	Newly Installed Capacity (MW)
>1000MW	Guodian	2600.4
	Datang	1739.85
	Huaneng	1644.75
	Huadian	1230.05
500-1000MW	CGNP	854.45
	Jingneng	797.5
	Guohua	590.25
100-500MW	CECIC	400.25
	CPI	319.67
	China Res Power	309.75
	Tianrun	309.75
	China Wind Power	295.5
	Hecic New-Energy	160.4
	SDIC	151.5
	SINOHYDR	148.5
	Ningxia Electric Power Group	143.5
	Zhongmin	130
	Shenneng North	129
	Luneng	102.25
	Honiton Energy	100
	Others	1645.89
	Total	13803.21

Source: Chinese Wind Energy Association These numbers have been checked with the developers and they have agreed with these numbers. However, they may publish their own statistics on 2009 market share, which may be different due to different statistical methodologies.

Table 21 Increase in Installed Wind Capacity by Major Developers in 2009

No.	Investor	Newly installed capacity (MW)	Cumulative installed Capacity (MW)	Annual growth rate (%)
1	Guodian	2,600.4	5,098.3	104.10%
2	Datang	1,739.85	3,805.8	84.20%
3	Huaneng	1,644.75	2,874.35	133.80%
4	Huadian	1,239.95	1,682.95	279.90%
5	Guohua	590.25	1,475.65	66.70%
6	CGNP	854.45	1,360.25	168.90%
7	Jingneng	757.5	1,200.3	171.10%
8	CPI	386.13	860.63	81.40%
9	CECIC	400.25	774.75	106.90%
10	JOINTO	260.4	493.85	111.50%
11	Others	3407.17	6,714.52	103.00%
Total		1,3881.1	2,6341.35	111.40%

4.3. Status of Wind Power Service Industry

Since the Renewable Energy Law was first promulgated in 2005, both the wind power market and manufacturing industry have developed rapidly and achieved a leap in quantity of Chinese-made products. This has required the development of a wind power service industry to support this important change. With the thriving demands of the market, a number of R & D institutions, quality assessors, consulting services and industrial intermediary institutions supporting the development of wind power have all steadily developed in recent years. The overall status of the wind power service industry is as follows:

4.3.1. The capability of R&D organisations

Early on in the development of wind energy, the research and development institutions involved in wind energy were relatively few and their capability poor. Although a national R&D center of wind power engineering technology had been established, the implementation of policy was extremely weak and the market outlook very narrow. These institutions had huge pressure just to survive, let alone to advance the improvement of the whole industrial technology. However, changes came after the promulgation of the law. Although wind power equipment and technology was at first mainly introduced from foreign countries by way of licensing, the capability, level and personnel of enterprises involved in research and development have significantly improved through active adaptation of their strategies, even inviting foreign teams to join them.

The efforts made by large-scale enterprises involved in wind power have also been strengthened. In particular they have established large specialist teams for research and development. This includes the leading enterprises as well as those manufacturing complete turbines and key components in the second and third ranks. Faced with intense competition, especially in a situation where the wind power manufacturing industry is rapidly developing and there is potentially surplus output capacity, all the companies regard reliability, quality and after-sale services as keys to a successful business. This has further highlighted the importance of research and development and improvements in core competitiveness.

China has also started to make efforts to establish a series of national research and development institutions. The National Energy Bureau, for example, granted licenses to 16 national energy research and development (experimental) centers at the beginning of 2010, including those involved in wind power blade research and development, large-scale wind power grid-connected systems research and development, and offshore wind power technology and equipment research and development. This shows that the government attaches importance to the basic research and development of the wind power equipment manufacturing industry. Although it has not been long since these institutions were established, they should lay the foundation for improvements in innovation and the competitiveness of China's future wind power industry.

Generally, however, there is still a large gap between the R&D level of China's wind power industry and the international standard in terms of the numbers of institutions, their employees and the quality of work.

4.3.2. Certification systems and standards

It is obvious that various standards, criteria and guidance play a leading role in the industry's development. For wind power in particular, which is an interdisciplinary hi-tech industry with multi-technological lines and a complicated operating environment, it is essential to stipulate standards. The shift from technology introduced through licenses to the current independent research and development within China also requires the establishment of a self-assessment system. At present, however, a technology criteria system for wind power has not been established, although discussion about the relevant standards has already been integrated into the agenda. In addition, China has set up a special wind power criteria experts committee aimed at establishing a satisfactory wind power industry criteria system, including product technology and grid connection standards.

With the growth of the wind power industry, the relevant capabilities of product monitoring and certification have also been developed. The methods used by institutions such as the China General Certification Centre, the China Classification Society and the China Quality Certification Centre have been constantly improved. A professional team has already been formed. Their capabilities of research, development, examination and certification are also being constantly enhanced. The certification institutions of some international organisations have also become involved. The entire industry is expecting an improvement in both monitoring and certification systems and anticipates that this will enhance the overall development of wind power in China.

4.3.3. Industry associations

Industry associations play an important role in planning, coordination, self-discipline, training, criteria formulation, market surveys, information exchange, consultation and assessment, intellectual property protection and qualification certification. As a significant bridge between the areas of production, teaching and research and government, these associations can stimulate positive interaction between enterprises, industry and governmental departments with the aim of boosting the healthy development of the whole industry.

During the development of renewable energy in China, a number of industry associations, such as the Chinese Renewable Energy Industries Association, the Chinese Renewable Energy Society and professional associations for wind and solar energy have all played important roles. These associations have had an important influence over the drafting of laws, planning research and policy decisions. They have been able to effectively communicate with the decision-making departments when the development of the renewable energy industry has demanded a significant change in policy, for example the rationalisation of the wind power concession price level and dealing with the issue of over-capacity. A good relationship between the market and policy and between enterprises and government is necessary for a mature industry. Industry associations have been able to play a full part in this process.

Because the whole renewable energy industry has made a great leap forward in just 5-6 years, and the competition in the market is fierce, the industry associations representing the new energy industries (including wind energy) have not played a full part in industry self-discipline, intellectual property protection and qualification certification. It should be noted, however, that since the State Council issued a severe caution to wind power turbine manufacturers in 2009, the whole industry has paid more attention to quality control, service management and criteria formulation. This indicates that the industry has begun to mature and enter a phase of stable development.

4.3.4. Consulting organisations

Compared with the rapid growth of the wind power manufacturing industry and the project development market, consulting services for wind power and other new energy sources are only at an early stage of development. Apart from information collection, analysis and management, consulting services can also cover issues such as the industry's prospects, the policy environment, enterprise strategy and investment potential. However, the companies engaged in this field are mainly multinational consulting institutions, and only a few are domestic institutions performing a range of consultancy work. A limited number of these offer a comprehensive and efficient service. With increased capital investment and a gradual maturing of the industry, the market demand for consulting services will increase progressively and more institutions will be attracted to participate.

5. Grid-Connected Price Mechanism and Reform Prospect of Wind Power

Pricing policy is the key factor affecting the level of active investment by developers and market growth. China has now formulated a stable grid-connected pricing policy for wind power through the introduction of a fixed regional grid connection price, although this took the government a long time to implement. The development of China's support mechanism for wind power has evolved from an analysis of the rate of return to project operators as a result of a bidding system, now finally changed to a feed-in tariff with variations based on differences in wind energy resources.

5.1. Historical Perspective

5.1.1. Capital & interest price and average return rate price

Before the introduction of the Renewable Energy Law in 2005, the grid tariff paid for wind power-generated electricity was based for a long time on an approved price. This was also divided into two parts, including a capital & interest price and an average return rate price. In 1994, it was decided that the grid management companies should allow the connection of wind power plants to the nearest grid and the generated electricity should be entirely purchased. The grid tariff would be determined by power generation costs, capital & interest and a reasonable profit. The difference between the wind power price and the average price for electricity would be shared across the whole grid, and the output purchased and handled by the power company. Since the interests of investors were secured, this enabled wind power plants to start commercial development. During this period the first wind power plants were built in Xinjiang, Inner Mongolia and Guangdong.

With the deepening of reforms to the energy market, the pricing system was also seen to be urgently in need of reform. The goal of price reform is the gradual "separation of plants from the grid operators, connecting to the grid by price competition". Prior to the performance of "connecting to the grid by price competition", the State Planning Commission therefore decided to make appropriate adjustments to the method of calculating grid tariffs in order to limit the increase in power costs and decrease the price paid for wind-generated electricity. According to the document Notice of State Planning Commission Concerning Regulating the Management of Electricity Price (Ji Jia Ge [2001] No. 701) issued in 2001, power generation projects are required to calculate an average grid tariff based on the reasonableness of the actual returns to operators over a number of years. In addition, wind power was included for the first time in the tax preference list issued by the State Planning Commission in 2001. This means that the development of wind power plants enjoys half the normal level of value-added tax, a concession which has been maintained until now.

5.1.2. Bidding price and approved price

To further advance the large-scale development of wind power, the National Development and Reform Commission organised the first bidding round for a national wind power concession in 2003. This introduced a competition mechanism into the development of wind power plants and allowed the grid tariff paid for the electricity generated to be determined by bidding. Five concession bidding rounds were completed up to 2007, and the total installed capacity achieved was 3.35 GW. The bidding price was generally lower than for other approved projects, so the aim of reducing the grid tariff was realised.

The NDRC issued Fa Gai Jia Ge [2006] No.7 Document, which proposed that "the grid connected price for wind power uses the government guide price, and this price standard shall be fixed by the price control department of the State Council according to the price resulting from bidding" in order to disseminate the experience of concession bidding. Based on these stipulations, some provinces, including Inner Mongolia, Jilin, Gansu and Fujian organised a number of bidding rounds for provincial wind power concessions and determined the approved prices for other wind power plant projects based on the winning bids.

Other provinces, regions and municipalities not involved in bidding mostly still applied the method of examining and approving projects one by one to decide the price. Several provinces, such as Guangdong, adopted a feed-in tariff policy to decide the benchmark price for wind power in their area. This meant that during this period there was a coexistence of different wind power price policies, including the bidding price, feed-in tariff and approved price.

5.1.3. Introduction of a feed-in tariff mechanism

With the establishment of policy frameworks covering grid connection, expenses allocation and subsidies resulting from the concession bidding, especially through the requirements of the Renewable Energy Law and the Medium and Long-term Development Plan for Renewable Energy, the installed capacity of wind power in China almost doubled for four consecutive years after 2006. Hundreds of wind power plants were built all over the country and a start was made on seven large 10 GW wind power bases in the northwest, north and northeast of China as well as in the coastal area of Jiangsu Province.

It was therefore considered sensible to introduce a feed-in tariff for wind power, with variations according to the quality of the wind resource in different regions. The NDRC issued Notice on Price Policy Improvement for Wind Power (Fa Gai Jia Ge [2009] No. 1906) in August 2009, the first feed-in tariff policy for wind power in China. This policy established a unified pricing standard, defined a specific investment return and indirectly influenced and standardised the development progress of wind power plants in all parts of the country. This in turn resulted in the development of wind power in China entering a mature and larger scale stage.

5.2. Characteristics and effects of different pricing mechanisms

5.2.1. Concession bidding price policy

The main characteristics of the wind power concession system are firstly, that the concession operation period (25 years) of the project falls into two stages. During the first stage, the price is the one proposed in the bidding document by the bid winners up to an electricity generation level of 30,000 equivalent full load hours. During the second stage, from a cumulative generation level of 30,000 equivalent full load hours onwards, the price is set at the average electricity price in the power market at that time. The project owners and the local grid enterprises reach long-term power purchase and/or sales agreements. The electricity generated is purchased by the local grid

Table 22 Details of five successive rounds of national concession wind power bidding projects

No.	Name of wind power plant	Installed capacity (MW)	Bid winner	Bid winning price (Yuan/kWh) Bidding price (Yuan/kWh)	Concession Round of
1	Jiangsu Rudong Wind Power Plant	100	Sino Wisdom Investment Group Co. Ltd.	0.4365	First.
2	Guangdong Huilai Shibei Mountain Wind Power Plant	100	Guangdong Yudean Group Co. Ltd.	0.5013	
3	Inner Mongolia Huitengxile Wind Power Plant (1)	100	A joint venture of Beijing International Power New Energy Co. Ltd. and Beijing International Power Development and Investment Co. Ltd.	0.3820	Second.
4	Inner Mongolia Huitengxile Wind Power Plant (2)	100	China Huadian Corporation	0.3820	
5	Jilin Tongyu Tuanjie Wind Power Plant (1)	200	A joint venture of Longyuan Power Group Co. Ltd., Jilin Jineng Power Group Co. Ltd. and Xiongya (Virgin) Co. Ltd.	0.5090	
6	Jilin Tongyu Tuanjie Wind Power Plant (2)	200	A joint venture of Huaneng New Energy and Environmental Protection Industry Holding Limited and China Huaneng Group Hong Kong Branch	0.5090	
7	Jiangsu Rudong Second Wind Power Plant	100	A joint venture of Longyuan Power Group Co. Ltd. and Xiongya (Virgin) Co. Ltd.	0.5190	
8	Jiangsu Dongtai Wind Power Plant	200	Guohua Energy Investment Co. Ltd.	0.4877	Third
9	Jiangsu Dafeng Wind Power Plant	200	China Power Investment Corporation	0.4877	
10	Gansu Anxi Wind Power Plant	100	Huanghe Hydropower Development Co. Ltd.	0.4616	
11	Inner Mongolia Xilingol League Huitengliang Wind Power Plant (1)	300	A joint venture of CGNPC and CGNPI	0.4200	Fourth
12	Inner Mongolia Xilingol League Huitengliang Wind Power Plant (2)	300	Northern United Power Corporation	0.4200	
13	Inner Mongolia Baotou Bayin Wind Power Plant	200	A joint venture of Longyuan Power Group Co., Ltd and Xiongya (Virgin) Co. Ltd.	0.4656	
14	Hebei Zhangbei Danjinghe Wind Power Plant	200	A Sino-foreign joint venture of China Energy Conservation and Environmental Protection Group and Hong Kong Construction (Holdings) Limited	0.5006	
15	Inner Mongolia Wulan Yiligeng Wind Power Plant	300	Beijing Jingneng International Energy Co. Ltd.	0.4680	Fifth
16	Inner Mongolia Tongliao Beiqinghe Wind Power Plant	300	A joint venture of Huadian International Power Co. Ltd. and Huadian Hong Kong Limited	0.5216	
17	Hebei Chengde Yudaokou Wind Power Plant	150	Hebei Construction & Investment New Energy Co. Ltd.	0.5510	
18	Gansu Yumen Changma Wind Power Plant	200	A joint venture of China Energy Conservation and Environmental Protection Group and Hong Kong Construction Limited	0.5206	

enterprises according to the above-stated price after the construction of the wind power plants.

Since the bidding projects are all large-scale wind power plants with a superior wind energy resource, and the sales of electricity and grid tariff are secured by the long-term purchase and/or sales agreements, they have attracted a lot of interest. The winning price is generally lower than that in other non-concession projects under competitive conditions. Table 22 shows the concession bidding details for each round.

5.2.2. Pricing policy for wind power in Guangdong Province

From 2004 onwards, a separate pricing policy has been implemented in Guangdong Province. The Price Control Bureau of Guangdong Province issued Notice on Releasing the Grid Tariff for Wind Power Project (Yue Jia [2004] No.110) in April 2004 which stipulated that apart from national concession demonstration projects which had been executed subject to the winning price, the grid tariff should be set at 0.528 yuan/kWh (including value-added tax) for new wind power projects put into production in Guangdong Province. This tariff would operate from the date at which the projects started commercial operation. The costs of any supporting grid connection to the wind power plants were excluded. If the supporting transmission connection was built by the project owners, however, the capital and interest payments could be added to the grid tariff.

More recently, the price of equipment and raw materials, as well as bank loan rates, have all increased. This has resulted in an increase in the development costs for wind power plants, and the benchmark price for wind power has been increased in Guangdong Province. In December 2007, the Price Control Bureau of Guangdong Province issued Notice on Perfecting the Grid Connected Price Mechanism for Wind Power (Yue Jia [2007] No.294) which stipulated that the benchmark price for wind power projects in Guangdong would be 0.689 yuan/kWh (including value-added tax), excluding the costs of grid connection. If the costs of grid connection were borne by the project owners, then some of the costs could be added to the benchmark price. Within 50 km, 0.01 yuan/kWh could be added to the benchmark price; 0.02 yuan/kWh could be added within 50-100 km and 0.03 yuan/kWh beyond 100 km.

5.2.3. Approved prices

Apart from the concession wind power plants, the grid tariff for wind power projects is mostly decided through a process of provincial government approval. The method used to calculate the tariff is done through a feasibility study, based on which a project application report is prepared and submitted for approval to the provincial Development and Reform Commission and logged for record with the National Development and Reform Commission. After this, the tariff gradually shifts towards an approved price decided by the NDRC. As of September 2006, the NDRC had examined and approved hundreds of projects in different areas in four batches. These results serve as the foundation for formulating the feed-in tariff policy based on variations in wind resources.

5.2.4. National feed-in tariff system

The NDRC issued Notice on Improving the Price Policy for Wind Power (Fa Gai Jia Ge [2009] No. 1906) in July 2009. This establishes the principles for formulating the benchmark price for land-based wind power based on different resource areas, dividing the country into four categories of wind energy resource area. The resulting four benchmark grid tariffs are correspondingly 0.51 yuan/kWh, 0.54 yuan/kWh, 0.58 yuan/kWh and 0.61 yuan/kWh. See Figure 18 and Table 23.

This means that all newly-built land-based wind power projects, including supratidal shoal areas above the average high water level in coastal areas and island areas with permanent residents, will now receive the uniform benchmark price for wind power, depending on their respective wind energy resource area. In principle, the same grid tariff will be paid for power plants that stretch across the borders between provinces, with the higher benchmark price being paid if two different resource categories are included.

The grid tariff for future offshore wind power projects will be decided by the appropriate department of the State Council, depending on the progress of construction. In addition, wind power projects approved by provincial investment and energy administrative authorities will be approved by the National Development and Reform Commission and National Energy Bureau.

Figure 18 Regional divisions for feed-in tariff in China

Table 23 Regional breakdown of benchmark grid tariffs for wind power in China

Resource area	Grid-connected electricity price (Yuan/kWh)	Regions included in each resource area
Category I resource area	0.51	Inner Mongolia Autonomous Region apart from Chifeng City, Tongliao City, Xingan League and Hulunbeier City; Urumqi Municipality, Yili Kazak Autonomous Prefecture, Changji Hui Autonomous Prefecture, Karamay City and Shihezi City of Xinjiang Uygur Autonomous Region
Category II resource area	0.54	Zhangjiakou City, Chengde City of Hebei Province; Chifeng City, Tongliao City, Xing ’ an League, Hulunbeir City of Inner Mongolia Autonomous Region; Zhangye City, Jiayuguan City, Jiuquan City of Gansu Province
Category III resource area	0.58	Baicheng City and Songyuan City of Jilin Province; Jixi City, Shuangyashan City, Qitaihe City, Suihua City, Yichun City and Daxing'anling Prefecture of Heilongiang Province; Gansu Province apart from Zhangye City, Jiayuguan City, Jiuquan City; Xinjiang Uygur Autonomous Region apart from Urumqi Municipality, Yili Kazak Autonomous Prefecture, Changji Hui Autonomous Prefecture, Karamay City and Shihezi City; Ningxia Hui Autonomous Region
Category IV resource area	0.61	All other regions

5.2.5. Issues related to pricing policy and development costs

There is no doubt that the introduction of the regional feed-in tariff policy has been a positive step in the development of wind power in China. By the end of 2005 there had been 1,864 wind turbines installed with a capacity of 1.265 GW. In 2009, the total capacity of newly-installed wind turbines had reached 13.80 GW, a doubling of output for four consecutive years. China has also now overtaken Europe and the USA to become the largest market for new wind power installations in the world. Implementation of the feed-in tariff policy has promoted the prosperity and development of the wind power market, and has also stimulated growth of the domestic wind power industry through the rapid expansion of market size. Since 2005, there have been dozens of newly-built wind turbine manufacturing enterprises, enabling China to build an industrial network that can support continuous and large-scale development.

Although the regional feed-in tariff policy has effectively facilitated the development of wind power, in terms of its actual implementation there are some regions which think that the division between resource areas is not detailed enough, resulting in the price in some regions not reaching the expected level. Furthermore, the current policy environment has changed, encouraging further debate about the price regulation system.

Firstly, difficulties in grid connection and wind turbine shutdown have resulted in a lowering of the actual development benefit. Wind turbine shutdown is not taken into account in the feed-in tariff policy. The expected output of the projects is calculated according to wind measurement data in a feasibility study. But the development of wind power is currently so fast that difficulties occur in the ability of the grid to accommodate wind power output and many plants are compelled to limit their power supply and shut down turbines. Despite the fact that all those involved are currently paying unprecedented attention to the issue of wind power acceptance by the grid, a level of shutdown is likely to continue for a long time in view of the power supply structure and the capacity for peak regulation.

Secondly, the development costs of wind power are gradually rising. China has started to implement a new value-added tax system as of 2009. This includes a minimisation of the taxes on wind power development enterprises, which plays an important role in encouraging their initial investment in clean energy. However, due to the structure of the wind power industry, this macroeconomic policy has affected the overall efficiency of the industry, including the taxes and local financial revenue it can generate. Under the consumption-orientated value-added tax system, the taxes paid by wind power plants greatly decrease because it allows the income tax amount included in newly-purchased equipment to be deducted. The result, however, is that the benefit obtained from the development of wind energy resources by local government greatly reduces. Those areas that are rich in wind energy, with great development potential, are also all poor and remote ones, which greatly influences their eagerness for wind power plants to be built in the first place. All kinds of other methods for collecting income from wind power developers have therefore been created, such as collecting land compensation fees and pre-operation expenses. All these increase the costs of a wind power development project.

Thirdly, the decrease in profits from Kyoto Protocol-based Clean Development Mechanism projects will also increase the financial pressure on wind power development enterprises. Although the profits from CDM projects have not been considered in determining the current price regime, many wind power developers regard these profits as an important compensation for the losses caused by failures in resource evaluation, reliability, the quality of equipment and the costs of operation and maintenance, especially faced with intense market competition. Uncertainty about the future of the CDM mechanism after 2012 will therefore greatly influence the developers' decision-making.

An emerging industry must be progressive in formulating its policies. As the industry grows the problems it faces will be different. At present, China's wind power industry has formally entered a large-scale development stage with an obvious improvement in its industrial basis, and the focus of policy has therefore shifted from advancing the industry's development and building equipment and technology to updating and upgrading the industry and solving the problems of large-scale grid connection and consumption. It is therefore absolutely crucial to set a correspondingly reasonable price according to the actual development situation, to continuously maintain a stable market demand and to effectively build a benefit allocation mechanism between costs and prices for the long-term and healthy development of wind power.

6. Wind Power and Sustainable Development

As the most economically competitive new energy source, wind power plays an essential role not only in energy security and the diversification of energy supplies, but also in economic growth, poverty alleviation, atmospheric pollution control and the reduction of greenhouse gas emissions. In summary, wind power will play a significant role in global economic growth, energy security and responding to climate change.

6.1. Wind Power and Economic Development

6.1.1. Wind power and the financial crisis

Since 2008 the financial crisis has swept across the world, causing the global economy to slip into recession. In 2009, however, the wind power industry was among the few new industries to stimulate the world economy towards recovery. Newly added installed capacity of global wind power rose by 42% and newly added capacity in China rose by 116%. Global investment in wind power exceeded USD 60 billion in 2009, of which China alone shared over USD 20 billion.

In 2009, China produced wind turbines with a capacity of over 15 GW and an output value totaling RMB 150 billion, and with taxes and fees totaling over RMB 30 billion. The industry offered nearly 150,000 jobs in areas directly related to wind power, such as design and manufacturing, installation and commissioning, operation and management. Meanwhile, it also encouraged growth in related sectors such as iron and steel, cement, composite materials, transportation, testing and accreditation, consulting, banking and insurance.

In 2009, Longyuan Power Group was listed on the Hong Kong Stock Exchange, resulting in financing worth HKD 30 billion and strongly supporting the growth of the stock market. Meanwhile, financial institutions such as Morgan Stanley, UBS AG and China Development Bank granted credit worth tens of billions of yuan to some of the largest wind turbine manufacturers, such as Goldwind, Huarui and Dongfang Steam Turbine and to parts manufacturers such as NGC, Huiteng and Zhongfu Lianzhong. This activity both supported the vigorous growth of the wind power industry and enlivened the financial market.

The development of the wind power industry also promotes international technological transfer and cooperation. In 2009 alone, Chinese enterprises paid the European Union (mainly Denmark, the Netherlands and Germany) and the USA an estimated USD 450 million for patent royalties, manufacturing licenses and technical consulting services, all of which supported the research and development of wind power technologies in both Europe and the USA.

6.1.2. Wind power and regional economic growth

The wind power industry not only creates jobs in local areas, it can also bring considerable income for local economic development. Under normal conditions, about 5 MW of wind power capacity can be installed in each square km of land in the "Three Northern Regions" of China, with an annual power generation of at least 10 million kWh. Based on a grid price of RMB 0.6 and taking into account potential CDM earnings, this could result in income of RMB 6 million. If about 5% of these earnings are returned to local finances, it will increase local income by RMB 300,000, equivalent to an annual income of RMB 3,000 per hectare of land, based on RMB 0.3 annual income per m^2 land. If a wind power project occupies 5% of the land, local income from renting out the land will be RMB 6 per m^2 of land every year. At present, all landowners in the United States, Germany, Spain and Italy are rewarded with about 3-5% of the earnings from renewable energy projects on their land. If such a policy becomes common practice, both local government and residents will give more support to wind power.

6.1.3. Global wind power and China's economic development

The Global Wind Energy Council estimates that worldwide wind power installed capacity will reach 1,000 GW by 2020, with power generation of 2.6 trillion kWh, taking it to about 12% of total global power output by then. This will generate a direct income of €130 billion, on the basis of €0.05 euros per kWh, while the yearly addition of about 100 GW will create €100 billion worth of investment. At present, all the main countries or regions, including the EU, the United States, China and India, see wind power as a major part of the response to climate change and economic regeneration.

Wind power is one of the key areas in the upcoming Development Planning of New Energy Industry of the Chinese government upcoming. In our report, the optimistic estimation is that the cumulative installed capacity of China’s wind power will reach 200GW by 2020, representing about 20% of the world's total installed capacity. This will generate 440 billion kWh of electricity annually and create more than RMB 250 billion in revenue.

Up to 2020, this would mean that the additional installed wind power capacity would have to be between 15-20 GW each year and the equipment manufacturing capacity between 20-30 GW. Not only would this generate over RMB 400 billion in added value, produce more than RMB 60 billion in taxes, involve the export of 10 GW of wind power equipment with a foreign exchange income of USD 8 billion, but would also provide about 500,000 jobs.

To summarise, the wind power industry will play an important role in both the Chinese and world economies for a long time into the future.

6.2. Wind Power and Environmental Protection

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, effects on bird migration and electromagnetic radiation. Compared with conventional power generation, however, wind power has few environmental effects, and these are avoidable.

On the whole, its advantages outweigh its disadvantages. In general, wind power protects the environment in the following ways:

6.2.1. Wind power helps reduce greenhouse gases emissions

According to the climate change evaluation report published by the Intergovernmental Panel on Climate Change (IPCC), the likelyhood that human activity is the main cause of global warming over the past fifty years is over 90%. The main cause of climate change is the build-up of greenhouse gases in the atmosphere, in particular carbon dioxide released from fossil fuels burnt to produce energy and satisfy other human needs. As a renewable energy source, wind power can reduce the emission of carbon dioxide involved in energy production. According to World Energy Council calculations, wind power can save 600 tons of carbon dioxide emissions for every GWh of electricity generated. The increased use of wind power will therefore slow the progress of climate change. By 2020, global wind power generation output will reach 260 GWh and reduce the emission of greenhouse gases by 1.56 billion tons each year, as shown in Figure 19. Assuming that the Chinese wind power industry has an installed capacity of 200 GW and a power generation output of 440,000 GWh by 2020, if not considering energy efficiency improvement, it will reduce the emission of greenhouse gases by 440 million tons.

6.2.2. Wind power and environmental pollution

Wind power can also prevent environmental pollution caused by conventional energy production such as the burning of coal. The annual development report issued by the Ministry of Environmental Protection states that emissions of sulphur dioxide and smoke dust caused by burning coal contribute about 70-80% of total polluting emissions in China. The area affected by acid rain, formed by the discharge of sulphur dioxide, covers a third of the Chinese land mass. Environmental pollution has inflicted a severe impact on China's social and economic development and its people's health. The World Bank[6] estimates that by 2020 the economic losses caused by air pollution, in terms of the environment and health, will account for 13% of China's GDP. If the installed capacity of wind power reaches 200 GW with a power output of 440,000 GWh in China in 2020, if not considering energy efficiency improvement, it will reduce coal consumption by about 150 million tons and the discharges of sulphur dioxide, particulates and heavy metals will also be substantially reduced.

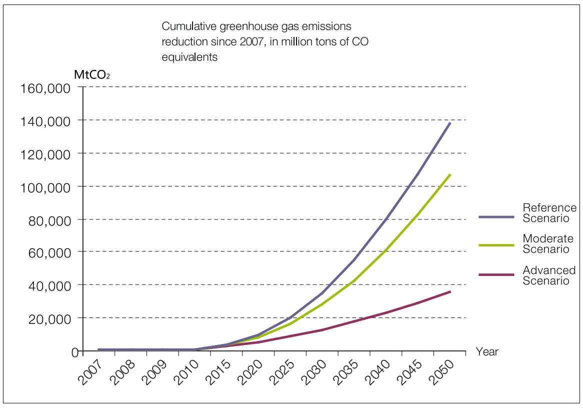


Figure 19 Contribution of Wind Power to the Reduction of Greenhouse Gas Emissions

Source: GWEC, Wind Power Outlook 2008

6 Janet L.Sawin. Review of the World's Renewable Energies[R]. 2005

6.2.3. Wind power and tourism

In China the best wind resources are in remote regions or coastal areas far away from cities and most wind farms are located in infertile highlands with low population densities. Herding and aquaculture can go on as before in pasturelands and coastal areas even if wind farms have been built there. In some countries, wind power is treated as a visual intrusion and not permitted. In China, however, most people treat white wind turbines as a beautiful sight and symbolic of a clean environment and sustainability. Many wind farms have therefore become tourist attractions in China. From June to September, for example, a number of tourists visit the Huitengxile wind farms in Inner Mongolia - riding horses, looking at the flowers, eating barbecued lamb or having a bonfire party. The income to the local herdsmen from tourism could represent as much as half of their total income. The wind farms in Dabancheng of Xinjiang, Guan Ting Reservoir of Beijing, and Bashang of Hebei have also all become popular locations for wedding photographs.

6.3. Limited Negative Environmental Side Effects

The main negative environmental side effects of wind power include noise, visual intrusion, impact on bird migration, electromagnetic radiation and marine organism mortality, although all these effects are very small. In order to ensure a correct understanding of the facts, these environmental impacts are described below.

6.3.1.Noise from wind turbines

The noise of wind farms comes from two sources: mechanical noise and airflow noise. The mechanical noise is made by the generator, gearbox and blades, whereas airflow noise occurs when the air flows across the blades and the turbines. Some noises from wind turbines are regular while others are not. With the increasing sophistication of manufacturing technology, the noise from wind turbines is generally decreasing. Also, compared with other noise sources such as transportation, construction and industry, the noise from wind turbines is very low. Wind farms are generally constructed far away from residential areas and have little impact on the lives of people.

6.3.2. Visual impact

It has not been clearly concluded whether visual impact can be considered as a factor to be taken into account in an environmental impact assessment. Only a few countries such as Britain and Italy, and some individuals and organisations, are concerned about the visual impact of wind power. Residents in many countries, including Denmark, Germany, the United States and Spain, have not raised serious doubts about the visual intrusion of wind farms. Relativity applies to everything, but wind farms bring much less visual damage than fossil fuel or nuclear plants, regardless of other environmental pollution.

6.3.3. Impact on birds

The construction of wind farms can result in impacts on the habitat, breeding and feeding of birds. The fast turning blades can also kill or hurt flying birds. According to Chinese regulations, an environmental assessment must therefore be made before a wind farm project starts construction. The assessment must address the issue of whether the location of the wind farm is on a bird migration route. If it is, the location should not be chosen. In addition, some birds may fly accidentally into the turning blades and

Table 24 Comparison of Noise Sources

Noise source	Noise density (decibels)
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 farm 350 metres away	35-45
Bedroom	35
Village at midnight	20-40

die. This seldom occurs, however, in finished wind farms. Local birds are familiar with their territory and will avoid the wind turbines when they start operation. Improving technology has also reduced the speed of the blades compared with 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 692 wind turbines in 18 wind farms had caused cause the death of 89 birds in total, 0.13 birds per wind turbine. In fact, birds are clever and can be good friends and neighbours with the turbines. Some of them love the turbines so much that they nest on their nacelles and shelter here.

A report produced by the Royal Society for the Protection of Birds in the UK 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 with the threat to birds from climate change, the harm caused by wind turbines is hardly noteworthy.

6.3.4. 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 100 kV, the radiation generated must be taken into account. At below 100 kV, the radiation is much less strong. Meanwhile, with the strict standards of electromagnetic radiation set for modern wind turbine, the impacts are becoming weaker and weaker.

6.3.5. Environmental impact 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 made by fishing boats and waves, thus having little impact on sea animals or plants. Practical experience shows that some marine animals make use of the new habitat.

To summarise, wind power has few negative impacts on the environment. On the contrary, 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. If we don't use clean and renewable energy and continue to rely on fossil fuels, the resource will eventually be exhausted and the pollution and climate change brought about will result in fatal damage to the human environment.

6.4. Wind Power and the Clean Development Mechanism

6.4.1. Background to the Clean Development Mechanism (CDM)

As climate change worsens the world community is increasingly recognising that it is necessary to make concerted efforts to slow down the earth's warming by coordinating international action. This is the only way for the sustainable development of human civilisation. At the 3rd Conference of Parties to the United Nations Framework Convention on Climate Change, held in Kyoto, Japan in December 1997, representatives from 149 countries and regions passed the Kyoto Protocol, which aimed to limit greenhouse gas emissions from developed countries to prevent the earth from warming further. The Kyoto Protocol stipulates that, by the end of 2012, the emissions of six greenhouse gases, including carbon dioxide, from all developed countries should be reduced by 5.2% compared with their levels in 1990. However, in working to achieve the Kyoto Protocol's goals, these nations are facing various options and challenges due to their varying levels of economic development, economic structures, energy consumption and modes, territorial and demographic situations, lifestyles etc.

The CDM is one of three international cooperation mechanisms created under the Kyoto Protocol to enable cooperation between the developed countries and developing countries in order to reduce greenhouse gas emissions and ensure sustainable development. It permits the developed countries listed in Appendix 1 of the Protocol to invest in and implement emission reduction projects in developing countries not listed in Appendix 1, which in turn allows them to obtain Certified Emission Reductions (CERs) to help them fulfill their binding quantitative obligations under the Protocol. At the same time, these CDM project activities also contribute to the sustainable development of the host developing country. On one hand, it provides the developed countries with more cost effective emissions reduction options and more technology transfer channels and markets. On the other hand, the CDM's effective operation can provide more opportunities for sustainable development in developing countries, including reducing the adverse impacts of climate change, diversifying financing options, obtaining sophisticated technologies, promoting the capacity of developing countries and reducing the creation of harmful pollutants.

6.4.2. Status of the CDM and wind power

Since the first project was approved in 2004, there have been more than 5,200 CDM projects all over the world, of which 2,245 projects have been successfully registered and 733 have been awarded CERs. As the major host countries, China, India, South Korea, Mexico, Chile and Egypt share 82% of all CDM projects around the world. A total of 869 Chinese projects have been approved by the United Nations, accounting for 38.71% of the total number of CDM projects registered and ranking first above India and Brazil as the most active developing country.

The CDM's underlying ambition is that developing countries help developed countries to achieve their emission reductions. The mechanism plays a significant role in the global carbon emissions trade, with turnover and trading volume making up 26% and 30.3% of the total respectively, just below the level of the EU's emissions trading system. It therefore contributes to the reduction of global greenhouse gas emissions. Although the trading volume of the primary CDM market based projects went down in 2008 due to the global financial crisis, the secondary market still remained active. In 2008, the CDM turnover and trading volume rose by 154.5% and 84.5% respectively from 2007 levels, far exceeding the levels of both the European Union Emissions Trading System and the Global Carbon Trading System.

So far the issued Certified Emission Reductions have reached 420 million tons of CO_2e around the world, of which China contributes 204 million tons of CO_2e, a dominant 49.21% share. Among the approved projects in China there are 1,776 involving new and renewable energy projects, accounting for 70.02% of the total. It is estimated that the annual emissions saved by these projects amounts to 220 million tons of CO_2, accounting for 46.89% of the total annual emissions saved by the CDM in China. Likewise, among all the CDM projects registered with the United Nations, projects involving new and renewable energies account for 74.41% of the total. By June 2010, 481 Chinese wind power projects had applied for CDM approval, accounting for 23% of the total projects in China and exceeding half of all global wind power projects. The installed capacity of wind power in these projects was 27.48 GW, more than the country's total installed capacity of 25.80 GW in 2009.

6.4.3. Barriers to Chinese wind power projects' CDM applications

Wind power projects generally feature high quality, short construction periods, simple methodologies and simple application procedures. These factors have been important advantages in their successful application and registration for CDM projects. As there are a great number of wind power projects featuring large-scale, high emission reductions and good quality, their registrations were easy to obtain, which was well received by the project developers and credit buyers. With the number of projects increasing, and more wind power projects applying to the CDM, however, issues and barriers have been steadily emerging.

As wind power CDM projects continue to boom in China, the CDM's Examining Board (EB) is imposing a more strict and rigid examination of Chinese projects' CDM applications. By the end of 2009, a large number of Chinese wind power projects were questioned and declined due to "additionality"[7], resulting in an atmosphere of distrust arising between the board of executive directors and the investment sector. China was suspected of fraudulently obtaining funds through a CDM "passport". This unexpected situation created a great disturbance in the Chinese wind power industry. By February 2010, 15 Chinese wind power projects had been rejected for CDM registration by the United Nations. The wind power enterprises, Chinese authorities and the International Emissions Trading Association all made responses to the EB's queries. The Chinese Renewable Energy Industries Association and the China-Denmark Wind Energy Development Projects Office also jointly released a research report on China's wind power and power price development, focusing in particular on wind power pricing issues and showing that the Chinese government's fixed wind power tariff was based on objective factors to do with wind power development and the grid network's capacity, and that the CDM was not taken into account. The report also stated that it was not true that the Chinese government had deliberately manipulated the wind power rate to enable companies to meet the "additionality" requirement. However, the EB has not yet accepted this interpretation, despite the fact that many projects have made representations and provided appropriate explanations. The EB has even proposed an "additionality" audit on all Chinese projects in the same district based on the highest power rate for the same district. This harsh requirement, without considering the actual conditions in the country, has placed many wind power CDM projects in a difficult dilemma. At the heart of the issue appears to be a series of misunderstandings resulting from the different historical backgrounds, economies and politics of different countries. It has also demonstrated that the CDM is lagging behind and becoming deficient.

In addition, the EB's queries have also lowered the expectations of CRE buyers, and some have even said that they will abandon the purchase of CERs from new energy projects like wind power and turn to other fields. Following the uncertain results of the Copenhagen Conference at the end of last year, some people have become perplexed and lost interest in the CDM. Statistics show that the number of China CDM registrations and their rate of success have both plunged. In March 2010 there were 37 Chinese projects registered with the EB, 32% down on the year before, and by April there were 19 Chinese projects registered, 45% down from a year earlier. It seems that the "2010 Effect" has been felt in the world of climate change.

Apart from the challenges of a more difficult project application process, due to technical development barriers, time extensions and a low acceptance rate, the development of wind power CDM projects is also limited to some extent by the Chinese industry's own supply capacity.

7 CDM additionality rules say that it must be proved that without the support of the external CDM (CER earnings), barriers such as access to financing channels would exist, making it difficult to execute the projects under local conditions,and the corresponding emissions reduction therefore difficult to achieve. CDM support can help overcome these barriers to ensure the project is executed and the resulting emissions reduction is additional. The EB query on Chinese wind power's CDM additionality was initiated by the recent power price changes, further affecting the projects' applications.

Although wind power has been strongly supported by the Chinese government over a long period, the growth trend for wind power projects has been slowing down, compared with the massive exploitation of wind power sources in recent years. It will be difficult to revive the previous boom in CDM projects, mainly due to a limitation on resources.

6.4.4. Impact of CDM market growth on Chinese wind power

Since the first Chinese wind power CDM project was registered in 2005, there have been 222 wind power CDM projects successfully agreed upon. Although various barriers and queries on CDM applications have emerged recently, the establishment of the CDM has undoubtedly encouraged the construction and development of renewable energies in China, mainly represented by wind power and hydropower. Three main conclusions can be drawn from the CDM experience so far.

1) The CDM has financially supported wind power development.

As one of the cooperation mechanisms in the global environmental field, the CDM has brought additional benefits to the Chinese renewable energy market, particularly wind power. If a wind farm has an installed capacity of 50 MW, for example, an annual grid electrical output of about 100 GWh, an annual emissions reduction of about 100,000 tons of CO_2 and an annual emissions reduction income of RMB 10 million, this is equivalent to a RMB 0.1 payment for every kWh, a substantial amount of additional earnings. This has strongly motivated wind power developers and promoted the faster growth of the Chinese wind power industry. If all the Chinese wind power projects successfully registered with the EB are effectively carried out, this can be expected to result in direct earnings to the Chinese wind power industry through CER sales providing income in excess of USD 420 million each year. These funds will become the driving force for China to deal with climate change, energy conservation and emissions reduction and to push for social sustainable development whilst still providing partial funding for the normal operation of Chinese wind power projects.

2) The CDM will stimulate wind power technology transfer and technological progress.

CDM projects help their promoters to import innovative ideas and technologies. Not only do these provide new financing sources, they also broaden the wind power enterprise's vision and increase their management performance levels in terms of standardised, scientific and intensive operation. CDM projects also provide opportunities for wind power enterprises to mature into larger businesses and enter the world market, promoting cooperation and technology transfer. For example, the China Energy Conservation Co. Ltd. has established multi-level emissions reduction cooperation relationships with partners in developed countries through investing in and running several wind power projects. These partners include Tokyo Electric Power, Vitol SA and CRM. The CDM has also introduced more sophisticated technologies, including facilities and know-how, into some Chinese wind power enterprises, facilitating the upgrading of wind power technologies and low-carbon economic development.

3) CDM's contribution to Chinese wind power development should not be overestimated.

Compared with the Chinese government’s investment, the scale of CDM project financing is not that large, mainly because the government has invested a large amount of funding in both energy conservation and emissions reduction. In 2008 and 2009, for example, the central government earmarked RMB 41.8 billion and RMB 49.5 billion for energy conservation and emission reductions respectively. The central government has also earmarked a large amount of funding for new renewable energies such as wind power, solar energy and biomass energy.

In the five years since the CDM was introduced, the total earnings it has brought to all Chinese CDM project enterprises is less than RMB 20 billion. By comparison, the income to wind power producers from power sales increased from RMB 138 million in 2006 to RMB 2.377 billion in 2009. This has stimulated the growth of China’s wind power installed capacity and enabled the country to leap forward as a major wind power country. In the same period, the annual CDM earnings of USD 420 million is roughly equivalent to the amount of the technical transfer royalties paid by Chinese enterprises each year.

6.4.5. Future CDM market trends

After the 2009 Copenhagen Conference, CDM transactions, which were booming before, were quickly reduced in number as the "2012 Effect" emerged and Chinese CDM project applications were repeatedly obstructed. The uncertainty created by this situation was worse among the Chinese CDM sector as it was hit by negative factors one after the other. It is therefore imperative to identify the likely future trend of CDM development at this critical point.

A World Bank report indicates that, according to Kyoto Protocol commitments, developed countries will purchase about 200-400 million carbon dioxide equivalent greenhouse gas units each year through CDM projects in the five years between 2008-2012. The World Bank's analysis of the Chinese CDM market potential also indicates that, by 2012, the Chinese CDM market will account for 35-45% of the global market, about 100-200 million tons of CO_2 equivalent greenhouse gases. This means that China will have a direct influence on supply and pricing in the carbon market, which will bring about a huge business opportunity for Chinese enterprises. So even if wind power projects are somewhat frustrated now, the CDM can still play a positive role in Chinese wind power development over the remaining period of the Kyoto Protocol. The Chinese wind power industry should seize this important opportunity to forge a pathway for Chinese sustainable development, treasure the benefits offered by the CDM, strictly observe CDM principles, enhance communication with the EB and keep close attention to CDM's new trends in order to actively develop and upgrade wind power projects.

Although, in the immediate aftermath of the Copenhagen Conference at the end of last year, it was not agreed how the Kyoto Protocol will develop after 2012, many experts have reached a consensus that the carbon transaction mechanism will definitely go on regardless of whether the CDM exists. It encourages market players to modify their decision-making via market signals instead of through regulations defining specific emissions reduction tasks or methods, and to achieve the emission reduction goal while maximizing the manufacturers' best interests. The ideas promoted by the CDM will still last after 2012, including carbon transactions, because they are in line with sustainable development principles as well as the principle of "common but differentiated responsibilities" among countries with varying economic strengths.

In the global political discussion about the carbon market after 2012, a "sectoral emissions reduction system" - setting a goal for a whole industry as well as a sector - together with participation in international emissions trading, thereby reducing additional emissions, was proposed to address the problems of ineffective CDM projects and the high costs of transactions as well as to promote emissions reduction in developing countries. In this way, the wind power industry, as a part of the electrical power sector, would gain more support from international carbon market funds and thereby reduce investment risk.

The future of carbon transactions and the CDM is also in large part dependent on the progress of the European Emissions Trading Scheme (EU ETS) and on whether a carbon emissions offset programme is introduced in the United States. If limits are set on the EU emissions transaction scheme, resulting in increased demand, and the United States ultimately passes the energy bill permitting the international carbon emissions offset project, then schemes like the CDM will be a perfect tool for accumulating carbon credits and facilitating technology transfer. The Chinese wind power and other renewable energy industries should make use of this tool and take an active and optimistic attitude towards the additional benefits obtainable from global carbon emission reduction practices under the CDM's market guidelines for a better exploitation of renewable energy sources. Meanwhile, China should recognise the importance of clean development under the inspiration of this new carbon market mechanism, and actively participate in greenhouse gas emissions reduction schemes. This will mean establishing a domestic carbon transaction system and market against the background of existing international schemes, promoting clean development under the government's guiding policies and encouraging the innovation of clean technologies in enterprises through market mechanisms.

7. Power Grid Bottlenecks and Solutions

As a variable power supply, large-scale wind power development is bound to result in problems in terms of its easy absorption into the electricity grid network. Wind farms in China are mainly located in areas far from load centres, and where the grid network is relatively weak, so the present design of the grid places constraints on the development of wind power. Concentrations of wind parks are currently in parts of Northwest, North and Northeast China, with the result that they cannot be readily connected to grid. This has become the biggest problem for the future development of wind power in the country. It is noteworthy that solar energy resources in these areas are also very rich, so the grid connection problems and absorption challenges for wind power will show up in the future after the large scale development of solar energy.

It should be clear, however, that China's wind power capacity does not stand idle in any large quantities, as the media has reported. In fact, there is an important difference between the installed capacity of wind power published by the wind power industry and that by the China Electricity Council. The installed capacity of wind power published by the industry refers to the equipment available after construction is completed and the equipment suppliers have finished their installation in accordance with the requirements of the developers. The installed equipment must then first complete a physical connection and later undergo electricity generation grid compliance tests. Those that meet the requirements of the grid companies can then be used as commercial grid capacity. Only those power companies with a grid connection application from developers and being qualified through the overall review in accordance with planning requirements can be regarded as commercial grid-connected generating capacity. It takes about 3-4 months from the start of grid connection compliance testing to the completion of the commercial grid licensing process.

Taking the year 2009 as an example, the 17 GW of wind power installed capacity published by the China Electricity Council is regarded as firm grid-connected capacity, the 22 GW published by the National Energy Administration is known as construction capacity, and the 25 GW figure published by the China Renewable Energy Association’s Wind Energy Professional Committee is described as ‘hoisting’ installed capacity. Besides the 17 GW of wind power capacity connected to the commercial grid, about 5 GW has been connected to the grid physically but not commercially, and is still being checked, and about 3 GW has been installed but does not yet meet the conditions for the physical grid and grid connection checking. These variations are reasonable.

According to the Statistical Report on 2009 China Wind Power Construction Result[8], by the end of 2009, out of 24.12GW of total installed capacity, the “total construction capacity”-the capacity of wind turbines already connected to the grid, those that had established a complete grid connection or been given the conditions for a grid connection, reached 22.68 GW, while the capacity of wind turbines that had connected to the grid and been put into use was 17.67 GW. Compared with the statistics at the end of 2008, the total installed capacity had increased by 11.95 GW (at the end of 2008 it was 12.17 GW) and the capacity of turbines connected to the grid and put into use had increased by 8.28 GW (it was 9.39 GW at the end of 2008). According to the Statistical Report on 2009 China Wind Power Construction Results, by the end of 2009 wind turbines with a capacity of 1,440 MW had finished

8 China Hydropower Engineering Consulting Company (CHECC), Statistical Report on 2009 China Wind Power Construction Results. March, 2010

installation, but they failed to connect to the grid due to an unfinished output line. Smaller amount failed to connect to the grid due to a reluctance of cooperation from the grid company.

Although wind power in China has formally entered the current stage of large scale development, with continuous progress and the rapid expansion of the market, the industry is still facing significant challenges. These issues will be prominent during discussions around the twelfth Five-Year Plan. Currently, the grid connection of wind power faces two overall problems: institutional issues and technological aspects.

7.1. Issues at an Institutional and Policy Level

7.1.1. Grid companies have no pressure to achieve their quotas

China's renewable energy law requires grid companies to acquire increasing volumes of renewable energy generation. The renewable energy development plan in the Eleventh Five-Year Plan issued in 2008 declared that from 2015 and 2020 there would be requirements for the power companies to achieve a 1% and 3% portfolio of renewable energy generation in their output. These provisions are not practical, however. There will be no punishment if the grid does not accept renewable energy generation and there is no compensation for the loss of wind power business, so the grid enterprises have no pressure to accept renewable energy generation, including wind power.

7.1.2. Compensation for accepting wind power is not enough to encourage the grid companies

As laid down in the Renewable Energy Law and the National Development and Reform Commission in the implementation details of cost-sharing, there are certain compensations for grid companies which purchase wind power, such as a subsidy of 0.01 yuan/kWh of electricity integration for wind farms which are less than 50 km away from the main grid infrastructure; 0.02 yuan/kWh for 50-100 km and 0.03 yuan/kWh for more than 100 km. However, compared with the overall revenue of the power grid enterprises, this income is minimal and not enough to encourage enterprises to actively accept wind power.

7.1.3. Power grid construction lags behind wind power construction.

The Renewable Energy Law and the national authorities clearly define that power grid companies should ensure that the enough grid capacity is available for renewable energy generated according to national plans and will buy the power output in accordance with state regulations. However, China's planned wind power development targets have in the past lagged behind the rate of development. According to the national wind power development plan, this means power grid construction could hardly satisfy the demands of rapidly developing wind power.

7.1.4. There are barriers in the compensation mechanism for inter-regional transmission of wind power

In the past, a fixed quantitative delivery mechanism was adopted for the cross-regional transmission grid. Any increase or decrease in throughput needed not only the consent of the power grid but also consultation with local governments of both sides of the border. The power transmission from Inner Mongolia to the Beijing-Tianjin-Tangshan power grid, for example, mainly relied on coal-fired power generation from near Ordos in Inner Mongolia rather than wind power. Due to a lack of coordination and compensation mechanisms, when the wind power capacity was under full load, no reduction in the power generated by the coal-fired power stations being delivered to Beijing-Tianjing-Tangshan district was allowed. As a result, reductions in the output from wind power in Inner Mongolia and Gansu were very common.

7.1.5. Imperfect electricity market

Nearly 30 years of development of wind power business in Europe and the United States has been built on a more mature free power market, and market mechanisms and administrative measures have been fully utilised to resolve the problems in wind power development. China's electricity market is not yet mature, the market model is imperfect and market optimisation resource allocation, technological progress, the distribution of benefits and micro-balancing and other basic features are all lacking. Although the renewable energy-based electricity price subsidies have been implemented, the current pricing system does not reflect the quality of various power generation projects and real-time market value, and the cost-sharing system does not compensate for the increased costs of electricity system operation/maintenance of the system. Problems of cost and risk-sharing and market competition will occur in power grid construction and the scheduling of large-scale renewable power generation alongside conventional power systems. The current obsolete power system therefore limits the full development of renewable energy markets.

7.2. Technical Issues

7.2.1. Electricity and power transmission issues

China's wind and solar photovoltaic power generation both have the characteristics of being "large-scale, variable and long-distance". Wind energy resource-rich areas are located in the "Three North" (north, northeast, northwest) regions. Based on the distribution of wind energy resources and the technical and economic conditions, development has focused on wind energy resource-rich areas such as Inner Mongolia, the northwest, northeast, Hebei Province, southeast coast and offshore islands. Among the proposed seven 10 GW wind power bases, apart from the wind power base in the coastal Jiangsu Province, all the other large bases have a low load level and small-scale power systems. Their wind power consumption capacity is therefore very limited and they cannot meet the requirements of large scale wind power development. Solar

energy resources and desert regions are located mainly in the west, so the majority of large desert power plants will be constructed there. Although combined development with wind power bases can be considered, the photovoltaic power would still need to be transmitted together with the wind power. Therefore these large-scale renewable power outputs need to be consumed within the wider regional or even the national power grid. The specialised construction of long-distance transmission lines to meet the needs of large-scale wind and solar power development is therefore an extremely necessary part of the country's energy infrastructure.

7.2.2. Grid compatibility

Wind power and PV both have the characteristic of variability. The range of output fluctuations is usually larger and fluctuates happen faster. In the absence of energy storage devices, the output cannot be arranged and controlled like other conventional power supply. Operating large-scale wind and photovoltaic grid systems will therefore increase the level of uncontrollable power output, affect the power system's ability to maintain a balance of supply and demand and result in a lot of pressure on the operation mode of various power supplies in the power system.

Water, oil and gas power stations all have a good regulation capability. But due to resource constraints, the power structure in areas with good wind resources in China is dominated by coal. The peaking performance of coal-fired power stations is poor and many technical and safety factors need to be considered. As a result, the capacity of the power grid to absorb wind and photovoltaic power is affected. The downward adjustment of combined heat and power generating units' output is also limited by their heating load, especially in winter when it is necessary to meet the demand for heating. As a result, thermal power has almost no peaking capacity. The hydropower generator systems that can be used to adjust the peaking are very limited. And hydroelectric power also has obvious seasonal characteristics. In addition to power generation, the reservoir water storage is also used to meet the needs of agricultural irrigation, so the hydropower peaking capacity will be restricted. In addition, in the power structure of China, the proportion of flexible power generation, such as gas and oil power generation, with a quick response time is less than 0.3%. This causes the acceptance capacity of the grid for wind power to be further restricted.

7.2.3. Wind power and energy demand

In the 1980s, when wind power and other renewable power generation industries started to develop fast in Europe and the United States, the large-scale electric power grid had been basically completed, and the overall demand for energy was stable. Since then renewable energy generation has gone through many phases in its relationship to the grid: from decentralised development and local absorption to enhancing the dispatch flexibility of the power grid and strong connection capacity through improvement of the peak regulation capacity of the power grid, large-scale grid connection and then to standard construction and electric power prediction. In China, the renewable energies, especially wind power, have just begun to develop rapidly in recent years. China now has to complete the work required to accommodate renewable energies – work that advanced countries spent nearly 30 years to finish. This is a very difficult task. At the same time, along with rapid economic and social development, electricity demand is still growing and the load is increasing. As a result, greater requirements have been placed on large-scale renewable energy generators to ensure power system security.

7.2.4. Technical support systems

China already has a considerable level of wind power equipment manufacturing capacity, but in comparison with other countries, investment in equipment R&D is seriously poor and there are no state-level R&D institutions, public testing platforms and standards or testing and certification systems.

Other countries with a large quantity of renewable energy have implemented technical standards and regulations for the integration of renewable power into the electricity grid system. These require both wind and photovoltaic power generation systems to have a dynamic reactive adjustment capability, gradeability of active tracking settings, the capacity for active regulation under certain circumstances and LVRT ability similar to that which conventional power generation systems, such as coal and gas, can provide. Most of the existing renewable energy generating equipment in China does not have this ability, however. In addition, compared with the research work carried out on the short-term power prediction of renewable power stations in other countries, the development of our short-term forecasting technology is still at an initial stage. There is still a big gap to fill between China and the advanced countries in terms of ensuring power system scheduling and safe and stable operation.

7.3 Policy solutions for difficult wind power connections

Raising awareness is the key factor in solving the problem of difficult wind power connections. After two or three years of intense debate and communication, the awareness of the power grid enterprises about wind power development is increasing. From regarding wind power as unwanted "spam" they are now taking active measures to accommodate it. The grid companies have now reached a consensus on the acceptance of 80 GW and 150 GW wind power in 2015 and 2020 respectively. It remains to be seen how this will be realised.

Although the grid companies continue to increase their awareness and move with the times, the state still needs to regard the power grid as a business. Incentives and penalties are implemented and administrative intervention and economic incentives co-exist. The following work therefore needs to be done at a system level:

7.3.1. Administrative intervention and economic incentives

Given the differences between the regions' wind resources, the costs for renewable energy development are variable. A combination of administrative intervention and policy incentives should be adopted, ensuring that market mechanisms and the law of value are brought into play to address conflicts of imbalance in renewable energy development between the regions. For renewable energy generation, a dual mechanism of economic scheduling and physical dispatch should be implemented to establish a renewable energy quota trading system and a scheduling compensation system. Trading should be allowed for the sale and purchase of renewable energy targets. In order to achieve the overall objective, the best economic benefits and the lowest cost should be realised.

7.3.2. Reasonable allocation of absorption costs

Power companies are required to implement relay scheduling for renewable energy generation, deliver renewable power as much as possible and absorb transmission costs by using the price difference between the different regions. Power enterprises should therefore be able to reasonably distribute and eliminate the costs of renewable energy. A sharing system should be adopted by the different power grids in order to balance out the extra costs of absorbing renewable energies. The construction of power lines dedicated to transmitting wind and photovoltaic power should be absorbed into power grid construction cost accounting, without implementing a one-way settlement. The price of the electricity generated by grid-connected renewable power could increase by approximately 5-10% if the price is clearly defined as part of the local fiscal revenue. Off-site renewable power purchase costs should be shared by the two regions and distributed through consultation.

7.3.3. Power grid construction planning for wind power projects

Firstly, the state should work out clear and reasonable wind power development plans according to the need for national economic development and make clear the key regions for the constructions of wind power and solar power. Development goals should be set in advance for the different regions during the planning period to prevent wind and solar power farms from being constructed in regions that have experienced difficulties in access to the grid and therefore influencing the effectiveness of the investment.

Secondly, the national power grid also needs to work out scientific and rational grid construction plans according to the renewable energy planning developed by the state, and make arrangements in advance to provide technical support for large-scale renewable power development.

Thirdly, the country should, on the basis of wind power construction and grid planning, make clear the electricity market for inter-district wind power transmission as soon as possible, coordinate the prices of buying and selling electricity and plan for a future large-scale wind power development pattern as soon as possible.

7.3.4. Mediation and guidance

Large-scale development of wind and other renewable power must include greater involvement by all elements in the power system. Current policies, including the electricity price, financial subsidies, localisation rate requirements and tax incentives are all basically focused on renewable energy equipment manufacturing, project development companies, R&D, demonstration and promotion activities, without taking into account the cost to the power system of integrating renewable power. No account is made in system costs for the delivery of renewable power, including the potential effects of efficiency reduction and interest loss caused by the participation of peaking power stations, backup power and the cost of long-distance transmission of renewable electricity through the grid and related power investments. The frequent start-up of peaking units, for example, reduces power generation efficiency or forces the company to sacrifice other easily controlled electricity production options for renewable energy, thus reducing their own income. There is not a reasonable compensation mechanism for this particular dilemma.

In the current market economy environment, the simple emphasis on corporate social responsibility cannot meet the need for the future large-scale development of renewable power. There must be sound institutional arrangements to fully mediate, encourage and guide the enthusiasm of all participants in the power system to develop renewable electricity, and fully tap their technical potential in order to encourage the grid to accept renewable power more effectively.

7.3.5. The use of price leverage

Current rules for the determination of the power price and power scheduling do not fully reflect the value of installed electricity, which can play different roles in the process of safe operation of the power grid, such as peak regulation and standby operation. The value is achieved indirectly through power scheduling by the grid business, which cannot motivate enterprises to participate in this type of power construction. Currently there is no policy for the pricing of power supply with flexible adjustment ability, including natural gas and pump storage power stations. The capacity value that they can play in the system cannot be effectively reflected.

On the other hand, from the consumer's point of view, there is currently no reasonable peak to trough price mechanism to encourage power consumers to conduct more economical power consumption behavior, thereby reducing the difference between the peak and trough load, which indirectly increases the peaking pressure on power grid companies.

The role of government in price leverage should therefore be given full play to mobilise the enthusiasm of market participants. Differential power prices such as a two-part price should be used to guide and encourage enterprises to construct power generation capacity with a flexible adjustment capacity and to increase the scheduling flexibility of the grid companies. At the same time, peak-trough prices should be used to guide the power use of electricity consumers, encourage off-peak power use and reduce the pressure on power grid enterprises for peak shaving.

7.3.6. Incentive policies

In addition to encouraging equipment manufacturers,

developers, power companies and even the peaking power thermal power companies to tap their own technical potentials, some incentives should be implemented to guide and encourage enterprises to apply and develop these new technologies for the purpose of maximising the acceptance of renewable power in the grid. Renewable energy is still an emerging industry and many of these new technologies cannot be rapidly applied. Some incentives should be given, for example, at the initial stage of the development of grid-friendly wind turbines, towards the introduction of thermal power units that can be adjusted, for the short-term forecasting of wind farms, the shedding of some marginal wind power from a wind farm in order to adapt to wind power scheduling, and to encourage the investment and conduct of these enterprises, thereby realising their technological potential as much as possible and indirectly reducing the peak shaving pressure on power grid enterprises.

7.4. Technical Solutions to Wind Power Grid Integration

Guaranteeing the integration of renewable energy into the grid is currently a vital topic for the development of renewable power generation. In terms of wind power, from the development experience of large wind power countries such as Germany and Denmark, the reasons for their higher market share are related not only to the distribution characteristics of wind power and the power system in Europe but also to the current stable power construction period in Europe and Europe's mature electricity market trading system. Because of differences in basic conditions and development levels, China cannot completely copy the foreign experience. The country is still in the initial stage of the large-scale development of wind power, and lacks independent innovation. In addition, the power grid enterprises have relatively limited experience of absorbing wind power.

Although there are differences in the obstacles facing the regional power grids with abundant wind energy resources in terms of accepting large-scale wind power, they are generally the same. The main issue is that the anti-peaking characteristics of wind power worsen the load characteristics of the power grid, increasing the difficulty of peak shaving. The regional peak load regulation capability is restricted in many ways and cannot maintain the same growth rate as wind power construction. Various technology options for consumption within the grid and external delivery of wind power are also uncertain due to a lack of clear policy.

Although China has basically established the policy framework to encourage renewable energy generation, including pricing, cost-sharing and preferential taxation, these have mainly been focused on specific parts of the market such as equipment manufacturing and power construction. There are no special policies for optimised power grid construction. In the existing policy system there is no mechanism to encourage and guide the power grid to consume renewable power, such as through gas or pumped storage electricity participation in peaking supply, or by developing standards for the connection of power grid-friendly units, tapping their technical potential and bringing their initiative into full play.

In short, the "full acquisition" principle emphasised in the Renewable Energy Law still faces many unresolved technical difficulties at an operational level. Furthermore, large-scale development of renewable power generation will create new interest groups and new ways of sharing the benefits brought by the renewable energies, the solution to cost accounting issues for long-distance wind power transmission by the grid and the construction of power supplies with the flexibility to adjust their output. These problems should be solved before wind power and other renewable energies continue on their healthy and sustainable path of large scale development. As noted previously, from the point of view of constructing the 10 GW-scale wind power bases, with the aim of enabling wind power to play a greater long-term role in the national economy, it is not enough just to emphasise the social responsibility of power companies. The main direction of wind power development should be cleared at a technical level, fair and reasonable arrangements at policy and institutional levels should be made, the interest transmission channels should be cleared and enterprises should be guided to invest in order to ensure the development of wind power resources to the maximum extent. The following aspects need to be addressed at a technical level:

7.4.1. Enhance short-term forecasting techniques for power system output

Wind power has random, variable and non-controllable features. To protect the security and stability of the power grids, the reserve capacity of the maximum output of wind power needs to be set aside to balance out fluctuations. Currently the proportion of wind power is small in China, so power grids are able to balance the fluctuations. But with the constant expansion of wind energy, the ability of the grid to cope will gradually be reduced. So we should learn from the successful experience of European wind power forecasting in promoting large-scale development, incorporate wind power forecasts as an important part of future power system construction based on the existing work, carry out research work as soon as possible, continuously improve prediction accuracy, minimise incremental demand for system peaking capacity due to the connection of wind power, thereby enhancing the economic efficiency of grid operation and absorbing wind power capacity.

Wind power forecasting needs close cooperation between wind power developers and power enterprises. Developers should provide basic data for grid companies to carry out power forecasting. Power grid enterprises should establish regional concentrated wind power prediction platforms for regional wind power forecasting and provide technical support for the development of a reasonable grid scheduling plan.

In addition, in the long run, the power sector should also establish a dedicated renewable energy power agency based on power prediction to take charge of coordinating wind and solar power, as well as other renewable energies.

7.4.2. Develop technical standards for grid connection

China's wind power industry is still at a developing stage. Several domestic wind power equipment manufacturers have made great progress in terms of technology and market size, but in terms of mastering the advanced wind turbine technology that adapts to the requirements of the power grid, the current technical levels of the enterprises and production capacities are still uneven, lagging well behind Europe. Most of the current domestic wind turbines, for example, do not have an online active and reactive power regulating capacity or LVRT capability. Of course, this is mainly because China is still at a growing stage, and the technological innovation capabilities and experience of the enterprises is limited. It should be remembered that we have not formulated as clear or strict technical standards for the connection of wind power to the power grid as in Europe. And we have not required the wind farms to have this capability or the wind turbines to have the ability to meet the requirements of the grid as strictly as in Europe.

With the continuous expansion of the wind power market, and from the point of view of an optimum system, the power grid by itself cannot solve the problem of wind power integration, but the technical potential of manufacturers, wind farm and other auxiliary powers within the grid should still be fully tapped. The wind power industry in China has made great progress, moving through a "technology transfer" phase and then on to a "joint design" stage. The country may now size up the situation and decide to abolish the conservation restrictions of the "localisation rate of 70 percent", aiming to strengthen innovation in the domestic industry and make it bigger and stronger. With the increasing strength of national frequency and control system manufacturers, and their full participation in the joint design process, most advanced manufacturers of wind turbines have the strength to further upgrade their systems with power grid-friendly technology such as low-voltage penetrating and active or idle power control. What should happen is that during the current intense competition in the wind power manufacturing industry, certain technical requirements should be worked out to encourage the innovative activities of enterprises.

Relevant technical standards, relevant policies and a supporting system should therefore be worked out as early as possible, and a mandatory market access system established to motivate enterprises to pay more attention to grid-friendly wind power technology. Moreover, real economic incentives should be implemented to encourage the innovation of enterprises in maintaining the vitality of domestic companies during the growth period.

7.4.3. Flexible adjustment issues

Wind power has the characteristic of being anti-peaking, making it difficult to participate in the process of power balancing, even if it is treated as a "baseload" supply in the system. In certain situations, according to the power load characteristics, the output from wind should therefore be reduced to a certain degree. Although part of the wind energy will be lost, the reduced marginal cost of this part of the output will be far less than the increased expensive marginal cost of peaking needed by the power system to guarantee grid security. This makes it economical from the perspective of the power system.

Although "wind abandoning" deviates from the principle of full acquisition in the Renewable Energy Law, it is an inevitable choice after determining the optimal value of “the total installed capacity of power" from the system perspective. Of course, there should be a system to guarantee appropriate wind abandoning:

Firstly, the reasonable proportion of abandoned wind should be considered carefully. The ratio of abandoned wind in regions with different load characteristics and peaking capacities should be different.

Secondly, compensation should be given for wind abandoning actions to the wind power developing company.

Thirdly, wind power construction must be planned ahead. Only when the overall layout of the construction of wind power is determined can the construction of power facilities be guaranteed, and the abandoned ratio of wind farms be reduced to the minimum.

7.4.4. Power grid construction and regional connection

Although China has established a relatively strong power system, compared with the power grid in Europe, in general it is still undergoing a rapid construction phase and cannot meet the requirements of large-scale wind power development. First, the capacity in China's wind power concentration area is low, and the grid is relatively weak, so it cannot meet the requirements of large-scale wind power consumption and transportation. Second, there is less power supply with a flexible adjustment capability. Water-rich areas are far away from the sites of large-scale wind power bases. The total installed capacity of natural gas and pumped storage power generation is low. Third, the link between the power grids of the major regions is weak. Regional connections only play a role as emergency standby and cannot provide strong support for large-scale wind power development. These are the three main factors in the difficult issue of strengthening the peak shaving capacity of the "Three North" power grid.

Although strengthening wind power forecasting and improving the performance of individual wind turbines can enhance wind power's ability to meet the requirements of grid compatibility, compared with conventional power, the randomness of wind power output cannot be changed fundamentally. It is therefore recommended to include wind power development in the planning of grid construction and to work out future development plans for wind power suppliers, other power suppliers and the grid as early as possible on a national scale, including increasing the grid capacity of the main wind power concentration regions. This would include focusing on the layout and construction of power supply, taking into account adjustment capacity such as pumped storage and gas power generation, and encouraging the production and application of thermal power equipment with in-depth adjustment capability. At the same time, we should strengthen the connection between inter-regional grids and increase the overall regulation power of the grid over a wider range. Natural gas in particular should be planned and deployed as early as possible to meet the development of large-scale wind and photovoltaic power in the future.

7.4.5. Distributed wind power development

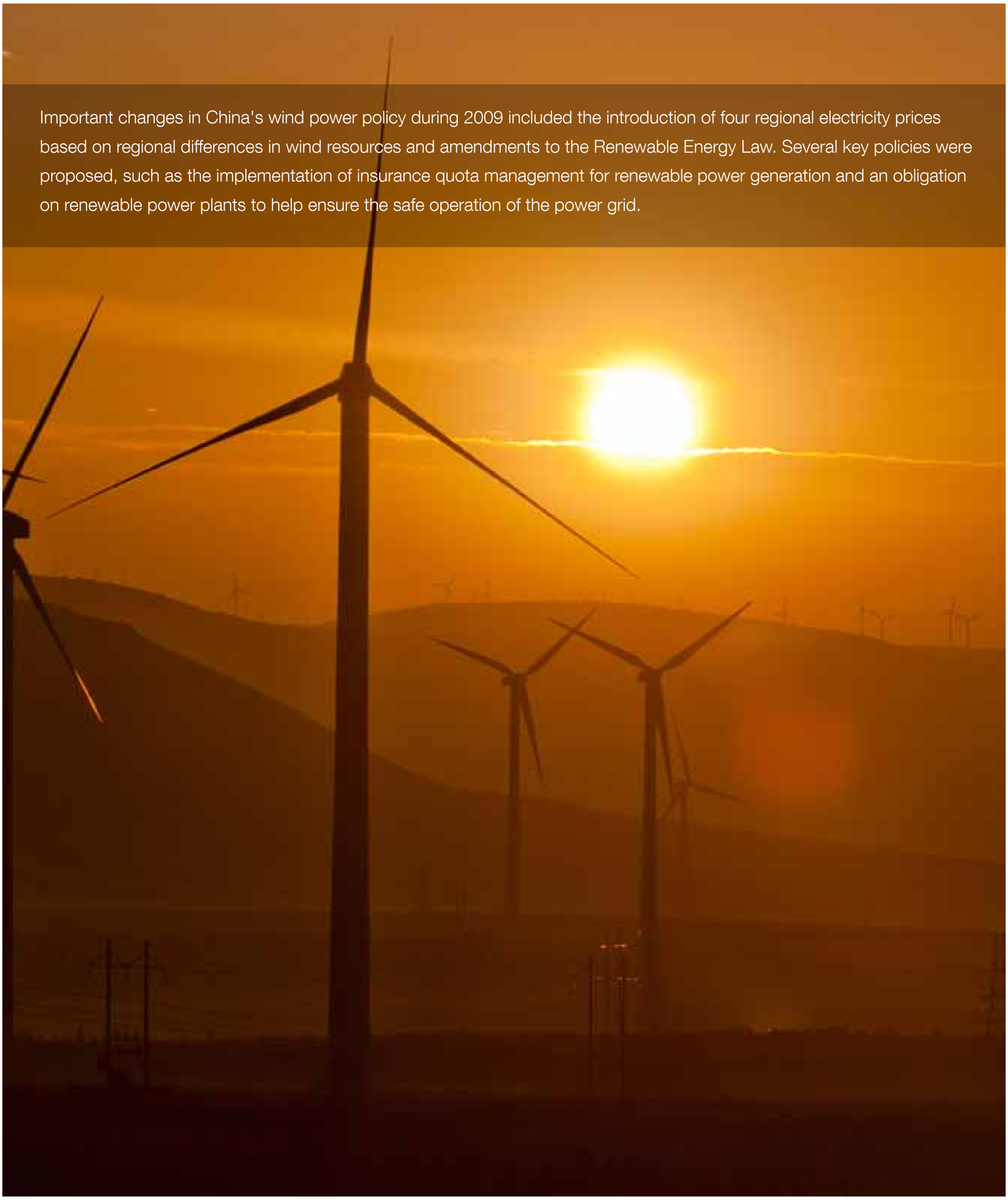
China's wind energy resource distribution is different from that of Germany and Denmark. Resources are mainly concentrated in remote areas with a small load demand and weak grid conditions. Wind power needs to be developed through concentrated construction and transmitted over a long distance. While constructing the 10 GW-scale large wind power bases, we should also actively guide and encourage the building of small wind electric farms in areas with poor terrain or without the conditions for building large wind farms (such as mountains, valleys and coastal islands), and consider the feasibility of an in situ wind power consumption programme, such as heating, to maximise the flexibility advantages of distributed power development, and to speed up the development process of wind power resources in the regions where conditions permit. For solar power, the coordinated development of photovoltaic urban architecture and desert power plants should be taken into account.

7.4.6. Energy storage and the smart grid

The variable nature of wind and solar power output cannot be changed fundamentally. Through the development of energy storage and intelligent grids and other new energy technologies, these variable energy sources can nonetheless be stored to meet a variety of energy needs with flexible adjustment. Powering electric vehicles, for example, will be one important direction for the development of emerging energy technologies. These new energy technologies are already at the point of cutting-edge research around the world. While developing the existing technology, China should attach importance to R&D, lay solid foundations, move progressively, persevere and devote long-term technical and human resources to achieving the early realisation of technology breakthrough.

8. Policies, Laws and Regulations affecting China's Wind Power Industry

Important changes in China's wind power policy during 2009 included the introduction of four regional electricity prices based on regional differences in wind resources and amendments to the Renewable Energy Law. Several key policies were proposed, such as the implementation of insurance quota management for renewable power generation and an obligation on renewable power plants to help ensure the safe operation of the power grid.



8.1. China's policies supporting development of the wind power industry

China's system of policies promoting the development of wind power is centered on the Renewable Energy Law and related implementation rules and regulations. These form a complete legal framework that can be summarised under the following main points.

8.1.1. Wind power grid-connected pricing and cost-sharing policies

Wind power grid-connected pricing and cost-sharing policies are the motivating force pushing forward wind power development, and these two issues are determined by the Renewable Energy Law as well as decisions made by relevant government departments.

1) Statutory Provisions

The legal framework is primarily laid down in the Renewable Energy Law (passed Feb. 2, 2005; Dec. 12, 2009 amendment effective Apr. 1, 2010). The Renewable Energy Law includes the following provisions:

Art. 19. Grid-connected power prices for renewable energy power generation projects shall be determined by the pricing authorities of the State Council on the basis of the unique characteristics of different types of renewable energy power generation as well as differing local conditions; and according to the determining principles of economic reasonableness and of benefiting the promotion of renewable energy development and utilisation; and on the basis of timely adjustments for the development and utilisation of renewable energy technology. The price of grid-connected power shall be publicly announced.

Provisions in Article 13, Paragraph 2 of this law implement bidding for the pricing of the output from grid-connected renewable energy power generation projects and based on successful tenders; however, such pricing cannot exceed the grid-connected power price levels of similar renewable energy power generation projects.

Art. 20. In terms of expenses incurred by power grid enterprises that purchase units of renewable energy power in accordance with grid-connected power pricing determinations made under Article 19 of this law, the varying margin of expense in excess of the calculation of expenses for the average grid-connected power price of conventional energy power generation shall be additionally compensated for by a national-level sales tax on the price of units of renewable energy power.

Art. 21. Power grid enterprises which, in order to purchase units of renewable energy power and to defray reasonable grid-connection expenses and other reasonably related expenses, may incur power grid transmission costs, can recover such expenses and costs from the sale price of power.

2) Administrative Regulations

In early 2006 the National Development and Reform Commission (NDRC) issued Management Rules Related to Renewable Energy Power Generation (NDRC Energy, 2006, No. 13; issued and effective Jan. 5, 2006), which included the following provision:

Art. 7. Grid-connected power prices for renewable energy power generation projects shall be determined by the pricing authorities of the State Council on the basis of the unique characteristics of different types of renewable energy power generation as well as differing local conditions; according to the determining principles of economic reasonableness and of benefiting the promotion of renewable energy development and utilisation; and on the basis of timely adjustments and announcements for the development and utilisation of renewable energy technology.

To implement bidding for the grid-connected power generation pricing of renewable energy power generation projects, through successful tenders to decide the pricing, the increased expenses to power-grid enterprises for the purchase and sale of non-hydroelectric renewable energy power shall, on a nationwide basis, be an expense shared by all power users, with specific measures on this to be separately formulated.

Also in early 2006, the NDRC issued Trial Measures on the Management of Cost-Sharing for Renewable Energy Power Generation Prices and Expenses (NDRC Pricing, 2006, No. 7; issued and effective Jan. 4, 2006), which included the following provisions:

Art. 6. The grid-connected price of power from wind power generation projects is decided by government-guided pricing; power pricing standards are determined by the pricing authorities of the State Council according to prices set through bidding.

Art. 11. That portion of grid-connected pricing from renewable energy power generation projects that exceeds local prices for benchmark units of desulphurised coal generation; and the portion of expenses from national construction investments or subsidies for the operation and maintenance of the public renewable energy independent power system that exceeds the local and provincial-level average power grid sales price for power; and the grid-connection expenses for renewable energy power generation projects; shall be resolved through the method of the collection of additions to power prices from power users.

Art. 13. Increases to renewable energy power prices shall be charged to energy users (including large users such as provincial grid companies' wholesale partners, self-equipped power plant users, and users that directly purchase power from power generation plants) at the provincial-level as well as within the service area of power-grid enterprises. Energy users on self-provided county power grids or in the Tibet area, as well as those engaged in the agricultural industry, are temporarily exempt from increases to prices.

Art. 14. Increases to prices for renewable energy power are checked and ratified by the pricing authorities of the State Council, calculated according to the actual energy usage by energy users, and implemented under a uniform nationwide standard.

In 2007, the NDRC issued Trial Measures on Allocation of Revenue from Additions to Renewable Energy Power Prices (Urgent, NDRC Pricing, 2007, No. 44; issued and effective Jan. 11, 2007), which included the following provisions:

Art. 6. Increases to prices for renewable energy power generation are, according to uniform standards checked and ratified by the pricing authorities of the State Council and within the scope of power fees directed at end users, received and retained, and are separately accounted-for special funds for dedicated use.

Art. 7. Increases to prices for renewable energy power generation received by provincial-level power grid enterprises shall be calculated according to the formula below, which serves as the basis for the allocation of increases to power pricing:

Total amount of increase to power prices = Increase to power price (x) sales energy volume at additional prices

Sales energy volume at increased prices = Total volume of power sales of provincial-level power grid enterprises (-) agricultural production energy volume

In 2009, the NRDC released Notice Regarding Perfecting Policies on Grid-Connected Power Pricing for Wind Power Generation (NDRC Pricing, 2009, No. 1906, issued and effective July 20, 2009), which included the following provisions:

The Notice provides that, according to the circumstances of wind energy natural resources and the conditions of construction projects, the whole of the country is divided into four types of wind power natural resource areas, corresponding to the formulated wind power benchmarks for grid-connected pricing. The four types of natural resources areas for wind power benchmarks by power pricing levels are divided into: 0.51 yuan/kWh, 0.54 yuan/kWh, 0.58 yuan/kWh, and 0.61 yuan/kWh. From today, newly constructed on-land wind power projects will uniformly receive, within the relevant wind power area, the wind power benchmark for grid-connected power prices. At the same time, the system of wind power cost-sharing is to remain effective, and the portion of grid-connected wind power pricing that exceeds local prices for unit benchmarks of desulphurised coal generation, shall be resolved through allocating the collection of additions to power prices.

8.1.2 Public Finance Policies

Public finance support is a fund management safeguard system for grid-connected pricing and cost-sharing, as well as an important means to financially support industrial development of technologies through research and development, testing and demonstration. Accordingly, the enacted law and public finance authorities both provide corresponding rules.

1) Statutory Provisions

The Renewable Energy Law includes the following public finance related provision:

Art. 24. National public finance authorities shall establish a Renewable Energy Development Fund, with Fund sources including national public financing via annual arrangements of special-project funds, as well as lawful revenues from levies on renewable energy power prices.

The Renewable Energy Development Fund uses reimbursements resulting from provisions on marginal expenses found in Articles 20 and 22 of this law, and is used to support the following activities:

(1) Science and technology research, standards formulation and project demonstration for renewable energy development and utilisation ;

(2) Projects utilising renewable energy in farming and ranching areas;

(3) Construction of free-standing electric power systems in remote land areas and islands;

(4) Construction of systems for renewable energy natural resources exploration and assessment, and related information systems;

(5) Promotion of the localisation of production of equipment for renewable energy development and utilisation.

Power grid enterprises that cannot recover, through power prices, grid connection expenses and other related expenses provided for in Article 21 of this law, may apply to the Renewable Energy Development Fund for support.

The specific measures applicable to the management of levies to the Renewable Energy Development Fund shall be formulated by the State Council financial departments in conjunction with State Council departments in charge of energy and pricing.

2) Administrative Regulations

The Ministry of Finance issued an announcement related to Interim Measures on Management of Special-Project Funds for the Industrialization of Wind Power Generation Equipment (Finance, 2008, No. 476, Aug. 11, 2008), which provided that:

In order to support key technology research and development for wind power equipment, and to accelerate the development of the wind power industry, the Ministry of Finance adheres to the "rewards replacing subsidies" method to support wind power equipment industrialisation. For enterprises eligible for support, the first 50 MW-class wind power units will be afforded a subsidy according to a 600 yuan/kW standard. Among these, complete unit manufacturing enterprises and key parts manufacturing enterprises each receive a 50% share of the available funds. The focus is on key parts that are "weak link" technologies; subsidised funds are primarily to be used for new product research and development.

8.1.3 Preferential Tax Policies

Preferential tax policies, based on price and expense cost sharing and a supporting system of public finance, go a step further in aiding the financial incentives that support the development of wind power. These tax policies are primarily enabled by statutes and administrative regulations.

1) Statutory Provisions

Again the primary law is the Renewable Energy Law, which includes the following provisions:

Art. 12. The government lists scientific and technical research in the development and utilisation of, and the industrialised development of, renewable energy, as a preferential area for high-tech development and high-tech industrial development in the national programme, and allocates funding for scientific and technical research, application demonstration and industrialisation of the development and utilisation of renewable energy so as to promote technical advancement in the development and utilisation of renewable energy, reduce the production cost of renewable energy products and improve their quality.

Art. 26. The government grants tax benefits to projects listed in the renewable energy industrial development guidance catalogue, and specific methods are to be prepared by the State Council.

The Enterprise Income Tax Law (passed Mar. 16, 2007; effective Jan. 1, 2008) contains the following related provisions:

Art. 28. As regards a small low-profit enterprise satisfying the prescribed conditions, the enterprise income tax shall be levied at a reduced rate of 20%.

As regards important high-tech enterprises which need to be supported by the state, the enterprise income tax shall be levied at a reduced rate of 15%.

2) Administrative Regulations

Among these, the primary regulation is the Renewable Energy Industrial Development Guidance Catalog (NDRC, Energy, 2005, No. 2517, issued and effective Nov. 29, 2005.):

Industrial Catalog's list includes wind power generation projects as well as wind power equipment manufacturing projects.

In addition, the Notice Regarding Policy Issues for Comprehension Utilization of Some Natural Resources and Value-Added Taxation of Other Goods (Ministry of Finance and the State Administration of Tax, Tax, 2001, No. 198, issued and effective Dec. 1, 2001) has the following related provisions:

2. From Jan. 1, 2001, a half-reduction collection policy (for example 17% reduced to 8.5%) on the value-added tax percentage for the following listed goods is in force:

(1) Utilisation of coal waste rock (gangue), coal slurry, coal shale and wind power generated electricity;

Also, the Notice on the List Related to the Interim Provisions on Import Tax Policies for Major Technology Equipment (Ministry of Finance and the State Administration of Taxation, issued Apr. 2010) states that:

Rule: Importation of parts and materials that are components to a single wind power turbine of no less than 1.5 MW power capacity are exempt of customs duties and import sector value-added tax; normal taxes apply to the importation of complete wind turbines not larger than 3 MW capacity.

8.1.4 Grid-Connected Wind Power Policy

Grid-connected wind power policy is the foundation of the wind power industry; thus statutes and administrative regulation both have clearly defined rules.

1) Statutory Provisions

The Renewable Energy Law includes the following provisions:

Art. 13. The government encourages and supports various types of grid-connected renewable energy power generation.

For the construction of renewable energy power generation projects, administrative permits shall be obtained or filing shall be made in accordance with the law and regulations of the State Council.

In the construction of renewable power generation projects, if there is more than one applicant for a project license, the licensee shall be determined through a tender.

Art. 14. The government implements a system of safeguards for the purchase of the full amount of power generated from renewable energy.

State Council departments in charge of energy, along with state power regulatory authorities and the Ministry of Finance shall, in accordance with the national plan for the development and utilisation of renewable energy, ensure that, within the time period of the plan, renewable energy targets as a proportion of total electric power volume shall be reached; and formulate specific measures for power-grid enterprises to prioritise management and fully purchase the power generated from renewable energy. State Council departments in charge of energy, along with state power regulatory authorities, shall supervise such implementation.

Power-grid enterprises shall, in accordance with renewable energy development and utilisation, plan construction, execute grid-connection agreements with renewable energy power generation enterprises that have legally obtained administrative licenses or for which filing has been made, and purchase the total amount of grid-connected electricity within their power-grid coverage area which conforms to grid-connected technology standards.

Power-grid enterprises shall strengthen power grid construction, expand the distribution range of renewable energy electric power, develop and apply technologies including smart grid and energy storage technologies, improve power-grid transmission management, raise capacity to absorb renewable energy electric power, and provide grid-connection services for renewable energy power generation.

Art. 15. The government supports the construction of independent renewable power systems in areas not covered by the power grid to provide power for local production and living.

2)Administrative Regulations

The NDRC's Management Rules Related to Renewable Energy Power Generation (NDRC Energy, 2006, No. 13; issued and effective Jan. 5, 2006) included the following provisions:

Art. 11. Power-grid enterprises shall, according to planning requirements, actively initiate power grid design and research feasibility work, and, according to the progress and demands during the construction of renewable energy power generation projects, advance power grid construction and conversion to ensure the total amount of renewable energy power generation is grid-connected.

Art. 12. The grid-connection systems for renewable energy power generation projects shall be established and managed by power-grid enterprises.

The power-grid connection systems of medium and large-scale renewable energy generation projects for hydropower, wind and biomass power that are directly transmitted to the power grid shall be power-grid enterprise invested, with the first post (shelf) outside of the power booster station (area) as the property demarcation point.

Art. 15. Renewable energy power generation project construction, operation and management shall conform to the demands of the relevant national and electric power industry laws and regulations, technical standards and specifications, shall carefully consider land use conservation and satisfy environmental protection and safety, among other demands.

Art. 16. Power generation enterprises shall, according to the relevant regulations of national renewable energy power generation project management, carefully complete preparation work, including on design, land use, water resources and environmental protection, and legally obtain the administrative licenses, without which construction shall not commence.

Projects that have received administrative permits shall begin construction and start generating power within the prescribed time limit. Without approval from the original licensing department for the project, any transfer, auction, or modification of the investing party is prohibited.

The Measures on the Supervision of Power-Grid Enterprise Purchases of the Full Amount of Renewable Energy Electricity (State Electricity Regulatory Commission, Order No. 25, issued and effective on July 25, 2007) include the following provisions:

Art. 4. Electric power enterprises shall, according to the relevant provisions of the law, administrative rules and regulations, engage in the construction, production and exchange of renewable energy power generation and, in accordance with the law, be supervised by electric power regulatory authorities.

Power-grid enterprises purchase the full amount, within the coverage area of their power grid, of grid-connected electricity from renewable energy power generation projects, and the renewable energy power generation enterprise shall provide support and cooperation.

Art. 5. Electric power regulatory authorities shall supervise grid-connection projects constructed by power-grid enterprises for renewable energy power generation projects.

Power-grid enterprises above the provincial level shall formulate a plan for the construction of supporting power-grid facilities for renewable energy, and after approval by the relevant provincial level People's Government and the State Council, file a record with the electric power regulatory authorities.

Power-grid enterprises shall, according to the plan, construct or convert the supporting power-grid facilities for renewable energy power generation, and complete the construction, testing, examination and putting into operation of grid-connection for renewable energy power generation projects, all in a timely fashion, ensuring the necessary grid conditions required for the power transmission of renewable energy grid-connected power generation.

Art. 6. Electric power regulatory authorities shall implement monitoring of the circumstances of renewable energy power generators and power-grid connection.

The connection between renewable energy power generators and the power-grid shall be in accordance with national technical standards for the grid connection of renewable energy power generation, and shall pass a grid-connection safety evaluation organised by the electric power regulatory authorities.

Power-grid enterprises shall execute purchase and sales contracts and grid-connection scheduling agreements with renewable energy power generation enterprises. The State Electricity Regulatory Commission shall, on the basis of the unique characteristics of renewable energy power generation, formulate and issue sample texts for purchase and sales contracts related to renewable energy power generation as well as for grid-connection scheduling agreements.

Art. 7. Electric power regulatory authorities shall conduct supervision of the circumstances of power grid enterprises providing timely grid-connection services for renewable energy power generation.

Art. 8. Electric power regulatory authorities shall conduct supervision of the circumstances of prioritising the dispatching of renewable energy power generation by power dispatching entities.

Power dispatching entities must, based on relevant state regulations and the requirements of the full grid-connection of renewable energy power, draft and formulate power generation dispatching plans and organise their implementation. Power dispatching entities shall carry out daily planned arrangements and real-time dispatching, and shall not limit the power generation of renewable energy except in cases of force majeure or threats to power grid safety and stability. Instances of threats to power grid safety and stability, as referred to in these Measures, shall be defined by electric power regulatory authorities.

Power dispatching entities shall, based on the relevant national regulations, set detailed operational rules which accord with the features of renewable energy power generators and ensure the full connection of renewable energy to the power grid, and file records of such with electric power regulatory authorities. The detailed operating rules for power dispatching across provinces or districts shall fully develop the benefits of cross-flow domain and peak load compensation, thereby realising full grid connection of renewable energy power across provinces and districts.

Art. 9. Electric power regulatory authorities shall implement monitoring for the circumstances of the safe operation of renewable energy grid-connected power generation.

Power-grid enterprises shall strengthen the maintenance of power transmission equipment and technical support systems, enhance power reliability management, and ensure the safety of equipment, to avoid or reduce equipment-related reasons leading to the inability of renewable energy power generation to achieve full grid connection.

The demarcation point of shared responsibility between power-grid enterprises and renewable energy power generation enterprises, in maintaining equipment and ensuring equipment safety, shall be exercised according to relevant national regulations. Duties not clarified by state regulations shall be negotiated and determined by the parties.

Art. 10. Electric power regulatory authorities shall conduct supervision of the circumstances of power-grid enterprises' purchase of the full amount of grid-connected power generated by renewable energy.

Power-grid enterprises shall purchase the full amount, within their power-grid coverage areas, of grid-connected electricity from renewable energy power generation projects. Should, for reasons of force majeure or threats to the safety and stability of the power grid, renewable energy power generation not be fully connected to the grid, power-grid enterprises shall promptly inform, through written notice, renewable energy power generation enterprises of the duration of the inability to fully grid connect, the estimated electric power volume and the exact reason for the disruption. Power-grid enterprises shall report, to electric power regulatory authorities, the renewable energy power generation failure to fully connect to the grid as well as its reason and improvement measures, and electric power regulatory authorities shall supervise the power-grid enterprises in carrying out improvement measures.

Art. 19. Staff employed by electric power regulatory authorities who do not perform supervision duties as provided in these Measures shall be held responsible according to law.

Art. 20. For power-grid enterprises or power dispatching entities involved in any of the following acts, thus creating economic loss for renewable energy power generation enterprises, power-grid enterprise shall be liable for compensation and shall be ordered by electric power regulatory authorities to make correction within a set time limit; in case of refusal to make corrections, the electric power regulatory authorities may further impose a fine in an amount not to exceed the original economic loss of the renewable energy power generation enterprise:

(1) Unlawfully failing to construct or to construct grid-connection projects for renewable energy power generation projects in a timely fashion;

(2) Refusing or hindering the execution of power purchase and sales contracts as well as grid connection dispatching agreements with renewable energy power generation enterprises;

(3) Failing to provide grid-connection services for renewable energy power generation in a timely fashion;

(4) Failing to prioritise on dispatching power generated by renewable energy;

(5) For other reasons, power grid enterprises or power dispatching entities create circumstances leading to the inability to purchase the full amount of renewable energy power generated.

Power-grid enterprises shall, within 15 days from the date electric power regulatory authorities confirm an economic loss, compensate renewable energy power generation enterprises.

Art. 21. Power-grid enterprises, in cases of not calculating electricity fees and not recording and keeping renewable energy power generation materials according to relevant national regulations, shall be held responsible according to law.

8.1.5 Preferential policies for foreign-investing enterprises

The government, in relation to foreign investment, has also set clear rules through a system of statues and administrative regulations.

1) Statutory Provisions

The Chinese-Foreign Equity Joint Venture Law (issued and effective March 15, 2001) includes the following relevant provisions:

Art. 8. After payment, pursuant to the provisions of the tax laws of the People's Republic of China, of the joint venture income tax on the gross profit earned by the joint venture and after deduction from the gross profit of a reserve fund, a bonus and welfare fund for staff and workers, and a venture expansion fund, as provided in the articles of association of the joint venture, the net profit shall be distributed to the parties to the joint venture in proportion to their respective contributions to the registered capital.

A joint venture may enjoy the preferential treatment of reduction of or exemption from tax pursuant to relevant state taxation laws or administrative decrees.

A foreign joint venture that reinvests in China its share of the net profit may apply for a refund of part of the income taxes already paid.

2) Administrative Regulations

The Catalogue for Guidance of Foreign Investment Industries (2007 revisions, issued by Ministry of Commerce, October 31, 2007) includes the following provisions concerning the encouragement of foreign investment:

III. Manufacturing Industries

20. Electric Machinery and Equipment Industries

(7) Manufacture of the equipment for New Energy electricity-power (limited to equity joint ventures and cooperative joint ventures): photovoltaic power, geothermal power generation, tidal power generation, wave power generation, waste power generation, methane power generation, wind power generation over 1.5 MW

IV. Production and Supply of Power, Gas and Water

5. Construction and management of New Energy power plants (including solar energy, wind energy, magnetic energy, geothermal energy, tidal energy and biomass energy)

The Circular on Preferential Import Tax Policies Applied to Foreign Investment Projects (State Administration of Taxation, 2007, No. 35, effective July 13, 2007), includes the following provision on preferential tax policies applied to foreign investment projects:

According to the laws and regulations related to foreign investment, Chinese-foreign equity joint ventures, Chinese-foreign contractual joint ventures and wholly foreign-owned enterprises (hereinafter collectively called foreign-invested enterprises) that are established within the territory of China and have obtained the related legal documents, including foreign-invested enterprise approval certificates and business licenses, of which the invested projects comply with the encouraged projects in The Catalogue for Guidance of Foreign Investment Industries or The Catalog of Priority Industry for Foreign Investments in Central and Western Areas, the imported self-use equipment and the supporting technology, fittings and spare parts (hereinafter referred to as self-use equipment), apart from the commodities listed in The Catalogue of Non Tax-Free Imported Commodities of Foreign-Invested Projects, shall be exempted from tariffs and import value-added taxes.

8.1.6 Local government policy for wind power industry

In wind resource-rich provinces, local governments have introduced policies for wind power development, including wind power development plans and 2020 targets, and interim measures for the administration of preliminary work for wind power projects. Inner Mongolia, Xinjiang, Gansu, Jilin, Hebei and Jiangsu provinces have all launched planning work for 10 GW-scale wind power bases under the unified organisation of the National Energy Administration. Local policies for the major provinces are summarised in Table 25.

8.1.7 Recent policy changes in China

The major changes in China's wind power policy in recent years are summarised in Table 26.

Table 25 Wind Power Policies Introduced by Local Governments

Provinces	Name	Main contents
Inner Mongolia	Wind power development plan during "Eleventh Five-Year Plan" period and Targets for 2020 in Inner Mongolia Autonomous Region.	Wind energy resources for the whole region are divided into 26 wind power areas on a scientific and rational basis. At the same time, development goals are proposed for the "Eleventh Five-Year Plan" period and for priority construction from 2011 to 2020.
	Notice on the issuance of wind energy development and utilisation management practices in the People's Government of Inner Mongolia Autonomous Region	Wind energy resource development and utilisation mainly includes wind energy resource survey and measurement, wind power development planning, detailed investigation of wind energy resources, project development and utilisation, pre-feasibility and feasibility studies. Administrative classification management and technical centralised management systems have been adopted for wind energy resource development and management. The Development and Reform Commission at all levels is the administrative department for wind energy resource development and utilisation in the region.
	Each city and county (banner) shall develop a wind power development plan to guide local wind power development.	Wind power planning reports for Kailu County of Tongliao city, Kezuo Middle Banner, Zhalute Banner, Naiman Banner, Horqin Left Wing Rear Banner, Huolinguole City, Hure Banner, Horqin Left Wing Rear Banner
Jiangsu	Development plan for wind power equipment in Jiangsu province	Determine the development objectives and basic principles, development priorities (including key areas, products and technologies) and development path for wind power equipment in Jiangsu Province.
	Wind Power Development Planning of Jiangsu Province (2006-2020)	It is planned that by the year 2010 the installed capacity of wind power in the whole province will reach 1.5 GW, all land-based wind power. The installed capacity of wind power will account for 2% of the total capacity of the province; by 2020, the total installed capacity of wind power will reach 10 GW, including 3 GW on land and 7 GW offshore. The installed capacity of wind power will account for about 5% of total capacity in the province and the annual output value of the turbine manufacturing industry will reach RMB 100 billion. The installed capacity of wind power will reach 21 GW in the long run, including 3 GW on land and 18 GW offshore. A "Three Gorges of the Sea" will be built in the coastal areas of Jiangsu Province.
Xinjiang	Wind power development of the "Eleventh Five-Year" and by 2020 in Xinjiang	Nine large-scale wind farms in total are planned in Xinjiang Autonomous Region with an eventual capacity of 37,050 MW. These are in Dabancheng wind zone in Urumqi, Alataw pass wind zone, Shisanjianfang wind area, Xiaocaohu wind area in Turpan, Irtysh River valley wind area, Laofengkou wind zone in Tacheng, Santanghu ~ Naomaohu wind area, Southeast wind zone of Kumul and the Lop Nur wind zone. The total installed capacity is planned to be 3,550 MW in 2010, with the increase in installed capacity between 2011 and 2020 set at 16,450 MW. By 2020 the total installed capacity will reach 20,000 MW.
Jilin	Interim measures for the administration of preliminary work on wind power projects in Jilin Province	Wind power projects under these measures mainly refer to wind farms with grid connection in Jilin province. Preliminary work management on wind power project includes the administrative organisation management and technical quality management for the measurement and evaluation of wind resources, wind power development plans, wind power project approval, the right to determine the development, project approval and so on.
Gansu	Notice on standardising wind power development and construction order of the General Office of Gansu Provincial People's Government	This notice stipulates that; firstly, the development of wind power throughout the province is organised by the provincial Development and Reform Commission in accordance with the principle of overall planning and phased development; secondly, the development of wind farm projects should be determined through bidding or tenders. The preparatory work is organised and carried out by the provincial Development and Reform Commission. The city, prefecture and county governments where the project is conducted will not be allowed to enter into various types of wind power development agreements with enterprises and individuals; thirdly, a grading system is adopted for wind farm construction projects. Wind power projects with a total installed capacity of 50 MW or more must be approved by the National Development and Reform Committee. Smaller projects will be approved by the provincial Development and Reform Commission. Procedures and conditions for approval shall be executed in accordance with the Interim Measures for Enterprise Investment Projects Approval (National Development and Reform Commissio n Decree No. 19).

Table 26 Recent National Wind Power Policy Changes in China

Policy name	Main contents
2008.12 Notice of Ministry of Finance and State Administration of Taxation on the Cessation of Tax Rebate Policy of Foreign Investment Enterprises to Purchase Domestic Equipment (Finance and Taxation No. [2008] 176)	Since January 1, 2009, the policy of full VAT refund for foreign invested enterprises to purchase domestic equipment within the total investment was stopped. Other relevant documents and articles were also repealed.
2009.07 Notice on Improving Pricing Policies of Grid-Connected Wind Power	Introduced benchmark pricing according to four types of wind resource The pricing level is more reasonable and profitable for investors
2009.08 Notice on the Adjustment of Import Tax Policies of Major Technologies and Equipment	The policy on equipment and raw materials that meet the requirements is changed from a refund after collection to a direct tax-free allocation
2009.09 Opinions on the Inhibition of Overcapacity and Duplication in Some Industries, and Guiding the Healthy Development of Industry	Encouraged independent innovation by enterprises and prevents low-level repetitive construction
2009.11 Notice on Abolishing the Localisation Rate Requirement for Equipment Procurement in Wind Power Projects by National Development and Reform Commission	Abolished the procurement requirement for a localisation (domestic manufacture) rate of 70%
2009.12 Decision on Amending the Renewable Energy Act of People's Republic of China by National People's Congress	Ensured the acquisition of renewable energy and established the renewable energy development fund
2010.02 Interim Measures for the Administration of Development and Construction of Offshore Wind Power	Made provisions for requirements on planning, project approval, sea areas for construction and environmental protection during the development of offshore wind power projects
2010.04 Notice on the List of the Interim Provisions on Adjustment of Import Tax Policies for Major Technical Equipment	In relation to key components and raw materials imported for wind turbines with a single-machine capacity not less than 1.5 MW, these are exempted from customs duties and import VAT Importing of wind turbines with a single rated power ≤3 MW shall not be exempt from taxes.

8.2. Main Problems or Deficiencies of China's Current Policy

8.2.1. Problems in the system of special funds for renewable energy

In accordance with domestic and international experience, in the process of formulating the Renewable Energy Law, a large amount of legal research shows that the establishment of a national renewable energy development fund would be the best choice. Taking into account the difficulty in the establishment of a national special fund, however, it has been proposed that special funds for renewable energy should be established at least at a central and local two-tiered level.

After the implementation of the Renewable Energy Law, the Ministry of Finance issued the Interim Measures on Special Funds for Renewable Energy Development in May 2006, which provided comprehensive provisions on the priorities for aiding, declaration and approval, financial management, evaluation and supervision of special funds. However, no specific amount of money was defined in this measure and there were no specific provisions on project application and the use of funds. It was therefore generally considered in the industry that there were too many uncertainties in implementing this approach. As a result its operation was weak. The Special Funds Management Approach has become an explanation for the special fund system under the Renewable Energy Law rather than a specific policy for implementation.

More recently the newly amended Renewable Energy Law has taken effect, under which the establishment of a Renewable Energy Fund is clearly proposed, but no supporting fund management approach has been issued yet.

8.2.2. Responsibility of power grid companies in renewable energy development

The Medium and Long-term Plan for Renewable Energy Development only provides renewable power generation portfolio for power supply enterprises. There are no quotas defined for power grid enterprises, which is one of the main reasons for the failure to implement the guaranteed acquisition system for renewable energy power proposed in the Renewable Energy Law. In order to promote the reform and development of grid, implementation of the renewable energy quota system should be improved as soon as possible. Through the implementation of a quota system, power grid enterprises would be required to purchase a certain quota of wind power and their responsibility would be clearly defined.

8.2.3. Development objectives lag behind development

Due to a fear that industrial development would not be able to keep pace, China's wind power development goals were much lower in the past than the rate of development. In 2007 the newly added installed capacity was 3.304 GW and the cumulative installed capacity was 5.906 GW, well ahead of the schedule to meet the target of 5,000 MW in 2010 set in the Medium and Long-term Plan for Renewable Energy Development. In 2008, newly installed capacity reached 6.245 GW and the total installed capacity exceeded 12 GW, this time achieved ahead of schedule for the target of 10 GW by 2010 in the Renewable Energy Development Plan in the Eleventh Five-Year Plan Period. Although the government has indicated on various occasions that the wind power development target should not be less than 80 GW by 2015 and 150 GW by 2020, this is still not a formal, legally binding document. The lagging of development objectives behind the pace of development has often become an excuse for the difficulties encountered in wind power grid connection.

8.2.4. Influence of changes in VAT

Changes in the national value-added tax system implemented on January 1, 2009, which have affected the investment enthusiasm of local governments, may also have a negative impact on wind power industry. These changes mean that VAT has been transformed from a production-based tax into a consumption-based tax. At the same time the cost of equipment purchased by a business is allowed to be deducted from its sales. At a national level, changing value-added tax from production to consumption and the implementation of a pre-tax deduction in terms of the machinery and equipment of secondary industries will reduce the tax burden on wind power development companies, but the income to local governments will be substantially reduced.

These changes have encouraged several types of local protectionism. Firstly, some local governments are requiring developers to purchase locally manufactured equipment in order to obtain the rights for project development; secondly, the wind power equipment manufacturers are being required to set up local factories, and only by doing so can their equipment be sold in the local market; thirdly, local governments are increasing or imposing new taxes under various names. Some local governments, for example, are increasing land prices and land use tax, some are levying special payments on developers for wind power construction and development rights. All of these will result in a major increase in wind power development costs and in the long run will have a negative impact on the rapid development of the wind power industry, industrial optimisation and industrial diversification.

8.3. Issues to Be Addressed for China to Support Wind Power in the Medium Term

China's wind power industry has experienced more than 20 years' development, a slow start turning into rapid development and then into explosive expansion. Now is a critical period for re-examination and coordinated development. Many issues need to be considered and handled properly, including the following:

8.3.1. The relationship between industrial development and basic research

China's wind power industry appears to be booming but there is no solid basis for research and development. The companies are all still very young and not as capable as industrial giants like GE or Siemens. There is also a lack of national long-term support and a solid social industrial foundation. Industrial companies are mainly going it alone. It is therefore essential for the country to provide greater support for basic research, development and the industrial base. To start with, China should establish a group of national laboratories like RISO in Denmark and NREL in the USA and support the establishment of a number of technically innovative companies like Fraunhofer and United Technologies which can provide vital services. Just as important is that greater input is needed into machine tools and other basic industrial development. The foundations can only be properly reinforced in this way rather than through establishing a number of flop-style national centres and laboratories that are unworthy of the name. At the same time, a group of enterprises with the technical strength of Siemens, GE, United Technologies and Applied Materials needs to be established in China.

8.3.2. The relationship between various stakeholders

As in other industries, the upstream and downstream of the wind power industry constitutes a continuous chain, with great interdependence and a united fate. During the rapid development period of the business it was understandable that rapid growth was achieved at the expense of certain interests. However, this is not a permanent solution. At present, if the relationship between manufacturers, parts producers, developers and local governments across the different regions, especially between the developed and less developed regions, is not well handled, then the overall development of wind power will be affected. As we know, without good quality components there can be no perfect and reliable turbine, without a reliable turbine, the benefits to developers cannot be guaranteed, and without the strong support of local government there can be no sustainable development of wind and solar power projects. Each process in the industry is tightly interrelated.

Even though this truth is evident, it is very difficult to put into practice. But now is the time to handle these relationships so as to guarantee the interests of parts manufacturers, complete machine manufacturers, developers and local government as well as compensation to wind power enterprises in order to achieve a win-win situation. In order to solve these problems, the government should consider increasing the grid-connection price by a modest amount so as to meet the interests of local governments and avoid the difficulties that have occurred in water and electricity development. In addition, the government should also take into account the relationship between SOEs and private enterprises, and the development and competition between foreign and local enterprises. In short, only when the relationships between the stakeholders are handled well can the wind power industry achieve a fast, healthy and harmonious development.

8.3.3. The relationship between legal provisions and practice

When making laws, government always wants to make them perfect and effective to meet every actual situation. For example, we all want to have a fund to subsidise wind power, but the cumbersome management of fund collection and dissemination and the complex market often cause such a policy to fail to be put into practice. Another example is that the full acquisition of renewable energy generating output is emphasised in law, but in practice obstacles emerged which make acquisition impossible and place the development of the industry in jeopardy.

There are some suggestions that the authors want to improve the Renewable Energy Fund. To start with, the fund can be divided into two parts. One part still utilizes the renewable surcharge, which is a surcharge added to each kWh of electricity produced in China to finance feed-in-tariff measures for renewables. This part of the fund keeps its function as before. Another part is the new function, which is used to mobilize the grid company to integrate more electricity from renewable energy. For grid connection, for example a maximum 5% of abandoniong could be allowed by the grid company. If the grid company drops more than 5% of the wind generated electricity, then they will compensate the wind farm. If the grid company purchases more than 95% of the wind farm's production, then they will be rewarded.

8.3.4. The issue of speedy and sound development

Wind power has increased dramatically in the past five years and become a mainstay of China's renewable energy market. In order to keep pace with the development in associated industries and for the sake of environmental stability and harmony, the growth rate should now decrease step by step, from 100% to 30-40%, 20-30%, or even less. On one hand, this will allow associated industries to catch up. On the other, it will be good to make a step-by-step change from rapid scale development to high quality and independent innovation. Problems in the wind power industry should be addressed by means of speeding up improvements in the market rules and environment and establishing a transparent market competition system. If the wind power industry in China can transform itself from "quantity" development to "quality" development in 3-5 years, there will be excellent wind power manufacturers with the ability to compete, and the uneven development of the industry will be improved. It would be a great achievement for the renewable energy industry if wind power could adapt to these competition rules and establish three to five world-class companies in China.

8.3.5. The problem of large-scale development

China has paid a lot of attention to large-scale development, such as the concession tendering projects with several GW of capacity, but the development of small-scale projects should not be ignored. Small-scale development also needs policy support. In Germany, for example, there are often just a few wind turbines, even one, in a particular wind farm. Such a deployment would be popular in the south and eastern coast of China, for example. As has happened with decentralised biomass power generation, such as biogas and straw gasification, power generation does not have to be at a megawatt scale. Many small contributions make a large one, and establishing a small scale wind farm at the end of the grid has the advantage that power losses are reduced. 10 GW-scale bases and desert power plants need to be developed, but small wind power, photovoltaic and biomass power generation should also not be ignored.

8.4. Proposals for reforming Wind Power Development Policy

Although there are many problems with China's wind power development, on the whole, the policy of encouraging wind power has been successful. Efforts should therefore mainly be put into amending and improving the current policies. In light of the above analysis, these are several suggestions for reform of the direction of wind power development policy. These suggestions should be referred to when China works out wind power policy during the Twelfth Five-Year Plan period for new energy sources. Policies that can be introduced in China soon include the following:

1) Present a clear development target which local governments, power companies, grid companies and manufacturing industry can all work towards. The installed wind power capacities for 2015 and 2020 (including offshore) should not be less than 110 GW and 200 GW; 130 GW and 230 GW would be better.

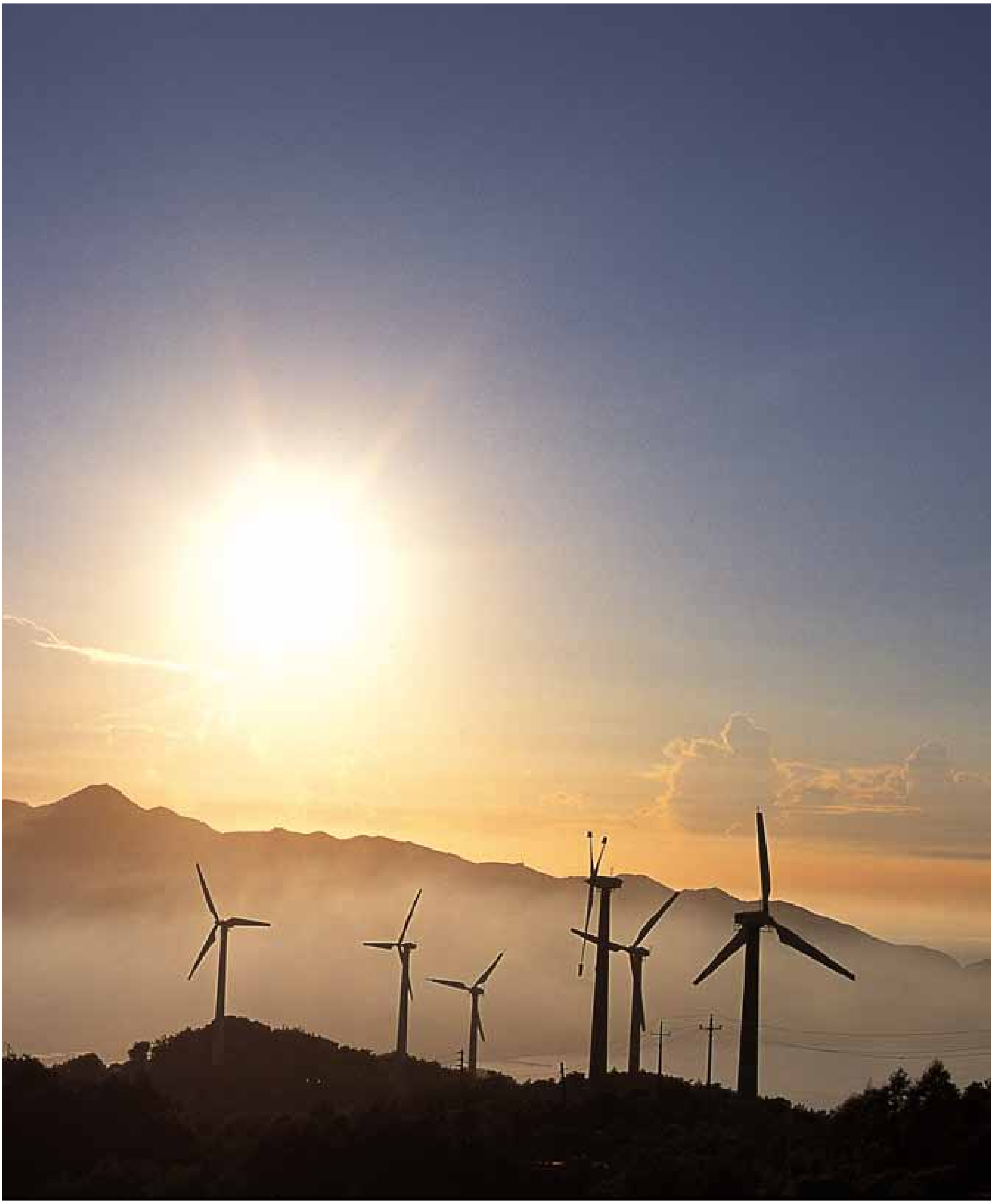
2) Develop economic incentive policies to coordinate the interests of all parties and protect local economic benefits, such as an increase of RMB 0.03-0.05 yuan in the price of electricity through the economic development fund. Western regions should enjoy more favourable policies. Various policies for China's western development should be put into effect.

3) Work out an effective economic policy to encourage integration into the power grid, including introducing wind power grid connection standards and specific implementation rules to guarantee acquisition, such as proposing appropriate wind abandoning quotas and improving the economic efficiency of wind power (see fuller discussion in Chapter 5).

4) Work out a renewable energy fund management approach as soon as possible and increase the transparency of acquisition and use.

5) Improve the various incentives and punishment measures to meet the requirements of the portfolio of installed capacity of electricity generated by non-hydropower renewable energy in large-scale electricity-generation companies according to the Medium and Long-term Development Planning of Renewable Energy, namely to reach 3% by 2010 and 8% by 2020.

9. Outlook for Wind Power in the World and China



9.1. World Development Outlook

The Global Wind Energy Council, Greenpeace and the German Aerospace Center (DLR) have updated their analysis of future global wind energy development every two years since 2005. Their latest survey, Global Wind Energy Outlook 2010, is published together with this report. It includes three different levels of future scenario - a reference scenario, moderate scenario and advanced scenario.

9.1.1. Scenario assumptions and model description

The reference scenario is based on data from the International Energy Agency (IEA) and is generally the most conservative of the three. In the latest version of the GWEC/Greenpeace analysis, the reference scenario for wind power development is based on the IEA's 2009 World Energy Outlook. This makes a forecast for wind power and other renewable energies up to 2030, and has then been extended, using the same assumptions as the IEA scenario, up to 2050. This scenario only takes existing policy measures to support renewable energy into consideration.

The moderate scenario is the one closest to the actual level of development. It not only takes current government development goals into account but also the current level of industrial activity. It is also assumed that investors are full of confidence in the current wind power market.

The third scenario is the advanced one. This makes the bold assumption that development-friendly wind power policies will be introduced and the policymakers of the world's leading wind power markets show strong political will to implement these policies.

After defining these three scenarios they are combined with two global energy demand scenarios in order to project the proportion of wind power in the energy structure in different scenarios. Energy demand is divided into two projections, one the reference projection, the other a high energy efficiency projection. The reference projection is based on the IEA's World Energy Outlook, which looks forward to 2030. Maintaining all the assumptions, this has then been extended to 2050 to obtain a parallel reference projection to the wind power series. The high energy efficiency projection is based on a substantial reduction in energy demand after taking some serious energy conservation measures.

9.1.2. Background to scenario analysis and outlook

Global Wind Energy Outlook is updated every two years, with the latest version published in 2010. The predecessors to this series were Wind Force 10 published in 1999 and Wind Force 12 published in 2005. These two reports were designed to assess the technical, economic and resource feasibility if wind power reached a proportion of 10% and 12% of global power generation. The two reports also assessed the feasibility of achieving this goal in the next 20 years.

The 1999 Wind Force 10 report, which used future electricity demand projections from the IEA had the aim of firstly assessing whether the global wind resources and power grid connection capacity could provide 10% of global power and secondly, assessing the feasibility in terms of technology and costs of reaching that 10% target within the next 20 years.

The 2005 Wind Force 12 report once again aimed to prove that wind power was able to provide 12% of global electricity by 2020, assessing the resources, economics and technological aspects of this goal.

From 2006 onwards, the Global Wind Energy Outlook reports made significant improvements on their predecessors. The supply of 12% global wind power was taken as the advanced scenario in this series, while the reference and moderate scenarios were both increased. Furthermore, the future electricity demand and supply projections are both improved in Outlook, with the IEA's energy demand forecast as the conservative base. Meanwhile, the issue of energy efficiency improvements is considered in the energy demand projections. The reports have also included an analysis of the social and environmental effects of wind power, such as employment, investment, CO_2 emissions reduction and other factors.

9.1.3. Wind power can meet 12% of global electricity demand by 2020

The Global Wind Energy Outlook scenarios (see Table 27) show that:

1) In the reference scenario for wind power development, the wind power market will provide 5% of global electricity by 2020 and 6% of global electricity by 2030.

2) If the wind power development is sound, it will provide 10% of global electricity by 2020, 17% by 2030 and 27% by 2050.

3) If the wind power development is advanced, it will provide 13% of global electricity by 2020, 23% by 2030 and 33% by 2050.

These results show that in the next 30 years, wind power will play an increasingly important role in the energy structure and will be an important element in meeting future electricity demand.

Table 28 lists the share of wind power in the global electric power system under different options.

9.2. Future Scenarios for China's Wind Power Development

9.2.1. Global Wind Energy Outlook forecast

Global Wind Energy Outlook 2010 also includes analysis and projections for the future of China's wind power development (see Table 30).

1) Reference scenario

In the reference scenario, the assumption is very conservative. It assumes that China's annual growth rate will be 9% from 2015-2020 and will drop to 3% in 2030. In this scenario, China's total installed capacity of wind power will only increase to 45 GW by 2015 and the

Table 27 Summary of the Global Wind Energy Outlook Scenarios

Summary of Global Wind Energy Outlook Scenarios for 2020						
Global wind energy scenarios	Cumulative installed capacity (GW)	Power generation (TWh)	Wind power's share of power supply (high energy efficiency demand forecast)	Annual installed capacity (GW)	Total annual investment (Million euro)	Employment (Millions)
Reference scenario	417	1,022	5%	28	32	0.55
Moderate scenario	870	2,133	10%	100	120	1.58
Advanced scenario	1,109	2,721	13%	137	159	2.15

Summary of Global Wind Energy Outlook Scenarios for 2030						
Reference scenario	574	1,408	6%	44	50	0.79
Moderate scenario	1,794	4,399	17%	138	155	2.26
Advanced scenario	2,432	5,641	23%	185	202	3.03

Summary of Global Wind Energy Outlook Scenarios for 2050						
Reference scenario	881	2,315	7%	57	56	0.91
Moderate scenario	3,263	8,576	27%	176	185	3.03
Advanced scenario	4,044	10,451	33%	185	187	3.39

Table 28 Share of Wind Power in the Global Electric Power System, Installed Capacity and Electricity Generation

Share of wind power in global electric power system (%)			
	2020	2030	2050
Reference scenario			
Share of wind power in global electricity (reference projection)	4.5	4.9	5.9
Share of wind power in global electricity (high energy efficiency projection)	4.8	5.7	7.3
Moderate scenario			
Share of wind power in global electricity (reference projection)	9	14.7	21.4
Share of wind power in global electricity (high energy efficiency projection)	9.6	17.1	26.5
Advanced scenario			
Share of wind power in global electricity (reference projection)	12	19	26.7
Share of wind power in global electricity (high energy efficiency projection)	12.7	22.8	33

Global cumulative installed capacity (GW) and electricity (TWh)					
		2015	2020	2030	2050
Reference scenario	GW	297	417	574	881
	TWh	729	1,022	1,408	2,315
Moderate scenario	GW	451	840	1,735	3,203
	TWh	1,106	4,258	6,530	8,417
Advanced scenario	GW	521	1,113	2,451	4,062
	TWh	1,277	2,730	5,684	10,497

annual installed capacity will be only 2.5 GW. By 2020, the installed capacity of wind power will be 70 GW and the annual installed capacity will be only 5 GW. It will reach only 95 GW by 2030 and the annual installed capacity then will only be 2.5 GW. Such a scenario is clearly much too conservative given the development tendency in China during the past few years, and is only taken in the report as a reference.

2) Moderate scenario

In the moderate scenario, the annual growth rate in China is assumed to be 16% from 2015-2020, and will then drop to 8% in 2030. In this scenario, China's wind power capacity will reach 122 GW by 2015, the annual installed capacity will reach 18 GW and the wind power generation output will reach 299 TWh. By 2020, the installed capacity of wind power will be 220 GW and the annual installed capacity will reach 20 GW. The total will reach 434 GW by 2030 and the annual installed capacity will be 15 GW.

In this scenario, the projected wind generation output could reach 540 TWh by 2020 and 1,065 TWh by 2030. This means that wind power could account for 8.7% of total electricity supply in China by 2020 (using the high energy efficiency projection) and would reach 14.2% in 2030.

3) Advanced scenario

In the advanced scenario, the annual growth rate in China is assumed to be 18% from 2015-2020 and will then drop to 8% in 2030. In this scenario, China's wind power capacity will reach 129 GW by 2015, the annual installed capacity will reach 15 GW and the wind power generation output will reach 317 TWh. By 2020, the installed capacity of wind power will be 253 GW and the annual installed capacity 25 GW. The total will reach 509 GW by 2030 and the annual installed capacity 22 GW.

In this scenario, the projected wind generation output will reach 622 TWh by 2020 and 1,251 TWh by 2030. This means that wind power will by then account for 10% of total electricity supply in China by 2020 (using the high energy efficiency projection) and will reach 16.7% in 2030.

In the different scenarios, wind power also has a major impact on employment, the reduction of greenhouse gas emission and investment.

The attractiveness of the wind power market to investors depends on many factors, including the installed cost, capital availability, price and expected rate of return. The equipment costs in this scenario analysis are based on a single year and assume that the cost of installed capacity per thousand watts is declining. The following conclusions are reached on this basis: in the reference scenario, investment in Chinese wind power will reach 6.75 million Euros in 2020 and 3.38 million Euros in 2030; in the moderate scenario, investment in Chinese wind power will reach 27.53 million Euros in 2020 and 20.75 million Euros in 2030; in the advanced scenario, investment in Chinese wind power will reach 33.75 million Euros in 2020 and 29.55 million Euros in 2030. This investment forecast is made on the basis of a global average wind turbine cost, however, and wind turbine costs in China have always been lower than the rest of the world. It is nonetheless likely that with the development of the Chinese economy, not least the constant appreciation of RMB, wind turbine costs in China will eventually increase to the world average level. This forecast should therefore only serve as a reference.

Wind power can also create a considerable amount of employment. In the reference scenario, wind power will generate 88,000 jobs by 2020, in the moderate scenario this figure will increase to 330,000, and in the advanced scenario it will reach 400,000. In the reference scenario, wind power will generate 61,000 jobs by 2030, in the moderate scenario this figure will reach 330,000 and in the advanced scenario it will reach 430,000.

In terms of the reduction of greenhouse gas emissions, wind power also plays a huge role and is increasingly becoming a major force for reductions in the power industry. In the reference scenario, wind power will generate 103 million tons of emission reductions by 2020; in the moderate scenario, this figure will reach 324 billion tons; and in the advanced scenario it will reach 373 billion tons. By 2030 in the reference scenario, wind power will result in emission reductions of 140 million tons, in the moderate scenario, this figure will reach 639 billion tons, and in the advanced scenario it will reach 750 billion tons.

9.2.2 . Chinese Expert Analysis of Future Wind Power Development

China achieved a doubling of its wind power capacity for the fourth consecutive year in 2009. Newly installed capacity was about 13.8 GW, with a total capacity at the end of the year of 25.8 GW. China's wind power industry has achieved a committed level of production and now has an annual growth rate of 10-20 GW of installed capacity. According to a comprehensive wind energy resource assessment, at an acceptable cost of 0.5 yuan/kWh, China's wind energy resources can provide at least 400 GW of installed capacity.[9] Looking at the future scale of China's wind energy development, experts from the Chinese Academy of Engineering and the National Development and Reform Commission have also put forward low, medium and high projections.

Of these, the regular development programme is the most conservative projection, and is regarded as a low forecast, the active programme involves strong policy promotion and is seen taken as a high forecast, while the medium programme is a compromise between the two which takes the possibility of development and actual needs into consideration.

The greatest difference between the high, medium and low options lies in their judgment of the development situation during the period from 2020 to 2030:

1) The low development programme, in which the pressure to lower greenhouse gas emissions was not taken into

Table 29 GWEC (Global Wind Energy Outlook) Analysis of China’s Future Wind Power Potential

Year	Scenario analysis of China ’ s wind power development during 2015-2050											
	Reference scenario				Moderate scenario				Advanced scenario			
	Cumulative installed capacity (MW)	Annual installed capacity (MW)	Cumulative annual growth rate of market	Annual growth rate of new market	Cumulative installed capacity (MW)	Annual installed capacity (MW)	Cumulative annual growth rate of market	Annual growth rate of new market	Cumulative installed capacity (MW)	Annual installed capacity (MW)	Cumulative annual growth rate of market	Annual growth rate of new market
2009	26	14	114.68%	131.21%	26	14	114.68%	131.21%	26	14	114.68%	131.21%
2010	33	7	27.13%	-49.29%	40	14	53.49%	0.00%	41	15	59%	10%
2015	45	3	8.41%	-22.69%	122	18	32.50%	7.56%	129	19	33.25%	6.29%
2020	70	5	11.61%	18.92%	220	20	15.88%	2.51%	254	25	18.32%	6.50%
2030	95	3	3.44%	-7.41%	434	15	7.84%	-3.09%	510	22	8.07%	-1.47%

Note: The growth rates in 2015 and 2020 are compound annual growth rates over five years while the growth rates in 2030, 2040, and 2050 are compound annual growth rates over ten years.

Source: GWEC, Global Wind Energy Outlook 2010

Table 30 Contribution of Chinese Wind Power Development to Investment, Employment and Reduction of Greenhouse Gas Emissions

	Reference Scenario			Moderate scenario			Advanced scenario		
	Investment (10,000 Euros)	Employment	Reduction in Emissions (million tons CO_2/ year)	Investment (10,000 Euros)	Employment	Reduction in Emissions (million tons CO_2/ year)	Investment (10,000 Euros)	Employment	Reduction in Emissions (million tons CO_2/ year)
2009	1,863	201,844	34	1,863	201,844	34	1,863	201,844	34
2010	945	108,935	43	1,863	206,445	52	2,055	226,822	54
2015	338	50,102	67	2,494	299,296	180	2,623	315,155	190
2020	675	88,435	103	2,753	338,501	324	3,375	409,520	373
2030	338	61,768	140	2,075	329,232	639	2,955	432,581	750

Source: GWEC, Global Wind Energy Outlook 2010

9 China Hydropower Engineering Consulting Company (CHECC), Statistical Report on 2009 China Wind Power Construction Results. March, 2010

account, conforms to conventional development. In terms of policy on renewable energy, although China can learn from the experience of developed countries, and make less detours, the overall investment is relatively small, which is unlikely to help the development of the wind energy industry. At the same time, this projection assumes the progress of power grid construction has lagged behind wind power construction, thus affecting the overall development of the market, making the development of wind power after 2020 relatively slow, and rapid development only beginning after 2030. This is the most conservative projection.

2) The high programme, in which it is assumed that China will undergo strong national environmental pressure to increase its R&D efforts, includes a major investment in wind power technology R&D and market promotion, and allows the maximum possible power consumption from wind energy through power grid and flexible power system construction. At the same time it promotes the development of existing wind power policies, makes prices reasonable, puts wind energy resource assessment in place and builds a complete wind power industry system with independent intellectual property rights. Distributed wind power development and utilisation are fully developed. Under these conditions, the proportion of wind power generation in the power structure will grow rapidly. This is a strong policy-driven development programme.

3) The medium development program falls between the two others. This is a balanced and sound development programme involving comprehensive consideration of the resource potential, environmental constraints and social factors.

The results of the three different options are shown in Table 31. By 2020 Chinese wind power capacity will reach 100 GW, 150 GW and 200 GW in the low, medium and high projections respectively, with a corresponding power output of 220 billion, 330 billion and 440 billion kWh. According to current calculations on coal consumption, these figures can substitute for fossil energy of 75.24, 112.86 and 150.48 million tons of coal equivalent respectively. However, the proportion of wind power in total energy consumption would only reach 1.6%, 2.5% and 3.3%. If wind power is looking to account for 5% of total energy consumption, then the installed capacity would need to reach over 300 GW. Put simply, the development of wind power still has a long way to go.

The external conditions in the three different wind development scenarios are as follows:

1. Low programme

Assumptions: industrial development maintains its existing level of turbine supply capacity, 6-8 GW new capacity. The progress of power grid construction lags behind the pace of wind power development and equipment capacity growth. This affects the overall market size.

※ The installed capacity of wind power will reach 100 GW by 2020 and the annual electricity supply will be 210 TWh;

※ The installed capacity of wind power will reach 200 GW by 2030 and the annual electricity supply will be 440 TWh;

2. Medium programme

Assumptions:

1. The pace of development is balanced at each stage, with the turbine manufacturing industry and wind power market development maintaining a reasonable growth rate.

※ The average annual growth of installed capacity during 2010-2020 will be 12 GW;

※ The average annual growth of installed capacity during 2020-2030 will be 15 GW;

2. Power grid planning and construction will take the actual needs of wind power development into account, carrying out national grid strengthening construction on schedule and adopting appropriate scheduling and peaking measures so that two-thirds of the wind power capacity and electricity in the three northern regions can be transported to load centres. Land and offshore wind energy resources near the load centres in the eastern and central part of the country will be more fully exploited by 2030.

Goals:

※ The installed capacity of wind power will reach 150 GW by 2020 and the annual electricity supply will be 300 TWh;

※ The installed capacity of wind power will reach 300 GW by 2030 and the annual electricity supply will be 640 TWh;

3. High programme

Assumptions:

1. With improvements in its economic efficiency, wind power development is accelerating, and both the turbine manufacturing industry and wind power market development maintaining a high growth rate.

※ The average annual growth of installed capacity during 2010-2015 will be 13 GW;

※ The average annual growth of installed capacity during 2015-2020 will be 21 GW;

※ The average annual growth of installed capacity during 2025-2030 will be 22 GW;

2. Power grid planning and construction take the actual needs of wind power development into account, carry out a national strengthening of the grid on schedule and adopt appropriate scheduling and peaking measures so that half of the wind power capacity's electricity from the three northern regions can be transported to load centres.

3. Land and offshore wind energy resources near the load centres in the eastern and central part of the country are more fully exploited by 2030.

4. Compared with the medium programme, the installed capacity of land and offshore wind power in the eastern and central areas is almost the same, due to restrictions on wind energy resources, available land etc. But in the latter part of the 2020-2030 period, deep sea wind power technology is applied, and power technology, power system technology and new wind power applications all make a qualitative breakthrough. At the same time, the technology for the off-grid connection of wind power, non-energy-intensive enterprises and economic energy storage is applied, and electric vehicles are used to balance the peaks and troughs in the power grid supply. All these developments will make the installed capacity of wind power in the northern areas, especially in Inner Mongolia, Gansu, Xinjiang, increase substantially.

Goals:

※ The installed capacity of wind power will reach 200 GW by 2020 and the annual electricity supply will be 440 TWh;

※ The installed capacity of wind power will reach 400 GW by 2030 and the annual electricity supply will be 850 TWh;

9.3. Forecasts of this Report on Wind Power Development in China

In the process of compiling this report the authors have also made three forecasts about the future for wind power development in China after analysis, comparison and discussion. The results are shown in Table 32.

The details of these scenarios are as follows:

(1) Conservative scenario: in this scenario, many factors restricting the development of wind power in China are taken into account. Grid problems are not effectively addressed, the quality of wind turbines will not be guaranteed until after

Table 31 Forecasts for China's Future Wind Power Development by the Chinese Academy of Engineering

Year	Development goal 1			Development goal 2			Development goal 3		
	Installed capacity	Average Newly increased	Average Growth rate	Installed capacity	Average Newly increased	Average Growth rate	Installed capacity	Average Newly increased	Average Growth rate
	GW	GW	%	GW	GW	%	GW	GW	%
2008	12.2	6.2							
2009	22	9.8	105%	22	0.98		22	9.8	
2010	30	8	36.40%	30	0.8	36.40%	30	8	8.10%
2015	60	6	14.87%	90	1.2	24.57%	95	13	25.93%
2020	100	8	10.76%	150	1.2	10.76%	200	21	16.05%
2030	200	10	7.18%	300	1.5	7.18%	400	20	7.18%

2020 and there is not much pressure for the reduction of greenhouse gas emissions. By 2020, wind power installed capacity will account for about 7% of the total installed capacity. Newly installed capacity will be 12 GW annually on average up to 2020, with total capacity reaching 80 GW by 2015. After 2020, the annual newly installed capacity will be 10 GW, and it will reach a total of 250 GW, 350 GW and 450 GW respectively by 2030, 2040 and 2050.

(2) Optimistic scenario: in this scenario, most of the problems in the development of wind power in China will be addressed. In the first place, bottlenecks in the grid will be eliminated, the proportion of electricity generated by natural gas will increase remarkably and the amount of wind power absorbed into the grid will be improved noticeably. The quality of wind turbines will also be improved remarkably, the cost of equipment regulated, and wind power resources effectively developed by 2050. The average annual installed capacity will reach 18 GW by 2020 and wind power will account for 12% of the total installed capacity. Cumulative installed capacity in 2020 will reach 200 GW. From then on, the average annual newly installed capacity will be 10 GW. Cumulative installed capacity in 2030, 2040 and 2050 will be 300 GW, 400 GW and 500 GW respectively.

(3) Positive scenario: in this scenario there will be much pressure for the reduction of greenhouse gas emissions. Government will introduce policies to actively support wind power. By 2050 those resources developable in terms of technology will have been basically exploited, and even some second-rate wind power resources developed. By 2020, the cumulative installed capacity will reach 230 GW. From then on, the annual newly installed capacity will be 15 GW. Cumulative installed capacity in 2030, 2040 and 2050 will reach 380 GW, 530 GW and 680 GW.

9.4. Contribution of Wind Power to Chinese Energy and Environmental Problems

In future, the development of wind power will also play a major role in solving China's energy and environmental problems.

9.4.1. Energy effect

Taking into account likely technological advances in future coal-fired power generation, and applying a calculation method for energy replacement by wind power, the authors have calculated the energy effect in different years. By 2020, the energy replacement effects in the conservative, optimistic and positive scenarios are 97, 130.7, 148.8 million tons of coal equivalent respectively. Given the energy consumption in 2020 is 4.5 billion tons of coal equivalent, the contribution rates in the three scenarios are 2.2%, 2.9% and 3.3% respectively.

Table 32 Expert Forecasts for Wind Power Development of this Report

Year	Conservative Scenario			Optimistic Scenario			Positive Scenario		
	Installed Capacity GW	Annual newly installed capacity GW	Annual average growth rate	Installed Capacity GW	Annual newly installed capacity GW	Annual average growth rate	Installed Capacity GW	Annual newly installed capacity GW	Annual average growth rate
2008	12.2	6.2		12.2			12.2		
2009	25.8	13.6	111.52%	25.8	13.6		25.8	13.6	
2010	35	9.2	35.63%	37	11.2	43.38%	40	14.2	55.01%
2015	80	9	17.98%	112	15	24.80%	130	18	26.58%
2020	150	14	13.40%	202	18	12.52%	230	20	12.09%
2030	250	10	5.24%	302	10	4.10%	380	15	5.15%
2040	350	10	3.42%	402	10	2.90%	530	15	3.38%
2050	450	10	2.54%	502	10	2.25%	680	15	2.52%

9.4.2. Environmental effect

Assuming that all the wind power installed is used to replace coal to generate electricity, the environmental effects in different years have been calculated according to the environmental effect parameters shown in Table 34. By 2020, the reduction amounts of greenhouse gas emissions in the three scenarios are 260, 370, and 410 million tons of CO_2 equivalents respectively. Meanwhile, a considerable amount of suspended particulates, sulphur dioxide and nitrogen oxides will also be reduced. By 2050, the reduction amounts of greenhouse gas emission in the three scenarios are 840, 940, and 1,270 million tons of CO_2 equivalents respectively.

Table 33 Estimates of the Energy Effect of Wind Power

Year		2010	2015	2020	2030	2040	2050
Conservative Scenario	Installed Capacity (GW)	35	80	150	250	350	450
	Generating Capacity (TWh)	60.7	150.4	303.2	537.5	770.0	990.0
	Replaced Energy (Mtce)	20.8	49.6	97.0	161.3	231.0	297.0
Optimistic Scenario	Installed Capacity (GW)	37	112	202	302	402	502
	Generating Capacity (TWh)	64.1	210.6	408.3	649.3	884.4	1104.4
	Replaced Energy (Mtce)	22.0	69.5	130.7	194.8	265.3	331.3
Positive Scenario	Installed Capacity (GW)	40.0	130.0	230.0	380.0	530.0	680.0
	Generating Capacity (TWh)	69.3	244.4	464.9	817.0	1166.0	1496.0
	Replaced Energy (Mtce)	23.8	80.7	148.8	245.1	349.8	448.8

Table 34 Relevant Parameters for Calculating the Environmental Effect of Wind Power

Environmental Reduction Parameter[10]	2010	2015	2020	2030	2040	2050
TSP (g/kWh)	0.355	0.355	0.355	0.355	0.355	0.355
SO_2 (g/kWh)	0.698	0.698	0.698	0.698	0.698	0.698
NOx (g/kWh)	0.65	0.65	0.65	0.65	0.65	0.65
CO_2 (kg/kWh)	0.983	0.938	0.89	0.85	0.85	0.85

Table 35 Estimates of the Environmental Effect of Wind Power

Year		2010	2015	2020	2030	2040	2050
Conservative Scenario	TSP (10 thousand tons)	2.2	5.3	10.8	19.1	27.3	35.1
	SO_2 (10 thousand tons)	4.2	10.5	21.2	37.5	53.7	69.1
	Nox (10 thousand tons)	3.9	9.8	19.7	34.9	50.1	64.4
	CO_2 (100 million tons)	0.6	1.4	2.7	4.6	6.5	8.4
Optimistic Scenario	TSP (10 thousand tons)	2.3	7.5	14.5	23.1	31.4	39.2
	SO_2 (10 thousand tons)	4.5	14.7	28.5	45.3	61.7	77.1
	Nox (10 thousand tons)	4.2	13.7	26.5	42.2	57.5	71.8
	CO_2 (100 million tons)	0.6	2.0	3.6	5.5	7.5	9.4
Positive Scenario	TSP (10 thousand tons)	2.5	8.7	16.5	29.0	41.4	53.1
	SO_2 (10 thousand tons)	4.8	17.1	32.4	57.0	81.4	104.4
	Nox (10 thousand tons)	4.5	15.9	30.2	53.1	75.8	97.2
	CO_2 (100 million tons)	0.7	2.3	4.1	6.9	9.9	12.7

10 The environmental reduction parameter is calculated on the basis of the reduction in emissions caused by wind power replacing coal generation. Since the technology of coal generation is improving, the relevant environmental reduction parameter is declining. In the table, TSP stands for total suspended particulates, SO2 stands for sulphur dioxide and NOx stands for nitrogen oxides. These are all pollutants caused by burning coal and the amount of such pollutants needs to be controlled for the sake of environmental protection

10. Postscript

Awareness of wind power has undergone continuous development. During the 1990s, when we still had controversy about whether 1 GW of wind power installed capacity could be achieved, the European Wind Energy Association proposed some ambitious targets, for example that the proportion of wind power in total electricity generation would reach 10%. In recent years, the European Wind Energy Association and GWEC have repeatedly raised the level of expected contribution from wind power. The latest estimate is that the proportion of global wind power generating output will reach 13% by 2020 and be as high as 23% by 2030.

The forecasts from Chinese experts do not seem to be as positive as GWEC, but still involve a qualitative leap. It should be remembered, however, that we were nervous when proposing the global development target of 20-30 GW by 2020 in 2003. In 2005, when we proposed that wind power installed capacity would reach 120 GW, accounting for 2% of total generation by 2020, in the Wind Force-12 report, we were even frightened for fear of condemnation. As a result, we joked that it was only a fairy tale. In less than five years, no one in China or foreign countries seems concerned about whether wind power can achieve 120 GW by 2020. Chinese experts have also made a bold prediction: that wind power can reach 200 GW by 2020. Although this still lags behind GWEC's advanced scenario, it was hardly different from their moderate scenario. And the prediction for 2030 is almost the same as in the GWEC scenario.

The reason why the outcome up to 2030 forecast in this report are far higher than those projected by domestic experts and GWEC is that China's rapidly developing economy is placing an increasingly higher demand on energy supply. The need to reduce greenhouse gas emissions therefore results in an increasingly tougher energy replacement task. Demand for electricity installed capacity in China is no longer 1,000 GW but 1,500-1,600 GW and the power generation output required is at least 6,000 – 6,400 TWh.

If the proportion of wind power installed capacity increases to 12% by 2020, this means that we will see 180-190 GW installed. The highest forecast of the Chinese experts just meets this minimum requirement. If wind power electricity production reaches a proportion of 12% of China's total electricity production, it means that wind power generating capacity is required to reach an output of 720-768 TWh, and then wind power installed capacity will reach 330-350 GW.

The reality is that no matter whether conservative, optimistic, positive, moderate or advanced scenarios are used, or the forecasts by the Chinese experts or GWEC, the generating capability of wind power in China by 2020 cannot reach a level where it accounts for 12% of the total electricity production. We are hopeful that the installed capability of wind power in China will reach 12% or 15% of the total capacity, and then the generating capability will reach 10%, 12% and 15% in 2030, 2040 and 2050 respectively.

Although the extraordinary development of wind power in 2009 dumbfounded many people, whether they liked it or not, the cumulative installed capacity at the end of the year was only equivalent to 10% of the 2020 target. The development of wind power has only just started and the real performance has yet to begin. To conclude, let us borrow the famous words of Sun Yat-sen: "The revolution has not yet been finished, so comrades still need to work."

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