

With the world's largest population and one of its fastest growing economies, China, and the development paths that it chooses, will have a dramatic effect on the rest of the world. **Jean Ku, Debra Lew, Shi Pengfei and William Wallace** discuss the future of wind in China.

**C**hina is the most populous country in the world, with about 1.3 billion people. It also has one of the largest economies in the world, and is growing quickly, with GDP increasing 9.5% in 2004 and showing no signs of slowing during the first quarter of 2005.<sup>1</sup> The amount of energy needed to fuel this growth is also rapidly increasing, with a total installed electric generation capacity of 440 GW at the end of 2004, and expectations that this will rise to 500-510 GW by the end of 2005.<sup>2</sup> Because about 74% of China's installed electric generating capacity is derived from coal, this expanding energy demand will place a great strain both on the local and global environment.

This article will provide an overview of the current wind situation in China, followed by a description of how the main barriers to wind development which existed as recently as 5 years ago have been removed or minimized. It will then discuss the current drivers for wind development in China, including an innovative wind concessions programme and a new national Renewable Energy Law that was passed swiftly by the National People's Congress in February 2005. Finally, it will point out the best opportunities for wind development and highlight key current and future markets.

## THE WIND SITUATION IN CHINA

### Wind resources

China has world-class wind resources. An early assessment of data at a 10-metre hub height from weather stations by the Chinese Academy of Meteorological Sciences estimated the technical on-shore wind potential in China at 250 GW (nominally 10% of the total wind resource estimate for China). More recently the off-shore wind potential has been estimated at 750 GW. At modern hub heights of 50-100 metres, the wind potential would be much higher. But even with these

1.2 MW Goldwind turbines at a wind farm in Dabancheng SHI PENGFEI



# The future is now

Accelerating wind development in China





conservative estimates, the wind potential is nearly double China's total energy generation capacity.

### INSTALLED CAPACITY

The installed capacity of wind power in China is rapidly increasing, as shown in Figure 1. The cumulative installed capacity in 2004 reached 764 MW, which was an increase of 35% above the capacity of 567 MW in 2003. In 2004, 197 MW of new capacity was added compared to 98.3 MW of capacity added in 2003, a growth rate of 101%. The 2004 capacity is distributed in 44 wind farms in 14 provinces.

The bar at the far right of Figure 1 indicates 20 GW of installed capacity by 2020, which is a long-term strategic planning target established by the Energy Bureau within the National Development and Reform Commission (NDRC) in Beijing. Although this target may seem ambitious, current provincial planning for wind development indicates that this target may in fact be an underestimate of the development potential for wind in this time frame. The Energy Bureau of the NDRC is investigating more than 30 new sites for potential development to achieve a near term target of 4 GW total installation capacity of wind in China by 2010. Spain (1890 MW) and Germany (2036 MW) each installed about 2 GW of wind capacity in 2004.<sup>3</sup> If China reaches a similar level of large-scale market development, the potential to reach the 2020 target in China is feasible.



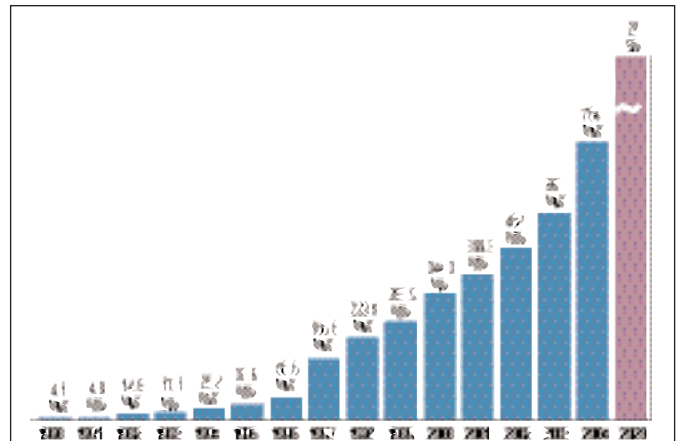
A new wind farm at Qingdao, one of many being built in China NORDEX

### Wind farms in China

Wind farms are currently found in fourteen, or about half, of China's provinces. 74% of the cumulative installed capacity in 2004 was in the six provinces and autonomous regions of

**The wind potential available is nearly double  
China's total energy generation capacity**

Inner Mongolia, Liaoning, Xinjiang, Guangdong, Ningxia, and Gansu. The largest operating wind farm, Dabancheng No. 2, is 83 MW and is located in the far western Xinjiang autonomous region. The size of installed wind turbines ranges from 55 kW Vestas turbines installed in 1986 to 1.5 MW GE turbines installed in 2004 in Inner Mongolia and Shanghai. Currently, newly installed wind turbines range in size from 600 kW to 1.5 MW. As of the end of 2004, in terms of cumulative installed capacity, 18% of wind turbines are from domestic companies, while about 82%



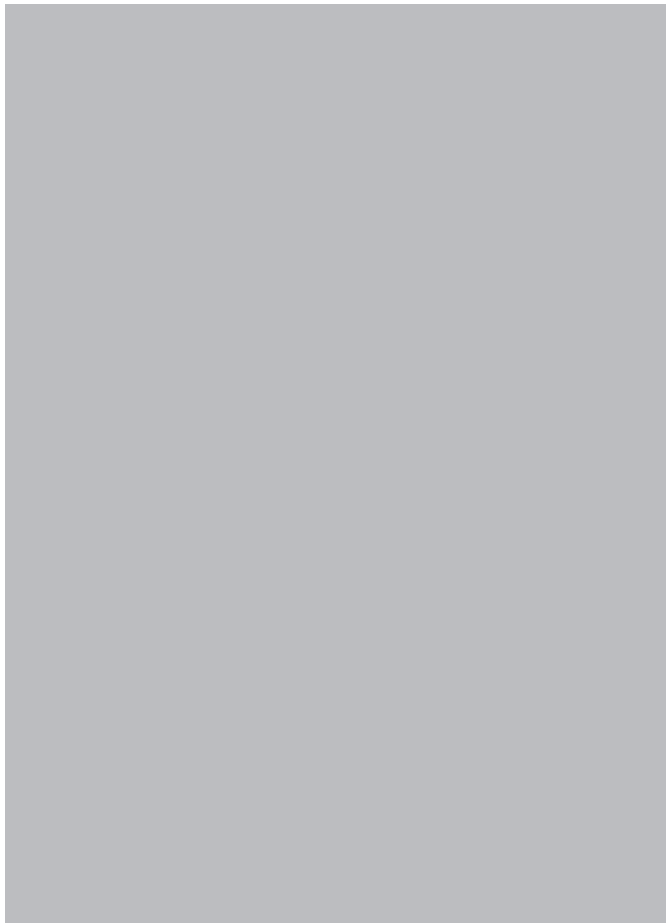
**FIGURE 1.** Installed capacity of wind in China, 1990–2020  
Source: Shi Pengfei, China Hydropower Planning General Institute



1.3 MW turbines installed at Qingdao NORDEX

of the wind turbines came from foreign companies.<sup>4</sup>

In the recent past, most wind farms in China were developed based on bilateral concessionary loans or grants, or they were small additions to existing wind farms. There was little commercial development. Most wind farms were built by subsidiaries of local utility companies, and there were virtually no long-term power purchase agreements. Power purchase prices were generally reviewed and adjusted annually by provincial price bureaus.



## RECENT PROGRESS

The environment for wind development in China has undergone a dramatic change since the mid 1990's. For years, developers and companies recognized China's vast wind resources, but were constrained by various policy, administrative, and power sector issues. As Table 1 illustrates, there is a considerable difference today compared to just 5 years ago.

### Electricity supply and demand

In 2000, a surplus in electricity generation meant there was little interest in wind development. Starting in 2003, China faced severe electricity shortages. More than two-thirds of its provinces suffered blackouts last year due to a shortage of

generators, problematic coal and transport links, and water shortages.

### Government reform

The power sector, including transmission, distribution, generation, and oversight, originally operated under the umbrella of the centralized State Power Corporation. In the spring of 2003, the State Power Corporation was divided into 2 power grid companies, 5 power generation companies, and 4 related companies, in an effort to restructure the utility sector.

In the past, two agencies (the State Economic and Trade Commission and the State Development Planning Commission) competed for renewable energy projects, and did not have clearly defined roles. There was also an overlap in administrative functions. Now, there is a single Energy Bureau with a renewable energy director under the National Development and Reform Commission, which succeeded the State Development Planning Commission in 2003 during government restructuring.

### Policy

Five years ago, the government did little to encourage wind development because they felt wind costs were too high. The policy was to treat wind farms like conventional generation, where the purchase price was re-negotiated each year based on the change in fuel and generation costs. The fluctuating power purchase price and weak policies discouraged wind development.

**TABLE 1: Comparisons between 2000 and 2005**

2000	2005
Surplus in electricity generation capacity	Electricity shortages, difficulties with coal and hydro
1 state power corporation	2 power grid companies, 5 power generation companies
Overlap in administrative functions of 2 government agencies	1 energy bureau, with renewable energy director
High wind tariffs, fluctuating power purchase price, weak policies	Concessions, VAT of 17% cut in half, renewable energy law, targets
Lack of funding for resource assessment	Multi-lateral and national programmes



The Chinese government will need to build many more wind turbines to reach its target of 4000 MW by 2010 NORDEX

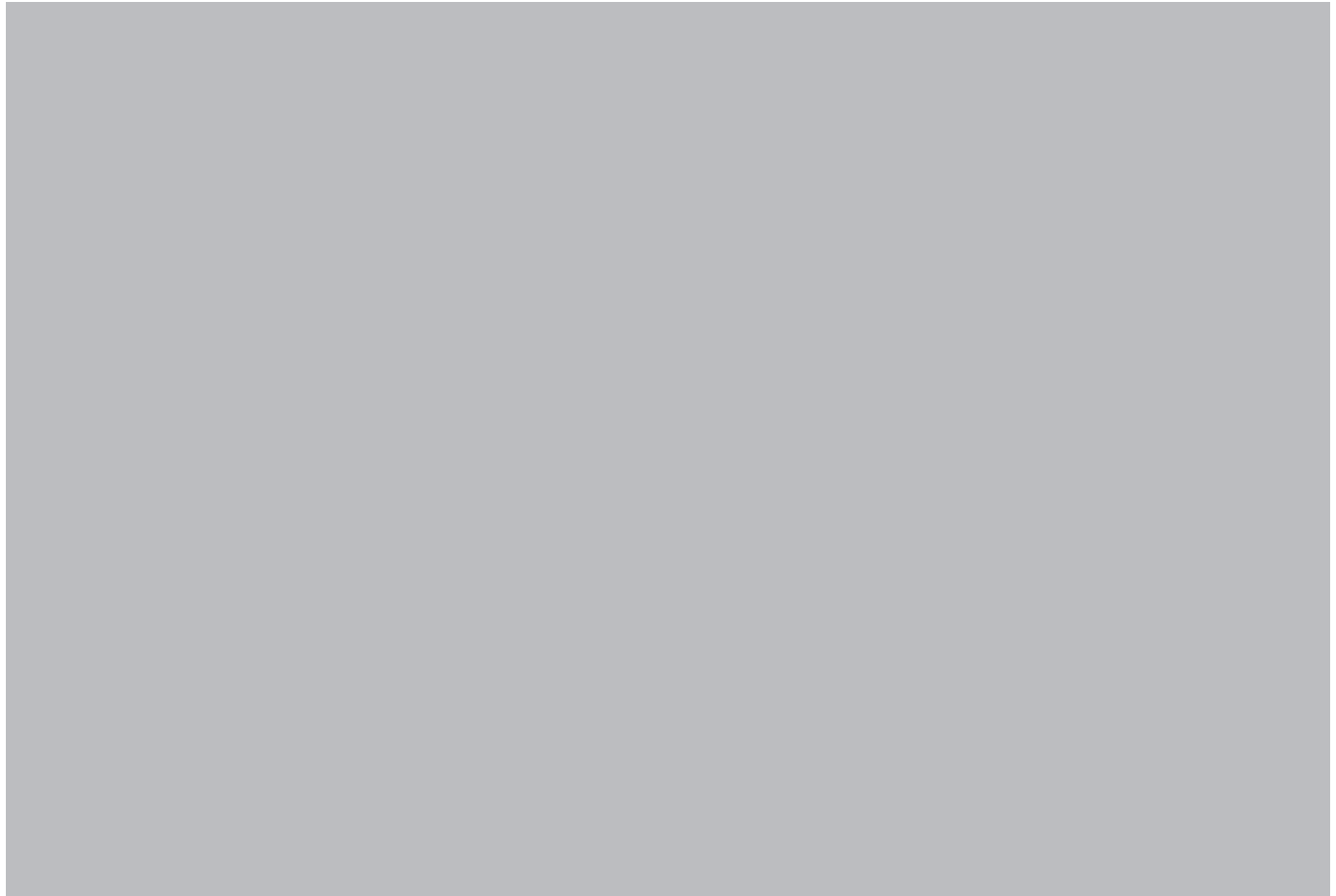
### Wind resource information

In 2000, there was a dearth of wind resource information in China, and little incentive to pursue wind mapping or site assessment. Currently, with the more promising wind market situation in China, several national and multi-lateral efforts are underway to provide wind mapping and on-site wind measurements. For instance, the National Renewable Energy Laboratory (NREL) is working with an in-country partner, the Chinese Centre for Renewable Energy Development, to provide technical analysis for a United Nations Environment Programme-sponsored wind mapping project called the Solar Wind Energy Resource Assessment (SWERA) project. The project will map 1 million km<sup>2</sup> in northern and eastern China. The

Tremendous changes have occurred since then. Starting in 2003, the Chinese government issued blocks of 100 MW wind concessions through a public tendering process. The concessions guaranteed the developer a 25 year power purchase agreement with a fixed price for the first 10–15 years. In addition, the value-added tax (VAT) for wind was cut from 17% to 8.5%. In February of 2005, the first ever national Renewable Energy Law was passed, with provisions specifically geared towards supporting large-scale wind development (and other renewables) in China.

US Environmental Protection Agency and Department of Energy, now sponsoring the Wind Technology Partnership Programme, supported early wind resource assessment work that provided momentum for future projects.

In addition, the United Nations Development Programme and the Global Environment Facility are sponsoring a wind measurement and site-specific characterization programme at ten high priority sites located in eight provinces distributed throughout China.<sup>5</sup> The NDRC has since expanded the site specific measurement scheme to more than thirty sites nationwide. The task of generating detailed off-shore wind



resource assessment data is also a near term priority of the NDRC. The NDRC is also giving attention to potential for development of 1000 MW scale projects in several provinces by bundling several smaller projects or assessing large-scale development potential at specific sites.

## MAIN DRIVERS FOR WIND DEVELOPMENT

Two key drivers for the increasingly attractive wind market in China are the wind concession programme and the new national Renewable Energy Law.

### Wind concessions

Wind concessions were modeled after the resource concessions that governments typically award to developers to extract oil, gas, and other resources. China borrowed this concept as a way to reduce their wind power costs which are higher than equivalent resource areas internationally and higher than local coal power costs. In China's wind concessions programme, the provincial government selects and opens a site to a public bidding procedure, and the developer who offers the lowest feed-in tariff wins the contract for a long-term power purchase agreement. Prices are driven downward through:

- Long-term power purchase agreement – a 25 year contract with a 10–15 year fixed price lowers the cost through reduced risk and better financing terms
- Competitive bidding – public tendering drives a more favourable price for wind

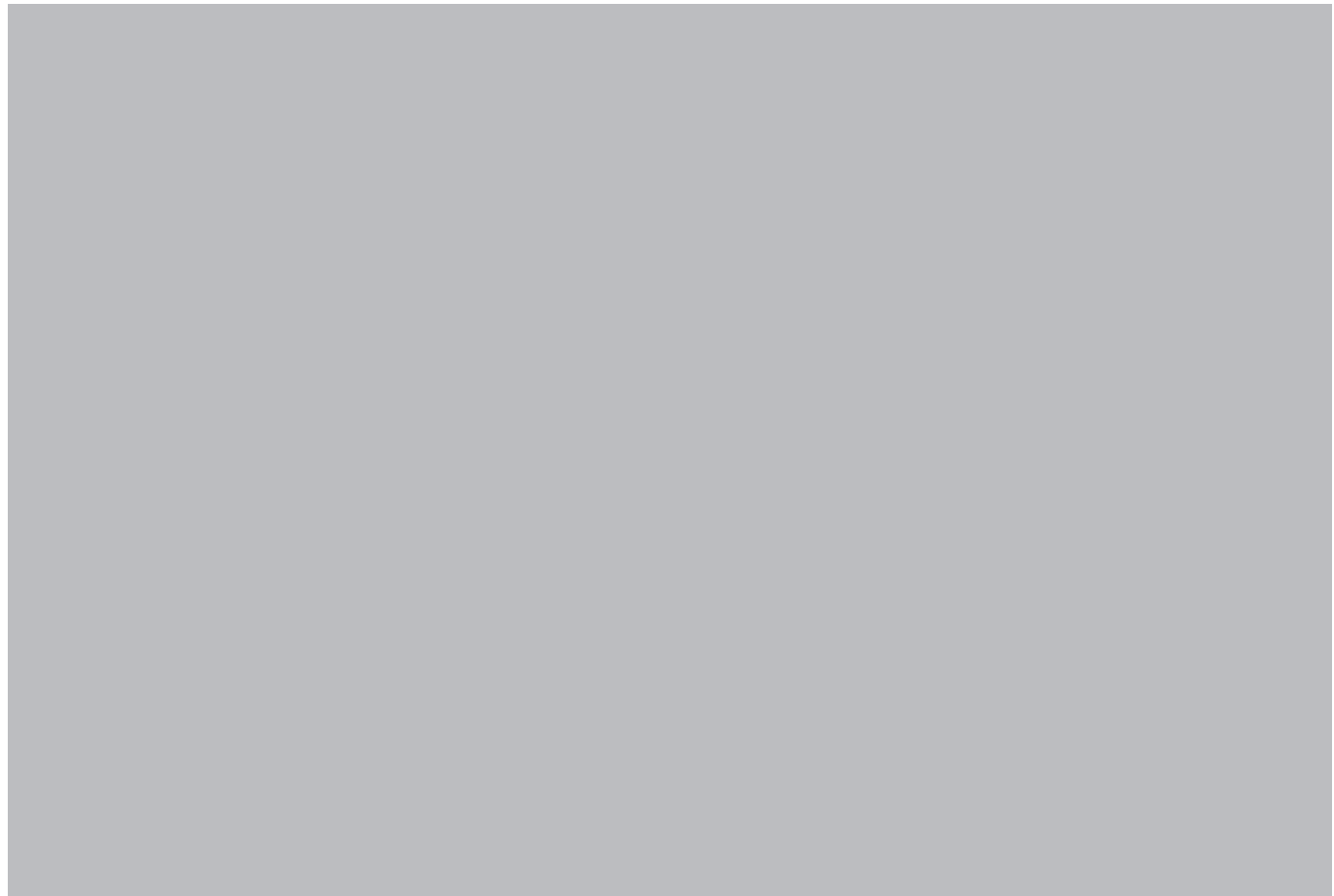
- Large scale of the new wind farms –100 MW to 200 MW – leading to economies of scale in construction and manufacturing.

In 2002, the Chinese government announced the wind concession model, and developed bidding documents. Interested developers purchased the bidding documents and were allowed to measure the wind resource on two sites. Chinese developers, as well as developers from Germany and Spain submitted proposals. They were required to make a RMB 1 million yuan deposit (US\$120,000) to discourage spurious speculation. In September 2003, the winning bidders were chosen, based on the lowest bid price.

By the end of 2004, six concession projects had been competitively bid and are now in various stages of negotiation and construction. The installed capacity of the six projects will total 850 MW. Currently, more than twenty-five sites are being investigated.

**Currently, more than twenty-five sites are being developed**

Provincial governments are motivated to establish wind concessions to derive the local tax revenue benefits, local economic and jobs development, as well as address electricity shortages. Table 2 lists the six existing concession projects. Two





**TABLE 2: Wind concession projects in China**

Site	Province	Project developer	Year	Size (MW)	Bid price		Status
					(yuan/kWh)	(US cents /kWh) <sup>a</sup>	
Rudong #1	Jiangsu	Hua Rui Group	2003	100	0.4365	5.3	Production at end of 2006
Huilai Shi Bei Shan	Guangdong	Guangdong Yuedian Company	2003	100	0.5013	6.1	Production at end of 2006
Tongyu A <sup>b</sup>	Jilin	1) China Longyuan Electric Power Group, 2) Xiongya Weierjin Ltd., Co., and 3) Jilin Jineng Electric Power Ltd., Co.	2004	200 <sup>b</sup>	0.509	6.1	Contracted, negotiations with manufacturers
Tongyu B <sup>c</sup>	Jilin	1) Huaneng New Energy Environment and Protection Holding Company and 2) China Huaneng Hong Kong Ltd., Co.	2004	200 <sup>b</sup>	0.509	6.1	Contracted, negotiations with manufacturers
Huitengxile	Inner Mongolia	Beijing International Electric Power New Energy Ltd., Co.	2004	100	0.382	4.6	Contracted, negotiations with manufacturers
Rudong #2	Jiangsu	1) China Longyuan Electric Power Group and 2) Xiongya Weierjin Ltd., Co.	2004	150 <sup>c</sup>	0.519	6.2	Contracted, negotiations with manufacturers

a Exchange rate used is 1 USD = 8.28 RMB

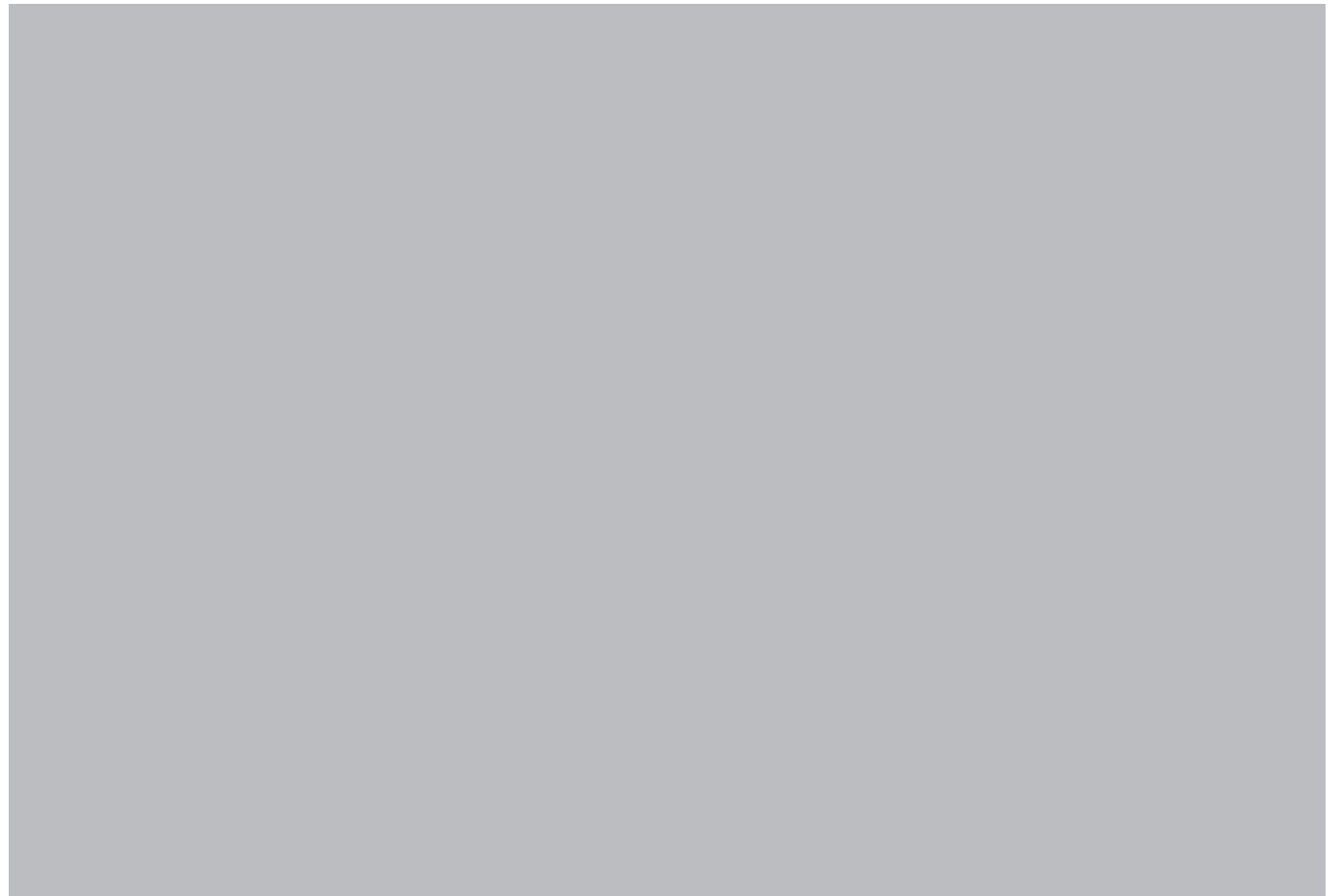
b The Tongyu site has 2 projects, each led by a different project developer. Each developer will install 100 MW immediately (total of 200 MW for two projects) and will then install an additional 100 MW each after three years (to allow time to develop an advanced large turbine, >1 MW in design).

c Size of the project was increased from 100 to 150 MW after award.

projects, Jiangsu–Rudong #1 and Guangdong, were contracted in 2003. Construction has started, and production is expected to begin at the end of 2006. The four projects selected in 2004 have been contracted, and developers are in negotiation with manufacturers.

The prices range from 4.6 to 6.2 US cents per kWh. Coal generation is nominally 3.6 US cents per kWh for new

generation. The wind concessions programme has had ramifications in other areas of wind policy. The government was interested in using feed-in tariffs to encourage wind but could not come to an agreement on how to set a reasonable tariff. The Guangdong bid price of 6.1 US cents per kWh helped set the provincial feed-in tariff at 6.4 US cents per kWh. The Jiangsu site selected in 2003 has a very moderate wind



resource, with a capacity factor that may be as low as 20%, so it's not clear if the bid price will be profitable. Other sites, however, e.g. in Inner Mongolia, have good class 4 resources.

The major components of the wind power concession projects are:

- Each project should be 100–200 MW, and wind turbine size cannot be smaller than 600 kW.
- 70% of the components should be domestically made and the wind turbines should be assembled in China. The two concession projects in 2003 required 50% domestic content in turbines, but the 2004 concession projects required 70% domestic content.
- The county government is responsible for the access road to the wind farm.
- The power grid company is responsible for the transmission line to the substation of the wind farm.
- The period of the wind concession is 25 years.
- All electricity generated by the wind project must be purchased by the provincial power grid company, according to the terms of the power purchase agreement.
- The incremental cost of wind power will be shared within the provincial power grid. Each concession is done on a provincial level, so the cost of wind over conventional generation is borne by the province.
- For the first 30,000 full load hours (for a 100 MW project, this is 3 billion kWh), the project owner will receive their bid price as the feed-in tariff. Depending on the site's wind resource, this could be about 10–15 years. After 30,000 full load hours, the project owner

will receive the average local feed-in-tariff on the power market at that time.

#### **Renewable energy law**

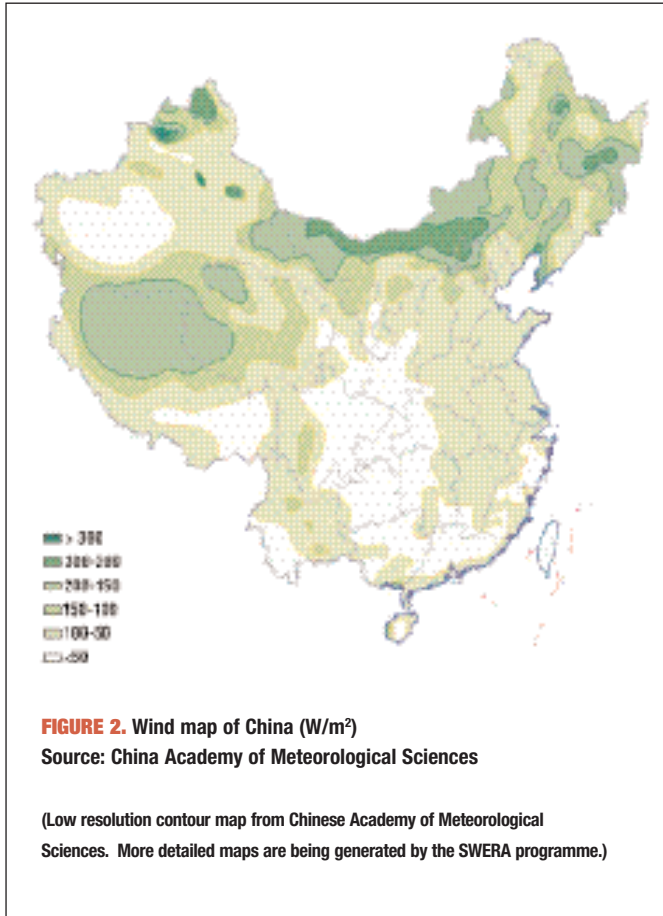
The first ever comprehensive national law on renewable energy was passed in February 2005, and goes into effect on January 1, 2006. This has sparked the interest of domestic and international companies interested in wind development. The law has explicit articles that support wind development.

The law stipulates that the power grid enterprises must buy the electricity from renewable energy generators. Power prices for grid-connected projects will be determined by

**To win concessions, 70% of components must be domestically made and turbines must be assembled in China**

tender or feed-in tariffs and the incremental cost of renewable energy will be shared by consumers on the entire national grid. Provisions for balancing the incremental costs between provinces based on the amount of renewable energy generation within each province will be developed. During the remainder of 2005, the NDRC and other appropriate agencies will be responsible for preparing detailed implementation regulations for the law, which will





determine establishment of feed-in tariffs and how the incremental costs of renewable energy will be shared among all electricity consumers. (For more information see the article by Zhu Li page 58 - this edition).

### KEY CURRENT AND FUTURE MARKETS

The northern areas and coastal areas and islands are generally considered the best markets for wind development in China. The 'three Norths' - Northwest, North, Northeast - have excellent wind resources. On the other hand, the coastal areas and islands in the east and southeast have good wind resources, high electricity demand, and generally the highest electricity prices. Coal resources are concentrated in the northern areas, leading to higher electricity prices in areas like Shanghai, due to transportation costs. The residential price of electricity in the coal rich northern areas are on the order of 3.6 US cents per kWh, while the price in coastal Guangdong province last year was 13 US cents per kWh.

In the short term, these are the most promising areas for wind. However, land costs are increasing as development, shrimp farms, and other needs compete for this land. Offshore wind potential is enormous and will be important in the future. Offshore wind sites are close to the main electricity load centres in eastern China, and provide great potential for future energy supply. And, as in other countries where wind is developing rapidly, grid interconnection and integration issues will be increasingly important.

## ACCELERATED DEVELOPMENT SCENARIO

During the past 15 years, China has pursued a persistent course of developing institutional capacity and gradually building an infrastructure that is now positioned to support accelerated national wind development on an increasingly commercial basis. The infrastructure established in China includes, for example: 1) a national expert base that is knowledgeable regarding international best practices for wind development and that is constantly improving its capabilities, 2) an established domestic turbine manufacturing base that is constantly improving its production capabilities and anxious to upgrade and build advanced turbine technology, 3) 15 years of experience with wind farm development, installations, and operation that is improving with time, 4) a long history of international cooperation on multiple levels from scientific exchanges and joint research to technology transfer and business joint ventures, 5) a core domestic and international project developer base, 6) increasing access to domestic and international sources of investment and financing, 7) basic standards and certification system that is being expanded, and 8) a government regulatory and policy infrastructure that is proactive in its support of wind development.

While there are deficiencies in this infrastructure, these will correct with time and with the incentives derived from accelerated development. For example, improvements in national wind resource assessment capabilities, more experience with commercial development and financing of wind farm projects, and fine-tuning of national legislation are still needed. Nevertheless, the near and long term targets established by the Chinese government for wind development (e.g., installed capacities of 4 GW by 2010 and 20 GW by 2020) are within reach and are being supported by strategic decisions and actions that are being taken now to lay the foundation to achieve these targets. The implication is that wind development in China will accelerate in the near future and provide opportunities for domestic and international developers and investors.

Please Note: The information in this article was first presented at Windpower 2005 in Denver, USA.

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