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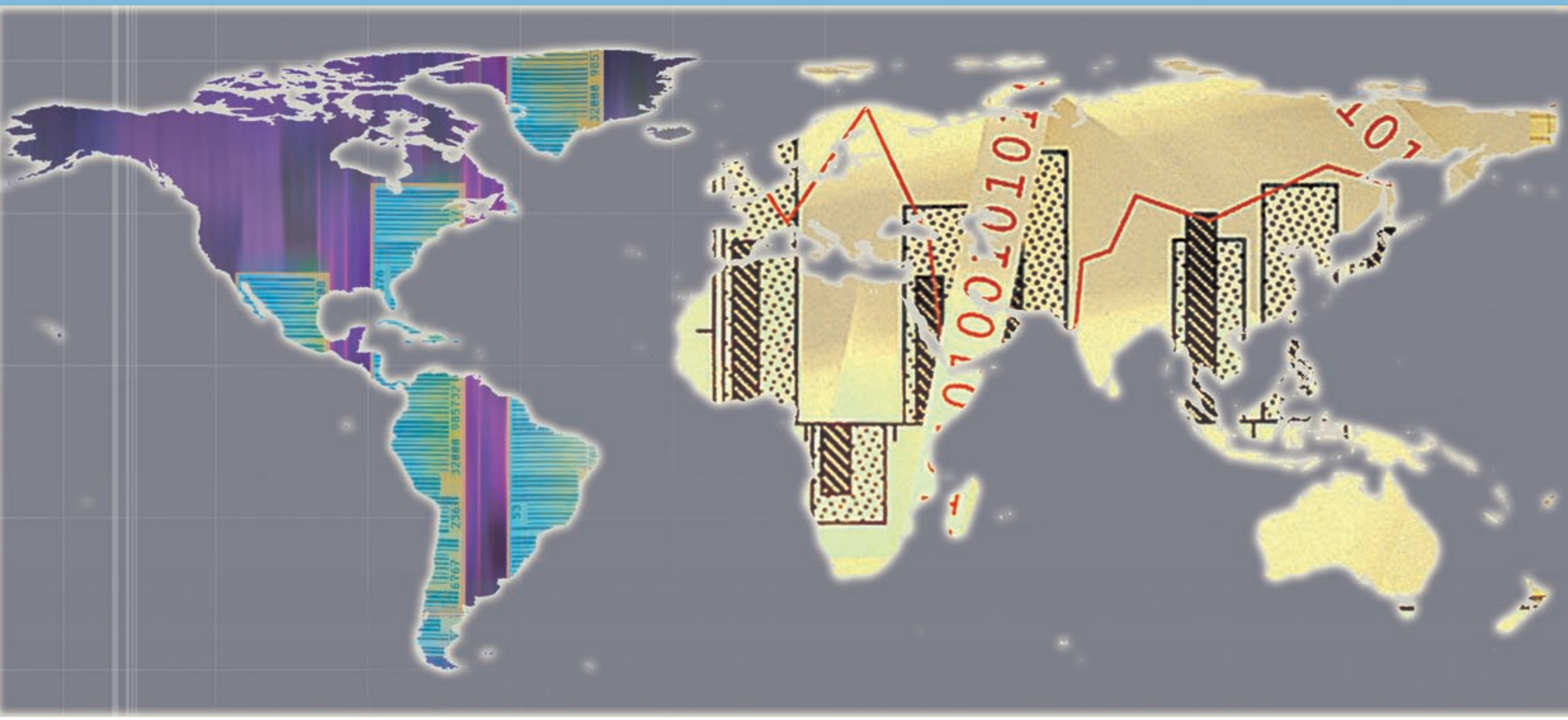

# Can green sunrise industries lead the drive into recovery?

## The case of the wind power industry in China and India

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# Can green sunrise industries lead the drive into recovery? The case of the wind power industry in China and India

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
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## 1. **Introduction**

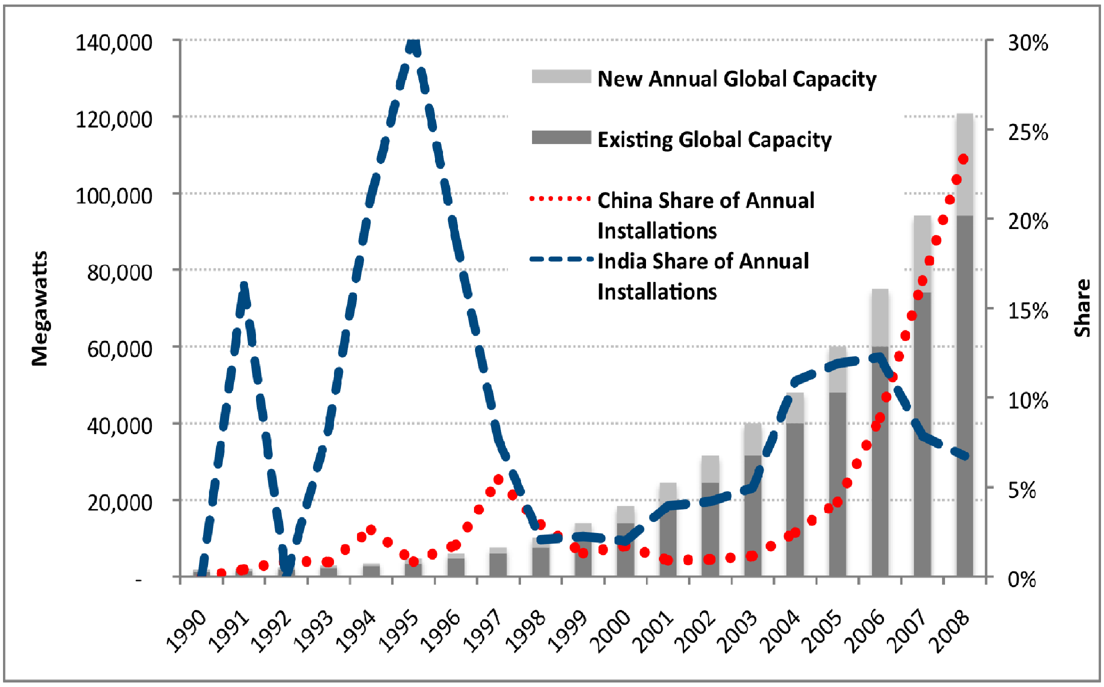
The global financial crisis of 2008 has affected the lending capacity of leading financial institutions around the world, which has in turn affected consumer confidence and demand. Widely believed to have originated in the advanced countries, the crisis is now being widely felt in developing countries as well. The impact on specific industries is only just becoming evident, different industries will likely face differing impacts on their performance and prospects depending on their structural characteristics and dynamics. Some have theorized that the "green" sunrise industries that manufacture sustainable products and competing on the basis of continuous innovation and technical change, and growing rapidly on the basis of new entry and output expansion, will more easily weather the economic turmoil than their "brown" counterparts (Ban Ki-moon, 2008; Atienza Jr., 2009).

This paper examines how the global financial crisis has affected the wind power industries of the two major emerging economy wind power leaders, China and India. It begins by examining the respective structure of the wind industry in each country, and government policy support that has shaped the evolutions of the industry over time. It then turns to a survey of how the economic downturn has affected wind power development globally, and what this has meant for wind turbine manufacturing firms in China and India. Looking ahead, the paper ends with an assessment of the outlook for the wind industry in each of the two countries, as well as providing recommendations for policy makers.

China and India play an increasingly important role as the emerging giants of the world economy and international energy markets. Energy developments in China and India are transforming the global energy system due to their sheer size, and the staggering pace of Chinese and Indian economic growth in the past few years has outstripping that of all other major countries. China and India together are projected to account for 45 per cent of the increase in demand in energy consumption globally between now and 2030 (IAEA, 2007; OECD, 2007). China and India also play an increasingly important role in global wind power development. Wind energy is the fastest growing energy source in the world, and an increasing share of this growth is occurring in emerging economies. As illustrated in Figure 1, China's share of annual wind power installations globally has been steadily increasing since 2003. India's share has fallen recently, but has comprised a much larger share of annual global installations over the past 2 decades.

Global climate change presents one of the greatest environmental challenges the world has ever faced. Globally, the additional investment needed in 2030 to return greenhouse gas emissions to current levels is an estimated $200 billion per year. Developing countries as a whole will invest $160 billion a year in the power sector between now and 2030, and "greening" that investment will require an additional $30 billion a year (UNFCCC, 2007). China and India are capturing increasing shares of investment flows for new capacity, manufacturing, and R&D in renewable energy.

**Figure 1. Global Wind Development and the Role of China and India**




In conducting a review of the impact of the financial crisis on China and India, this study may also illuminate broader industrial development strategies for the developing world. While many advanced, sustainable technologies were initially developed in the industrialized world, they are increasingly being manufactured in the emerging economies. As these countries become not just manufacturing bases but technology innovators in their own right, it will be increasingly important for these industries to look for new ways to compete in the global marketplace, and for policy makers to strategically foster the growth of these industries for domestic and international expansion. As the world increasingly addresses the causes of global climate change, green technologies will play an increasingly important role in global energy infrastructure in the transformation to a low carbon economy.

## 2. China's Wind Industry

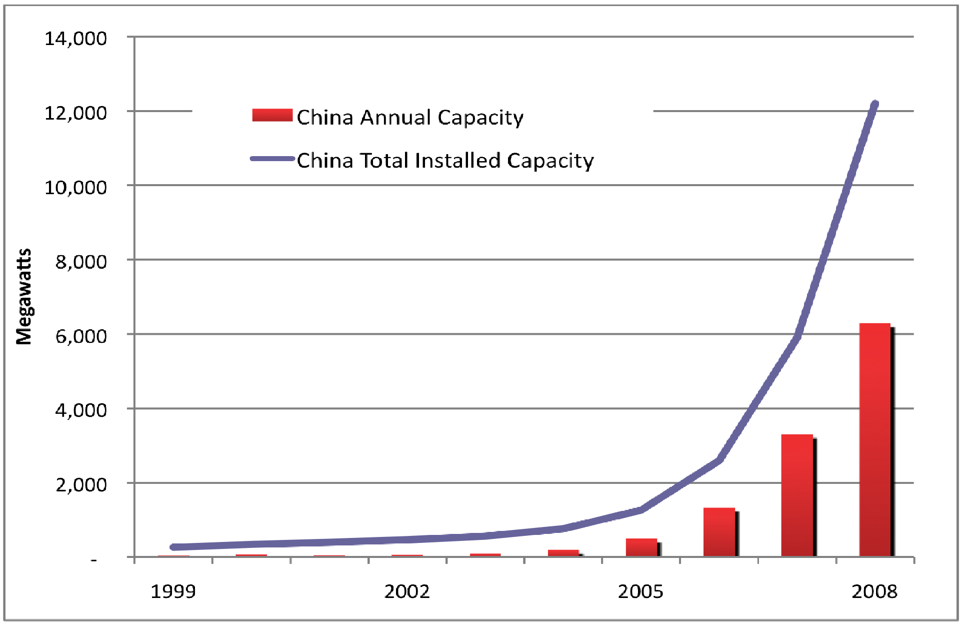
### 2.1. Origins and Status

China is now the second largest wind power market in the world after the United States, having surpassed the annual capacity additions of European leaders like Germany and Spain (and prior developing country leader India) in 2008 with 6 GW of new installations. China now has a total cumulative installed capacity of 12.2 GW, making it the fourth largest wind power base in the world after the U.S., Germany and Spain[1]. Chinese wind power generation capacity, it is estimated, could reach 20 gigawatts by the end of 2009 (Interfax-China, 2009).

Wind power technology has been particularly successful in China due to excellent wind resources and rapid technological improvements in China's domestic wind industry. The environmental and health benefits of wind are significant: if China develops even one-half of its total exploitable wind power resources estimated at 250 gigawatts (GW), it could generate around 275 billion kilowatt-hours of power each year, (22 per cent of China's total electricity generation in 2000). This would displace the need for 135 million tons of coal and the accompanying two million tons of sulfur dioxide and 70 million tons of carbon emissions (Lew and Logan, 2001). A recent study suggests that the electricity that could be generated economically from wind in China could result in savings of $CO_2$ emissions by as much as 0.62 gigatons of $CO_2$ per year, equal to 9.4 per cent of total current annual Chinese emissions of 6.6 gigatons of $CO_2$ per year (McElroy, Lu, Nielsen, Wang, 2009). Since China uses about 1400 million tons of coal per year, and emits about 20 million tons of sulfur dioxide and 900 million tons of carbon annually, wind power, even developed to its maximum potential, will only begin to make a dent in reducing China's total emissions. It nonetheless could be a very important part of a future energy development scenario incorporating clean technologies and energy efficiency measures across sectors.

[1] Due to the fact that some of China's wind farms installed in 2008 were reportedly not connected to the grid by the end of the year, one study claims that China's wind power generation capacity in 2008 should actually have been calculated as 8.94 instead of 12.15 gigawatts. Source: China State Electricity Research Council, *China Wind Report 2009* (Global Wind Energy Council, 2008).

**Figure 2. Wind Power Development in China, 1990-2008**

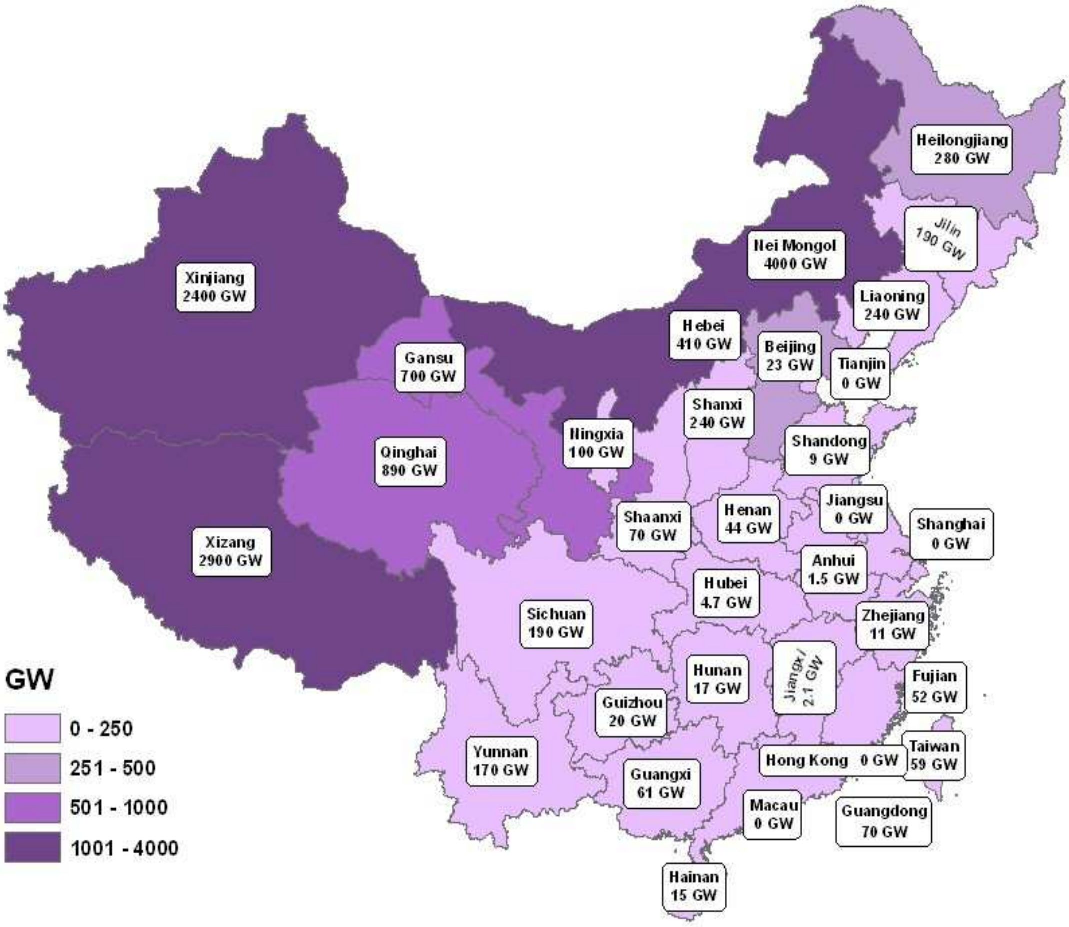



China has an estimated one million MW of total exploitable wind resources, including about 250,000 MW on land and 750,000 MW offshore[2]. Installed electric power generation capacity in China totaled about 792.5 GW at the end of 2008, with wind power capacity (12 GW) representing just about 2 per cent of total installed power capacity. Electricity generated by wind turbines is estimated to have contributed to less than one per cent of China's total electricity production in 2008.

China's best wind resources are concentrated in the northern and western parts of the country where there is less electricity demand. This increasingly requires transmission to be built to bring the power to provinces that need it. However the northern and western provinces, such as Gansu, are less developed, and poor electric grids cannot manage the fluctuations in electricity production inherent in wind power (Wang, 2009). As a result, some problems with power delivery due to grid challenges have been reported.

[2] While these are the wind resource statistics most commonly cited in China (see e.g. Wan Zhihong, "Wind energy, the future", *China Daily*, November 29, 2007), recent studies show that the maximum onshore wind resource potential could generate 24.7 PWh of electricity annually, more than seven times China's current national electricity consumption (McElroy et al., 2009).

**Figure 3. China Wind Resource Map (GIS analysis, 2009)**



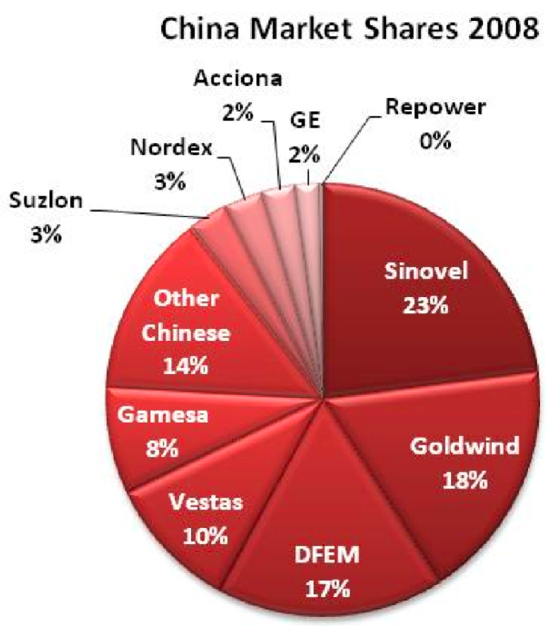

## 2.2. Industry Structure and Key Players

When large-scale wind power development began in China in the early 1990s, there were no Chinese wind turbine manufacturers in the market. The picture has changed dramatically since then, with over 80 Chinese wind turbine manufacturers reportedly in the market today. While not all of these companies have produced commercially-available wind turbines, several Chinese companies have moved ahead of foreign-owned wind turbine manufacturers in terms of Chinese market share. The evolution of the Chinese marketplace and the current status of the wind turbine manufacturing industry and wind farm development are discussed below.

#### 2.2.1. **Manufacturers**

The Chinese market is now split among the domestic Chinese turbine manufacturers, and the large global turbine manufacturers - all of which are now locally manufacturing at least the majority of their wind turbines in China. Today, the largest market share is held by Chinese firm Sinovel, a relative newcomer to the industry, with 23 per cent of the market in 2008. In second place is Chinese firm Goldwind, the most established Chinese manufacturer, with 18 per cent, followed by another relatively new Chinese manufacturer, Dongfang (DFEM), with 17 per cent. The leading global wind turbine manufacturers with a notable presence in China in 2008 include Denmark's Vestas with 10 per cent of market share, Spain's Gamesa with 8 per cent, India's Suzlon with 3 per cent, Germany's Nordex with 3 per cent, Spain's Acciona with 2 per cent, and the United States' GE with 2 per cent. The rest of the market is divided among smaller Chinese manufacturers, including Windey, SEC, Xiangdian, Mingyang, Changzhou, Beizhong, Guodian, Hanwei, Envision, Huayi, and CSR, as well as a few smaller foreign manufacturers like REpower (Pengfei, 2009).

**Figure 4. China Market Shares: 2008 Wind Turbine Sales by Manufacturer**



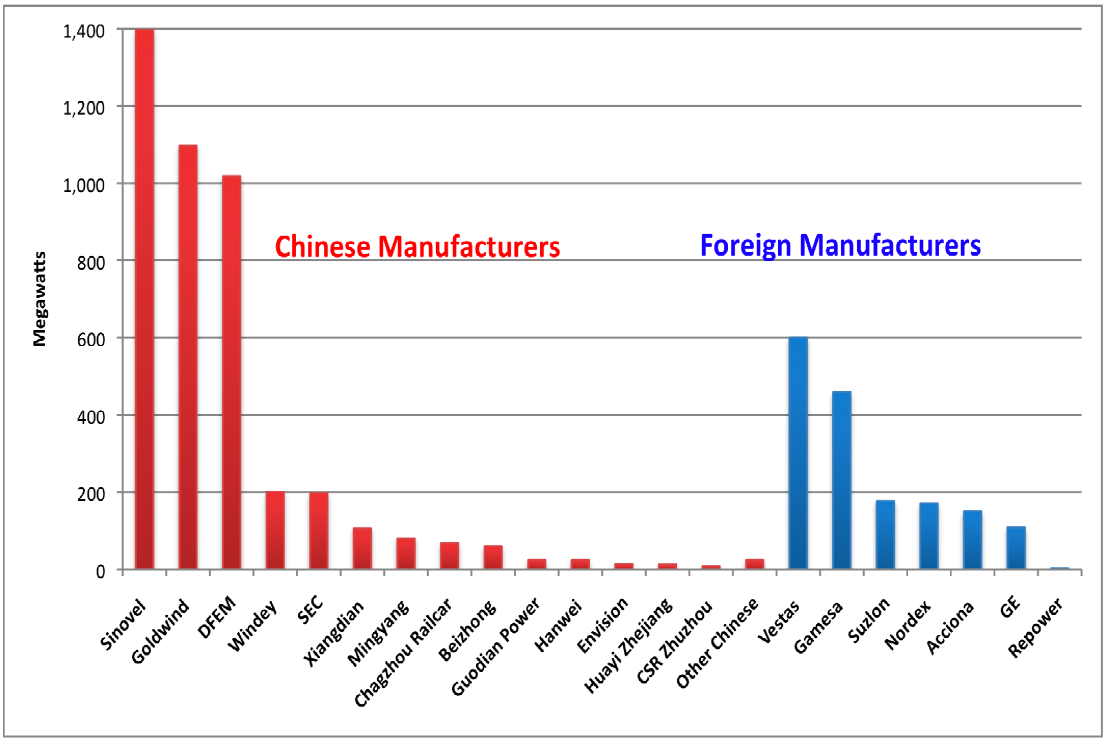

While many of the leading international wind turbine manufacturers are still active in the Chinese market, they have been disadvantaged by several government policies which have aimed to directly support rising Chinese turbine manufacturers (discussed in the next section). As a result, many foreign manufacturers have complained that the Chinese market is not open and competitive. While many leading international manufacturers still claim sizable market shares, however, it is hard to claim that this is completely the case. In addition, foreign wind farm equipment, although generally more expensive than Chinese equipment, is still generally considered to be at the forefront of technological development and preferable in terms of long-term cost efficiency. This is also supported by recent data on wind farm performance in China which has raised concerns about quality control in Chinese wind turbine manufacturing. For example, recent studies have highlighted the fact that capacity factors (CF) for wind farms in China are much lower than in the United States: 23 per cent compared with 34 per cent (and some U.S. wind farms have a CF as high as 48 per cent)[3]. This is problematic because this is making wind energy less competitive than it should be. If less power is being generated, less electricity is sold, and the project is more expensive overall. If the capacity factor in China were increased to 34 per cent, the average cost of wind power in China could be decreased from 0.55 RMB/KWh to 0.38 RMB/kWh (Meyer, 2008). The relatively low performance may be due to factors other than just turbine quality, however, including the sub-optimal siting of wind farms due to inadequate wind resource studies, limitations of the Chinese electricity grid in handling wind's intermittency, and the potentially lower quality of the domestically produced turbines deployed in China as compared with turbines available on the international market.

Despite some claims about turbine performance, Chinese wind turbines compete with foreign wind turbine technology primarily based on their cost advantage. The average price of wind turbine technology being offered by local Chinese brands is approximately 5500 RBM/kW (US$805/kW) installed, compared with about 7000 RMB/kW (US$1,025) for foreign brands, or about 20 per cent lower (Soares, 2009). This ability to compete based on price is further reinforced by the focus on low tariffs being offered by projects competing for wind concession and wind base projects. Developers in China often focus on price, rather than the overall IRR over the lifespan of the project, because tariff price is what typically determines the selection of developer for a project. The development of an indigenous manufacturing base to support the growth of wind installations in China also promises to achieve significant further reductions in generating costs. Presently, wind generated power costs 0.5–0.6 RMB/kWh (7.3–8.7 U.S. cents/kWh) to produce, while the cost of power from coal-fired plants is far less, at 0.2–0.3 RMB/kWh (2.9–4.3 U.S. cents/kWh) (Schwartz, 2009).

[3] The capacity factor (CF) defines the fraction of the rated power potential of a turbine that is actually realized over the course of a year given expected variations in wind speed. This represents a difference of 2000 vs. 3000 full load hours.

China does remain largely dependent on imports for key components, such as precision bearings, electrical and control systems, and inverters (Schwartz, 2009). For example, leading Chinese wind turbine manufacturers Sinovel and Dongfang import electrical and control systems technology form American Superconductor Corp (AMSC). Parts and raw materials used to manufacture wind turbine components are subject to a program of tax rebates instituted by the Chinese Ministry of Finance in January 2008.

**Figure 5. 2008 China Wind Turbine Installations by Manufacturer (Megawatts) (Soares, 2009)**




## Key Industry Player: Goldwind

Goldwind (*Jinfeng*) was China's first leading wind turbine manufacturer. An investigation of how Goldwind acquired its wind turbine technology provides a clear example of how China is obtaining advanced wind power technology through international technology transfers. While every firm in China has adopted a somewhat different strategy and established different technology partnerships, most firms have used licensing, merger and acquisition and joint research strategies similar to that of Goldwind.

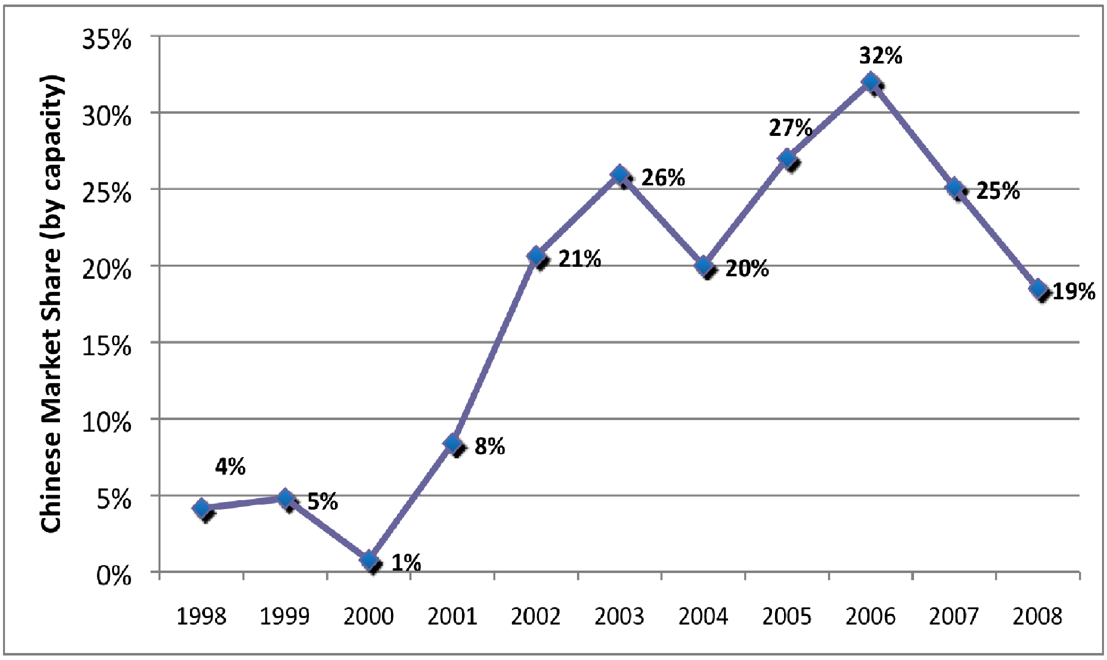
Goldwind first obtained its wind turbine technology through purchasing a license from Jacobs, a small German wind turbine manufacturer that has since been purchased by REpower, to manufacture 600 kW wind turbines. Subsequently, Goldwind also obtained a license from REpower for its 750 kW turbine, and a license from another German company, Vensys, for a gearless (direct drive) 1.2 MW turbine. Vensys, unlike REpower, was not directly manufacturing wind turbines themselves, just designing them, and was looking for a partner with the manufacturing capability to produce its turbine designs. The Vensys gearless turbine technology was then (and is now) still somewhat rare in wind turbine designs, but is thought to have many advantages, including less parts that can become damaged and require replacement (De Vries, 2007). When Vensys developed a low wind speed version with a larger 64 m-diameter rotor that increased output to 1.5 MW, Goldwind acquired the license for that turbine as well. The company is currently working with Vensys to produce a 2.5 MW gearless turbine for onshore use, and larger turbines with a view toward offshore applications.

In early 2008 when several other firms made a bid to purchase Vensys, Goldwind opted to instead purchase a 70 per cent stake in the company outright so that it could continue its important partnership. Becoming the controlling owner of the company gave Goldwind more control over the direction of the research and development of the Vensys, as well as less constraints over access to its intellectual property. Goldwind, somewhat surprisingly, has opted to encourage rather than discourage Vensys' partnerships overseas, encouraging its licensing arrangements with overseas companies that include Enerwind of Argentina (primarily selling to the Brazilian market), ReGen Powertech in India, Eozen in Spain, a Canadian subsidiary of Vensys, and most recently KD Nove Energo in the Czech Republic and Slovakia. Wu Gang, Goldwind's CEO, believes that it is important to give the designers at Vensys the creative freedom that they need, and by allowing them to directly engage in the manufacturing process, they may improve the quality of their designs through more direct learning by doing[4].

As the company has expanded, it has become increasingly able to compete for the most skilled workers in the wind turbine industry, and reportedly has been able to attract former employees from GE, Gamesa, Vestas and Siemens. Goldwind is currently manufacturing turbines for the Chinese market almost exclusively, but it is in the process of building a small demonstration wind farm in Minnesota, and has plans to expand in the United States and Australian markets.

[4] Wu Gang, Goldwind CEO, in conversation with author, October 8, 2009.

**Figure 6. Goldwind's Market Share in China, 1991-2008 (Lewis annually)**




### 2.2.2. **Developers**

Wind power development in China is quickly changing as the growing industry attracts the interest of an increasingly wider range of investors. There are around 200 wind farm developers currently active in China, though 91 per cent of total installations in 2008 were developed by 25 companies. These same companies are in the process of developing much of China's near term wind projects as well. Dominating this mix are China's large power utilities that have become very engaged in wind power development in recent years, including Longyuan, Datang, Shenhua, Huaneng, Huadian as well as Guangdong Nuclear and Guodian.

Despite the dominance of the large state-owned power companies in China's wind development, wind farms now are increasingly being developed by private developers, including wholly foreign owned companies. However, foreign power sector development in China still remains somewhat restricted by the government. While renewable energy is not an area that is specifically restricted, foreign firms still reportedly have a difficult time obtaining approval for project development.

### 2.3. **Government Wind Energy Policy Support**

The first major policy to specifically support wind power in China came in 1994 when the Chinese government, led by what was then the Ministry of Electric Power, released "Provisions for Grid-Connected Wind Farm Management." The Provisions mandated that grid operators facilitate interconnection of wind farms, and set a purchasing price for wind power based on a pricing principle of generation cost, plus repayment of loan and interest, plus a "reasonable" profit (Liu et al., 2002). In addition, the Provisions stipulated that any incremental cost of wind power over the average cost of conventional electricity be borne by the entire grid. This cost-plus-profit formula persisted in China for several years, encouraging wind development in certain provinces but reportedly leading to huge subsidies in many instances where the profit margin was set relatively high.

A new era of policies to support renewable energy development began in China in 2005 with the launch of the National Renewable Energy Law. The major policies driving wind power development in China today are described below.

#### 2.3.1. **Wind Concessions**

Recognizing that one way to promote wind development in China is to provide clear policies, release technical information and to set up mechanisms to facilitate government approval for projects, the Chinese government, led by the National Development and Reform Commission (NDRC), issued wind resource concessions for government-selected sites through a competitive bidding process to potential developers. From 2003-2007, 18 concession projects were implemented. Each concession project included approval to develop the selected project site, a PPA for the first 30,000 hours of the project, guaranteed grid interconnection, financial support for grid extension and access roads, and preferential tax and loan conditions will all be granted to the winning bidder by the central government.

The primary goal of the wind concession program was to steadily ramp up new wind power capacity at the lowest possible cost while maintaining government control over development decisions. After years of high wind electricity tariffs, the government hoped that introducing a competitive bidding process for wind farm development would reveal the true current price of wind power in China. Additional program goals include promoting the technology transfer of advanced wind energy technology, and increasing local manufacturing of wind energy systems and technology components (Wind Concession Group, 2003). Projects were usually

100 MW in size, and had to use wind turbines over 600 kW in capacity that initially used 50 per cent local content, increasing to 70 per cent in later rounds of concessions.

While the concession projects are generally though to have been a success, the structure of the bidding progress led to some challenges and criticisms. In 2005 concessions, the price that potential developers bid in as their power price for the project was the most important criteria used to evaluate the project, weighted at 40 per cent. This resulted in many developers bidding power prices that were later found to be too low, and revised after the bidder had already been awarded the right to develop the project. These practices caused a lot of concern within in the industry. As a result, the weight given to price in the evaluation process was eventually reduced to 25 per cent in 2006, and in 2007 it was decided that the average tariff price across all the bids should be used to determine which project should be selected.

### 2.3.2. **Wind Bases**

China's 2007 Mid and Long Term Renewable Energy Implementation Plan first announced the government's plans for large-scale wind power bases across China, with plans refined further in the March 2008 11th Five-Year Renewable Energy Development Plan. The wind bases include five 1 GW wind bases in Hebei, Inner Mongolia, Gansu, Jilin, and Liaoning by 2010, and an additional six 1 GW wind bases in Xinjiang, Gansu, Jiangsu, Inner Mongolia, Hebei and Jilin by 2020. These are the provinces with some of the best-proven wind resources. The earliest of these mega wind projects, a 10 GW wind farm in Juiquan, Gansu province, only recently received NDRC approval.

The wind bases provide a strong signal for the future of China's future wind power development. Few countries in the world are pursuing gigawatt-scale wind power development. In addition, government-announced plans for large wind bases allow for transmission planning to occur around these bases, better facilitating coordination between project developers, the grid company, and the central government. The wind bases are also designed to promote the development of a local wind power industry in the area surrounding the base. This is causing turbine manufacturers to shift at least portions of their facilities to the region near the base, though in many cases they are just conducting assembly at the site, rather than building an entirely new manufacturing facility if they already have operations in place in China. For example, Goldwind is already setting up facilities near several wind bases including in Hebei, Guangdong, Gansu, Xinjiang, Inner Mongolia and Ningxia. In addition, several of the wind base projects have set a specific size for the turbines to be installed there in the range of 1.5 MW to 2.MW.

Criticisms of the wind power bases surround the manner in which they are allocated and distributed to project developers. Unlike the previous wind concession projects which operated a quasi-transparent, competitive bidding system, these projects are being distributed without a bidding process. A public auction was announced for several of the wind bases, but the projects were allocated in a somewhat less structured fashion than the previous wind concession projects, reportedly being handed out to developers directly by the local governments without being based on an organized bidding or tendering process. As a result, the majority of the projects are being allocated to the large state-owned power companies. At least some of the projects have been allocated to foreign developers, however it is not yet clear whether any wind turbines manufactured by foreign-owned companies will be used.

### 2.3.3. **Tariffs**

While China has experimented with feed-in tariffs for wind power over the years with various levels of success, a July 2009 central government announcement set four feed-in tariff levels across the country, varying by region based on wind resource class. Tariff prices range from 0.51 Yuan/kWh for wind power in regions with the most wind resources, such as Inner Mongolia, to 0.61 Yuan/kWh for regions with the least wind resources (U.S. cent 7.5–8.9/kWh). Setting a higher tariff in low wind resource regions encourages wind power development there despite less opportunity for electricity production.

### 2.3.4. **Mandated Renewable Energy Shares**

The July 2008 Mid and Long Term Renewable Energy Implementation Plan announced that China's share of non-hydro renewables should reach 1 per cent of total power generation by 2010 and 3 per cent by 2020 for regions served by centralized power grids. In addition, a specific obligation was placed on any power producer owning a total generation portfolio of more than 5 GW to increase its actual ownership of power capacity from non-hydro Renewables to 3 per cent by 2010 and 8 per cent by 2020. This obligation falls upon the large power companies and is one of the primarily reasons these companies have been developing large wind projects in the last two years**.**

### 2.3.5 **Industrial Policies**

China has taken several steps to directly encourage local wind turbine manufacturing, including policies that encourage joint-ventures and technology transfers in large wind turbine technology, policies that mandate locally-made wind turbines, differential customs duties favoring domestic rather than overseas turbine assembly, and public R&D support. In 1997, the SETC launched the "Double Increase" (*Shuangjia*) project that aimed at doubling the 80 MW of wind capacity that were then installed, and encouraged (but did not mandate) that a larger share of local content be incorporated in turbines used. However, the future outlook for wind power utilization in China was likely too uncertain, and 80 MW too small a quantity, to encourage local manufacturing by turbine suppliers at this stage. Additionally, local content requirements conflicted with the requirement of most foreign government loans which were already being used to support many wind farm ventures in China. These loans were typically in the form of tied-aid that came from various foreign governments (including Denmark, Germany and the U.S.) to support the sales of their own domestic wind farm technology to China. However, 74 MW of wind power was successfully installed under this program, essentially meeting the target (MOST, SDPC, State Economic and Trade Commission, 2002).

The Ministry of Science and Technology (MOST) has subsidized wind energy R&D expenditures at varied levels over time, beginning most notably in 1996 with the establishment of a renewable energy fund (MOST et al., 2002). In an effort to help Chinese turbine manufacturers develop products and technologies, MOST funded research to develop technologies for 600 kW machines during the Ninth Five-Year Plan (1996-2000). A prototype machine developed through this research was approved at the national level. MOST is now supporting the development of megawatt-size wind turbines, including technologies for variable pitch rotors and variable speed generators, as part of the "863 Wind Program" under the Eleventh Five-Year Plan (2006-2010).

In 1997 the SDPC began its "Ride the Wind Program" (*Chengfeng)* in order to promote a model of "demand created by the government, production by joint venture enterprise, and ordered competition in the market" (Liu et al., 2002). Two joint venture enterprises to domestically manufacture wind turbines were established: one between the Spanish company Made and Chinese company Yituo, part of China's Luoyang First Tractor Factory, a commercial wing of the Chinese Ministry of Machinery. The technology transfers carried out through this program started with a 20 per cent local content requirement and a goal of an increase to 80 per cent as learning on the Chinese side progressed (Lew, 2000). The Made-Yituo joint venture focused on a 660 kW turbine transferred by Made, and the Xi'an-Nordex joint venture focused on a 600 kW turbine transferred by Nordex. The Ride the Wind program experienced limited success, blamed on the fact that foreign companies were not able to choose their Chinese partners; rather they were selected by the Chinese government. Companies were selected from industries that were thought to be appropriate to wind technology-primarily the aerospace industry-but had little experience, or interest, in manufacturing wind turbines; similar to what happened in the early years of the United States wind industry. Additionally, China's target of 1000 MW of wind by the year 2000 was not met by a long shot, which members of the wind industry blamed on unclear approval procedures and unrealistic local content requirements (Feifel, 2001).

China continues to implement local content requirements in a variety of forms. Wind farm projects approved by the National Development and Reform Commission (NDRC) during the Ninth Five-Year Plan (1996-2000) required that wind turbine equipment purchased for these projects contain at least 40 per cent locally made components. The wind concession program that began in 2003 includes local content requirements that have been growing more stringent over time. Today, all wind farms in China are subject to a local content requirement of 70 per cent.

In April 2008, the Chinese Ministry of Finance issued a new regulation on tax refunds for importing large wind turbines (2.5 MW and above) and key components. In this new regulation, the tax revenue for the key components and raw materials for large turbines (2.5 MW and above) will be used for technology innovation and capacity building. The tax rebate is not returned directly to the company, but to the state, which will establish special programs to channel the money back into the wind industry.

In August 2008 the Ministry of Finance issued another incentive policy on funding support for 2008, the commercialization of wind power generation equipment. According to this regulation, for all the domestic brands (with over 51 per cent Chinese investment) the first 50 wind turbines over 1 MW will be rewarded with RMB 600/kW (60 Euro) from the government. The rule specifies that the wind turbines must be tested and certified by China General Certification (CGC), and must have entered the market, been put into operation and connected to the grid. The regulation further requires that the rewarded turbines must use domestic manufactured components and share the awards proportionate with component manufacturers (Soares, 2009).

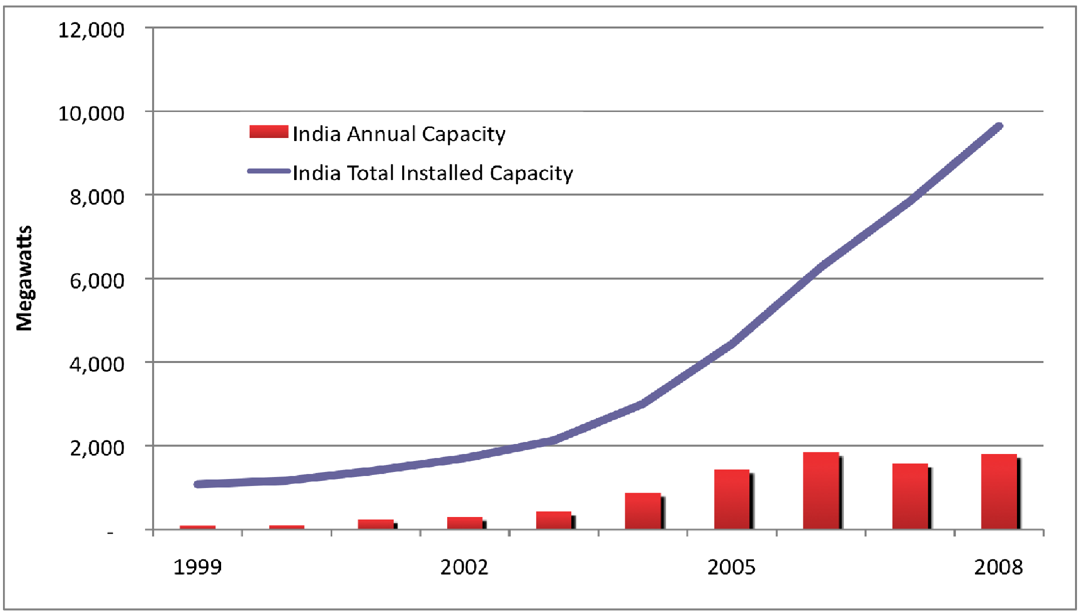
Concerns about overcapacity and an overheated wind industry lead the Chinese government in October 2009 to limit new entry into the wind industry and restrict the manufacturing of wind equipment (Dyer and Lau, 2009). This announcement by the State Council was part of a plan to combat overcapacity in seven national industries, admits concern that rising overcapacity in the economy could hamper recovery and lead to a surge in non-performing bank loans. The government is also restricting the operations within China of existing firms, not allowing for expansions into other regions in China. Many find this policy to be unnecessary, believing that the entry of many firms into a new industry is natural, and most will be weeded out in the coming months as it becomes clear whether they are able to develop a viable, competitive technology.

## 3. India's Wind Industry

### 3.1. Origins and Status

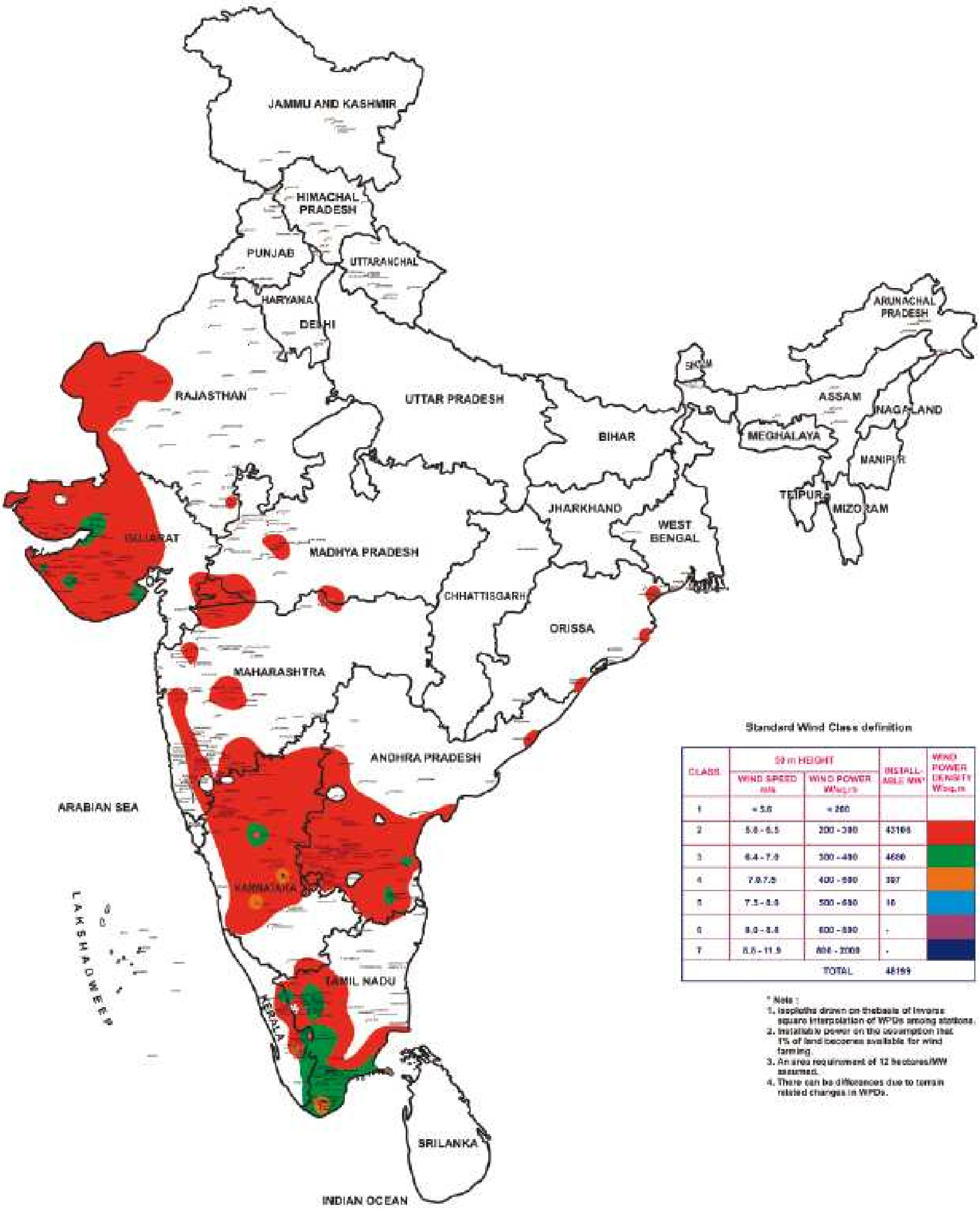
As of 2008, India ranked 5th in the world after the U.S., Germany, Spain and China in grid connected wind power installations, with 9,645 MW installed. It was the third largest wind market in the world in annual installations in 2008, after the United States and China, with 1,800 MW installed that year. The Indian government has set a target for 10,500 MW by 2012 as part of the 11th five-year plan. Wind power still comprises less than one per cent of India's total electricity generation.

**Figure 7. Wind Power Development in India, 1990-2008**



The potential for wind power in India is estimated at 45,000 MW, though due to a lack of detailed national resource assessment, many estimate that the actual number may be higher (Parthan and Lemaire, 2007). India's wind resources are best in the east and southern parts of the country, particularly near the coasts. The highest wind energy potential is believed to be located in the Indian states of Kamataka (11.5 GW), Gujarat (10.6 GW), and Andhra Pradesh (8.9 GW), followed by Tamil Nadu (5.5 GW), Rajasthan (4.8 GW) and Maharashtra (4.5 GW) (GWEC, 2009).

**Figure 8. India Wind Resource Map** (GWEC, 2009)



Wind development in India has occurred despite many technical challenges that persist within the country's power sector, including frequent blackouts and brownouts, fluctuations in voltage and frequency, and a demand for electricity that exceeds the supply.

India's wind power industry began to take off in the early 1990s, though has experienced periods of boom and bust over the past two decades. In the late 1990s in particular, the industry experienced a slowdown, reportedly due to the reduction in government tax benefits, delays in processing land approval, and technical problems related to poor installation practices in the preceding years. In 2003, growth started to take off again with the 2003 Electricity Act. Over the past few years, both the government and the wind power industry have succeeded in injecting greater stability into the Indian market, encouraging larger private and public sector enterprises to invest in wind.

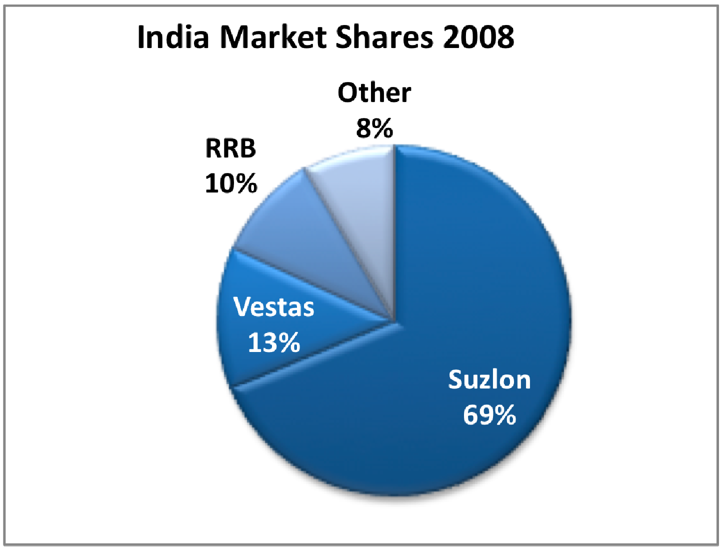
## 3.2. **Industry Structure and Key Players**

India now has a rather concentrated local wind power industry of relatively few but powerful turbine manufacturers and developers.

### 3.2.1. **Manufacturers**

India has a solid domestic manufacturing base, led by Indian company Suzlon, which held 69 per cent of Indian market share in 2008. While Suzlon is an Indian company, it now sells turbines all over the world. Other key players in the Indian market Vestas with 13 per cent market share in 2008, and RRB with 10 per cent. Several other international turbine manufacturers have established production facilities in India, including Enercon, GE, Gamesa, Siemens, ReGen Power Tech, LM Glasfiber, WinWinD, Kenersys and Global Wind Power. Overall, a dozen international companies now manufacture wind turbines in India, through either joint ventures under licensed production, as subsidiaries of foreign companies or as Indian companies with their own technology (GWEC, 2009).

**Figure 9. Wind Turbine Market Shares in India, 2008**




The current annual production capacity of wind turbines manufactured in India is about 3,000-3,500 MW, projected to rise to 5,000 MW per year by 2015 (GWEC, 2009). This annual production capacity includes turbines for the domestic as well as for the export markets. India's wind power market has been dominated recently by Indian wind turbine manufacturers, though many leading foreign-owned wind companies have set up manufacturing facilities in India. Some foreign companies now source more than 80 per cent of the components for their turbines in India and export them around the world. Components and turbines have been exported from India by Suzlon, Vestas Wind Technologies, Enercon, RRB Energy, Southern Wind Farms and Shriram EPC. The average capital cost of wind projects in India is about 45 million Indian Rupees per MW installed, or about US$958 per kilowatt (Mizuno, 2007).

Almost all Indian manufacturers are now looking at the export market, where better prices can be achieved than in the domestic market. Wind turbines and turbine blades produced in India have been exported to the USA, Europe, Australia, China and Brazil. Looking to the export market is also driven in part by policy uncertainty in the Indian wind market, and competition with local Indian manufacturers that can often outcompete the foreign manufacturers based on price. For example, U.S. firm GE had trouble selling its technology in the Indian market in 2004 and 2005 and withdrew from the market for a few years. They reportedly plan to re-enter the Indian market, with plans to build an assembly plant in India by 2010. They are reportedly going to be sourcing 70 per cent of their turbines in India (Forbes India, 2009).

**Key Industry Player: Suzlon**

Indian company Suzlon, the world's fifth largest turbine manufacturer, is now well established in the international wind market beyond India, operating in 20 countries around the world and supplying turbines to projects in Asia, North and South America and Europe. Suzlon is owned by entrepreneur Tulsi Tanti and his siblings. Tanti started in the textile industry, and turned to a few wind turbines to power his business when faced with soaring power costs and the infrequent availability of power. This led him to establish Suzlon, India's first homegrown wind power company. Within five years Suzlon had made the list of top ten wind companies, and the company has remained there since. Co-investors include two major American investment funds, City Group and Chryscapital, each of which injected $25 million into the company (Windpower Monthly, 2004:25). Suzlon recently established its international headquarters in Aarhus, Denmark, strategically selecting Denmark due to its base of wind energy expertise and extensive network of components suppliers[5]. Suzlon has also developed sales offices in Australia, China and the U.S. (as well as India) and R&D centers in Germany, the Netherlands, and India (www.suzlon.com).

Suzlon first obtained its wind turbine technology in a 1995 technical collaboration agreement with a German company, Südwind, in which Südwind shared technical information relating to the manufacturing of its 270, 300, 350, 600, and 750 kW wind turbine models, in return for royalty payments. Then in 2001, Suzlon obtained a license to manufacture rotor blades from Aerpac B.V, and entered into an agreement with Enron Wind Rotor Production B.V. in which Suzlon made a one-time payment to acquire the necessary moulds, production line, and technical support to produce another model of rotor blades in India (Herring, 2005).

In 2005, the firm began manufacturing generators through a subsidiary, Suzlon Generators, of which it owns 74.9 per cent and is a joint venture with Elin EBG Motoren GmbH of Austria. In 2006, Suzlon purchased Hansen, the second largest gearbox manufacturer in the world, expanding its access to gearbox technology and marking the second largest foreign corporate takeover by an Indian company in any industry. Suzlon also has an arrangement with Winergy AG, the leading gearbox supplier in India, which allows for the use of domestically manufactured gearboxes, while it continues to work to advance its own technology. In May of 2007, Suzlon acquired German manufacturer REpower for approximately €1 billion (which had licensed wind turbine technology to the Chinese manufacturer Goldwind), though the two

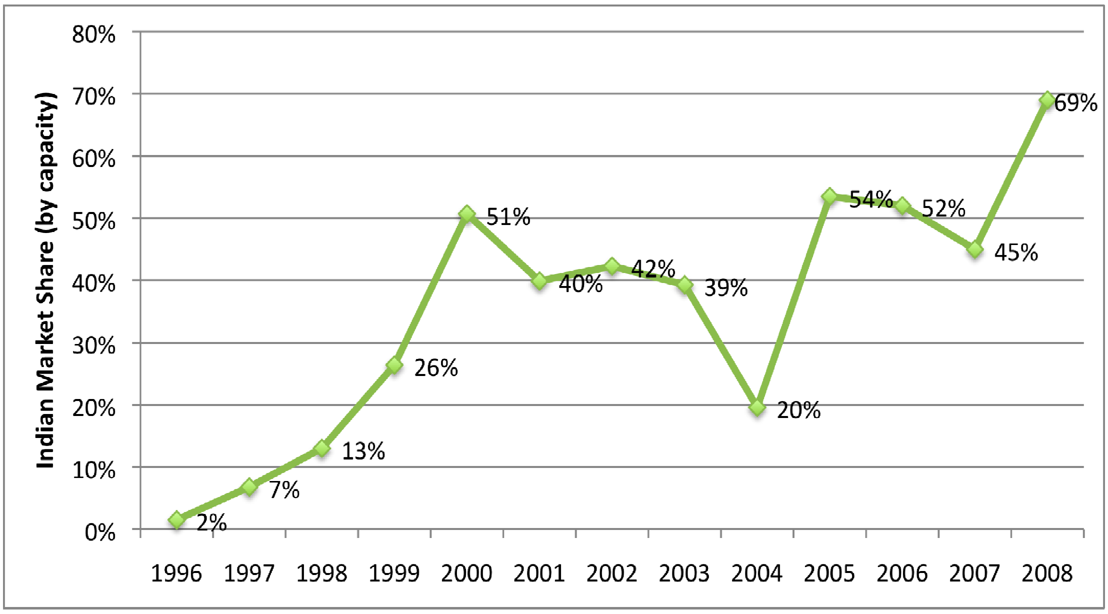
[5] Placement of the international headquarters in Denmark was particularly strategic in 2004 now since many former workers for the leading Danish wind companies, Vestas and NEG Micon, were recently laid off after streamlining in conjunction with the merger of the two companies (WPM, October 2004:25).

companies are still operating somewhat independently of each other, with little technology cooperation or knowledge exchange, reportedly to due German regulations surrounding the acquisition (Lewis and Wiser, 2007).

Suzlon currently offers wind turbines that range in size from 600 kW to 2.1 MW. The company's manufacturing strategy has been to build upon the licensing and joint venture agreements described above with its own research and development, and to manufacture as many wind turbine components as possible in-house. The firm believes that increasing its in-house manufacturing capabilities will help them to lower wind turbine costs by giving them greater control over the supply chain, and enable quicker and more efficient assembly for faster delivery times to customers (Herring, 2005). This strategy of developing integrated manufacturing capability is particularly aimed at supporting high-growth regions, including India, China, and the United States. Suzlon has also established R&D centers throughout the world. One research center based in The Netherlands benefits from local Dutch expertise in turbine blade development, while another research center located in Germany benefits from gearbox expertise.

Suzlon experienced a technological setback in 2007 when instances of blade cracks were discovered during the operation of some of Suzlon's wind turbines in the United States. In response, Suzlon opted to retrofit its total fleet of 1,251 blades (India PRwire, 2009). As a result, some industry reports indicate that recent technology failures have led to order cancellations, and may hurt Suzlon's market performance in the coming months (India PRwire, 2009).

**Figure 10. Suzlon's Market Share in India, 1996-2008 (Lewis, annually)**




### 3.2.2. **Developers**

Developers in India's wind industry have been mainly motivated by the tax benefits offered by the Indian government, and as a result tend to be Indian companies with large tax liabilities. Many of the major wind turbine manufacturers in India, including Suzlon and Vestas, also operate as project developers. In addition, the introduction of many state-level renewable portfolio standards in recent years has resulted in many large utilities and independent power producers investing in wind development.

India's economic reforms dating back to 1991 created more opportunities for Foreign Direct Investment (FDI) which directly benefited wind power development. The Indian government permitted and encouraged financial collaborations, joint ventures and technical collaborations for 35 high-priority, capital intensive and hi-technology sectors, including the power sector and renewable energy facilities. The Ministry of Industry also began streamlined its approval process for foreign investment projects (Mizuno, 2007).

## 3.3. **Government Policy to Support Wind Energy**

The Indian Government has been supporting research and development in wind power technology since the 1980s (Mizuno, 2007). In the 1990s, India's market experienced a significant boom as a result of various tax incentives, attractive buy-back rates, and some preferential loans. For example, 100 per cent depreciation of wind equipment was allowed in the first year of project installation, and a 5-year tax holiday was allowed (Van Hulle and Jansen, 1999). The national Guidelines for Clearance of Wind Power Projects implemented in July 1995 (and further refined in June 1996) mandated that all State electricity boards and their nodal agencies make plans ensuring grid compatibility with planned wind developments, and that they seek Detailed Project Reports (DPRs) from independent consultants (for capacities above 1 MW) on all proposed wind development projects to verify project capital costs and proposed power generation against certified wind turbine power curves and wind data at the site, before granting approval for projects (Van Hulle et al., 2009).

The expectations for future market growth in the early-mid 1990s attracted a number of firms to the Indian market. However, even with extensive government regulations pertaining to wind farm development, inaccurate resource data, poor installation practices and poor power plant performance led to a dramatic slowdown of installed capacity in the Indian market in the late 1990s and early 2000s. While Indian policy to support wind power development was somewhat unstable in the 1990s and early 2000s, reforms in the last few years have resulted in clearer signals to developers and turbine manufactures and a renewed industry boom. The Indian government has a stated target for renewable energy to contribute 10 per cent of total power generation capacity by 2012. The National Electricity Act of 2003 established an overarching framework for electricity sector restructuring, including the promotion of renewable energy development.

### 3.3.1. **Tax Credits**

Tax exemptions and accelerated depreciation up to 80 per cent of project cost in the first year have proved successful in driving the wind power sector in India. This tax depreciation incentive was initially based on the installation of wind turbines, rather than on their electricity generation or performance, resulting in the building of many wind farms that were never connected the power grid. A revised policy, called the Generation Based Incentive (GBI) scheme, was announced by the Ministry of New & Renewable Energy (MNRE) in early 2009. This new policy stipulated that tax incentives will be given only for the amount of power produced, not for the number of turbines installed. In addition, a tariff subsidy scheme was announced for investors who decided not to take claim the tax depreciation benefit, opening the market to a broader range of developers.

### 3.3.2. **Tariffs**

In June 2008, the MNRE announced a national generation-based incentive scheme for grid connected wind power projects less than 49 MW, providing an incentive of 0.5 rupees per KWh. In early 2009 this was expanded to all projects to provide this incentive to investors for a period of 10 years, provided they do not claim the depreciation benefit. This expanded tariff incentive was meant to provide an incentive for wind development that was attractive to investors that because of their small size or lack of tax liability cannot draw any benefit from accelerated depreciation. In addition to the MNRE incentive, many Indian states have set feed-in tariffs to support wind power development. Tariff rates range from 3.14 in Kerala to 4.5 in Rajasthan.

### 3.3.3. **Mandated Renewable Energy Shares**

The 2003 Electricity Act 2003 stated that each state should fix its own minimum percentage for purchase of renewable energy, taking into account availability of such resources in the region and its impact on retail tariffs. As a result most states have established mandatory renewable energy shares. One of the more aggressive Renewable Portfolio Standards for wind is found in Tamil Nadu, where the standard is set at 10 per cent between 2008-2009, increasing to 13 per cent between 2009-2010, and to 14 per cent between 2010-2011 (GWEC, 2009).

### 3.3.4. **Industrial Policies**

India has taken some direct steps to encourage local wind turbine manufacturing. For example, India has manipulated customs duties in favor of importing wind turbine components over importing complete machines. There is no customs duty on special bearings, gearboxes, yaw components and sensors for the manufacture of wind turbines, or on parts and raw materials used in the manufacture of rotor blades. There is a reduced customs duty on brake hydraulics, flexible coupling, brake calipers, wind turbine controllers and rotor blades for the manufacture of wind turbines, and the excise duty is exempted for parts used in the manufacture of electric generators (Van Hulle et al., 1999).

India has also developed a national certification program for wind turbines administered by the Ministry on Non-Conventional Energy Sources (MNES), based in large part on international testing and certification standards.

## 4. The Financial Crisis and the Global Wind Industry

This section of the report examines how the global financial downturn has influenced wind power development in key markets around the world, and what this has meant for Chinese and Indian wind turbine manufacturers operating in China and India, as well as abroad.

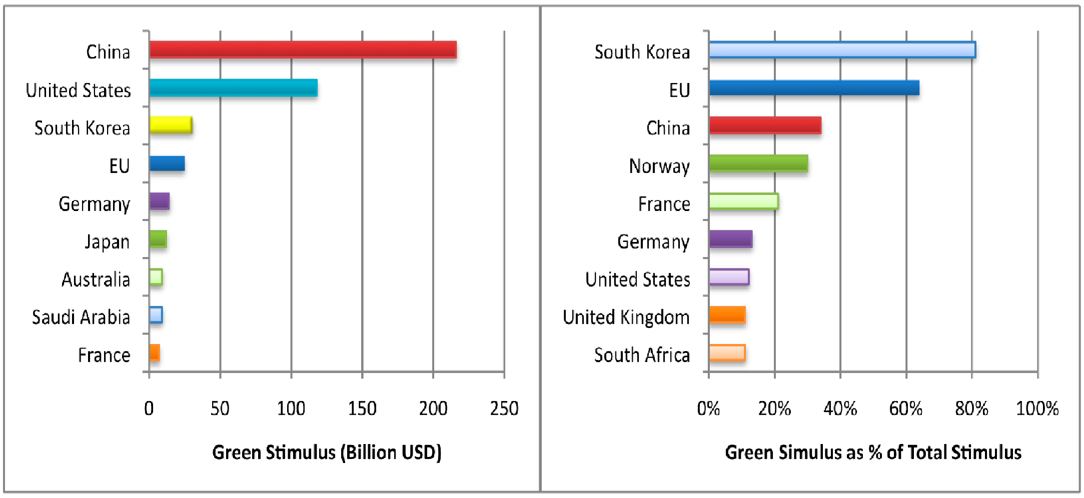
Globally, as banks have become increasingly reluctant to lend, wind energy development has felt the impacts of this constraint. Regional wind markets that are less reliant on bank project finance have been less affected. For example, The European wind energy market is less reliant on bank project finance than just three or four years ago, as an increasing share of new installations are financed by institutional investors, infrastructure funds and from power company balance sheets (EWEA, 2009). In addition, the wind energy sector is attracting new sources of capital that compensate for banks' general reluctance to provide debt finance for projects. The cost of capital is an important factor in any wind energy project, and banks hiked up the interest rate spread for wind projects from under 1 per cent to above 2 per cent in the late 2008-early 2009. However, rate hikes were reportedly been more than offset by the general decrease in central bank base rates (EWEA, 2009).

### 4.1. Government Responses

In response to the global financial crisis, many governments have implemented emergency economic stimulus packages in an effort to boost their economies. Large portions of these stimulus packages tend to focus on infrastructure projects, and many include large amounts of support for energy development in general, and renewable energy development in particular.

A HSBC study estimates that approximately 15 per cent of the $3.1 trillion in fiscal measures that have been committed by nations around the world is being directed towards climate-friendly investment, including support for renewable energy and energy efficiency (HSBC Global Research, 2009). Asia has the largest quantify of "green" stimulus, with over 20 per cent of global stimulus spending in key climate areas, led by China, Japan and South Korea. The American Recovery and Reinvestment Act comes in second, containing the broadest-based stimulus in terms of fiscal support for renewable, building efficiency, low carbon vehicles, rail, grids as well as water and waste. In Europe, the stimulus in general and the green stimulus in particular is smaller than in other regions of the world, due in part to the existence of automatic fiscal stabilizers (HSBC, 2009).

**Figure 11. Green Stimulus Funding: Regional Comparisons** (HSBC, 2009)




Most stimulus support is being distributed in 2009 and into 2010, so major economic impacts are not expected to be felt until into 2010. Some delay in distributing stimulus funds can also be expected. Some of the largest stimulus packages with sizable portions to encourage renewable energy development are detailed below.

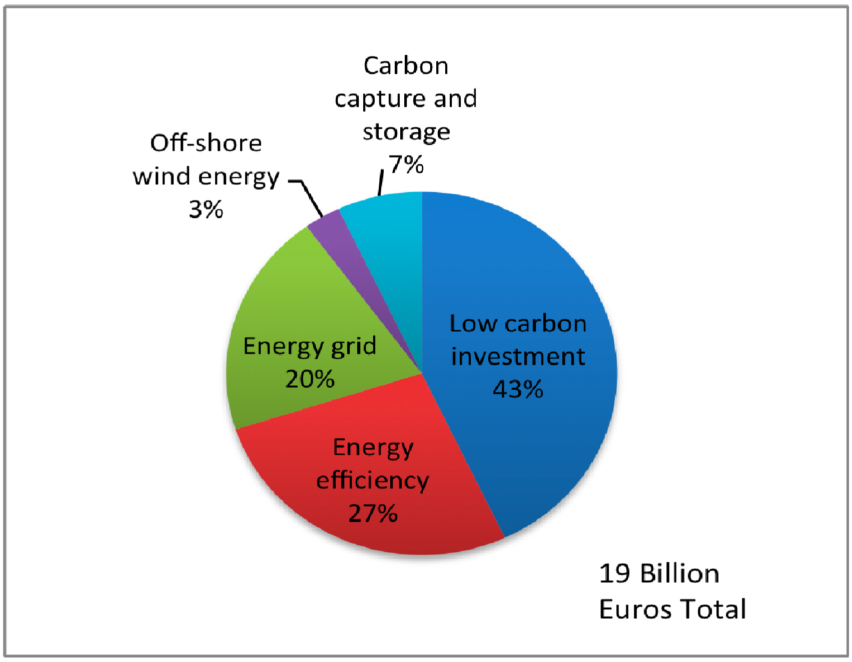
### 4.1.1. **European Union**

The EU economy entered recession in the third quarter of 2008. In November 2008, the European Commission tabled the European Economic Recovery Plan. This plan proposed a comprehensive package of measures at both the EU and national levels, amounting to 200 billion Euros total, or approximately 1.5 per cent of EU GDP (HSBC, 2009). The majority of the funding is to be spent by the 27 EU member states, except for about 30 billion which is to be spent by the European Investment Bank and by the EU directly. The final plan presented by EU leaders in March 2009 included over 400 billion Euros of support, along with other economic stabilizers such as unemployment and other welfare measures. It is estimated the total stimulus support including these measures brings the European stimulus to around 4 per cent of EU GDP, spread over 2009 and 2010 (HSBC, 2009).

As part of the stimulus package, the European Investment Bank will increase annual investments for energy and climate change-related infrastructure by up to 6 billion Euros per year for 2009-2010. In addition, the 2020 Fund for Energy, Climate Change and Infrastructure is being established to co-invest alongside institutional investors. The stimulus plan specifically allocates 565 million Euros to offshore wind generation and grid connection to support wind development (European Commission, 2009). In addition, increased levels of

RD&D support for wind energy were proposed. The European Wind Energy Association (EWEA) has stated that this subsidy will enable larger volumes of wind-generated electricity to be integrated quickly into the existing grid (EWEA, 2009).

**Figure 12. European Union Green Stimulus Breakdown**

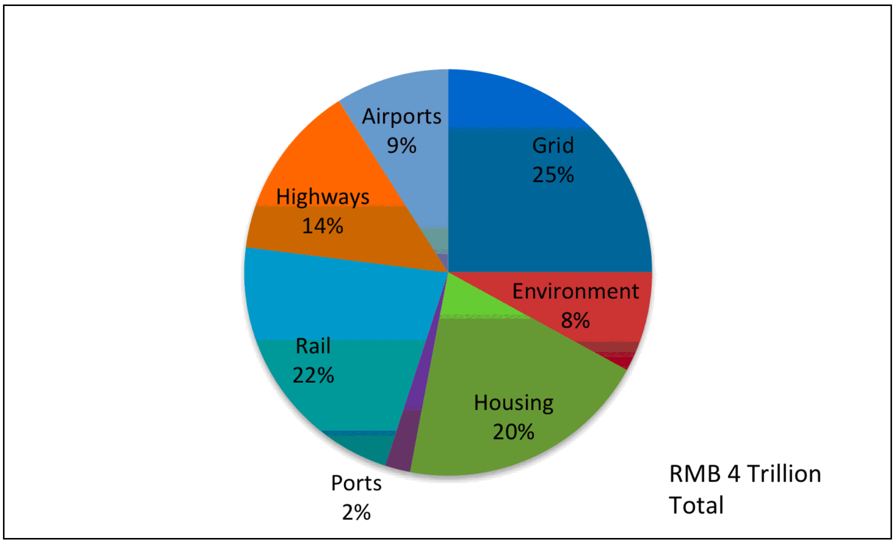



4.1.2. **China**

China responded rapidly to the economic downtown by launching large, economy-wide stimulus support. Launched on 9 November 2008, China's stimulus package of RMB 4 trillion (about $586 billion) over two years is equivalent to 13.4 per cent of China's 2008 nominal GDP. China's economic stimulus plan allocated 37 per cent of its US$586 billion ($4 trillion Yuan) to "greentech" sectors (China Greentech Initiative, 2009). HSBC estimates that US$221 billion of the overall plan, including grid, water and rail infrastructure investments, is greentech-related, making it the second largest "green stimulus" package in the word after the American Recovery and Reinvestment Plan (China Greentech Initiative, 2009; HSBC, 2009). Additional reports have indicated that China may also launch an additional stimulus package worth three trillion Yuan (US$444 billion) over multiple years focused on renewable energy alone (Sina.com, 2009).

Much of China's stimulus plan is focused on boosting investment in railways, roads, public housing and rural infrastructure as well as environmental protection. The priorities of the plan are also aligned to the long-term development of a low-carbon economy. This includes the development of more flexible and sophisticated electric grid infrastructure to enable the increased use of renewable energy sources and cut transmission losses. China has committed RMB 1.1 trillion to expand power lines and build out transmission over 2009-11 (China Greentech Initiative, 2009; HSBC, 2009).

**Figure 13. Chinese Green Stimulus Breakdown**

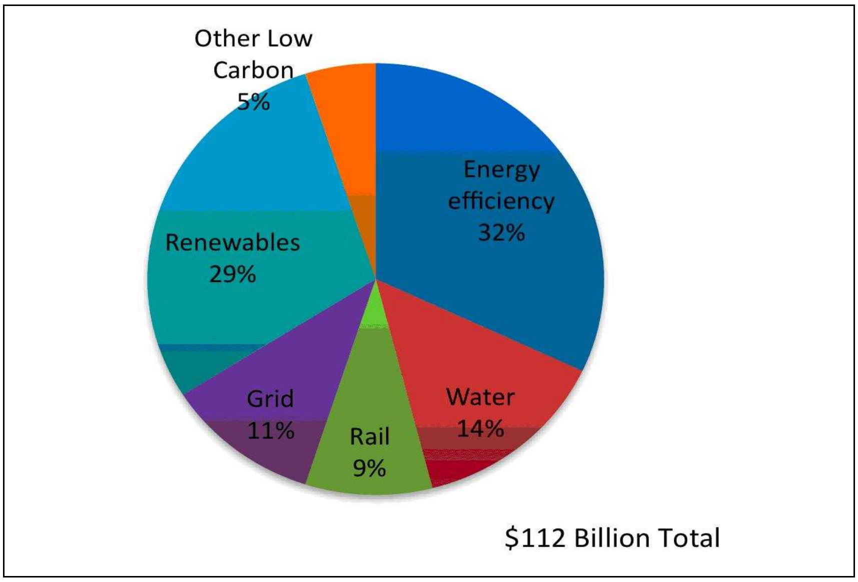



4.1.3. **United States**

The 3.8 per cent decline in U.S. GDP experienced in the fourth quarter of 2008 was the largest quarterly decline since the first quarter of 1982. In October 2008, U.S. Congress approved the Emergency Economic Stabilization Act, the centerpiece of which was the $700 billion rescue package for the financial sector. Alongside the Troubled Assets Relief Program (TARP), the Act contained $185 billion of tax cuts and credits, including USD18.2bn for clean energy (HSBC, 2009). At the last moment, the Production Tax Credit (PTC) for wind and the Investment Tax Credit (ITC) for solar were extended to 2012, with a total value of $9.45 billion (HSBC, 2009). According to estimates, every megawatt of wind power deployed results in a net reduction of 496 tons of $CO_2$ per year. Spending $1 billion on production tax credits yields 1,466 megawatts of additional wind generation capacity and cuts CO2 emissions by 727,700 tons per year. Extending the PTC through 2012, as called for in current proposals, would result in an additional 13,400 megawatts of wind and cost taxpayers $9.14 billion (WRI and Peterson Institute for International Economics, 2009).

The $787 billion American Recovery and Reinvestment Act includes about $12 billion for green spending, with the majority of the money to be spent in the first 18 months. The Recovery Act expanded incentives available to promote renewable energy, most directly by extending the Production Tax Credit (PTC) for the sectors under TARP (notably wind, biomass and geothermal) for three years, or allowing developers to swap the PTC for an Investment Tax Credit (ITC), resulting in a 30 per cent capital subsidy during 2009-10, and extending the 50 per cent bonus depreciation (HSBC, 2009). Providing developers the option to receive cash grants from the Treasury in lieu of the ITC was particularly beneficial to many developers without sufficient taxable profits to offset. Furthermore, the package provided $6 billion of Department of Energy loan guarantees, and introduced a new "build in America" manufacturing ITC, providing a 30 per cent capital subsidy for companies wishing to construct new plants in the U.S. (HSBC, 2009). Overall it is estimated that ARRA provides $22.5 billion of incentives for the U.S. renewable energy sector.

**Figure 14. USA Green Stimulus Breakdown**




#### 4.1.4. **India**

After a period of high economic growth exceeding 9 per cent in 2006 and 2007, the 2008 financial crisis saw India's growth rate fall to about 5-6 per cent in the fourth quarter of 2008-09 (The Government Monitor, 2009). India unveiled a modest $4.0 billion economic stimulus package for the first four months of the economic crisis (Vidya, 2008). In addition, India received several loans from the international development banks.

A US$2 billion World Bank Banking Sector Support Loan was provided to the Government of India to enhance the lending capacity of public sector banks, which have experienced increased demand due to private and foreign banks having slowed their lending and deposit taking. This loan is expected to will help maintain credit growth levels, support social banking and employment growth, and help strengthen the economic recovery ahead (The Government Monitor, 2009). In addition, the World Bank made a US$1.2 billion loan to the India Infrastructure Finance Company Ltd. (IIFCL) to support infrastructure investments in India's roads, railways, ports, airports, communication, and power supply. The Bank also approved US$1 billion for the Fifth Power System Development Project to strengthen the existing transmission system as well as expand the Indian national grid which will help the Government of India achieve its objective of 'Power for All by 2012'. Almost half of Indian households (44 per cent) do not have access to electricity, this project is designed to help address India's acute deficit of power by helping the power grid strengthen five transmission systems in the northern, western and southern regions of the country. The Bank has supported Power Grid since its inception, during which time the company has nearly tripled its transmission network to become one of the world's largest electricity transmission system operators. The Bank also approved a loan of US$150 million for the Andhra Pradesh Rural Water Supply and Sanitation Project, which aims to provide piped water to 2.1 million people and extend sanitation services to 1 million people who currently do not have access (The Government Monitor, 2009).

## 4.2. The Financial Crisis and Wind Development in China and India

### 4.2.1. Impact on Domestic Markets

In China, the enormous volume of the stimulus package announced by the central government in 2008 immediately raised hopes in the wind power sector among Chinese and foreign investors alike (China Greentech Initiative, 2009). It increasingly became evident, however, that the Chinese state-owned enterprises that were already beginning to dominate the wind development sector were going to be the primarily beneficiaries of government stimulus support.

The ability of the government to directly and efficiently support state-owned enterprises has been beneficial for the industry overall in this time of economic downturn. Dominant market players, particularly state-controlled entities, have historically enjoyed relatively easy access to capital, which sometimes discouraged efficient economic practices. China's four major commercial banks, the Agricultural Bank of China, Bank of China, China Construction Bank and Industrial and Commercial Bank of China, have occasionally been subject to policy-directed lending (China Greentech Initiative, 2009). Even though they appear to have become more disciplined in their lending in recent years, with non-performing loan ratios dropping from nearly 16 per cent in 2004 to under 3 per cent in 2008, policy-directed lending continues, and several market analysts suggest that these non-performing loans are currently on the rise (China Greentech Initiative, 2009). China's directed lending strategy under its current economic stimulus plan is expected to be a considerable driver of local renewable energy technology markets.

Signs are emerging that stimulus packages announced last year, especially from China, have started to have a material economic and industrial impact. In China, infrastructure investment surged by 70 to 120 per cent year-on-year, while credit growth rebounded to a 10-year high of over 30 per cent year-on-year in March 2009 (HSBC, 2009). Another sign of the stimulus helping recovery is the improvement in industrial production, which averaged 5.2 per cent in the Jan-Feb period (11 per cent year-on-year in February) (HSBC, 2009). The Financial Crisis we are facing at the moment has benefited infra-structure projects, especially those related to Renewable Energy, and State-owned enterprises in particular have benefited from government stimulus support. In fact, there are some concerns that government support has resulted in overcapacity in wind turbine manufacturing in China, which as previously mentioned triggered a recent government response to restrict new entry into the industry and new manufacturing activities.

China's economy has been more resilient to the global economic crisis than any other large country. With the world's largest foreign exchange reserves, the government's four trillion Yuan (US$586 billion) economic stimulus package was the second largest in the world. China's economy grew 7.1 per cent in the first half of 2009 and is projected to grow at 9 per cent in 2010 (China Greentech Initiative, 2009).

India hasn't fared as well as China in the economic downturn. The Indian Central Bank is reiterating concerns on inflationary pressures, and seems to reflect the growing tension between fiscal and monetary policies in India. Wholesale prices rose for the first time in 14 weeks in the latest data, with the headline inflation rate turning up 0.12 per cent on the year in the week to September 5 (Wall Street Journal, 2009). Economists say the rate is likely to breach 5 per cent as early as December 2009. The Indian government is continuing to provide stimulus support until signs of stronger recoveries in Europe and the United States are more apparent (Wall Street Journal, 2009).

India is facing non-financial challenges this year as well. Monsoon rains, which are crucial for around 60 per cent of the country's farmland, are 21 per cent below the 50-year average in the summer monsoon period. There is concern that lower than average summer crop outputs could cause food supply shortages and prices to increase further. As a result, the government is encouraging imports of essential commodities that are in short supply, such as sugar, edible oil and pulses (Wall Street Journal, 2009).

The current economic situation in India has not meant good news for wind power development there. But most importantly, the structure of the Indian wind industry makes it more vulnerable to global economic vulnerabilities than the Chinese wind industry. This is because the leading wind turbine manufacturers in India are global in reach, with India comprising smaller and smaller shares of their total wind turbine technology sales.

This is in stark contrast to the Chinese wind industry, where leading Chinese firms have yet to expand outside of China. As a result, Chinese turbine manufacturers are much more insulated by the sizable stimulus support being provided by the Chinese government. In addition, the fact that most of the leading developers and manufacturers are at least partially state owned makes them eligible for direct lending from Chinese central banks, and affords them additional government financial support in the form of research and development funds, and economically favorable project development opportunities.

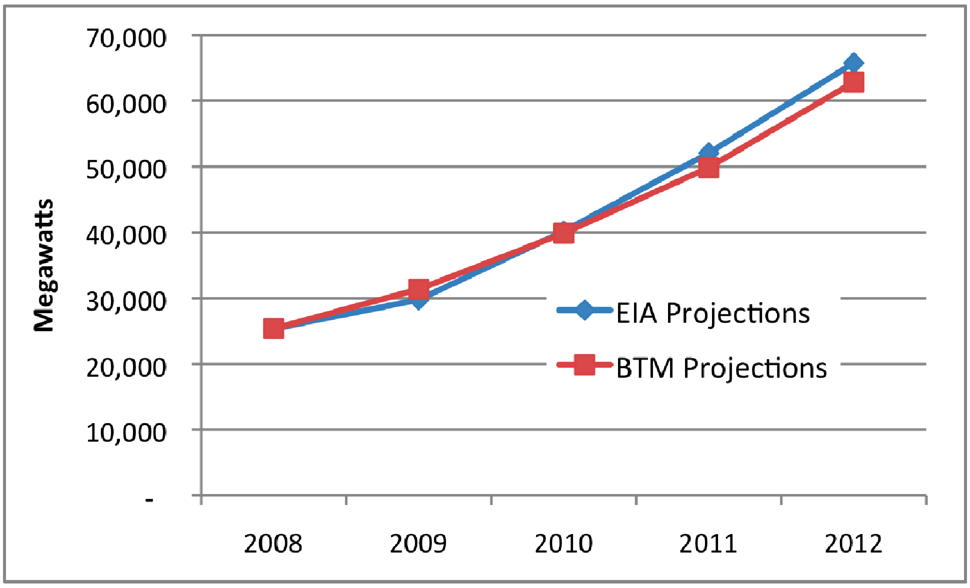
#### 4.2.2. **Opportunities for Expanded International Markets**

Since the United States was the largest wind energy market in the world in 2008. The U.S. market also represents the largest potential overseas market for Chinese and Indian wind turbine manufacturers. As a result, an investigation of the current economic status of the U.S. wind industry provides insights into opportunities for Chinese and Indian manufacturers in the largest potential expert market.

In the USA, "green stimulus" funds under the American Recovery and Reinvestment Act (ARRA) have started to flow, which will mean increased activity in renewable energy development, as well as in other targeted green industrial sectors. According to the U.S. Department of Energy, recent allocations include $41.9 million to accelerate the commercialization of fuel cells and more than $3.3 billion towards smart-grid technology development grants, with an additional $615 million for smart-grid storage, monitoring and technology viability (HSBC, 2009). This represents just 10 per cent of the money to be deployed in 2009/2010 under the ARRA. However, unlike in China, these announcements have yet to have a sizable macroeconomic effect.

In the U.S. wind industry, there are signs of increased activity. New wind energy installations reached nearly 1,650 megawatts in the third quarter, helped by stimulus funds for renewable energy projects, up from the 1,210 MW of capacity installed in the second quarter. Overall, new wind power systems under construction this year are about 38 per cent behind where they were last year. As a result, China is expected to become the world's top producer this year, surpassing the United States (Isensee, 2009).

**Figure 15. United States Wind Power Market Growth Projections, 2009-2012 (Wiser, 2009)**




While is not expected that the U.S. stimulus bill will buy new 2009 wind activations substantially, though by 2010, there are expected to be further opportunities for large-scale growth. While $950 million of cash grants have already been allocated to wind projects from the stimulus bill, the overall health of the U.S. wind power industry is currently heavily dependent on the return of liquidity in the U.S. wind project financing market.

## 5. Wind Industry Outlook

### 5.1. China

Overall, the outlook for the Chinese wind turbine industry is strong. An increasingly stable and favorable policy environment for wind in China will continue to make China one of the largest markets for wind power development in the world, and Chinese firms will continue to be awarded the majority of the domestic projects. In addition, Chinese firms will increasingly look to export markets and will likely be able to complete globally based on their ability to offer lower-priced products.

### 5.1.1. **Competitive advantages of Chinese firms**

Chinese wind turbine manufacturers are well positioned to continue their expansion within China for years to come. In addition, it is very likely that several of the leading Chinese firms will begin to export their turbines for sale abroad. This is due to the increasingly crowded market within China resulting from more and more new entrants, which has increased competition as turbine manufactures vie for projects. Among Chinese companies, firms attempt to differentiate themselves based on several factors. Some use name recognition, as many wind turbine manufacturers started in other industries in which they built a reputation. Others compete based on their relationship to large state-owned companies which gives them preferential financial support. There is not much difference in price across the Chinese manufacturers, so this is not a major means of differentiation. As Chinese firms gain operating experience, however, the primary means of differentiation is likely to become product quality. To date, so few companies have operating experience beyond a couple years, and few even have that.

Chinese turbine manufacturing companies have a competitive advantage over the majority of international wind turbine companies when it comes to price. This advantage currently exists in the Chinese marketplace, even as foreign turbine companies have shifted their manufacturing facilities to China and have been able to take advantage of comparably lower Chinese wage rates. This indicates that Chinese turbines may in fact be lower cost due to inputs other than just inexpensive labor. If Chinese firms begin to export their turbines overseas, they will likely be extremely competitive in other markets as well. While few Chinese turbines have been exported outside of China, there are several being exported the United States and Australia. Leading Chinese manufacturer Goldwind is currently building its first U.S. wind farm in Minnesota, and has plans to expand its manufacturing base across the country[6].

[6] Wu Gang, Goldwind CEO, in conversation with author, October 8, 2009

Chinese wind turbines manufacturers have and will continue to benefit from the largest domestic market for wind power development in China. China was the second largest wind market in the world in 2008, and is projected to be the largest in 2009. This gives China-based firms a huge opportunity to sell their products, develop their technology base, and gain operation experience.

Chinese wind turbine manufacturers have also benefited greatly from government support, particularly in recent years. While local content requirements instituted in 2003 gave local manufactures an early boost, 2008 Ministry of Finance Programs to directly support the development of advanced Chinese wind turbine technology, along with the awarding of concession and wind base projects that utilize Chinese technology, have been extremely beneficial to emerging wind turbine manufacturing companies in China. These policies have given Chinese firms a strong advantage over their foreign competitors in the Chinese marketplace, and this may assist these firms as they expand into markets outside of China.

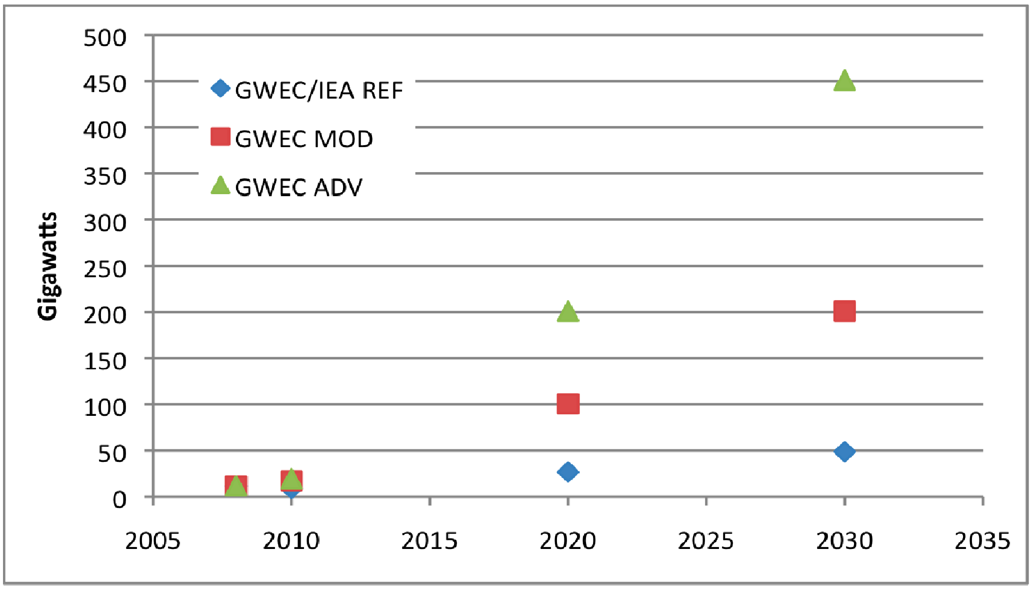
Despite an overall successful outlook for Chinese manufacturers, several key weaknesses exist as well. Very few firms in China have sufficient operating experience with their wind turbine technology. It is very common for companies in the early stages of developing a new product to experience technical challenges and setbacks. Goldwind, one of the few Chinese firms with several years of operating experience, experienced major failures in hundreds of their wind turbines that had been installed across China, which was later traced to a material defect. While Goldwind was able to repair the turbines and recover form this setback, unexpected technical failures can be extremely costly and can threaten the financial stability of a company. In addition, technical failures can be very harmful for a firm's reputation, particularly if this reputation does not have years of successful performance to counter any difficulties they may encounter. Very few Chinese wind turbine manufacturers have built any sort of reputation domestically, and this is one area in which the foreign turbine manufacturers that have been in the wind industry for decades have some competitive advantage.

#### 5.1.2. **Short & Medium Term Outlook**

Projections for wind power development in China for the next 1-2 decades vary dramatically. The International Energy Agency projects modest growth for China‘s wind industry, with installed capacity reaching 27 GW in 2020 and 49 GW in 2030. Those watching the Chinese industry more closely, however, find those projections to be extremely conservative. The Global Wind Energy Council's moderate scenario projects 101 GW of capacity installed in

China by 2020, and 201 by 2030. Their advances scenario lays out an extremely ambitious future for wind power in China, with over 200 GW in place by 2020, and 450 GW by 2030. The variation in these projections is illustrated in Figure 14.

**Figure 16. Projections of Wind Energy Growth in China through 2020 and 2030**




5.2. **India**

The outlook for India's wind power industry is generally positive, though somewhat uncertain. While the policy environment for wind power in India has improved in recent years, the industry is still heavily dependent on tax incentives which attract a narrow range of investors. India reliance on foreign banks has made it particularly vulnerable in the global financial crisis, and turned to international development bank loans to shore up the public banking system. While Indian wind turbine manufacturers possess advanced technology and solid operating experience, their global reputation is still somewhat uneven.

5.2.1. **Competitive Advantages of Indian Firms**

Indian wind turbine manufacturers have several competitive advantages compared with manufacturers from other countries. First of all, they can compete based on price, with some Indian turbines reportedly selling for even lower prices than turbines in China. Indian wage rates are still lower compared with China, and as a result labor can be one way in which prices can be competitive.

Indian wind turbine manufacturers, while still relatively new entrants into the wind power industry compared with some early European and American firms, have years of operating experience. This is something that most of their Chinese counterparts lack. Within the Indian market, there only a handful of firms competing for market share, unlike in China, where the number of firms increases daily and is reportedly greater than 80. In addition, Suzlon has developed advanced wind turbine technology through years of international partnerships, mergers and licensing agreements, such that they are a world-class technology provider in an industry where Chinese firms are still playing technological catch-up.

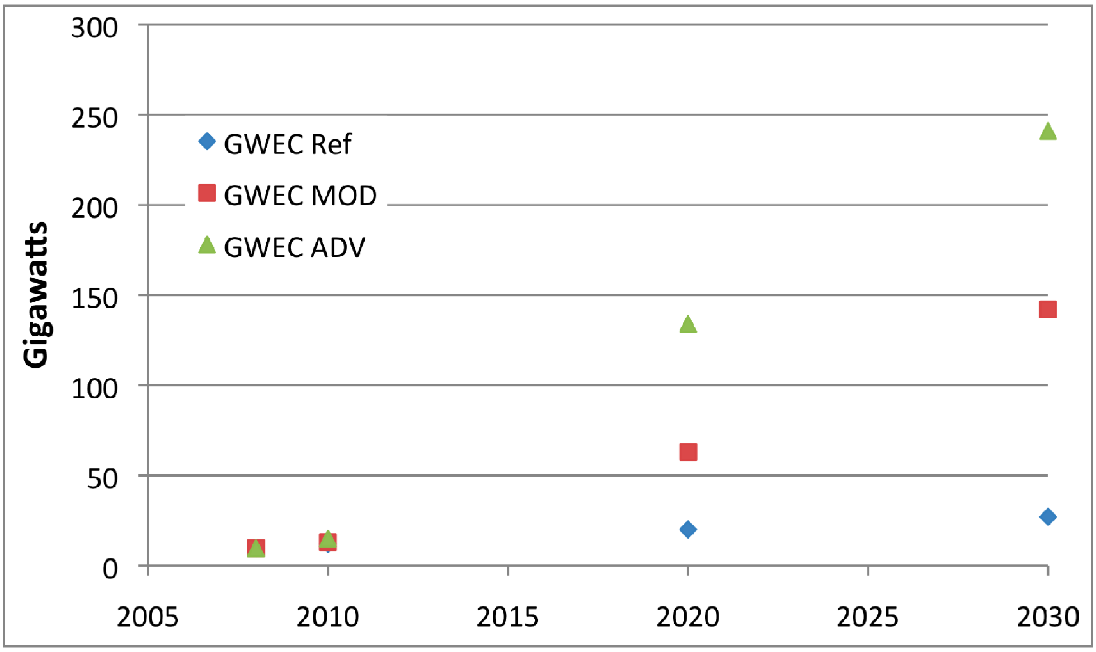
Indian firms like Suzlon have developed a global reach, allowing them to sell their product in leading markets all around the world, while Chinese firms have let to leave China's boarders. With this global reach comes market flexibility - when the Indian market slows, Indian firms can continue to sell their products to other markets. This reduces their vulnerability to one particularly policy system. With this global reach, however, also comes increased risk. The larger and more distributed the firms operations, the more financially extended they become.

While the Indian wind market is likely poised for growth, fundamental vulnerabilities in the industry remain. India has had an unstable policy environment for wind power development over time, and while this has improved somewhat, the outlook is still quite uncertain. Most support for wind in India is determined at the state level, leading to a patchwork of uneven support across the country. India is also still a poor country with a vulnerable economic environment, and access to private investment is crucial to maintain the industry's growth. One of the largest barriers to wind power development in India is the fact that the Indian power sector plagued with inefficiencies and severe reliability problems. These institutional and technical challenges in India's power sector are unlikely to be resolved anytime soon, and they create a difficult environment for wind power growth.

### 5.2.2. **Short & Medium Term Outlook**

Projections for future growth in wind power development in India vary rather substantially. The IEA projects 27 GW of wind capacity in India by 2030: just three times current installations. In contrast, the Global Wind Energy Council's most aggressive scenario projects over 240 GW of installed capacity for India. The variation in these projections is illustrated in Figure 15. It is interesting to note that even the most aggressive projections for India are little more than half as ambitious as the projections for China.

**Figure 17. Projections of Wind Energy Growth in India through 2020 and 2030**




## 6. **Conclusions**

An investigation of the implications of the global financial crisis on the wind power industries of China and India provides insights to the industry's structural characteristics, the manner in which firms can and do respond to economic fluctuations, and how monumental government stimulus support has shaped the evolution of wind development worldwide.

### 6.1. **Assessment and Policy Recommendations**

This study finds that China and India have been able to develop strong wind power industries which are still very much in a growth stage, and have been dampened but not smothered by the global financial crisis. The Chinese wind power industry in particular seems to have emerged almost unscathed from the global economic downturn, and in fact is being subject to government restrictions to slow down an overheated industry. This is found to be due to government policy support that directly supports Chinese wind turbine manufacturers. While some of this support has been allocated in direct response to the economic crisis, the majority of the support was already in place prior to the downturn, and the impacts of this continued government support is just now coming to fruition in the form of dozens of new Chinese wind turbine manufacturers entering the market. While India has not fared as well as China until the economic downturn, India's wind industry is more established than China's, and therefore is less vulnerable to short-term fluctuations in domestic market demand. India's turbine manufacturers are also much more global in their presence, providing additional opportunities for expansion, but making them that much more susceptible to economic trends in these other markets as well.

Currently, both Chinese and Indian turbine manufacturers can complete with the more established wind turbines around the world on the basis of price. While India's leading wind turbine manufacturer, Suzlon, is having some trouble competing with Chinese companies in the Chinese market, it has long dominated the Indian wind turbine market. While Suzlon has more advanced wind turbine technology than most of its Chinese counterparts, it has suffered some technical challenges in recent years which have influenced its global reputation. In contrast, Chinese firms do not have much of a global reputation due to their very limited experience selling wind turbines outside of China. This is likely to change dramatically in the near term, however, as several of China's leading manufacturers have set their sights on large global wind markets, and primarily on the United States.

### 6.1.1. **India**

There are still many challenges faced by both the Indian and Chinese wind industries that could be addressed by government policy reforms. In India, wind resource development has not been fully realized due to the lack of a national policy to promote renewable energy, resulting in inconsistent implementation across the country. While some states have set high renewable portfolio standards, other states only have low or no targets, and enforcement is insufficient (GWEC, 2009). As a result, India would benefit from better national-level support to promote wind power development, which could be facilitated by a national renewable portfolio standard, and a national feed-in tariff for wind electricity. Indian wind development has been highly uneven over time to due fluctuating policy support. As a result, any policies to promote renewable energy in India should be clear, stable and long-term.

In addition, government procedures for the approval of wind projects needs to be clarified and accelerated in order to avid lengthy, costly delays in wind project development. Project development would also be facilitated by greater access to financing.

There are still significant uncertainties on the future potential of wind energy development in India due to a lack of information on wind resource potential and land availability. As a result, an updated wind resource assessment of India would help to inform developers of the future potential for wind throughout the country.

Wind development in India has occurred despite many technical challenges that persist within the country's power sector, including frequent blackouts and brownouts, fluctuations in voltage and frequency, and a demand for electricity that exceeds the supply. As a result, wind development would benefit from broader power sector reforms to address these core challenges as well.

### 6.1.2. **China**

In China, several policy reforms are needed to ensure continued growth in the wind power industry. The first is improved transmission networks to ensure that wind projects can be developed in areas with excellent resources but low electricity demand. An improved transmission infrastructure in China will be crucial to fully exploiting its wind power resources.

Wind projects in China have in many cases experienced challenges in obtaining access to the power grid. If wind developers cannot connect their projects, they cannot meet their contracts to supply electricity. In many cases the grid companies in China fear that wind energy will threaten the stability of their entire power system. It's necessary that additional studies are done to look at high penetration wind scenarios on China's power grids, particularly in parts of China where a smaller, regional grid is not interconnected to a larger network. Smart-grid technology will facilitate the interconnection of much larger amounts of wind energy to the electricity grid. As a result, policy makers in China should begin examining how to best deploy smart-grid technology to maximize wind power utilization.

China's wind power technology industry is still relatively immature. As a result, Chinese turbine manufacturers would benefit from government-facilitated research, development and demonstration activities. China would benefit greatly from a national renewable energy laboratory to conduct independent testing of wind power technologies, similar to the United States' National Renewable Energy Laboratory in Golden, Colorado. In addition, enhance utilization of internationally established certification and testing standards for would help Chinese wind turbine manufacturers improve their technology by identifying technical problems. Certification would also help to companies differentiate their products in the marketplace with quality assurances.

## 6.2. **Global Implications**

Wind power is by all accounts a growth industry globally. Currently, wind power provides a modest 1 per cent of global electricity supply. This share could potentially be much larger, allowing wind power to play an important role in greenhouse gas mitigation. Wind power offers an immediate option for reducing the carbon footprint of the electricity sector, as it is a mature, zero-emission technology that represents a relatively low-cost carbon abatement option when compared with other technologies currently available. As a result, the demand for wind power technologies will only increase as nations around the world adopt policies to regulate carbon emissions. While there are some technical challenges to dramatically increased deployment of wind power technology, namely electricity transmission and grid integration, none are thought to be insurmountable (Wiser and Hand, 2009).

This investigation of how the dominant, locally owned wind turbine companies of India and China acquired their ability to manufacture wind turbines provides a look at how two leading developing-country firms have acquired and assimilated advanced technologies. Such insights are crucial to facilitating international technology transfers, which will be an important component of any technological leapfrogging strategy to achieve lower greenhouse gas emissions in the developing world.

The institutional and other barriers present in large, developing countries such as China and India certainly challenge simplistic notions of energy leapfrogging. Yet, as an examination of wind turbine development in these countries has shown, substantial technical advances are indeed possible in relatively short amounts of time. It took China and India less than 10 years to go from having companies with no wind turbine manufacturing experience to companies capable of manufacturing complete wind turbine systems, with almost all components produced locally. This was done within the constraints of national and international intellectual property law, and primarily through the acquisition of technology licenses or via the purchasing of smaller wind technology companies, in addition to taking advantage of hiring skilled workers in the industry and establishing RD&D facilities abroad.

As technology development becomes increasingly global, developing-country firms can take advantage of their increasing access to technological know-how that was previously developed primarily by and for the developed world. The lessons of India and China's successes in harnessing global technology for local- and increasingly global-use, illustrates new models of technology development in the developing world.

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