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WIND POWER IN CHINA 2008

AN ANALYSIS OF THE STATUS QUO AND PERSPECTIVES FOR DEVELOPMENT

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on behalf of

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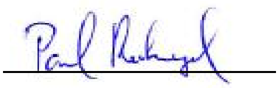

Paul Recknagel

Abstract

This study reviews the status quo of wind power in China in the year 2008 and offers an outlook to future development, in order to provide a sound basis for the alignment of the German Development Corporation's (GTZ) wind power activities with actual market conditions. Government policies as well as other determinants of wind power development are analyzed in-depth and possible pitfalls for development are identified. As a conclusion, the study presents recommendations for measures to promote a long-term sustained development of wind power in China.

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Finally, I want to show my deepest appreciation to my family for their love and unfailing support.

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Abbreviations

ADB	Asian Development Bank
BCSE	Australian Business Council for Sustainable Energy
BMU	*Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit*
CAGR	Compound Annual Growth Rate
CDM	Clean Development Mechanism
CEPRI	China Electric Power Research Institute
CLYPG	China Longyuan Power Group
CMA	China Meteorological Association
CNY	China Yuan Renminbi
cp.	compare
CRED	Center for Renewable Energy Development
CREIA	Chinese Renewable Energies Industry Association
CWPP	GTZ China Wind Power Project
DE	domestic enterprise
EEG	*Erneuerbare Energien Gesetz*
EEP	EU-China Energy and Environment Programme
ERI	Energy Research Institute
EWEA	European Wind Energy Association
FIE	foreign-invested enterprise
GDP	gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gas
GTZ	*Gesellschaft für Technische Zusammenarbeit*
GW	gigawatt
GWEC	Global Wind Energy Council
IGES	Institute for Global Environmental Studies
IMAR	Inner Mongolia Autonomous Region
IPCC	Intergovernmental Panel on Climate Change
IPP	independent power producer
m	meter
MW	megawatt
NDRC	National Development and Reform Commission
NEA	National Energy Administration
NREL	National Renewable Energy Laboratory
O&M	operation and maintenance
OECD	Organisation for Economic Co-Operation and Development
PPA	power purchase agreement
R&D	research and development
RE Law	Renewable Energy Law
REEEP	Renewable Energy and Energy Efficiency Partnership
REN21	Renewable Energy Policy Network for the 21st Century
SWERA	Solar and Wind Energy Resource Assessment
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP	United Nations Environment Programme
US	United States
VAT	value added tax
WERT	Wind Environment Research & Training Initiative (BMU & GTZ)
WED	Danish-Chinese Wind Energy Development Programme
WTG	wind turbine generator
WTO	World Trade Organisation

1 Introduction

1.1 Background

The last two years mark a turning point in public perception of human-induced climate change as a problem of global importance.[1] The widespread acceptance that *"most of the observed increase in globally-averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas [GHG] concentrations"* [2] has increased political pressure on governments to reduce GHG emissions. At the same time, rising oil prices have made the reduction of dependence on energy imports and diversification of the energy mix strategic imperatives for many countries around the world.

While governments worldwide are confronted with this dual challenge, it is of special relevance to China. On the one hand, China has recently become the world's largest emitter of CO_2, accounting for 24% of global annual CO_2 emissions.[3] China is therefore one of the most important players to effectively mitigate global warming and pressure from governments around the world on China to join emission reductions efforts is mounting. On the other hand, energy demand is growing exponentially and China is increasingly relying on energy imports to satisfy energy needs.[4] Worried that growing dependency on energy imports may be accompanied by foreign-policy and economic pressures that might threaten national security as well as social and political stability, China has implemented a number of policies to address this issue ranging from policies to save energy and reduce energy intensity, to the diversification of oil supply sources and routes, the support of equity oil overseas acquisitions and the build up of strategic oil reserves to the diversification of the energy portfolio.[5]

In line with the objective to diversify the composition of the energy mix, China's leadership is increasingly realizing the need to reduce emissions and support renewable energy development. At a recently held *Politburo* study session, President Hu Jintao exclaimed: "*Our task is tough, and our time is limited. Party organisations and governments at all levels must give priority to emission reduction and bring the idea deep into people's hearts"*.[6] To address the issue of energy security, the Chinese government has adapted a two-pronged approach. While measures to promote energy savings and efficiency curb the increase in energy demand, the support of renewable and nuclear energy reduces dependency on energy imports and contributes to the broadening of the foundation of energy supply.[7]

This study focuses on China's renewable energy policy and the development of wind energy in China in particular. Commitment by the highest levels of government and a host of favourable policies have triggered a boom in renewable energy in China, especially in the wind power sector. A major step in the development of renewable energy in China has been the *Renewable Energy Law* that came into

[1] Main drivers of public awareness of climate change were Al Gore's movie "An Inconvenient Truth" (May 2006), the Stern Report (October 2006), the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (2007) and the Nobel Peace Prize for Al Gore and the IPPC (December 2007).
[2] IPCC (2007), p. 10
[3] Netherlands Environmental Assessment Agency (2007), *online* / The Climate Group (2008), p. 5
[4] In 2006, China relied on imports for 50% of its total oil consumption. China started to import gas in 2006, and has become a net importer of coal in 2007. The energy imports are expected to increase markedly in future, accompanied by a growing impact on international fuel trade. (cp. OECD/IEA (2007), p. 325 et seqq.)
[5] cp. OECD/IEA (2007), p. 175 et seqq.
[6] cp. Watts (2008), *online*
[7] China is also supporting the development of a natural gas market as well as R&D and deployment of clean coal, coal-to-liquid and biofuel technologies.

effect in January 2006. In addition, the government has set ambitious targets for energy intensity reduction, and share of renewable energy of primary energy consumption.

China is on the way to become the world leader in renewable energies. In 2007, investment in renewable energies in China amounted to approximately US$ 12 billion, second only to Germany. In terms of installed renewable energy capacity, China leads the world with 151 GW of installed capacity, largely due to the widespread utilization of hydropower for electricity generation.[8] According to a report by the United Nations Environmental Programme, China is the world's leading manufacturer of solar cells, with an estimated annual production capacity of 3.000 MW.[9] China's wind power market was the third biggest worldwide in 2007 and growth rates continue to exceed expectations. In 2009, China is expected to take the lead as the largest manufacturer of wind turbines.[10]

Hydro power represents the most important source of renewable energy in China and plays an important part in the power generation portfolio, most notably since the construction of the Three Gorges Dam. Hydro capacity is expected to double to 290 GW until 2020, but concerns about the social and environmental impact of large-scale hydro power are becoming stronger.[11] Although China is the world's leading solar manufacturer, installed solar photovoltaic power capacity amounts to a mere 0.01% of total power generation capacity (80 MW, approx. 50% of which are off-grid).[12] Solar power equipment is produced almost exclusively for export. Considering China's enormous energy demand and the pace of its growth, deployment of solar photovoltaic power is not viewed as a first-rate solution to satisfy China's energy needs, since it features high costs and low efficiencies compared to other renewables like hydro or wind power. While China does not have significant amounts of solar PV capacity, it is the biggest market for solar thermal systems for heating and hot water supply with 64,5% of global capacity, amounting to 68 GW.[13] Biomass covers 13% of primary energy demand, mostly used in rural households for heating and cooking. In 2007, only 0,28% of power generation capacity were fuelled by biomass. The government plans to expand biomass capacity from 2 to 30 GW by 2020.[14] Despite the impressive progress of recent years, renewable energies - excluding hydro - only contribute less than 1% to China's electricity supply and the skies above China's urban areas continue to be shrouded by smog.

Since coal-fired power generation accounts for 82,9% of total electricity supply, it is no surprise that half of China's emissions are attributable to power generation.[15] With electricity demand growing rapidly alongside the economy, dependency on coal as the major source for power generation is likely to persist. However, as the most important source of renewable energy next to hydro, and growth of installed capacity constantly accelerating, peaking at about 130% in 2007, wind power is one of – if not the – most promising option on China's path towards diversification of the energy mix. In recent years wind power has become a mainstream source of renewable energy excelling with mature technology and power generation costs almost competitive with conventional power sources, providing a viable alternative to coal as a source of electricity generation.

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[8] Hydro power accounts for 145 GW out of 151 GW renewable energy capacity (2007). Cp. The Climate Group (2008), p. 8
[9] Data from 2007. cp. May (2008), *online*
[10] cp. Schwartz/Hodum (2008b), *online*
[11] cp. The Climate Group (2008), p. 8
[12] cp. The Climate Group (2008), p. 8 et seqq.
[13] cp. REN21 (2008), p. 12
[14] cp. cp. The Climate Group (2008), p. 11
[15] cp. Shi (2008b), p. 1

In 2005, just before the development of wind power started to pick up pace, the China Wind Power Training and Research Project (CWPP) of the German Development Cooperation (GTZ)[16] saw its inception, with the aim of improving the conditions for sustained development of wind power in China. Primary objective of CWPP is the support of sustained long-term wind power development in China. To attain this goal CWPP supports the improvement of technical capabilities of private and government institutions and organizations through activities in the fields of wind power training, technical support and research. The project's engagement ranges from training of technicians in charge of operation and maintenance (O&M) at wind farms to the introduction and localisation of software vital to wind resource assessment. These capacity building activities are complemented by wind power information services as well as policy advice to relevant government institutions.

The CWPP activities and the indicators measuring its success are based on an analysis of framework conditions in 2003/2004. However, since then the general conditions for wind power in China have changed drastically due to policy changes inducing exponential growth of the industry. While from 2000 to 2005 total installed capacity grew at an average rate of 31%, it more than doubled in the last two years. Newly installed capacity increased at an even faster rate averaging 156% annual growth from 2005 till 2007.[17] In light of the boom in the Chinese wind power sector, it is imperative to realign project activities with actual market conditions on the basis of an up-to-date assessment of the current situation and future outlook. This analysis of the wind power sector in China in 2008 will serve as a basis for the review of current CWPP activities with the aim of developing recommendations for adaptations where deemed necessary.

1.2 Content & Methodology

The study is divided into seven chapters. Subsequent to the introduction, the global development of wind power, its major drivers and trends are discussed briefly serving as a backdrop to the study. The third chapter introduces CWPP and its activities along with the current status of project implementation. The fourth and fifth chapter form the main body of this study. Beginning with the current picture of energy supply and demand, the fourth chapter goes on to introduce the relevant government authorities in charge of Chinese renewable energy policy. Since the basis for wind power development is government support, a detailed examination of renewable energy policy in China is given. The policies governing the wind power sector are reviewed in order to explore the origins of the current boom of the wind power industry. The fifth chapter offers an in-depth discussion of wind power in China, including wind power potential, current status of the market and future development as well as the situation with regards to wind power equipment manufacturers and project developers. In the sixth chapter, major determinants that have the potential to negatively affect the perspectives of wind power development in China are identified and discussed. As a conclusion, chapter seven offers recommendations for the realignment of CWPP activities according to the actual needs of the market.

A series of expert interviews was conducted within the scope of the study.[18] The experts interviewed included representatives of relevant government authorities, foreign and domestic wind turbine manufacturers, component suppliers, project developers, industry associations, universities, research institutes, consultancies, CDM agencies and environmental organizations. These interviews serve as a

[16] The webpages of the GTZ wind power activities in China can be found under www.cwpc.cn.
[17] cp. Shi (2008a), p.1 et seqq.
[18] For summaries of selected interviews conducted in Beijing between March and July 2008, please refer to the annex.

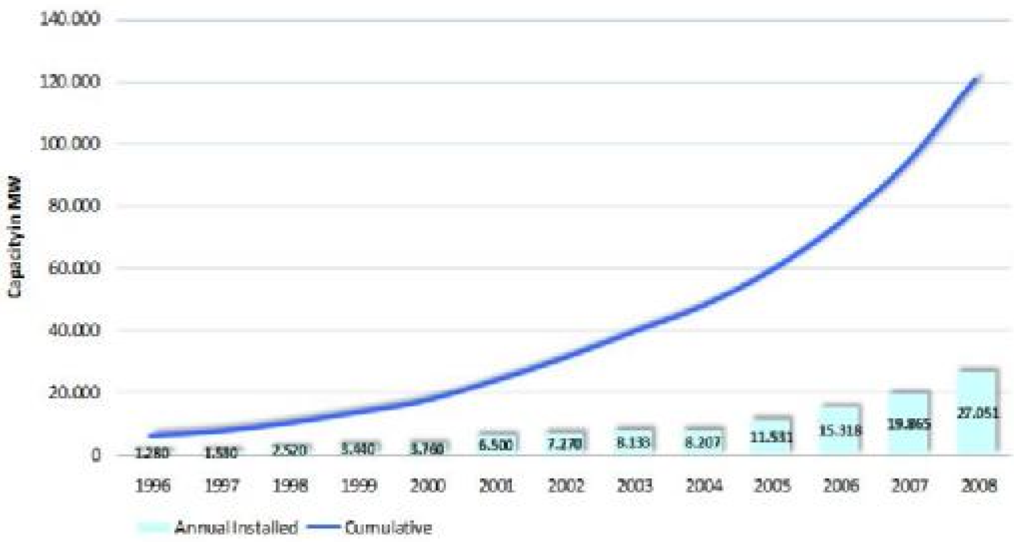
supplement to the evaluation of secondary literature and online sources so as to guarantee the timeliness and validity of information in the study. In cooperation with the China Electric Power Research Institute (CEPRI) and the Chinese Wind Energy Association (CWEA) the need for wind power-specific training and education for wind power equipment manufacturers and power generation companies was assessed through two separate surveys. In addition, two polls were conducted among wind turbine and component manufacturers at the China Wind Energy Exhibition 2008 in Shanghai and the Wind Power Asia 2008 in Beijing.[19] These polls helped to identify the major challenges for the wind sector's future development in China and contributed to the assessment of the current situation with regard to human resources and qualification.

2 The Global Development of Wind Power

2.1 Development of the Global Wind Power Market

2008 marked another record year for the wind industry. Worldwide installed capacity of wind power has been growing at a rate of 28% annually for the last ten years (see Figure 1). By the end of 2008, total installed capacity has reached 120.000 MW enough to satisfy the residential electricity needs of more than 150 million people.[20] 27.000 MW of wind power have been installed in 2008 alone representing a record addition of wind energy capacity, equivalent to around € 36 billion of investment and a growth rate of 36% over the previous year.

Figure 1 *Global Installed Wind Power Capacity Development*



Source: author, data from GWEC (2009), p. 10

One in every three countries derives part of its electricity from wind, with 13 countries possessing more than 1.000 MW of installed capacity.[21] Steve Sawyer, secretary general of the Global Wind

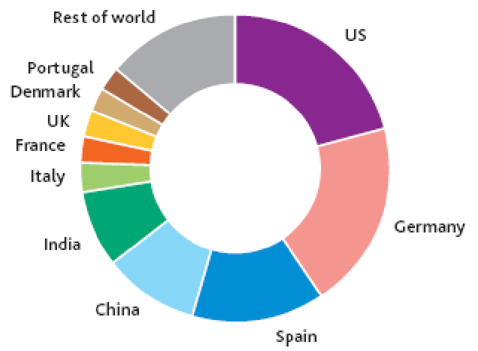
[19] For a detailed evaluation of the CEPRI and CWEA surveys as well as the two polls please refer to the annex.
[20] Dorn (2008), *online*
[21] cp. GWEC (2008), p. 1

Energy Council (GWEC), stated that by 2020 wind power could account for as much as 12% of the world's electricity needs, up from just above 1% today.[22]

The top growth markets for wind power were the USA, China and India. 2008 marks the fourth consecutive year, the USA has led the world in new installations – its 8.400 MW of newly-added capacity account for almost a third of total global additions. In total, the USA has an installed wind power capacity of 25.200 MW. Rapid wind power growth has been spurred by government support through the Production Tax Credit (PTC), worth 2 cents per kWh.[23] The USA is overtook Germany as a leader in installed capacity in 2008. However, the future of wind power in the USA – analogue to all around the globe – is heavily dependant on continued policy support.[24]

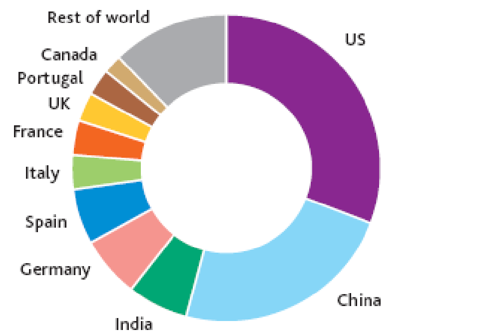
Table 1 *Global Total Installed and New Wind Power Capacity 2008*

TOP 10 TOTAL INSTALLED CAPACITY 2008



	MW	%
USA	25,170	20.8
Germany	23,903	19.8
Spain	16,754	13.9
China	12,210	10.1
India	9,645	8.0
Italy	3,736	3.1
France	3,404	2.8
UK	3,241	2.7
Denmark	3,180	2.6
Portugal	2,862	2.4
Rest of world	16,693	13.8
Total top 10	**104,104**	**86.2**
World total	**120,798**	**100.0**

TOP 10 NEW CAPACITY 2008



	MW	%
USA	8,358	30.9
China	6,300	23.3
India	1,800	6.7
Germany	1,665	6.2
Spain	1,609	5.9
Italy	1,010	3.7
France	950	3.5
UK	836	3.1
Portugal	712	2.6
Canada	526	1.9
Rest of world	3,285	12.2
Total top 10	**23,766**	**87.8**
World total	**27,051**	**100.0**

Source: GWEC (2009), p. 9

With 6.300 MW installed in 2008, China was the second largest market in terms of capacity additions of wind power, up from third in 2007. Regarding total installed capacity, with more than 12.200 MW China moved up one rank to fourth place. In spite of recent growth rates of annual installed capacity well-above 100%, wind power makes up only 0,8% of installed power generation capacity in China.[25]

[22] Reuters (2008), *online*

[23] The PTC for wind power has recently been extended for one year within the scope of the US$ 700 billion "bailout" package that was passed in the beginning of October 2008.

[24] cp. Russel (2008), *online*

[25] For details on the current status of wind power in China, please refer to chapter 5.2.

With 1.800 MW installed in 2008, India reached a total installed capacity of 9.600 MW falling from fourth to fifth place on the list of top wind power countries. Renewable energy in India lacks broad policy support. In contrast to China there is no national renewable energy law establishing targets and few economic incentives for renewable energy development.[26]

Europe installed almost 8.900 MW of wind power capacity in 2008, representing almost 33% of the total global installations. Marking a historic shift in Europe's power generation portfolio, in 2007 wind power capacity additions exceeded the additions of any other power source in Europe for the first time. In 2008 wind power accounted for more than 35% of all new power installations. Power generated from wind now makes up around 4% of Europe's electricity demand.[27] With 23.900 MW, Germany lost the position as a global leader in terms of total installed capacity (see Table 1) to the USA with 25.200 MW. In terms of newly-added capacity Germany only placed fourth behind the USA, Spain, China and India. The reasons for slowing market growth in Germany can be traced back to the saturation of suitable sites for wind power deployment onshore as well as the degression of the feed-in tariff for wind power. Wind power accounts for approximately 7% of electricity generation in Germany. Spain has witnessed a slowing of growth in installed capacity in 2008, with only 1.600 MW installed compared to 3.500 MW added in 2007, falling from second to fifth place in terms of newly installed capacity. In terms of total capacity installed Spain ranks third, while it only trails Denmark in terms of the portion of electricity generated from wind (~10%).[28]

2.2 Drivers and Trends of Wind Power Development

Drivers

Wind power is booming worldwide. Identifying the underlying drivers that triggered the boom and fuel the rapid commercialization of the wind power industry is necessary in order to steer the development and guarantee for sustained development in the long-term.

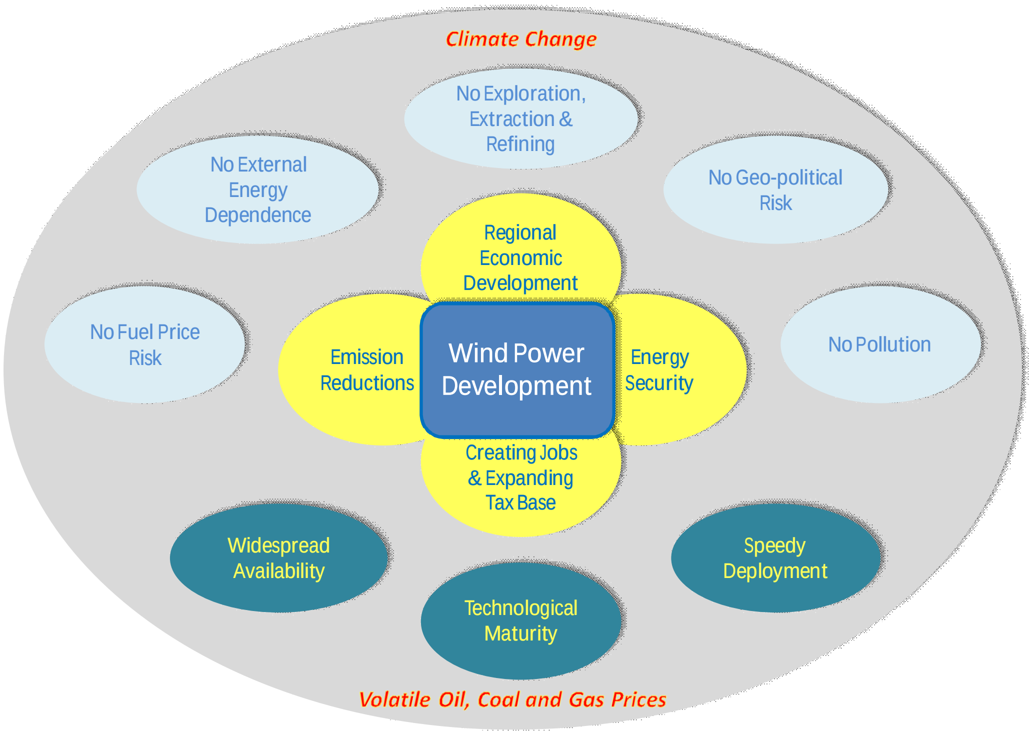
Government support has been the single most important driver of wind power development, prerequisite for fast development of wind power markets and industries worldwide. Policies in support of wind power have made the exploitation of wind resources a business with a secure and profitable return. Economic incentives, like feed-in tariffs and tax credits, attract investment in wind power projects by making them economically viable. In some cases, mandatory market share (MMS) policies forced the often oligopolistic power industry to enter a path towards diversification of energy supply. Without governmental support of wind power, the wind power industry would not have witnessed the development it has in recent years.

The year 2007 marked a decisive turning point towards support of wind power and renewable energies in general. Climate change became a major topic receiving broad media coverage and public attention. The Intergovernmental Panel on Climate Change (IPCC) stated in its' 4th report that global warming is very likely to be attributable to human influence. Together with Al Gore, distinguished for his movie about global warming "An Inconvenient Truth", the IPCC was awarded the Nobel Peace Prize for the promotion of public awareness of climate change.

[26] cp. Dorn (2008), *online*
[27] cp. Dorn (2008), *online*
[28] cp. Dorn (2008), *online*

More and more governments acknowledge climate change as one of the major challenges of the 21st century and have put the reduction of GHG emissions on the national agenda to limit its' effects. Since power generation is accounting for 41% of total energy-related emissions worldwide, increasing the share of renewable energies in the electricity generation portfolio is a major path towards lowering emissions - besides saving energy and increasing energy efficiency.[29] In March 2008, the European Union has confirmed the goal to reduce emissions by 20% by 2020 and at the same time raise the share of renewables in energy supply to 20%.[30] Air pollution and other forms of environmental degradation caused by conventional sources of energy, can be avoided through a switch to renewables. As a clean emissions-free source of energy and one of the most mature renewable energy technologies, wind power has significantly profited from increasing public awareness of climate change and is bound to profit even more as governments around the world commit to binding renewable energy targets or start to participate in emission trading systems.

Figure 2 *Drivers of Wind Power Development*



Source: author

Figure 2 illustrates the underlying arguments driving government support of wind power. There are four major drivers of wind power development: volatile fossil fuel prices, avoiding climate change and environmental degradation by reducing emissions through replacement of conventional power sources, increasing energy security through a reduction of dependence on energy imports, and last but not least the promotion of economic development through support of domestic industry, technological innovation, job creation and economic development in rural areas.

Wind power does not generate any emissions during the phase of electricity generation. Hence, wind power can significantly contribute to the improvement of environmental conditions. A switch to wind

[29] Data for 2005 from IEA (2007), p. 195

[30] The EU committed to raising its target to 30% emissions reductions if the USA and major developing countries, like India and China, also commit to significant binding targets.

power will help lower the external costs of electricity generation via replacement of conventional sources of energy. The costs of pollution to society may be reduced, mainly via reduction of air pollution. In countries like China, which depend heavily on coal for electricity generation, taking a path towards cleaner energy supply is of special importance.

Along with growing public awareness of climate change and the need to take action against it, the rising prices for oil, gas and coal have contributed to increasing the attractiveness of wind power.[31] When prices for conventional sources of energy increase, renewable energy becomes more competitive. The comparative advantage of lower costs for power generation of fossil fuels diminishes with a rise in prices of input fuels. Renewables are not dependant on the vagaries of global commodity markets, but instead rely on ubiquitous resources of natural energy. Accordingly, their prices for electricity generation, exhibit a greater stability, largely unfazed by the ups and downs on the commodity markets. Thus, an investment in indigenous renewable energy sources hedges against unpredictable fossil fuel prices. Moreover, while still well above prices for conventional energy at the moment, costs of renewables are constantly decreasing due to advances in technology and emerging economies of scale.[32]

Contrary to popular belief, wind power may even help to keep electricity prices low. In Germany, a study revealed, the more wind power is produced, the lower the wholesale electricity prices on the Leipzig Power Exchange fall. When wind is blowing strong in Germany, the most expensive power stations are shut off. The purchase of electricity from wind farms mandated by the ***Erneuerbare Energien Gesetz*** (EEG) displaces electricity generated by the most expensive power stations.[33] This is called the *merit-order effect.* According to a study by the *Fraunhofer Institute*, in the year 2006 the savings attributed to the *merit-order effect* (~ € 5 bn.) surpassed the additional costs of renewable energies (EEG costs: € 3.3 bn.) by € 1.7 billion.[34]

Renewables, like wind power, also increase energy security through reduced dependency on energy imports. Energy security is an important strategic consideration for governments, especially considering the political instability or unreliability of energy exporters like Iran or Russia. As the share of renewable energy increases, the geo-political risk of dependency on energy imports decreases. In addition, the costs for energy imports will be reduced.

The development of wind power is often accompanied by regional economic development, creating jobs and increasing tax revenue. Since wind resources are often most abundant in rural regions which are relatively underdeveloped economically, wind power deployment can contribute significantly to regional economic development. Jobs are created for skilled workers needed for planning, erection, operation and maintenance of wind farms. With proper government support, the development of a domestic wind industry can be facilitated. The wind power industry creates a range of jobs across the value chain, from assembly line workers at suppliers of wind turbine components, over engineers in research and development (R&D) at wind turbine manufacturers and scientists at research institutes

[31] Oil prices peaked at US$147.27 over worries of Iranian missile tests in July, but have declined ever since to below US$100 in September 2008. Coal prices have almost doubled in 2008.

[32] The cost of renewable energy equipment is subject to the variations in prices of the raw materials needed for their production as well as supply and demand. Still, the price sensitivity of renewables is far below conventional energy generation.

[33] cp. BWE (20 Sept. 2006), *online*

[34] cp. Sensfuß/Raugwitz (2007), p. 10 and BMU (2007), p. 41

studying grid integration, to IT-professionals working on wind resource assessment or micrositing.[35] While R&D and production expands, more tax revenues are generated through taxation of the sale of products, incomes and electricity.

The deployment of wind power does feature relatively high initial costs for planning and construction, however once the wind farm is built, power is generated without the input of fuel. Since input fuels do not have to be purchased and transported, costs and emissions are saved. There is no need for large upfront investments into exploration or extraction, like with oil, gas and coal. Of course, wind resource assessments and studies on grid integration have to be made in order to ensure selection of adequate sites and proper reception of wind-generated electricity into the regional grid. The costs for connecting wind power to the grid are sometimes substantial, but tend to be significantly lower than construction of the infrastructure necessary for conventional fuels, e.g. building an oil pipeline.

Another important driver for wind power development is the constantly rising energy demand requiring the continuous expansion of power generation capacity worldwide. Traditional thermal (coal-fired) power plants usually have a running time of 50 years or more. Building a thermal power plant today, is thus determining the mode of electricity production for a generation to come. This fact, also referred to as technological *lock-in effect*, stresses the importance of todays' actions for the composition of future energy supply. In view of rising energy demand, wind power provides a viable alternative source of power to avoid the *lock-in effect* of conventional power generation technologies. The deployment of wind power today, is a step towards sustainable power generation for the future and will contribute to the lowering of emissions.

Trends

Rising prices of coal, gas and oil as well as governmental support have increased the relative competitiveness of wind power and made investment in wind power projects and the wind industry more profitable. However, in cases where government support of wind power remains steady as rising fuel costs drive up wholesale electricity prices, the premium of wind power development actually decreases. External costs of traditional sources of power generation, mainly in the shape of costs of environmental pollution and increased costs to society's health care, are not figured into wholesale power prices in absence of a global emissions trading system. Wind power on the other hand is almost emissions-free with no significant external costs. The increase of the share of wind power in the power mix, may even contribute to lowering electricity prices adding to the net benefit of wind power to society as a whole. Yet, these considerations are not part of the equation of the individual investor considering the diminishing profitability of an investment in wind power project development. Therefore, paradoxically the rise in fuel prices is also putting pressure on wind power companies along the value chain if government support schemes are not adjusted. Take the feed-in tariff in Germany for example: It provides a fixed feed-in tariff of € 9,25 cents for the first five years of operation, this initial tariff is then replaced by a lower tariff. When fuel prices rise, the wholesale electricity price increases. If government support of wind power remains the same, the advantage in profitability of wind power in comparison to conventional power decreases.

In 2007, the global wind industry has made important steps on its path to globalisation. The rapid expansion of wind power markets worldwide, especially in the USA, Spain and China, was accompanied by large investments in build-up of production capacities and project development

[35] Micrositing refers to the placement of individual wind turbine generators within a wind farm.

around the world. GWEC asserted at the beginning of 2007: *"Experts predict that there is no end in sight for this boom."*[36] The continued rapid growth of demand for wind power has surpassed any expectations and thereby created a sellers' market with demand outstripping the available supply of wind turbines by far. Especially, component suppliers have not been able to manufacture in sufficient quantities. The explosion in demand for wind turbines as well as increases in turbine size coupled with pressures in the global machine tools industry, have created intense supply-chain difficulties. This development translates into rising turbine prices and an increasing order backlog of up to three years for wind turbine manufacturers. In addition to demand and supply imbalances, higher prices of commodities needed for wind turbine production (e.g. steel, copper and carbon fibre) drive the increase in turbine prices. For project developers, the bottleneck in turbine supply has increased capital costs and made long-term equipment purchase arrangements necessary in order to enable timely project realisation.

Along with heavy expansion of production capacity of traditional wind turbine manufacturers, rapid market growth has also attracted companies outside the wind industry to enter the wind power business. Especially in China, large enterprises, e.g. from the heavy machinery and electric power equipment industry, and even power generation companies are starting wind turbine manufacturing enterprises in order to participate in the booming market.

The types of companies developing and owning wind farms is also changing – from relatively small, specialized independent project developers towards utilities, large independent power producers (IPPs) and multinational oil companies. The trend points to greater market consolidation, with big utilities and large IPPs increasing the share of wind power in their portfolio through acquisition of smaller project developers. Power generation companies, as well as institutional and private investors are increasingly looking to wind power as a promising investment with secure and profitable returns.[37]

In the mid-term the wind power market is moving from a sellers' to a buyers' market. While the market situation has been characterized by supply-chain constraints, long wind turbine delivery lead times and an abundance of funds in the past, in face of the global financial crisis and the expansion of manufacturing capacity the market is expected to consolidate further in future. A turbine surplus is expected as early as 2010, the availability of financing will be constrained and focus on quality projects and turbines will increase.[38]

3 The GTZ China Wind Power Project

As mentioned in the introductory remarks, the GTZ China Wind Power Project strives to improve the "*technical capabilities of private and state institutions for the nationwide development of grid-bound wind energy use"*.[39] The project was started in April 2005 and is scheduled to run through February 2010 with a funding of € 5 million from the German Ministry of Economic Cooperation and Development (BMZ). At the outset of the project, the lack of qualified technical personnel and managers with expertise in the wind energy sector has been identified as one of the core problems to be addressed by project activities. In addition, a stated goal of the project is to promote the sustained

[36] cp. REN21 (2008), p. 18
[37] cp. GWEC (2008), p. 2
[38] cp. New Energy Finance (2008), *presentation* held at Global Wind Power 2008, Beijing
[39] Neubauer (2008), p. 3

development of the Chinese wind power sector by enhancing the capacity of domestic institutes and organizations with regard to the establishment of technical guidelines and standards as well as regulatory framework. A third objective, influencing government agencies towards the establishment of a renewable energy policy framework conducive to the development of wind power was in part accomplished, when the Renewable Energy Law was introduced.

In order to achieve these goals, CWPP cooperates with two partners or implementing organisations: China Longyuan Power Group (CLYPG), the nation's leading wind power developer and a subsidiary of Guodian, one of the five big power generation companies[40], and the Chinese Electric Power Research Institute (CEPRI), a leading academic institution providing research and services for the power sector, affiliated with the bigger of the two national grid companies State Grid Corporation of China.

The cooperation with CEPRI is focussing on capacity building with regard to research, consultancy and technical services facilitating the development of wind power in China. As a result of project activities, the Renewable Energy Department (RED) was established at CEPRI in 2006, which has since developed into a principal institution in the field of wind power research and services. CWPP supports the RED with respect to capacity building in the field of wind resource measurement, micrositing, wind turbine testing and grid integration of wind power. The support includes financial backing of the purchase of equipment for testing and other purposes, software localization and training, as well as support in improving capabilities with regard to technical consulting and services.

Main groups calling upon CEPRI's expertise for technical support and advice are wind farm developers, grid operators on provincial level, wind turbine manufacturers as well as government agencies. RED is consistently engaged in consultancy services for wind farm planning and output calculation as well as diverse research projects, e.g. concerning the testing of wind turbines with "low voltage ride-through" capability.[41] Moreover, CEPRI took over the distribution and support of two kinds of wind resource assessment software used for wind farm planning. In cooperation with CLYPG, RED is currently conducting a project to develop recommendations on how China's specific climatic and geographical conditions affect the deployment of wind power. In summary, it can be asserted that CEPRI's RED has garnered recognition throughout the Chinese wind power sector and is accepted as a leading institution in the field. To cope with demand for its services the number of staff was increased from 8 to more than 20 employees.[42]

To improve the situation with regard to much-needed technical wind power training, CWPP established a training centre together with CLYPG. Located in Suzhou, the Suzhou Training Centre of CWPP, also known as Suzhou Longyuan Bailu Wind Power Vocational Training Center, offers training for technical as well as executive personnel in the wind industry. The training courses focus on imparting practical knowledge in a variety of areas: from long-term courses (two to three months) on basic wind power knowledge for recent graduates aiming at operation and maintenance technicians, to short-term seminars (two to four days) on wind resource assessment, wind farm planning, construction management or wind turbine design primarily directed at development engineers and

[40] Also known as "*the Big Five*": Huaneng Power Group Corp., Datang (Group) Corp., Huadian Corp., Guodian (Group) Corp., China Power Investment Corp.

[41] Fault ride-through capability enables wind turbines to continue delivering electricity to the grid in spite of temporary grid defects, instead of shutting off the turbine - and essentially the wind farm altogether.

[42] GTZ Projektfortschrittsbericht (2008), p. 3

management personnel. The training activities of the CWPP Suzhou Training Centre have been well-received, mainly by project developers, but also by wind turbine manufacturers. The operation and maintenance staff and safety training was certified by the China Electricity Council (CEC) and the current progress indicates that activities are underway of exceeding the targets set at project inception (see Table 2). However, in face of the enormous boom in the Chinese wind power sector since the original project planning, the training activities in Suzhou are only a drop in the ocean considering the demand.[43]

Table 2 *Participants in CWPP Advanced Training*

Target Groups	2005	2006	2007	2008	Total	Target 2010
Technicians	0	0	128	266	394	200
Wind Farm Operators			111	198	309	
Turbine Manufacturers			17	68	85	
Management Personnel	11	0	20	43	74	60
Engineers / Scientists	127	258	178	240	803	100
Wind Farm Developers / Investors	10	10	7	16	43	40
In Total	*148*	*268*	*333*	*565*	*1314*	*400*

Source: GTZ (2009), p. 8

The lack of qualified personnel seriously impairs the development of the industry leading to reduced performance in research, planning and manufacturing processes. A wide array of problems may arise or intensify if this issue is not addressed properly: erroneous wind resource assessment and micrositing may reduce wind farm performance, faulty wind turbine design or inadequate wind turbine testing may result in low-quality or even defective turbines, flaws in turbine erection and wind farm construction may cause safety risks and affect reliability, sub-par condition monitoring may drive up maintenance costs and reduces wind turbine availability, etc. The outcome: underperforming wind farms with electricity outputs not living up to expectations and revenues failing to recoup investment costs. If actions to prevent this development are not taken, the trust in wind power technology in general may be seriously undermined. Since the domestic industry in China, for the most part, relies on technology licensed or bought from overseas companies, occurring problems might cast a shade on foreign technology in particular. To avoid those pitfalls, the CWPP training activities are essential and have to be reviewed with regard to scope and content in order to be subsequently adapted to the current market situation.

[43] cp. GTZ Projektfortschrittsbericht (2008), p. 3

4 Energy Policy in China

4.1 Energy Supply and Demand

The fast pace of economic growth has made China a major player on the global energy market. In 2007, China ranked second in terms of energy consumption behind the United States, set to become the world's largest energy consumer by 2010.[44] In face of this enormous demand for energy, China is in need of affordable, secure and environmentally sustainable sources of energy for its 1.3 billion people. Since China is no longer self-sufficient in meeting national energy needs[45], China's energy footprint will have a direct impact on energy markets around the world. In addition, the pattern of energy demand, generation and consumption has major implications for the local and global environment. Consequently, Chinas' energy future will affect economies and the environment around the world.

At the end of the 1970s Deng Xiaoping started a process of economic reform through the promotion of "Socialism with Chinese characteristics". The introduction of a socialist market economy helped spur economic development and modernize the country. Since 1980 GDP growth has averaged a striking 9.8% per year, accelerating to around 11% in 2006 and 2007. Main drivers of growth were market liberalisation, reform of state enterprises and later-on the accession to the WTO. The acceptance into the WTO in 2001 facilitated Chinas' integration into the global economy. In 2007 China was the top recipient of foreign direct investment (FDI) and the third-largest trader worldwide. Domestic consumption and investment in conjunction with the relocation of manufacturing processes from other countries to China have spurred the production of energy-intensive goods.

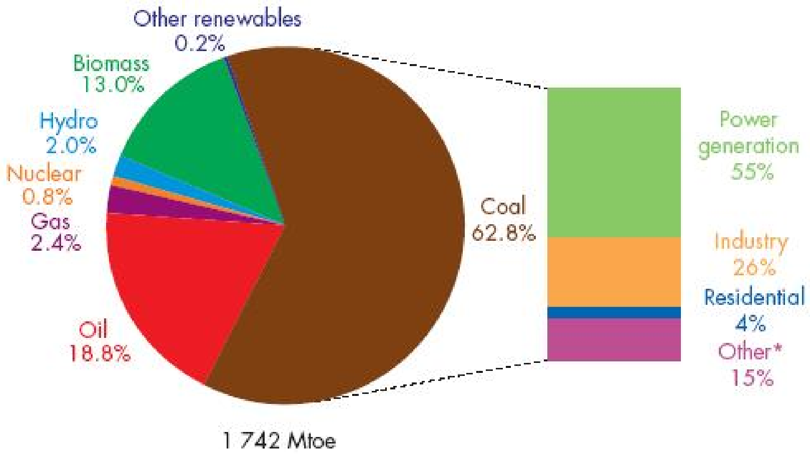
The main source of economic growth is the industrial sector, heavy industry in particular. The chemical industry, industrial output of manufactured goods for export and domestic markets as well as the production of iron, steel and building materials for domestic use are constantly growing. While China was able to meet its energy needs entirely from domestic sources for many years, today it is increasingly relying on energy imports raising national concern about supply security.

Primary Energy - Supply and Demand

In the period from 2005 to 2030, China's primary energy demand is expected to more than double according to the International Energy Agency (IEA). In order to fulfil its energy needs China relies heavily on coal. Of the total primary energy demand more than 60% are met by coal (2005), followed by oil and biomass (see Figure 3).[46] Despite its vast coal resources, in 2007 China became a net coal importer for the first time in order to satisfy demand. The share of coal of primary energy demand is expected to remain steady around 60% until 2030 according to the reference scenario of IEA projections.[47] The reliance on resource-intensive industries as a driver of economic growth leads to an insatiable demand for energy and severe environmental problems. Even more so, since the lion's share of energy demand in China is satisfied from coal.

[44] IEA (2007), p. 261
[45] In 2006, China was the world's third largest oil importer after the USA and Japan. In addition, China has started to import natural gas, and in 2007 became a net importer of coal. (cp. IEA (2007), p. 261)
[46] mostly traditional biomass used for heating and cooking in rural households
[47] IEA (2007), p. 283 et seqq.

Figure 3 *Total Primary Energy Demand in China 2005*



Source: IEA (2007), p. 262

The replacement of old fossil fuel power plants by more efficient super- and ultra critical power plants may help to reduce the environmental impact.[48] The use of carbon capture and storage (CCS) technology, which is currently under development, may be an option to minimize emissions in the long-term. Nevertheless, the projected increase in energy demand will inescapably be accompanied by a further surge in emissions. Since per-capita emissions are still much lower than those in the USA or OECD, China sees the industrial nations in the responsibility to lower emissions first, allowing for China to catch up to their economic development.

Electricity Generation - Supply and Demand

Increasing demand for electricity is one of the major drivers of the surge in primary energy demand. China had a power generation capacity of 713 GW in 2007 which is characterized by a heavy dependence on coal (see Table 3).[49] 554 GW of installed capacity, representing 82.9% of the power generated, were attributable to coal-fired power plants.

Table 3 *Sources of Power Generation in China 2007*

	Installed Capacity		Power Generation	
	GW	%	TWh	%
Thermal (Coal)	554,0	77,6	2.698,0	82,9
Hydro	145,0	20,3	486,7	15,0
Nuclear	8,8	1,2	62,6	1,9
Wind	*5,9*	*0,8*	*5,6*	*0,2*
Others			3,0	0,1
Total	713,7	100	3.252,9	100

Source: adapted from Shi (2008b), p. 1

Hydro power is the second biggest source of electricity and with 15.0% makes up a significant portion of power generation. Nuclear energy accounted for 1.9% of the electricity. As the most significant of

[48] While subcritical fossil fuel power plants operate at an efficiency of 36 to 40%, supercritical and ultra critical designs achieve efficiencies of up to 48%.

[49] In comparison, Germany possessed only a fifth of China's electricity generation capacity in 2007 (138 GW), with 38% or 52 GW coal-fired power generation capacity. Cp. BMWi, Energiedaten Tabelle 22, *online*

renewable energies after hydro power, wind power contributed only a relatively small amount of electricity. With 5.9 GW or 0.8% of power generation capacity, the electricity generated by wind power amounted to a mere 0.2% of the total power generated.

In 2006 and 2007 around 100 GW of power generation capacity were added per year, with most of the capacity increases in form of thermal power plants. In 2007 alone, 88 GW of coal-fired power plants were built; i.e. China installed more coal-fired power plants in a year than the total power generation capacity of the United Kingdom.[50] Considering the share of coal in its power generation profile it comes as no surprise that China has recently become the worlds' largest emitter of carbon dioxide. 20 of the world's 30 most polluted cities are located in China. Environmental pollution and related detrimental effects on people's health are causing huge costs to society - air pollution is estimated to cost China from 3 to 7% of GDP annually.[51]

The recent financial crisis on the American financial markets is affecting economies around the globe. As liquidity in the markets dries up and consumer confidence deteriorates, China will feel the effects of the global economic downturn. Officially, exports made up close to 40% of GDP in 2007. This would suggest that China is hit especially hard by a global economic slump. However, according to estimates by Swiss bank UBS the "true" export share of GDP is just under 10% of GDP.[52] On that account, and due to strong domestic demand China's economy is likely to be less affected by the financial crisis as commonly expected. Nevertheless, after five years of double-digit growth, for 2008 economic growth is expected to be in the single digits. Since exports account for as much as 28% of its energy consumption (2004), the growth of energy demand in China is likely to slow down as well.[53]

The Chinese government is searching for ways to secure its' energy supply, while providing for sustainable development, avoiding social unrest and maintaining strategic independence. Already, mismatches between energy supply and demand have led to power shortages in part of the country.[54] Sharply rising energy imports have prompted China to reach out to African countries rich in energy resources in order to secure energy supply.[55] China is also promoting structural adjustment by increased efforts to curb investment in overheated sectors and to cut energy intensity. In addition, the diversification of energy supply has recently become a stated goal of Chinese energy policy, signified by increased policy support of nuclear and renewable energy. The implementation of the ***Renewable Energy Law*** in 2006 has manifested the Chinese governments' commitment to the development of renewable energies as part of its' energy strategy and triggered a boom in renewable energy, especially in wind power.

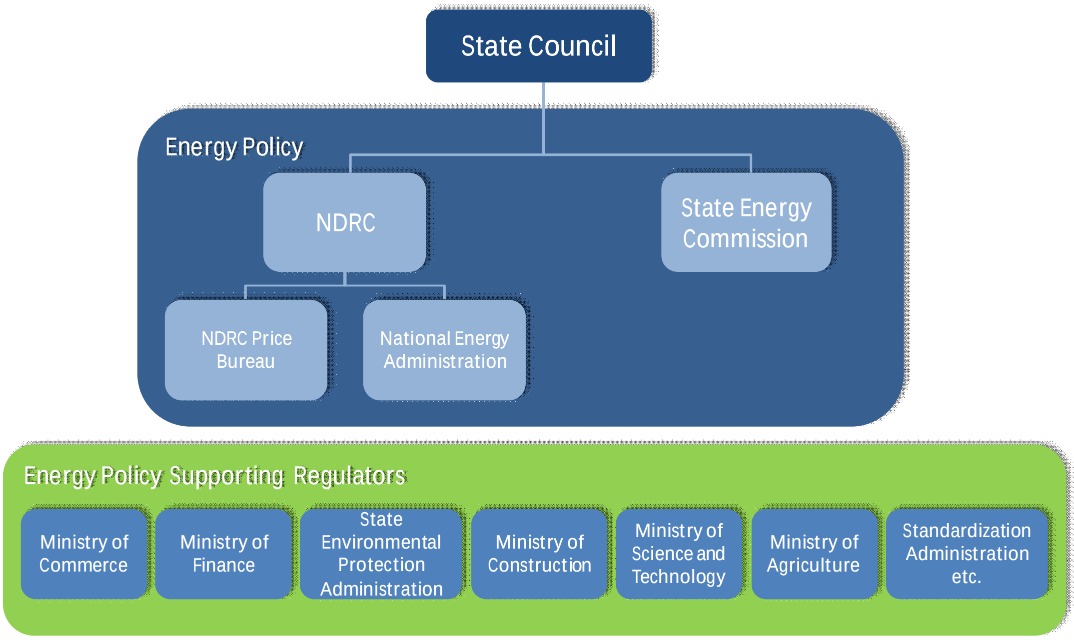
[50] cp. Heinberg (2008), *online*
[51] cp. IEA (2007), p. 252
[52] Jonathan Anderson, an economist at UBS, argues since exports are measured in gross revenue and GDP in value-added terms they are not comparable. In order to measure exports in value-added terms, Anderson strips out imported components and converts the remaining domestic content into value-added terms by subtracting inputs purchased from other domestic sectors. With these adjustments the effective share of exports amounts to 10% of GDP. Cp. Economist.com (2008), *online*
[53] cp. IEA (2007), p. 290
[54] Energy shortages are mainly attributed to higher than expected industrial growth, deficiencies in the national power grid as well as imperfect planning of expansion of power generation capacity, in part due to conflicts arising from the mixture of market-based fossil fuel pricing and government-guided electricity pricing.
[55] One third of China's oil imports in 2006 stemmed from Africa (for the most part from Angola, Equatorial Guinea, Nigeria, the Republic of Congo, and Sudan).

4.2 Relevant Players in Energy Policy Making

The Chinese power sector has undergone a gradual reform process since the mid-1980s. In 2002, an important move has been made with the reform of the structure and ownership of China's power markets. The State Power Corporation was disintegrated and its assets distributed among two grid companies and five power generation companies. The separation of power generation from the grid (transmission & distribution) aims at improving operational efficiency and lowering prices, taking advantage of market forces to profit from more efficient allocation of resources.[56] As a result of this reform, five big state-owned power generation companies are dominating the power sector to this day. As powerful, relatively autonomous players with full or vice-ministerial rank, they are able to influence government energy policy directly. As the influence of market forces on China's electricity sector remains limited, supply and demand imbalances persist with power shortages and overcapacity alternating in boom and bust cycles.

As the power sector was restructured, China's energy policymaking apparatus has also been subject to frequent discussion and reorganization. In March 2008, the National People's Congress resolved upon the latest institutional reform of energy governance (see Figure 4). In future, energy policy will be guided by the State Energy Commission (SEC), a high-level strategy and coordination board, and the National Energy Administration (NEA), a vice-ministerial body under the National Development and Reform Commission (NDRC).

Figure 4 *Major Players in Energy Policymaking in China*



Source: author

The SEC, replacing the National Energy Leading Group, will be in charge of the national energy development strategy, energy security and overall strategic oversight. The NEA, the successor to the Energy Bureau, will deal with the drafting of plans and policies, as well as their implementation, supervision and administration. In addition, the NEA has a mandate to negotiate with international

56 OECD/IEA (2006), p. 33 et seqq.

energy agencies and approve foreign energy investments.[57] Specific regulations in support of energy policy are issued by a host of respective ministries. The provincial level authorities are responsible for the execution, administration and monitoring of national policies on provincial level, with autonomous regulatory power over certain projects.[58]

Although the establishment of the NEA is a step towards integration of the fragmented energy policymaking apparatus, the NEA lacks the autonomy, authority and resources (especially manpower) necessary to tackle the challenges China faces in the energy sector. Most importantly, the NEA can make recommendations, but has no authority over energy pricing. Since the setting of energy prices is one of the major instruments of macroeconomic control, it is not surprising that NDRC and ultimately the State Council retain that power. Opposition to a more powerful "Ministry of Energy" was strong, from both NDRC, fighting to keep control over power pricing, and the big power generation companies, who do not want to relinquish their current influence on the government and fear stricter regulation. As a consequence, energy policymaking will continue to be limited by a series of factors: *"conflicts of interest will impede decision-making; the energy companies will remain important drivers of projects and policies; state-set energy prices will continue to contribute to periodic domestic energy supply shortfalls; and the NEA, with no authority to adjust energy prices, probably will resort to "second best" administrative measures to try to eradicate those shortages"*.[59] In absence of market price signals, NDRC attempts to accurately forecast demand, approve new generation capacity accordingly and adjust prices to keep profits within a reasonable range. Unfortunately, this approach has resulted in a volatile power sector, swinging between power shortages and supply surpluses.[60]

4.3 Renewable Energy and Wind Power Policy

In recent years, China went from a country primarily looking to coal-fired power plants for electricity generation to one of the world's foremost advocates of renewable energy. Through swift and resolute policy action China managed to create a burgeoning market for renewable energy as well as a thriving domestic renewable energy industry. Looking at the enormous amount of thermal power generation capacity additions necessary each year to satisfy the rapidly increasing energy demand, the present boom of renewables in China may only seem like a drop in the ocean. Nevertheless, government policy support has initiated a development opening up the path towards a sustainable energy future for China.

It was only four years ago, at a renewable energy conference in Germany, that China announced the ambitious goal of generating 16% of its energy from renewables by 2020. Since then, through the implementation of a series of policy measures, renewable energy deployment has gathered momentum, triggering a boom in the renewable energy sector in China unimaginable in 2004. By pushing the major players in the power sector towards renewable energy development via government targets and mandatory market share requirements for renewables and pulling investors to investment in project development and the domestic renewable energy industry by installing a series of economic incentives

[57] cp. Dows (2008), *online*

[58] With regard to the wind power sector provincial authorities are in charge of approval and regulation of wind farms with a capacity of less than 50 MW.

[59] Dows (2008), *online*

[60] cp. Rosen/Houser (2007), p. 26

the government created a billion dollar market for renewable energies in general, and wind power in particular.

The Chinese market for new renewable energy capacity was worth US$ 12 billion in 2007, equal to 20% of the worldwide investments just behind world leader Germany who invested US$ 14 billion. The investment needed to accomplish China's 2020 renewable energy development goals is estimated at a staggering US$ 268 billion.[61] The biggest share, US$ 91,1 billion representing 34% of renewable investment, is expected to be invested in new wind power installations. Actual investment figures may even be bigger, since these numbers do not include investment in new manufacturing capacity, R&D spending or government subsidies.[62]

4.3.1 The Concession Programme and Origins of Wind Power Pricing

One of the most influential determinants of wind power development in China is the wind power tariff or pricing system. Development of wind power pricing can be divided into three distinct phases. During the first phase from the late 1980s to the late 1990s, wind power project development was for the most part funded by overseas donors (international assistance funds) with very low electricity tariffs of less than 0,3 yuan/kWh, comparable to coal-fired plants, barely covering maintenance costs. The second phase, from late 1990s to 2002, was characterized by local governments determining the tariff, which was then approved by central government, with prices varying widely from very low up to generous 1,2 yuan/kWh. In the third phase, from 2003 up until now, wind power prices for national concession projects are decided by competitive bidding.[63] Today, tender-based pricing as well as an "approved price", decided directly by the government, are applied. Provincial authorities are responsible for projects of less than 50 MW capacity (pending verification by NDRC), while for wind farms with a capacity above 50 MW, NDRC is in charge of the approval process.[64] The pricing regime and the allocation of project development rights have been criticised by project developers and wind turbine manufacturers as opaque, due to a lack of transparency in permission and negotiation processes.

The concessionary approach to wind power development was adopted since wind power was not able to compete with coal power due to high costs. Financial viability of wind farms suffered from small project sizes and a lack of economies of scale. The domestic wind industry was small without the capacity to manufacture large MW-scale turbines. Moreover, difficulties in obtaining connection to the power grid hindered project development.[65]

In 2002, the Chinese government sought to stimulate the development of wind power in China by initiating the national wind concession programme. Under the concession programme the right to build wind farms in certain sites, selected by the NDRC, is allocated through a bidding process with the lowest electricity tariff winning the bid. The main objectives of the concessionary approach to wind power development are: promoting larger project sizes, support of the evolution of the domestic wind industry, realizing economies of scale and as a consequence driving down the cost of wind power.

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[61] For details on China's renewable energy targets, please refer to chapter 4.3.2.
[62] cp. The Climate Group (2008), p. 25 et seqq., *New Energy Finance* estimates (excl. large hydro)
[63] cp. Li et al. (2006), p. 3 et seqq.
[64] For more information on wind power pricing, also see Chapter 4.3.2.
[65] Shi (2006), *presentation* held at the Great Wall Renewable Energy Forum

The government stipulated a number of features for concession projects: The project size was determined to be least 100 MW. Contracts have a duration of 25 years. The government guarantees a fixed price (feed-in tariff) for the first 30.000 hours of full operation; subsequently the average local electricity price is adopted. The grid company is mandated to provide for the grid-connection of the wind farm and purchase all electricity generated. The difference between the wind power price and the conventional power price is shared across the national grid (until 2006 across the provincial grid). The provincial government conducts pre-preparation work (wind resource assessment, site selection, land rent etc.) and is responsible for the road access to wind farms. A minimum turbine capacity of 750kW (until 2006 600KW), a 70% local content requirement (until 2004 50%) and assembly in China are mandatory. The 70% localization rate has been extended to non-concession wind power projects in 2005.[66] Since 2006, the bidders have to specify the wind turbine manufacturer in project application.[67]

A batch of two to four concession projects are put out for tender on an annual basis. Five rounds of concessions - one every year - have been conducted so far, accounting for almost 3,4 GW, equivalent to 60% of total installed wind power capacity until the end of 2007.[68] Results of the sixth concession conducted in 2008 are still pending. The wind power concession programme has been largely successful at promoting the development of the domestic wind industry, creating a sizable demand for wind turbines with a high localisation rate[69], thereby enabling cost reductions at manufacturers through economies of scale. A multitude of domestic wind turbine manufacturers are emerging supported by a host of wind turbine component manufacturers. In addition, the goal of increasing project size was achieved with the average total capacity of wind farms increasing from 14,6 MW at the end of 2002 to 37,4 MW by the end of 2007.

On the other hand, the provision that the lowest bid wins, resulted in bidders engaging in detrimental price competition. Investors either overstated wind resources and electricity output or underestimated wind equipment and maintenance costs, so that electricity prices calculated in the feasibility studies were on the low side. While calculation of prices is based on standard operation of mature wind turbine models, the domestically manufactured turbines are regularly not sufficiently tested and have to be troubleshooted and improved as a result of operational experience. This has resulted in a swath of largely unprofitable wind farms, with a considerable number of winning tariff bids too low to recover capital costs. One expert on the concession programme has stated that *"all the projects authorized so far [through 2006] will suffer a net loss"*.[70]

Therefore, the concession programme is dominated by large state-owned power generation companies with strong financial backing able to cross-subsidise the wind concessions through revenues from profitable thermal or hydro power plants. Drivers for the power generation companies to invest in wind power in spite of low returns are often of political nature, e.g. fulfilling mandatory market share requirements, promoting a good image through clean energy development or enhancing government *guanxi*.[71] Another motive is securing sites with rich wind resources in order to win control over the

[66] cp. Baker & McKenzie (2007), p. 39
[67] cp. Li et al. (2007), p. 8
[68] Not all of the 3,4 GW capacity is directly attributable to allocation through tenders. In some cases, when scale and wind resources of the development area allowed for it, after negotiations, NDRC authorized additional projects of the same scale, conditions and bidding price as the winning bid.
[69] Some wind turbine manufacturers have been known for circumventing the localisation rate of wind turbine generators in lack of a proper monitoring mechanism, simply re-labeling imported components.
[70] cp. Li et al. (2006/2008), *Executive Summary*/p. 8
[71] guanxi (关系) = network of relationships

resources or speculate with the rights for project development. Looking at project implementation of the second through fourth concession round (2004-2006), only 28% of planned capacity had been installed until 2007, suggesting that investors are focussing on acquisition of project development rights ahead of project profitability.[72]

In contrast to other investors, the big power companies benefit from close ties with China's state banks, enabling them to secure loans in spite of questionable profitability of projects. Some companies have gained an unfair advantage by exploiting a loophole in the Chinese tax code, in order to avoid VAT and reduce income tax. Projects with a share of over 25% foreign investment are eligible for a full VAT refund on fixed asset purchases. Unfortunately, this measure has not been able to attract foreign investors as originally intended, but was taken advantage of by domestic companies by establishing joint ventures registered abroad.[73]

Small and medium-size developers have been discouraged by the costs of the bidding process, which can easily run into tens of millions of yuan, e.g. for preparing the bidding documents and conducting feasibility studies. Likewise, private and foreign investors have been deterred from participation in the concession programme by high transaction costs and unreasonable returns. Thus, the concession programme has not been able to diversify sources of investment, but added to the dominance of the big power companies instead.[74]

Another downside of the concessionary programme is that wind electricity tariffs determined in concessions, exerted intense pressure on project developers and wind turbine manufacturers to reduce costs wherever possible. Up until now, no distinct study on the performance of national concession projects exists and data collection on the electricity output and availability of wind turbines of wind farms is generally difficult. Persons in charge at project developers, power generation companies and wind turbine manufacturers are reluctant to give out information in fear of loosing face, damaging *guanxi* or endangering their own position. Nevertheless, the strong pressure to drive down project costs almost certainly has an impact on wind farm performance.[75] Project developers pressured to reduce costs may cut expenditures for planning and construction, while wind turbine manufacturers may choose to use less expensive components or raw materials and have less money to invest into research and development. In the end, once in operation wind farm performance consequently suffers from the use of low-quality equipment, potential lower efficiency of wind turbine operation or even wind turbine collapse. In some cases, the provision of inaccurate wind resource assessment data by government authorities may have added to this effect. Unprofitable projects generate fewer taxes and as a consequence do not contribute significantly to local economic development. If profits for provincial governments fail to materialize, willingness of government officials to support future wind power development may deteriorate.

The negative impacts of the concessionary pricing policy have not gone unnoticed. Thus, the criteria for the awarding of concession projects were continuously revised since 2005. While the lowest bid won the concession in the beginning, the weighting of price as the determining factor was reduced to 40% in 2005 and 25% in 2006. Factors like local manufacturing content, technical competence and financing capacity gained in importance. Since these measures did not significantly improve the

[72] cp. Suzlon (2008), *presentation* held at the Renewable Energy Finance Forum
[73] *Personal communication* with Prof. Dai Huizhu, Senior Advisor, Chinese Electric Power Research Institute
[74] cp. Li et al. (2006), p. 27/58
[75] On wind farm performance, please also see chapter 6.4.

situation with regard to project profitability, by the fifth round *"in 2007 the winning criterion was set as the bid closest to the average bidding price, excluding the highest and the lowest bid"*.[76] As a consequence, the average electricity tariff of concession projects rose above 0,5 yuan/kWh for the first time since the concession programme was started. The average tariff increased by 0,0637 yuan/kWh compared to 2006 (to 0,5253 yuan/kWh).[77]

While the concessionary programme is commended for jumpstarting the Chinese wind turbine industry, the flawed pricing policy, at least in the first four rounds of the programme, induced high cost pressure and added to the dominance of unsound motives in investment decisions. An adverse long-term effect on wind farm performance and the manufacturing capability of the domestic wind industry may be the result. It remains to be seen, how the recent revision of bidding criteria influences wind electricity prices in the long run, and how project performance of already awarded concessions turns out with respect to financial conditions, annual electricity sales and wind turbine performance after a couple of years.[78] While the tender-based wind power pricing mechanism is supposed to provide a basis for fair competition, it has proven to be a flawed pricing instrument in the Chinese market environment. Essentially, the government is taking the role of the regulator as well as the implementer at the same time, with the state organizing a bidding for state-owned power generation companies. This makes a fair commercial bidding virtually impossible.[79]

4.3.2 The Renewable Energy Law

The *Renewable Energy Law*, enacted in February 2005, came into effect on 1 January 2006. One of the main objectives of the law was to attract stakeholder interest in the Chinese renewable energy sector. Sending out a clear signal of the Chinese government's commitment to renewable energy development by establishing favourable investment conditions and a stable market for renewable energy, the *Renewable Energy Law* aims to increase the share of renewables in China's power mix, promote the domestic renewable energy industry, and support regional economic development.[80]

The *Renewable Energy Law* does not in itself promulgate binding renewable energy development targets or economic incentives, but instead serves as a framework law designating responsible government authorities, on national and provincial level, to draft renewable energy development and utilization plans as well as supporting legislation. NDRC is in charge of energy pricing and planning issues, the Standardization Administration of China administers technical standards and codes related to renewable energy projects, the Ministry of Finance is responsible for economic incentive mechanisms, like tax breaks, and government financial support of renewable energy in form of subsidised loans and research and development encouragement. In line with Chinese legislatory practice, the law is purposely vague in its stipulations, serving as an umbrella document providing an outline of general principles to be clarified in subsequently released "implementing regulations". This approach allows for high flexibility of the regulatory framework, since the implementing regulations are easily revised to improve effectiveness and reflect market conditions.[81]

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[76] Li et al. (2007), p. 8
[77] cp. CWEA (2008), *presentation*
[78] cp. Li et al. (2007), p. 8
[79] cp. Liu (2006), *online*
[80] cp. Baker & McKenzie (2007), p. 10 et seqq.
[81] cp. Baker & McKenzie (2007), p. 12

While broad in language, the *Renewable Energy Law* does include a number of supporting measures crucial to the creation of a favourable market environment for renewable energy. Power grid companies are obliged to connect all licensed renewable energy projects to the grid and purchase the energy generated within their power grid. The expenses for grid connection as well as the excess cost of renewable energy compared to conventional power can be (partially) retrieved via a renewable energy surcharge on the electricity price (also known as renewable energy premium).[82] The burden of the renewable energy surcharge is shared across all electricity consumers, with the exemption of agricultural communities and other low-income administrative divisions.[83]

Wind Power Pricing under the Renewable Energy Law

The *Renewable Energy Law* stipulates that feed-in tariffs for renewable energy are to be determined by the price management department of NDRC according to type of renewable energy and specific regional conditions. Moreover, the price setting shall be favourable to renewable energy development and guarantee economic viability, i.e. the return on investment of renewable energy projects should be higher than the average return on investment of conventional power projects. Drafts of the *Renewable Energy Law* included a fixed feed-in tariff for wind power based on the price of coal-fired electricity plus a subsidy. This type of pricing mechanism has been much anticipated by investors, since it would create a clear and stable framework for wind power investment, providing a sound basis for planning and calculation of projects. As it turned out, the government decided to rely on a different mechanism for wind power pricing based on the experiences of the concession programme.

In January 2006, a directive pertaining to wind power pricing was issued, imposing the following principle: "*The grid-connected power price of wind power projects will be determined by government guided pricing, the standard of which is set by the responsible pricing department of the State Council in accordance with the price selected through a public request for tenders.*"[84] Modelled after the practice of the concession programme, the government conducts public biddings for wind power projects in order to determine the wind electricity price and select the project developer. The tender-based mode of pricing under government supervision aims at determining the wind power price levels appropriate for different regions, accounting for distinctive local circumstances with regard to wind resources and geographical conditions.

In another implementing regulation, the responsibilities for reviewing and approving wind power projects are divided among NDRC and Provincial Development and Reform Commissions (PDRC): wind power projects with an installed capacity of at least 50 MW need NDRC approval, while smaller projects can be approved by provincial authorities, but still need verification by the NDRC pricing bureau.[85] Following this, tenders based on the same principles as the concession programme were conducted on provincial level. According to GWEC, these provincial level tenders account for 3.000 MW of project development.[86] In addition, some wind power projects are implemented based on government approval without a bidding being held. These projects are sometimes politically motivated

[82] The tax-exempt renewable energy surcharge has been set at 0.001 yuan/kWh, raised to 0.002 yuan/kWh in 2008. cp. Renewable Energy Surcharge Level Regulation, NDRC Price [2006] No. 28-33 & GWEC (2009), p. 26

[83] The renewable energy surcharge is collected by the government and then redistributed to developers and grid companies through a fund (worth RMB 3 bn. In 2007). cp. GWEC (2009), p. 26

[84] Trial Measures for Pricing and Cost Sharing Management for Renewable Energy Power, *government document*

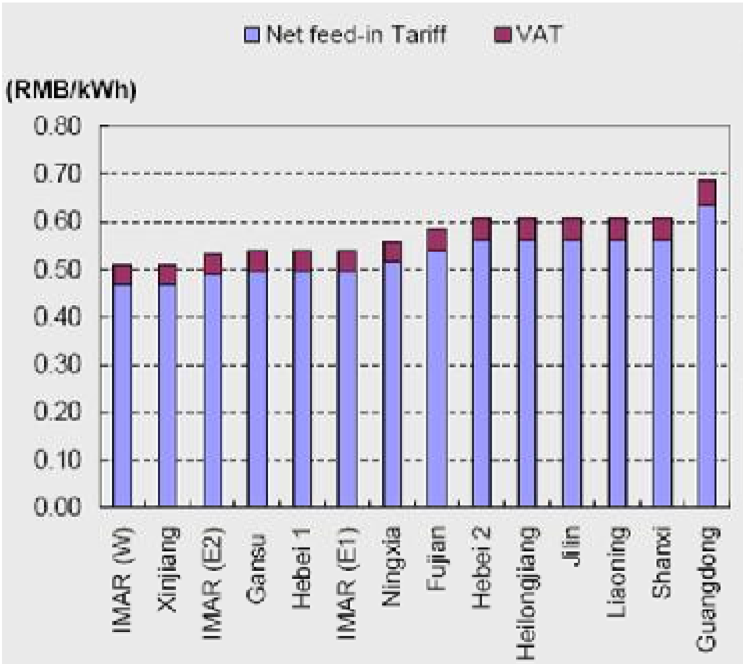
[85] Relevant Regulations on the Administration of Power Generation from Renewable Energy, *government document*

[86] cp. GWEC (2008), p. 30

pushed by high level government officials. In one instance, in order to help the local economy in face of the decline of the local coal industry a large wind power project was approved despite unfavourable wind resource conditions.[87]

In practice, prices of large-scale projects approved by NDRC tend to be lower than the prices of projects approved on provincial level. Lower prices may result in less financially viable projects. Approval procedures on national level are also known to often consume more time and effort than provincial approval resulting in higher transaction costs. Provincial governments offer higher prices in order to attract wind power investors and increase their tax base, at times attracting not only project development, but also investment in local manufacturing capacity. All these factors combined had the effect that most of the wind power projects built and under development are less than 50 MW in size, in order to avoid the approval process on national level. Many are featuring an installed capacity of 49,5 MW.

Figure 5 *NDRC Approved Feed-In Tariffs*



Source: Azure International (2008), *presentation*

Recently, wind power pricing policy in China has been moving away from the tender-based approach towards a fixed feed-in tariff regime. Prices are now regularly determined by provincial governments, and then approved by NDRC, without going through a bidding process. Since June 2007, NDRC has issued two pricing documents approving feed-in tariffs for 95 projects in eleven provinces (see Figure 5). To a large extent, the prices are the same for projects within one province, with few exceptions to account for special resource and investment conditions. The prices approved in these pricing documents mark a movement towards a more realistic and economically viable pricing regime in China. As in projects allocated by bidding, the feed-in tariffs apply to the first 30.000 hours of operation. Guangdong decides on wind power pricing autonomously from the central government and was the first province to establish a province wide fixed feed-in tariff (0.064 yuan/kWh). It may be expected that other provinces will follow suit.[88] Although wind power electricity tariffs in China

[87] *Personal communication* with Prof. Dai Huizhu, Senior Advisor, Chinese Electric Power Research Institute
[88] cp. Azure International (2008), *presentation* held at the Renewable Energy Finance Forum

remain low by international standards, the tendency to approve uniform price levels on provincial level improved investment conditions by increasing predictability and security for investors.

Renewable Energy Targets and Mandatory Market Share Requirements

In September 2007, more than one and a half years after the *Renewable Energy Law* called for the establishment of overarching renewable energy targets, the NDRC released the *Medium and long-term Plan for Renewable Energy Development* (see Figure 6). It was the first time the Chinese government set explicit quantified goals for renewable energy development. The plan establishes a national renewable energy target (incl. hydro power) of 10% of total primary energy consumption by 2010, and 15% by 2020. In addition, specific development targets for different types of renewable energy technologies were set, including a 5 GW target for wind power by 2010, and 30 GW by 2020. These targets have been adjusted upwards since, in order to accommodate for the tremendous pace of renewable energy development, with the wind power target adjusted to 10 GW by 2010.

Figure 6 *Medium and Long-Term Development Plan for Renewable Energy*

	2010	2020
RE Objectives in Terms of Energy Consumption	10% of total primary energy consumption from renewables (incl. hydro)	15% of total primary energy consumption from renewables (incl. hydro)
Wind Power Objectives	5 GW (*adjusted to 10 GW*) 100-200 MW offshore	30 GW 1 GW offshore
MMS for Non-Hydro Renewables	Mandated market share (quota) for *non-hydro* renewable power generation	
	1% of total power generation	> 3% of total power generation
	for power generators with a total power generation capacity > 5 GW	
	3% of their total capacity	> 8% of their total capacity

Source: author, based on NDRC (2007)

In order to encourage the development of clean sources of energy and establish a stable market for the domestic industry the *Medium and long-term Plan for Renewable Energy Development* also introduced mandatory market share (MMS) policies[89] setting a national target of 1% of total power generation capacity from non-hydro renewable energy by 2010, rising to 3% by 2020. Every power generation company with a capacity of more than 5 GW was mandated to increase their share of installed non-hydro renewable energy capacity to 3% by 2010, and to 8% by 2020. According to estimates from the Chinese Wind Energy Association (CWEA), in order to reach these targets approximately 20 GW of wind power capacity have to be installed by 2010, and around 100 GW by 2020.[90]

The definition of renewable energy targets for big power generation companies in terms of installed capacity instead of electricity generated serves as a critical distortion of incentives for wind power project development. The performance of wind farms – and turbines for that matter – is not considered a primary objective. As long as the capacity is installed, it is not important if and how much electricity

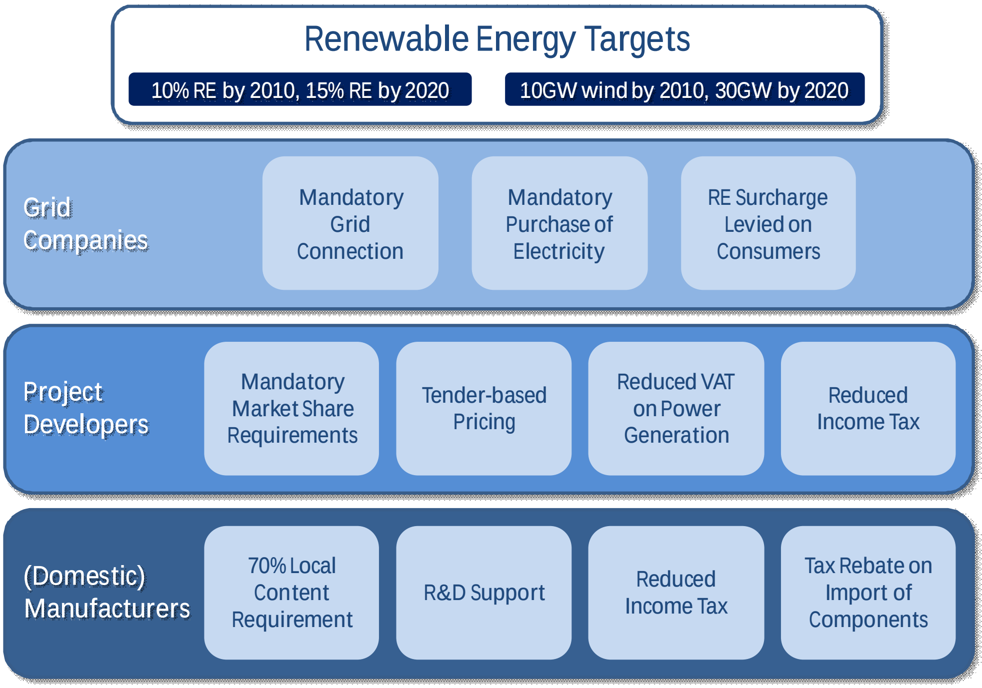
[89] *Mandatory market share* policies are also known as *renewable portfolio standards* or renewable energy obligations.

[90] Shi (2008b), p. 6

is generated. According to Gao Hu, Deputy Director of the Center for Renewable Energy Development at ERI/NDRC, the renewable targets are likely to be redefined in terms of energy output soon.[91]

Even if the *Renewable Energy Law* and its implementing regulations do not define penalties for not fulfilling government targets, it marks a pivotal moment in building confidence in the Chinese renewable market. Investors were assured of government commitment to take an active role in the promotion of renewable energy. The establishment of an overarching target for renewable energy as a share of total energy consumption in conjunction with the definition of a set of technology-specific renewable objectives and the introduction of a binding renewable energy quota for power generation companies, established the conditions necessary for renewable energy to prosper.

Figure 7 *Policy Framework Governing the Wind Power Sector in China*



Source: author

Particularly the wind power sector profited from the favourable market conditions the *Renewable Energy Law* helped to establish. As the most competitive of renewable energies in terms of costs, maturity of technology and feasibility of large-scale deployment, wind energy is the premier renewable energy technology benefitting from the government targets. Government targets and quota policies in combination with a series of measures in support of the domestic industry and a protectionist tax incentive and tariff policy[92] created a stable, foreseeable environment for wind power investment in China. As market development became more predictable, investment in the domestic industry exploded and foreign companies set up shop in China in order to secure a piece of the pie.[93] It is save to say that the clear policy direction of the *Renewable Energy Law* serves as the foundation for the thriving wind power sector existing in China today. Figure 7 illustrates the most important

[91] *Personal communication* with Gao Hu, Ph. D., Deputy Director, Center for Renewable Energy Development, Energy Research Institute, NDRC
[92] For details on tax and tariff policies, please refer to Chapter 4.3.3.
[93] On account of the localisation requirements for wind turbine manufacture, foreign companies where forced to produce locally to participate in the market.

government policies currently governing the wind power sector in China according to the players affected. It includes financial policies described in detail in the following chapter.

4.3.3 Investment Conditions & Financial Incentives

Diversification of the energy supply and development of renewable energy is a stated priority at the highest levels of government. But despite the recent boom in the renewable energy industry, clean energy investment is still facing barriers related to government policy and macroeconomic measures. The uncertainty with regard to the interpretation and implementation of government policies and a lack of transparency in the decision-making processes are one major impediment. Thus, the size of the market for renewable energies, continues to be limited unable to realize its full potential.

China's allocation of investment capital lacks efficiency and is inherently biased against the private sector. Despite US$ 1.4 trillion in foreign currency reserve, US$ 3.6 trillions deposited in Chinese banks and the fact that preferential financing was announced in the *Renewable Energy Law*, financing for clean energy is still difficult to arrange in China. China's capital markets are among the smallest financial markets in the world. Financing through corporate bonds is practically non-existent, while debt finance lacks flexibility. Strikingly, one quarter of new investment that goes to private companies accounts for more than half of the nation's gross domestic product (GDP). State-owned companies using much of the nation's credit only produce about a quarter of GDP.[94] Since it proves difficult for private companies to gain access to capital for investment, the wind power sector, same as other capital-intensive industries, is dominated by state-owned companies.

Credit Crunch – Rising Reserve Ratios & Interest Rates

Reserve ratios and interest rates have been on the rise for the past two years binding capital and drawing liquidity from the market. Reserve ratios have more than doubled from 8% in 2006 to 16.5% in 2008. A 0.5% increase in the loan reserve rate ties up 200 billion CNY, which will not be available to investors. Already, some regional subsidiaries of state-owned commercial banks have been prevented from disbursing approved loans. Interest rates for long-term loans have increased by more than 1.5% from 6.12% to 7.82% during the same period.[95]

The rise in long-term interest rates has a negative effect on the commercial viability of wind power projects which typically feature large initial capital investments and long payback periods of 15 years or more. In addition, a company implementing a renewable energy project has to pay an amount equal to ten percent of the interest payments as a withholding tax.[96] Due to the fact that wind power projects are financed by up to 80% debt, investment in wind power is especially affected by the lack of liquidity in the Chinese financial markets.

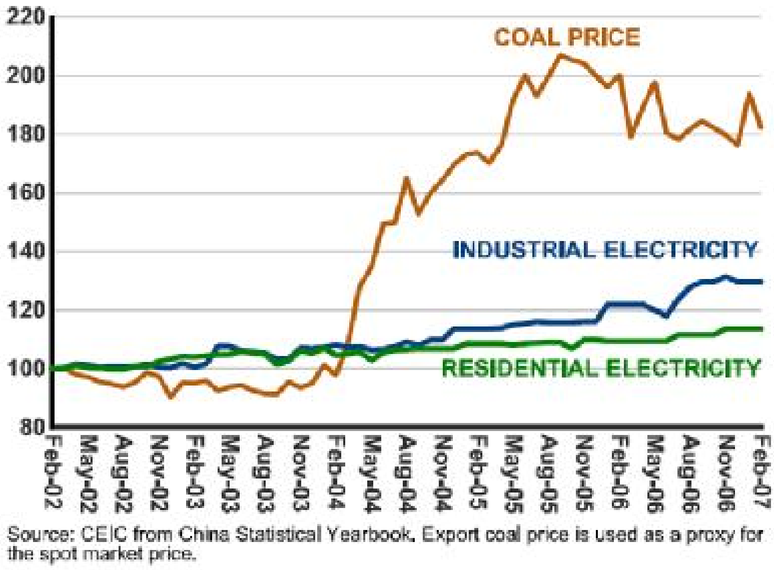
Rising Coal Prices

The big power generation companies, responsible for most of wind power development in China, face another trend contributing to a lack of investment capital - the intense pressure on equity capital due to rising coal prices. Rising costs for transportation, workforce and equipment, improvements in labour and security standards and increasing bargaining power of coal mines in the context of supply

[94] cp. Chandler/Gwin (2007), p. 2-3
[95] cp. Azure International (2008), *presentation* held at the Renewable Energy Finance Forum, Beijing
[96] cp. Chandler/Gwin (2007), p. 3

shortages, drive the increase in coal prices (see Figure 8). The coexistence of deregulated coal prices and regulated electricity tariffs illustrates the paradox of a "socialist market economy". Unable to pass on the coal price increase to customers, the generation companies have to deal with decreasing profit margins and even net losses. Consequently, equity capital for investment is becoming scarce. In an effort to address the issue of operating losses in the power industry, on-grid power tariffs were raised twice in 2008 in July and August.[97] While this helped to improve cash flow, operating losses are far from being eliminated according to industry insiders.[98] This leaves power companies with less capital to invest in renewable energy projects and in the medium-term may impact the growth of wind power in China.

Figure 8 *China Coal and Electricity Price Growth* (nationwide avg., Jan. 2002=100)



Source: Rosen/Houser (2007), p.25

Contrary to that notion, at the same time rising coal prices drive power companies to look for alternative sources of energy to invest in. The dependence on the input of resources with highly volatile prices is posing a significant risk for profitability. The rise in coal prices has even pushed China, which has rich coal resources, to import coal from Australia. As one of the most competitive and mature types of renewable energy, wind power is likely to benefit from this trend.

Taxes & Tariffs

In addition to the tender-based pricing mechanism that, despite recent movement towards a feed-in tariff on provincial level, still introduces a fair degree of uncertainty for wind power investors and project developers, renewable energy tax incentive policy remains an issue to be addressed in a comprehensive fashion by government authorities. Article 26 of the Renewable Energy Law promulgates "*the Government grants tax benefits to projects listed in the renewable energy industrial development guidance catalogue, and specific methods are to be prepared by the State Council*"[99]. While, as of yet, no comprehensive implementation guideline regarding taxation has been issued, a

[97] In addition, the government introduced a cap on coal prices at June 19th levels till the end of the year, increased the export tariff on coal and cut the export quota.
[98] cp. Interfax China (7 July 2008), *online*
[99] Renewable Energy Law (2006)

number of incentives have been put in place, designated to promote encouraged industries in general and the development of the domestic wind industry in particular.

The *China Corporate Income Tax Law*, which became effective on 1 January 2008, sets a unified income tax rate of 25% for domestic enterprises (DE) and foreign-invested enterprises (FIE). Before, nominally the tax rate for DEs and FIEs was the same (33%), but the effective tax rate after application of tax benefits was 25% for DEs and 12% for FIEs.[100] The new tax law levels the playing field and marks the consolidation of two separate enterprise income tax regimes into one. It provides equal tax benefits for investment in encouraged industries for both FIEs and DEs, while gradually abolishing preferential tax treatment of companies in special geographic areas (special economic zones) and phasing out the general manufacturing tax holiday for FIEs. In practice, this will lead to an increase in tax burden for most FIEs and a decrease of taxes paid by DEs.[101]

The new income tax law represents a move away from the focus on the promotion of development within special geographical areas towards an industry-oriented tax regime. The government seeks to channel investment into selected "encouraged" industry sectors and projects, especially in the fields of technological development (high-tech), environmental protection, energy conservation as well as infrastructure and agriculture. For companies qualifying as "encouraged" high-tech industries, the tax rate is reduced to 15% regardless of their location. The manufacturing of equipment for renewable energy electricity generation is one of these encouraged industries. For wind power, preferential treatment is applicable to construction and management of wind farms as well as Cooperative Joint Ventures (CJVs) and Equity Joint Ventures (EJVs) producing wind power generators bigger than 1.5 MW locally. Wholly Foreign Owned Enterprises (WFOEs) are at a disadvantage, since they are not eligible for the reduced tax rate.[102] Project developers in China benefit from a reduced VAT on power generation from wind energy. Since 2002, the electricity generated at wind farms is taxed at 8,5% instead of the usual 17%.[103]

In April 2008, in a move to ease supply chain bottlenecks and further promote the development of the domestic wind power industry through technology transfer the Ministry of Finance introduced a VAT and import tariff rebate on the import of certain wind turbine components. The rebate, retroactive from 1 January 2008, applies to wind turbine manufacturers with an annual sales volume of more than 50 turbines with a capacity of at least 1,2 MW per turbine. Since Chinese wind turbine manufacturers still rely on imports for key components, such as converters, control systems and bearings, this provision will certainly help the domestic industry in scaling up production to meet demand. These measures, aimed at stirring innovation of domestic manufacturers, are also an indication of the increasing maturity of the Chinese wind industry. Not long ago Chinese manufacturers did not have the technological know-how and manufacturing capability to manufacture MW-scale turbines, however the ability of the domestic wind industry to manufacture larger turbines has evolved quickly.[104]

[100] cp. Wei/Xiang (2007), p. 13
[101] cp. PriceWaterhouseCoopers (2007), p. 1/2
[102] cp. *Catalogue for the Guidance of Foreign Investment Industries*, p.13/17 (government document)
[103] cp. GTZ Terna (2007), p. 6
[104] Velten (2008), *online*

R&D Support of Domestic Industry

Just recently, on 11 August 2008, the Ministry of Finance issued *The Management Regulations on Special Fund for Wind Power Manufacturing Sector in China.* The document specifies guidelines for the establishment of a special fund in support of domestic research and development of MW-scale wind turbine systems. Wind power equipment manufacturers fulfilling the fund's qualification criteria will be eligible for a 600 yuan/kW grant for the first 50 wind turbines produced.[105]

The criteria for qualification are as follows: [106]

- Companies eligible must be state-owned or Chinese-controlled wind power equipment manufacturers (incl. wind turbine and component manufacturers).
- Developed equipment must have Chinese Intellectual Property Right (IPR), i.e. the company must own critical technology or techniques.
- The capacity of the wind turbine unit must be 1,5 MW or greater.
- The wind turbine must have passed product certification at China General Certification Center [CGC] in Beijing.
- Blades, gearboxes and generators of the wind turbine must be manufactured by Chinese-controlled companies. Turbines with Chinese-made converters and bearings are encouraged.
- If a company applies for a grant for different product models using the same technology, the power differences of the products must be equal to, or more than, 500kW.
- The wind turbine systems must be manufactured installed and tested in China and must be operated without fault for more than 240 hours.

The grant will be divided half-and-half between wind turbine manufacturer and critical component manufacturers. The grant for component manufacturers will be allocated according to production costs, and will particularly favour converter and bearing manufacturers. The dedicated grant is restricted to cover costs of new wind power equipment research and development. Applications must be submitted to the respective provincial government's financial administration, or directly to the Ministry of Finance in case of state-owned companies.

The establishment of the special fund marks a major step towards a Chinese wind power industry with strong indigenous innovation capacity. On the one hand, it is likely to spur investment into innovation and development of large wind turbine systems and contribute to the establishment of a complete wind turbine component supply chain by promoting domestic design and production of core components. On the other hand, the inclusion of provisions with regard to wind turbine certification and testing, establishes incentives for diligent quality control in design and production processes facilitating the development of the international competitiveness of the domestic industry. For research and development of a 1,5 MW wind turbine model, the grant will be worth 45 million yuan (€ 4,83 million), accounting for approximately 10% of the development costs.[107]

[105] This section is based on the *Management Regulations on Special Fund for Wind Power Manufacturing Sector in China* (government document).
[106] cp. Ministry of Finance (2008)
[107] 1 CNY = 0.107287 EUR, 1 EUR = 9.32083 CNY

Conditions for Foreign Investment

The Chinese government has established a series of regulations supporting the development of the domestic wind power industry, while protecting it from excessive competition of foreign companies. Foreign investors, in the field of wind power manufacturing and project development, are facing a number of regulations impacting their ability to make profitable investments in the wind power sector in China.

Restrictions on foreign equity investments are limiting foreign investors' willingness to invest in any type of project in China, including renewable energy projects. The State Administration of Foreign Exchange (SAFE) exerts strict control over foreign investors' ability to repatriate foreign exchange. However, not being able to recover money invested in China is one of the major concerns of investors. This policy, which was implemented at a time when foreign currency was scarce, seems out of place in face of China's US$ 1.4 trillion foreign exchange surplus.[108]

The following constraints are not particular to the wind industry, but affect investment in the wind power sector nonetheless. Legal workarounds may be found, but require time and generate additional transaction costs (e.g. in form of legal and consulting fees) for the project developer, while potentially keeping projects from being realized at all:

- *"The investor cannot make a direct investment in the project but must create a corporate joint venture into which it can invest.*
- *The investor cannot easily make a "preferred stock" investment, and thus cannot get a priority return on investment.*
- *The investor cannot lend money to the joint venture without also making a major equity investment.*
- *Even if the investor makes a major equity investment, a shareholder loan generally is not permitted to collect an interest rate equal to the risk involved [capped to roughly 8%]."*[109]

In addition, foreign investors are seriously deterred by discriminating regulations with regard to debt financing and the Clean Development Mechanism (CDM).[110] Foreign wind power developers are limited to borrowing 66% of the project costs, while domestic investors can borrow up to 80%. This negatively affects the return on equity of foreign-invested projects. Furthermore, in China in order to qualify as a CDM-project, the project has to be at least 51% Chinese-owned, effectively forcing foreign investors to hand over control of the project to a Chinese partner, and thereby increasing project risk. In conjunction with relatively low electricity prices the above mentioned restrictive policies lead to a rate of return for foreign wind power investors of only 2% to 4% - not a big incentive for investment. Domestic investors regularly achieve a rate of return of 8% or more.[111]

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[108] cp. Chandler/Gwin (2007), p. 5

[109] Source: Chandler/Gwin (2007), p. 5-6

[110] The CDM is a mechanism under the Kyoto Protocol facilitating investment in projects resulting in emissions reductions in developing countries. Projects registered under the CDM enhance their financial viability by generating certified emission reductions (CERs), which can be sold or used by companies required to lower their emissions.

[111] cp. IEA (2007), p. 353 et seqq.

5 Wind Power in China

5.1 Wind Energy Resource Characteristics and Development Potential

Resource Potential

Since the late 1980s there have been several studies to assess China's wind resource potential with widely varying results. The third national wind energy resource survey conducted by the China Meteorological Administration (CMA) is among the most commonly cited studies.[112] Based on historical data collected from 1971 to 2000 at more than 2000 weather stations across the country, wind resources at a height of 10 meters were assessed.[113] These assessments identified technically exploitable on-shore wind resources representing a power generation capacity of 250 GW or 300 GW respectively, and an off-shore potential of around 750 GW.[114]

In a study conducted by the National Renewable Energy Laboratory (NREL) as part of the Solar and Wind Energy Resource Assessment (SWERA) project for the United Nations Environment Programme (UNEP), the exploitable resource potential at 50m is estimated at 3250 GW on land and 800 GW off-shore (wind power>300 W/km², 5 MW/km²).[115] The Center for Wind and Solar Energy Assessment estimates the technically exploitable potential on-shore at 2680 GW and the off-shore potential at 180 GW.[116]

It is important to note that the studies mentioned, for the most part do not represent the actual, economically exploitable wind resource potential; i.e. land-use exclusions, the existing transmission grid and accessibility with regard to infrastructure are not taken into consideration. Considering these factors only around 30% of the potential may be available for wind power projects.[117] The variation of results is largely due to differences in the methodologies used for resource assessment. Different assumptions with respect to the height at which resources where assessed, the threshold above which wind power intensity is deemed to be exploitable and the density at which wind turbines may be installed are further explanations for the widely differing results. The height at which wind resources are assessed is of crucial importance: compared to 10m, at 50m the wind resource potential is usually twice as much, at 70m resource potential is increasing by another 10%.[118]

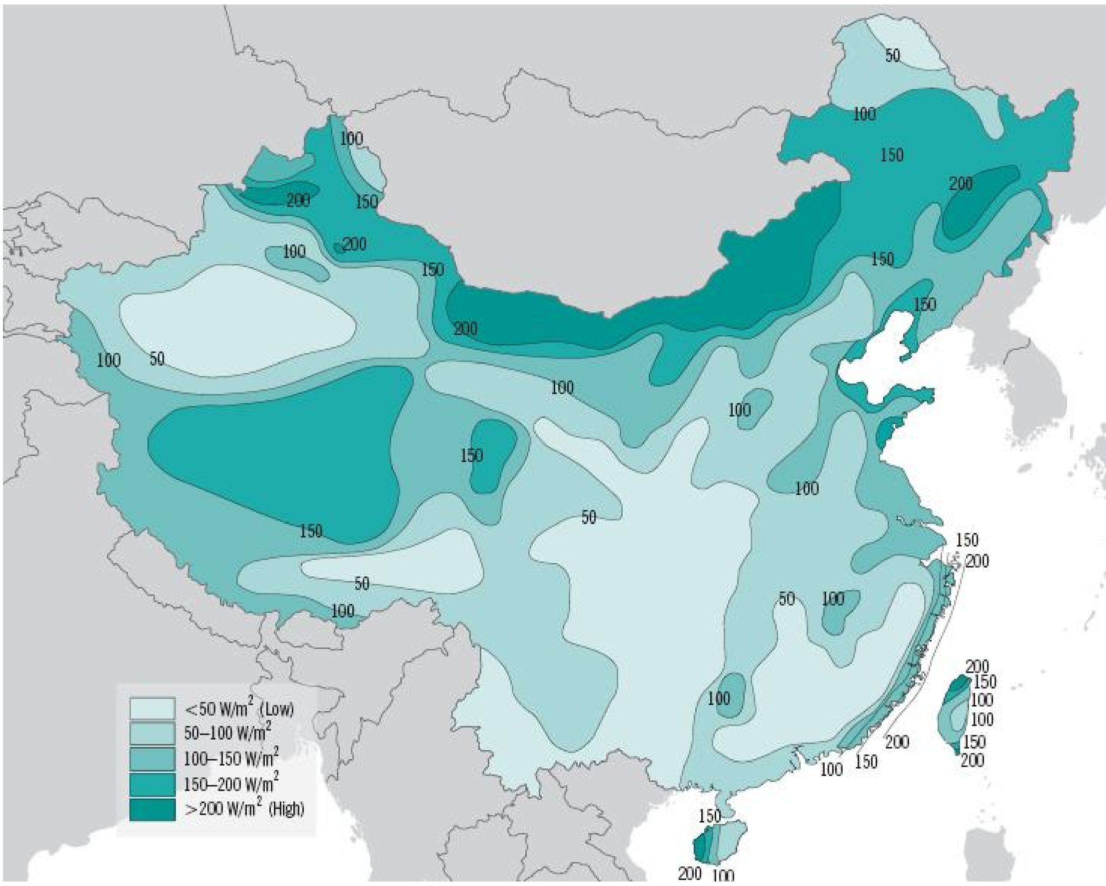
Wind resource assessment studies conducted to date lack accuracy and do not satisfy the requirements for proper identification of wind farm sites. Hence, inaccurate resource assessment poses a major impediment to the formulation of detailed provincial wind power development plans. In addition, lack of reliable wind resource data negatively impacts the risk profile, restricting access to loans and proper insurance of wind power projects.[119] Currently, CMA is in the process of preparing a new, more detailed nation-wide wind resource survey to address the problem of inaccurate resource assessment. More than 400 specially designed masts of 70m, 100m and 120m height are to be erected in China's wind resource rich areas. The survey, which is supposed to be completed by 2011, will combine wind

[112] CMA, December 2006
[113] cp. Energy Bureau (2008), p. 23
[114] cp. Li et al. (2007), p. 2
[115] The NREL study did not cover the whole of China, but vast areas of northern and eastern China (in total 3 million km²). cp. NREL (2006), p.14
[116] cp. Shi (2008b), p. 6
[117] cp. Shi (2008b), p. 6
[118] *Personal communication* with Prof. Zhu Ruizhao, Chinese Academy of Meteorological Sciences
[119] cp. Wong (2008), *online*

resource observation data, data modelling methods and comprehensive evaluation in order to develop a detailed wind resource map serving as a sound basis for future wind power development.[120]

Despite the absence of good data today, there is agreement that China is bestowed with rich wind resources allowing for the development of wind power on a large scale. The most commonly cited estimate on economically exploitable potential for wind power development in China, including both on- and offshore installations, amounts to 1.000 GW. The present total installed capacity of almost 6 GW represents only a tiny fraction of less than one percent of the total wind resource potential, leaving the vast amount of resource potential untapped and open for large scale wind power development.

Figure 9 *Distribution of Wind Power Density in China*



Source: BCSE/CREIA (2006), p. 33

The areas with the richest wind energy resources are located in the north of China as well as the south-eastern coastal areas and its adjacent islands (see Figure 9). In addition, there are several wind-rich areas inland as well as off-shore. In northern China, a 200 km-wide belt rich in wind energy spans from the north-eastern provinces of Liaoning, Jilin and Heilongjiang, via Inner Mongolia, Gansu and Ningxia to Xinjiang in the northwest. Wind power intensity in these areas is usually between 200 and 300 W/m² with wind power intensities reaching a maximum of 500 W/m² in the areas with the strongest wind in Xinjiang and Inner Mongolia.[121]

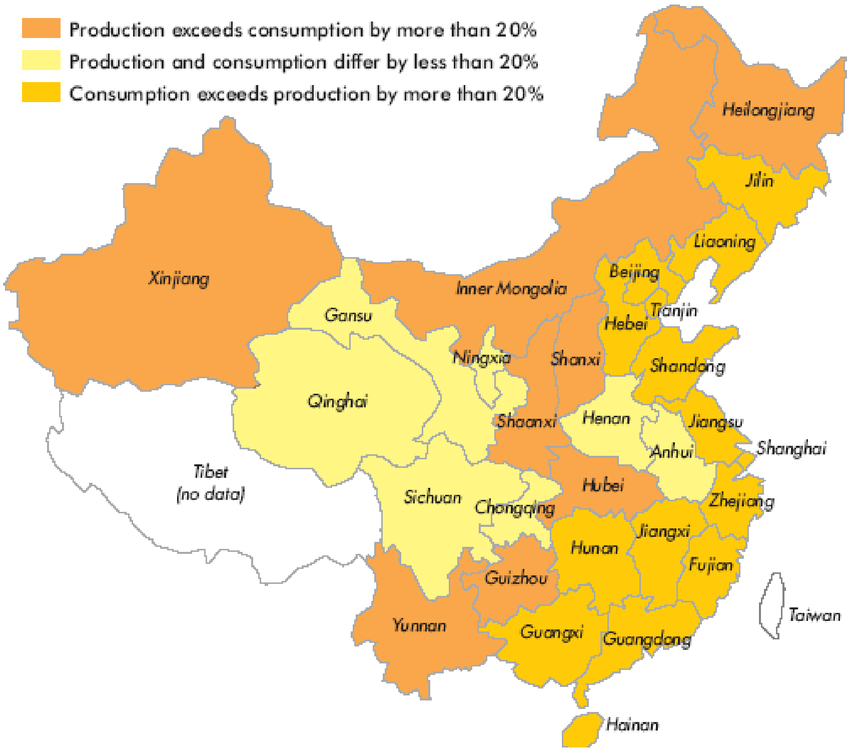
120 *Personal communication* with Prof. Zhu Ruizhao, Chinese Academy of Meteorological Sciences
121 cp. Li et al. (2007), p. 2

The most abundant wind energy resources along the coastline and near-coast islands are located within a 10 km-wide belt including the provinces of Shandong, Zhejiang, Fujian, Guangdong, Guangxi and Hainan with an annual wind power intensity above 200 W/m². Except for some areas where wind resource potential is influenced by special geographic characteristics like lakes, in most inland regions outside the two areas mentioned above the wind power intensity is generally below 100W/m². Furthermore, vast areas with potential for off-shore wind power development can be found along the eastern coastal areas at easily accessible water depths ranging form 5 to 20 metres. These resources are mainly located in the provinces of Jiangsu, Fujian, Shandong and Guangdong.[122]

Seasonal Characteristics and Distance to Load Centres

In their seasonal variation China's wind and hydro resources complement each other. The high-season for hydropower generation is in summer. Especially in south China, winters are dry and flooding season in summer accounts for most of the annual rainfall. Wind on the other hand is generally strong during spring, autumn and winter, while being scarce in summer. Therefore, wind power can help compensate for the lack of electricity generation from hydropower during dry season in spring and winter.[123]

Figure 10 *Imbalance of Power Production and Consumption in China*



Source: IEA (2007), p. 267

The geographical distribution of wind energy resource does not match the country's power load profile however. The heavy power loads are concentrated in the economic centres along eastern coastal provinces, where inland wind resources are scarce (see Figure 10). Consequently, wind power development is amplifying the present imbalance of power production and consumption. While in the northern regions, where wind resources are abundant, the power loads are small and the grid infrastructure is weak. The large distance between wind-rich areas and power load centres makes

[122] cp. Energy Bureau (2008), p. 24
[123] cp. Energy Bureau (2008), p. 25

heavy investment into grid reinforcement necessary, in order to support large-scale wind power development. In future, as off-shore technology matures and becomes economically viable the deployment of wind farms on sea close to the load centres may help alleviate the problem of geographical dispersion of wind resources. The large-scale exploitation of offshore wind resources is not expected for the near future though, because of the rich inland resources and the technical challenges of offshore wind farm construction and operation.[124]

5.2 Current Status of Development

In 2007, investment in China's wind energy sector amounted to an estimated 24 billion yuan (US$ 3,28 billion). According to conservative estimates between 2006 and 2015 around 100 billion yuan (US$ 14,5 billion) will be spent on wind power equipment and component purchases. The enormous amount of investment, not surprisingly, spawned the development of a thriving domestic wind power industry of around 100 wind power equipment manufacturers.

Figure 11 *Development of Wind Power Installations in China*

Source: author, data from Li et al. (2007) p. 7 & Shi (2009), p. 3

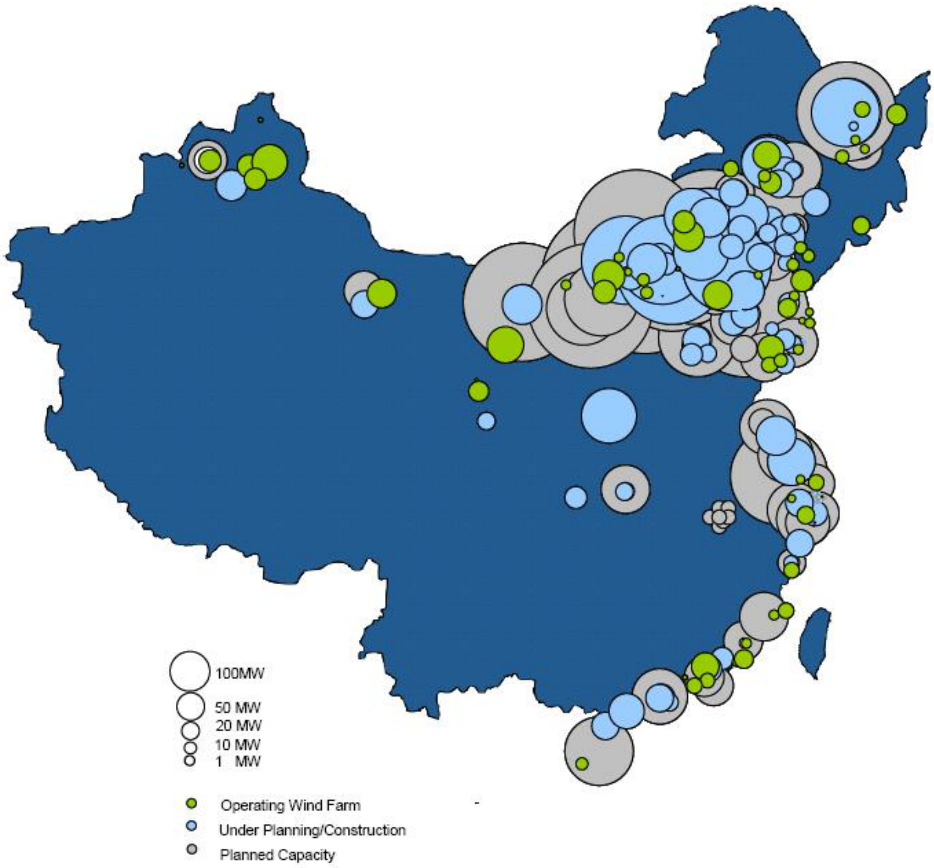
The development of growth rates of total installed capacity and capacity additions manifests how the development of wind power has gradually picked up speed since the beginning of the century (see Figure 11). Total wind power installations grew by 16% in 2001. Since then, the growth rate of cumulative capacity has persistently grown peaking in 2007 at 127%. The newly installed capacity exhibited even faster growth, peaking in 2006, when annual capacity additions increased by the factor 2,6. For the past four years the newly installed capacity has more than doubled each year. In 2008 the growth of the wind power market in China slowed down, while still exhibiting strong growth.

If you look at the development of wind power in China in terms of capacity installed, the exceptional pace of growth becomes evident. Total installed capacity having almost doubled in 2007 - from 2.600 to 5.900 MW, in 2008 wind power growth lost some momentum. With 6.250 MW installed in 2008,

[124] cp. Li et al. (2007), p. 3

the annual growth rate fell by roughly 20% to 106%. In terms of newly installed capacity China came in on second place in 2008 worldwide, only trailing the USA. Reaching a total installed capacity of almost more than 12 GW, China became the fourth largest producer of wind power in 2008, after Germany, the USA and Germany. The government target of 5 GW by 2010 of installed capacity, promulgated in the ***Medium and Long-term Plan for Renewable Energy Development***, was already surpassed in 2007 - 3 years earlier than planned.[125] The strong growth of the wind power market in recent years has consistently surpassed even the most optimistic expectations of industry observers.

Figure 12 *Geographical Distribution of Wind Farms in China*



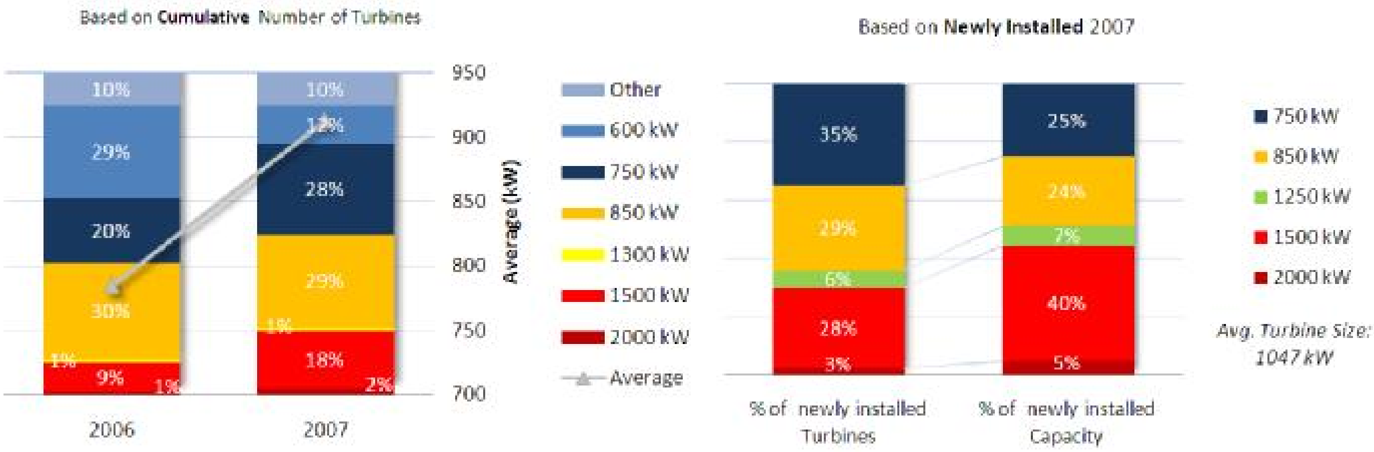
Source: Azure International (2008)

At the end of 2008, the cumulative installation of wind power in China amounted to 12.2 GW, distributed over 158 wind farms in 21 provinces.[126] According to data by Azure International, a consultancy in Beijing, 445 sites have been targeted for development.[127] Most of the wind farms are located in Chinas' windy north, along with some development along the coast (see Figure 12). The wind resource-rich corridor in China's north, accounts for almost 70% of wind power installed in China. One quarter of installed capacity is concentrated in wind farms in Inner Mongolia alone. Other provinces with significant wind power capacity include the coastal provinces Hebei, Shandong, Fujian and Guangdong.

[125] The target has since been adapted upward by NDRC first to 10 GW by 2010.
[126] For detailed statistics on installed wind power capacity in China, please refer to Shi (2008a). See Annex.
[127] cp. Azure International (2008), held in May 2008 at REFF

With regard to the type of wind turbines installed in China, the trend towards turbines with more capacity is apparent (see Figure 13).[128] Looking at the total installed capacity, the share of wind turbines with a capacity of 1.500kW increased from 9% in 2006 to 18% in 2007, while the share of 600kW turbines decreased by 10%. In the same time the average turbine capacity increased from 785kW to 913kW. The tendency towards larger turbines is even more evident, when looking at the turbines newly installed in 2007. While 79% of all turbines still have a capacity less than 1 MW, 37% of the turbines that were installed in 2007 were MW-scale turbines, i.e. 52% of newly installed capacity was attributable to turbines with a capacity of more than 1 MW. The average size of turbines installed in 2007 was 1047kW.

Figure 13 *Market Shares According to Turbine Size in China*



Source: author, data from Shi (2008a), Li et al. (2007) & ERI (2008)

The largest single unit is Vestas' 2 MW wind turbine. CSIC and REpower North are testing prototypes of the same capacity. The Chinese-Japanese joint venture Hunan Hara XEMC has reached small batch production of a 2 MW direct drive wind turbine. CSIC and REpower North also deployed prototypes of 2 MW turbines. While the Chinese wind power market is dominated by wind turbines with variable pitch and speed technology, Goldwind and XEMC have made a significant technological advance by developing direct drive turbines, which have been installed in 2007 and are currently tested. Goldwind is the only manufacturer in China that has an offshore wind turbine prototype in operation at the moment.

Offshore Wind Power Development

With possibly even larger wind resources offshore than on land, a huge potential for wind power development is waiting to be developed along China's coastlines. However, the deployment of wind power offshore is by far more demanding than on land, mainly due to the constant exposure to tough environmental conditions. Offshore wind farms present technological challenges with regard to construction, operation and maintenance as well as wind turbine durability. Thus, wind farm construction offshore costs more than twice as much as on land. That is why the exploitation of the immense inland wind resources is first priority for wind power developers in China. Offshore development lags behind in international comparison. Construction of China's first offshore wind farm

[128] Since 2008 data on turbine sizes in China was not available at the time of the study, the information on turbine sizes is based on 2007 data.

(102 MW) starts in 2009 in the sea off Shanghai, north of Donghai bridge. The wind farm is scheduled to pick up operation in time for the World Expo 2010.

5.3 Market Forecast

> *A few years ago wind energy was boutique, something to show off to foreigners to prove how green they are but now it is a very serious part of their energy policy. They can make things happen so quickly in China compared to the west. When they make up their minds, it is incredible how fast things happen.* - Steve Sawyer (GWEC)[129]

The above statement stands exemplary for the recent and future development of wind power in China. With the support of the government, the Chinese wind industry along with the huge domestic market is destined to play a major role in global wind power development. In a German survey conducted among companies in the wind power sector, China ranked first as the most important wind power market of the future.[130]

In a recent publication, rating the attractiveness of renewable energy investment in different countries China ranks among the top five in the long- and short-term wind indices.[131] While the long-term index takes into account the infrastructure for renewables alongside technology factors, the short-term index includes power offtake attractiveness, tax climate, resource quality, market growth potential as well as project size. Despite the fact that a number of government policies discriminate against foreign and private investors, the favourable rating of Chinas' wind power investment attractiveness – up two ranks from 2007 only trailing the USA and Germany in the long-term – can be attributed to the thriving market for wind power that has emerged as a result of persistent government action and commitment to the active pursuit of fast-paced, large-scale wind power deployment.

Recently, the Chinese government has moved towards vigorous support of the development of large wind power clusters of several gigawatts of capacity, usually using the conditions of wind power concession projects as a template. In Hebei (Danjinghe), following the approval of a 200 MW wind power concession project nine further wind farms with a total capacity of 1.200 MW were approved in the area under the same conditions. Similarly, in Liaoning (Beiqinghe) four additional wind farms, with a capacity of 300 MW each, were authorized subsequent to the approval of a 300 MW concession. In Gansu provinces' Jiuquan, a cluster consisting of 20 wind farms with a total of 3.800 MW was approved in 2007.[132] By 2020, wind power clusters - each 10 GW or more in size - are planned to be developed on sites designated by the government in Xinjiang, Inner Mongolia, Gansu, Hebei and Jiangsu.[133]

The fast pace of capacity additions and the regional concentration of wind power, in conjunction with the fact that it is often neglected to integrate national grid companies into wind power development

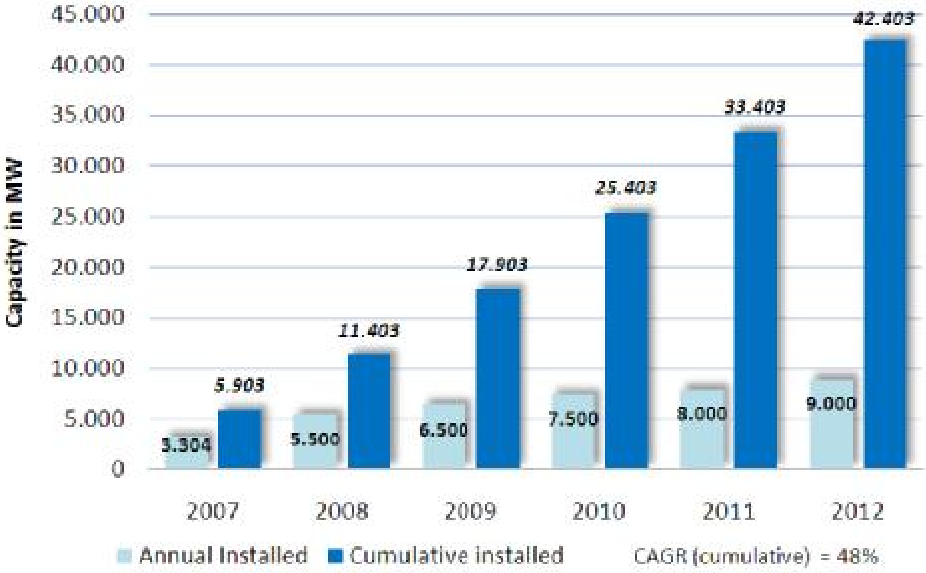
[129] Watts (2008), *online*
[130] cp. HUSUM WindEnergy (2008), *presentation*
[131] Ernst & Young (2008), p. 9 et seqq.
[132] cp. CEPRI (2008), *presentation* held at the WERT-Centre Wind Power Grid Integration Workshop, Beijing
[133] Also known as the 10 GW Wind Base Programme. Other Wind Base projects also under development include: 20 GW at Mengxi (Western Inner Mongolia); 30 GW at Mengdong (Eastern Inner Mongolia); 20 GW at Xinjiang Hami and 10 GW in Jiangsu Province, 7 GW of which will be offshore. cp. GWEC (2009), p. 11/24

planning at an early stage, is expected to result in significant challenges regarding the integration of wind power into the power grid.[134]

For 2009, the total installed wind power capacity in China is expected to nearly double again.[135] The financial crisis has prompted the Chinese government to identify wind power development as a key area of economic development, providing for very promising prospects future growth of the market. At this rate, China is on track to overtake Germany and Spain to reach second place with regard to total wind power capacity in 2010. In that case, China would meet its 2020 target of 30 GW ten years ahead of schedule.

Based on current growth rates, the Chinese Renewable Energy Industry Association (CREIA) makes a rather conservative prediction of a total capacity of 50 GW by 2015. According to a different forecast by a renowned wind power consultancy, by 2010 a total of 25 GW of wind power will be installed in China (see Figure 14). Following this trend, by the end of 2013 a total installed capacity of 50 GW seems plausible. As previously mentioned, government targets are still set at 30 GW by 2020, however as much as 120 GW of wind power installations are expected by industry insiders.[136] As previous predictions for growth of wind power installations in China have consistently been surpassed by actual installations, it may be expected that the current estimates will also be exceeded.

Figure 14 *China Market Forecast 2008 - 2012*[137]



Source: author, data from Suzlon (2008), *presentation*[138]

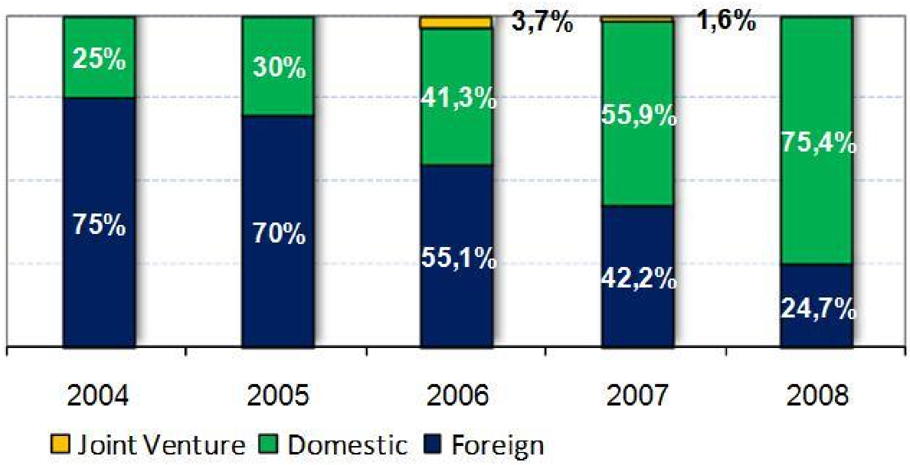
If these predictions hold to be true, China is on track to surpass the target of 3% non-hydro renewable energy in power generation as put forward in the *Medium and Long-term Renewable Energy Development Plan* and would add significantly more wind power capacity within the next twelve years than are currently installed worldwide. In face of an average annual growth rate of more than 100% over the past five years (2004 - 2008), the projections do not seem excessive.

[134] *Personal communication* with Prof. Dai Huizhu, Senior Advisor, Chinese Electric Power Research Institute
[135] cp. GWEC (2009), p. 9
[136] *Personal communication* with Prof. Shi Pengfei, Vice President, Chinese Wind Energy Association
[137] The Figure 14 is based on *conservative* estimates from 2008.
[138] based on BTM Consult estimates

5.4 Wind Turbine Manufacturers

2007 marks a milestone in the development of the wind power industry in China for three reasons: for the first time domestic manufacturers captured a bigger share of the wind turbine market than foreign manufacturers; secondly, two Chinese companies entered the global top ten of wind turbine manufacturers (Goldwind on 8th rank, Sinovel on 10th); thirdly, for the first time have Chinese manufacturers announced the export of wind turbines. The development is evidence of the level of maturity the domestic industry has achieved within a very short timeframe and indicates a promising future. Steve Sawyer, secretary general of GWEC, estimates that China becomes the world's largest wind turbine manufacturer in 2009.[139] This chapter analyses the role of domestic and foreign wind turbine manufacturers in the Chinese wind industry, reviewing their manufacturing capacity and plans for export.

Figure 15 *Wind Turbine Manufacturer Market Shares in China (Annual Installed)*[140]



Source: author, data from GWEC (2007), p.29 & Shi (2009), p. 4

Rapid market growth complemented by legislation mandating localization of production, gave rise to more than 40 aspiring wind turbine manufacturers and a myriad of component suppliers.[141] 17 of the wind turbine manufacturers are Chinese state-owned enterprises, 12 privately owned Chinese companies, 7 are Joint Ventures and 4 wholly foreign-owned enterprises (WFOE).[142] Since 2004 the Chinese wind turbine manufacturers' market share of newly installed wind turbines has consistently increased, bolstered by government policies in support of the domestic industry (see Figure 15). At the end of 2006, it was still "***estimated that Chinese manufacture of wind turbine equipment will not play a significant part in the market until 2010***".[143] As recently as 2004, the market was dominated by foreign manufacturers by a ratio of 3 to 1 and while the Joint Ventures – among the most notable CASC-Acciona (Spain) and REpower North (Germany) – failed to capture a significant share of the market since then, domestic manufacturers gradually took over. While by the end of 2007, foreign-owned manufacturers still held 53% of the total installed capacity, slightly more than the Chinese manufacturers, by the end of 2008 their market share dropped to 38%. Of the newly installed turbines

[139] cp. Watts (2008), *online*
[140] In 2008, figures Domestic manufacturers and Chinese-foreign JVs are consolidated.
[141] In 2008, more than 20 new wind turbine manufacturers entered the Chinese market, bringing the total to 70. cp. GWEC (2009), p. 27
[142] cp. Schwartz/Hodum (2008b), *online* (numbers do not include investment into R&D and manufacturing capacity.)
[143] Li et al. (2006), *Executive Summary*

a striking 75%, three out of four wind turbines, was made by Chinese manufacturers. The top three Chinese-owned manufacturers alone, Goldwind and Sinovel, account for 57% of newly installed capacity – equating to 76% of domestic manufacturers' market share. The two leading foreign manufacturers, Vestas and Gamesa, contribute 18% to new installations – equivalent to 72% of foreign-owned manufacturers' capacity additions.[144]

The trend towards increasing market domination by domestic manufacturers is likely to continue. Nevertheless, the fast growth of the wind turbine market in conjunction with the excellent reputation of wind turbines produced by foreign-owned manufacturers in terms of performance and reliability, is likely to guarantee that wind turbines produced by WFOE in China are sure to find buyers despite the increasing number of domestic competitors.

On another note, the large number of new wind turbine manufacturers entering the Chinese market will cause intense competition and many an upcoming competitor will have a difficult time standing their ground against the established domestic and foreign-owned manufacturers. Therefore, over the coming years a strong trend towards consolidation of the wind turbine manufacturers' market is expected, unless the market expansion picks up even more pace or the manufacturers begin to export in large numbers.

Domestic Wind Turbine Manufacturers

By 2008, there were around 70 Chinese companies aspiring to manufacture wind turbines commercially. Only a handful of these have acquired the capability of mass production. In 2008, the total capacity additions of domestic manufacturers and Chinese-foreign joint ventures amounted to 4.710 MW. Of the Chinese-owned manufacturers' newly installed and cumulative capacity market shares 85% and 89% respectively is divided among five manufacturers: Goldwind, Sinovel, Dongfang, Windey and Sewind. Except for these five, that already entered mass production, most of the Chinese-owned wind turbine manufacturers are in early phases of wind turbine development, ranging from wind turbine design, prototyping and testing, to trial and small-batch production. The top three take the lions' share of capacity additions with Sinovel, Goldwind and Dongfang accounting for 30%, 24% and 22% of domestic-owned manufacturers' market share respectively.[145]

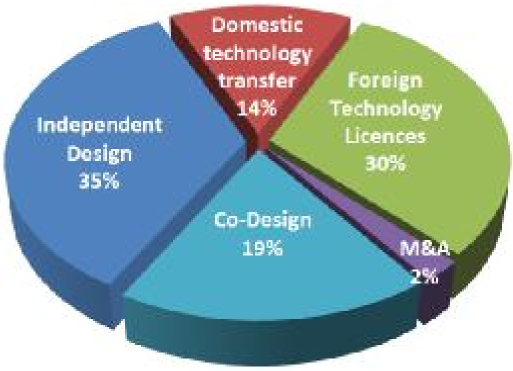
The Chinese wind industry relies heavily on technology transfer from experienced foreign wind turbine manufacturers or design institutes in order to rapidly attain the stage of commercialisation. The current state of the domestic wind industry is marked by an almost complete lack of wind turbine models with indigenous intellectual property rights. All of the top five Chinese manufacturers rely on technology licenses from Germany for turbine design, if not exclusively then at least for one of their models: Goldwind from RePower/Vensys, Sinovel from WindTec/AMSC, Dongfang and Windey from RePower, Sewind from Dewind.

Regarding the upcoming manufacturers still in the phase of conducting R&D and testing, a more diverse picture of technology sourcing is emerging (see Figure 16). About half of the wind turbines under development are still based on foreign technology – either via licensing or co-design (joint design). It is interesting to note that about three quarters of the foreign wind turbine technology is sourced from Germany. The other half of wind turbine models is developed locally – either via

[144] cp. Shi (2008a), p. 3 et seqq. & Shi (2009), p. 4 et seqq.
[145] cp. Shi (2008a), p. 9

domestic technology transfer or independent design. Domestic technology transfer refers to turbine technology transferred from Chinese companies or universities. One of six wind turbine models referred to under this category is developed based on technology from the Shenyang University of Technology (SUT). A sizable amount of wind turbine models under development, 15 out of 42, are based on independent R&D. Since most of these did not reach the stage of commercialization yet, the reliability and performance of wholly domestically developed wind turbine models has yet to be proven.[146]

Figure 16 *Technology Sources of Chinese Wind Turbine R&D*



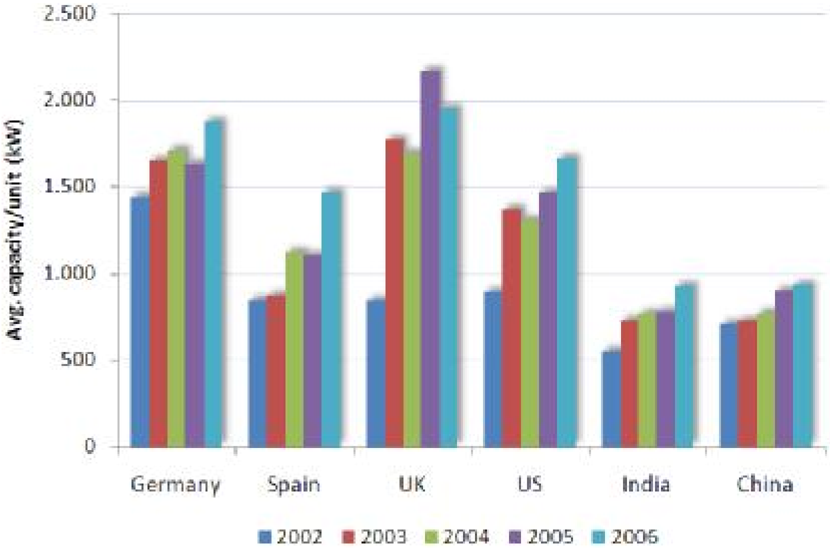
Source: author, data from ERI (2008), p. 46

The licensing of foreign wind turbine technology or the acquisition of independent property rights (IPR) through co-design with foreign companies enabled the Chinese wind industry to evolve quickly. Nevertheless, the reliance on import of wind turbine technologies also has its disadvantages. The licensing of technology may be accompanied by a number of potential pitfalls: a lack of support by the licensor, the licensor is not "invested" in the success of the enterprise, if technological problems occur the licensee may face unanticipated costs or limited success, restrictions in terms of geographic areas of use may inhibit the licensee. In addition, licensors are often reluctant to transfer the latest high-technology. Due to overreliance on technology transfer and a lack of experienced R&D personnel the domestic indigenous innovation capacity remains low. Overall, the Chinese wind turbine manufacturing industry is still in early stage of the transition from technology transfer and absorption to independent turbine design.[147] Realizing the need to strengthen domestic innovation capacity, the Chinese government just recently announced the creation of a special fund supporting development of wind turbine models on the basis of indigenous design and technology. The special fund is sure to promote R&D spending and increase the international competitiveness of Chinese-owned manufacturers.[148]

In terms of turbine size, i.e. capacity per unit, China lags behind the wind power markets in Europe and the USA (see Figure 17). While in Europe or the USA the average turbine capacity was close to 2 MW, the median size of Chinese-made turbines was only half of that, averaging close to 1 MW in 2006 – an indication of the technological head-start of the European and USA wind power manufacturers. Regarding the average wind turbine capacity, the Chinese market is trailing the German market by about 8 years.

[146] cp. ERI (2008), p.47 et seqq. & Shi (2008a), p. 10
[147] cp. ERI/NDRC (2008), p. 24 et seqq.
[148] For more information on the R&D incentives, please refer to Chapter 4.4.

Figure 17 *Average Capacity of Wind Turbines*



Source: author, data from Wang (2008), p. 9 / BTM Consult

Although only a handful of Chinese wind turbine manufacturers had reached the stage of mass production of MW-scale turbines in 2007, there are a large number of wind turbine models with a capacity greater than 1 MW under development. Close to 20 models with a capacity of 1,5 MW were in the design or prototype stage of development at Chinese-owned manufacturers in 2007. Whether all of these turbine models will attain the stage of marketability remains to be seen. However, even if some may not, in the near future the market will be flooded with Chinese-made MW-scale wind turbines. Since then a considerable number of new domestic manufacturer has been pushing onto the market. The result will be intense competition, especially in the market segment of 1,5 MW wind turbines, causing wind turbine prices to fall and profit margins of wind turbines manufacturers to decrease. This development will contribute to the increase of average wind turbine capacity in China. Moreover, the Chinese wind turbine manufacturers are increasingly looking to development of prototypes for larger wind turbines with capacities of 2 MW to 5 MW for on- and offshore deployment.

One characteristic feature of the Chinese wind industry is the entry of large corporate groups or industrial conglomerates, mainly from the heavy industry and power sector, into wind turbine manufacturing. Sinovel and the Dongfang Steam Turbine Co., two of Chinas' top wind turbine manufacturers are examples of this trend: while Sinovel is backed by Dalian Heavy Industries, a major player in the heavy machinery industry in China, Dongfang Turbine Co. is a subsidiary of Dongfang Electric Corporation a large producer of power generating equipment. ***"It's a totally different situation from the start of the European industry, where often the pioneering companies were relatively small enterprises,"*** says Andrew Garrad of UK consultancy Garrad Hassan.[149]

A number of wind power equipment manufacturers are subsidiaries of major manufacturing businesses, mainly from the heavy industry. While these often huge conglomerates regularly have no experience in the design and production of wind turbines, they can sometimes draw upon experience in related businesses, e.g. manufacturing of power generating equipment or blades for steam turbines. Even more importantly, mighty corporate groups possess the resources necessary for undertaking the endeavour to diversify their business activities and venture into wind turbine design and

[149] Aubrey (2008), p. 33

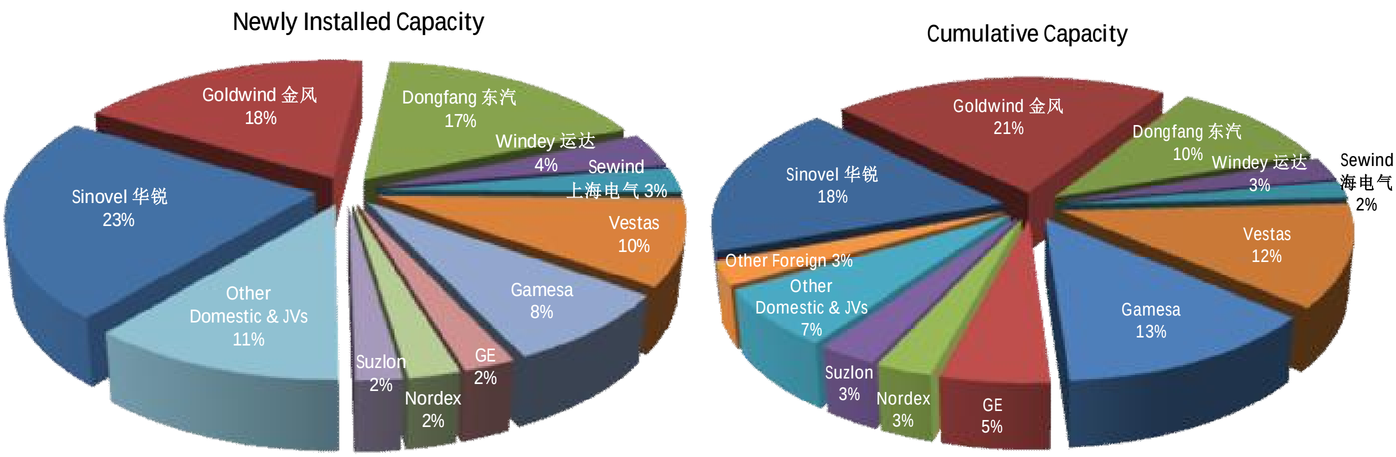
manufacturing. The companies usually feature extensive engineering experience, while having a massive workforce and large amounts of capital for investment at their disposal. Under these favourable preconditions big manufacturing corporations are able to dedicate sufficient funds to independent technology development, joint design with foreign manufacturers or to gain access to knowledge through mergers and acquisitions.

Goldwind, China's leading wind turbine manufacturer, claims to have consistently grown 100% each year for the last eight years. After starting out with licensed production from German companies Repower and Vensys, Goldwind recently acquired a majority share of the wind technology provider Vensys, planning to produce the 1,5 MW and 2,5 MW Vensys wind turbine in Saarbrücken, Germany. The acquisition greatly strengthens Goldwind's capacity to innovate and develop wind turbine models in-house. In 2009, the testing of a 3 MW turbine model is set to begin.[150] With Goldwind, Sinovel and Dongfang mass producing MW-scale wind turbines and numerous upcoming domestic wind turbine manufacturers prototyping large wind turbines, China's wind industry has matured rapidly in a short amount of time providing a strong foundation for large-scale development of wind power in China.

Foreign-owned Wind Turbine Manufacturers

The main motivation for foreign wind turbine and component manufacturers to set up shop in China, are the huge domestic wind power market in conjunction with the emerging neighbouring markets, as well as the low manufacturing costs. In addition, the mandatory wind turbine localisation rate of 70% forces foreign manufacturers to establish production facilities in China in order to participate in the market. At the same time, companies are considering the establishment of a manufacturing base in China a strategic investment in order to supply neighbouring as well as overseas markets at a competitive cost. The general concern of foreign manufacturing businesses in China, including wind power equipment manufacturers, is the uncontrolled leakage of intellectual property.

Figure 18 *Wind Turbine Manufacturers' Market Shares in China 2008*



Source: author, data from Shi (2009), p. 4 et seqq.

In 2008, the total capacity additions of foreign-owned wind turbine manufacturers amounted to 1.540 MW. Six foreign-owned manufacturers installed wind turbines in China: Vestas of Denmark, Gamesa of Spain, GE of USA, Nordex of Germany, Suzlon of India and new entry Envision Energy backed by a European clean energy fund. Together these six manufacturers accounted for 25% of newly installed

[150] cp. Watts (2008), *online*

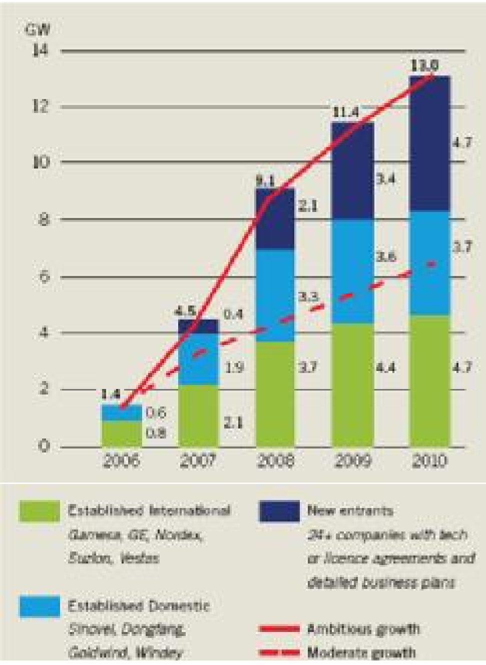
and 38% of cumulative wind power capacity (see Figure 18). Vestas took the lead in capacity additions from Gamesa with 600 MW installed. Gamesa, GE, Nordex, Suzlon and Envision Energy accounted for 508 MW, 146 MW, 144 MW, 129 MW and 14 MW respectively.

Although market shares have been declining, foreign-owned manufacturers are well-positioned on the Chinese market. Vestas, Gamesa and Suzlon have set up shop in Tianjin. Gamesa invested 60 million euro in a wind turbine factory. Nordex plans to grow its China business four-fold, investing 500 million yuan (US$ 71 million) over the next three years.[151] The foreign manufacturers enjoy a high reputation with regards to wind turbine quality and reliability, and are known to be dependable when it comes to delivery times.

Manufacturing Capacity

Worldwide, the average time from the order of turbines to delivery increased from six months mid-2007 to two to three years mid-2008.[152] A similar development can be observed in China. The rapid growth of the Chinese wind power market has created a rapidly expanding demand for wind turbines that could not be met by manufacturers. The result was a supply shortfall causing a rise in wind turbine prices and delivery lead times. The global average of wind turbine prices has risen from around € 0.73 million per MW in the first quarter of 2002 to almost € 1.0 million in the second quarter of 2008.[153]

Figure 19 *Planned Expansion of Chinese Wind Turbine Production*



Source: Azure International in Aubrey (2008)

According to Azure International estimates backlog life in China adds up to 30 months taking into account the annualized installation rate of the last quarter in 2007.[154] This is more than twice as long as average turbine supply lead times on global scale, estimated at 15 months in April 2008.[155] One of the major bottlenecks for wind turbine production is the dearth of component supply. Wind turbine manufacturers with a fully integrated supply chain, i.e. Gamesa and Suzlon, are at an advantage, while others are in need of long-term supply contracts.

In face of rapid market expansion, wind turbine manufacturers in China have been hard-pressed to expand their manufacturing capacity in order to keep up with demand. At the same time, countless new players are pushing onto the market. Hence, manufacturing capacity is set to increase quickly driving down delivery lead times. Azure International estimates manufacturing capacity to reach 9 GW in 2008, at least 3 GW more than the predicted market size that year (see Figure 19). More recent estimates predict an even faster increase in manufacturing capacity, up to 11 GW this year and 16 GW by 2010. If actual production lives up to these expectations, overcapacity will soon

[151] cp. Schwartz/Hodum (2008b), *online*
[152] cp. Chhabara (2008), *online*
[153] cp. New Energy Finance (2008), *presentation* held at Global Wind Power 2008, Beijing
[154] cp. Azure International (2008), *presentation* held at Renewable Energy Finance Forum 2008, Beijing
[155] cp. New Energy Finance (2008), *presentation* held at Global Wind Power 2008, Beijing

affect the Chinese and in turn the global wind power market. Wind turbine Manufacturers in China will have to look for markets other than China to find buyers soon.

It is probably going to be the most competitive turbine market in the world very quickly. Elsewhere, it is a seller's market. Now in China, we are on the tipping point of it becoming a buyers' market. - Sebastian Meyer (Azure International)[156]

Export

After having established the enormous build-up in wind turbine production capacity in China, let us look at the prospects for export of Chinese-made turbines. 2007 marks the first year, a wind turbine manufacturer in China announced the export of turbines. Mingyang Wind Power Technology Company closed a deal with U.S. renewables developer Greenhunter Energy for the supply of 600 1,5 MW turbines by 2012. The turbine had only been tested in operation for four months at the time of the deal, but a Greenhunter representative is expressed confidence that the turbine will compete favourably with wind turbines from US and European manufacturers, since the wind turbine was developed in cooperation with wind turbine design consultancy Aerodyn and is being certified by Germanischer Lloyd (GL), two German companies with extensive experience in the wind power sector. Unlike many other Chinese manufacturers that have entered restrictive licensed production agreements Mingyang is not restricted to sell its wind turbine on the Chinese market.[157]

The two top Chinese manufacturers, Goldwind and Sinovel, plan to start export in 2009 and 2010. Export of Chinese-made wind turbines is expected to pick up around 2010, when the Chinese wind industry has further matured and domestically manufactured wind turbines have a proven track record of performance and reliability. Only then will financing and insurance institutions around the globe be willing to accept Chinese-made wind turbines and open up the path to global prevalence. Wind turbine manufacturers worldwide are already anticipating the emerging competition out of from China. *"For my members now, one of the big issues is to prepare for the onslaught of relatively inexpensive Chinese turbines onto the world market,"* stated Steve Sawyer (GWEC).[158]

The major motivation for wind turbine manufacturers to produce in China is access to the huge Chinese market. Moreover, wind turbine manufacturers in China benefit from relatively low manufacturing costs, due to abundantly available cheap labour. Overall, wind turbines made in China are produced at costs 10 to 25% below western costs. Similar to other manufacturing sectors that have been relocated to China, foreign-owned as well as Chinese wind power companies are prone to use the cost advantage of producing in China to be competitive on the global market. Ultimately, when the domestic market is saturated, wind turbines made in China will be exported on a larger scale. Wind turbine exports from China are expected to start making a significant impact on the global market by 2010. In the long run, wind power equipment made in China will alleviate supply chain bottlenecks, increase global competition and drive down turbine cost.[159]

[156] cp. Watts (2008), *online*
[157] cp. Anderson/Yang (2008), p. 27 et seqq.
[158] Reuters (2008), *online*
[159] cp. Aubrey (2008), p. 34

5.5 Wind Turbine Component Suppliers

The Chinese wind power industry can rely on domestic suppliers for most wind turbine components. With experience through mass production and long-term operation of wind turbines mounting, the quality of domestically manufactured main parts and accessories is improving, while deficits in R&D capacity remain. Suppliers have acquired the capability to mass produce blades, gearboxes and generators and are ramping up manufacturing capacity. However, Chinese wind turbine manufacturers continue to rely on imports for some critical parts, namely converters, bearings and electrical control systems.[160] Moreover, production capacity of domestic component manufacturers (e.g. blades) still falls short of keeping up with skyrocketing demand, causing supply chain bottlenecks that contribute to limit production capacity and to rising wind turbine prices. Recently, government policy has addressed this issue. Research and development activities of the domestic industry will receive financial support. Especially encouraged are technological innovation and capacity building with regard to the current weak spots of bearings and converters. In a similar vein, import taxes on crucial wind turbine components have been slashed to alleviate supply chain constraints. This, in turn, will put increased pressure on the global supply of wind turbine components.

5.6 Project Developers

The vast majority of wind power development in China is shouldered by state-owned enterprises. The five national utilities (also known as the *Big Five*) are among the most prominent investors in wind power, not least since they – as power generation companies with a total capacity larger than 5 GW – are obligated by mandatory market share requirements to generate a portion of their electricity from renewables.[161] The *Big Five* account for 45% of installed wind power capacity (see Table 4).

Table 4 *Top Project Developers in China - Installed Capacity and Pipeline (June 2008)*

	(ranked by installed + imminent development)	installed (MW)	imminent development (MW)	long-term incremental pipeline (MW)
1	Longyuan	1,486	3,565	4,893
2	Datang	630	2,722	4,390
3	Huaneng	380	2,770	3,719
4	Huadian	232	2,169	5,129
5	Shenhua	506	1,681	8,791
6	CPI	122	1,698	2,807
7	Guangdong Nuclear	99	1,635	4,102
8	Shandong Luneng	146	1,333	1,000
9	State Grid Co.	572	740	2,831
10	Beijing Energy Investment	153	958	1,451
11	Hebei Construction	135	722	1,642
12	CECIC	222	612	0
13	Guodian	46	783	4,575
14	Ningxia Power	281	364	1,152
15	China Resources Power (Holdings) Company Ltd.	36	554	313
	Other (180+ companies)	1,357	13,009	41,548
	total:	6,403	35,315	88,343
	total cumulative:	6,403	41,718	130,061

Source: Azure International

Looking at wind farms already in operation and imminent wind power development, all of the top 15 wind power developers are state-owned companies (representing 79% of installed capacity). The remaining 21% of installed capacity is shared among 180 companies, including a few private and

[160] ERI/NDRC (2008), p. 21 et seqq. & Li et al. (2007), p. 17 et seqq.
[161] 3% of total generating capacity from renewables by 2010. 8% by 2020 (see chapter 4.3.2)

foreign investors. Investment decisions within state-owned companies are not always governed by the same economic rationale as in private companies. The neglect of financial viability in making decisions about wind power project investment in state-owned companies has caused detrimental price competition, leaving a tremendous potential of private and foreign investment sources untapped. [162]

Looking at the wind turbine contracts from 2007 to 2008 (end of October), one interesting fact is that the Big 5 state-owned power generators, responsible for more than half of the total 4,9 GW contracted, rely on domestic manufacturers for two thirds of the contracted volume (45% of which from the top 3 Chinese manufacturers), while foreign investors, representing 8% of contracted volume, will for the most part employ wind turbines by foreign manufacturers (76% of contracted volume). The trend towards foreign wind turbine manufacturers with foreign as well as smaller domestic project developers may be due to a greater scepticism regarding the quality of domestically manufactured turbines.[163]

The dominance of the big state-owned power generation companies in combination with rising interest rates and low wind electricity tariffs makes it difficult for smaller private investors to enter the market for project development. The national utilities profit from close ties to the grid companies and financial institutions, providing a strong foundation for project acquisition and timely realization. However, their ability to cross-subsidise less profitable wind power projects with revenues from conventional power generation projects (mainly coal-fired power plants) that essentially prevents the emergence of a competitive market for wind power project development, is diminishing in face of rising coal prices. In future, wind power development by the national utilities could be complemented by more investment from private or foreign investors. At the moment restrictive policies for foreign investment deter overseas investors and the economics of wind power projects in China compare unfavourably with the Western world. Whether wind power project development will be able to rely on more diverse sources of investment in future depends to a large extent on the government's willingness to attract these investors through adjustment of wind power pricing, CDM and FDI policies.

5.7 Project Economics

In comparison to the grid-connected electricity prices for coal-fired electricity, wind power is still expensive. While coal-fired electricity tariffs vary from province to province from 0,26 to 0,44 yuan/kWh, wind electricity tariffs range from 0,42 to 0,78 yuan/kWh.[164] However, since costs for extraction and transportation of coal are on the rise wind power is becoming more and more competitive. Li Junfeng, secretary general of CREIA, states: *"It is widely believed that wind power will be able to compete with coal generation by as early as 2015."*[165] Still, at present the cost advantage of conventional power projects, weak environmental regulation and a market environment dominated by a malign incentive structure present a challenge to the competitiveness of wind power in China.

[162] For details on the incentive structure of state-owned power generation companies, please refer to Chapter 4.3.1.
[163] cp. New Energy Finance (2008), *presentation* held at Global Wind Power 2008, Beijing
[164] cp. Li et al. (2007), p. 42 et seqq.
[165] Watts (2008), *online*

Financial viability of wind power projects is for the most part dominated by two contrary influences. On the one hand, wind power projects in China are less capital-intensive than in the European Union or the USA. The project costs amount to approximately 8.000 to 9.000 yuan/kW, 60% to 70% of which are equipment purchases.[166] Lower costs for equipment, land and installation contribute to low overall capital costs. Purchasing a five-year warranty on equipment - as is prerequisite for securing financing in Europe and North America - is not standard practice in China. Hence, investors in China assume the full risk after two years of operation, although the turbines used are often relatively new and untested.[167]

On the other hand, wind power on-grid electricity tariffs in China are still on the low side and as a result project profitability suffers. Project developers in China, and in consequence wind turbine manufacturers, are exposed to high pressures to drive down capital costs. Prices differ greatly, between concession projects and projects approved on provincial level. Recently, prices approved by NDRC pointed towards a uniform fixed feed-in regime with provincial prices set according to regional wind resource conditions.[168] While wind power tariffs of concession projects determined through bidding are rather low, hovering around 0,5 yuan/kWh (incl. VAT), non-bidding prices determined by the provincial governments are usually higher, ranging from 0,50 to 0,70 yuan/kWh (incl. VAT).[169] The internal rate of return of wind power projects in China is usually between 7 or 8%, lower for foreign investors.[170] However, investors have little incentive to disclose high returns, since highly profitable projects run counter to their objective of obtaining high wind power tariffs, minimising tax expense and retaining eligibility for CDM registration.

Wind Power and CDM

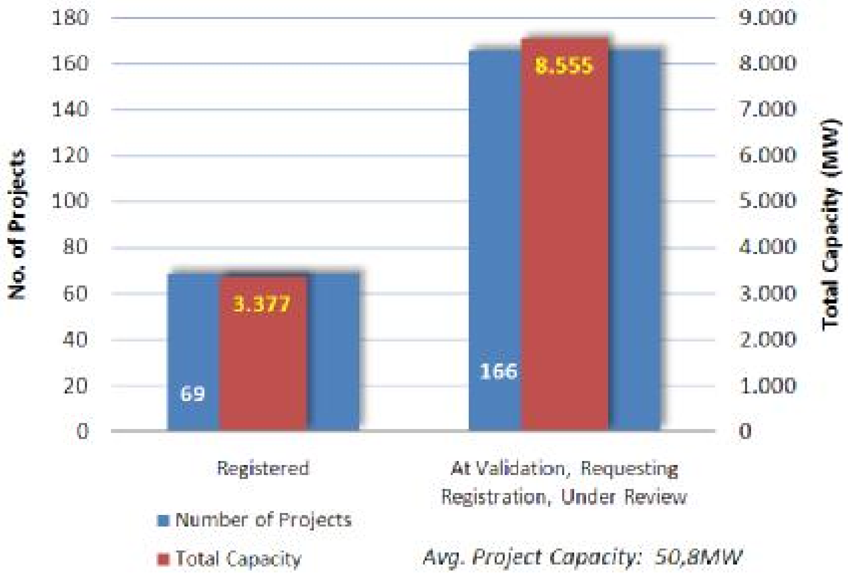
Since low wind power electricity prices threaten the profitability of wind power projects in China, almost all of China's non-concession wind power projects rely on extra revenue from the Kyoto Protocol's Clean Development Mechanism (CDM) to pass the threshold of viability. Approximately half of China's installed wind power capacity can be attributed to wind farms registered with the United Nations Framework Convention on Climate Change (UNFCCC) as CDM projects. In September 2008, 69 Chinese wind farms with a total installed capacity of 3.377 MW were registered under the CDM (see Figure 20). A total of 166 Chinese wind power projects representing 8.555 MW of capacity were in the process of CDM approval. Of all CDM wind power projects registered worldwide 46% are located in China.[171]

Recently, discussion of the eligibility of Chinese wind power projects for CDM has intensified. It is argued that many wind farms would also be built if they were not accepted as CDM projects, i.e. they do not meet the criterion of ***additionality***.[172] The low level of wind power electricity tariffs refutes this argument. Project developers argue that due to low wind power tariffs the extra revenue from CER sales is utterly necessary in order to raise the IRR above the threshold of 8% and make wind power development financially viable. Preserving eligibility of wind power projects for CDM may be a

[166] cp. Schwartz/Hodum (2008b), *online*
[167] cp. IEA (2007), p. 353
[168] For details on wind power pricing, please refer to Chapters 4.3.1 and 4.3.2
[169] Based on data disclosed in CDM project documents.
[170] cp. Li et al. (2007), p. 42 et seqq.
[171] Based on UNFCCC CDM Project Database (September 2008)
[172] cp. McElwee (2008), *online*

decisive argument for the government to maintain a low price level and refrain from changes in wind power pricing policy.

Figure 20 *Wind Power CDM-Projects in China*



Source: author, data from UNEP Risoe website (Sept. 2008)

National and international CDM authorities have trouble coping with the rapidly increasing number of wind power projects applying for CDM. Therefore, the CDM approval process is taking more and more time. Currently, on average one year passes from initial application with the designated national authority in China (NDRC) to registration with the UNFCCC. Furthermore, wind power development in China may be afflicted by an impending downturn in global carbon markets. The Worldbank recently warned of a demand gap caused by the fact that *"the window of opportunity closes to get a CDM project off the ground before the end of the first commitment period of the Kyoto Protocol"* and proposals by the European Commission to severely restrict the use of Certified Emissions Reductions (CERs) in the EU Emissions Trading Scheme after 2012.[173]

6 Potential Pitfalls for Wind Power Development in China

Wind power in China faces a series of adverse outer influences at present. Most of these are not expected to constitute insurmountable barriers to wind power development, but will impact the pace of development nonetheless. The financial crisis on Wall Street that has spread to financial markets around the world, spurs serious worries of a global economic downturn. The renewable energy sector is hit particularly hard by a deterioration of investor confidence, since many observers assume that renewable energy development same as environmental concerns will be shelved until the economies show signs of recovery. The wind industry in China will not be exempt from negative effects of the crisis. Since raising capital will prove difficult in this situation, planned IPOs will be moved back and investments may be deferred. The fall in oil prices in fear of a recession contributes to increase the discrepancy in profitability between conventional power and renewable energy projects (decrease the relative competitiveness of renewables). The rise in coal prices and the credit squeeze further draws

[173] Carbon Finance (2008), *online*

liquidity from the market for project development. Rising prices in raw materials drive the increase in wind turbine prices.

However, wind power development in China also faces a series of challenges of intrinsic nature. The tremendous pace at which the Chinese wind power sector has been evolving entails an inherent risk of undesirable developments. Reports of wind turbines not performing as expected or even collapsing, lack of due diligence in planning of wind farms, serial production errors in turbines, the counterfeiting of components. These incidents are often portrayed as isolated, but may be representative of greater erroneous trends in the industry. Government regulation will be essential in addressing the issues at stake and preventing them from becoming fundamental barriers to future wind power development.

6.1 Policy

As mentioned before, government renewable energy and wind power policy have been the single most important driver for wind power development around the world. This is also true for China. A combination of wind power development targets, mandatory market share requirements, economic incentives and protective policies have created a burgeoning wind power market and a thriving domestic industry. Nevertheless, in order to prevent a bust from following the boom, a few adjustments of the policy framework are necessary in order to provide for sustained wind power development.

Restrictive government policies, particularly with regard to wind power pricing and foreign investment, pose a serious barrier to the exploitation of a diverse set of investment sources for wind power development in China. Obstructive regulations for FDI, especially with regard to debt financing and CDM project ownership, serve as deterrents for foreign investors. Modes for participation in the regulatory process are unclear, as are rights to appeal regulatory decisions. The lack of a clear pricing policy guaranteeing secure and attractive profit margins for wind power projects has kept many potential investors at bay. Limited access to proper financing and insurance further discourages private and foreign investors. The development of a competitive power sector is also impeded by the dominance of state-owned power generators, who retain strong and often opaque links to state funds, while their levels of profit, subsidies and cross-subsidisation are undisclosed.[174]

The government has largely recognized the challenge to open up the market to private and foreign investors. Movement towards further improvement of the policy framework governing wind power is visible. Recently, the government has been addressing many of the most important barriers impeding wind power development. Wind power pricing policy has been slowly moving towards a more predictable and lucrative system of fixed feed-in tariffs. Government action has been taken to alleviate deficiencies regarding reliable wind resource data and the innovation capability of the domestic industry. According to some observers, CDM regulations are expected to be loosened in favour of foreign investors.

Still, a number of challenges remain to be addressed, demanding government guidance in order to facilitate sustained, long-term development of wind power in China:

[174] cp, OECD/IEA (2006), p. 72

1. Enforce efforts to provide adequate wind power education and training programmes to ease the human resource deficit.
2. Establish strong mandatory wind turbine certification standards and support capacity building in the field of turbine testing, in order to ensure turbine quality/reliability and in the long-run improve global competitiveness of the domestic wind industry.[175]
3. Facilitate smooth grid integration of wind power by
   - strengthening the national power grid and interregional transmission capacity, taking into consideration the integration of wind power in the design of grid expansion plans by establishing management regulations and technical specifications to integrate wind power into grid planning.
   - mapping out comprehensive wind power development plans on national and provincial level in consultation with the grid companies, taking into account construction of other power generation capacity, (interregional) transmission capacity as well as the specific requirements of wind power grid integration.
   - redoubling research efforts with regard to the analysis of the influence of extensive deployment of wind power on the operation and management of the power grid, intensifying studies on accurate wind power forecasting to allow for effective dispatch of power and establishing a national grid code for wind turbines to ensure maximum electricity output of wind farms.
4. Tweak FDI, CDM and wind power policies to allow for more diversity in investment and enhance the efficiency of the power sector by creating a fair and open market. Clarify wind power pricing policies and facilitate access to government subsidized bank loans.
5. Increase transparency within the wind industry and power sector, e.g. with regard to information on wind farm energy output and turbine availability, in order to facilitate competition and intra-industry learning processes, enable timely identification of challenges and build investor confidence. Information transparency is also necessary to improve energy demand and (wind power) supply forecasts and thus provide for proper dispatch of power plants.

6.2 Human Resources

The quality and reliability of wind power generators (wind turbines) is a major factor determining the energy output of wind farms and thereby their financial viability. In order to ensure a reasonable return on investment and reduce risks due to low wind turbine availability or turbine breakdowns, banks and insurance companies have become stricter with regard to standards and requirements. This is true for certification of materials and products, processing techniques and testing standards and affects enterprises at all stages along the value chain. Quality control and management are of crucial importance in every aspect of wind power equipment manufacturers' ventures, from initial research and design processes, via testing procedures to mass production. Off-shore wind power generators are exposed to even higher mechanical loads and adverse environmental conditions than turbines on land, therefore demanding even higher standards.

[175] This issue has been addressed by the issuance of *The Management Regulations on Special Fund for Wind Power Manufacturing Sector in China* in August 2008 promulgating a link between a subsidy policy and a testing and certification system. It remains to be seen how effective this policy will be at increasing the competitiveness of the domestic industry.

The same applies to project developers and operators in the wind industry, with economic success of wind farm projects heavily reliant on the qualification and skill of their employees. From personnel involved in wind resource assessment and micrositing of turbines, via engineers overseeing construction and grid integration to management, maintenance and troubleshooting of the wind farm during operation, the profitability of the project is dangling on the string of staff qualifications.

A wide range of qualified personnel with technical, legal as well as economic knowledge is needed in order to meet the high requirements of the wind industry at all stages of the value chain. Employees have to apply their knowledge in order to innovate products and processes, be able to identify problems and solve them independently. Only companies with skilled personnel and qualification schemes in place to advance the knowledge base of their employees in order to keep up with technological innovation, will be able to survive in an ever more competitive industry. For that reason, qualification is of central importance to all companies in the wind power sector.

In late 2006, Paolo Fernando Soares, Chief Executive Officer of China operations of foreign-owned wind turbine manufacturer Suzlon, stated *“Human Resources is the most important aspect of the Wind Power Business in China”*.[176] This assertion applies not only to domestic and foreign wind turbine manufacturers in China, but to the same degree to wind power project developers. The pace of wind power development in China has given rise to an enormous shortage in adequately qualified personnel. The dearth of personnel extends from technically proficient production workers, over engineers possessing the inter-disciplinary knowledge necessary for product development in the wind industry to skilled staff able to cope with the specific challenges arising during operation and maintenance of wind farms. Especially for the process of wind turbine design, but also for research, testing and certification, staff needs to be able to apply knowledge of a wide range of disciplines, demanding a comprehensive approach to education and training of wind industry personnel: from mechanical and electrical engineering, aerodynamics, structural analysis, statics, material science, computer control technology, power electronics, load measurement, to meteorology and more.

In order to assess the specific needs of the wind power industry in China with regard to human resources, within the scope of this study, the GTZ China Wind Power Project conducted a series of sample surveys. In cooperation with CEPRI and CWEA two polls were conducted at the China Wind Energy Exhibition 2008 in Shanghai and the Wind Power Asia 2008 in Beijing.[177] In addition, CWEA and CEPRI tapped their extensive network of connections in the wind power industry, so as to get an overview over the present situation with regard to personnel supply and demand.

The surveys support the claim that lack of qualified staff presents one of the most important challenges to the wind power industry in China today. When asked about the potential barriers to wind power development in China, a shortage in personnel was named as the premier challenge. With regard to the question which qualifications are needed, answers have been spread widely reflecting the broad range of companies and job profiles in the wind industry. Wind turbine manufacturers are especially in need of technical personnel since it makes up around 60 to 70% of their employees; electrical and mechanical engineers are particularly sought after. Managers and IT professionals are a smaller but equally vital part of the workforce. An education focussed on wind power or experience in the field is a bonus, but not prerequisite, since personnel qualified in this regard is rare and demand for staff high.

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[176] Suzlon (2006), *presentation*

[177] For in-depth evaluation of the two training surveys, please refer to the Annex.

It is difficult to quantify the need for qualified personnel and training of the sector, because no aggregated data on employment and training exists. The surveys conducted are only of indicative value, since they do not cover all of the active companies. He Dexin, president of CWEA, estimates the total employment in the Chinese wind power sector at 20.000 people (incl. suppliers).[178] If the wind power market keeps expanding, the employment in the sector will grow along with it. For example, Goldwind, China's biggest manufacturer, plans to increase personnel by more than 40% in the next two years from 933 to 1603.[179] If total employment grows by 10% over the next years, by 2013 the number of people employed in the Chinese wind power sector will have doubled to around 40.000. The number of technicians employed in customer services at wind turbine manufacturers and in operation and maintenance at wind farms will increase particularly fast, as more and more wind farms go into operation. In order to be able to quickly solve emerging problems, these service technicians will need to be trained in monitoring, servicing and troubleshooting of wind turbines. At the same time, the demand for highly qualified personnel needed for R&D, wind turbine production as well as turbine quality control and extensive testing will rise.

Similar to the situation in other countries with a rapidly evolving wind power industry, despite the fact that the wind power sector is in need of staff with integrated knowledge of a range of different scientific disciplines only very few vocational schools and university programmes in China address wind power specifically in their courses of studies.[180] Graduates with a wind power-specific degree are extremely rare. The Suzhou Training Centre of CWPP is the only training institution of its kind in China. More training institutions are in dire need in order to provide fundamental training in wind power technology, improve the trainees' practical skills through hands-on practice and convey highly sought-after understanding of specific methodologies and procedures needed for wind turbine testing and certification. On the one hand, the expansion of wind power installations is pushed at a tremendous pace. On the other hand, power generation companies acting as wind power project developers and service companies do not have the experience or the structural capacities necessary to provide adequate training and further education of their staff.[181] This is why they are in need of external support.

A vast majority of companies in the wind power industry relies on internal training in absence of adequate alternatives. Many wind power equipment manufacturers have established basic wind power knowledge courses in order to introduce job starters to the wind power fundamentals needed for the specific job profile. Joint design or licensing agreements of domestic manufacturers with foreign companies may open up the road to conduct internal training profiting from the experience of their technology partners. Needless to say this type of training is regularly restricted to the conveyance of a narrow scope of knowledge and skills, most often focussing on manufacturing processes. The training by foreign partners is limited to the training and/or technology transfer that is defined in contracts, and will usually not expand the knowledge base of the recipient significantly, let alone improve the indigenous innovation capacity. Therefore, wind power-specific education at vocational schools and

[178] *Personal communication* with He Dexin, President, Chinese Wind Energy Association
[179] *Personal communication* with Wang Jin, General Manager, Goldwind
[180] North China Electric Power University (NCEPU) is the only university in China with a four-year wind power bachelor programme (started in 2006 with 29 students; 2007: 30; 2008: 60, 2010: 120 (planned)). Other notable universities offering courses or active in the field of wind power research include the Shenyang University of Technology, North East Electric Power University, Northwestern Polytechnical University Xi'an, Tsinghua University and the Chinese Academy of Sciences.
[181] *Personal communication* with Dieter Sommer, Director, CWPP Suzhou Training Centre

universities to equip future employees with the necessary knowledge from the start as well as external training complementing internal training activities is urgently needed.

Foreign-owned companies often have the advantage of long-term experience and a base of well-qualified personnel in their country of origin. Tapping this reservoir through training of Chinese employees abroad or on location in China, can contribute to alleviating the problem of lack of qualified staff, but in the long run is not sufficient to meet demand.

In summary, demand for personnel with wind power-specific qualifications is large and rapidly expanding, as the Chinese wind industry is growing. Competition for staff with a wind power degree or experience in the field is fierce. Considering the importance of qualified personnel for healthy sustained growth of the wind power sector, the need for action to establish adequate educational and training programmes is urgent.

6.3 Wind Farm Performance & Lack of Transparency

The performance of wind farms is a topic of great importance for the future development of wind power in China. The success of wind power deployment today naturally affects the confidence wind power will be given as a power generation technology in the future. A wide-spread disappointment of expectations with regard to performance of wind farms poses a major risk and may have a serious impact on the perspectives for wind power development in China.

Unfortunately, data on the performance of wind farms, i.e. the average availability of wind turbines or the annual electricity output of a wind farm, is rarely available. Project developers, power generation companies as well as wind turbine manufacturers are afraid of economic losses, damage to their image and "loosing face", if data on underperforming wind farms or turbines is released. Furthermore, persons in charge do not want to cast a cloud on precious relationship networks or incriminate themselves and endanger their position. Hence, the wind power industry in China is shrouded by a lack of transparency.

The existing data on wind farm electricity output indicates a rather low average performance of wind farms in China. In an analysis of data from 47 existing wind farms with a total installed capacity of 1.580 MW conducted by CWEA, the average value for annual full load hours across provinces was around 1.800, the average capacity factor beeing 20%.[182] Based on data from 36 registered Chinese wind power CDM projects with CERs already issued, the current CER issuance rate is 79%.[183] These numbers supports the assumption that a vast majority of wind farms in China does not deliver the energy output predicted in feasibility studies.[184] Overall, actual energy output of Chinese wind farms appears to be 10 to 20% lower than expected.

The reasons for wind farms not living up to the performance predicted in the feasibility studies are manifold. The investigation of possible problems and bottlenecks is - again - hampered by lack of access to significant data. The CWEA study suspects the low value in full load hours to be a question of an inaccurate assessment of wind resources and subsequent overestimation of electricity output.

[182] Shi (2008b), p. 2
[183] Based on IGES CDM Project Database (18 September 2008)
[184] The amount of CERs issued is directly dependent on the amount of emissions avoided, which in turn is determined based on the energy output of the wind farm.

Other explanations include deficiencies in the micrositing, faulty erection or insufficient maintenance or condition monitoring of wind turbines. The performance of wind farms has also been affected by problems with wind turbine design and quality, resulting in low availability or even breakdown of turbines. Fast market growth is one source of the problem, creating huge demand-side pressures and driving wind turbine manufacturers to rush *"into large-scale production and operation [increasing] technical and economic risks."* [185] The excessive pace of commercialization in the domestic industry led to a number of technical failures due to faults or inaccuracies in design and production processes.[186] Insufficient wind turbine testing and certification in conjunction with a lack of qualified personnel is adding to these problems.

The imperfect incentive structure dominating investment decisions of wind power developers is contributing to underperformance of wind farms in China. For big power companies who are mandated to fulfil a renewable energy quota, electricity output of wind farms may be of minor importance, since the renewable energy obligation is calculated by installed capacity. The big utilities are known to cross-finance unviable wind power projects with revenues generated by fossil fuel power plants. All too often are investment decisions in wind power guided by political considerations like improving connections to the central government in order to win support for future non-renewable projects or increasing chances of a promotion to highly sought-after government positions. Securing sites with favourable wind resources not for immediate development, but for speculation is another ill-fated motive. Moreover, the detrimental price competition in projects allotted through a bidding process puts pressure on developers and wind turbine manufacturers to reduce costs in project realization. This may lead to wind turbine manufacturers using cheaper components, project developers choosing unfit raw materials during construction or malign saving of costs in project planning and operation.

In summary, not enough data is available to date to make a qualified judgment on the quality of Chinese wind turbines or the performance of wind farms. However, a tendency towards performance turning out lower than expected can be asserted. A lack of transparency stands in the way of a comprehensive analysis of the current state of China's wind power industry preventing a timely and accurate identification of issues and challenges. As the flow of information is slow and centralized collection of industry-wide data does not exist, it is extremely difficult for government agencies to improve existing legislation governing the sector and devise adequate measures to avoid undesirable developments. In addition, the reluctance to share basic information and experiences among project developers and across the value chain predominant among component and wind turbine manufacturers, results in a less integrated, fragmented industry. Consequently, the lack of transparency is seriously affecting the competitiveness of China's domestic industry.

6.4 Grid Integration

Wind power development faces a significant challenge in that wind power resources are for the most part located far from populous markets and centres of economic activity. However, China does not possess a well-connected national power grid, seriously compromising the capacity to transmit power between regions with a surplus in generating capacity to areas facing power shortages. Interregional transmission of electricity is constrained by limited transmission capacity and weak interconnections

[185] ERI/NDRC (2008), p. 25 et seqq.
[186] For a list of sources of wind turbine malfunctions, please refer to p.26 in ERI/NDRC (2008).

between regional power grids. In addition, outdated grid technology and weaknesses in the transmission of bulk power at local levels persist, further impeding the stable operation of regional as well as the national grid.[187]

As a consequence, the national power grid poses a significant bottleneck to large-scale wind power deployment, which depends on transmission of power from remote regions rich in wind resources to load centres. Other significant impediments to wind power development are the delays regularly occurring in the connection of wind farms to the grid. Although, grid companies are obligated by the *Renewable Energy Law* to connect wind power to the grid, regularly wind farms have to wait several months for grid connection. According to statistics of CEC and CWEA, by the end of 2007 one third of installed capacity – roughly 2 GW – was still awaiting connection to the grid.[188] In absence of penalties, grid companies cannot be held accountable for excessive delays in hooking up wind power projects to the grid.

The weak interconnections of the power grid in conjunction with the duopoly of the two grid companies, State Grid and China Southern Grid, prevent a competitive market for electricity to emerge on national level. Heavy investment in grid expansion is necessary in order to enable smooth transmission of power between regions and spur competition among power generators. Recognizing this deficit, the government has included provisions for investment in grid expansion as a key element of future plans for the power sector. Schemes to enhance west-to-east as well as north-to-south transmission capacity are in place.[189]

The strong focus on the concentration of wind power in massive regional clusters in China, poses an additional challenge to the grid companies, particularly with regard to the integration of wind power into the power grid. The fluctuation and intermittency of electricity generated from wind, creates the need to balance wind power through a combination of different means: additional reserves of conventional power, interconnection of regional power grids, load management and energy storage.[190] Decentralized wind power development[191] carried by individual or small private investors, which was largely responsible for the boom of wind power in Germany, would help to spread wind power more evenly across the country, alleviating the issue of grid transmission bottlenecks, while adding to the overall balance and stability of the power grid. Due to legal restrictions, mainly regarding ownership of power generation facilities and land use, China has not been able to facilitate a decentralized deployment of wind power to this day.[192]

Although the establishment of the general conditions necessary for the smooth integration of wind power into the grid inevitably causes extra costs, overall the benefits of a high penetration of wind in the electricity generation portfolio prevail. The costs for wind power are expected to decrease substantially in future.[193] Moreover, in a fossil fuel dominated power generation portfolio wind power,

[187] cp. OECD/IEA (2006), p. 42
[188] cp. Interfax China (2008a), *online*
[189] cp. OECD/IEA (2006), p. 42 et seqq. & p. 120
[190] cp. EWEA (2006), *presentation*
[191] Decentralized wind power development refers to the installation of a single or small number of wind turbines, usually in areas featuring good wind resources and a well developed grid but limitations with regard to space. To date no study regarding the potential of decentralized wind power development in China exists.
[192] *Personal communication* with Andreas DuBois, Project Director, GTZ China Wind Power Project, DECON
[193] By 2020 the cost for wind power onshore is expected to drop by 20%, offshore by 40%. Cp. EWEA (2006), *presentation*

as a power source with zero fixed costs, reduces overall generating costs and risks, not to mention the benefits of CO_2 emissions reductions and other environmental benefits. At the same time, grid upgrades for wind power integration, contribute to establishing the grid conditions necessary to make real competition in the national electricity market possible.[194]

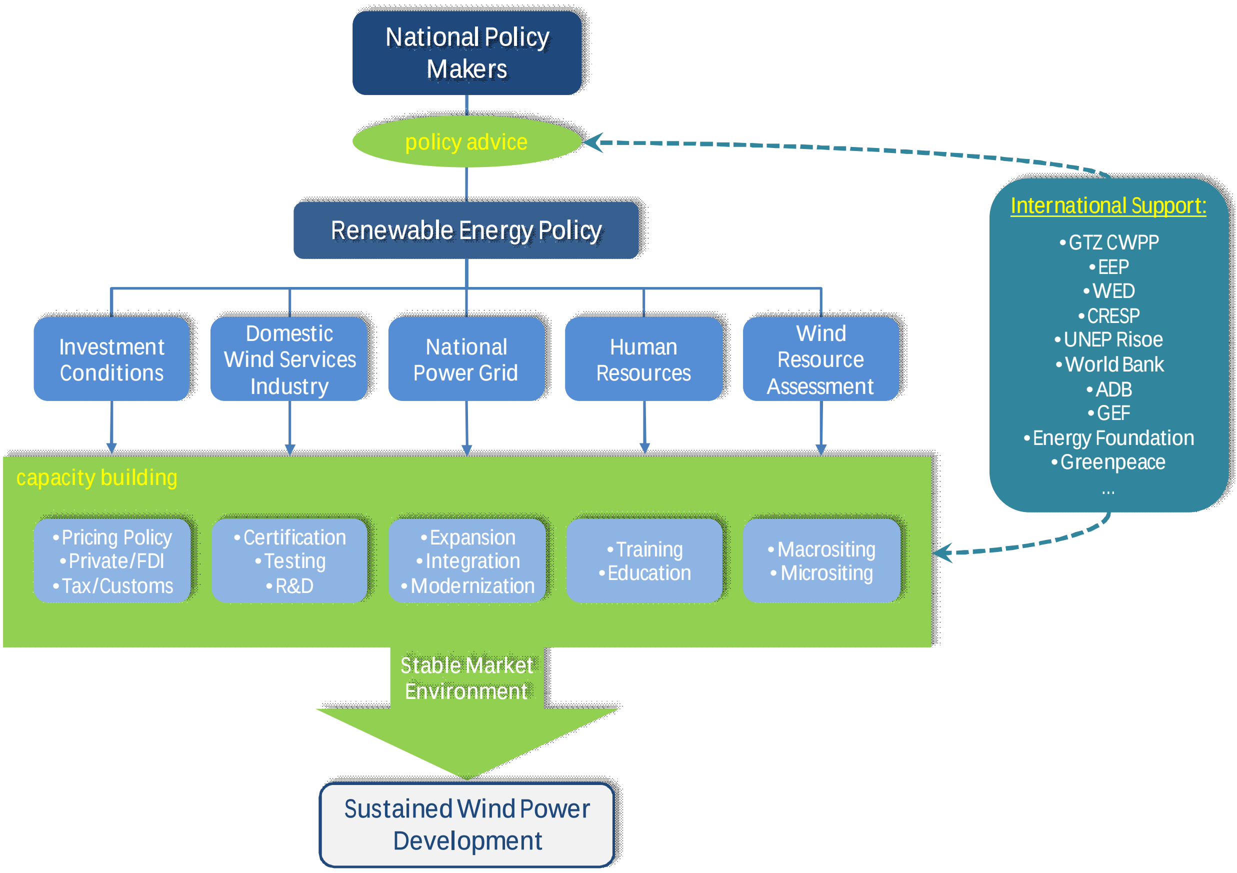
Between 2006 and 2010, US$ 130 billion are planned to be invested in the buildout of China's transmission network.[195] According to the reference scenario of the IEA's *World Energy Outlook 2007* over the period to 2030, the investments in expansion of the national power grid, amounting to US$ 1.510 billion, will surpass investments in generating capacity (US$ 1.255 billion).[196] While massive investment in the expansion of the grid is underway, the specific requirements of the integration of wind power are regularly not considered to an adequate extent in the design of grid expansion plans.

[194] cp. EWEA (2006), *presentation*
[195] cp. Rosen/Houser (2007), p. 25
[196] cp. OECD/IEA (2007), p. 359

7 Recommendations for the GTZ China Wind Power Project

This chapter offers recommendations on how CWPP may be adapted to ensure a significant impact of project activities and facilitate sustained development of the wind power sector in China. In face of the boom of the sector, the question might arise, if foreign support of wind power in China is still needed. Looking at the previous chapter and the pitfalls for future development of wind power in China, the answer is clearly yes. Due to the enormous pace at which the wind power sector evolved and the lack of extensive experience in China, the development of wind power is still fragile and in need of support to avoid pitfalls. Figure 21 displays the major determinants of future wind power development in China and how international assistance programmes and organizations may support the sector.

Figure 21 *International Support of the Chinese Wind Power Sector*



Source: author

Firstly, as mentioned before, government policy is the single most decisive factor determining wind power development not only in China, but around the globe. Influencing the policymaking process may seemingly be the most effective way to nourish a healthy wind power sector in China, at the same time it is also the most difficult approach to implement. Many reasons contribute to the difficulty of influencing policymakers: the strong hierarchy dominating Chinese legislative processes makes it hard to gain access to relevant decision makers; the government often relies on internal research institutes or other government agencies for policy advice; the sheer mass of stakeholders trying to influence policymaking – domestic and foreign, private and state-owned – adds to the difficulty of individual voices to be heard. Nevertheless, in fields where other countries or companies have a proven track record of success, international experience is valued greatly and will be heard if the proper channels of communications can be opened.

The second and more accessible approach is the support of capacity building activities, as the ones in the field of wind power training and research that have been laid out by CWPP. Foreign assistance is especially valuable with regard to building technological capabilities, since the Chinese wind industry is still young and behind in terms of technological development. From R&D, certification & testing, resource assessment, siting or condition monitoring, load forecasting, to education and training, the domestic wind power sector is sure to profit from the extensive wind power experience Germany has accumulated.

Recently, on 18 November 2008, the German Ministry for the Environment, Natural Conservation and Nuclear Energy (BMU) announced a new Sino-German initiative in support of the Chinese wind power sector. In association with the German Development Cooperation (GTZ) and the Chinese implementing partners State Grid Corporation of China (SGCC) as well as the China Electric Power Research Institute (CEPRI), the Wind Environment Research & Training (WERT) Centre jointly with selected universities will offer a platform for Chinese and German industry to carry out research, education and training activities for the wind power sector.[197] The WERT Centre funded by the BMU with € 4 million (~35 million CNY[198]) will complement the activities of CWPP focussing on tests and standardization with regard to grid connection of wind power plants, advanced technical education (incl. online classes) as well as training not covered by the CWPP Suzhou Training centre, and research in support of the establishment of grid codes adapted to China’s specific conditions.

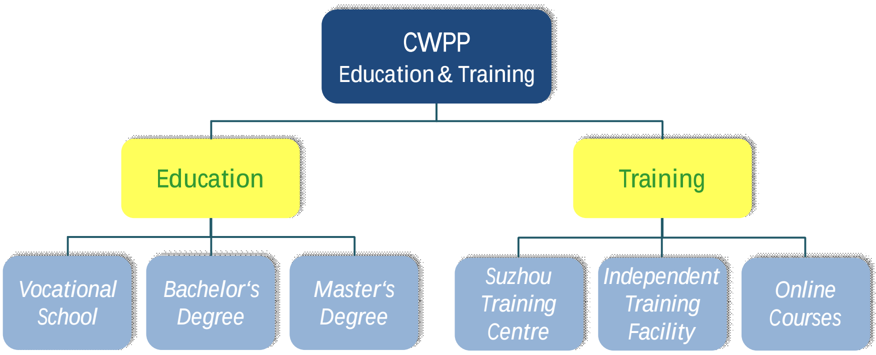
7.1 Wind Power Education & Training

As the lack of qualified human resources is one of the most pressing challenges the Chinese wind power industry faces, international support in this regard is of crucial importance. From the German perspective it is especially important to strengthen efforts to improve the situation with regard to lack of personnel, since many Chinese manufacturers rely on German technology. It has to be prevented that failures resulting from human errors fall back on the source of technology and thereby harm the image of German companies. Basically, there are two approaches to support the Chinese wind power sector with regard to qualification of personnel: supporting the establishment of wind power-specific education at vocational schools and universities, and intensifying efforts to supply adequate training for wind power staff, mainly recent graduates and personnel already on the job (see Figure 22).

The Suzhou Training Centre of CWPP has been a decisive step in building capacity to train service technicians and prepare them in a practice-oriented fashion for a job in operation and maintenance. Short-term courses for managers and R&D personnel have complemented this training. However, doubts have been raised with regard to the organizational structure of the Suzhou Training Centre. Since the centre is administered and financed in cooperation with CLYPG, voices have been questioning the independence of the centre raising the concern of labour piracy.[199]

[197] BMU (2008), *presentation* held at WERT-Centre Wind Power Grid Integration Workshop, Beijing
[198] exchange rate 28.11.08: 1 EUR = 8.69168 CNY
[199] *Personal communication* with Paolo Soares, CEO, Suzlon Energy (Tianjin) Ltd.

Figure 22 *CWPP Options to Support Education and Training*



Source: author

Therefore, drawing upon the experiences gained in setting up and operation of the CWPP Suzhou Training Centre, the establishment of an independent training facility, possibly in cooperation with German and Chinese universities experienced in the field of wind power education, should be considered. The training should encompass a high level of practice, since the practical application of knowledge is often neglected in Chinese education. The integration of courses or seminars conducted in association with manufacturers, industry associations and consultancies is sure to increase the timeliness, practical orientation and applicability of knowledge. However, organizational ties to the industry have to be avoided in order to preserve independence. In face of the tremendous demand for wind power training services, online training offers an especially attractive alternative to face-to-face teaching, since it can reach a large number of trainees at minimal costs. Online training may be adapted for specific courses that do not require hands-on practice, e.g. basic wind power knowledge, and has the advantage of minimizing absence from the workplace of direly needed personnel. Table 5 shows a selection of typical training needed at power generation companies and wind turbine manufacturers.

Table 5 *Typical Training Needs of Project Developers & Manufacturers in China*

Training for project developers	Training for manufacturers
§ Basic wind power knowledge	§ Basic wind power knowledge
§ Wind farm management	§ Turbine design
§ Construction / erection	§ Grid code
§ Operation & maintenance	§ Certification standards
§ Centralized/automated monitoring & error detection	§ Testing methods
§ IT training (resource assessment, siting, output prediction...)	§ Debugging/troubleshooting
	§ IT training
	§ Offshore technology

Source: author

Wind turbine manufacturers, research institutes as well as project developers are in great demand of highly-qualified personnel with an integrated wind power knowledge. This type of knowledge can only be build through years of experience or comprehensive wind power courses of studies at universities. In the case of vocational schools, existing professional education, e.g. in the field of mechanics, mechatronics or electrical engineering, may be supplemented with wind power-specific components. With regard to higher education, with ties to leading German universities offering wind power-specific education in place, CWPP is perfectly set up to support the establishment of a wind power-specific degree programme in China. The establishment of a two-year wind power master programme is an attractive option as a first step. Including experienced professors from Germany in the consultations, CWPP can facilitate the design of a proper curriculum, contribute to the compilation and selection of teaching materials, assist in lab construction and organise the exchange of professors and students to improve the quality of education, while strengthening the Sino-German relationship. Cooperation with CEPRI on a post-graduate wind power course of studies is one of the premier options that comes to mind. Other eligible partners for cooperation in the establishment of a wind power degree programme are primarily the Chinese universities that are already active in the field of wind power, either by conducting research or offering wind power-related seminars.

If independence can be secured the establishment of an institution for wind power training and/or education close to industrial centres of the wind industry may be considered (e.g. Tianjin, Baoding, Jiuquan). For instance, the Director of the Baoding National New High-Tech Industrial Development Zone, where setting up renewable energy companies is especially encouraged, expressed great interest to facilitate the establishment of an educational institution focussed on wind power.[200]

7.2 R&D and Technological Capacity Building

In the previous chapter, it has been established that the wind power sector in China is facing multiple technological challenges, especially with regard to the thorough testing of wind turbines, the establishment of a mandatory turbine certification system and the smooth integration of wind-generated electricity into the grid. In order to ensure the sustained development of wind power and support wind power in becoming a crucial component in China's energy mix, the GTZ China Wind Power Project will need to address these challenges and assist government efforts to improve upon the public service system supporting the wind power sector. In future, as the industry grows along with the market, there is great need for coordinated action to establish public facilities catering to the necessities of the wind power industry, so as to strengthen the competitiveness of the domestic industry and ensure healthy long-term wind power development.[201] Most notably, the establishment of the following facilities is needed:

- a national wind technology R&D centre
- a national trial and demonstration wind farm
- a national wind turbine testing and certification centre

In the establishment of these public facilities, it has to be kept in mind that their efficiency and success is directly dependent on their accessibility, independence and expertise. The facilities will only serve their purpose to enhance overall competitiveness and longevity of the Chinese wind industry, if they are open to all market participants, domestic or foreign, strict protection of independent property rights is guaranteed and the level of technological expertise, methodologies and processes is world class.

Already, CWPP has played an integral part in helping to assemble and improve the physical and intellectual resources at CEPRI to create a Renewable Energy Department that provides services and consultancy to the wind power sector, ranging from resource assessment, via testing to grid integration.

[200] *Personal communication* with Ma Xuelu, Director, Baoding National New and High-tech Development Zone, Vice Director, Chinese Wind Energy Association

[201] Please compare the policy recommendations in ERI (2008) and Li et al. (2007).

The current engagement with CEPRI serves as a formidable example of successful international assistance in capacity building in the Chinese wind power sector and presents a foundation to support government efforts in the establishment of aforementioned institutions. If allocated the necessary financial resources, CWPP will be able to assist the development of a wind power service industry in China with international experience and advice with regard to:

- institutional and organizational design
- methodologies, processes and best practices
- technological equipment
- training of staff
- financial support
- German experience and cooperation

To advance the primary objective of CWPP and improve the "*technical capabilities of private and state institutions for the nationwide development of grid-bound wind energy use"* a participation in the development of a public national wind power sector support system will be of great value. In order to attain this goal, CWPP has to intensify relations with government research and planning bodies at NDRC, in particularly ERI and NEA. The credentials and *guanxi* that have been built through previous project activities with CEPRI and CLYPG as well as the excellent reputation of the German wind industry may help to create a foundation of trust. Furthermore, the utilization of the specialized knowledge of the implementing partners should be integrated into CWPP's strategy to contribute to an effective Chinese wind power public service system from the start. Best results may be achieved via cooperation with German companies or institutions, which are acclaimed experts in the wind power sector and can contribute valuable industry experience and expertise, like Germanischer Lloyd, TÜV or WindGuard. Since in China all government policy and administrative decisions are following a strongly hierarchical pattern, the support of high-level officials from the German government and the GTZ China Office will be necessary to gain access and establish working relationships.

In addition, it is necessary for CWPP to intensify efforts to support research with regard to large-scale integration of wind power in the Chinese power supply at strategic partner CEPRI. In Jilin the regional power grid broke down repeatedly, due to insufficient grid code requirements for wind turbines. In order to avoid this kind of far-reaching failures in future, coordination of provincial and national authorities with regard to wind power expansion plans and of national grid companies with regard to grid expansion plans has to be facilitated. Reviewing international experience and best practices will be of advantage. In spite of different circumstances, grid integration in China is sure to benefit from looking at the experiences and research carried out in Europe.[202] CWPP can play a vital part in transferring this knowledge via exchange of experts, study tours, supporting research efforts and introducing best practices from Germany.

7.3 Information Services

Central collection and analysis of wind farm performance data, in conjunction with a more transparent power sector information policy has number of positive effects for the power sector in general and the wind power sector in particular: ranging from a more competitive power market and prevention of

[202] One of the interesting studies in that context is the study on "Large Scale Integration of Wind Energy in the European Power Supply" conducted by EWEA in 2005.

unruly market practices to practical issues like more accurate energy demand and supply forecasts and efficient power plant dispatch.[203] In the long-run the domestic wind power industry would benefit through more efficient development of reliable wind turbines, higher wind farm output, increased wind power development activity and smooth uptake of wind power into the grid. At the same time, transparency in the power sector would attract more diverse sources of investment, create competition and would contribute a more balanced and efficient development of supply and demand by giving rise to the dominance of market signals in investment decisions.

Since the players in the power market in China are reluctant to provide information on any number of critical issues, from wind turbine availability, wind farm electricity output, over technical problems to information on financial aspects like (cross-) subsidization, a comprehensive analysis of the state of the Chinese wind power sector is difficult. The secrecy of market participants, from manufacturers over power generation companies to grid companies, in conjunction with the market structure, where the government – directly or in form of state-owned companies – is taking on the role of project developer selling electricity, the grid company buying electricity and the regulator determining prices and allocating development rights, prevents the development of a competitive wind power market. The absence of transparency and market signals has a significant influence on the deployment of wind power today, while posing a serious threat to the future of wind power in China.[204]

As it stands today, a centralized collection of data will only be possible on order of the government. Efforts to collect information from individual market participants have been made, but do not create a comprehensive picture of the wind power sector, while at the same time being very demanding in terms of resources necessary – i.e. financial resources, manpower and time. If the government were convinced that the establishment of a public wind power information system on national level would bring significant benefits for wind power development in general and the evolution of the domestic wind industry in particular, government action to mandate release of certain information seems possible. Major benefits of a public wind power information system are[205]:

- It facilitates intra-industry learning processes across the value chain increasing overall competitiveness of the industry.
- It helps to avoid pitfalls for development by allowing for speedy identification and addressing of problems.
- *“It helps to avoid regulatory capture [e.g. by influential state-owned market participants] and prevents corruption in the regulatory process. Market players [...] can apply pressure for rules to be applied as intended.*
- *It supports the provision of essential information – costs, prices, etc. – without which competitive markets cannot function, or function efficiently.*
- *It identifies who is responsible for each aspect of the new market framework.*
- *It shows where regulator’s powers are relatively weak, making its views – and the responses of regulated firms and other key players – a matter of public record […].*
- *It reveals information about market rules, supporting [e.g.] the prevention of cross-subsidisation between the competitive and monopoly elements of the value chain.*

[203] For in-depth information on the benefits of transparency, please refer to OECD/IEA (2006), p. 73 et seqq.
[204] Please compare chapter 6.3 for details on the impact of a malign incentive structure and a lack of transparency on wind farm performance, and in turn perspectives for wind power development.
[205] Most of the benefits mentioned here, also apply to a more general power sector information system.

§ *It provides regular communication about reform developments, which can help to sustain reform enthusiasm."*[206]

To get the ball rolling, CWPP installed a public domain (website) with data currently available on the wind power sector. CWPP can further support the establishment of an industry-wide information system by explaining its benefits by means of the example of information best practices in Germany. In the mid-term, possible content providers as well as the relevant government institutions (CRED/ERI & NEA) have to be actively involved in the effort of the construction of a public domain in order to guarantee the validity and significance of information and give them a stake in the success of the venture. Ultimately, the wind power industry and the power sector in general will benefit from a more accessible, competitive and efficient market.

7.4 Final Remarks

As interviews were conducted, surveys were carried out and the research for the CWPP China Wind Power Study 2008 progressed, it became more and more apparent that the current CWPP project activities are not sufficient to cope with the challenges that arise alongside the boom of wind power in China. This is one reason why all through the course of conducting the study, negotiations were underway to start a new Sino-German project in support of the Chinese wind power sector. As previously mentioned, in November 2008 BMU and GTZ on the German side and NDRC, SGCC and CEPRI on the Chinese side joined forces to initiate the Wind Environment Research and Training (WERT) Centre forming a counterpart to the existing China Wind Power Project (CWPP). Intermediate results of the research and analysis for the CWPP China Wind Power Study 2008 were incorporated into the planning of the WERT Centre and contributed to the formulation of its objectives. The identification of challenges as well as the recommendations for future areas of Sino-German cooperation in this study will serve to enable an efficient sharing of responsibilities between CWPP and the WERT Centre and provide an up-to-date basis for the adaptation of activities to actual market conditions.

[206] OECD/IEA (2006), p. 73 et seqq.

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