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# Asia Energy Sector

Regional: Energy

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## Climate change in Asia – China's wind and nuclear industries

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### Summary

- In this report, we discuss the issue of climate change, one of the environmental problems in Asia, with a focus on the trend of carbon dioxide (CO<sub>2</sub>)-emission reduction in the power-generation industry. We studied the industry trends in Asian countries and focused on China's wind and nuclear industries, considering their markets' scale and growth rates.
- We expect related companies to benefit significantly from the expansion of the huge domestic market, led by the PRC Government's energy policy. We believe these companies would also improve their global positions in the long term.
- In our opinion, the top companies to watch include: China High Speed Transmission Equipment Group (658 HK, HK\$15.72, Not rated), Dongfang Electric (1072 HK, HK\$30.50, Not rated), HLS Systems (HOLI US, US\$5.95, Not rated), Doosan Heavy Industries (034020 KS, W73,800, Not rated), and Suzlon Energy (SUEL IN, Rs126.45, Not rated).

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# 1. Macro-economic overview of the power-generation industry in China

## 1.1 Energy-consumption structure in China

**China is dependent heavily on coal energy**

Coal energy accounts for 70% of China's total primary-energy consumption. The country has vast coal reserves, which have contributed to its high energy-self-sufficiency ratio of about 90%. Meanwhile, among the country's total electricity generation, coal accounts for 81%, hydropower 15%, and nuclear power 2%, creating a portfolio with a favourable cost performance. Therefore, power prices in China are low on a global basis.

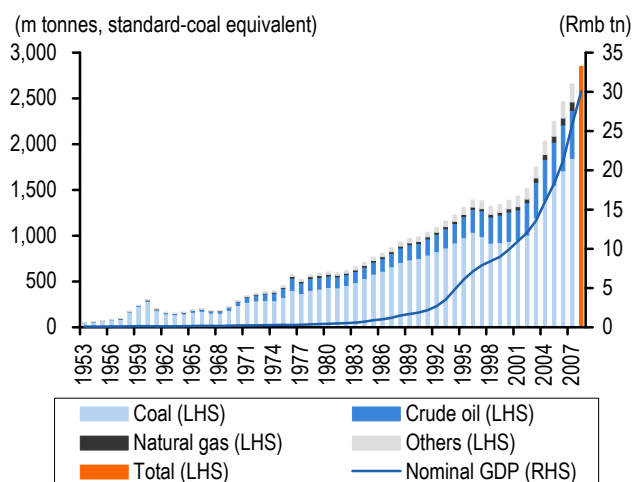
**Risks associated with this high dependency on coal have emerged**

Energy demand in China surged as the country's economic growth accelerated after 2003. As a result, problems arose, such as bottlenecks in railway transportation, which is the primary means by which to transport coal, highlighting the fact that excessive dependence on coal leads to energy-supply risks. In addition, high usage of coal is also negative in terms of CO<sub>2</sub> emissions, as the CO<sub>2</sub> emission amount of coal per unit power generation (energy) is the largest among the various power-generation fuels.

**Reduced dependency on coal is essential for China's energy policy, in our view**

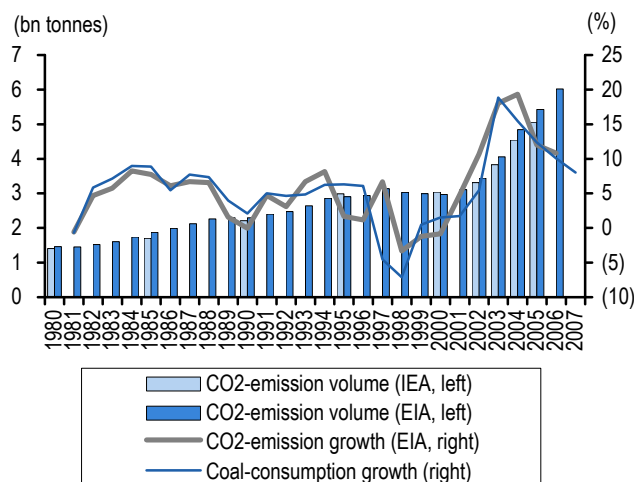
Going forward, we will monitor how the PRC Government positions coal in its energy policy. China is now engaged in the diversification of its power-generation fuels. We believe the expansion of the domestic alternative energy market in China will be affected by the country's progress in reducing its dependency on coal energy.

**China: energy consumption and nominal GDP**



Source: CEIC

**China: CO<sub>2</sub> emissions and coal consumption**



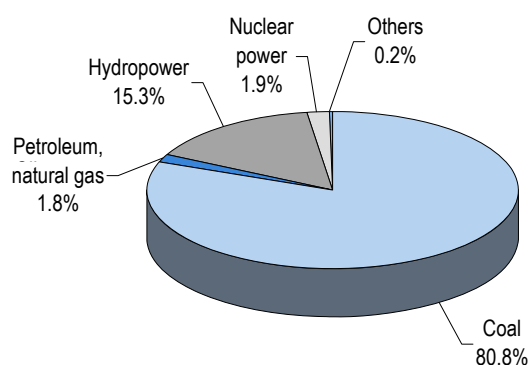
Source: IEA, EIA, CEIC

**China: primary-energy sources, self-sufficiency ratio (2007)**

	Primary energy total	Oil (bn barrel)	Natural gas (tn m <sup>3</sup> )	Coal (m toe)	Others
Proved reserve		15.5	1.88	114,500	
Production		1.37	0.069	1,289.6	
Consumption		2.87	0.067	1,311.4	
Production (m tonnes)	1,662.1	186.7	62.4	1,289.6	123.4
Consumption (m tonnes)	1,863.4	368.0	60.6	1,311.4	123.4
% of total consumption	100	20	3	70	7
Self-sufficiency rate (%)	89	51	103	98	100
Reserve-production ratio (years)	-	11.3	27.1	88.8	-

Source: BP

**China: power-generation mix (2006)**



Source: IEA

## 1.2 Energy policy in China

**China has adopted policies related to the climate change issue ...**

According to the energy policy stipulated in the Eleventh Five-Year Plan (2006-10), China has set the following goals in relation to issue of climate change:

- Reduce the energy consumption per unit GDP by 20% through energy saving and energy-efficiency improvements.
- Expand energy supply through the diversification of energy sources (including not only nuclear-power and renewable-energy sources, but also gas sources).
- Regarding the use of coal, the primary energy source, strive to improve efficiency, reduce the environmental load, and to ensure security of the supply.

**... reflecting international sentiment**

China's energy policy, and its efforts to reduce greenhouse-gas emissions, reflect international opinion, which holds that China is a threat in terms of its expanding usage and procurement of energy. The major actions China has taken to respond to such international views are shown in the following table.

Major events related to China's energy policy		
Time	Event	Implication
1-Jul-04	Announcement of <i>Renewable Energy Utilization Promotion Law</i>	Full-start of preparation for the promotion of renewable energy
1-Nov-04	Announcement of <i>Medium to Long-Term Energy-Conservation Special Plan</i>	Numerical target was set for the reduction of energy consumption per unit GDP
1-Jan-06	Promulgation of <i>Renewable Energy Law</i>	Promulgation of <i>Renewable Energy Law</i>
1-Mar-06	Announcement of Eleventh Five-Year Plan	Speeding up the reduction of energy consumption per unit GDP
1-Jun-07	Publication of <i>National Plan in Response to Climate Change</i>	Appealed the stance of China in the developing international discussion about the global warming issue
1-Jun-07	Announcement of <i>Comprehensive Work Plan for Energy Conservation and Emission Reduction</i>	Aimed at encouraging emission reduction by making the energy-conservation and emission-reduction plans more concrete
1-Sep-07	Announcement of <i>Medium to Long-Term Development Plan for Renewable Energy</i>	Official announcement of the installation target for each type of energy
1-Dec-07	Publication of <i>China's Energy Situation and Policy</i>	Explanation of the actual state of energy consumption, denial of discussion in which China is regarded as a threat
1-Apr-08	Promulgation of <i>Revised Renewable Energy Law</i>	Determined the details of methods, control, encouragement measures and legal responsibility, aiming further promotion of the law
1-Oct-08	Announcement of <i>Policies and Measures on Climate Change</i>	Official announcement of China's awareness of the global-warming issue and the current situation of its active efforts

Source: Announcements by the PRC Government, compiled by Daiwa

### Energy saving and energy-efficiency improvement

**Energy-saving policies have been implemented since 1998 ...**

China's efforts in terms of saving energy and improving energy efficiency had started before the Eleventh Five-Year Plan period. The *Energy Conservation Law* came into effect in 1998. In November 2004, the government announced the *Medium to Long Term Energy Conservation Special Plan*, setting a goal to reduce energy consumption per unit GDP by an annual rate of 2.2% in 2003-10, and by an annual rate of 3% in 2003-20. In addition, in order to achieve that goal, targets for specific energy consumption of major products and energy-efficiency for major equipment were set out in the special plan. The Eleventh Five-Year Plan calls for an acceleration in the pace of reduction of energy consumption (to an annual rate of about 4%).

**... and have become more strict since 2006**

Following the Eleventh Five-Year Plan, the *Comprehensive Work Plan for Energy Conservation and Emission Reduction* was issued in June 2007, including goals such as the disposal of old power-generation facilities, ten major energy-saving projects, and targets for energy-consumption reduction through the enhancement of energy-saving and environment-protecting power generation. In November 2007, a 'target-responsible' system was introduced with the announcement of the *Statistics, Monitoring and Examination of Energy Saving* directive. In April 2008, the *Revised Energy Conservation Law* took effect, determining the details of management and specific methods to save energy, as well as measures to encourage energy saving and legal responsibility.

Meanwhile, according to the PRC Government, energy consumption per unit GDP was reduced in 2006, 2007 and 2008 by 1.79%, 4.04% and 4.59%, respectively, which was behind the targeted pace.

### Diversification of energy sources

**China introduced its Renewable Energy Law in 2006**

In the course of diversifying its energy sources, China has enacted laws and regulations to promote renewable energies, which need policy support to be adopted by companies, as they require relatively high power-generation costs. In January 2006, the *Renewable Energy Law* was promulgated, including rules such as: 1) requiring power grid companies to purchase power generated and provided to power grids by power producers using renewable energies, 2) if a grid company purchases power generated using renewable energy at a premium to the standard price, the grid company can pass the premium it paid on to its selling price, and 3) requiring provisions for the introduction of preferential loans and taxes for renewable-power projects. In the renewable-energy medium- to long-term development plan announced in September 2007, the official target of the ratio of renewable energies to the total primary-energy consumption was set at 10% and 15% for 2010 and 2020, respectively. Accordingly, China also set specific targets for the various types of renewable energies to be introduced by 2020.

**We think the government's targets for wind- and nuclear-power projects could be revised up**

Among the renewable-energy projects, the introduction of wind power has exceeded the government's original target. A total of 12.2GW of wind-power generation capacity was installed by the end of 2008, and the original target of introducing 30GW by 2020 may be achieved as early as in 2010. While the PRC Government has not announced any upward revision to its target for wind-power installation, we believe it could revise this up to at least 100GW, given the progress made to date (meanwhile, the estimated potential-market size in China is about 1,000GW).

For nuclear-power projects, the government is considering revising up its target by 2020 from 40GW originally to at least 70GW. While a series of construction projects for nuclear-power plants commenced in 2H08, there has been no recent increase in the cumulative installed capacity, as the construction of a nuclear-power plant takes a long period of time (about five years). However, the nuclear-power projects have become more important to the country, in view of its energy-source diversification strategy, in our view.

#### China: targets for the introduction of renewable/nuclear energy

Energy type	Unit	2005	2010	2020
Hydropower (for large and medium sized plants)	GW	79	140	225
Hydropower (for small sized plants)	GW	38	50	75
Biomass	GW	2.0	5.5	30
Bio-solid fuel	m tonnes	-	1.0	50
Methane gas	bn m <sup>3</sup>	7.0	19	44
Liquid fuel				
Food fuel	m tonnes	1.02	-	-
Non-food fuel	m tonnes	0.0	2.0	10
Bio-diesel fuel	m tonnes	0.05	0.2	2
Wind power	GW	1.26	**5→10	30
Solar power	GW	0.07	0.3	1.8
Solar water heater	m tonnes (standard-coal equivalent)		30	60
	m m <sup>2</sup>	80	150	300
Ground heat	m tonnes (standard-coal equivalent)	0.0	4.0	12
Tidal power	GW	0.0	-	0.1
*Renewable energy ratio	%	7.5	10	15
Nuclear power	GW	6.6	-	**40→70

Source: PRC Government, compiled by Daiwa

Note 1: \*Renewable energy ratio indicates the ratio of the renewable energies in the total primary-energy consumption

Note 2: \*\*Targets for the wind power (2010) and nuclear power (2020) have been revised up from the original plan

**The ratio of thermal-power plants in total added capacity is decreasing**

Looking at the breakdown of the power-generation capacity increases, the decreasing ratio of thermal power-generation capacity to the increase in total capacity indicates that the policy measures are proving effective, gradually. From 2006 to 2008, the ratio of thermal plants to total increase in power-generation capacity dropped from 89% to 73%. We forecast a further reduction in the addition of thermal capacity in line with a decline in power demand for the next few years, leading to increases in the proportion of other energy sources.

**China: power-generation capacity increases and breakdown**

		Total					(%)			
		Thermal	Nuclear	Water	Wind	Thermal	Nuclear	Water	Wind	
Added capacity (GW)	2006	101.2	90.5	0.0	9.7	0.9	89.4	0.0	9.6	0.9
	2007	100.1	81.6	2.0	13.1	3.0	81.5	2.0	13.1	3.0
	2008	90.5	65.8	0.0	20.1	4.7	72.6	0.0	22.2	5.1
Cumulative installed capacity (GW)	2008	792.5	601.3	8.9	171.5	8.9	75.9	1.1	21.6	1.1
Power generation (TWh)	2008	3,433.4	2,779.3	68.4	563.3	12.8	80.9	2.0	16.4	0.4

Source: Announcements by the PRC Government, compiled by Daiwa

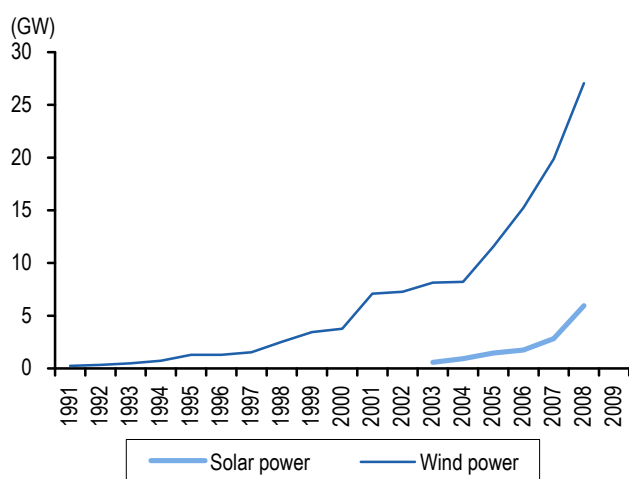
**Looking ahead**

**We will monitor China's progress in introducing solar-power generation**

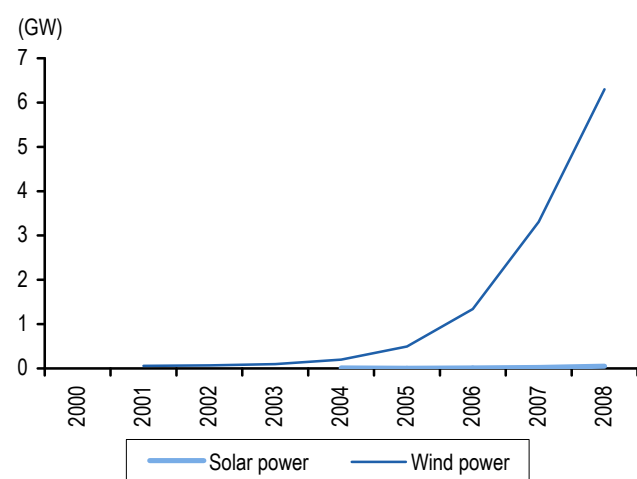
Among the energy-diversification projects in China, we would pay most attention to the introduction of solar-power generation. While wind-power generation capacity has started increasing, and preparation for the full introduction of nuclear-power generation is progressing steadily, no effective measures have been introduced for the promotion of solar-power generation.

However, the government has announced 'support for initial investments in solar power generation projects (Rmb20/W subsidy for more than 50kW projects)' as a supportive measure for the solar-power generation business, which is different from the supportive measures for wind-power generation projects (purchase of power generated by wind-power plants at a fixed price). While details of the supportive measures, such as the upper limit of subsidy to be provided, have yet to be announced, we believe they are likely to provide an incentive for the development of the solar-power market in China.

**Wind-/solar-power generation capacity addition (global)**



**Wind-/solar-power generation capacity addition (China)**



Source: The PRC Government, compiled by Daiwa

### 1.3 Focus on climate change and global discussions

***China has a number of environmental problems***

China has paid relatively less attention to the issue of climate change, as the country's rapid urbanisation and industrialisation has raised the need to cope with all kinds of environmental problems related to public hygiene, the provision of safe drinking water, air pollution from the increase in sulphur dioxide (SO<sub>2</sub>) and nitrogen oxide (NOX) emissions, acid rain, and water pollution from industrial waste. These problems would continue to have serious influences on the health of the people in the country if left unattended, so we believe it is imperative that the government takes immediate measures. The emission of CO<sub>2</sub>, however, differs significantly from other environmental problems in that the effects on human health are not evident in the short term.

***China has started taking efforts to reduce its CO<sub>2</sub> emissions ...***

Meanwhile, China's CO<sub>2</sub> emissions have continued to increase rapidly since 2003, and in 2006, it became the world's largest CO<sub>2</sub>-emitting country. For this reason, there has been increasing pressure on the country from the rest of the world. The PRC Government reported the presence of the warming phenomenon in China and its findings that many negative influences of the phenomenon have been observed in 'Policies and Measures on Climate Change' paper in October 2008, which raised the awareness of the issue in the country. In response to these situations, China is taking measures including: 1) suppressing CO<sub>2</sub> emissions as a part of its energy policy, by improving the energy saving and energy efficiency on the demand side, and by expanding the utilisation of nuclear-power and renewable energy on the supply side, and 2) in order to realise 1), actively inviting technology transfer and investment from overseas.

***... and to try and appeal its presence and involvement via the white papers***

In international discussions, China claims, as well as other emerging countries, to have a 'common, but different responsibility', asserting that the developed countries should carry out CO<sub>2</sub> reduction policies in accordance with the scenario presented by the Intergovernmental Panel on Climate Change (IPCC) (the reduction targets of the major countries are 25-40% with respect to the level as at 1990). The *Policies and Measures on Climate Change* announced in October 2008 contributed to justify the position and stance of China in the eyes of the rest of the world, together with the white paper *China's Energy Situation and Policy*. In the 'Policies', China maintained that: 1) cumulative CO<sub>2</sub> emissions from fossil-fuel combustion in 1904-04 was 8%, and China is ranked 92nd in the world in terms of accumulated CO<sub>2</sub> emission volume per capita, 2) China is still in a period of industrialisation, urbanisation and modernisation, and 3) it has been engaged in the suppression of CO<sub>2</sub> emissions actively, targeting, for example, a 20% reduction in energy consumption per unit GDP in 2006-10.

#### Looking ahead

***Developed countries are likely to set reasonable numeric targets first***

Most believe the stance and assertion of emerging countries is reasonable, and the view that developed countries should speed up the reduction of their CO<sub>2</sub> emissions first is becoming mainstream. Following the EU, which has committed to CO<sub>2</sub> reduction, Japan is taking steps to achieve its target in 2009. Australia and the US are also becoming more active in the reduction of greenhouse-gas emissions with their new political administrations. However, the reduction targets set by the major developed countries (except for the EU) currently differ significantly from the IPCC's scenario of greenhouse-gas emissions being reduced by half by 2050. We believe it will take a long time to take the step of setting reasonable targets for the developed countries to realise the IPCC scenario, and then to set the quantitative targets for the emerging countries.

***A reasonable medium-term target could be set at COP 15 in December 2009***

However, according to the Bali Roadmap adopted during the United Nations climate change conference, COP 13, held in December 2007, a framework for greenhouse-gas reductions after 2013 is to be determined during COP 15, scheduled to be held in December 2009. In other words, the point is whether or not a reasonable medium-term target (for 2020) can be set.

At the moment, we do not think a framework in accordance with the half-reduction scenario by 2050 is likely to be established by the end of 2009. However, the awareness of the need to address the climate-change issue is still strong, and we think there is a fair chance that certain action will be taken over the next few months to promote the progress of completing the framework. However, we cannot be certain whether this action would be successful or not. In February 2009, Secretary of State Clinton visited China and agreed to focus efforts on the success of COP 15.

The co-operation of the two major CO<sub>2</sub>-emitting countries deserves the most attention, in our view. First, whether or not the US can revise its current reduction target (to reduce emissions to the level of 1990 by 2020) will be the focus of attention, as it could lead to the possibility that, even though China and the US may not be able to set a target at the level that developed countries are requesting, China could promise to make further efforts in the suppression and reduction of greenhouse gases. If this materialises, we would expect a positive effect on the markets related to technologies for reducing CO<sub>2</sub> emissions in the power-generation sector, which is the focus of our attention.

### Major international discussions

Time	Event
June 1992	The <i>Earth Summit</i> is held in Rio de Janeiro, Brasil in 1992, during which the <i>Climate Change Framework Treaty</i> is adopted.
December 1997	COP 3 is held in Kyoto. The Kyoto Protocol is adopted.
June 2000	The EU initiates the Europe Climate Change Programme (ECCCP), to be put into operation by 2005.
February 2005	The Kyoto protocol comes into effect.
July 2005	In the G8 summit (Gleneagles, UK), the global warming issue is adopted as the main topic for the first time.
November 2005	International cooperation after 2013 was discussed for the first time in COP11 (Montreal)
October 2006	Publication of the 'Stern Review' (Economics of Climate Change).
Jan-Feb 2007	Publication of the IPCC's Fourth Assessment Report (Working Group I).
December 2007	A roadmap related to the establishment of a framework after 2013 (to be finalised in COP 15 at the end of 2009) is plotted in COP 13 (Bali).
January 2008	The EU announces a policy package, appealing for enhanced efforts by other developed countries.
December 2008	No progress on the development of the framework after 2013 is made in COP 14 (Poznan, Poland).
December 2009	COP 15 is to be held in Copenhagen: deadline for the establishment of the framework according to the Bali roadmap.

Source: Various reports, compiled by Daiwa

## 1.4 Influence of changes in fossil-fuel/ CO<sub>2</sub> prices and the financing environment

### ***China has been active in greenhouse-gas reduction through CDM projects***

China is attracting active investment from foreign countries (mainly from developed countries) in renewable-energy businesses in the country. This is because the ratifiers of the Kyoto Protocol, ie, the countries undertaking obligations to reduce greenhouse-gas emissions, are engaging in the greenhouse-gas reduction businesses in China, using the Clean Development Mechanism (CDM), which is one of the Kyoto mechanisms. China passed related laws in 2004, and started operation of the CDM system. Since then, the number of approved CDM projects by investing countries and the hosting country (China), and the number of registered projects by the United Nations CDM Executive board have been increasing. At the end of March 2009, China accounted for 32.3% (494 projects) of the total number of CDM projects registered globally, and for 56.7% (158m tonnes) of the global reduction volume (CO<sub>2</sub> equivalent). The renewable energies accounted for the largest portion (73%, 361 projects) in the CDM projects registered in China, with hydropower (for small plants) and wind power making up the most of the renewable-energy CDM projects in China.

### ***CDM projects in China are attracting investment***

China has been popular as a CDM-investment destination, on the basis that: 1) the country's energy efficiency is low compared with that of developed countries, and 2) coal, which causes the highest CO<sub>2</sub> emission, accounts for a large part of China's power-generation mix, leading to a large amount (about 1kg/kWh) of CO<sub>2</sub>-emission reduction per unit power generation. In addition, in China, the government has set the CO<sub>2</sub> price around €8-11/tonne, well below the CO<sub>2</sub>-emission-rights market prices especially in the Europe market. The income from

trading CO<sub>2</sub>-emission quotas is to be shared by the government and the company involved, the government has set a low distribution rate (2%) for itself, in order to attract investment from countries and to promote CO<sub>2</sub> reduction projects (65% for HFC and PFC gases, 30% for N<sub>2</sub>O gas, 5% for others).

**Wind-power generation is benefiting the most from CDM projects**

Of the renewable energies (solar power, wind power and nuclear power) that are attracting attention, wind power is benefiting the most from the expansion of CDM businesses. With a wind-power project, in addition to the income of Rmb0.5-0.6/kWh according to the fixed-price purchase system, when the project is qualified as a CDM business, the internal rate of return increases from about 6% to about 9%, with the income from the disposal of the CO<sub>2</sub> emission volume (€8-11/tonne in China). We believe the active utilisation of the CDM system, and the inflow of foreign investments for the CDM projects have contributed to the expansion of the market.

**Looking ahead**

**Global macro-economic slowdown has influence on China-related industries**

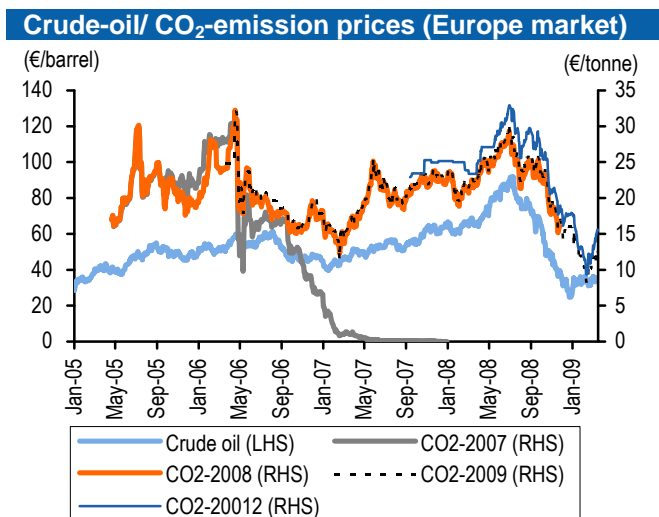
Decreasing fossil prices after 2H08, decreasing CO<sub>2</sub> emissions due to the economic slowdown, decreasing CO<sub>2</sub> emission-quota prices due to the decline in emission volume, and a deterioration in the financing environment have had a negative impact on investment in renewable energies globally, in the form of: 1) a slowdown in investment from major power and heavy industrial companies that were trying to secure emission quotas at a faster pace, 2) depressed investment sentiment of companies engaged in emission-quota trading, and 3) difficulties in raising finance and lower investment profitability for power producers and developers seeking expansion by operating renewable-energy businesses. These negative effects have started having an impact on the solar-power (generation) industry in China, which relies on foreign markets for over 90% of its final demand. It may affect demand for the wind-power industry in China as well, in our view, as the increase in demand will depend on further activation of CDM projects.

**Uncertainty about the CDM-project trends after 2013**

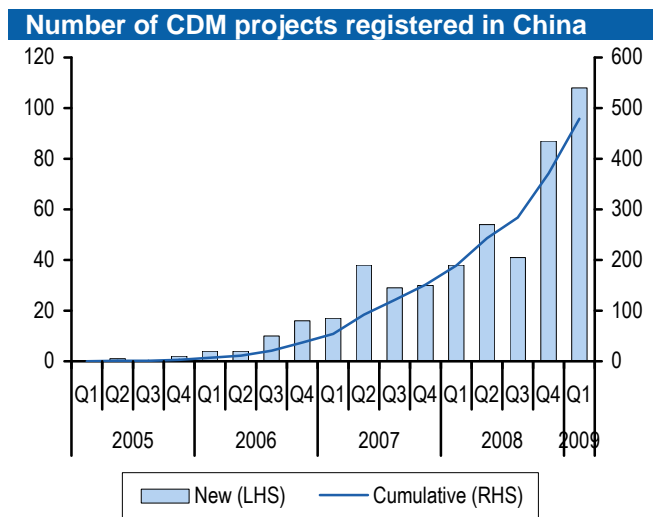
In addition, the absence of a framework for the period after 2013 in global CO<sub>2</sub> reduction has created uncertainty in terms of the CDM-project trends. The EU has proposed that countries engaged in CDM should be limited to low-income developing countries in the framework after 2013. We would advise keeping an eye on future trends of the international discussions.

**Government may implement market-stimulus measures**

Meanwhile, China is considering implementing measures to respond to market changes, such as bringing down the lower limit of CO<sub>2</sub> emission-quota selling prices from about €8 originally to about €6. We think the government may also consider stimulating renewable-energy related markets in order to shore up domestic demand and create jobs.



Source: Datastream, Bloomberg



Source: NDRC

## 1.5 Technology transfer from overseas, development of domestic industries

*China has actively accepted technology transfer from overseas*

China has actively accepted technology transfer from overseas in major capital-goods markets. Recent typical examples are the rolling-stock manufacturing and railway operation technologies for the high-speed passenger-dedicated railways in the railway industry. In the field of rolling-stock manufacturing, the top-four global companies (Bombardier, Alstom, Siemens and Kawasaki Heavy Industries) have been transferring their manufacturing technologies to China since 2004. The commercial operation with the rolling stock manufactured in China started between Beijing and Tianjin (350km/h) in August 2008. The country is also engaged in the improvement of the domestic-content ratio and has launched domestically-developed models.

*The huge potential market in China has encouraged the technology transfer*

Such technology transfer has been realised in exchange for technology licence fees. For overseas companies, there is a risk that PRC companies may become their competitors in future, so it is not easy for a technology transfer to take place. Nonetheless, the transfer has taken place because every company, especially a major European company that not only manufactures rolling stock but is also engaged in core-component and control-system businesses, believes it can continue to gain business opportunities in the huge China market, in our view. Thus, in terms of technology transfer, China has advantages that other countries do not have.

*Development of domestic industries to increase the domestic-content ratio*

In fact, for the wind-power and nuclear-power generation industries, the government has been trying to develop the domestic industries by setting a target for the domestic-content ratio at over 70% and by accepting technology transfer from overseas (described in detail later). China has made gradual progress in the development of wind-power plants: from the dependence on licensed manufacturing at the start, stepping up to joint development, and further to self development. Meanwhile, PRC companies account for over half of the global wind-turbine manufacturing market share. In the field of nuclear-power plants, most of the second-generation plants – the mainstream plants in operation currently – are produced domestically. In addition, China is planning full adoption of the third-generation plants to be launched later, after introducing technology from overseas and completing the manufacture of a standard model, for which preparation has progressed steadily.

*Venture enterprises have led the solar-power generation industry*

Unlike the cases of wind-power and nuclear-power generation, the speedy start-up of solar-power generation (especially the cell production) was led by venture enterprises established by entrepreneurs who acquired technology overseas. However, the development of upstream businesses (polycrystalline silicon) has been slow compared with that of the cell and module businesses, and this remains a challenge for the future.

### Looking ahead

*Keys will be advance into foreign markets for the wind power and full-scale domestic introduction for the nuclear power*

China is playing rapid catch-up in the field of wind-power plants, involving increasing the scale of plants, developing floating power plants, and so on. While we expect PRC companies to keep responding to the expansion of the domestic market in the foreseeable future, we note that some companies have started gradually making moves into the overseas markets. For the development of the nuclear-power plant business in China, we believe a clear timetable for the domestic full adoption of nuclear plants should be established first. Then, we would watch the order flow and progress toward achieving the target of adopting at least 70GW of nuclear-power generation capacity by 2020.

*Development of the upstream industries will be key for solar power*

One of the highlights of the solar-power plant business will be how fast upstream industries and production-equipment businesses are developed, in our view. When China establishes a vertical structure domestically to enhance its product competitiveness (especially cost competitiveness), the country will be able to further solidify its position in the world, in our view. In addition, a significant decline in costs would stimulate the expansion of the domestic market, and PRC

companies are likely to benefit the most from expansion of the market. However, we would be cautious of the moves by Korean companies, which are targeting substantial market-share gains in future.

### Power-related capex trends

According to State Electricity Regulatory Commission, investment in power-related equipment totalled Rmb57.63bn in 2008, of which Rmb28.79bn (49.9%) was in the power-generation field. Looking at the recent investment trend, the ratio of investment in the power-generation field increased in the period from 2003 to 2005, when rapid economic growth raised concerns about power shortages. After that period, however, the power-generation-investment ratio declined to 49.9% of total power-related investment in 2008, falling below 50% for the first time since 2002. We believe this is because the need for investment in power grids is increasing, due to the difference between the major power-generating areas (inland regions) and the major power-consuming areas (coastal regions), increasing the need for power grids in the inland regions, the demand for responding to new energy sources, and the need to improving the efficiency of power grids.

**Increasing ratio of power-grid capex compared with power-generation capex**

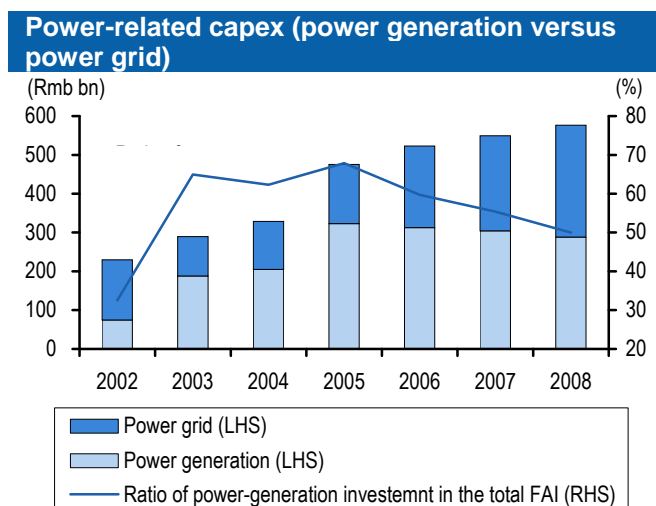
**Increasing ratio of wind-and nuclear-power generation in the power-generation capex**

Among the total power-generation investment in 2008, thermal-power generation accounted for the majority (51.2%). However, the investment amount in thermal power peaked in 2005 (when thermal power accounted for 70.3% of total power-generation investment) and has been decreasing since then. On the other hand, investment in wind-power and nuclear-power generation has been expanding rapidly since 2005, increasing by 88.1% and 71.9% YoY, respectively, in 2008, and accounting for 10.5%, 9.2% of total power-generation investment, respectively. Meanwhile, investment in the solar-power generation is categorised as 'others', given that the scale of solar-power investment is still small.

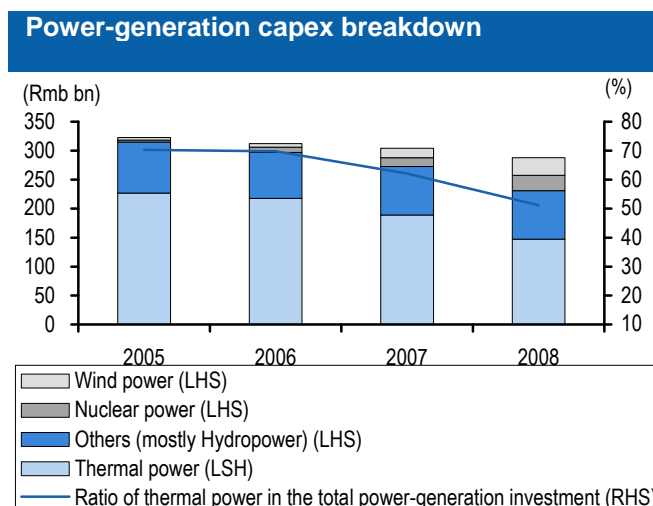
**Ratio of power-related investment in the total FAI in China is decreasing**

According to the National Bureau of Statistics of China, investment in the power industry (including thermal-related investment) in 2008 increased by 14.4% YoY to Rmb90.45bn, accounting for 6.1% of the total fixed-asset investment (FAI) for the year. The ratio of the power-related investment in the total FAI is decreasing after reaching 8.7% in 2005, because while investment in power grids, wind-power and nuclear-power generation is increasing, the investment amount in thermal-power generation is decreasing, and total power-related investment growth has been only about 10% YoY every year, below the 25% YoY growth of total FAI.

Thus, relative to the total FAI in China, we do not think power-plant investment is overheated, as the total amount of power-plant investment is adjusted by the controlled investment in thermal (especially coal-fired) power generation. If China's economic growth rate picks up again, leading to the expectation of an increase in the power-plant utilisation rate, investment in thermal-power generation may expand again. However, in 2009-10, we expect a trend similar to that for the past three years.



Source: State Electricity Regulatory Commission



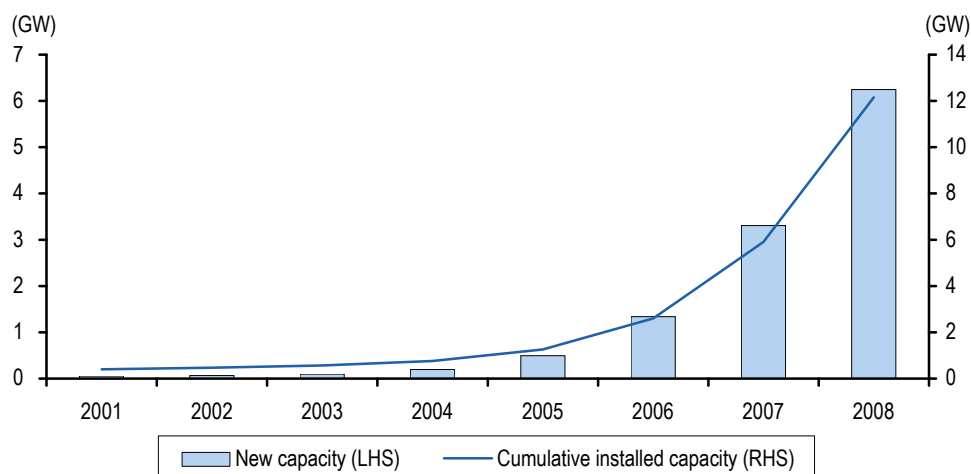
Source: State Electricity Regulatory Commission

## 2. Industry trends in China

### 2.1 Wind power

#### Market trends

##### Wind-power installed capacity



Source: GWEC

#### ***The second-biggest market in the world***

After China's *Renewable Energy Law* was enacted in 2006, the wind-power market began to expand in earnest. The amount of new capacity added in 2007 increased by 147% from one year earlier to 3.3 gigawatts (GW) and in 2008 rose by another 91% to 6.3GW, placing the country just behind the US (8.4 GW), according to data from the Global Wind Energy Council (GWEC) and the Chinese Renewable Energy Industries Association (CREIA). In terms of cumulative installed capacity, at the end of 2008, China had 12.2GW of capacity, behind only that for the US and Germany. The GWEC (and CREIA) estimates the potential market size in China is 1,000GW, when offshore sites are included.

#### ***Medium- to long-term goals revised up sharply***

Under the *Medium to Long-Term Development Plan for Renewable Energy* that was published in August 2007, China plans to have 5GW of cumulative wind-power capacity by 2010 and 30GW by 2020. However, the country already had 5.9GW by the end of 2007, so the goal for 2010 was revised up to 10GW. This new goal was reached in 2008, making it increasingly likely that capacity will reach 30GW by 2010. As a result, we think it is likely that China will revise up its target for 2020 sharply. There are rising expectations in the market that it will revise the goal up to at least 100GW.

#### ***Gradually settling on a fixed-price policy***

Following the enactment of the *Renewable Energy Law*, the government issued provisional administrative instructions in April 2006 that introduced bidding as a price-setting mechanism for government purchases of electricity. However, the wide disparities in pricing for each project meant that there was limited foreign and private investment. These disparities became smaller in 2007 as more projects were completed. In a pricing survey conducted by the PRC Government in June 2007 in four provinces (Inner Mongolia, Jilin, Xinjiang, and Gansu [23 projects]), prices ranged from Rmb0.51-0.61/kWh. The 2008 survey provided similar results, indicating that the investment climate had improved. Under the pricing scheme, 30,000 hours are purchased at the same price, and afterwards electricity is purchased at the average wholesale price for the region.

#### ***CDM projects are one reason for the market's expansion***

The CDM has made a major contribution to the expansion of the wind-power market. In fact, it appears that some 90% of China's wind-power projects (excluding government projects) have applied for designation as CDM projects. Once registered as a CDM project, a project can generate income not only from

electricity sales, but also from sales of greenhouse-gas emission credits, enhancing the return on the investment. Wind power is purchased for Rmb0.51-0.61/kWh and emission credits sell for €8-11/tonne. Assuming conversion rates of 1kg/kWh and €Rmb9, the revenue generated is Rmb0.072-0.09/kWh. This has the effect of boosting income by 12-18%. It also raises the internal rate of return from 6% to 9%, depending on the project.

***Wind power is an attractive source of renewable energy***

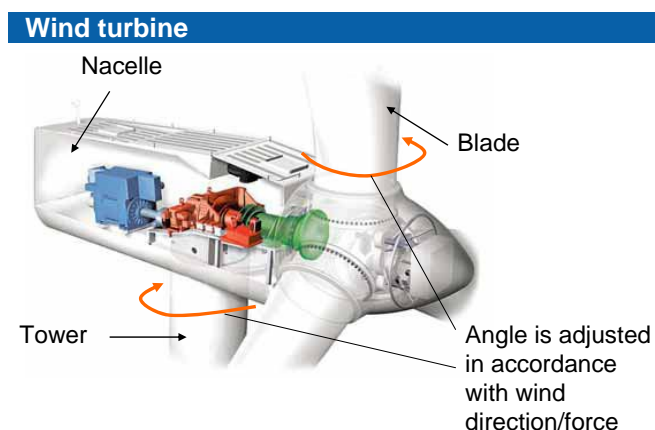
Wholesale prices are dictated almost entirely by the wholesale price of coal power (using desulphurisation equipment), which ranges from about Rmb0.3-0.4/kWh. By comparison, wind power is relatively expensive, ranging from Rmb0.51-0.61/kWh. However, wind power is relatively cheap when compared with other renewable-energy sources and can be installed fairly quickly, and it generates reasonable returns when registered as a CDM project. This is encouraging the spread of wind power. In addition, the government is making the widespread use of wind power a priority, because it expects the cost of wind power and coal power to be roughly the same in 2020, and the lower the cost of generation, the lower the price that is passed on to the user.

In February 2009, CREIA announced the actual figure for 2008 along with its forecast for 2009. The association forecast the amount of new capacity in 2009 to be roughly double the capacity added in 2008, so China should be able to reach its 2010 wind-power capacity target of 30GW. Looking at CDM project registrations, we think there should be no major changes in this upward trend. Nevertheless, some companies are reducing investment due to the economic downturn, so it will be necessary to keep a close eye on future developments.

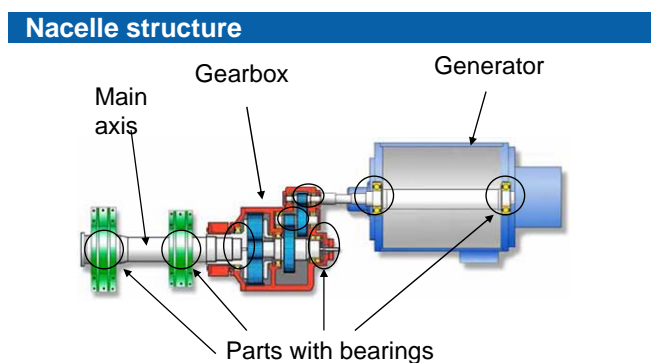
### Cost structure

***Main components are power equipment inside the nacelle and the blades***

The costs of installing wind-power facilities (wind turbines) can be divided broadly into two categories: equipment (about 70%) and construction (about 30%). Within the equipment category, the nacelle containing the electrical-generation equipment accounts for about 35% of the cost, the rotor about 20%, and the tower about 15%. Within the nacelle itself, the gearbox accounts for about 15% of the cost, and the generator about 10%. Besides these, bearings are used in various parts and couplings, and cast and forged parts are also used.



Source: Kleentechnos Co., Ltd.



Source: Kleentechnos Co., Ltd.

In 2007, the cost of installing wind-power facilities in China was Rmb8,000-10,000/kWh (Rmb8.0-10.0bn/GW). Equipment made in China is likely to be 10-20% cheaper than imported equipment with the same capacity. Installation costs rose in 2008 due to inflation. However, prices of raw materials are falling, so installation costs should stop rising. Furthermore, the market now seems tight because of its rapid expansion, but if growth slows in a year or two from now, prices should start falling again as a result of economies of scale and increased competition.

## Companies

### *Mainland companies increasing their share of the China market*

Mainland companies have been increasing their share of the domestic market over recent years. Looking at companies involved in turbines (those that design facilities, or those that manufacture or procure parts), the market share controlled by purely domestic companies and domestic-foreign partnerships rose from 25% for 2004 to 76% for 2008. There are a number of factors behind this increase in market share: the PRC Government set a goal of achieving 70% domestic production, the government began limiting tax rebates for imported items, and a number of Mainland companies entered the market from other areas.

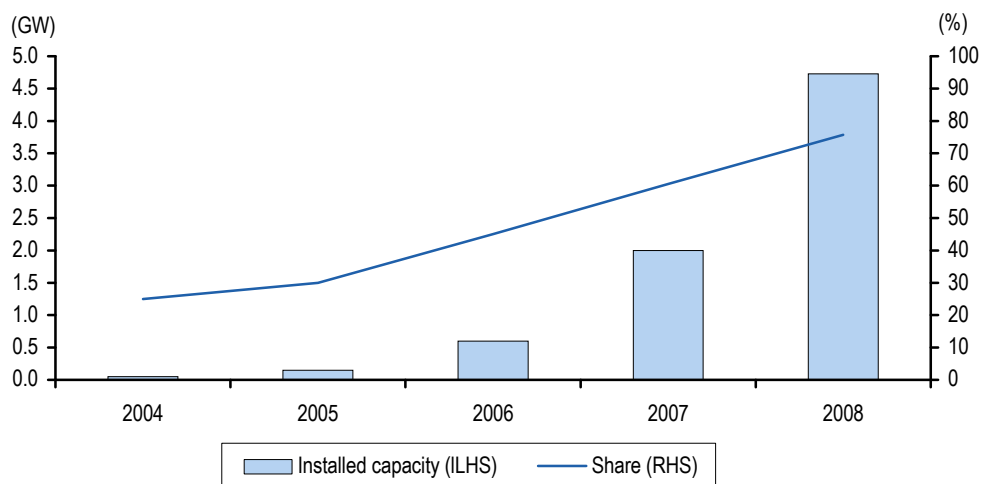
### *Remarkable changes in market share*

In the turbine market, the change in market share has been remarkable. There are three items of note with respect to the figures for 2008. First, foreign companies continued to lose market share, and latecomers from China gained market share rapidly. Second, Goldwind Science and Technology, which has long been the leader among China companies, fell to second place in terms of wind-turbine market share, behind Sinovel Wind. Third, there are only a limited number of companies that are candidates to join the top rank in the future, in our opinion.

### *The line-up of the top companies has become clear, in our opinion*

The third point is especially significant. Three domestic companies, Sinovel Wind, Goldwind Science and Technology, and Dongfang Steam Turbine Works (part of the Dongfang Electric group), make up the leading group of companies in terms of wind-turbine market share. Two foreign companies (Vestas and Gamesa) comprise the second-tier group. Seven other companies (Yunda, Shanghai Electric, CASC Acciona, GE, Nordex, Hara XEMC Windpower, and Xiangtan Electric Group) account for the remaining 2-5% of the market. Going forward, competition will probably be limited to the five companies in the first two groups and some of the companies in the third group (possibly Shanghai Electric and General Electric). Nevertheless, the top group is not set in stone, as there are some companies that plan to enter the market with 2MW turbines.

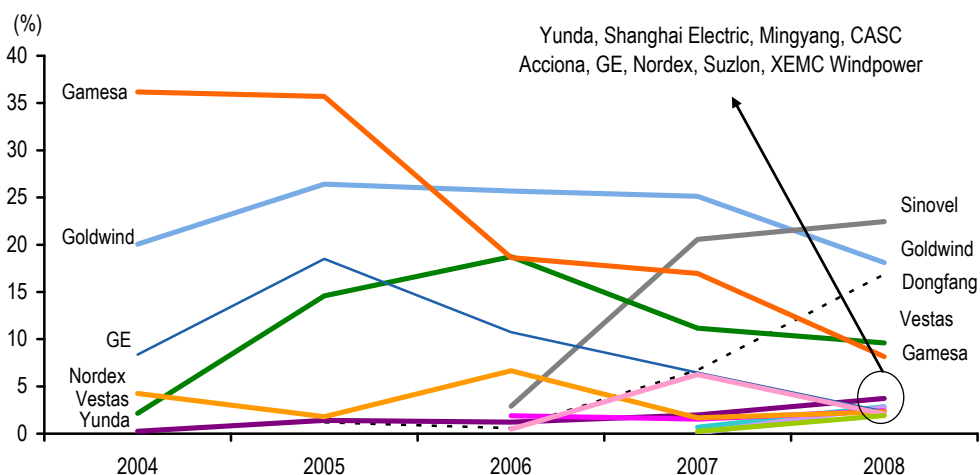
### Mainland companies: wind-turbine share



Source: CWEA, NWTTC

Note: 'Mainland companies' includes domestic-foreign partnerships

Mainland wind-turbine market share by company



Source: CWEA, NWTC

*It is becoming harder to start up operations quickly, in our view*

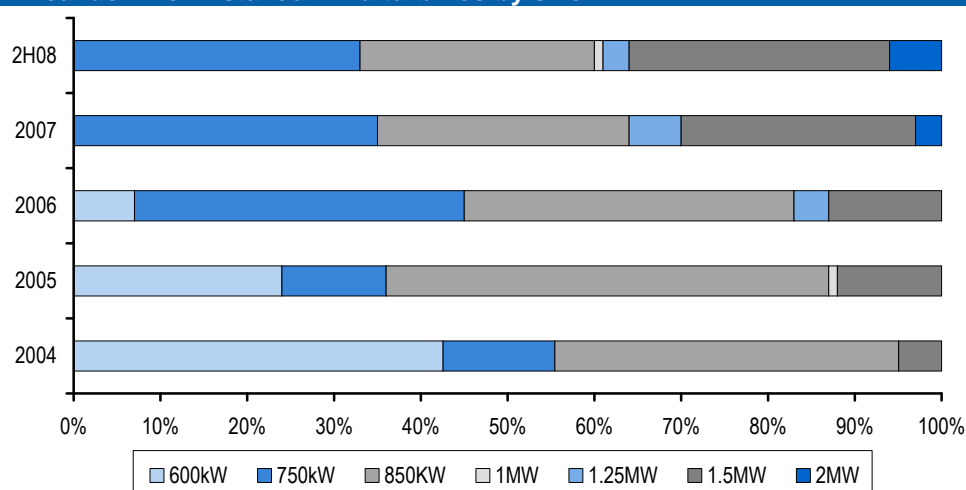
Reflecting the disparity between domestic and foreign technology, in the past technology was frequently licensed for 1.5MW and smaller turbines. However, now that the 1.5MW market has been established, competition is shifting to 2MW and bigger turbines. With the disparities between foreign and domestic technology disappearing and with Mainland companies beginning to turn their sights on overseas markets, the top domestic companies are increasingly developing their own technology or jointly developing technology for turbines of 2MW and higher. As a result, it is becoming more difficult to start up a new business quickly.

Technology sources for Mainland wind turbines

Company name	Products	Size (MW)	Manufacturing/development type	Partner company	Partner company nationality
Goldwind Science & Technology	Goldwind 50	0.75	Licensed manufacturing	REpower	Germany
	Goldwind 70	1.5	Joint development	Vensys	Germany
	Goldwind 77	1.5	Joint development	Vensys	Germany
Sinovel Wind	70/FL1500	1.5	Licensed manufacturing	Fuhrlander	Germany
	77/FL1500	1.5	Licensed manufacturing	Fuhrlander	Germany
Dongfang Steam Turbine Works	FD70B	1.5	Licensed manufacturing	Repower	Germany
	FD77B	1.5	Licensed manufacturing	Repower	Germany
Zhejiang Yunda	WD49	0.75	Licensed manufacturing	Repower	Germany
	WD54	0.8	Independent development	-	-
	WD77	1.5	Independent development	-	-
Shanghai Electric	SEC64	1.25	Licensed manufacturing	DeWind	UK
	SEC82	2.0	Joint development	Aerodyn	Germany
Guangdong Mingyang Windpower	83/MY1.5se	1.5	Joint development	Aerodyn	Germany
XEMC Windpower	Z72	2.0	Joint development	Harakosan	Japan
			(different technology source)	Lagerway	The Netherlands

Source: China Environmental Science Press

### Breakdown of installed wind turbines by size



Source: Zhongke Yuneng

#### ***Gearboxes***

China High Speed Transmission Equipment (through its Nanjing High-Speed & Accurate Gear subsidiary) is the market leader in gearboxes. According to the company, in 2007 it supplied about 80% of the gearboxes for turbines made in China (or more than 40% of the gearboxes used in all the turbines sold in China). Other major suppliers are Chongqing Gearbox and Hangzhou Advance Gearbox, makers of gearboxes for conventional industrial use. DHI-DCW Group (the parent company of Sinovel Wind) and Dongfang Steam Turbine Works are also active in the market.

#### ***Bearings***

As in the global market, SKF is the market leader in bearings in China, followed by Schaeffler (FAG). As the China market expands, major domestic bearing makers, such as Wafangdian Bearing and Luoyang LYC Bearing, are expanding their operations that supply wind-power equipment makers. Recently, it seems to us that the supply of the bearings incorporated into gearboxes, rather than the gearboxes themselves, have become a bottleneck. As a result, companies such as Zhejiang Tianma Bearing, which has a strong track record in bearings for the railway industry, plans to enter the market. In addition, Timken has formed a joint venture with Xiangtan Electric and has signed an agreement to supply China High Speed Transmission Equipment.

#### ***Generators***

In the generators market, the top companies are Lanzhou Electric, Yongji Electric Machine, Hadian Wind Power Equipment, and Xiangtan Electric. DHI-DCW Group, Dongfang Steam Turbine Works and Shanghai Electric have also started up production. ABB is the global industry leader in this area, and is expanding throughout China in various capital-goods markets, but it has not been aggressively expanding into the market for generators used in wind power.

#### ***Ability to procure bottleneck products influences market share***

So far we have discussed the main parts of the nacelle, which is the central component of a wind turbine. In 2007 and 2008 there were shortages of gearboxes (or the bearings or cast parts used in gearboxes), so the ability to procure gearboxes affected market share in wind-turbine markets globally. Ultimately, companies with the capacity to manufacture gearboxes themselves gained the upper hand, so there was a trend towards taking production in-house or finding new supply channels. The same was true in the China market. Latecomers such as Sinovel Wind and Dongfang Steam Turbine Works took advantage of the strength of their company groups to diversify their sources for parts, and also to begin producing their own gearboxes and generators.

#### ***Blades***

Zhonghan (Baoding) Huiteng Wind Power Equipment was the main supplier of blades in China even before the market began booming. Nevertheless, a rising number of companies have entered the market since it began taking off and since the market for megawatt-class projects has become viable. Companies such as

Lianyungang Lianzhong Composite Group (under China National Building Material Group), Sinomatech Wind Power Blade (a subsidiary of Sinoma Science & Technology under China National Materials), Shanghai Lengguang Industrial, Xinmao Science & Technology, and Baoding Huayi Wind Turbine Blade are developing megawatt-class businesses. Dongfang Electric has begun manufacturing blades within the company group. LM Glasfiber, the world's top supplier of blades, opened a factory in China in 2002. Vestas, Gamesa, and Suzlon also have their own production facilities in China.

***Power-generation enterprises***

The main wind-turbine operators in China are mainly major state-owned power and energy companies such as Longyuan Electric (a subsidiary of China Guodian Group, one of the country's five major electric-power companies) and Guohua Power. The *Medium to Long-Term Development Plan for Renewable Energy* presented goals for the installation of wind turbines. In order to achieve these goals, we think it is only natural that state-run enterprises should be involved. Furthermore, the *Renewable Energy Law* contains provisions requiring that the price for renewable energy be set at a level that achieves an internal rate of return above that of coal power.

**Foreign companies**

***Foreign companies are losing share in the turbine market***

Vestas, Gamesa, GE, Suzlon, Nordex, and Acciona (joint venture) are all involved in the turbine market, but foreign companies have been losing market share. In 2008, Vestas and Gamesa accounted for about 10% of the market, but other companies had a market share of only about 2%. The government's strategy of encouraging a transition to domestic production and difficulties in developing the market for high-capacity turbines (an area dominated by foreign companies) has had the effect of reducing the market share of foreign companies. Despite this, 1.5MW-class turbines are becoming mainstream in China, and 2MW turbines should be introduced shortly. Moreover, in recent years the major foreign companies have been focused on improving their manufacturing capacity in China. The primary motivation for this is to narrow the cost differences between themselves and Mainland companies as much as possible. However, now that megawatt-class turbines have become the norm, locations in China can serve as one of their bases for operations internationally.

***Foreign companies are also localising production***

In 2006, a number of foreign companies brought Chinese manufacturing plants on line. Vestas, Gamesa, and Suzlon began manufacturing in Tianjin, GE in Shenyang, and Nordex in Yinchuan (and in Dongguan in the following year). Vestas is continuing to invest in China, using the manufacturing cost of Mainland companies as a benchmark. LM Glasfiber began manufacturing blades in China in 2002, before its competitors. The company has plants in Tianjin and Urumqi, and recently announced it would open a new factory in Qinhuangdao in cooperation with Goldwind Science and Technology. Hansen, a major producer of gearboxes (it continues to supply other companies despite being acquired by Suzlon in 2006), began shipping its first products from its Tianjin plant in March 2009. In addition to SKF and Schaeffler (under the FAG brand), Timken recently entered the bearing market. SKF launched production in the 1990s through 51%-owned joint ventures with a subsidiary of the Ministry of Railways and Wafangdian Bearing, a leading Mainland company, based in Beijing and Dalian respectively. It has a long track record in large bearings and a solid reputation, in our opinion.

Although foreign companies are losing market share, we believe it is unlikely that Mainland companies would control the market completely, because: 1) the cost differential between domestic and foreign companies may narrow steadily as foreign companies upgrade their manufacturing capabilities, and 2) the turbines made by foreign companies are preferred in some CDM projects for reasons of reliability.

## Moving into overseas markets

*Mass production + proprietary development = advances overseas?*

Buoyed by rapid market expansion, companies in the industries connected with wind power in China are strengthening their manufacturing and technological capabilities. On the technical-development side, they are not only manufacturing under licence, but are also involved in joint development and proprietary development as they strive to transition to domestic production from the design stage onwards. In most cases, products made under licence can be sold only in China, so proprietary development (or joint development) is the key to moving into overseas markets. Relatively more progress has been made in supplying various components, so the opportunities for entering overseas markets are better in this area, we believe. For example, China High Speed Transmission Equipment has won a sizeable order from GE.

*Companies should be focused on meeting domestic demand for the next 1-2 years*

Nevertheless, we think that for at least the next year or two most companies will be focused on meeting rising demand in China, so probably only a few companies will move aggressively into overseas markets. We do not expect the China market to continue expanding at exponential rates after a year or two. As a result, Mainland companies may be encouraged to move into overseas markets once the rate of increase in the domestic market starts to slow.

*Three blueprints for overseas expansion*

In our opinion, Mainland companies could make rapid strides into overseas markets by: 1) forming alliances with foreign turbine companies that have a high opinion of their product quality and cost-competitiveness (in the case of component makers), 2) by developing markets in Africa and Asia due to their superior track record in infrastructure construction projects (in the case of turbine companies), or 3) making skilful use of buyouts and strategic alliances (India's Suzlon has done this, as we explain later). In 2008, Goldwind Science and Technology moved to acquire a 70% stake in Germany's Vensys. Considering what they have accomplished in their existing turbine businesses, Sinovel Wind (DHI-DCW Group), Dongfang Steam Turbine Works (Dongfang Electric), and Shanghai Electric have the potential to expand overseas, in our view. In the components space, we think the candidates for overseas business development include China High Speed Transmission Equipment in gearboxes, and China Composite, Lianyungang Lianzhong Composite Group, and Sinomatech Wind Power Blade in blades.

## Comparison with neighbouring countries

*India has the fifth biggest installed capacity in the world after China*

The first conspicuous market for wind power in Asia was India, in the second half of the 1990s. Although the market subsequently contracted, it began expanding again in the following decade. It is now the world's fifth-largest market in terms of cumulative installed capacity, behind China. The country has installed capacity ranging from 1.5G-2GW for each of the past three years (1.8GW for 2008), and as of the end of 2008 its cumulative installed capacity was about 9.6GW. The government has announced plans to increase capacity by about 2GW a year. Although India covers a large area, there are relatively few locations that are appropriate for wind power, so the total potential for wind power (land-based only) is estimated at 45GW.

*Suzlon accounts for more than half of the market*

Suzlon is the biggest player in India, accounting for more than 50% of the country's wind-turbine market. The second-biggest company, RRB Energy (Vestas withdrew from the joint venture in 2006) has a market share of less than 10%, and overseas companies (Enercon, Vestas, and Gamesa) account for the remainder of the market, so there is no sign that Suzlon will lose its high market share.

*Suzlon leads Mainland companies in expanding overseas*

India's wind-power market is already showing signs of slowing, so it serves as a useful reference when looking at China's wind-power industry. Suzlon began stepping up its overseas expansion at just about the same time that the domestic market started showing signs of maturing. In 2006, Suzlon acquired control of Hansen Transmission, one of the world's biggest gearbox makers, and in 2007 it

acquired control of REpower, one of leaders in the development of large turbines. In doing so, it was able to diversify its range of products and ensure supplies of critical components. As a result, it became the fifth-largest wind-turbine maker in the world (a 10.5% market share for 2007, a 13.8% share if REpower is included, putting it in the second tier). Driven by its US business, regions outside of India now account for more than half of its sales. The company has also been able to join the ranks of the world's top companies by geographically decentralising sales and production, and creating a vertically-integrated manufacturing framework (taking parts production in-house). It will be interesting to see whether or not Mainland companies develop aggressive strategies when the domestic market matures and enterprise value starts to decline.

*Korea has a manufacturing base in capital goods*

The potential market in Korea is not that big, in our view, but the country has a solid manufacturing base for capital goods and the heavy-industry sector has a world-class track record. Only 43MW of new capacity was installed in 2008, taking cumulative capacity to 193MW as at the end of 2008, but the government aims to install 2.25GW of capacity by 2012. Previously, Korea installed foreign-made equipment from companies such as Vestas, but it has now drawn up a technological roadmap in order to move to domestic production. Korea companies are already making 1.5MW-class turbines domestically, and are developing 2MW-class turbines for installation on land and 3MW and 4MW turbines for offshore use.

*Major companies from other industries are entering market*

In addition to companies such as Unison, Hyosung, Doosan Heavy Industries and Hajin, Hyundai Heavy Industries, Samsung Heavy Industries and STX Engine have entered the market for turbines. At the end of 2008, Hyundai Heavy Industries announced that it had acquired a licence from Austria's Windtec, a subsidiary of AMSC, a US company, to manufacture 1.65MW and 2MW wind turbines. The licence includes marketing rights globally, indicating that Hyundai Heavy Industries has set its sights on quickly entering international markets.

*Some companies already have a track record of constructing towers overseas*

Korea companies have a track record of construction globally, and Unison and Dongkuk S&C are active internationally in building towers for wind turbines. They are also strong in forged components, and are supplying these to leading global companies, including Vestas. By taking advantage of this industrial infrastructure, we think Korea companies could distinguish themselves on the global stage.

## Looking ahead

Looking ahead, some of the key issues we see are listed below:

- **Will demand in the China market decline after increasing so strongly?** If it does not fall back, will growth slow, leading to an excess of supply? We think it will probably be necessary to pay close attention to CO<sub>2</sub> emissions in industrialised nations, CO<sub>2</sub> pricing, and CDM projects.
- **Will overseas companies stop losing market share?** Overseas companies' market shares have flattened out, and the question will be whether they can recover lost territory.
- **The operational status of equipment in place** (operating problems). Should a specific company experience major problems with its equipment, the focus would shift to product quality, and that could cause a change in market share.
- **Entry into overseas markets.** Once Mainland companies have been able to establish a certain level of product quality, they will have the chance to supply components to international turbine manufacturers. We will be watching to see if Mainland companies come up with aggressive strategies to move into overseas markets, such as through acquisitions and alliances.

## Wind power: list of companies

Country, product	Company	Bloomberg code	Company profile	Indicates large impact (on listed company)
<b>China</b>				
Turbines	Goldwind Science and Technology	002202 CH	A pioneer in the Mainland turbine industry, and dedicated to the turbine business. The company's market share for 2008 declined to the second-largest after it lagged behind in adjusting to the MW-class turbine market.	√
	Sinovel Wind	-	Dedicated to the turbine business, under Dalian Heavy Industries & Crane Group. Developing aggressively with expansion into the 1.5MW-class market. Had the biggest market share for 2008.	
	Dongfang Electric	1072 HK	Owned by State-owned Assets Supervision and Administration Commission (SASAC). One of the three major heavy electric-machinery companies. Involved in the business through its subsidiary, Dongfang Turbine. Its market share rose significantly (to third) for 2008, backed by aggressive business expansion in the 1.5MW-class market.	
	Yunda (Winday)	-	More than 10 years of technical research, based on work by the Zhejiang Institute of Mechanical & Electrical Engineering Co. Wind Power Research Institute.	
	Shanghai Electric	2727 HK	Owned by the Shanghai municipal government. One of the three major heavy electric-machinery companies. Involved in the business through its subsidiary, Shanghai Electric Wind Power Equipment, which was jointly established with a subsidiary of Huadian group and is planning to expand rapidly from 2009-2010.	
	CASC-Acciona	-	A joint venture of the China Aerospace Science and Technology Corporation (CASC, mainly engaged in rocket and weapon development, and owned by SASAC) and a major construction/energy company from Spain, Acciona.	
	Xiangtan Electric	600416 CH	Mainly manufactures electric machinery such as industrial motors and pumps. It has also entered the railway/military/mining industries. Involved in the business through its subsidiary, XEMC Windpower.	
Gearboxes	China High Speed Transmission Equipment	658 HK	A major manufacturer of general industrial gears. It became the industry leader after shifting its management resources to the wind-power business. Its international customers include GE, Fuji Heavy Industries, Nordex, Alstom, and ZF.	√
	Chongqing Gear	-	Part of China State Shipbuilding Corp. (CSSC), under SASAC. Engaged in the manufacture of various general industrial gears.	
	Hangzhou Gear	-	A major manufacturer of general industrial gears, with customers all over the world. It has acquired technologies from Komatsu and ZF, and has worked in the wind-power business with Gamesa and GE, among others.	
	Others		Dongfang Turbine, and Dalian Heavy Industries & Crane Group.	
Bearings	Wafangdian Bearing	200706 CH	Product brand is ZWZ. A leading company in the bearing industry in China. Based in Wafangdian, Liaoning province.	
	Luoyang LYC Bearing	-	Product brand is LYC. A major bearing manufacturer in China.	
	Tianma Bearing	002122 CH	Product brand is TMB. A major bearing manufacturer in China, particularly strong in railway bearings.	
Generators	Lanzhou Electric	-	Mainly manufactures medium- to large-size industrial motors. Product range: 0.55kW-20MW.	
	Yongji Electric Machine	-	Part of China Northern Locomotive and Rolling Stock (under SASAC, one of the two major rolling-stock manufacturers in China). Mainly manufactures railway electric components.	
	Harbin Power Equipment	1133 HK	Owned by SASAC. One of the three major heavy electric-machinery companies. Involved in the wind-power equipment business through its subsidiary, Hadian Wind Power Equipment. Its share of the turbine market is small.	
	Others		Xiangtan Electric, Dalian Heavy Industries & Crane Group, Dongfang Electric, and Shanghai Electric.	
Blades	Zhonghan (Baoding) Huiteng	-	A pioneer and leader in the industry in China. Established in 2001 by a subsidiary of Aviation Industry Corporation of China and a US investment company, Tang Energy.	
	China National Building Material	3323 HK	Part of China National Building Material Group, under SASAC. Involved in the business through Lianyungang Composites Group, which is part of China Composites Group.	
	Sinoma Science & Technology	002080 CH	Part of China National Materials Group, under SASAC. Acquired technologies from Beijing Research and Design Institution of FRP (under China National Materials Group) through Sinoma Science & Technology Wind Power Blade (42.35% owned by the company). Product brand is Sinoma.	
	Shanghai Lengguang Industrial	600629 CH	Owned by Shanghai Building Material. Entered the blade market by acquiring Shanghai FRP Research Institute in 2009. Mainly manufactures concrete products and polysilicon. It started producing polysilicon for solar cells in 2006.	
	Xinmao Science & Technolog	000836 CH	Involved in the business through its subsidiary, Xinmao Xinfeng Energy Technology. Its main business is management participation/investment in information electronics companies (as an incubator).	
	Other company		Dongfang Electric.	
Others				
Forged products	China Wind Systems	CWSI US	Entered the forged-product market for bearing/shaft for wind power and for general industries in 2007. Originally, it manufactured dyeing machines and industrial pressure vessels.	√
	HLS Systems	HOLI US	Ranked second in the China process-automation market. It has entered the railway and nuclear-power businesses, and started developing control devices with Goldwind Science and Technology in 2008.	
Control apparatus	China Wind Power	182 HK		√
Power-generation businesses				

Source: Daiwa

## Wind power: list of companies (cont'd)

Country, product	Company	Bloomberg code	Company profile	Indicates large impact (on listed company)
<b>Companies doing business in China</b>				
Turbines	Vestas (Denmark)	VWS DC	The world's leading turbine company in terms of market share. It accounted for about a 10% share of the China market for 2008.	√
	Gamesa (Spain)	GAM SM	Initially expanded through cooperation with Vestas. The major shareholder is Iberdrola (23.95%). It is the world's third-largest turbine company in terms of market share, with a high market share in Spain and an 8% share of the China market for 2008.	√
	GE (US)	GE US	Became a major capital-goods company by acquiring Enron's wind-power business. Its share of the US market is more than 40%. Accounted for a 2% share of the China market for 2008.	
	Suzlon (India)	SUEL IN	Dedicated to the turbine business. Its market share in India is more than 50%. It had a 2% share of the China market for 2008.	√
	Nordex (Germany)	NDX1 GR	Dedicated to the turbine business. It had a 2% share of the China market for 2008 (accounted for the leading share before 2002).	√
	Acciona Spain)	ANA SM	Established as a major construction company, it is expanding its energy business. Accounted for a 2% share of the China market for 2008 (it has a joint venture with CASC in China).	
Gearboxes	Hansen Transmission	HSN LN	The world's leading gearbox company in terms of market share. Recently focused its management resources on the wind-power business. It accounted for a share of about 30% of the global wind-power market in 2007. Completed the first delivery from its China factory in March 2009.	√
Bearings	SKF	SKFB SS	The world's leading manufacturer of bearings in terms of market share, and particularly strong in large-size bearings. It accounted for an 80% share of the global wind-power bearing market a few years ago, with 2-3% of its revenue coming from wind-power bearings.	
	Schaeffler(FAG)	-	A major bearing manufacturer based in Germany.	
	Timken	TKR US	The leading company in the US bearing market. Its large-size bearing product range was improved after merging with Trirington.	
Blades	LM Glasfiber	-	The world's top independent blade company. Its customers include eight of the world's top 10 turbine manufacturers (including those making blades themselves).	
<b>India</b>				
Turbines	Suzlon	SUEL IN	See the description of the company above.	√
	RRB Energy	-	Acquired the stake (49%) held by its joint-venture partner Vestas in 2006. It entered the US market in 2007 with investment from Merrill Lynch	
<b>Korea</b>				
Turbines	Unison	018000 KS	Engaged in the manufacture of wind-power turbines, forged parts for wind-power and other heavy industries, vibration-reduction material for roads, as well as in the renewable-energy development business.	
	Hyosung	004800 KS	Engaged in the manufacture of wind-power turbines, and the fibre, steel-structure, construction, and motor businesses.	
	Doosan heavy Industries	034020 KS	Mainly engaged in (thermal and nuclear) power-generation related equipment, desalination plants and forged products, as well as construction.	
	Others		Hyundai Heavy Industries, Samsung Heavy Industries, and STX Engine.	
Towers	Dongkuk S&C	-	Has delivered products to Vestas, Gamesa and Enercon. Engaged in the manufacture of various steel-structure products as well as in the construction business.	
	Unison	018000 KS	Manufactures flanges for towers in Korea and the US.	

Source: Daiwa

## 2.2 Nuclear power

### Nuclear power in China

#### *Industry developed out of military applications*

China's nuclear power industry has a relatively long history. The China Institute of Atomic Energy was established after the PRC was founded in 1949 with the aim of developing military applications. From 1955-59, efforts to develop nuclear power were bolstered by a nuclear-cooperation pact with the Soviet Union. China has been developing nuclear power on its own since 1960. After it began producing and enriching uranium it conducted its first nuclear test in 1964, its first hydrogen bomb test in 1967, and its first nuclear submarine sea trial in 1971.

#### *CNNC serves as the nucleus of the development framework*

The Shanghai Nuclear Engineering Research and Design Institute was established in 1972 to build China's first domestically-designed nuclear power plant. It began developing and designing the *Qinshan Nuclear Power Plant* in 1973. In 1982, the Ministry of Nuclear Industry (MNI) was established to direct nuclear-power development in the country. In 1993, it was given the same status as the ministries that report directly to the State Council. As part of the administrative reforms carried out in 1998, business and government functions were divided, and the administrative apparatus of the MNI was transferred to the Commission for Science, Technology and Industry for National Defence. Then, in 1999, with privatisation under consideration, it was divided into the China National Nuclear Corporation (CNNC) and the China Nuclear Engineering and Construction Corporation (CNEC). CNNC is responsible for power generation, fuel, and R&D, while CNEC is responsible for plant construction and foundation work.

***Transitioning to domestic content for generation facilities***

## **Nuclear-power policy**

China had always wanted to build nuclear-power facilities using its own technology, and this basic policy is unchanged. However, because it is difficult for it to build world-class facilities using solely its own technology, in the 1980s China began actively working to acquire foreign technology. It signed a nuclear-power cooperation agreement with France in 1983, with Germany in 1984, with the UK and Japan in 1985, and with Russia in 1992. In 1984, China joined the International Atomic Energy Agency (IAEA), and in 1992 it signed the Treaty on the Non-Proliferation of Nuclear Weapons, laying the foundation for the introduction of new technology.

The development of China's plant-construction technology can be divided broadly into three stages. In the first stage, it built *Qinshan-1* (310MW) using domestic technology, and *Daya Bay* (984MW x 2) with technology from France. Construction on *Qinshan-1* began in 1985. The plant began operating on a trial basis in 1991, and entered commercial service in 1994. Meanwhile, the *Daya Bay* reactors began operating commercially in 1993 and 1994. In the second stage, China developed a larger reactor (600 MW) based on the *Daya Bay* power plant and brought in even more foreign technology (700-1000MW). The foreign technology was imported from France, Russia, and Canada, and the plants began operating commercially by 2007.

In the third stage, China continued to develop yet larger plants ('second-generation improved-version nuclear-power plants') and began importing third-generation technology. China designed and then began building the *CRP-1000* (1GW) in 2005. Meanwhile, for third-generation technology it decided to import the *AP-1000* (1.2GW x 4 units) from Westinghouse (a unit of Toshiba) of the US. In addition to signing technology-transfer agreements, China aims to accelerate design standardisation with the goal of having a third-generation domestically-designed nuclear power plants by 2020. China decided to import the European Pressurised Reactor (EPR) (1.75GW x 2) from France's Areva with the intention of acquiring manufacturing and operating technology.

***China continuing to pursue development of future technologies aggressively***

Over the long term, after getting the standardised domestic third-generation plants into widespread use, China intends to begin commercially operating fast-breeder reactors in 2030, and subsequently to get them into widespread use. Fast-breeder reactors have the advantage of significantly raising the utilisation of uranium sources. However, most of the prototype reactors and experimental reactors in industrialised nations have been closed, shut down, or stopped at the planning stage due to safety issues (the dangers associated with liquid-sodium coolant, the dangers associated with radiation from plutonium, and the frequency of accidents) and political issues (the production of weapons-grade plutonium). Nevertheless, Russia, India, and China are moving ahead in a relatively proactive way. China initiated the project in 1987. In 2002 it announced it had completed the civil engineering and construction for its experimental reactor (65MW), and it aimed to reach critical state in 2009. In addition, in 2008 China agreed to build a demonstration reactor with Russia.

China has long-term designs to shift to nuclear-fusion reactors (some believe that nuclear-fusion reactors will become viable in the second half of the 21st century, but there is no clear roadmap). In 2006, China finished building a test facility based on domestic R&D (the EAST reactor using superconductive tokamak technology). China has added its name to the list of participants in the International Thermonuclear Experimental Reactor project, along with Japan, the US, the EU, Korea, Russia, and India. In 1992, China launched a project to develop technology for a high-temperature gas-cooled reactor, which is seen as one of the next generation of nuclear technologies. In 2000, it completed the construction of an experimental reactor and achieved first criticality, and in 2003 it realised connectivity to the power grid. The country plans to begin construction of a pilot plant (200MW class) in 2009 for completion in 2013.

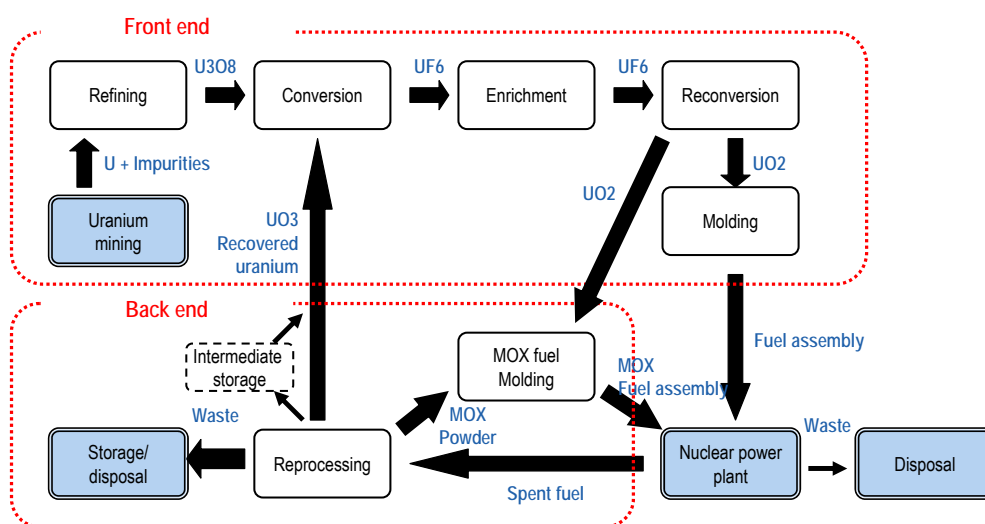
**China aims to produce fuel domestically and is also developing resources abroad**

With respect to fuel, China aims to handle everything from uranium resources development to waste disposal on its own. The country has uranium reserves of 73,000tU (January 2007, WNA data), which represents just over 1% of the world's reserves (however, potential reserves are said to be 1.7mtU), and annual production totals 840tU. Meanwhile, it is estimated by WNA that China will require about 2,000 tonnes of uranium in 2009. It is making up the shortfall with imports from Kazakhstan, Russia and Namibia. It signed an import agreement with Australia in 2006, and as a result imports are poised to rise substantially from 2010 onwards. China is also aggressively developing resources not only within its own borders, but also overseas, in countries including Kazakhstan, Niger and Australia.

**Adopting closed-cycle technology**

China has adopted a closed fuel-cycle strategy under which it reuses spent fuel, and it is also eyeing mixed-oxide (MOX) fuel fabrication. In 2007, it reached an agreement to co-operate with France's Areva on the construction of a commercial plant for reprocessing and recycling fuel, to be completed in 2020. High-level radioactive waste is to be vitrified and placed in a subterranean repository. The possible locations for this repository have been narrowed to the Beishan area of the Gobi Desert, with the final site selection ongoing. Work is due to begin in 2040 or later, after the certification process is complete.

### Nuclear-fuel cycle



Source: Compiled by Daiwa

### Companies

**Fuel-cycle development is mainly in the hands of CNNC**

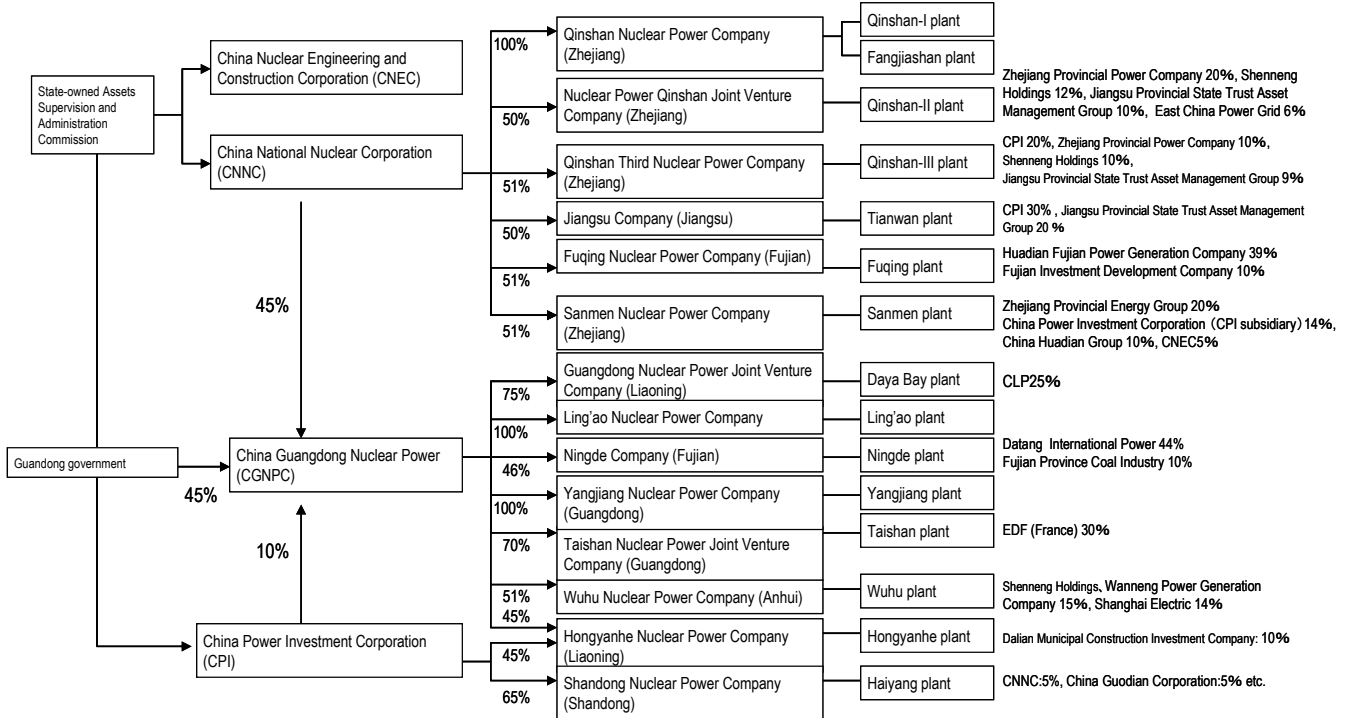
Pre-processing (uranium mining to fuel processing) and post-processing (processing of spent fuel) is handled largely by companies controlled by CNNC. The Mainland companies involved in uranium mining are China National Uranium Corporation, a unit of CNNC that conducts operations within China, and China Nuclear International Uranium Corporation (SinoUranium), a CNNC unit that operates overseas. China has been aggressively developing resources overseas in recent years. It has been developing resources in Kazakhstan through a joint venture between Kazatomprom and CNNC and China Guangdong Nuclear Power Holding Co., Ltd. (CGNPC), in Niger through SinoUranium, and in Australia through the state-owned Sinosteel. In 2008 CGNPC, along with a government-connected investment fund, acquired a 49% stake in UraMin (which has uranium rights in South Africa, Namibia, and the Central African Republic) from Areva.

**Ownership/operation revolves around three major companies, but more are taking stakes**

China's nuclear-power plants are operated by three companies: CNNC, CGNPC and China Power Investment Corporation (CPI). CGNPC was established in 1994. CNNC has a 45% stake in the company, Guangdong Province 45%, and CPI 10%. CPI was established in 2002 as one of the five major electricity companies in China when the State Power Corporation was split up, and it inherited the State Power Corporation's investments in nuclear-power plants. The nuclear-power plants are

being turned into separate corporations, while CNNC, CGNPC, and CPI will continue to exist as holding companies. Recently there has been a trend towards spreading ownership around, with the aim of reducing the burden on these three companies and also to satisfy the strong desire of other companies to enter this industry.

**Investment in nuclear-power plants**

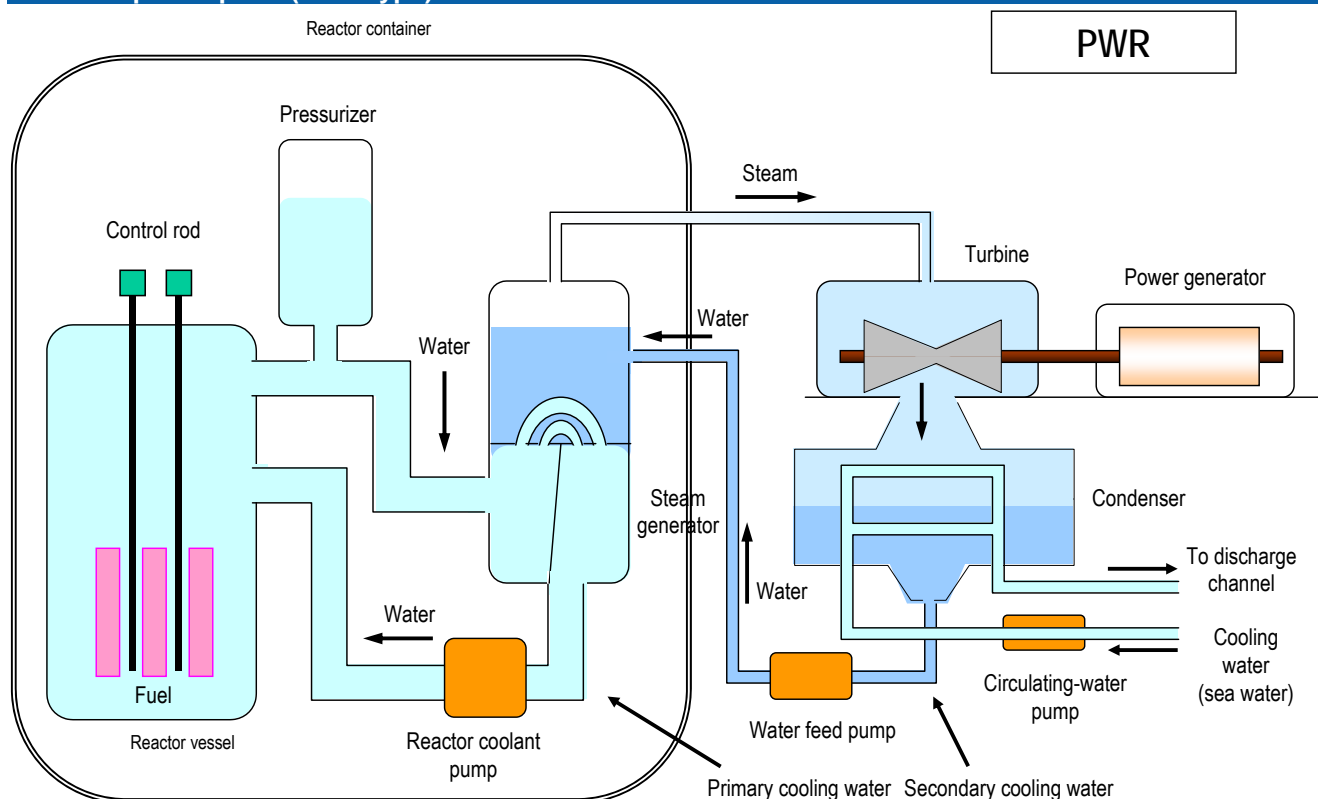


Source: Various data, compiled by Daiwa

**Most design work has been carried out by state-owned companies**

Power-plant design is the responsibility of the design institutes that are controlled by CNNC and CGNPC. The three heavy electrical giants (Shanghai Electric, Dongfang Group and Harbin Group), as well as First Heavy Industries Group, make the nuclear-reactor pressure vessels and the steam generators on the nuclear-reactor side of the plant and the steam turbines and electrical generators that are on the electricity-generation side of the plant. In addition, CNNC has a number of companies under its control that manufacture associated components. Meanwhile, China depends on overseas companies when introducing the latest technologies during the design stages. When this is the case, key components are either obtained from overseas companies or they are supplied through joint ventures or other alliances between China and foreign companies.

## Nuclear-power plant (PWR-type)



Source: Compiled by Daiwa

### The 'domestication' of nuclear power

#### *Moving to the domestic production of second-generation reactors with technology from France*

In *Qinshan Phase 2*, China developed the *CNP-600*, which is based on the *Daya Bay* plant that used technology from France. Shanghai Electric built and delivered the key components of the nuclear reactor (the pressure vessel and the steam generator) using technology that was licensed from Mitsubishi Heavy Industries and ENSA (Spain). Meanwhile, France supplied all of the technology used in the *CPR-1000*. Dongfang Electric formed joint ventures with Areva and Alstom. It will license technology for key reactor components from Areva and for steam turbines and generators from Alstom. *Lingao Phase 1* was built under the direction of a French company, but Phase 2 (due for completion in 2010) appears to be being built under the direction of Dongfang Electric, even though it is still using imported technology. As a result, Dongfang Electric appears to have won a large proportion of the orders in connection with the *CPR-1000* reactor. Moreover, CGNPC is more active in building *CPR-1000* nuclear-power plants than CNNC.

#### *The technology for third-generation reactors comes from Westinghouse*

Turning to third-generation plants, CNNC intends to lead the way in designing a standardised reactor based on Westinghouse's *AP-1000*. The State Nuclear Power Technology Corporation was created in May 2007 mainly to pursue this objective. The state has a 60% stake in the company, and CNNC, CGNPC, CPI and China National Technical Import and Export Corporation each have 10% stakes. The first four reactors have been ordered, but the main nuclear-reactor components will come from Korea's Doosan Heavy Industries, one of Westinghouse's suppliers. Doosan Heavy Industries has signed agreements to transfer technology to First Heavy Industries and Harbin Power Equipment for the Sanmen plant and to Shanghai Electric for the Haiyang plant. Meanwhile, CGNPC has decided to import Areva's EPR. Construction and engineering will be handled by a joint venture with Areva, facilities construction will be handled by Dongfang Electric with support from Areva and Alstom, and the plant will be operated by a joint venture between CGNPC and France's EDF. The objective of this alliance is to acquire technology for all of the processes connected with EPR, and the alliance is drawing attention because it is considering expanding overseas.

## List of China's nuclear-power plants and the companies supplying equipment

	Plant name	Location (province)	Design	Equipment provider			Project leader	Reactor type	Reactor name	Generation capacity gross (MW)	Construction start	Commercial operation start	
				Nuclear-island pressure vessel	Steam generator	Conventional-island steam turbine, generator							
In operation	Dayawan I	Guangdong	Areva	Areva	Areva	Alstom	CGNPC	PWR	M-310	984	1987/8	1994/2	
	Dayawan II	Guangdong	Areva	Areva	Areva	Alstom	CGNPC	PWR	M-310	984	1988/4	1994/5	
	Qinshan I	Zhejiang	CNNC	Mitsubishi Heavy Industries	Babcock & Wilcox	Shanghai Electric	CNNC	PWR	-	310	1985/3	1994/1	
	Qinshan II-1	Zhejiang	CNNC	Mitsubishi Heavy Industries	ENSA	Harbin Power Equipment	CNNC	PWR	CNP-600	650	1996/6	2002/4	
	Qinshan II-2	Zhejiang	CNNC	Shanghai Electric	Shanghai Electric	Hitachi	CNNC	PWR	CNP-600	650	1997/4	2004/5	
	Qinshan III-1	Zhejiang	AECL	Alstom (*)	Doosan Heavy Industries	Hitachi	CNNC	PHWR	CANDU	700	1998/6	2002/12	
	Qinshan III-2	Zhejiang	AECL	Alstom (*)	Doosan Heavy Industries	Hitachi	CNNC	PHWR	CANDU	700	1998/9	2003/7	
	Ling'ao 1	Guangdong	Areva	Areva · Dongfang Electric	Areva · Dongfang Electric	Alstom	CGNPC	PWR	M-310	990	1997/5	2002/5	
	Ling'ao 2	Guangdong	Areva	Areva · Dongfang Electric	Areva · Dongfang Electric	Alstom	CGNPC	PWR	M-310	990	1997/11	2003/1	
	Tianwan 1	Jiangsu	ASE	OMZ	OMZ	Power Machines	CNNC	PWR	VVER-1000	1000	1999/10	2007/5	
	Tianwan 2	Jiangsu	ASE	OMZ	OMZ	Power Machines	CNNC	PWR	VVER-1000	1000	2000/10	2007/8	
	Not in operation	Ling'ao II-1	Guangdong	CNNC	Dongfang Electric	Dongfang Electric	Alstom(&Dongfang Electric)	CGNPC	PWR	CPR-1000	1080	2005/12	2010
		Ling'ao II-2	Guangdong	CNNC	Dongfang Electric	Dongfang Electric	Alstom(&Dongfang Electric)	CGNPC	PWR	CPR-1000	1080	2006/6	2010
	yet	Qinshan II-3	Zhejiang	CNNC	Doosan Heavy Industries	Shanghai Electric	Shanghai Electric	CNNC	PWR	CNP-600	650	2006/3	2011
Qinshan II-4		Zhejiang	CNNC	Doosan Heavy Industries	Shanghai Electric	Shanghai Electric	CNNC	PWR	CNP-600	650	2007/1	2011	
Hongyanhe 1		Liaoning	CNNC	First Heavy Industries	Shanghai Electric	Alstom · Dongfang Electric	CGNPC	PWR	CPR-1000	1080	2007/8	2012	
Hongyanhe 2		Liaoning	CNNC	Dongfang Electric	Dongfang Electric	Alstom · Dongfang Electric	CGNPC	PWR	CPR-1000	1080	2008/3	2013	
Ningde I-1		Fujian	CNNC	Dongfang Electric	Dongfang Electric	Dongfang Electric	CGNPC	PWR	CPR-1000	1080	2008/2	2012	
Ningde I-2		Fujian	CNNC	Dongfang Electric	Dongfang Electric	Dongfang Electric	CGNPC	PWR	CPR-1000	1080	2008/11	2013	
Fuqing 1		Fujian	CNNC	First Heavy Industries	Dongfang Electric	Dongfang Electric	CNNC	PWR	CPR-1000	1080	2008/11	2013	
Fuqing 2		Fujian	CNNC	First Heavy Industries	First Heavy Industries	Dongfang Electric	CNNC	PWR	CPR-1000	1080	2009	2014	
Fangjiashan 1		Zhejiang	CNNC	First Heavy Industries	First Heavy Industries	Dongfang Electric	CNNC	PWR	CPR-1000	1080	2008/12	2013	
Fangjiashan 2		Zhejiang	CNNC	First Heavy Industries	First Heavy Industries	Dongfang Electric	CNNC	PWR	CPR-1000	1080	2009/6	2014	
Yangjiang 1		Guangdong	CNNC	First Heavy Industries	· Harbin Electric	Shanghai Electric	CGNPC	PWR	CPR-1000	1080	2008/12	2013	
Yangjiang 2		Guangdong	CNNC	First Heavy Industries	· Harbin Electric	Shanghai Electric	CGNPC	PWR	CPR-1000	1080	2009/2	2014	
Yangjiang 3		Guangdong	CNNC	First Heavy Industries	· Harbin Electric	Shanghai Electric	CGNPC	PWR	CPR-1000	1080	2009/9	2015	
Yangjiang 4		Guangdong	CNNC	First Heavy Industries	· Harbin Electric	Shanghai Electric	CGNPC	PWR	CPR-1000	1080	2010/7	2015	
Taishan 1		Guangdong	Areva	Areva · Dongfang Electric	Areva · Dongfang Electric	Alstom · Dongfang Electric	CGNPC	PWR	EPR	1750	2009	2013	
Taishan 2		Guangdong	Areva	Areva · Dongfang Electric	Areva · Dongfang Electric	Alstom · Dongfang Electric	CGNPC	PWR	EPR	1750	2010	2015	
Sanmen 1		Zhejiang	WH	Doosan Heavy Industries	Doosan Heavy Industries	Mitsubishi (& Harbin Power Equipment)	CNNC	PWR	AP-1000	1200	2009	2013	
Sanmen 2		Zhejiang	WH	First Heavy Industries	Harbin Power Equipment	Mitsubishi (& Harbin Power Equipment)	CNNC	PWR	AP-1000	1200	-	2014	
Haiyang 1		Shandong	WH	Doosan Heavy Industries	Doosan Heavy Industries	Mitsubishi (& Harbin Power Equipment)	CPI	PWR	AP-1000	1200	2009	2014	
Haiyang 2	Shandong	WH	Shanghai Electric	Shanghai Electric	Mitsubishi (& Harbin Power Equipment)	CPI	PWR	AP-1000	1200	-	2015		

Source: IAEA, WNA, various reports, compiled by Daiwa

Note 1: among those plants not operating yet, the projects not highlighted are those that are currently under construction (11 projects) according to the WNA, as of February 2009.

Note 2: besides those listed above, and in addition to the expansion of existing power plants (generally up to six reactors), there are plans for Shidaowan, Hongshiding, Changjiang, Xianning, Fangchenggang (Bailong), Yaogu, Lufeng, and Taohuaijiang.

(\*) Uses a calandria instead of a pressure vessel

### Control systems also transitioning to domestic production

Control systems are not shown in the preceding table, but China is working on producing these domestically for the *CPR-1000*. CGNPC plans to forge ahead on the construction of new plants based on the *CPR-1000*, and it has formed a joint venture called Beijing Guangli Nuclear Systems Engineering with HLS Systems, a leading Mainland company engaged in design-process automation and train-control systems. In co-operation with Mitsubishi Electric, Beijing Guangli Nuclear Systems Engineering has won orders for the control systems for the Hongyanhe and Ningde projects (six reactors). For the first two reactors, deployment will take place under the guidance of Mitsubishi Electric, and Mitsubishi Electric will also be responsible for the reactor's critical areas. Nevertheless, the technology is to be transferred gradually to the Mainland company, which will ultimately deploy the equipment and assume a leadership role. HLS Systems is involved in a nuclear-power plant in Pakistan that is China's sole export project.

### Domestic content targets established for each reactor model

According to the PRC Government, the domestic-content ratio (based on financial amounts) at *Qinshan 1* (310MW) is more than 80% and at *Qinshan 2-2* (650MW) it is about 70%. It expects to achieve 90% domestic content at *Qinshan 2-3* and *2-4*. It also aims to raise the domestic content of the *CPR-1000* to 75%, and expects to reach this goal at the Ningde and Yangjiang plants, which have been under construction since 2008. The government aims to raise domestic content to 100% for the third-generation plants that will be based on Westinghouse's *AP-1000*. Orders have been placed for the first four *AP-1000* reactors (Sanmen and Haiyang), and about 50% of their content should be domestic.

## Production bottlenecks

### *Massive forgings are creating a bottleneck*

There are concerns in the market about a global shortage of the massive forgings that are used to make components for the nuclear-power industry, such as pressure vessels. Only a limited number of companies in the entire world are capable of supplying these parts. Up until now, in addition to industry leader, Japan Steel Works, these parts have come from France and Russia, and companies like Doosan Heavy Industries and First Heavy Industries. However, a 14,000-15,000 tonne class forging press is needed to make the forgings for third-generation reactors exceeding 1 GW, and only Japan Steel Works has the capacity to supply these parts with the requisite quality. Various companies are building capacity with an eye on increased demand in the future.

### *In China, these are handled by First Heavy Industries*

First Heavy Industries began operating a 15,000-tonne class press at the end of 2006, but at present it doesn't have sufficient manufacturing expertise to supply parts for reactors above 1 GW. Japan Steel Works is supplying the forgings for the *CPR-1000* (second-generation improved version) reactors at the *Hongyanhe* and *Ningde* power plants to Dongfang Electric, and this also suggests that First Heavy Industries lacks the capacity to supply these parts. For China to pursue an expansion strategy of its own, it would need to design domestic models entirely itself, but it will also need to ensure that manufacturers have the capacity to supply the massive forgings that will be needed.

## Foreign companies

We have already discussed how foreign companies are licensing the technology for third-generation designs and reactors. Westinghouse and Areva are providing technical support in the design area, while Doosan Heavy Industries and Areva are providing technical support for nuclear reactors. In our view, Areva, or possibly Russia, are likely to lead the way in technology transfers connected with fuel recycling.

### List of companies supplying equipment to China's nuclear power plants

<b>Austria</b>		<b>Germany</b>	
Andritz	Pumps	Areva NP	Pressure vessels, heat exchangers, etc.
Boehler Edelstahl	Forged auxiliary components	AUMA	Valve actuators (motor devices)
Erne Fittings	Piping/auxiliary components	H. Butting	Piping/auxiliary components
<b>Canada</b>		KSB	Pumps
CCI Thermal Technologies	Pressure vessel filters, dryer, etc.	Lisega	Piping auxiliary components
<b>France</b>		MTU	Power generators
Alstom	Heat exchangers, power generators	Schneider (headquartered in France)	Valves
Areva NP	Pressure vessels, steam generator, etc.	Siemens	Valve controls
Cletral	Pump	Siemens	Control panels, relays
Creusot Forge	Forged components/containers	Tyco Electronics	Cable connection components
Data Systems & Solutions	Reactor protection systems, pressure/temperature sensors	Wilh. Schlz	Pipes
Emerson		WPI	Valves
Fives Nordon	Piping auxiliary components	<b>Italy</b>	
Georgin	Pressure switches, temperature switches	Forge Monchieri	Containers
GRISS	Valves	Tectubi Raccordi	Piping auxiliary components
IST Auxitrol Nuclear	Low-pressure device auxiliary components	<b>Korea</b>	
Jeumont Systems Pumps	Pump, control bar drive systems	Hy-Lok	Piping/auxiliary components
Kley	Piping auxiliary components	Samshin	Valves
KSB	Valves	<b>Spain</b>	
Manoir Industries Custines	Forged components for containers, pumps/valves	ENSA	Pressure vessels, steam generators, heat exchangers
Manoir Industries Pitres	Piping/auxiliary components	Ringo Valvulas	Valves
MGP	NAI meters (sensors)	<b>Sweden</b>	
Nexans	Cables	Alfa Laval	Heat exchangers
Prysmian	Electric cables	<b>UK</b>	
Pyro-Controle	Temperature sensors	Clydepumps	Pumps
Quiri	Attenuator auxiliary components	Pall	Pressure vessel filters
Reel	Fuel transport pipes	Weir Valves & Controls	Valves
Segault	Valve	<b>US</b>	
Sofinel	Heat exchanger, Piping/auxiliary components, etc.	Curtiss-Wright	Pumps
Union Pump	Pumps	Fisher Controls	Valves
Valinox Nucleaire	Heat-exchanger pipes	Flowserve	Valves
Vanatone	Valves	Invensys (headquartered in UK)	Control devices
Velan	Valves	Rosemont Nuclear Instrument	Pressure sensors/transformers
<b>Japan</b>		Swagelok	Valves, pipes
Japan Steel Works	Forged components	Trentec	Valves
Fuji Electric	Radiation sensors	Weed Instrument	Temperature sensors
Mitsubishi Heavy Industries	Pressure vessels, pumps	Westinghouse	Pressure vessels, steam generators, etc.
Mitsubishi Electric	Control panels, control systems, etc.		

Source: PRC Government, compiled by Daiwa

### ***Steam turbines supplied by the big-three in China***

Meanwhile, China's big-three power-equipment manufacturers are basically supplying most of the steam turbines and power generators in China. Each of these has co-operative arrangements with top foreign companies that allow them to obtain support as needed. Dongfang Electric will receive technical support for the *CNP-600* and *CPR-1000*, as well as for the ERP from Alstom via a joint venture between the two companies. Shanghai Electric already has an alliance with Siemens, which has invested in one of its affiliates. Harbin intends to continue the transition towards domestic production by licensing technology from Mitsubishi Heavy Industries for the *AP-1000* and other products. It also has a co-operative relationship with GE.

### ***Foreign companies using alliances as part of their global strategies***

Foreign companies derive some benefit from their business with China, but also have designs on incorporating China into their international strategies. Siemens wants to see its products used in thermal power-plant projects around the world, while the French consortium (Areva, Alstom, and EDF), along with Chinese companies (CGNPC and Dongfang Electric), aim to bring the EPR into widespread use globally.

### ***Are there still business opportunities?***

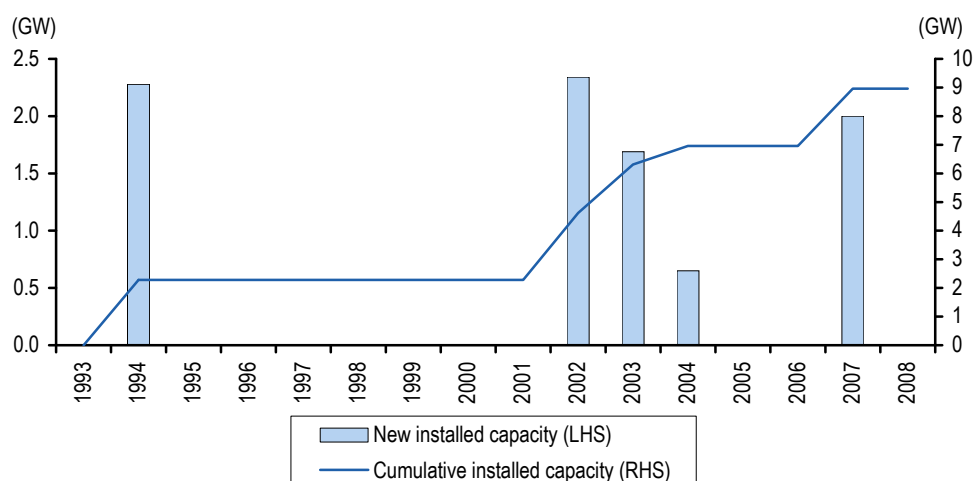
Although China's nuclear-power industry continues its transition towards domestic production, there are many components besides the core ones that must also be of high quality, so numerous foreign companies are seeking business opportunities. The previous table contains a list of companies that are registered to conduct business in China. Basically, there are no obstacles to registration, as long as a company has a certain amount of experience in the global nuclear-power industry, and 66 companies were registered as of 3 March 2009.

## **Market trends**

### ***11 operating reactors***

China began operating nuclear power plants commercially in 1994, and has 11 reactors operating currently. The gross cumulative installed capacity is 9.0 GW, and the net capacity is 8.6 GW after excluding the power used by the plants themselves. This makes China the 11<sup>th</sup>-biggest nuclear-power country in the world. However, over the past 10 years, it has installed 6.4 GW of capacity, more than any other country. It is building 11 new reactors currently, and is generally using pressurized water reactors (PWRs).

### **Nuclear-power generation – installed capacity (gross)**



Source: IAEA

### ***Installed-capacity goal may be increased from 40 GW to at least 70 GW***

China unveiled its *Medium and Long-term Development Plan for Nuclear Power (2005-2020)* in October 2007. Under this plan, by 2020, China hopes to generate 4% of its electricity from nuclear power, have added 40 GW of capacity, and have a further 18 GW of capacity under construction. Lately, the government seems to be moving in the direction of raising these goals to 5% of total capacity, 70 GW of new installed capacity, and 30 GW of capacity under construction by 2020. In fact,

looking at the construction plans that have already been unveiled, the amount of capacity completed is scheduled to increase steadily from 2 GW in 2010 to 8.8 GW (eight reactors) in 2014. If China continues to build new plants at the same pace in 2015 and beyond, we estimate its cumulative installed capacity would reach about 76 GW (excluding the 2 GW completed in 2007) by 2020. Therefore, revising the figure up to 70 GW would be realistic, in our opinion.

***For now, second-generation reactors are being put into widespread use thanks to their low cost***

The PRC Government estimates the construction costs of the *CPR-1000* to be Rmb11.6bn/GW for Hongyanhe, Rmb11.6bn/GW for Ningde, Rmb15.4bn/GW for Fuqing, Rmb12.0bn for Fangjiashan, and Rmb10.8bn for Yangjiang. These are far lower than industry estimates of the cost in industrialised countries (at least US\$3.0-4.0bn/GW [Rmb20.5-27.3bn]). While costs may decline as more and more projects are built in the future, there is also the risk of inflation, and China will also be building relatively more expensive third-generation reactors. Assuming that the average cost of construction for the five projects is Rmb12.3bn/GW, Rmb108.2bn would be needed to build 8.8 GW annually. In 2008, China invested Rmb287.9bn in power projects, and Rmb26.5bn of that was invested in nuclear power. Bearing in mind the projects already underway, we expect the size of the market to roughly quadruple from the 2008 level even earlier than 2014.

***Most of the cost is the nuclear reactor itself***

According to Areva, the core nuclear reactor components account for 30% of the cost of building a nuclear-power plant, electrical generation equipment accounts for about 20%, control systems about 3%, with construction cost (including the outer walls of the nuclear reactor) making up the remainder. However, bearing in mind the fact that China is the world's biggest producer of thermal power plants using steam turbines, electrical generation equipment may account for a smaller proportion of the cost in China. Therefore, we estimate that equipment would account for more than half of the entire cost, and that the breakdown between the nuclear reactor, electrical generation equipment and control systems would be roughly 6:3:1.

### **Advances into overseas markets**

***Chinese companies setting their sights on the global market***

China's nuclear-power industry is moving aggressively toward domestic production. The aim of this is not only to keep the cost of generating electricity as low as possible, but also to foster the domestic industry and ensure that companies are competitive even in overseas markets in the future. Throughout the world, many countries are seeking to introduce nuclear power. These include a large number of countries in Asia, the Middle East, and Africa that are key export partners for Chinese infrastructure and transport equipment. Lately, Chinese companies, especially CGNPC, have been forming alliances aggressively with foreign markets in mind. They may be able to make big strides in developing this business even before third-generation plants are made entirely in China.

***China has an overseas track record, although it is short***

China's nuclear-power industry has been involved in Pakistan (nuclear power-plant construction), Algeria (research reactor export), and India (enriched uranium export). In Pakistan, the first reactor began operating commercially in 2000, and a second is under construction currently. China has signed nuclear co-operation agreements with a dozen or so countries, but these have been mainly for the import of technology and products. However, the agreements with Jordan (August 2008), Belarus (August 2008), the UAE (April 2008) and Vietnam were concluded with exports in mind.

***CGNPC in alliance with French consortium with an eye towards global expansion***

In 2007, China and France entered a comprehensive alliance, involving mainly CGNPC on China's side. This alliance covers: 1) the import of a third-generation EPR, 2) the supply of fuel to this plant, 3) an investment in this plant by EDF, 4) a joint venture for the construction and operation of the EPR (55% CGNPC and 45% Areva), and 5) the transfer of technology for the production of EPR facilities (from Areva and Alstom to Dongfang Electric). It was agreed that the joint venture would also pursue business outside of China. This would have benefits not only for China, but also France. In addition to maintaining their place in the nuclear power industry

at home, French companies are already busy breaking into the US and UK markets. Co-operating with Chinese companies would help them to boost capacity. They already have a strong toehold in China, thanks to the co-operative relationship that they have had in manufacturing for the Chinese market with Dongfang Electric since the 1990s. This would also help them to become more cost competitive in the global market, in our opinion.

*Negotiations taking place over next five years will be critical*

In reality, we think that it will be 2015 before the development of the global nuclear-power industry produces real benefits in related markets. Nevertheless, the negotiating has already begun, so those that are late to the table could miss out on the chance to benefit from future market expansion. Therefore, this alliance with France is extremely significant for China because it could help the country to develop purely Chinese reactors.

#### Countries that are planning to introduce nuclear power

Europe, East Europe	Africa. Middle East	Asia Pacific and others
Poland	Morocco	Bangladesh
Turkey	Algeria	Vietnam
Belarus	Libya	Thailand
Georgia	Egypt	Philippines
Kazakhstan	UAE	Malaysia
	Israel	Indonesia
	Iran	Australia
	Jordan	Chile
	Yemen	
	GCC member countries	

Source: Japan Ministry of Economy, Trade and Industry

Note 1. Includes countries that have already introduced older technology

Note 2. Gulf Cooperation Council (GCC): United Arab Emirates, Bahrain, Kuwait, Oman, Qatar, and Saudi Arabia (six countries)

#### Capital-market presence

*Companies may seek to raise capital*

If we divide the companies into four categories – construction, equipment manufacturing, power-plant operation, and fuel – most of the ones that are traded publicly are involved in equipment manufacturing. The only other listed companies with exposure to the nuclear-power industry are power companies that operate mainly non-nuclear power plants, but have stakes in companies that have nuclear-power plants. However, bearing in mind the future need for increased investment, companies may need to raise money by offering some of their shares for sale in the equity market, as has been the case for other infrastructure-related industries.

*Groundwork is being laid for privatisation*

In fact, companies have taken some steps with privatisation in mind. The structural reforms of 1998-99 were done with an eye on future privatisation. As a result, CNEC (construction) and CNNC (owner and operator, with fuel companies also under its control), CGNPC, and CPI are already under the control of the State-owned Assets Supervision and Administration Commission (SASAC) as independent companies. Then, in August 2006 the Commission for Science, Technology and Industry for National Defense (COSTIND) released the *11<sup>th</sup> Five Year Plan for the Nuclear Power Industry*. This plan envisages an increased need for funding in the future, and charts out a strategy for raising capital that includes equity financing. Meanwhile, judging by what has been happening in China lately, the industry seems to be following the same path as the rail industry. In 2004, the government laid out plans to expand the rail infrastructure, and in 2006 it raised capital in the equity markets through some rail operators. Then, in 2008 two major construction companies (China Railway Group and China Railway Construction), as well as China South Locomotive and Rolling Stock (one of the two biggest companies, along with China North Locomotive and Rolling Stock), went public. Bearing this in mind, CNEC (construction), First Heavy Industries (equipment manufacturing) and CGNPC (owner/operator) are possible candidates for public listing.

***Companies with little effect on energy policy are in the best position***

However, enterprises involved in operating and supplying fuel to nuclear-power plants have a substantial impact on government energy policy, so we believe it is unlikely that the government would move proactively towards taking these companies public. This would be a low priority, in our opinion. Because of this, it is hard to imagine a stock offering for CNNC. Even France, which is highly dependent on nuclear energy, has moved more slowly to privatise the nuclear-power industry than other industries. EDF owns all of France's nuclear-power plants, and supplies more than 70% of the country's electricity needs through nuclear power. In 2005, it released about 13% of its shares to the stock market, but by law the French government must own more than 70% of the company's shares. For Areva, which manufactures equipment and handles fuel recycling, only investment certificates, which are shares without voting rights, are traded on the stock market. These are equivalent to 4% of the company's total shares.

**Comparison with other Asian countries**

***Korea is in the lead among neighbouring Asian countries***

In our view, China's nuclear-power industry is in a good position in terms of its potential for future market expansion, but Korea has taken the lead when it comes to the maturity of the domestic industry and having a foothold for expansion overseas. Korea had an installed capacity of 17.6 GW (net) at the end of 2008. Nuclear power accounted for 36% of country's electricity generation in 2007. The energy plan unveiled by the Korea Government in August 2008 set goals of increasing nuclear power to account for 59% of electricity generation and 28% of total energy consumption (compared with 15% in 2007) in 2030. In December 2008, the government also announced plans to add 12 more reactors (about 15 GW) by 2022, increasing nuclear power's share of total electricity generation to 48%. In Korea, design and engineering is concentrated mainly in the hands of Korea Power Engineering Company (KOEPC), equipment manufacturing in the hands of Doosan Heavy Industries, and ownership and operation in the hands of Korea Electric Power Corporation (KEPCO), and our impression is that the nuclear-power industry has developed relatively quickly.

***Doosan Heavy Industries supplies critical equipment and is a global player***

Korea brought in equipment and technology from both France and Canada, but ultimately it developed its own indigenous models based on technology from ABB CE (which has now been absorbed by Westinghouse), so it has already achieved a high level of domestic content. Korea has also made third-generation reactors that contain almost entirely domestic content, and has begun working on securing contracts overseas. Doosan Heavy Industries is the sole provider of the main components, and it is working actively to develop markets globally. Doosan is one of the main suppliers of important nuclear-reactor components to Westinghouse, and it will be supplying these components for the third-generation reactors (*AP-1000*) that have been ordered from Westinghouse by buyers in China and the US. It is also licensing technology to Ishikawajima-Harima Heavy Industries, a Westinghouse shareholder (which has supplied components for the Toshiba BWR in the past), and to China, which is aiming to boost domestic content.

***Doosan Heavy Industries also has the top global market share in other products***

Furthermore, Doosan Heavy Industries has the world's top market share (19%) in heat recovery steam generators (HRSG), equipment that is necessary for combined cycle gas turbine power plants, so it has ensured a global position in the thermal power arena for itself. Additionally, from a wider environmental perspective, the company also has the top global market share (41% in desalination facilities using multi-stage flash distillation), so it has a strong reputation in the environmental arena.

***India catching up with China***

Meanwhile, India had installed 3.8 GW (net) of capacity by the end of 2008, and is continuously increasing its capacity. However, it imports technology from abroad, and is behind China in terms of producing indigenous models that it can use to enter the global market. Before conducting its first test in 1974, India imported nuclear-reactor design technology from GE and AECL (Canada), but afterwards it developed nuclear power on its own. However, like China, India decided to rapidly increase the use of nuclear power after the demand for energy surged and

petroleum prices soared. India has not signed the Nuclear Non-Proliferation Treaty (NPT), but it has concluded nuclear power co-operation agreements with major countries on the condition that its peaceful nuclear-power facilities will apply IAEA safeguards. It has already placed orders with Russia (AES) and France (Areva) so that it can bring in new technology. India plans to install 40 GW of capacity by 2020 and 63 GW of capacity by 2032.

***First it is accumulating technology domestically***

Nuclear Power Corporation of India Limited (NPCIL) is the main organisation pursuing the development of nuclear-power plants in India. The company designs and operates plants. NTPC Limited (formerly National Thermal Power Corporation) also has plans to operate nuclear power plants. In equipment manufacturing, Larsen & Toubro (L&T) is involved on the nuclear-reactor side. Bharat Heavy Electrical Ltd (BHEL) is the leading company on the electricity-generation side, while Walchandnagar Industries Ltd. (WIL) is also involved. Fuel is supplied by Uranium Corporation of India Limited (UCIL). L&T has formed alliances with AECL and GE, with the intention of co-operating with them in importing nuclear-reactor technology.

**Looking ahead**

***Status of third-generation technology in China***

Looking ahead, we believe one of the key issues will be how quickly the transition to domestic content in third-generation reactors and the design of indigenous, standardised reactors takes place. When it comes to equipment, the progress made in starting up production of the massive forgings used in 1 GW and larger reactors will draw the most attention. First Heavy Industries has been operating a 15,000-tonne press since 2006, but it would have to acquire more advanced technology to produce forgings used in 1 GW and larger nuclear reactors (it obtains technology currently from Doosan Heavy Industries). First Heavy Industry aims to have the capacity to supply five-to-six reactors every year by the middle of the next decade. How things go in starting up this production will have a significant influence on the installation of nuclear-power capacity in China. Depending on what happens, Japan Steel Works, which is already supplying these forgings, could continue to benefit over the long term, or Doosan Heavy Industries (which plans to begin operating a 17,000-tonne press in 2010) could become a new beneficiary.

Meanwhile, the progress made with the design of indigenous, standardised reactors would also affect the pace of installation of nuclear-power capacity in China over the medium to longer term. Furthermore, China's vision is to put these indigenous, standardised reactors into widespread use overseas, so this would affect the competition for orders in the global market (especially in emerging markets).

The progress made with the plans by China (CGNPC) and France (EDF and Areva) to import EPRs will also draw attention. This alliance includes provisions for expansion into foreign markets, so it may also affect global competition for orders.

## Nuclear power: List of companies

Country/product	Company name	Ticker	Company profile	Indicates large impact (on listed company)
<b>China</b>				
Design/engineering etc.	China National Nuclear Corporation (CNNC)	-	Owned by SASAC. The design institute under its umbrella has the lead in nuclear-power plant design in China. Also owns various fuel-related companies.	
	China Nuclear Engineering and Construction Corporation (CNEC)	-	Engaged in nuclear-power plant construction.	
Turbines & generators	Shanghai Electric	2727 HK	Owned by Shanghai government. Part of the three major heavy electric machinery companies.	
Pressure vessels & steam generators	Dongfang Electric	1072 HK	Owned by SASAC government. Part of the three major heavy electric machinery companies.	√
	Harbin Power Equipment	1133 HK	Owned by SASAC government. Part of the three major heavy electric machinery companies.	
Large forged components (Other components)	First Heavy Industries	-	Owned by SASAC government. Part of the three major heavy electric machinery companies.	
Equipment	Second Heavy Industries		Manufactures peripheral equipment for reactors.	
Control systems	HLS systems	HOLI US	Established a control-system joint venture with CGNPC. Works on domestic production with the technology transfer from Mitsubishi Electric	
Power producers	China National Nuclear Corporation (CGNPC)	-	Same as above	
	China Guangdong Nuclear Power	-	Owned by SASAC. Its shares are held by CNNC (45%), Guangdong province (45%) and CPI (10%).	
	China Power Investment Corporation (CPI)	-	Owned by SASAC. Part of the five major power producers. Continues the nuclear-power business owned by the former State Power Corporation.	
	Others		China Datang Corporation, etc.	
<b>Companies doing business in China</b>				
Design/engineering	Toshiba (WH)	6502 JP	Toshiba owns the majority of the shares of Westinghouse. Works on technology transfer for the domestic production of third-generation reactors in China.	√
	Areva	CEI FP	Engaged not only in reactor-design, and the equipment-manufacturing businesses, but also the fuel business. Working on introducing EPR in China and other countries in co-operation with CGNPC.	√
	ASE	-	Exporter of Russian reactors.	
Equipment, control systems	Mitsubishi Heavy Industries	7011 JP	Engaged in the reactor equipment/turbine businesses. It has a track record of delivering pressure vessels, and has received orders for turbines jointly with Harbin Power Equipment.	
	Mitsubishi Electric	6503 JP	Engaged in generator/control system businesses. It received orders for control systems for CGNPC and for generators jointly with Harbin Power Equipment.	
	Hitachi	6501 JP		
	Areva	CEI FP	See the description for the company above.	√
	Alstom	ALO FP	Engaged in turbine/generator businesses. Owns a joint venture with Dongfang Electric.	
	Power Machines	-	A leading company in the Russia generator market.	
Large forged components	OMZ	-	Engaged in the manufacturing of Russian reactor equipment.	
	Doosan Heavy Industries	034020 KS	Dominant company in reactor equipment, generator devices, large forged component businesses and plays the leading role in the adoption of AP-1000.	√
	Japan Steel Works	5631 JP	Engaged in the manufacturing of large forged components. Will be the main supplier for China until production by First Heavy Industries Group gets off the ground.	√
Power producers	EDF	EDF FP	Planning to acquire a 30% stake in the Taishan power plant that is adopting an EPR.	
<b>India</b>				
	Nuclear Power Corporation of India (NPCIL)	-	Has the leading role in the nuclear-power plant design in India	
	Larsen & Toubro	LT IN	Engaged in the manufacturing of major reactor components and the engineering business.	
	BHEL	BHEL IN	A leading company in the generator market.	√
	WALCHANDNAGAR	WI IN	Manufactures reactor peripheral equipment.	
	NTPC	NTPC IN	Owns and operates thermal-power plants, and is going to start a nuclear-power generation business.	
<b>Korea</b>				
Design/engineering	Korea Power Engineering Company	-	Dominant company in design and engineering.	
Operation	Korea Electric Power Corporation	-	Major power producer in Korea. Dominant owner and operator of nuclear-power plants.	
Equipment	Doosan Heavy Industries	034020 KS	After consolidation, became the dominant company in the major equipment business for nuclear-power plants in the country.	√

Source: Daiwa

### 3. Top companies to watch

While many companies are involved in CO<sub>2</sub>-reduction related industries, a limited number of them are heavily dependent on these areas and have listed their shares on the stock markets, other than those in the Mainland China. Therefore, we have picked entities that satisfy the condition 'heavily dependent on related industries' as much as possible as noteworthy companies.

*The leading gearbox manufacturer in China*

#### China High Speed Transmission Equipment (658 HK)

China High Speed Transmission Equipment is a major industrial gearbox manufacturer, and ranks top in the domestic gearbox business for wind-power turbines. Its customers include major Chinese companies, Goldwind Science and Technology, Dongfang Electric, Shanghai Electric, as well as GE, Repower, Nordex, Fuji Heavy Industries. The wind-power gearbox business accounted for 38% of its revenue for 2007 and 52% for 2008. For other industries, it plans to expand its business by taking advantage of international co-operation. The company has formed an alliance with ZF in the shipbuilding business, and with Alstom in the railway business, which we see as indicating that international companies hold the company's technology in high regard. Therefore, we believe the company has the potential to become a global company.

The company is engaged in joint development of the 1.5MW turbine-manufacturing business with GE, and has signed a contract for delivery that would make it the company's major export business. However, the shipment schedule under this contract has been delayed, which has resulted in the company revising down its forecasts. However, since the domestic China market is expanding at a faster pace than the company expected, the delay would only have a small impact on the business-expansion plans of the entire group, in our view. The company expects its shipments of wind-power gearboxes to increase from 1.3GW for 2007, to 3.5GW for 2008, and 6GW for 2009.

*Relatively good market position, but its growth depends on thermal-power plant market trend*

#### Dongfang Electric (1072 HK)

Nuclear-power production does not account for a significant portion of the company's revenue at the moment. Its revenue depends mainly on the thermal-power generation (75% of the total revenue for 2008), and the performance of its nuclear-power business is not a determining factor of the company's earnings trend. However, we have picked Dongfang Electric as a noteworthy company because: 1) we believe it is in a relatively favourable position in the nuclear-power business compared with its peers, 2) we believe the company is in a strong position, as it has a vertically-integrated business model and is in the top-share group of the wind-power equipment market (it had a 17% share for 2008), 3) in terms of new contracts in 2008, the nuclear and wind businesses accounted for 23.5% and 14.8% respectively. For reference, the company had a 33% share of the thermal-power plant market, and a 40% share of the hydro-electric power-plant market in China in 2008.

For its nuclear-power business, Dongfang Electric has obtained technology transfers from Areva and Alstom in France, and manufactures major reactor equipment, including pressure vessels, steam generators, power generators and steam turbines. Recently, the company succeeded in winning orders from CGNPC (for the *CPR-1000*). While the PRC Government was working on introducing the technology for the *AP-1000*, Dongfang could not receive the first batch of orders (Shanghai Electric, Harbin Power Equipment and First Heavy Industries won the orders). However, the company received orders for both reactors and generators for the EPR that CGNPC is importing from France, jointly again with French companies, and is still targeting obtaining orders for the *AP-1000*. In addition, we believe the company has a chance of delivering equipment for the joint project between Areva and CGNPC for the international expansion of the EPR.

The company's earnings trend was affected negatively by the Sichuan earthquake in 2008, as its main bases are in Sichuan Province. While the thermal-power equipment business accounts for the majority of the company's revenue and has a relatively high margin, we believe the division is unlikely to record earnings growth for 2009. In order to increase its earnings significantly again, the company needs to further develop its nuclear-power-plant and wind-power equipment businesses, and increase its dependence on these businesses, as well as see a recovery in the thermal-power plant market, in our view.

### HLS Systems (HOLI US)

*Core business is the development and sale of automation and railway-related systems*

HLS's core business is process automation (while it has also embarked on the programmable-logic-controller business for factory automation), where it ranks top among its domestic peers, and has the second-largest share of the China domestic market behind ABB. Meanwhile, the company is expanding its train-control system business (for high-speed passenger-dedicated [PD] railways and underground railways) as its second main business. HLS has received orders for high-speed PD railway systems jointly with Hitachi and Ansaldo, and for underground-railway systems as a main contractor. The company's strategy calls for product development and sales in markets in which few domestic companies are involved, while combining existing technologies and imported technologies from overseas.

For its nuclear-power business, the company established Beijing Guangli Nuclear Systems Engineering with CGNPC, and plans to deliver products for CGNPC's *CPR-1000* with technology transfer from Mitsubishi Electric. In addition, in 2008, HLS started developing control equipment for turbines in the field of wind-power generation jointly with Goldwind Science and Technology. The company's railway business can be viewed as an environment-related business in a broad sense, as China is expanding its railways aggressively as a measure to reduce car usage as much as possible and to realise energy savings.

In terms of the company's revenue breakdown, we expect the contribution from the railway business to increase further from about 25%, and that from the nuclear business to expand to about 10%, of its total revenue over the next one-to-two years. In addition, if HLS gets its wind-power business on track, we would evaluate the company positively for its significant dependence on environment-related businesses.

## 3.1 Companies in neighbouring countries

### Doosan Heavy Industries (034020 KS)

*Positioned well to benefit from the global expansion of the nuclear-power plant market*

The company has a dominant position in the manufacturing of main equipment for nuclear-power plants installed in Korea, and is on the list of major equipment suppliers for Westinghouse, along with Mitsubishi Heavy Industries, Ansaldo and ENSA. For Westinghouse's third-generation model, the *AP-1000*, Doosan has received orders for two projects in the US, as well as the orders for product delivery for the first two units in China and for production-technology injection after delivery. Meanwhile, the company acquired Mitsui Babcock in the UK and changed the name of the acquired company to Doosan Babcock, and is focused on pursuing orders in the nuclear-power equipment market in the UK where competition is intensifying. The company is also engaged in the manufacturing of large forged products, and is preparing to start operating 17,000-tonne press machines in 2010.

*Core business is the manufacturing and sales of thermal power-generation plant*

Its nuclear-power-related revenue comes from nuclear-power-plant equipment sales, which account for 14% of total revenue for the power-generation equipment division (which accounted for 66% of the company's total revenue for 2008), and a part of sales for the forged- and cast-product division (11% of the 2008 total revenue), and does not account for a significant portion of the company's total revenue. However, we expect the revenue contribution from the nuclear-power

business to increase over the next five-to-10 years. For the thermal-power business, the company produces turbines and power generators, and has the top global market share (19%) in the manufacturing of exhaust heat recovery boilers that are essential for the adoption of high-efficiency combined cycle gas turbines. Meanwhile, water-desalination apparatus accounts for 77% of the company's industrial division's revenue (which accounted for 11% of the 2008 total revenue). The company manufactures multiple-stage flash-type water-desalination units, and has the top global market share (41%) in the field. Thus, we believe it is worth watching as a manufacturer and vendor of environment-related equipment in various fields.

### **Suzlon (SUEL IN)**

#### ***Leading wind-turbine manufacturer in India***

With the wind-turbine business as its mainstay, Suzlon is capable of producing a complete set of components internally. The company has maintained its market share at over 50% in India, and was ranked fifth globally with a market share of about 11% (14% including the share of REpower) in 2007. When the wind-power generation equipment market in India boomed in the 1990s, the company expanded its wind-power turbine business, led by the foresight of the founder, Mr. Tanti. The company is also keen on global expansion, and acquired a controlling stake in a major global wind-power gearbox manufacturer, Hansen (which had about a 30% share of the global market in 2005), in 2006. In 2007, Suzlon won the competitive bid over Areva to acquire a majority stake in Repower, which had an edge in the large-turbine business. The company's production bases are located in India, Europe, as well as the US and China. Of its revenue for the fiscal year ended March 2008, the US accounted for 36%, India 34%, Oceania 12%, Europe 9%, and China 7%. The US accounted for 49% of the order backlog for the same period. We believe Suzlon satisfies our criteria, and should be regarded as a global company.

In 2Q08, quality defects in Suzlon's turbine products were found in the US, which dampened its order acquisition momentum. The company is still booking costs for dealing with the matter. In addition, it is having difficulties with obtaining financing due to its worsening financial structure after aggressive acquisitions, an increase in working capital, cash outflows to purchase shares from the major shareholders of REpower, and so on. Meanwhile, the earnings of its subsidiaries, REpower and Hansen, have been increasing steadily so far.

In our view, it may take some time for Suzlon to regain its earnings-growth momentum (on a parent-company basis). We also see continued downward risk for its earnings due to the impact of the global economic slowdown. However, over the long term, we see opportunities for the company to boost its businesses again with the development of wind-power-related industries. In addition, we intend to keep watching the company's progress, since it is an emerging-country enterprise that has established a global-business structure ahead of its peers.

## Earnings summary and share-price movements of companies to watch

## China High Speed Transmission Equipment Group (658 HK)

Year to Dec 31	2006	2007	2008	2009E	2010E
Revenue (Rmb m)	1,184	1,905	3,439	5,176	6,971
YoY (%)	25	61	81	50	35
EBT (Rmb m)	94	324	764	928	1,254
YoY (%)	(17)	246	136	21	35
EPS (Rmb)	0.14	0.29	0.45	0.66	0.89
YoY (%)	(18)	107	55	47	35



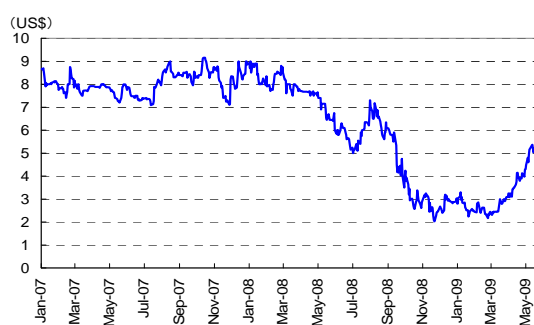
## Dongfang Electric (1072 HK)

Year to Dec 31	2006	2007	2008	2009E	2010E
Revenue (Rmb m)	22,434	24,099	27,171	26,982	28,488
YoY (%)	-	7	13	(1)	6
EBT (Rmb m)	2,782	2,754	392	1,748	2,212
YoY (%)	-	(1)	(86)	346	27
EPS (Rmb)	2.78	2.72	0.58	1.80	2.13
YoY (%)	-	(2)	(79)	209	18



## HLS Systems (HOLI US)

Year to Jun 30	2006	2007	2008	2009E	2010E
Revenue (US\$m)	90	102	121	158	194
YoY (%)	-	13	19	30	23
EBT (US\$m)	23	19	2	16	35
YoY (%)	-	(19)	(88)	598	121
EPS (US\$)	0.57	0.38	(0.03)	0.17	0.60
YoY (%)	-	(33)	-	-	253



## Doosan Heavy Industries (034020 KS)

Year to Dec 31	2006	2007	2008	2009E	2010E
Revenue (Wbn)	3,509	4,090	5,710	6,734	8,062
YoY (%)	6	17	40	18	20
Operating profit (Wbn)	208	283	474	531	720
YoY (%)	(6)	36	67	12	36
EPS (W)	710	2,852	(765)	2,679	4,823
YoY (%)	(63)	302	-	-	-



## Suzlon Energy (SUEL IN)

Year to Mar 31	2006 (Mar06)	2007	2008	2009E	2010E
Revenue (Rs m)	38,410	79,857	136,794	192,083	209,725
YoY (%)	98	108	71	40	9
EBT (Rs m)	9,027	11,196	13,558	13,594	13,562
YoY (%)	130	24	21	0	0
EPS (Rs)	5.55	5.99	7.07	5.60	8.35
YoY (%)	93	8	18	(21)	49



Source: Companies, Bloomberg, Datastream (2009E and 2010E are based on Bloomberg)

CO<sub>2</sub> reduction-related companies: valuation

Ticker	Currency	Share price	Market cap (US\$m)	Fiscal year end current year	PER (x)		Dividend yield (%)		PBR (x)	ROE (%)	EBIT margin (%)		Share-price performance (%)			
					current year	next year	current year	next year			current year	next year	1 month	3 months	6 months	
<b>Wind</b>																
Xinjiang Goldwind SCI&Tech-A	002202 CH	Rmb	33.94	6,958	12/09	34.7	26.8	0.5	0.7	9.3	26.0	14.6	13.7	14.3	44.6	128.8
Dongfang Electric Corp Ltd-H	1072 HK	HK\$	30.00	5,489	12/09	18.1	14.5	0.7	0.9	6.3	47.6	7.0	8.0	47.1	111.3	74.4
Shanghai Electric GRP Co L-H	2727 HK	HK\$	3.66	16,401	12/09	20.0	18.8	1.5	1.6	1.9	10.0	6.7	6.8	30.7	86.7	36.3
Xiangtan Electric Manufact-A	600416 CH	Rmb	24.42	840	12/09	43.1	26.5	0.8	-	4.0	9.0	-	-	33.9	117.3	218.0
China High Speed Transmissio	658 HK	HK\$	16.30	2,618	12/09	24.3	18.5	1.2	1.5	4.7	20.6	17.7	17.7	16.4	61.1	130.2
Wafangdian Bearing Co Ltd-B	200706 CH	HK\$	5.19	270	-	-	-	-	-	-	-	-	-	8.4	16.1	23.0
Zhejiang Tianma Bearing Co-A	002122 CH	Rmb	29.36	2,554	12/09	23.0	18.6	0.7	1.0	4.9	24.8	22.5	22.9	(2.0)	4.7	34.2
Harbin Power Equipment Co-H	1133 HK	HK\$	8.32	1,478	12/09	12.6	13.3	0.9	0.8	1.3	10.0	5.3	5.8	41.3	82.5	61.2
China National Building Ma-H	3323 HK	HK\$	16.90	5,409	12/09	19.1	15.3	0.5	0.8	3.3	19.8	12.1	13.5	2.8	87.8	187.9
Sinoma Science&Technology -A	002080 CH	Rmb	31.40	690	12/09	34.1	27.0	-	-	5.5	15.6	-	-	22.7	36.5	67.5
Shanghai Lenguang Indus-A	600629 CH	Rmb	13.47	531	12/09	44.9	38.5	-	-	-	-	-	-	6.1	16.5	55.9
Tianjin Xinmao Technology -A	000836 CH	Rmb	10.24	295	12/09	-	-	-	-	-	-	-	-	(3.0)	43.7	93.2
China Wind Systems Inc	CWSI US	US\$	0.93	42	-	-	-	-	-	-	-	-	-	97.9	126.8	29.2
Hls Systems International Lt	HOLI US	US\$	5.74	252	06/09	10.4	9.6	-	-	-	-	-	-	33.5	134.3	129.6
China Windpower Group Ltd	182 HK	HK\$	0.80	645	03/09	25.0	12.9	-	-	-	-	-	-	158.1	227.9	314.5
Vestas Wind Systems A/S	VWS DC	DKK	384.00	14,816	12/09	20.4	16.7	0.0	0.4	3.3	18.9	10.6	11.1	(0.1)	48.3	56.4
Gamesa Corp Tecnologica SA	GAM SM	€	15.75	5,404	12/09	25.3	20.7	1.2	1.3	2.4	9.8	6.6	6.9	9.5	49.0	29.1
General Electric Co	GE US	US\$	13.48	142,748	12/09	13.5	14.3	6.1	3.1	1.4	10.2	8.3	8.1	6.6	58.4	(21.5)
Suzlon Energy Limited	SUEL IN	Rs	97.90	3,115	03/09	12.2	14.9	0.9	0.9	1.7	13.6	10.6	10.6	53.9	140.8	148.2
Nordex AG	NDX1 GR	€	12.31	1,160	12/09	24.8	17.6	0.0	0.0	2.3	9.1	4.2	5.4	(6.1)	56.0	31.5
Acciona SA	ANA SM	€	92.30	8,272	12/09	8.1	21.4	3.3	3.0	1.1	18.7	8.5	11.0	18.2	17.4	39.7
Hansen Transmissions Int	HSN LN	£p	164.00	1,777	03/10	26.5	15.5	0.0	0.0	1.7	6.8	11.5	14.1	10.8	78.3	85.8
SKF AB-B Shares	SKFB SS	SEK	88.75	5,333	12/09	17.3	13.3	3.9	4.0	2.0	11.5	7.0	8.6	(0.6)	17.2	48.5
Timken Co	TKR US	US\$	16.91	1,637	12/09	-	18.8	2.7	2.1	-	0.8	1.9	4.5	5.2	38.8	16.5
Unison Co Ltd	018000 KS	W	16,950	313	-	-	-	-	-	-	-	-	-	2.7	43.0	28.9
Hyosung Corporation	004800 KS	W	102,000	2,867	12/09	15.3	13.9	0.7	0.7	1.6	12.1	-	-	27.5	102.0	213.8
Doosan Heavy Industries	034020 KS	W	73,000	6,135	12/09	15.7	11.6	0.7	0.8	2.8	19.3	8.7	10.1	(12.6)	22.1	32.7
<b>Nuclear</b>																
Shanghai Electric GRP Co L-H	2727 HK	Go to above line														
Dongfang Electric Corp Ltd-H	1072 HK	Go to above line														
Harbin Power Equipment Co-H	1133 HK	Go to above line														
HLS Systems International Lt	HOLI US	Go to above line														
Toshiba Corp	6502 JP	¥	357	12,119	03/10	(14.6)	21.1	1.6	1.5	2.6	(27.3)	(1.0)	2.2	5.0	48.8	8.5
Areva - CI	CEI FP	€	415.55	20,771	12/09	18.1	16.8	1.8	1.9	2.1	11.9	8.4	8.8	8.8	22.4	17.1
Mitsubishi Heavy Industries	7011 JP	¥	341	12,062	03/10	113.1	41.7	1.3	1.4	0.9	0.8	1.7	2.4	5.6	22.7	(9.5)
Mitsubishi Electric Corp	6503 JP	¥	552	12,427	03/10	(47.3)	20.6	1.3	1.8	1.4	(3.4)	1.2	3.1	4.5	40.5	11.5
Hitachi Ltd	6501 JP	¥	315	11,124	03/10	(5.3)	50.5	0.7	1.3	1.1	(24.4)	(0.3)	1.6	(8.7)	27.0	(26.7)
Alstom	ALO FP	€	44.55	18,144	03/10	10.3	11.7	2.7	2.6	3.4	38.2	8.3	7.4	(6.9)	17.9	14.3
Doosan Heavy Industries	034020 KS	Go to above line														
Japan Steel Works Ltd	5631 JP	¥	1,239	4,826	03/10	28.1	23.8	1.0	1.2	4.6	18.0	13.1	14.4	15.4	38.3	30.4
EDF	EDF FP	€	36.95	94,940	12/09	14.6	13.1	3.6	3.9	2.4	17.8	15.9	16.8	4.6	19.5	(14.1)
Larsen & Toubro Limited	LT IN	Rs	1,402.20	17,440	03/10	25.9	22.4	0.8	0.9	5.2	21.6	10.9	10.5	59.5	128.5	99.5
Bharat Heavy Electricals	BHEL IN	Rs	2,178.15	22,642	03/10	-	-	-	-	-	-	-	-	31.6	55.2	71.5
Walchandnagar Industries	WI IN	Rs	196.05	158	-	-	-	-	-	-	-	-	-	64.9	148.2	132.6
NTPC Limited	NATP IN	Rs	215.40	37,716	03/10	20.1	18.4	1.9	2.1	2.9	14.5	-	-	13.4	16.4	37.7

Source: Bloomberg

Note 1: Share prices as of 29 May 2009

Note 2: Blue highlights indicates a non-Chinese company

*Note: This is the translation of selected chapters of the original report published in Japanese on 6 April 2009.*

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