Microeconomics of Competitiveness

Wind Turbine Cluster in Inner Mongolia

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Required Disclosures

(1) Nationals of the Country: only Arthur Mak and Carol Yu of the team are Hong Kong Chinese citizens. Both Arthur and Carol have never been to Inner Mongolia.

(2) No special access or nonpublic access to information. Our team utilized resources from Harvard's H.C. Fung's Library and MIT Databases that may not be accessible by HBS students.

(3) No team members traveled to China during the project period.

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I. Country Analysis: China

i. Introduction

The People's Republic of China was founded in 1949. For almost 30 years after MAO Zedong founded the country, he adopted Soviet Union's centrally-planned economy and authoritarian politics. His many mass political campaigns led to a near-collapse of China's political, social and economic state. After Mao passed away, pragmatist DENG Xiaoping assumed leadership from 1978 to 1989. The country Deng inherited was in chaos: no functioning institutions, no money and no food in the shops. Deng decided to implement several economic reforms to lift the country out of the catastrophic abyss. Some concepts that contributed to his stunning success include:

1. **Decentralization**: give power and incentivize local governments to focus on economic development rather than political class struggles
2. **Market economy**: dismantle planned economy and offer enterprises autonomy in production, operation and sales.
3. **Diversified ownership**: convert state owned enterprises (SOE) to mixed ownership, enabling private enterprises to become drivers of economic development.
4. **Opening**: adopt export-orientation and welcomed FDI to become "world's factory."
5. **Experimentalism**: adopt a bottom-up approach of deciding policies of proven effectiveness as Deng believed that the country not only had to be willing to experiment, but also learn from the experiences, retaining what was right, correcting what was wrong and solving new problems in a timely manner.
6. **Stable political environment**: ensure single-party state remained powerful and stable, allowing government effectiveness at rolling out reforms. (Deng, 1994):

The Chinese Communist Party (CCP) has been in power ever since the founding of the country, and multiparty democracy is not on the agenda. However, the party has professionalized itself and made attempts to improve policy formulation and governance. National leaders are not elected but instead emerge from the CCP's political-bureaucratic structure. However, village elections in China were promulgated in the 1990's, and have allowed two-thirds of the nation's 1.3 billion people to directly participate in electing their local leaders. Nevertheless, rule of law, transparency, accountability and responsiveness are still big challenges. China is divided into 22 provinces, 5 autonomous regions and 4 municipalities. Provincial leaders are entrusted with significant control over policy in their regions, and central policies are usually left to local authorities to decide on the details of implementation.

Economic reforms and opening since 1978 have dramatically raised living standards. China has lifted several hundred millions of people out of poverty since 1978. The poverty rate was reduced from 31.5% in 1990 to 9.9% in 2006 (UNDP, 2007/2008).[1] However, economic reform has exacerbated economic inequality among urban, rural and different geographical regions of China. The average income of the richest 20% households is 11 times that of the poorest 20% households, and the average disposable income of urban residents is 3 times more than that of rural residents. The current leadership has responded to growing economic disparities and promoted the concept of "harmonious" development policies, which emphasizes on sustainable and equitable economic growth via developing rural and inland areas.

Table: Comparison of Different Regions in China (CSY, 2008)

	Eastern Region	Central Region	Western Region	NE Region	Country
Urban household per capita income [USD]	14,967	9,902	9,728	9,830	13,786
Rural household per capita income [USD]	5,188	3,283	2,588	3,745	4,140
GDP % of total	55%	19%	17%	9%	100%
Population % of total	36%	27%	28%	8%	100%

Demographically, China's greatest challenge is its sheer size of the population. However, China's "one-child" policy is making China one of the fastest aging nations, with the population aged 65

[1] This refers to the percentage of population living below the poverty line of $1 a day.

and over to rise from 10% in 1995 to 22% by 2030 (EIU, 2009). China boosted its life expectancy from 35 years old before 1949 to of 72 years in 2005, which is above the world average of 67 years. China has reduced the maternal mortality rate from 94.7 maternal deaths per 100,000 live births in 1990 to 36.6 per 100,000 live births in 2007 (MDG Monitor, 2009).

Sound public finance policy coupled with a booming economy created macroeconomic stability, which is a source of the nation's competitive advantage, especially during the 2008 financial crisis. The government budget saw a surplus for the first time in 2007 (stands at 154 billion RMB), while the government's low debt ratio of 18.4% of GDP allows government the flexibility to acquire new capital for economic development (CIA, 2009). Although rising inflation has been a concern, overall consumer price inflation has remained relatively low at 4.8% in 2007 (EIU, 2009).

ii. National Diamond Analysis

Factor Conditions

China has phenomenal **natural endowments**. China's vast countryside possesses natural resources. The notable mineral resources include coal, iron ore, petroleum, natural gas, large variety of precious metals, and world's largest hydropower potential. Large part of the eastern and southern border is exposed to the ocean, enabling trading through its 14 large-scale ports. China has an unequalled labor force of 800 million employed workers in 2007, concentrated in agriculture, manufacturing, retail, and construction industry sectors (Index Mundi, 2009).

China's **physical infrastructure** has improved significantly due to massive government spending in the past 3 decades, with extensive national road network and railways in all major cities, which enables efficient provincial trade networks. However, logistics services have lagged in development. China's electricity supply and communications infrastructures are poor, especially in the interior and Western regions of China.

China's **human resource infrastructure** requires significant development. Even though adult illiteracy rate is only 8.4% in 2007, rates are uneven among different provinces. Despite the national policy of 9 years of free compulsory education and 99.5% primary school enrollment for all school-age children in 2007, many rural schools are inadequately funded, and there is widespread truancy and absenteeism (EIU, 2009). China has a large supply of technical talents with estimates from 200,000 to 600,000 engineers graduating each year (Every Day Economist, 2009). However, its education system requires substantial upgrade. The relatively poor quality of management schools cannot counteract the drastic demand for good managers.

China's **administrative structure** has significant strengths and shortcomings. On the one hand, single-party rule enables the country to have a vision, to have consistent policies and efficiency in decision-making and implementations; on the other hand, the lack of check-and-balances also increases the risk of poor political decisions being made and unbalanced considerations to various stakeholders.

Demand Conditions

China has undergone an economic miracle with an average 10% growth rate since the beginning of the economic reform 3 decades ago. GDP per capita increased 50 folds from 1978 to 2007 (CSY, 2008). In addition, China has seen dramatic shift of households into middle class income levels over the past decade from around 20% of households in 1997 to around 60% in 2007. Rising incomes and larger middle class contribute to increased domestic consumption and boost domestic demand.

However, the structure of the economy is unbalanced. Gross fixed investments has been the main driver of economic growth and accounted for around 40% of GDP from 2003-2007, while private

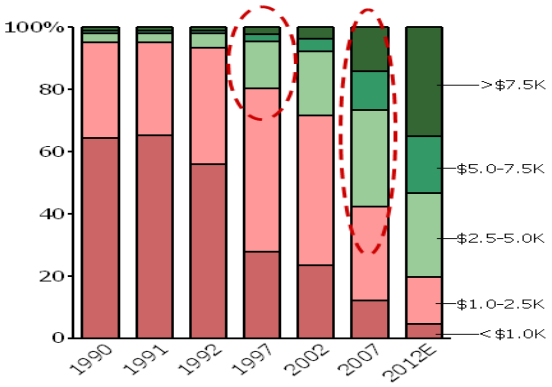
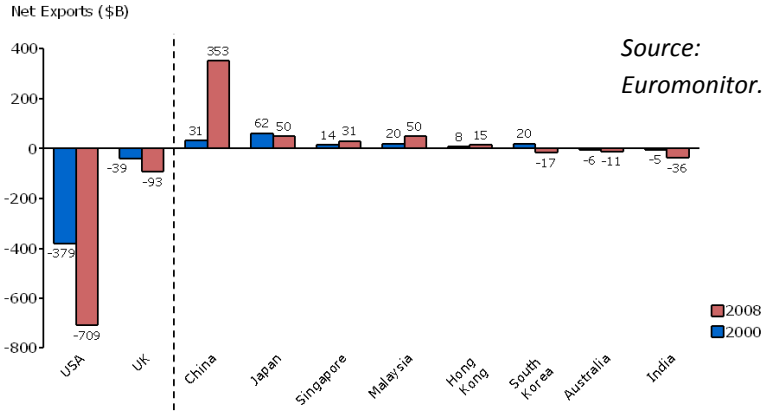


Figure: Household distribution by annual disposable income (rising middle class)`

consumption's share of GDP declined over the past few years and only accounted for 35.4% of GDP in 2007. This low level of consumption reflects the poor condition of the country's social safety net and people's fear of having to pay for rising healthcare, education, housing expenses among others. Therefore, national savings rate is extremely high, which stands at 31.6% in 2008, compares to a mere 2.8% in the U.S.

Following the accession to the World Trade Organization in December 2001, export growth surged, averaging 29% a year in 2002-2007. Share of its total exports in GDP has risen from 29.4% in 2003 to 38.8% in 2007, which has made it more vulnerable to global economic crisis.



Source: Euromonitor.

Figure: China's Large Trade Surpluses

Context for Strategy and Rivalry

In terms of the **financing environment**, China has an impressive track record of foreign direct investment (FDI) since its opening in 1978. FDI were US $748 million in 2007, while from 1979 to 2007, accumulative foreign direct investments reached US $7.6 billion (CSY 2008). However, the funding environment for small-and-medium enterprises (SME's) and private enterprises remains tough. Banks have a bias to lend to large enterprises and state-owned enterprises. Private enterprises often lack the significant collaterals required to secure bank loans, and domestic equity and debt markets are still relatively underdeveloped, despite government efforts to reform. The country still remains as one of the most capital flow starved economy in the world.

Productivity and innovation has become increasingly vital, as China is experiencing increase in worker's wage levels, and low value-added manufacturing operations have started to migrate to other even lower-cost nations. Government is actively promoting measures that would improve factory and workers' productivity through numerous technical training programs.

The government is also actively promoting the development of innovation and high value-added industries. China's State Council has created medium and long-term plans for the development of science and technology for 2006 to 2020. 52 science parks have been built since 1992 to help the promotion of entrepreneurship and technology. 6,100 patents were filed in 2007, placing China sixth in the number of utility patent being filed (Levin Institute, 2009). 800 international firms have established R&D operations in China with increasing R&D budget proportions.

Despite headways on the innovation path, government still needs to provide much more incentives to transform China into a innovation-based economy. The government's overall spending on R&D is only at 1.23% spending on GDP - low when compared to developed world of 3% GDP spending but significantly ahead of India with only 0.8% (Financial Express, 2008).

Most firms in China tend to compete on price instead of differentiation. Upgrades in value chain and brand development are prized possessions that are hard to achieve. Further, low returns of investment and high percentages of bad loans make banks and foreign investors wary of investment opportunities.

In the past decade, as the government abolished the need for 50% local partnership to do business in China (except for strategic industries such as automotive and energy industries), the number of joint ventures has reduced by 25% a year since 2000 (FEER, 2008). Foreign firms experience the advantage of low wage labor while paying very low level of tax. The corporate tax rate for foreign firms is substantially lower than that for domestic firms. On the other hand, many foreign firms are not

effective at selling products and services to the large local markets, where local knowledge and government connection are often critical for business success.

Overall, the most problematic factors for doing business in China now are access to financing, policy instability and inefficient government bureaucracy. Other investment concerns arise from systemic corruption, lack of borrowers' and lenders' rights protection, inefficient monitoring of corporate boards, insufficient protection of minority shareholder's interests, and weak accounting and auditing standards of company's performance.

Related and Supporting Industries

Capable, locally based suppliers and industries

China has no shortage of local suppliers and manufacturers. The cost advantage of local suppliers is being eroded with increasing wages and appreciation of the currency. The operations are also much less efficient and are producing products of lower quality when compared with its Japanese counterpart. Operations are typically labor-intensive. The availability of new manufacturing technologies is also relatively low.

The shortage of core technology means that many firms need to produce goods at lower level of the value chain. Industry value chain is often incomplete with the need of foreign firms to supplement high value portion of the value chain. Many industries also create huge surplus of production, making industries dependent on international markets. From environmental point of view, many industries are often highly inefficient and have enormous energy consumption requirements. Finally, industries are often adversely affected by government's unpredictable behavior, such as the close down of factories during the Olympics Games, rapid re-zoning of industrial zones, and reduction of incentives for certain industry categories.

Abundance of Clusters

China has made phenomenal effort on cluster development, collaboration in cluster and cluster policies. The biggest clusters are Information Technology, Communications Equipment, Metal Mining and Manufacturing and Apparel. Of the 43 identified clusters, 42 of them have both positive CAGR in national share of exports from 1997 to 2007, as shown in Figure 6. This indicates that major industries in China have increasing capabilities to compete globally.

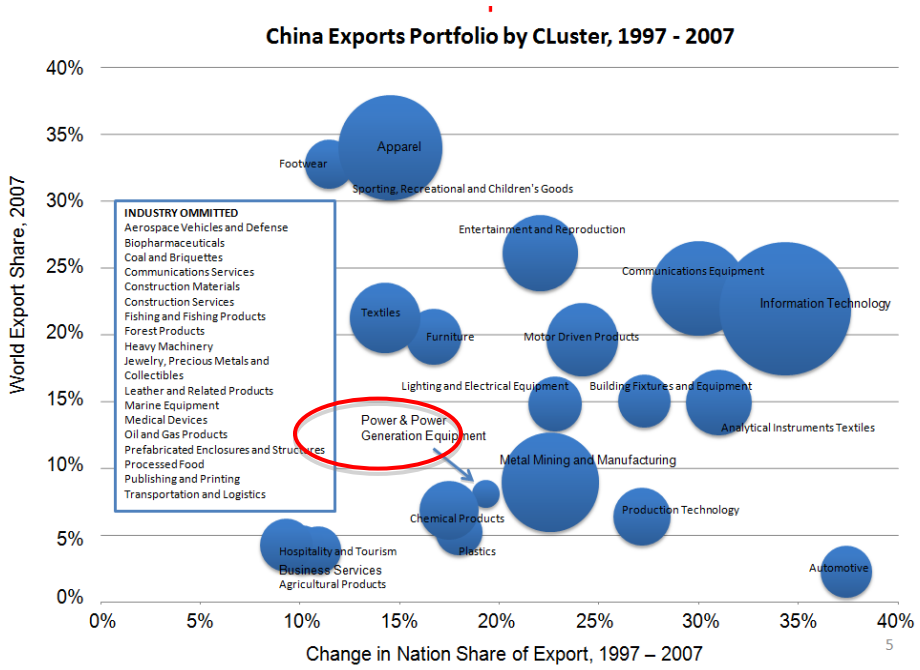


Figure I-3: China Exports Portfolio by Cluster, 1997-2007

China's Overall Competitiveness

China's total factor productivity growth stands at 4.7% in 2008, with an average 10-year growth of 4.85% in the last decade. Compared to other BRIC countries and developed countries, China has achieved the highest growth.

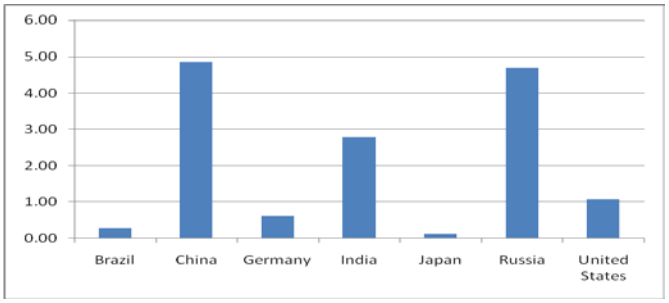


Figure I-4: Average TFP growth, 1998-2008 (%)

In terms of China's National Diamond, China's demand conditions are the strongest, with huge domestic market, phenomenal economic growth, rising consumption power and high export surplus. The context for strategy and rivalry is the weakest link with limited access to capital for SME's and private enterprises. Factor conditions and related and supporting industries is mixed.

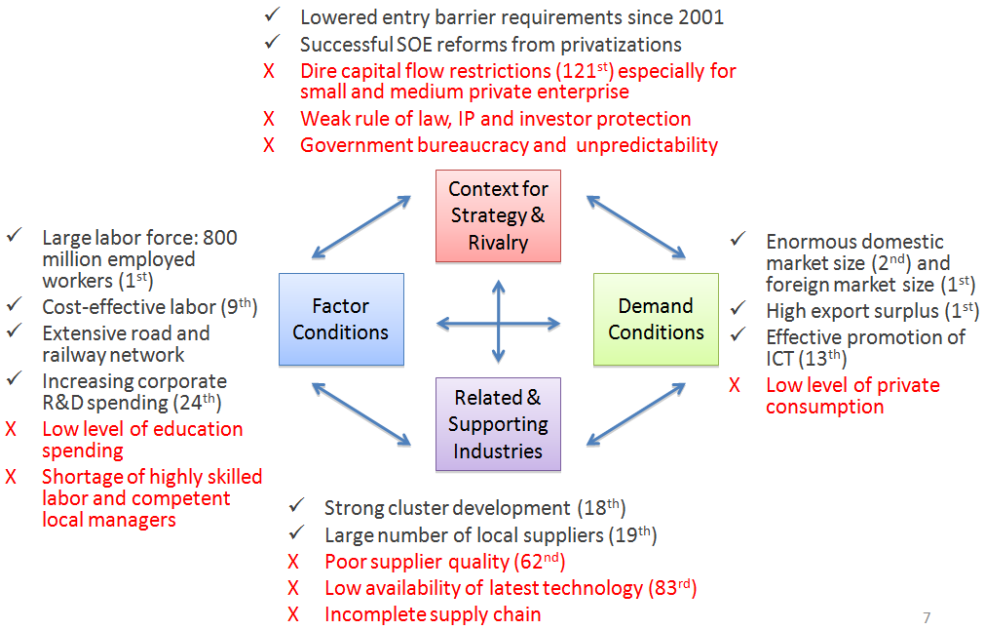


Figure I-5: China's National Diamond

China's overall competitiveness ranking has risen from 52 to 43 in the recent three years. China's overall competitiveness can be more clearly demonstrated by comparing China with its neighboring Asian countries from various competitiveness indices.

Figure I-6: Competitiveness Ranking Across Asian Countries[2]

Asian Countries	Global Competitiveness Index (GCI)	Microeconomic Competitiveness (MICRO)	Social Infrastructure and Political Institutions (SIPI)	Macroeconomic Policy (MP)
China	43	40	49	39
India	65	35	61	115
Vietnam	76	79	79	83
Japan	19	12	27	52
South Korea	28	28	47	1
	Ranking improve by 10 or less	Ranking worsen by 10 or less	Ranking worsen by more than 10	Ranking worsen by more than 30

iii. Challenges and Recommendations

Challenges	Recommendations
Difficult access to financing by firms	Provide incentives for capital investments in SME's, such as: • Revise loan performance metrics of state-owned banks to be quality-based rather than volume-based and ownership-based • Promote private equity and venture capital • Develop corporate bond market
Governance issues such as: - policy stability - gov. bureaucracy - weak rule of law - intellectual property	• Develop legal institutions and an independent judiciary • Train more lawyers • Increase accountability by (i) revising performance metrics to reflect emphasis on a service-oriented government and efficiency and (ii) link civil service promotion metrics to individual performance
Poor higher education and training	• Develop more professional schools to provide specialized labor (training of managers, technological/innovation talents) • Devise policies to attract diasporas back to the country • Further increase government spending on education
Strong dependence on the export sector	• Shift from export-oriented economy towards domestic-demand driven economy • Increase investment in social services to counter worries in spending

[2] Number represent ranking in 2008. "Ranking change" period is from 2004 to 2008.

II. Province Analysis: Inner Mongolia

i. Factor Conditions

Inner Mongolia is a treasure trove of commodities with the world's largest deposit of beryllium (an alloying agent) and tantalum (element used in electronic components), and sizable reserves of oil, gas, iron, zinc, tin and lead. More importantly, it is China's second largest production base for coal and steel.

Inner Mongolia has an excellent transportation network. There are 9 airports of civil aviation, 15 national highways and three arterial railways Beijing—Baotou, Baotou—Lanzhou and Jining—Erlianhot.It is also only a two-hour flight from Beijing and Tianjin.

Inner Mongolia has a population of 24 million people; urban unemployment rate in 2007 was 3.99%, close to the national average of 4% (China Data Online). Government expenditures for education and health had been constantly rising at a very high rate. There are 33 universities, colleges and institutes in the province such as Inner Mongolia University, Agricultural University of Inner Mongolia and Normal University of Inner Mongolia, etc. In 2005 there were 229,400 undergraduate students (MoC PRC, 2009).

ii. Demand Conditions

Inner Mongolia conjures images of vast grasslands, the Gobi Desert, nomadic men and women in colorful ethnic clothes on horseback and living in yurts. Less known is Inner Mongolia is the country's fastest growing provinces with a spectacular 17.1% average annual increase in GDP for the past decade. From being in the lower echelons at RMB 5.05 billion in 1999, Inner Mongolia's GDP per capita surpassed the national average in 2005.

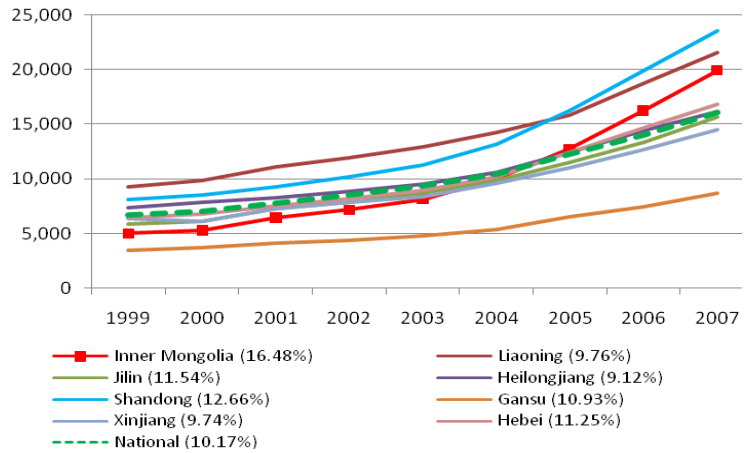


Figure: GDP per Capita (RMB millions)

Source: CEIC database

Two key forces are fueling Inner Mongolia's meteoric economic growth. The first is a surge in national demand for Inner Mongolia's natural endowments in light of China's rapid industrialization; second is the FDI-friendly central and state government's policies that have attracted an influx of investments.

iii. Context for Strategy and Rivalry

Favorable central and state government's policies for foreign investment have been central to Inner Mongolia's rapid development. From the figure below, we observe that Inner Mongolia's inward foreign direct investment (FDI) has been growing at five times of the national rate and just hit US$2.1 million in 2007. In spite of Inner Mongolia's rich resources, what has been most enticing for overseas investors is the preferential treatment they enjoy beyond what they receive in the coastal cities or even in their home countries.

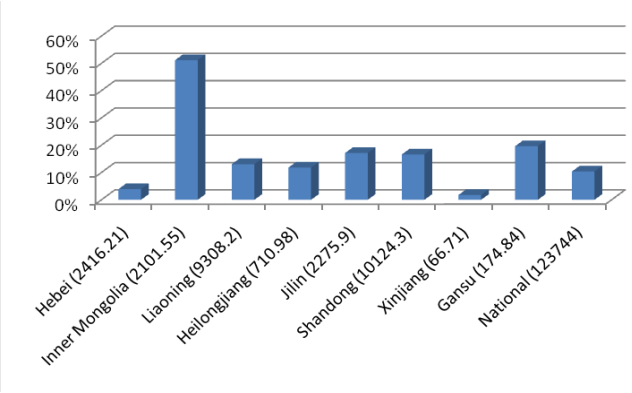


Figure: FDI's CAGR and 2007 [amount in millions of dollar]

Under the central government's "Go West" initiative, firms operating in Western region enjoy a lower corporate tax regime of 15 percent for firms operating in Western provinces (compared to 23 percent elsewhere). Furthermore, the Inner Mongolian government is offering foreign investors an array of incentives covering taxation, land use and convenience in administrative approval procedures, such as the ones listed below.

Figure: Incentives for Foreign Investors

Taxation	• If a foreign enterprise has operated for more than 10 years in Inner Mongolia or is located in one of the high-tech development zones, the government will return the company the first 5 years of taxes and 25% of the amount paid for the following 5 years.
Land use	• Foreign enterprises are exempted from land use fees during construction. • Foreign enterprises engaged in commodity export, high technology, energy and infrastructure construction and with an operational period of more than 15 years will be free from land use fees for certain years. • Foreign-funded enterprises engaged in grain production and animal husbandry can be granted 50 years of land use rights bylocal governments.
Administrative convenience	• Foreign enterprises enjoy national treatment when applying for bank loans and will have preferential treatment in receiving water, electricity and gas supplies and telecommunications connections. • Foreign-funded enterprises offering job opportunities to laid-off workers from SOE will enjoy both the State's and the autonomous region's preferential policies related to laid-off worker re-employment. • Foreign enterprises can settle approval procedures in all areas of the autonomous region because the local industrial and commercial, taxation, urban construction, environmental protection, land administration, financial and planning departments have established one-stop service centers especially for such enterprises.

iv. Related and supporting industries

Inner Mongolia has a diverse industry portfolio ranging from being the dairy and cashmere capital of China to manufacturing petrochemicals and equipment. Given it's abundance in natural resources as well, it is not surprising that metallurgy and coal mining/processing comprise 24% and 11.9% of Inner Mongolia's economy respectively.

In addition to these large coal reserves, Rich solar power and wind power resources make Inner Mongolia one of the key power suppliers for China's Northeast Power Grid, the Beijing-Tianjin-Tangshan Power Grid and China's neighboring country, Mongolia. Seven out of 10 light bulbs in Beijing are said to be powered by electricity transmitted from Inner Mongolia.

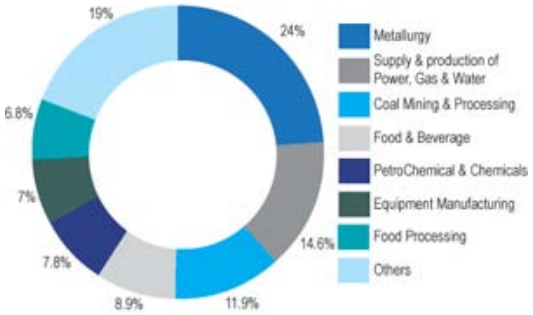


Figure: Gross Output Share of Industries in 2006 (IMSY, 2007)

Further, the government plans to upgrade its economy through actualizing 100 industrial independent innovative industrialization projects, such as establishing 50 key laboratories, 50 research centers of engineering technologies and 100 enterprise technology centers.

v. Challenges and Recommendations

Challenges	Recommendations
Low level of education, shortage of engineers and scientists	• Increase spending in education • Develop specialized training and engineering/management schools • Devise incentives to attract talents from other provinces or abroad
Low level of R&D spending	• Find incentives for companies to spend more in R&D
Imperfect law regulating wind	• Adopt changes to the current laws, eliminate preferences

power manufacturers	to the domestic manufacturers
Problems with the quality and safety of products	• Increase quality and safety standards for companies to upgrade their product
Local governance problems	• Increase efficiency of the local authorities, create a forum for companies to discuss their needs with gov.

III. Cluster Analysis: Wind Turbine Cluster in Inner Mongolia

i. Wind Cluster Factor Conditions

Inner Mongolia is blessed with excellent natural endowments for wind turbine cluster development. It has iron and coal deposits that are the ingredients to steel, which is the key raw material of wind turbines. Its abundant wind reserves, which is approximately 40% of China's, has attracted many wind farms to be built in Inner Mongolia and neighboring province, Gansu. Since wind turbines are heavy and large, Inner Mongolia has a comparative advantage over other provinces to build the wind turbine manufacturing facility closer to the end consumer.

Furthermore, Inner Mongolia has a long history with small-scale wind turbine technology. Due to Inner Mongolia's dispersed population, isolation from the main grid and abundant wind resources, Inner Mongolia started to develop wind power by constructing small-scale off-grid standalone wind turbines for herdsmen in the 1970s. Under this rural electrification project, many herdsmen attend training courses by the National Science and Technology Commission. The wind energy electrification program support team also maintains regular contact with these herdsmen through home visits or meetings at marketplaces (Hedon, 2009).

Nonetheless, Inner Mongolia lacks professionals with expertise of the large wind turbine industry. This experienced labor shortage is arguably the largest limiting factor of Inner Mongolia's wind turbine cluster's development because the wind industry is technology-intensive and constantly evolving. It needs to attract and train business executives and engineers that not only have knowledge related to wind power equipment manufacturing, wind energy resource assessment and wind power

plant management, but are also innovative and fast learners. The leading domestic manufacturer, Goldwind sets a good example for other domestic manufacturers to improve their technical capacity by sending their employees for advanced training. Two-thirds of its staff has attended events for technical exchange or further training by foreign companies or institutes, and several senior managers are pursuing MBA or executive education courses abroad (ABS, 2008).

ii. Wind Cluster Demand Conditions

In Inner Mongolia, initial demand for small wind turbines was not driven by environmental awareness but rather a cost effective way to provide electricity to two-fifths of the population that was isolated from the grid (APFED, 2003). With the government's active promotion and financial support of development agencies such as the World Bank, China has become the world's largest manufacturer of small turbines, with roughly 170,000 small turbines installed, totaling 42 MW of capacity. Due to Inner Mongolia's industrialization, its energy demand has increased substantially as well.

Domestic Energy Shortage

Due to skyrocketing demand of energy exceeding supply, China's overall energy shortage reached 44.72 million tons of standard coal equivalent (SCE) in 2007, while Inner Mongolia's energy shortage reached 1.2 million tons of SCE in 2006. Coupling this concern of energy shortages inhibiting economic growth with increased pressure to reduce carbon emissions after signing the Kyoto Protocal, China has enacted an ambitious renewable energy agenda.

To achieve its goal of satisfying 10% of its energy needs from renewables, including wind power, by 2020, thirty 100MW wind farms and three 1 GW wind farms planned in Jiangsu, Hebei, and Inner Mongolia. By the end of 2008, China's accumulative installed capacity has reached 13.24 GW, the new installed capacity was 7.33 GW during the year. Just this week on May 4th, the Chinese government tripled its original target for 2020 from 30GW to 100GW, as it has already exceeded its 2010 target of

12GW. While China is the world's fastest growing wind energy nation, Inner Mongolia is the fastest growing market in China (GWEC, 2008).

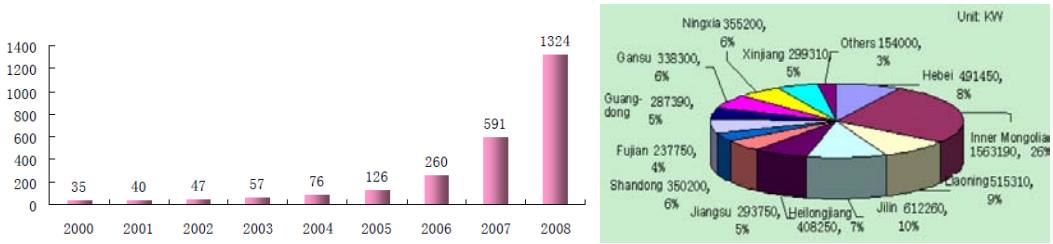


Figure: China's accumulative installed capacity nationally [10MW[and regionally [kW] (RIC, 2008)

Global Demand for Wind Turbines

Global demand for electricity is forecasted to double in the next 20 years. The wind industry is one the world's fastest growing energy sectors, as it is currently the renewable energy that is most cost effective and has mature technology after hydro power. From the figures below, we can see that not only has there been a hockey stick-like increase in wind power adoption but that there exists potential for future growth due to increasing energy demand.

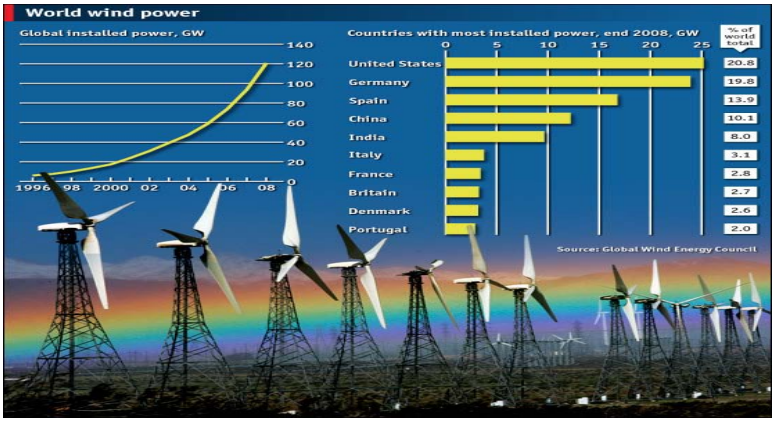
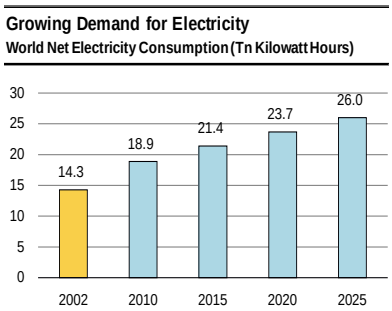


Figure: Global Installed Capacity (Economist, 2009)



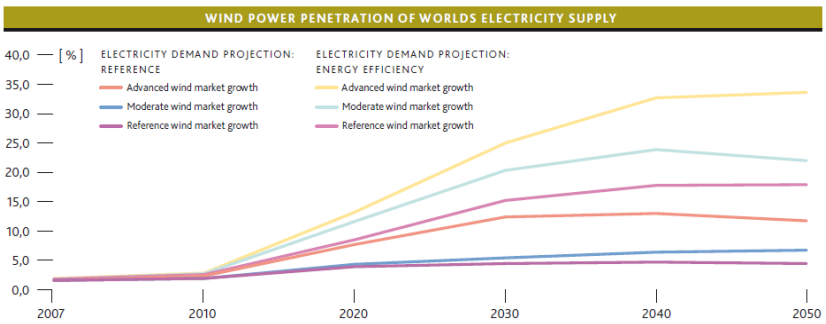


Figure: Wind Power Penetration Figure (IEO, 2005)

ii. Wind Cluster Context for Strategy and Rivalry

The evolution of the wind turbine manufacturing cluster in Inner Mongolia and China is closely tied to the policy environment for wind energy. There are three historically distinct phases of wind energy policy development in China (Lema and Ruby, 2007). The *initial demonstration period* (1986–1993) involved building small-scale demonstration wind farms with grants and zero-interest loans. Support from the government was mainly in terms of financial backing. In the *incremental phase/industrialization period* (1994–1999), the wind power industry developed slowly due to its high cost relative to coal and inconsistent policies from the two wind-energy related authorities (State Development and Planning Commission and State Economic and Trade Commission).

During the recent *coordinated phase/scaling-up domestic production period* (2000–2008), policy making was consolidated into a single regulatory entity - the National Development and Reform Commission (NDRC) while execution was decentralized by separating the state power generation (developers) and transmission (grid companies) were separated into the "big five" developers (Huaneng, Huadian, Datang, Guodian, China Power Investment Group) and two grid companies (State Grid Corporation of China, China Southern Power Grid Corporation).

The NDRC's recent policy initiatives not only caused numerous companies abroad to set up manufacturing bases in China, but more importantly initiated local firms in related industries such as heavy equipment, construction, aeronautics, locomotive motors and ship building, to venture into wind power equipment (turbines and components) manufacturing. The removal of high import tax of wind turbine components was critical because domestic enterprises without wind turbine R&D capacity could not afford the cost of importing wind turbine components[i].

Table: Comparison of Incremental and Coordinated Phases of Wind Energy Policy

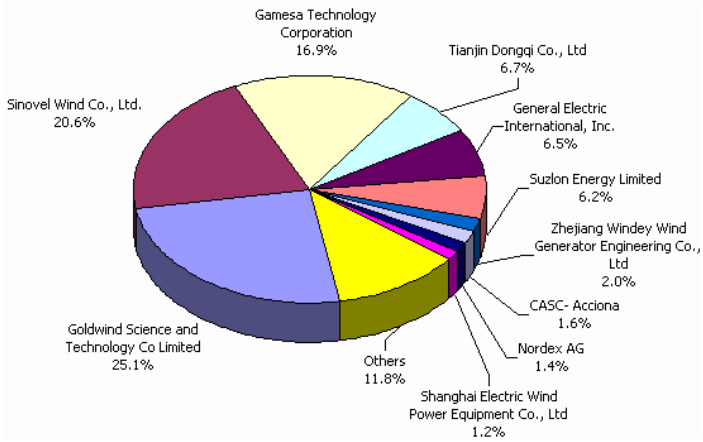
Incremental Phase (1994-1999)	Coordinated Phase (2000-2006)
Bureaucratic organization and reform	
- Competing government agencies - One integrated power company: China State	- One energy bureau with one Director in charge of renewable energy

Power Corporation - Weak state-industry communication	- Two power grid companies and five power generation companies (developers) - Institutionalized state-industry interactions
Regulations	
- Weak power purchase agreement - No demands to developers to include renewable in their portfolio - Average import duty	- Power purchase agreement by law - Renewable portfolio standard obliges developers with10% renewable by 2010 - Increased tariffs on imported turbines favor local manufacturing and assembly - Mandatory market share and strategic goals
Economic policies and incentives	
- Value added tax: 17% - Corporate tax for wind: 33% - Small incentives for developers and manufacturers - Weak resource assessment funding	- Value added tax: 8% - Corporate tax for wind: 15% - Large incentives for developers and manufacturers through the concession projects - National and multilateral funding of wind power resources through grants and subsidies

Domestic Competitive Landscape

In spite of all the power generation companies in China being state-owned, a variety of ownership can be observed in the 67 wind turbine manufacturers present in China: 27 state-owned or controlled enterprises, 23 private domestic companies, 8 are joint ventures and 9 wholly foreign-owned subsidiaries. The government has been encouraging foreign investment since many indigenous companies are still reliant on foreign firms for core technologies through licensing and joint development. As of January 2009, there are five large and eight small wind turbine manufacturers in Inner Mongolia that includes China's two largest (Goldwind, Sinovel) and the world's leading manufacturer (Vestas) being the key anchor tenants, such as Avalon (Canada) and RepowerNorth.

China has been the world's largest manufacturer of small wind turbines. Yet, it was initially dominated by foreign giants as they received low-interest loans from their home governments. However, Chinese manufacturers, such as Goldwind, Sinovel and Dongfang Steam Turbine, have gradually mastered the technology, and are swiftly gaining market share (see figures below).



Source: China Power Plant Market Report (April 7, 2009) by Frost and Sullivan

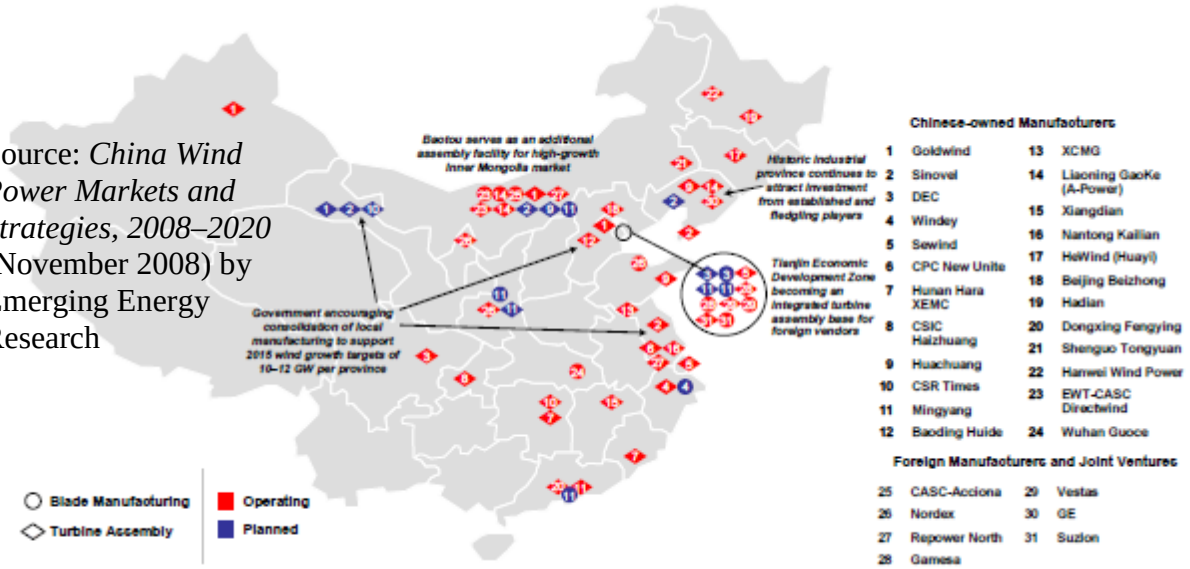
Figure: Market Share of Companies in China by Revenues 2008

Province	Facts
Tianjin	- Integrated turbine assembly base for foreign vendors: Gamesa, Vestas, Suzlon. - Port city
Jiangsu	- CASC-Acciona turbine, China High Speed gearbox, Sinoma, - Established manufacturing center for other industries - Adjacent to China's largest offshore wind farm in Shanghai
Hebei	- Specializes in blade manufacturing,as it hosts China's Blade R&D Center - China's largest coal and steel manufacturing production base
Zhejiang	- Windey/Hewind turbine, Hangzhou gearbox, Tianma bearing
Sichuan	- Dongfang turbine, China Erzhong gearbox, Dongfeng generator, Deyang casting
Liaoning	- Turbines: GE turbine manufacturing facilities (Shenyang, Dalian), China Creative Wind Energy - Shenyang University Research Institute
Guangdong	- Established manufacturing center for other industries - Port city - Also has well-developed rural wind electrification programs.
Shaanxi	- Turbine: Xian-Nordex (JV initiated by government), Sino-steel Xian Machinery - Hosts an R&D center
Xinjiang	- Goldwind's headquarters - Related industries: LM Fiberglass (Blade)

The proliferation of wind turbine manufacturers has occurred closely to where the wind bases are to be built to reduce transportation costs due to the weight and size of turbines While Tianjin has been the integrated turbine assembly base for foreign vendors, Baotou in Inner Mongolia serves as the next

largest assembly cluster due to 40.7% of future wind farms are to be based in Inner Mongolia Due to the diverse range of topography that Inner Mongolia wind cluster has, its wind turbine manufacturing cluster has the competitive advantage of producing utility-scale onshore wind turbines to wind farms of different climates.

Source: *China Wind Power Markets and Strategies, 2008–2020* (November 2008) by Emerging Energy Research



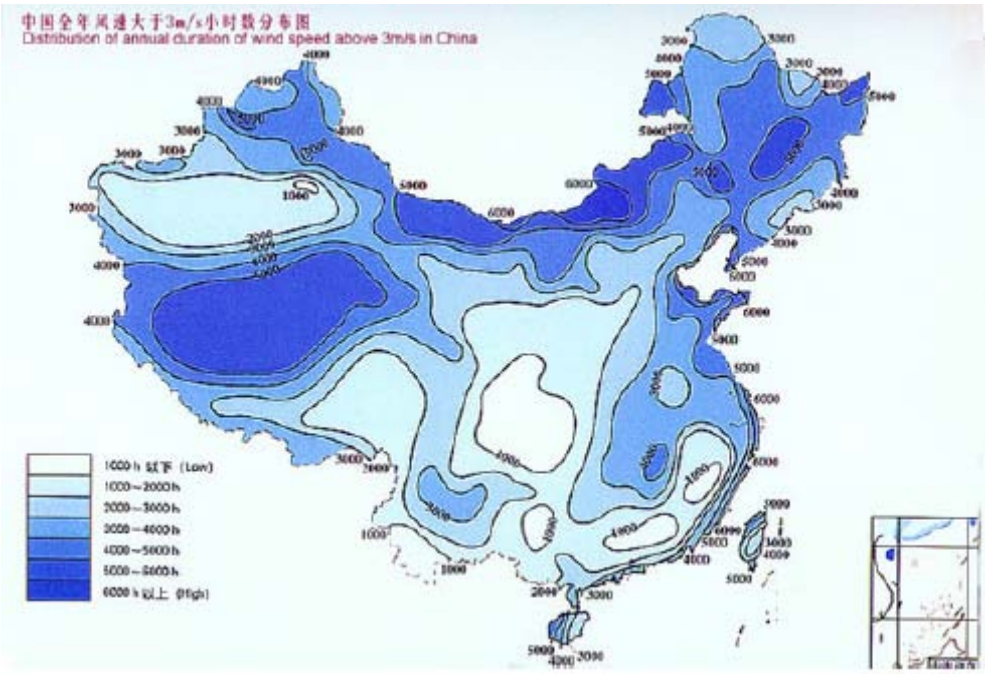
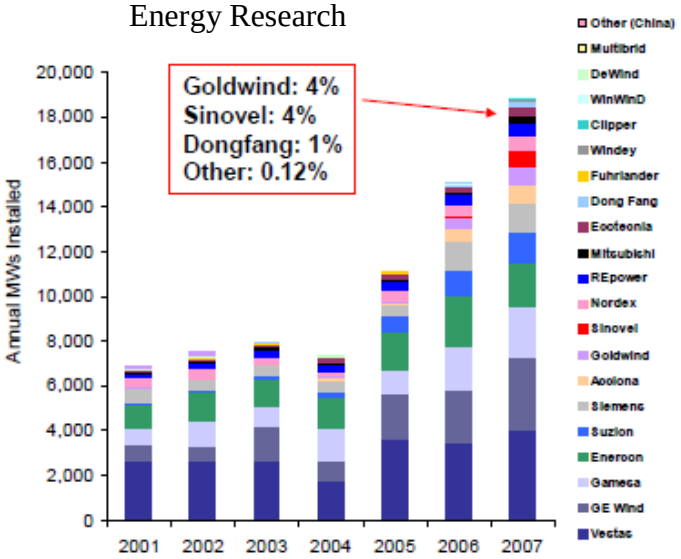


Figure: Geographic Spread of Wind Turbine Manufacturers in China vs. Wind Resource Potential

Global Competitive Landscape

Source: Emerging Energy Research



The global wind turbine manufacturing industry is dominated by established industry stalwarts - Vestas (Denmark), General Electric Wind (US), Gamesa (Spain), Enercon (Germany), Siemens (Germany) and Acciona (Spain). Nonetheless, leading Chinese players -- Goldwind, Sinovel and Dongfang, are emerging in the league table due to China's booming wind turbine manufacturing industry and have captured 9% of global market share in 2007. With China's short five-year history of manufacturing large wind turbines, China is still a nascent large wind turbine exporter but is rapidly increasing its export sales. Goldwind has customers in more than 6 countries with the first being Cuba; Jiangsu Lianyungang Zhongfu Lianzhong Composites Group Co., Ltd has exported 11 sets of wind turbine for 1.5-megawatt power generators to Argentina. A major concern is that most Chinese firms have been competing on price; for instance, Chinese-made turbines are 60-65% cheaper than American ones.

Wind developers are price sensitive, however security is a major concern, and they are willing to pay more to ensure that no accident occurs. Anecdotally, domestic wind turbines have also been said to require more time and money to maintain. Therefore, Chinese companies ought to refigure their strategy of focusing on quality, productivity and innovation, especially since many still rely on licensing and joint development for wind turbine technology.

China's major competitor nations for large wind turbine manufacturing are the countries from which the industry stalwarts originate from -- Denmark (Vestas), United States (General Electric Wind), Spain (Gamesa, Acciona), Germany (Siemens, Enercon), and India (Suzlon). Besides India, the key

advantage that China has above the others is its labor costs but is in both its innovative capacity and technical expertise. Even Suzlon in India has built a relatively stronger global supply chain through vertical integration and strategic alliances that Chinese wind turbine manufacturers with global ambitions are starting to emulate, such as Goldwind establishing an R&D center in Germany. While Chinese manufacturers could learn from collaborating with these established players, they are also differentiating themselves by targeting less developed nations that share similar capital constraints, energy needs or labor cost advantages but are less mature wind energy markets. Goldwind and Sinovel have pursued different strategies: the first has taken the turnkey approach of handling every step in the wind project from assembly to maintainence with an ISO 9001 certification while Sinovel focuses on solely wind turbine supply and has its own intellectual property.

iv. Wind Cluster Related and Supporting Industries

The cluster map below summarizes the stakeholders in the wind power food chain besides the government..

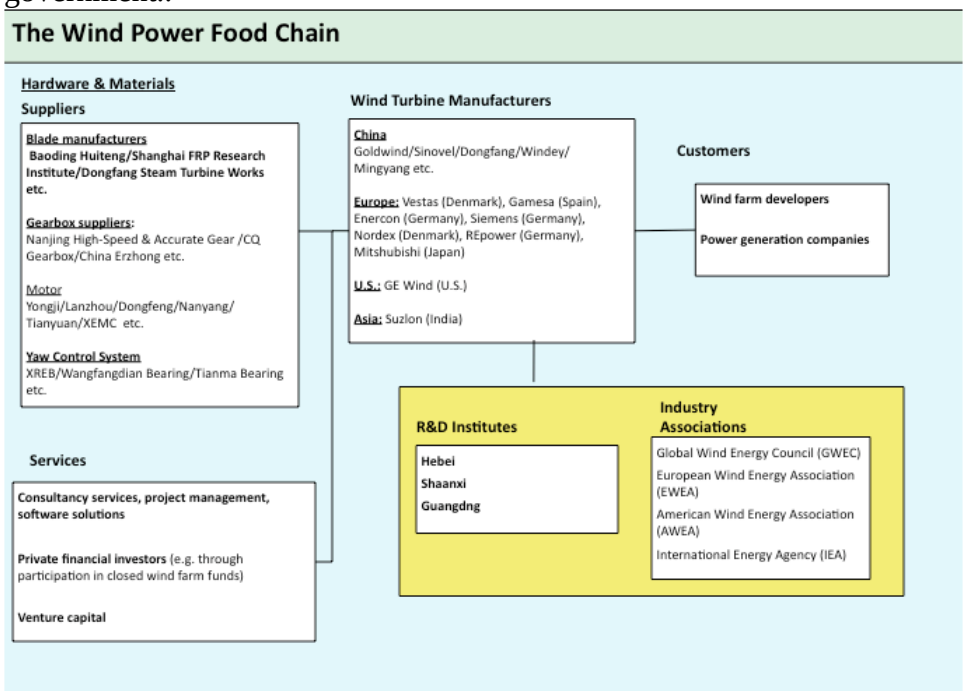


Figure: Cluster Map of China's Wind Turbine Manufacturing Industry

The major components in a wind turbine include nacelle & controls, rotor, tower, gearbox, drive train, generator, and grid infrastructure (as seen in the figure below).

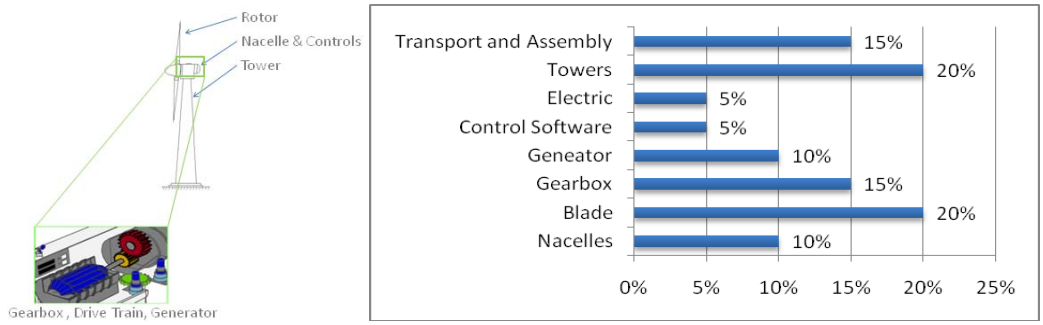


Figure: Wind Turbine Components

Domestic suppliers for the various components mentioned are critical for wind turbine manufacturing efficiency. The local supply of large components, such as blades, cannot be replaced by foreign supplies, especially when Inner Mongolia needs to build larger scale wind turbines. The size of the blade for a typical 1.5MW wind turbine is enormous (~40m) and heavy (~20 tons). [3] The transportation of such massive components is difficult. Thus, the proximity and productivity of local supplier is critical for turbine manufacturer's success.

Although not all the component manufacturers are in Inner Mongolia as seen from the table below, it can access these components through the eight provinces bordering it.

Component	Blade	Nacelle	Generator	Gearbox	Electrical Control	Tower	System Integrator
No. of Firms	3	1	3	5	0	3	15

On a national level, there is a dearth of companies manufacturing electric controls and monitoring systems, as well as occasional supply bottlenecks for blades and gearboxes due to the explosive demand. These hiccups in the supply chain can be detrimental as they cause prices to increase substantially. Another concern among customers has been the quality and reliability of these components.

The Inner Mongolia and China's wind turbine manufacturing cluster is relatively young, so its institutions for collaboration can play a more active role in fostering industry collaboration The Chinese Renewable Energy Industries (CREIA), the Chinese Wind Energy Association (CWEA), and Global

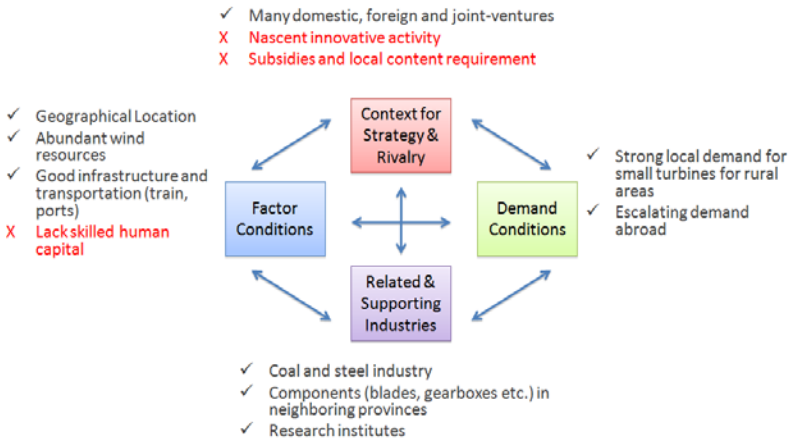
[3] China Market Report, Nov 2008, "Analysis of China Wind Power Equipment – Blade"

Wind Energy Council (GWEC) have contributed to the development of the Inner Mongolia's wind turbine supply chain through providing publicly available information on the provincial and national clusters as well as networking opportunities through bi-annual conferences. CREIA is an industrial association independent of the government and has its over 100 corporate members come from all sectors of renewable energy in China which offers it considerable bargaining power. CWEA is a non-profit that serves as a bridge between academia and industry. GWEC acts as a window of China's wind industry to the world and vice versa since it represents over 1,500 companies and institutions, which account for 99% of world's installed wind power. R&D institutes too have been mushrooming across the country, some of which are adjacent to the Inner Mongolian wind turbine cluster such as the blade center in Hebei.

Another key segment is industries of end customers are the 80 wind farms, grid companies (State Grid, China Southern Grid, Inner Mongolia Grid), and power generation companies (China Huaneng, China Datang, China Huadian, China Guodian). These state-owned enterprises have moved from a tendor/government approved price to a bidding concession project system in hope to create a more competitive project allocation process. However the unintended consequences of domestic firms bidding with unrealistically low feed-in tarifd have been discouraging to foreign investors interested in participating.

Other peripheral services that are important to the wind turbine manufacturing industry include financial services for local residents, entrepreneurs, companies and utility-scale wind farms (eg. China Power Investment). Support services such as IT/software solutions, consulting services, project management firm are also present in Inner Mongolia. One area that is missing though is maintanence/after-sale services in case any problems with the turbines arise.

iv. Diamond Analysis for Inner Mongolia Wind Turbine Manufacturing Cluster



IV. Challenges and Recommendations

Challenges	Recommendations		
	Central (C) and Provincial (P) Governments	**Private Sector**	**Universities (U) /Institutions for Collaborations (IFCs)**
Factor Conditions			
-Lack managerial and innovative engineering talent	-C&P: Instead of subsidizing manufacturing costs, match companies' investments in training. -P: Increase quality of life in Inner Mongolia through better amenities, such as healthcare and pension..	-Design shadowing opportunities, summer/winter internships as well as full-time professional programs to promote careers in the wind industry among students, experienced professionals and herdsmen. -Offer competitive packages to attract diaspora and talents from other provinces (such as Tsinghua and Peking University in Beijing). Could create a rotational program across functions or facilities across the country or globe. Canuse position titles and responsibilities as incentives.	-U: Offer full/part-time wind turbine and renewable energy-related courses; establish academic-industry collaboration on research projects and internships. -IFCs: Engage local community with wind industry-related events, such as seminars/conferences, facility tours and wind farm visits.

Demand Conditions -Strong domestic demand in the next three years but potential slowdown in demand abroad due to economic downturn, cheaper oil and rise in protectionism	-C&P: Maintain clear and consistent policy direction to reduce regulatory risk for investors and manufacturers. Pursue ownership neutral measures in hope that others will not be protectionist either. -C: Improve grid compatibility for wind power to ensure wind energy demand.	-Diversify turbine portfolio to include small wind turbines for residential and retail use, especially since Inner Mongolia has historical experiences with small wind turbines. -Explore markets in other developing nations with wind potential but no existing wind turbine manufacturing sector, such as Philippines and Mongolia.	-IFCs: The China Wind Energy Association could use its membership in the Global Wind Energy Council to inform its members about global opportunities and trends.
Related and Supporting Industries -Short of the technology to design and produce large wind turbines and their key components -Lack wind resource assessment skills and wind turbine performance test technologies and equipments -Most of the accessible technologies through licensing are outdated, and foreign companies are more and more concerned about setting up joint ventures and growing potential competition [4] -Distinct quality and	-C&P: Invest in R&D and establish incubators, focus on quality rather than quantitity -C&P: facilitate direct cooperation with foreign turbine designers and R&D centers independent of the foreign wind turbine manufacturers to build up own capacities and own the intellectual property rights -C&P: Strengthen intellectual property protection and enforcement to encourage technology transfer of both hardware (equipment)	- Explore technologies of lightweight composite materials and composite manufacturing, lightweight drive train, modular pole direct drive generators, hybrid space frame towers, and large gearbox and bearing designs that are tolerant of slower speeds and large scale. Lightweight components are also in high demand, as they could reduce logistics costs. -Directly seek out foreign turbine designers and R&D centers -Build more robust supply chains by establishing linkages within and across provincial clusters. -Improve after-services/maintenance (location proximity	-IFCs: Foster stronger industry collaboration and linkage between the industry and academia

[4] ABS Energy Research: 2008.

reliability problems, which increase the operation risks. -Lack after-sales services that would provide continuous stream of profits	and software (skills and managerial expertise) in industry collaboration. -C&P: Address supply bottlenecks by encouraging new entrants as well as existing manufacturers to increase capacity.	advantage over foreign competitors)	
Context for Strategy and Rivalry -Domestic firms use low price as competitive advantage. -Despite small "pockets" of opportunity for private investors, it is clear that in wind energy, as in other renewable energy technologies, the Chinese government continues to be the driving force behind development funding.	-C&P: Create a fair certification process to ensure quality of locally-made components and to help boost the image of Chinese-made turbines.-C&P: Encourage private investments (domestic and foreign) into this sector. -C&P: Continue FDI-friendly policies.	-Domestic players need to shift their strategies from imitation and low-cost to innovation and high-quality by investing in R&D and quality control. -	-IFCs: Collaborate with other wind turbine manufacturing associations worldwide to devise a quality standard, such as the L.E.E.D standard for green buildings or ISO9001, which is recognized globally. -U: Include strategy courses.

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