



Scaling Wind and Solar Power in China: Building the Grid to Meet Targets

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Overview

China's 12th Five Year Plan sets out ambitious goals for de-carbonizing China's electricity supply, emphasizing a concerted effort to expand all dimensions of renewable and low-carbon electricity sources. In our October 2011 report *Hydropower in China: Opportunities and Risks*¹ we examined China's hydropower ambitions. In this report we examine the wind power and solar power sectors.

Based on our conservative analyses, achievement of China's renewable energy goals or targets (formal and informal) through 2015 and 2020 are dependent on an aggressive and successful expansion of the electricity transmission grid. In particular, the wind power sector is facing adverse forces that are likely to slow near-term growth from now into the 2014 period. With 20 GW of new installed capacity added in 2011 and only 16 GW incrementally connected to the grid in 2011, the pace of additions to installed capacity has exceeded the rate at which the wind power capacity can be grid connected. Currently we estimate that by the end of 2012 there will be an approximate 5 GW overhang of wind power installations awaiting connection to the grid (over and above what we estimate to be an amount of installed capacity awaiting interconnection at any point in time equal to approximately 75% of total new installations built in any year, totaling 15 GW in 2011), and that an overhang may continue into 2014.

Recent central government action to reign in poorly coordinated growth was undertaken, we believe, to regain firm management of the sector and coordinate growth with grid expansion programs. As a result we believe these actions may cause annual new wind power installations to slow to the 14 GW pace during the next three years. Slowing the pace of new wind turbine installations will allow this overhang to be cleared as queued installed capacity is connected to the grid. Thereafter, we forecast 16 GW to be installed in 2015 and between 18 GW – 20 GW per year in the 2016-2020 period, a pace in line with a trajectory consistent with the central government's 2015 and 2020 targets. To return to this faster pace, China must accomplish a considerable electricity transmission grid expansion program.

With regard to solar, China now informally aims for 30–50 GW of solar PV by 2020. We estimate China will install 30 GW of grid-connected solar power by 2020, compared with less than 1 GW now. To date, China's modest adoption of solar PV compared with wind power stems from a combination of relatively high costs, the geographic remoteness

¹ Access this report, "Hydropower in China – Opportunities and Risks," at http://www.dbcca.com/dbcca/EN/ media/Hydropower_in_China-Opportunities_and-Risks.pdf



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of resource-rich regions, and a lack of transmission from those areas. With the recent introduction of a feed-in tariff, rooftop and grid-scale solar now have clearer policy support than traditional capital cost subsidies offered, although we see distributed rooftop as being slow to grow.

Our wind and solar power production and installed capacity forecasts, set forth in our “DBCCA Forecast Summary” below, are contingent on the successful execution of a substantial electricity transmission grid expansion program in China.

Our key findings include:

- **Substantial Opportunity for Longer-Term Wind Power Development, Near-term Constraints** – China's 12th Five-Year Plan (FYP) calls for the country to install 70 GW of wind power generating capacity by 2015 (resulting in 115 GW of cumulative installed capacity by 2015). Comments from some Chinese officials have even indicated a target for annual wind power installations as high as 15-20 GW per year. While we can see the 70 GW target being achieved, due to grid constraints in the 2-3 years, we see an annual installation rate in the 14 GW range until 2015. This base case projection for annual wind installations between 2012-2015 is on the conservative side of published forecasts and is contingent upon expanded electricity grid capacity becoming available sometime in 2014. Further, resumption of an annual pace of installation in line with the government's notional 15 – 20 GW range in 2015 and beyond is contingent upon successful and timely expansion of electricity transmission grid capacity.
- **Current Wind Power Market Indigestion** – Putting aside broader volatility in financial markets, the wind power OEM (original equipment manufacturer) and developer market has experienced adverse trading conditions in the face of this expected slowdown. This reflects an accumulated overhang of installed yet unconnected idle wind turbines. We estimate by the end of 2012 this overhang could approximate 5 GW (over and above what we estimate to be a normal amount of installed capacity awaiting interconnection at any point in time equal to approximately 75% of total new installations built in any year, representing 15 GW in 2011). With a shift to a centralized permitting process, we believe the excess overhang can be absorbed into the grid so long as expanded transmission capacity is available. Recent changes to the permitting process have brought permitting from provincial to central government control for projects less than 50 MW in size, allowing for better planning and closer harmonization of expansion plans for renewables and the necessary transmission grid. On the other hand, *if the industry continues to build wind turbines at a rate materially faster than the rate at which the transmission grid can be expanded or turbines can be connected to the grid – for whatever reason, be it policy or economic – then we see the risk of an accumulated overhang of wind turbines possibly reaching 29 GW by 2020, causing ongoing uncertainty.*
- Looking out to 2020, China's National Development and Reform Commission (NDRC) and State Grid of China target 150 GW of *grid-connected* cumulative installed wind power generating capacity. Provided that China completes scheduled transmission expansions (with the earliest completion dates in late 2013), we expect China to meet and exceed this target. Contingent upon grid upgrades allowing the pace of new build construction and interconnection to increase after 2015, we expect that by 2020 China will have 216 GW of cumulative installed wind power capacity, with 201 GW being grid-connected. For comparison, at year end 2011 China had 65 GW of cumulative installed wind capacity, with 47 GW of this being connected to the electricity grid.
- In the years beyond 2020, we expect China to continue aggressive development of wind resources that we believe may result in approximately 800 - 1,000 GW of capacity in economically feasible onshore and offshore regions by 2050. We believe solar power resources could expand to the 85-100 GW level by 2035. Such growth could result in incremental cumulative capital investment of RMB 5,090 billion (USD \$808 billion in the 2011-



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2050 period for wind power systems and RMB 675 billion (USD \$107 billion) for solar power systems over the 2011-2035 period.

- **Sunny Long-Term Outlook for Solar PV as well** – China now informally aims for 30–50 GW of solar PV by 2020. We estimate China will install 30 GW of grid-connected solar power by 2020, compared with less than 1 GW now. To date, China's modest adoption of solar PV compared with wind power stems from a combination of relatively high costs, the geographic remoteness of resource-rich regions, and a lack of transmission from those areas. With the recent introduction of a feed-in tariff, rooftop and grid-scale solar now have clearer policy support than traditional capital cost subsidies offered, although we see distributed rooftop as being slow to grow.
- **Clear Long-Term Policy Support for Wind and Solar with Central Planning Control** – China has enacted and is improving policies to accommodate the rapid development of both wind and solar power. Clear targets for development exist. Initial capital subsidy programs to defray high initial capex have been replaced with more effective feed-in tariff models (FiTs) incentivizing the generation of wind and solar electricity. Lastly, transmission grid constraints are being actively addressed with significant capacity expansion expected to begin coming on-line in the 2014 period.
- **In August 2011 there was a material change to the planning process**, when Chinese central authorities took back control of the permitting of new wind projects in order to address the problems of grid congestion and poorly coordinated provincial policies for wind power projects less than 50 MW in size.
- **Electricity Grid Investment** – Much policy and investment focus is accorded to wind power and solar power in China. However, most of these resources are not close to the load centers. While some roof-top solar power and low-speed wind power development can be undertaken locally, thus avoiding transmission bottlenecks, transmission capacity will need to expand dramatically to accommodate the power needed for the economy and to bring the renewable power from the resource-rich regions into the load centers. Without substantial transmission grid capacity expansion, we believe China may have difficulty achieving 2020 goals and targets. Such high-voltage transmission grid expansion could represent a cumulative investment by 2020 of at least RMB 500 billion (USD \$80 billion) and could reach RMB 675 billion (USD \$107 billion). Additional investment is likely beyond 2020 to support long-term wind and solar development policies through 2050.
- **Wind Power Development Focus Shifts to Low Wind Speed Regions** – Since it will take several years to build transmission capacity to take full advantage of China's strong northern wind resources, we expect China to steer developers – through policy actions – toward lower wind speed regions closer to the load centers as a means to continue wind power growth while avoiding transmission constraints. Such prudent action would help alleviate expected ~50 GW and ~70 GW electricity shortfalls during peak hours in nearby load center cities in 2012 and 2013, respectively.
- **Expect Offshore Wind Development Activity** – China's practicably exploitable coastal and offshore wind resources are substantial, estimated to be 100–200 GW. Although challenging and relatively expensive compared to onshore wind opportunities, we expect technological development work to accelerate in this area and bring down costs. The offshore wind resources are closer to the load centers, have very attractive energy characteristics (e.g. higher capacity factors) and development of offshore expertise enhances China's ability to export offshore wind turbines.
- **Natural Gas Turbines Complement Renewables** – Since renewable electricity sources are inherently variable and in some cases (e.g. wind) have peak output periods not well aligned with electricity demand, we see an opportunity for gas turbines to be deployed to provide necessary grid-stabilizing characteristics. These turbines could be fueled from indigenous gas supplies and imported gas pipelines adjacent to major wind development areas. Such use would require China to amend stated rules restricting natural gas use for electricity generation.



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Broadly speaking, if China could develop and source more natural gas, we believe the most effective way to decarbonize the country's electricity systems in the near-term is to switch significant portions of coal-fired generation to natural gas. We will explore this topic in future reports.

DBCCA Forecast Summary

In formulating our analyses to model China's energy system we made several key assumptions. Since energy use is directly linked to macroeconomic activity, one key assumption was GDP growth. We forecast moderating macroeconomic growth with the economy expanding at 7% rates by 2020, a level consistent with China's repeated comments² on stable long-term growth targets. We then examined historical improvements in energy efficiency and energy intensity. We forecast energy intensity improving at 5+% rates initially, a level consistent with historical trends. In the 2015-2020 period, the rate of improvement tapers off to an approximate 3.5% per year, consistent with the 12th FYP. A detailed discussion of our forecast is contained in Section IV (DBCCA's Wind and Solar Power Forecast).

We set forth below our estimates of the composition of both China's electricity fleet and electricity production for the years 2010, 2015 and 2020.

Table 1: DBCCA Wind and Solar PV Base Case

	Electricity Production (TWh)						Cumulative Installed Generation Capacity (GW)					
	2010		2015		2020		2010		2015		2020	
Wind – Installed Capacity	NM	NM	NM	NM	NM	NM	45	NM	123	NM	216	NM
Wind – Grid Connected ⁽¹⁾	43	1%	212	3%	431	5%	31	3%	111	8%	201	11%
Solar	0	0%	16	0.3%	37	0.4%	0.2	0%	15	1%	30	2%
Hydro	721	17%	935	15%	1,135	13%	213	22%	290	20%	341	18%
Other RE	38	1%	48	1%	63	1%	5.5	1%	13	1%	17	1%
Sub-Total RE⁽¹⁾	803	19%	1,211	19%	1,667	20%	250	26%	429	29%	589	31%
All Fuels Total	4,207	100%	6,421	100%	8,452	100%	962	100%	1,467	100%	1,904	100%

Source: National Bureau of Statistics of China and DBCCA analysis, 2011.

Note 1: Includes only Grid-Connected wind power. Does not include Installed Capacity amounts that are not Grid-Connected.

Methodology: In our above forecast we have estimated the annual installation rate to achieve what appear to be China's current 2020 ambitions for renewables, albeit based on unofficial commentary from government officials rather than from formally promulgated goals. Such a view suggests that China plans to install, an incremental 58 GW in the 2012-2015 period and an incremental 93 GW in the 2016-2020 period. This is also a pace we believe consistent with the ability of the grid to connect new wind turbine capacity, yet is contingent upon expanded electricity transmission grid capacity becoming available in 2014 and thereafter. Our base case forecast, assuming incremental transmission capacity becomes available in 2014, absorbs the current awkward surplus or "overhang" of unconnected

² National Development and Reform Commission 12th Five Year Plan and various remarks by Wen Jiabao on sustainable, balanced, coordinated growth.



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turbines and does not result in material future “overhang” of unconnected and idle turbines (again, given that we estimate a target level of turbines waiting connection at any point in time to be equal to 75% of the amount of newly installed turbines in the year). In our work, we believe focusing on grid-connected capacity is critical as those are the resources that produce usable low-carbon electricity. While there are other more aggressive “build” forecasts in the public sphere we consider, we believe overly aggressive build patterns could lead to a very awkward overhang of up to 29 GW of “built, yet unconnected” wind power capacity by 2020. We also acknowledge there is the chance that such a situation could develop if China’s government were to believe that it was in the country’s broader economic or social interest to build capacity more rapidly. Further, we believe the overhang situation could be exacerbated if China fails to expand the transmission grid on a timely basis. Such failure could result in slower growth in 2014 and beyond.

Our forecast for solar power development is consistent with stated government objectives for 30 GW grid-connected by 2020. We think this is a prudent estimate given the centralization of control over large-scale solar development exerted by the NDRC (similar to wind power oversight) and given the critical need for electricity grid transmission capacity expansion in order to take full advantage of solar electricity production.

Benchmarking Our View

At this point it should be noted that there are a range of forecasts estimating China’s annual incremental growth of wind power installed capacity. An analysis of available research shows a range of annual 2015 annual installation estimates of 12.4 GW on the low end, to 21.9 GW on the high end³ – this compares to the DBCCA forecast of 16 GW. Several research groups also provide 2020 wind forecasts, ranging from 21.9 to 22.9 GW – the DBCCA forecast of 18 GW is shown to be a conservative forecast. In terms of grid connected wind capacity forecasts, only certain research groups perform this type of analysis, and our 2011-2015 estimates of grid-connected capacity are between 1 and 3 GW below the average of the selected pool of published estimates⁴.

In Table 2 below we compare our view on annual incremental growth for Installed Wind Capacity in China over the 2011 to 2020 period.

Table 2: Forecasts for Annual Wind Power Incremental Installed Capacity Additions

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
BNEF	19.6	20.1	18.8	19.0	18.6					
Garrad Hassan	15.0	15.0	15.0	15.0	15.0					
Goldman Sachs	17.0	16.7	16.5	16.1	15.5					
Jefferies	14.0	15.0	16.0	17.5	18.5					
Nomura	11.5	11.6	9.0	9.0	12.4	17.9	19.2	20.3	21.6	22.9
Yuanta Securities	20.8	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9
DBCCA	20.0	14.0	14.0	14.0	16.0	20.0	19.0	18.0	18.0	18.0

Source: Bloomberg New Energy Finance, Garrad Hassan, Goldman Sachs, Jefferies, Nomura, Yuanta Securities and DBCCA analysis, 2011.

Investment Opportunities and Implications

It is quite clear that China’s effort to reduce unbridled growth in the wind power sector has created uncertainty for the wind supply chain, in particular wind turbine manufacturers. Rumors of substantial idled manufacturing capacity and

³ Sources: BNEF, Garrad Hassan, Goldman Sachs, Nomura, Yuanta Securities and DBCCA analysis, 2011

⁴ Sources: BAML, CLSA, and DBCCA analysis, 2011



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inventoried turbines are creating substantial price pressure in the wind turbine market. The industry, generally speaking, did not foresee the national government's effort to reign in unbridled and counterproductive growth. The major Chinese wind turbine makers are the most likely to weather this process while Tier 2 and Tier 3 vendors may experience consolidation on buyers' terms. Thus, until we see a material increase in unit shipments of wind turbines into the northern regions, the outlook for the hardware sector in the near-term will likely prove challenging. We believe these trading conditions could continue into 2014 unless the NDRC's renewable energy work plan holds positive surprises about grid expansion. However, with a government leadership transition this year, January 2012 announcements of possible plans to overhaul all of China's energy planning processes and in the face of physical grid constraints we do not expect major policy surprises to dramatically accelerate growth in the sector.

Low Energy Wind Development Creates Blade-related Opportunity

One positive theme, though, is the shift in wind power project development away from the high-energy grid-constrained northern regions to the lower energy eastern and southern regions. There remain significant electricity shortfall problems in the eastern and southeastern load centers, and refocusing wind turbine technology to maximize yield from lower energy wind areas is likely to be a fertile area. The turbine designs are likely to be similar, but with different blades used to power the generator. Longer, thinner blades to capture more low-speed wind will be necessary, suggesting demand for the services of both blade fabrication companies as well as materials suppliers who make the range of glass fiber, carbon fiber and epoxy resins used to fabricate blades. We believe the low-speed wind areas may also stimulate development and adoption of more rigorous wind forecasting technologies and services.

Wind and Solar Power Project Development Opportunity

The prospects for wind and solar project developers are mixed. With more wind turbines and solar panels than there is worldwide demand for and with manufacturers' inventories backed up, those OEM's are forced to compete aggressively on price when renewable power project developers seek bids. As equipment is cheaper, a well-positioned developer (e.g. one allied with the renewable power units of the major SOE's) may be able to craft projects, especially in low energy wind regions close to load centers without transmission grid constraints. Until grid connection congestion and transmission capacity expansion can be rectified, we think development of new projects in the northern regions with appealing wind resources will prove difficult. We believe the current solar panel and turbine makers' travails are to the renewable power project developers' benefit – so long as the developer is well-connected and able to gain the necessary national permits and authorizations needed to enjoy the feed-in tariffs, secure grid connection and to experience minimized curtailment.

Transmission Grid Investment Opportunities

The other less obvious yet essential opportunity necessary for the continued growth of China's renewable sector is the expansion of the transmission grid. Not only must the grid "play catch up" to alleviate current constraints, capacity must be built in advance of future renewables development since transmission construction timetables are longer in duration than wind power and solar power installation durations. We can be no clearer: achievement of China's 2015 and 2020 renewable power goals are contingent upon successful and timely expansion of electricity transmission grid capacity. We have noted in our April 2011 note on the 12th Five Year Plan that China plans to spend RMB500 billion (US\$80 billion) by 2015 on UHV related transmission grid expansion⁵. Further, Min Li of Yuanta Securities estimates that by 2020 China may invest a total of RMB675 billion (US\$107 billion) in UHV and related grid transmission capacity.

Approximately half of the cost of the transmission line (49% for AC lines and 54% for DC lines) is related to the end points of the line where significant investment in transformers, reactive power control devices, circuit breakers,

⁵ "12th Five Year Plan – Chinese Leadership Towards a Low Carbon Economy", DBCCA, April 4 2011. Access this report at http://www.dbcca.com/dbcca/EN/_media/China_12th_Five_Year_Plan.pdf



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isolation switches, surge arrestors and related subsystems is necessary. In the case of DC transmission lines, converter and rectification equipment is also necessary. The remaining portion of the cost of a transmission line (51% for AC lines, 46% for DC lines) is related to the actual transmission cable, insulators and towers to support the cable. In addition to there being potential investment opportunity in these above components, there will be a range of construction materials (concrete, steel and erection equipment) necessary to build the lines.

We expect the actual transmission lines to be property of China's grid companies (State Grid Corporation of China, China Southern Power Grid Company and Inner Mongolia Power Group) and thus investment directly in the ownership and operation of a transmission line is, in our view, not a likely opportunity. We suspect much of China's grid expansion will focus on using locally-supplied components and materials, thus tempering what some might see as opportunity for Japanese, European and American electricity transmission equipment vendors.

Natural Gas Generation to Buffer Wind and Solar Variability

To manage the challenges of intraday variability in power output from wind and solar farms and thus improve electricity grid transmission stability, we believe natural gas turbines could be deployed in high wind energy regions, with gas supplied from adjacent natural gas reserves and pipelines. The electricity generation and operational characteristics of gas turbines makes them ideal complements to wind and solar power by acting as rapid throttle response sources of both real and reactive power. Providing real power can ensure optimized loading of transmission lines and smooth power flow. Reactive power contributions of gas turbine generators are helpful in providing the electrical characteristics necessary for the stable and smooth flow of electricity from the generating sources to the load. Should China alter its 2007 natural gas use priority orders to accommodate the complementary deployment of natural gas turbines, we believe there is great opportunity for natural gas turbines to complement wind power farms as elements that can provide stabilizing power output and other necessary grid management characteristics including frequency and reactive power control.



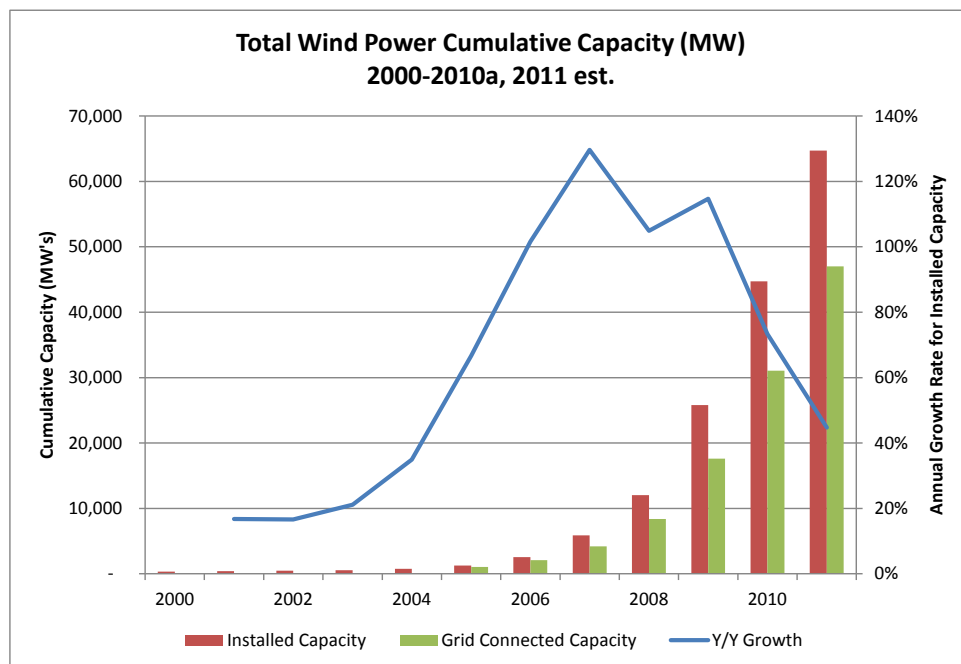
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I.I Wind Power Resources

Where is China Now?

In 2006, China embarked on the 11th Five Year Plan codifying and cultivating a trend that began in 2005 to exploit China's vast onshore and offshore wind power resources. By 2010 China overtook the US to occupy the position of being the world's largest deployer of wind power. In our view this is a monumental accomplishment as China's wind power installations have grown extremely rapidly year-on-year since 2005 in order to reach such a significant level. Figure 1 below provides a graphic illustration of this growth.

Figure 1: China's Rapid Rise to World Wind Leadership



Source: Global Wind Energy Council, China Wind Energy Association and DBCC analysis, 2011

In Figure 1 we have shown both the cumulative amount of wind power built and the amount that is connected to the grid. There is considerable confusion with regard to these statistics. We will discuss later the reasons behind why cumulative Installed Capacity is different from cumulative Grid-Connected Capacity. For the time being, "Installed Capacity" refers to wind turbines that are erected in the field and may be grid connected or awaiting connection and commissioning for operation. "Grid-Connected Capacity" refers to those wind turbines that have been certified, commissioned into operation and connected to the electricity grid.

To place the trajectory of China's general investment in wind power in perspective, in 2005, China's cumulative wind installations accounted for 2% of the then world's total installed wind power capacity. By the end of 2010, China's share of cumulative installed capacity had expanded to 23% of global installations. There has, however, been a recent decline in the growth rate of China's wind installations. For several years the industry expanded at hothouse 100%+ annual rates, a situation that may be sustainable in the software and internet arena, but in a capital intensive



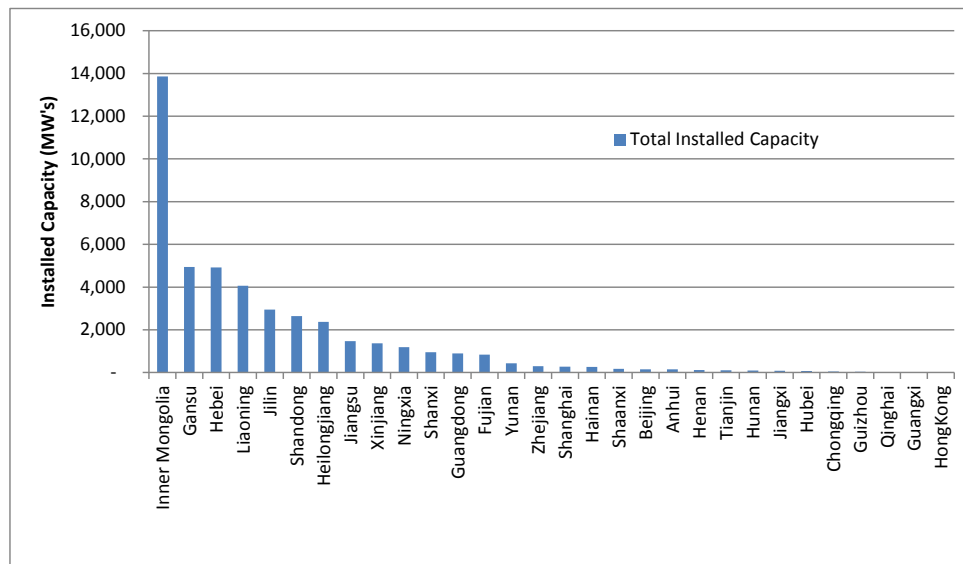
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energy sector such growth rates must be tempered as energy systems are far slower to adapt (physically and procedurally) than software and internet services. Grid congestion impairing off-take of wind power and/or difficulties in establishing grid connections (for procedural or capacity constraint reasons) resulted in a slowing of growth.

To address concerns that provincial governments were encouraging wind power development too rapidly, in August 2011 the national government removed local permitting authority for projects less than 50 MW in size – an area of the market where provinces previously had discretion to authorize new projects. With this material change, wind farms now require national government approval in order to enjoy approved wind tariffs and for grid connection authorization. This action was taken to restore a sense of manageable growth to a sector where unbridled growth was creating under-utilized capacity.

Development of land-based wind resources has been the initial focus of activity in China, although offshore resources are abundant. The reason for initial development occurring in the onshore areas is simple: onshore is less technically challenging and less expensive than offshore development which can be 3x-4x more expensive. Examining current installed capacity, the lion's share is found in Inner Mongolia. The next two provinces with the largest installed base are each less than 1/3 of Inner Mongolia's Installed Capacity as depicted in Figure 2.

Figure 2: Total Cumulative Installed Wind Power Capacity by Province in 2010



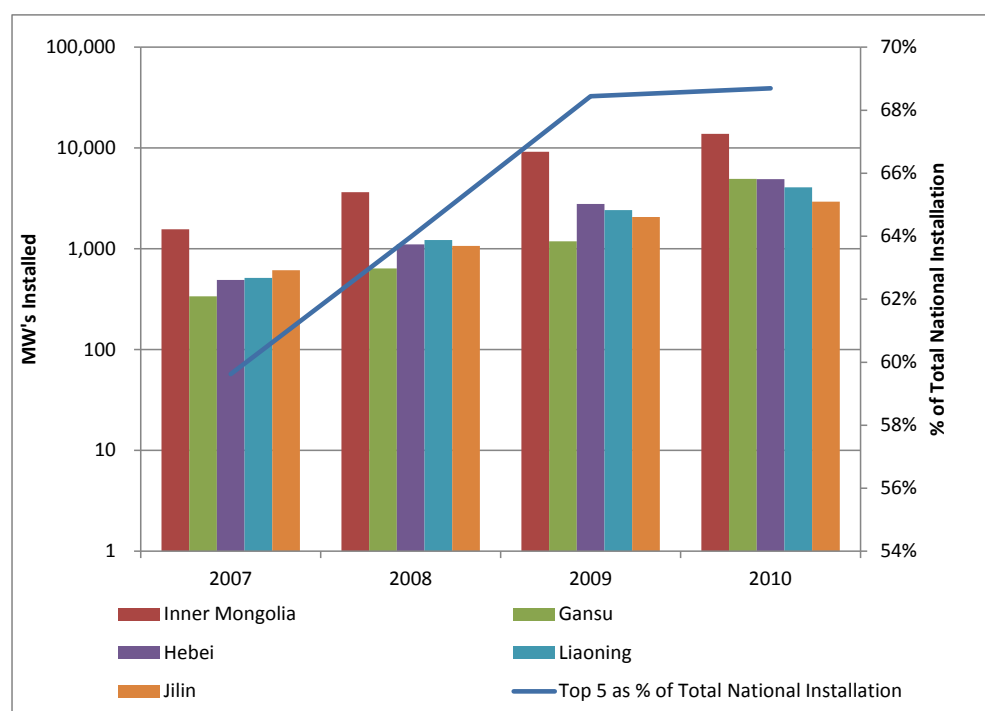
Source: "China Wind Power Outlook 2010" China Wind Energy Association and DBCCA analysis, 2011.

The "Top 5" wind provinces have demonstrated consistent leadership in new installations over the past several years increasing their collective share of China's installed base from the approximate 60% level in 2007 to 68+% in 2010 as depicted in Figure 3 below.



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Figure 3: The Big Get Bigger – The Top 5 Provinces



Source: "China Wind Power Outlook 2010" China Wind Energy Association and DBCCA analysis, 2011.

While these "Top 5" provinces are well ahead of others, we do believe that developmental attention will shift from these areas to lower wind speed areas in the southern and southeastern regions closer to load centers while China undertakes long distance and regional transmission grid expansion.

Development Mostly Driven by State-Owned Enterprises

In China the electricity generation and transmission areas are dominated by the state owned enterprises (SOE's). Wind power development follows this trend with the renewable power units of the central and provincial SOE's responsible for the lion's share of wind power development to date. Table 3 below lists the major developers, their status and market share.

Table 3: Top 15 Wind Project Developer in China (Cumulative Installed Capacity by the end of 2010)

	Developer		Type	Installed Capacity (MW)	Market Share (%)
1	国电集团	Guodian Group (1)	Central SOE	8,941	20.0%
2	华能集团	Huaneng Group	Central SOE	6,331	14.2%
3	大唐集团	Datang Group	Central SOE	5,620	12.6%
4	华电集团	Huadian Group	Central SOE	2,557	5.7%
5	中广核	China Guangdong Nuclear Power Group	Central SOE	2,365	5.3%
6	国华	Guohua	Central SOE	2,346	5.2%



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7	中电投集团	China Power Investment group	Central SOE	1,708	3.8%
8	京能	Power Beijing	Prov. SOE	1,314	2.9%
9	华润	China Resources Co.	Central SOE	977	2.2%
10	新天绿色能源	Suntlen Green Energy	Prov. SOE	935	2.1%
11	中节能	China Energy Conservation and Environmental Protection Group	Central SOE	805	1.8%
12	中国风电	China Wind Power	Private	767	1.7%
13	宁夏发电	Ningxia Power	Prov. SOE	745	1.7%
14	三峡集团	Three Gorges	Central SOE	731	1.6%
15	天润	Tianrun	Private	726	1.6%
	其他	Other		7,867	17.6%
	总计	Total		44,733	100%

Source: CREIA, CWEA and DBCCA analysis 2011

Note 1: Guodian Group includes Longyuan Power and Guodian Power and it is the controlling shareholder of those two entities. Longyuan Power has wind power installed capacity of 6,609 MW while Guodian Power has 2,332 MW.

As can be seen in the above data, the central and provincial SOE's accounted for 79% of all wind power development in China. Only two private developers, collectively accounting for 3.3% of total installed capacity, are among the "Top 15" developers. The segmentation between state owned enterprises and private developers (IPP's) for the "Other" group representing 17.6% of installed capacity is unknown.

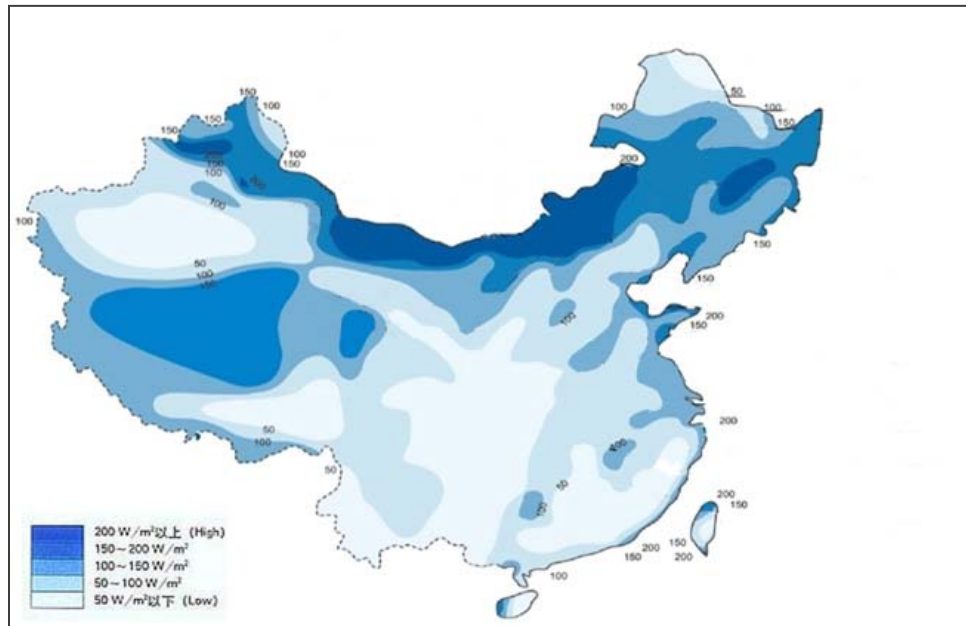
Potential Wind Resources

The efficacy of wind as a power source can be characterized by two major characteristics: average wind speed and hours in a year of when the wind is blowing at those speeds – these equate to the capacity factor of a wind farm, measured as a percentage. In China's case, the majority of the onshore resources are located in the North and the West. Coastal and offshore resources are only now beginning to be exploited. Progress, to date, has focused almost exclusively on exploiting the wind-rich northern and western onshore regions as the technical issues were more easily addressed compared to the challenging – and more costly – coastal and offshore regions. Figure 4, known as a wind resources map, depicts the location of wind-rich regions based on years of average annual data.



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Figure 4: China – The Windy North and West



Source: China Wind Power International Corp., DBCCA analysis 2011

In Figure 4, the more intense the wind speed (i.e. wind energy), the darker the shade of blue. While China is fortunate to have such broad swathes of wind-rich areas, the locations are frustratingly distant from the major load centers. Further, the average wind speeds depicted in the map are “average” and it is important to remember that considerable variation exists in the aggregate profile of wind in any area. Table 4 provides a glimpse of this variability. One of China’s greatest prospective opportunities in wind power development, we believe, will be to develop more suitable systems to harvest the moderate and lower energy wind resources whose areas comprise almost 70% of the entire country.

Table 4: National Wind Resources Distribution in China

	Resource Rich Region	Moderate Resource Region	Low Resource Region	Resource Poor Region
Annual wind energy intensity (W/m^2)	> 200	150-200	50-150	< 50
Hours of wind speed $\geq 3m/s$ annually (h)	> 5000	4000-5000	2000-4000	< 2000
Hours of wind speed $\geq 6m/s$ annually (h)	> 2200	1500-2200	350-1500	< 350
Percentage of national land area	8%	18%	50%	24%

Source: China Renewable Energy Industries Association and DBCCA analysis, 2011

Later we will discuss in more detail the challenges arising from the problem of currently developed wind power resources being quite distant from coastal load centers in China. One obvious strategy is to shift development from wind-rich regions to those with lesser, albeit still attractive wind resources closer to the demand centers.

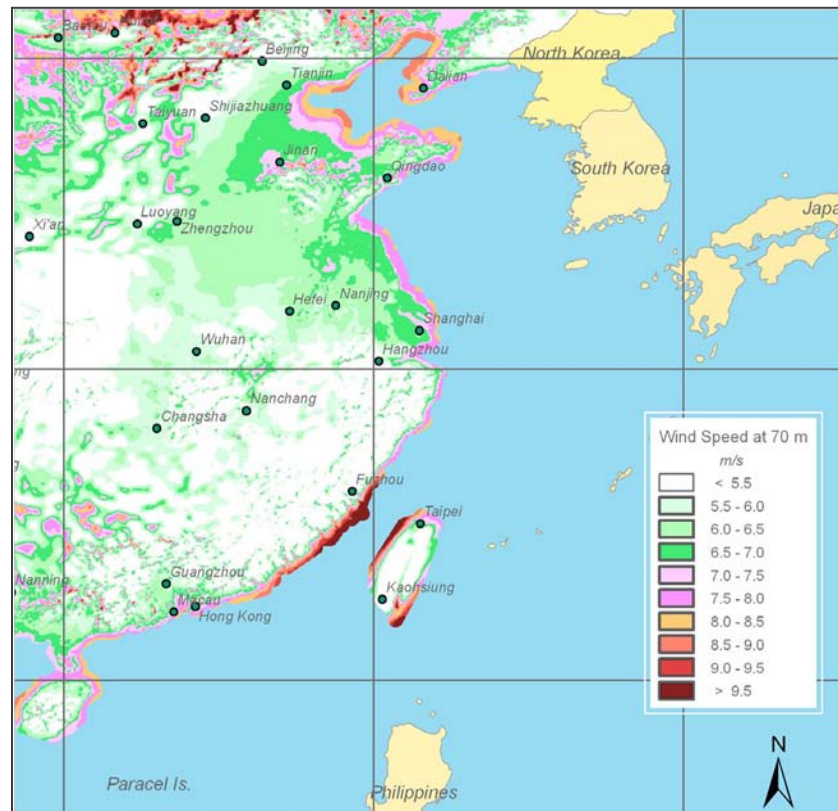


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Offshore a Focus: Technological and Cost Hurdles as Challenges to be Solved

Despite the challenges of offshore development (harsher conditions, higher capital and O&M costs and transmission challenges), China's southeastern coastal waters are expected to be a major focus of development activity in the coming years. Figure 5 below depicts the coastal areas with attractive wind characteristics.

Figure 5: China's Offshore Future



Source: AWS Truepower and DBCCA analysis, 2011.

China's offshore wind resources are located, practically speaking, in the intertidal and littoral coastal areas spanning the seaboard from Hainan Island in the south to Dalian and its eastern environs in the east-northeast region. Initial development has begun in the Shanghai area where there are currently approximately 132 MW of installed capacity in the Jiangsu and Shanghai coastal waters. Offshore technological development is ongoing around the world. We suspect China's plans for 5 GW of offshore installed capacity by 2015 is part of a clear strategy for China to develop and perfect offshore wind systems for broad use, not only in China's territorial waters but ultimately for export markets (e.g. offshore wind turbines).

Overall, How Much Wind Opportunity Might There Be?

Given the pace with which China is developing wind power resources, there is considerable variability in overall estimates of total wind power resources that might be economically developed. Generally speaking, economically



Section I – Wind and Solar Power Resources in China

exploitable onshore resources are estimated to range between 253 GW⁶ on the low side up to ~1,000 GW on the high side⁷. These amounts compare to NREL's estimate of a theoretical maximum resource for the combined onshore east, north and central regions of 3,250 GW⁸, although this is based simply on acreage and without regard to economic or technical feasibility of development. As technologies and costs improve, some of these resources may shift from the "theoretical" to the "economically feasible" category. Please refer to [Appendix II](#) for NREL's province by province theoretical estimates.

Economically practical offshore resources are estimated to comprise 100-200 GW⁹ or up to 500 GW⁷, depending on sources. Certainly there remains great uncertainty with regard to the true scope of off shore wind in China.

Generally speaking, we believe an aggregate commercially practical national wind energy resource approximating 800-1,000 GW (combined onshore and offshore) is not beyond the realm of reasonable potential.

I.II Solar Power Resources

Where is China Now?

Although China is the world's largest producer of solar photovoltaic cells and panels, Solar Power, be it photovoltaic ("PV") or concentrated solar thermal ("CST"), as a deployed energy technology within China, remains in its infancy. At the end of 2010, China had deployed 893 MW (of which 238 MW was grid-connected and the balance is deployed "off grid", providing power in remote areas with no other electricity access) which is 2% of China's comparable 2010 wind power installed base.

Solar Resources

As with wind energy, China's considerable physical expanse endows it with sizeable solar PV resources: approximately 60% of the land mass enjoys more than 2,200 hours of sunlight a year with solar irradiance greater than 5,000 MJ/m² (1,389 kWh/m²) although in our view some areas may see moderated energy levels due to shielding effects of air pollution in the metropolitan areas. Figure 6 depicts the average solar irradiance for China.

⁶ "Present Situation and Future Development of Wind Power in China," Yongjun Chen, *IEEE Spectrum* 1988, pages 1664-1667

⁷ "Building an Offshore Sector to Rival Europe," Wu Qi, *Windpower Monthly*, China Wind Sector Special Report, October 2011, page 9

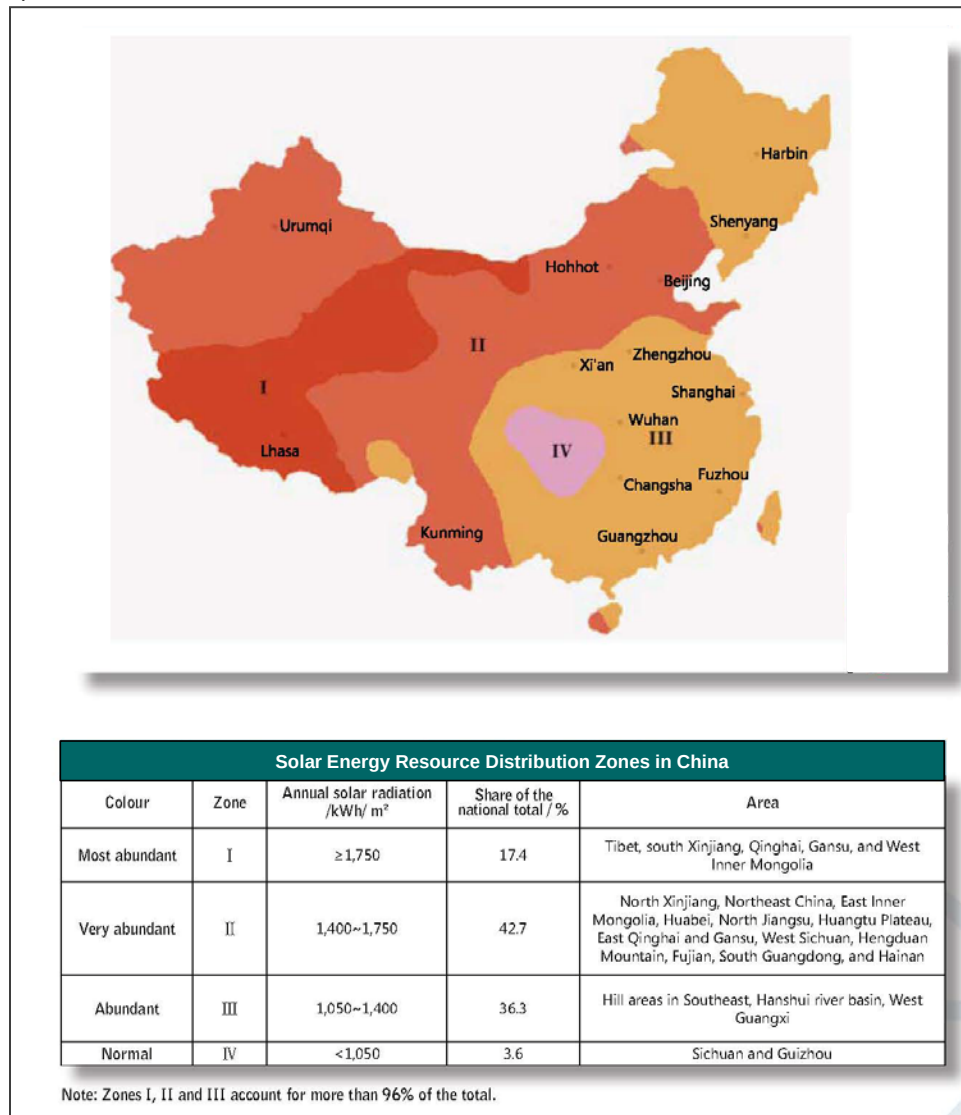
⁸ "China Wind Energy Resource Mapping Activity," NREL, August 2008

⁹ "China Wind Power Outlook," China Wind Energy Association, 2010



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Figure 6: Sun, Best in the West



Source: "China Solar PV Report – 2007," Li Jiufeng, Wang Sicheng, Greenpeace and DBCCA analysis 2011

In the above irradiance map, the darker the shade of orange, the greater the amount of solar energy reaching the ground. Comparing this map to Figure 10 and the provincial load Table (Table 11), below, it becomes apparent that China's ability to develop solar power faces some of the same constraints facing wind power. Like wind energy resources, China's solar energy resources are, for the most part, in the Western regions (placing them 2-3 "sunlight hours" later or behind the load centers in the east). This is remote territory, high on the Qinghai-Tibet Plateau, with little major electricity interconnection with the rest of China (please see Figure 12 – Regionalized Transmission Grid). We believe the exploitation of China's solar resources will unfold in parallel with UHV grid transmission expansion plans. The development of grid-scale energy storage would also serve as a catalyst for large-scale development given the 2-3 hour difference between peak sun hours in the West and time of peak load in the east.

Interestingly, we have been unable to identify any substantive analyses of the maximum feasible amount of grid scale solar PV that China might be able to develop. However, we note that the IEA estimates that China could have up to



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85 GW of solar PV by 2035 and that Greenpeace estimates 100 GW. Compared to the current installed base of 0.9 GW, it appears that China has developed only ~1% of what the IEA and Greenpeace believe may be possible in 2035.



Section II – Government Plan and Policies for Wind and Solar Power

Section II – Government Plan and Policies for Wind and Solar Power

China began policy efforts in 2005 that served as the catalyst for dramatic domestic renewables expansion. In that year, the Renewable Energy Law was passed (and later amended in 2009). The law directed the various ministries to undertake surveys of renewable energy resources and to set goals for renewables development and undertake administrative action and rule-making in support of achieving those goals. While this was a positive step, it did create complications given that the initial metric of success appeared to focus on installed capacity goals rather than targeting actual generation of renewable energy with assured transmission access. This second point - transmission access - was addressed more thoroughly in the 2009 amendment.

The planning and administration of energy policy in China is, for the most part, controlled by the NDRC although several other agencies and major SOE's have meaningful policy influence. In January 2012, announcements from Beijing suggest that the country's leadership may be considering an overhaul and streamlining of the energy policy and planning process. Although we cannot predict the timing and scope of such a restructuring, we believe China will remain committed to the development of renewables for years to come. Should an administrative overhaul and streamlining unfold, it may cause a period of uncertainty until positions and their enforcement becomes apparent.

II.I Wind Power Policy

Volume Targets for Wind Power Installation

Table 5: China's Policy Targets for Wind Power

Date	Promulgating Authority	Wind Power Generation Capacity Target	DBCCA analysis
March 2011	12 th Five-Year Plan	70 GW of new installed capacity by 2015, leading to 2015 cumulative installed capacity of 115 GW.	Given a 2011 current installed base of 65 GW, this target implies annual capacity additions of 13 GW/yr. But discussion of 15–20GW can be found in public commentary.
April 2011	NDRC/ERI and State Grid	2020 target of 150 GW cited in public conferences.	State Grid affirms commitment to support 150 GW of grid connected wind power by 2020 with informal government comments suggesting annual installations rates ranging between 15–20 GW.
October 2011	NDRC/ ERI	"200+ GW" 2020 target cited in public releases.	Energy Research Institute unit of NDRC discusses "200+GW" 2020 target in long-term 2050 planning documents. It is unclear if this is a "grid-connected" target or an "installed capacity" target.

Source: NDRC, Xinhua and DBCCA analysis, 2011

China is in the midst of developing the key work plans for the various ministries and major industries as a normal part of the five-year planning process. These work plans provide incremental operational details on how the high level



Section II – Government Plan and Policies for Wind and Solar Power

goals set out in the 12th Five Year Plan (please see our earlier research notes “*12th Five Year Plan – Chinese Leadership Towards A Low Carbon Economy*”¹⁰ and “*China 12th Five-Year Plan Update - The Work Plan. Focus on Energy Conservation and Emission Reduction*”¹¹ for additional details) will be undertaken. While we await the work plan for the energy and electricity sectors, commentary from various official and occasionally unofficial sources suggest possible new target details come into the public sphere. These bits of information are often lacking much detail and major distinctions (for example, are the informally floated numbers “grid connected,” or simply “installed capacity?”). In Table 5, above, we have set out the major announcements concern wind power targets.

The upshot of these informal and somewhat opaque pieces of new information is a degree of market confusion, especially in light of material policy changes implemented in August 2011 that centralized all wind power permitting authority under the NDRC, removing what had been provincial discretion to authorize projects less than 50 MW in size. This material policy change caused some to wonder if this consolidation of authority and control signaled a shift in China’s commitment to wind power development. Addressing the previously articulated “200+” GW goal by 2020, un-named Chinese government officials have reportedly affirmed that China will continue to install 15-20 GW annually, a notion originally set forth by the Chinese Renewable Energy Association in December 2010. Focusing at the low end of the band suggests ~200 GW of installed capacity by 2020, yet we believe many industry players (both SOEs and Independent Power Producers) prefer to focus on the upper end. This has led, we believe, to unrealistic expectations about growth in the pace of annual new installations in the next few years. We do not believe estimates focusing on growth at the upper end of 15-20 GW range are reasonable, shorter term, due to the grid-connection constraints we will discuss later in our forecast section.

As for the August 2011 policy change consolidating permitting authority, we see this as a positive step for the sector since wind power construction activity in the provinces should, in our view, be conducted in a manner harmonized with transmission grid expansion plans. Ultimately, whether China expands wind power resources at 14 GW per year as we forecast for the next several years or at a higher rate is, we believe, a matter of government policy which will likely aim to strike a balance between the practicalities of grid connection, the pace of grid expansion and the growth of the indigenous wind power sector. Since renewables units of the major SOE’s represent the vast majority of the wind farm development (79% owned by SOE’s exiting 2010), we believe they will plan and manage towards government targets. Whether China chooses to focus on 14 GW or more of annual incremental installed capacity, these amounts are significant in comparison to the rest of the world: the Global Wind Energy Council (GWEC) estimates 48 GW will be added globally in 2012 alone and the United Kingdom hopes that by 2020 they will have built 13–18 GW of offshore capacity in total.

The Lucky Number 8 – China’s Wind Megabase Strategy

As part of the 11th Five year Plan (2006-2010), China embarked on a strategy to initially develop seven 10 GW wind “mega-bases”. With the addition of Shandong, this number increased to eight. Given the currently envisaged wind base plans (on and offshore), by 2020, these bases could represent an aggregate 148 GW of installed wind power capacity. We remind readers that exiting 2010, China had installed 45 GW of wind power capacity in all areas. Table 6 identifies both the wind bases and the government’s development targets for those bases for 2015 and 2020. These large bases are intended to maximize the economics of wind development given the remote locations and distances involved. China has clearly made a serious and long-term national commitment to wind energy, although successful build-out of these megabases is contingent upon successful expansion of the electricity transmission grid.

¹⁰ Access this report at http://www.dbcca.com/dbcca/EN/_media/China_12th_Five_Year_Plan.pdf

¹¹ Access this report at http://www.dbcca.com/dbcca/EN/_media/China_EE_WorkPlan.pdf



Section II – Government Plan and Policies for Wind and Solar Power

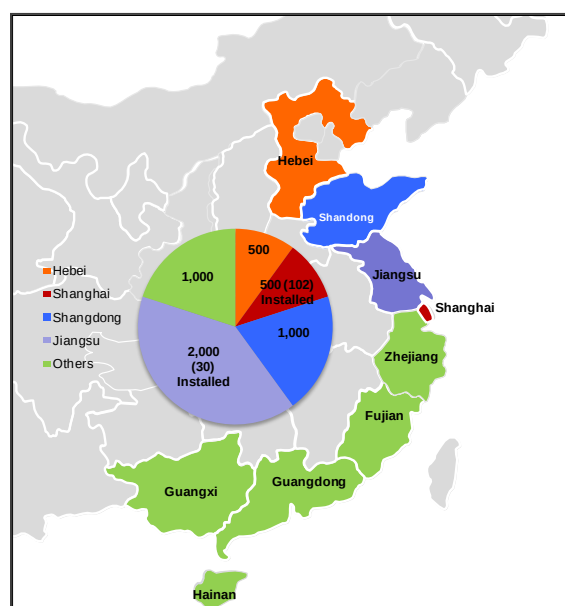
Table 6: 148 GW Target for 8 Mega-Bases by 2020

Wind Power Base	2015 Planned MWs	2020 Planned MWs
Hebei	8,980	14,130
Inner Mongolia East	13,211	30,811
Inner Mongolia West	17,970	38,320
Jilin	10,115	21,315
Jiangsu	5,800	10,000
Gansu Jiuquan	8,000	12,710
Xinjiang Hami	5,000	10,800
Shandong	2,638	10,000
Total	71,715	148,086

Source: China Wind Energy Association and DBCCA analysis, 2011.

For the 2015-2020 period, the average annual rate of growth for the installed base at the eight combined mega-bases approximates 15.6%. In addition to the onshore wind bases, coastal and offshore targets are not to be dismissed. Figure 7 depicts the provincial segmentation of the 2015 target of 5,000 MW (i.e. 5 GW) of offshore wind power. According to the China Wind Energy Association, by 2020 32-33 GW of offshore wind could be developed.

Figure 7: 2015 Offshore Target – 5 GW



Source: "China Wind Power Outlook 2010" China Wind Energy Association and DBCCA analysis, 2011.

Initially, wind power tariffs were agreed upon using a traditional "regulated rate of return" style process. In 2001, wind power tariffs moved from project-specific terms to use of "average reasonable returns" with the "average" being assessed over several years of comparative data. By 2003, competitive bidding (also known as a reverse auction)



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was used to establish power prices. In 2006 in order to foster accelerated industry learning and expertise development, fixed power tariffs were established. Until further refinement of the fixed price tariffs in 2009, the 2006-2009 period represented one of the fastest periods in terms of new wind installations (see Figure 1 in Section I). Table 7 below provides a conceptual timeline of the wind power tariffs in China.

Tariffs in Support of Wind Power Installation

Table 7: Wind Power Tariff Evolution

Tariff Period	Tariff Determination Philosophy
1994-2001	Traditional “regulated rate of return” calculated on capital and financing costs plus allowance for profit
2001-2003	Tariff based on historical multi-year average of “reasonable returns”
2003-2006	Reverse auction competitive bidding
2006-2009	Fixed prices to foster “industry learning and development.” Focus more on installed capacity than energy generated.
2009 - Current	Regionalized fixed price feed-in tariffs (FiTs) to reflect different wind qualities and localized costs. Assumes power produced can be delivered and does not contemplate inability to sell power.

Source: China Wind Energy Association and DBCCA analysis, 2011.

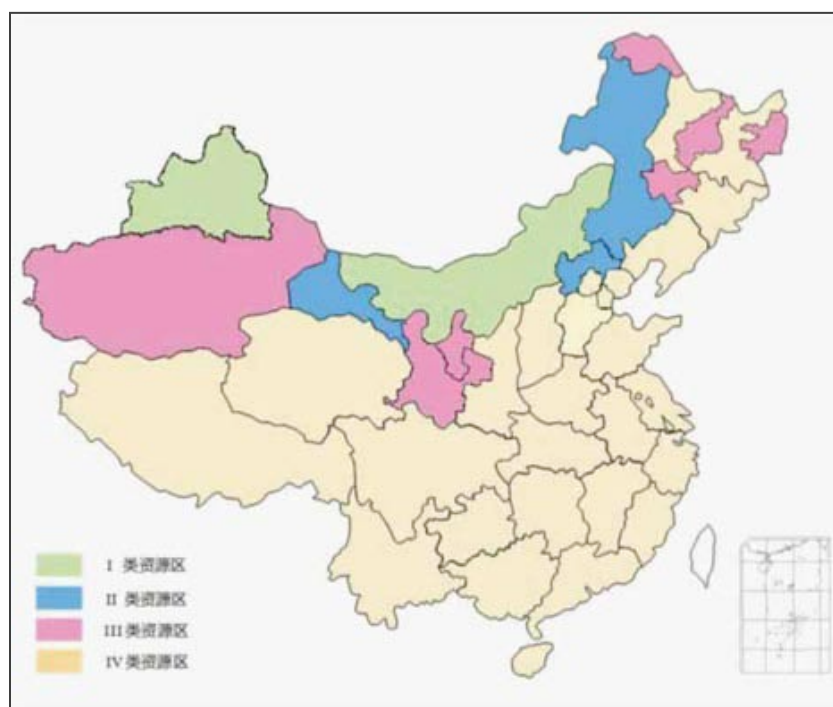
The wind tariff situation in China is complicated and reflects the national and provincial political practicalities of an electricity system that is not fully deregulated. Combined with the Renewable Energy Law, the upshot has been a focus on “installing capacity” to satisfy various goals rather than orchestrating growth by focusing on wind power electricity production. Growth under such policies has resulted in misalignment between electricity grid capacity, grid operation and wind power development. We will discuss these challenges later in Section III (“Building Out the Grid”).

The current regionalized wind power tariff scheme aims to capture the combined effect of both differences in wind resources and local construction costs. The applicability of a particular tariff class remains subject to provincial review. To avoid confusion, we believe it is important to point out that the “classes” of the wind power tariff DO NOT correspond directly to the class designations generally used in international practice to segment wind energy (i.e. wind speed) levels.



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Figure 8: General Location of China's Four Wind Power Tariff Classes



Source: NDRC, Wind Ally and DBCCA analysis, 2011.

Table 8: Four Categories of Resource Areas Defined by NDRC for Wind Power Projects

Category ⁽¹⁾	Benchmark Tariff Price (RMB/kWh)	Covered Regions
Class I	0.51	- Inner Mongolia Autonomous Region except Chifeng City, Tongliao City, Xing'an League and Hulunbeier City - Urumqi Municipality, Yili Kazak Autonomous Prefecture, Changji Hui Autonomous Prefecture, Karamay City and Shihezi City of Xinjiang Uygur Autonomous Region
Class II	0.54	- Zhangjiakou City, Chengde City of Hebei Province - Chifeng City, Tongliao City, Xing'an League, Hulunbeier City of Inner Mongolia Autonomous Region - Zhangye City, Jiayuguan City, Jiuquan City of Gansu Province
Class III	0.58	- Baicheng City and Songyuan City of Jilin Province - Jixi City, Shuangyashan City, Qitaihe City, Suihua City, Yichun City and Daxing'anling Prefecture of Heilongjiang Province - Gansu Province except Zhangye City, Jiayuguan City, Jiuquan City - Xinjiang Uygur Autonomous Region except Urumqi Municipality, Yili Kazak Autonomous Prefecture, Changji Hui Autonomous Prefecture, Karamay City and Shihezi City - Ningxia Hui Autonomous Region
Class IV	0.61	All other regions

Source: NDRC and DBCCA analysis, 2011.

Note 1 – Class number does not correspond to Wind Power Class measures and is instead a Chinese categorization accounting for varying installation costs and wind resources



Section II – Government Plan and Policies for Wind and Solar Power

Table 9: Provincial Incremental Tariffs

Province	Wind Power (RMB/kWh)		Solar Power (RMB/kWh)	
	National Benchmark	Provincial Electricity Tariff	National Benchmark	Electricity Tariff
Guangdong	0.61	0.61-0.72	1.00-1.15	N/A
Jiangsu	0.61	N/A	1.00-1.15	1.40
Liaoning	0.61	N/A	1.00-1.15	1.27-1.30
Shandong	0.61	0.61-0.71	1.00-1.15	1.20-1.40

Source: NDRC, provincial documents and DBCCA analysis, 2011.

The issue of supplemental tariffs arises in the context of wind and solar power. Only limited provinces have explicit supplemental tariffs that serve to increase wind by an approximate RMB 0.10 – 0.11/kWh and solar tariffs by an approximately RMB 0.05 – 0.25/kWh. Shandong and Liaoning province both adopted a descending supplemental tariff scheme for future solar projects since the leveled cost of electricity is expected to decrease substantially as the technology for solar PV evolves. For example, Shandong set forth RMB 0.40/kWh additional tariff for solar projects completed and connected in 2011 and only RMB 0.2/kWh for projects in 2012. At the same time, Liaoning province took a longer term view by pointing out the additional tariff will decrease by 10% each year starting from RMB 0.30/kWh for solar projects before the end of 2012. Some provinces elect to negotiate and grant additional tariffs or supplemental tax preferences to developers on a project by project basis making it very hard to identify a definitive supplemental tariff. As the pace of solar power development quickens, we suspect “custom cut” tariffs developed as part of the project development process may become less common.

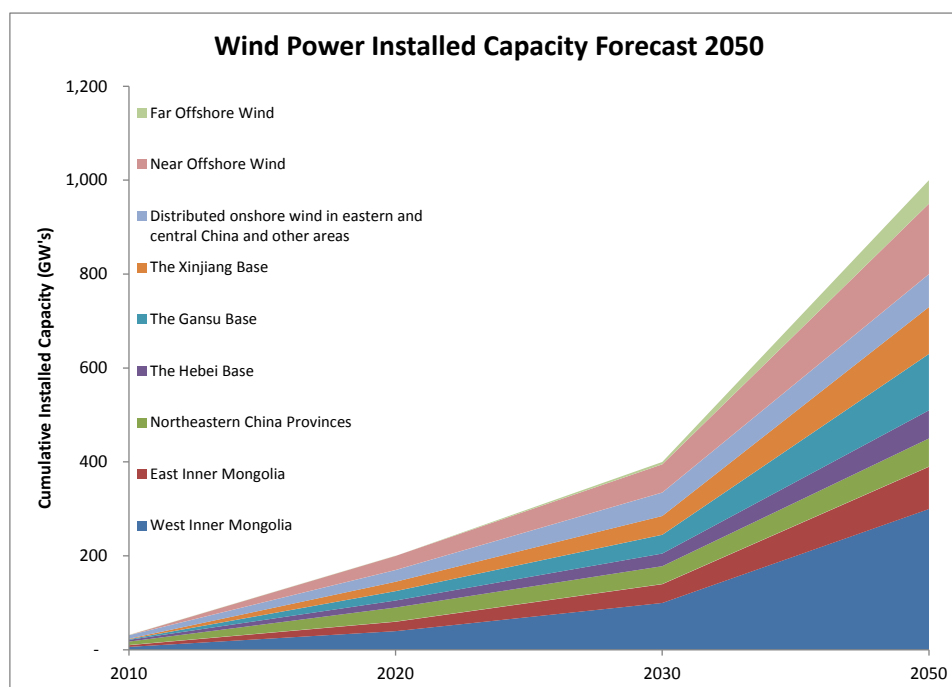
The Long-Term Policy Outlook for Chinese Wind Power

Looking beyond the 2020 horizon, China has large plans to continue developing wind power to the maximum extent possible. China’s Energy Research Institute and the International Energy Agency postulate that by 2050 China’s combined onshore and offshore wind power fleet could comprise 1,000 GW of installed capacity, consistent with the economically feasible potential discussed previously. The most aggressive period of growth is expected to occur in the 2030-2050 period. Current grid expansion plans are now behind the current pace of wind power installation and substantial further grid investment – what might be seen as tantamount to a wholesale rebuilding of China’s electricity sector – would, in our opinion, be necessary for 1,000 GW of wind capacity to be possible.



Section II – Government Plan and Policies for Wind and Solar Power

Figure 9: The Wind Bases Expand Through 2050



Source: "Chinese Wind Power Development Roadmap 2050," IEA and NDRC/ERI and DBCCA analysis, 2011.

II.II Solar Power Policy

China's solar planning efforts are not yet as sophisticated as her wind power efforts. The 12th Five Year Plan initially set forth a 5–10 GW target by 2015. Within months of publication, that target was informally increased to 20 GW by 2020 and is now discussed as a 30-50 GW target for 2020. Until the NDRC releases a renewable energy work plan, there is little firm detail. Although the 30-50 GW "informal" goal reflects a dramatic change from the March 2011 12th Five Year Plan release, we believe China could set a far more ambitious target for solar development.

Table 10: Synopsis of Changes in 12th Five Year Plan Goals and Targets

Date	Promulgating Authority	Solar Power Generation Capacity Target	DBCCA analysis
March 2011	12 th Five-Year Plan	5-10 GW of new installed capacity by 2015 leading to an installed base of 6 GW -11 GW	Given a 2011 current installed base of 1 GW, this target implies annual capacity additions of 2 GW/yr to reach the 10 GW level
April 2011	NDRC	2020 target of 20 GW cited in public conferences.	Such a goal would result in an average 2 GW/year installation rate.
May 2011	NDRC/ ERI	2020 target of 30-50GW cited in public releases.	Such a goal would result in an annual installation rate of ~5 GW/year to achieve the 50 GW level.

Source: NDRC, Xinhua and DBCCA analysis, 2011



Section II – Government Plan and Policies for Wind and Solar Power

China's efforts to stimulate solar PV growth were initially executed through traditional purchase price subsidies. The most recent such program was the Golden Sun program that, from July 2009 through August 2011, offered a 50% - 70% capex subsidy for projects in excess of 300 KW and project capital budgets greater than RMB 100 million.

In August 2011 the Golden Sun program was replaced by a feed-in tariff (FiT) program offering a feed-in tariff of RMB 1.15/ kWh for projects commissioned before the end of 2011 and RMB 1.00/kWh for projects thereafter. Those projects that received subsidies under the Golden Sun program are not eligible for the FiT and can only sell power to grid at the "local benchmark" price authorized for coal-fired electricity.

The only provinces, so far, to formally offer an incremental FiT are Shandong where developers can earn an extra RMB 0.20 – 0.25/kWh in addition to the national FiT, Jiangsu where an RMB 0.25-0.40/kWh supplement tariff is available and in Liaoning Where an RMB 0.15-0.30 supplemental tariff is available. (Please see Table 9 – Provincial Incremental Tariffs, above).

Although not purely a policy matter, legal and social issues arise in China that we think makes the development of rooftop solar, especially residential, more challenging than in the West. The notion of property rights in China is quite different than in the West. In major urban areas most people live in very large multi-dwelling units raising the issue of who has a claim to power generated on the building; even though people may consider their apartment their home, title is not always so clear and thus allocation of harvested rooftop power is equally unclear. Secondly, for free-standing homes and smaller multi-dwelling units, roof space is often consumed with solar hot water systems thus creating competition for roof space and disrupting the existing household "utility services" model.

For large scale commercial rooftops, we believe FiT-eligible grid connected systems will be developed, yet are concerned that the systems may disappoint in terms of performance due to pollution and dust-related impaired sunlight in many urban areas. In those western regions with significant solar resources, ground-mounted systems are more practical as there are far fewer buildings.



Section III – Building Out The Grid

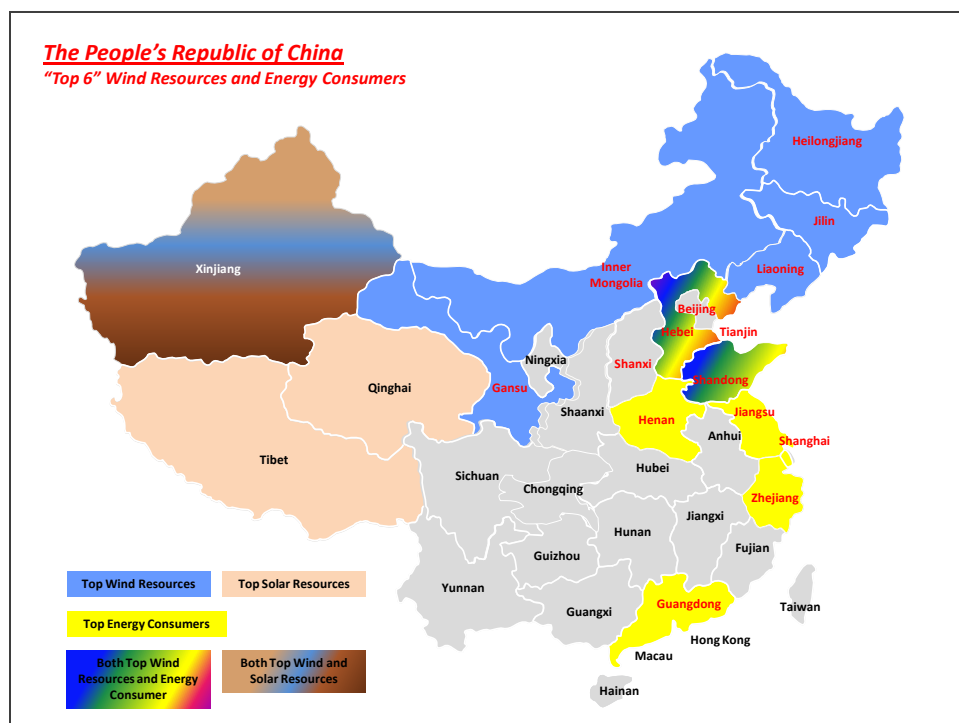
Section III – Building Out the Grid

The Grid is the Problem: Geographic Mismatch Between Wind and Solar Resources, and Electricity Demand

Like much of the West, China's electricity industry and grid planning has lagged behind economic growth. Significant amounts of power are generated in the coal rich regions (Inner Mongolia and Shanxi, for example) rather than being generated in other areas closer to the load centers. The transmission system originally created was planned to convey coal-fired electricity moderate distances to the load centers. As economic growth accelerated, the pace of grid investment did not. Review of electricity transmission planning documents from 2004 for planning the grid through 2020 envisaged a much smaller electricity industry: planners designed transmission systems for estimated national, electricity consumption of 4,600 TWh of electricity in 2020. With China having used 4,207 TWh in 2010 and forecast to use 8,452 TWh by 2020, the 10-15 year transmission expansion plans, formulated in 2004, are now proving woefully inadequate. Further, plans made in 2004 for the next 15 years envisaged only 11–30 GW of non-hydro renewable power by 2020. In 2010 China had, in fact, 31 GW of wind power capacity connected to the grid.

China's rapid economic growth has necessitated substantial and sustained electricity imports to power the factories and homes of the leading GDP producing sectors. Figure 10 graphically depicts the location challenges facing the development of China's wind and solar sectors.

Figure 10: Renewable Resources and Loads: Separated by Distance



Source: National Bureau of Statistics of China and DBCCA analysis, 2011

The amount of power being imported into the "Top 6" GDP provinces are substantial in terms of needed electricity within those regions as depicted in Table 11, below. Despite imported power running on average at 15% of average



Section III – Building Out The Grid

annual electricity needs in these provinces, power shortfalls and mandatory curtailment remain ongoing facts of life. This winter the industrial load centers are forecast by the various power authorities to be facing 30–40 GW electricity shortfalls and perhaps 50 GW shortfalls in summer 2012 and estimated 70 GW shortfalls in summer 2013. Should cash-strapped thermal electricity generators have difficulty accessing capital for further capacity expansion, the risk of expanded power outages could increase.



Section III – Building Out The Grid

Table 11: Provincial Power Import/Export Data

	GDP Rank	GDP 2009 (Bn RMB)	Electricity Generation (Twhe)					Electricity Consumption (Twhe)					Imports/Exports (Twhe)					Imports/Exports as % of	
			2006	2007	2008	2009	2010	2006	2007	2008	2009	2010	2006	2007	2008	2009	2010	Consumption	Supply
广东 Guangdong	1	3,948	247	273	272	276	310	300	339	351	361	406	-54	-66	-79	-85	-96	23.6%	
江苏 Jiangsu	2	3,446	254	267	282	293	336	257	295	312	331	386	-3	-28	-30	-39	-51	13.1%	
山东 Shandong	3	3,390	231	270	265	286	304	227	260	273	294	330	4	10	-8	-8	-26	7.8%	
浙江 Zhejiang	4	2,299	177	192	191	225	250	191	219	232	247	282	-14	-27	-42	-23	-32	11.5%	
河南 Henan	5	1,948	160	192	198	206	218	153	186	209	228	235	7	5	-11	-22	-17	7.4%	
河北 Hebei	6	1,724	146	165	153	174	199	173	201	210	234	269	-27	-37	-57	-60	-70	26.0%	
辽宁 Liaoning	7	1,521	101	112	114	116	129	123	136	141	149	172	-21	-24	-27	-33	-42	24.7%	
上海 Shanghai	8	1,505	72	74	77	78	88	99	107	114	115	130	-27	-33	-36	-38	-42	32.4%	
四川 Sichuan	9	1,415	123	126	138	158	168	106	118	121	136	155	17	9	17	22	13		8.0%
湖南 Hunan	10	1,306	75	86	93	103	119	91	102	113	123	117	-16	-16	-20	-20	1		
湖北 Hubei	11	1,296	131	159	183	182	203	89	101	108	118	133	41	58	75	64	70		34.4%
福建 Fujian	12	1,224	90	104	113	117	136	87	100	115	122	132	4	4	-2	-4	4		
北京 Beijing	13	1,215	21	23	24	24	27	62	68	71	76	81	-40	-45	-46	-52	-54	66.8%	
安徽 Anhui	14	1,006	73	87	112	132	144	66	77	86	95	108	7	10	27	37	37		25.3%
内蒙古 Inner Mongolia	15	974	141	193	218	224	248	122	116	122	129	154	19	77	96	95	95		38.1%
黑龙江 Heilongjiang	16	859	65	69	73	72	77	60	64	70	69	75	5	4	4	3	3		
陕西 Shaanxi	17	817	58	71	85	91	110	58	65	71	74	86	0	5	14	17	24		22.0%
广西 Guangxi	18	776	52	68	87	94	100	58	68	76	86	99	-6	0	11	9	1		0.8%
江西 Jiangxi	19	766	44	50	58	53	62	45	52	55	61	70	-1	-1	3	-8	-8	11.9%	
天津 Tianjin	20	752	36	39	38	42	59	45	51	54	58	65	-9	-12	-15	-16	-6	8.8%	
山西 Shanxi	21	736	153	176	179	187	212	110	135	131	127	146	43	41	48	61	66		31.2%
吉林 Jilin	22	728	44	49	58	54	59	41	46	50	52	58	3	3	8	3	2		
重庆 Chongqing	23	653	29	37	46	47	46	41	45	49	53	63	-11	-7	-3	-6	-17	27.1%	
云南 Yunnan	24	617	75	90	108	117	133	65	75	83	89	100	11	16	25	28	33		24.5%
新疆 Xinjiang	25	428	36	41	49	55	65	36	42	48	55	66	0	-0	1	0	-1	1.5%	
贵州 Guizhou	26	391	99	117	121	138	139	58	67	68	75	84	40	50	53	63	55		39.7%
甘肃 Gansu	27	339	53	62	70	70	78	54	61	68	71	80	-1	0	2	-1	-2		
海南 Hainan	28	165	10	11	12	13	15	10	11	12	13	16	-0	0	-0	-1	-1		
宁夏 Ningxia	29	135	39	45	47	48	59	38	44	44	47	55	1	1	3	1	4		
青海 Qinghai	30	108	28	31	31	38	46	25	29	31	34	47	4	2	-0	4	-1		
西藏 Tibet	31	44	2	2	2	2	2	1	1	2	2	2	0	0	0	0	0		
Total		36,530	2,866	3,282	3,496	3,715	4,141	2,890	3,282	3,487	3,723	4,200	NM	NM	NM	NM	NM		

Source: National Bureau of Statistics of China and DBCCA analysis, 2011

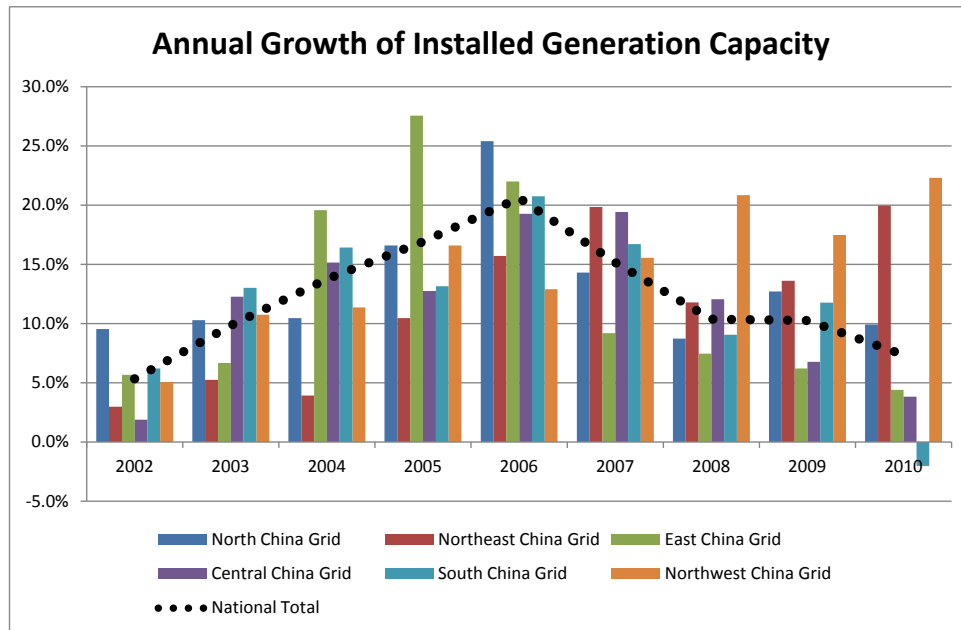
Net Power Importers	Net Power Exporters
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Section III – Building Out The Grid

Contributing to these shortfalls has been a marked lack of generation expansion in the high energy consuming provinces. While some capacity expansion in the East outstripped national growth in the 2004-2005 period (we think in anticipation of the Olympics and Shanghai Exposition), since then the rate of growth in the East and the South has lagged national growth. As can be seen in Figure 11, below, growth in the northeast and northwest regions has exceeded national growth rates for several years when wind power resources were cultivated.

Figure 11: Capacity in the North Expands



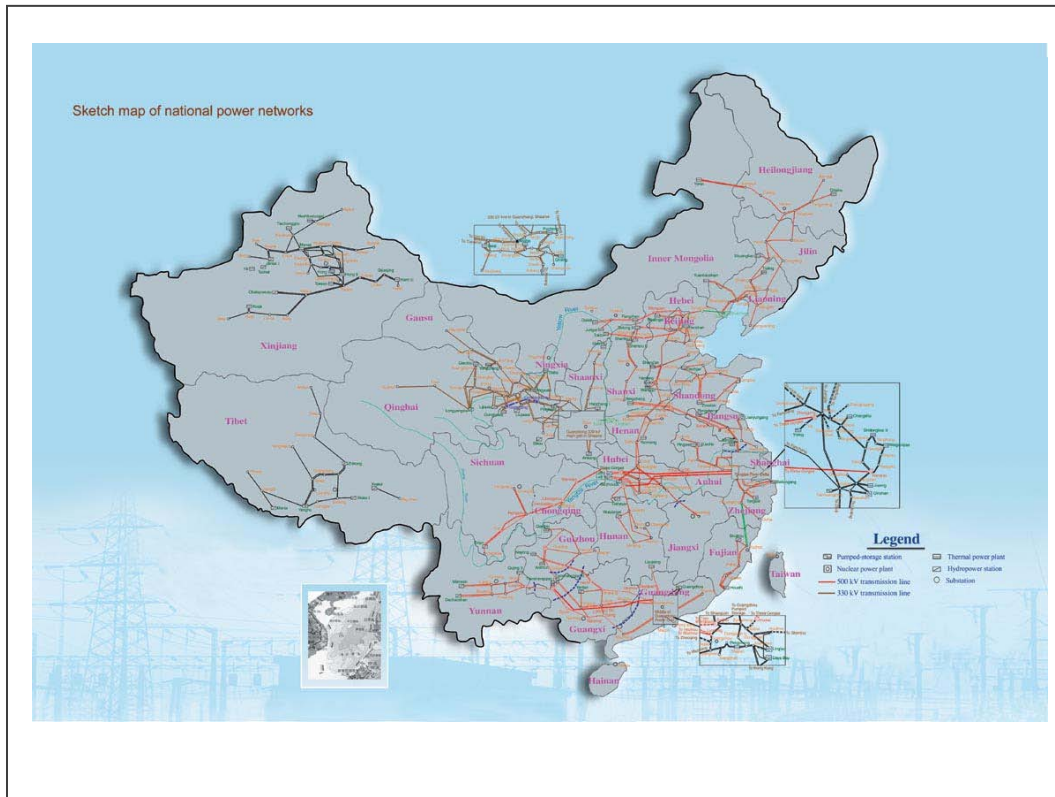
Source: National Bureau of Statistics of China and DBCCA analysis, 2011

Quite simply a combination of inadequate local generation compounded by physical transmission constraints and “local politics” concerning “when whose electricity moves on which wires” creates significant electricity bottlenecks that are compounded by dislocations in the electricity business model where regulated electricity prices have collided with free-market priced coal. The upshot of all this is idled renewable power capacity in the distant North and Northwest while businesses suffer a periodic lack of electricity in the southern and coastal regions.

The electricity transmission grid in place as the wind power sector began rapid growth from the 2005 period was still a highly regionalized structure as illustrated in Figure 12. Planners did not design a transmission grid to accommodate large amounts of remote wind and solar renewable capacity, especially at the scale to which China's de-carbonizing efforts have caused it to grow.



Figure 12: Regionalized Transmission Becomes a Growth Constraint

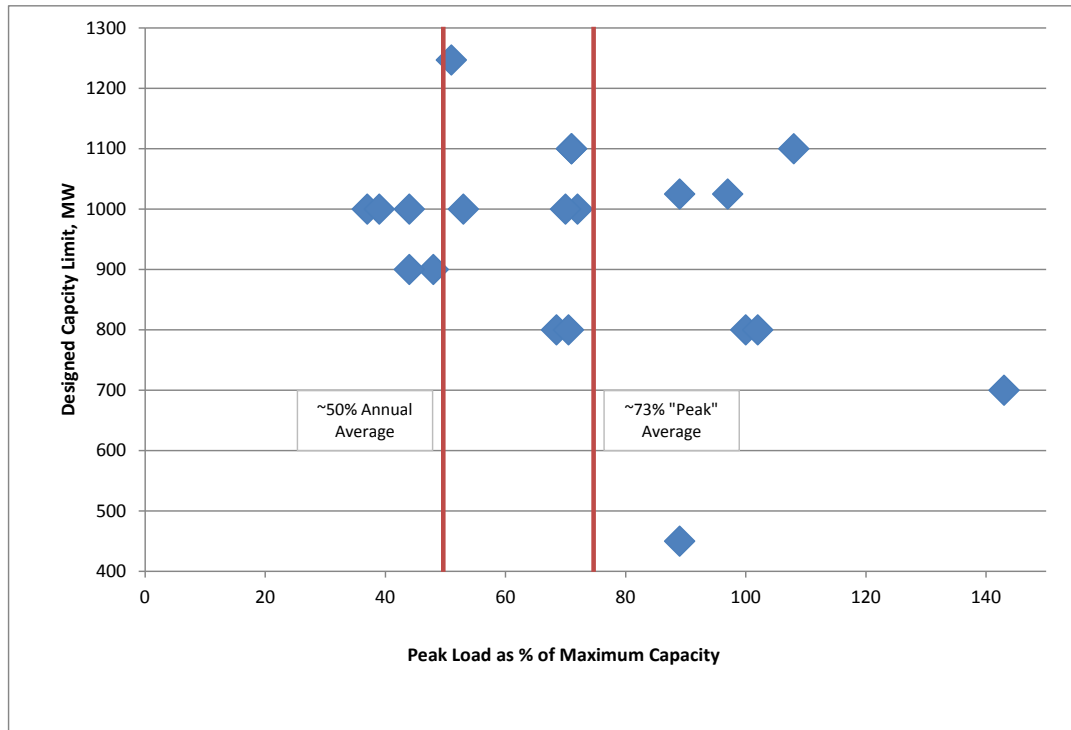


Source: State Grid Corporation of China and DBCCA analysis, 2011

The current transmission system was designed to accommodate the base load or slowly varying output of coal-fired stations. Wind power and solar power, on the other hand, are significantly more variable in terms of output. Based on our research, it appears that typical transmission lines in China reach average annual peak loading of approximately 50% of capacity. This is deceptive because many lines are operated near or above capacity while other lines are relatively unburdened. Figure 13 displays the typical peak loading occurring in any month for a sample group of 20 transmission lines in China. The average "peak load" is 73% as compared to 50% when "average" loading is assessed across annual periods. It is worth noting that 25% of the transmission lines experienced peak loading of 90%-100% of capacity and 10% of the lines were operated at loads in excess of design capacity. This underscores the gravity of the transmission problem, especially when one considers that hourly loadings can be far higher than average monthly peak loads. Data for hourly transmission loading is not publicly available in China.



Figure 13: Sample Transmission Line Loading Characteristics

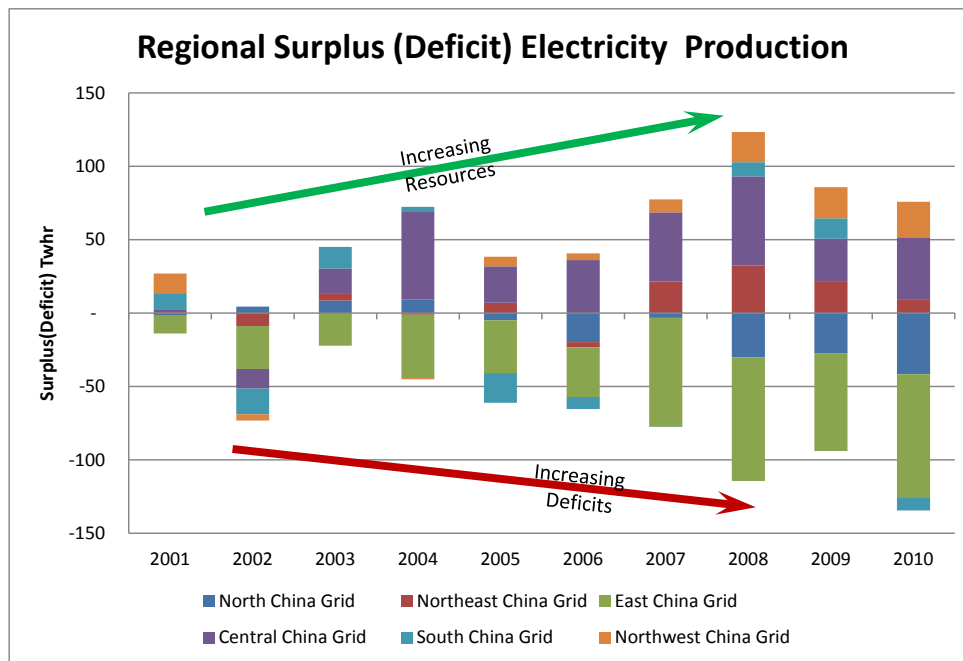


Source: "Allocation Method of Cross-Region (Trans-Province) Electricity Transmission Security Costs," Li, Han, Gao, Guan, State Grid Research Institute and North China Electric Power University and DBCCA analysis, 2011

Peak loading and transmission constraints make it hard to transport power into the high consumption areas. Power shortages disrupt the local economies. As can be seen in Figure 14, the net power deficits (what a region can generate minus what a region consumes) are increasing over time while surplus electricity generation in the northern regions is increasing. We believe the Chinese are aware of this problem and are taking accelerated actions to expand transmission capacity to capture the power resources being installed in the rich wind resource regions (and to be installed in the solar producing regions), and to make more reliable a power infrastructure in support of continued economic expansion. With continued expansion of wind power in the North and solar power in the West, we see two likely strategies unfolding for China.



Figure 14: Locational Mismatch between Generation and Load Expands



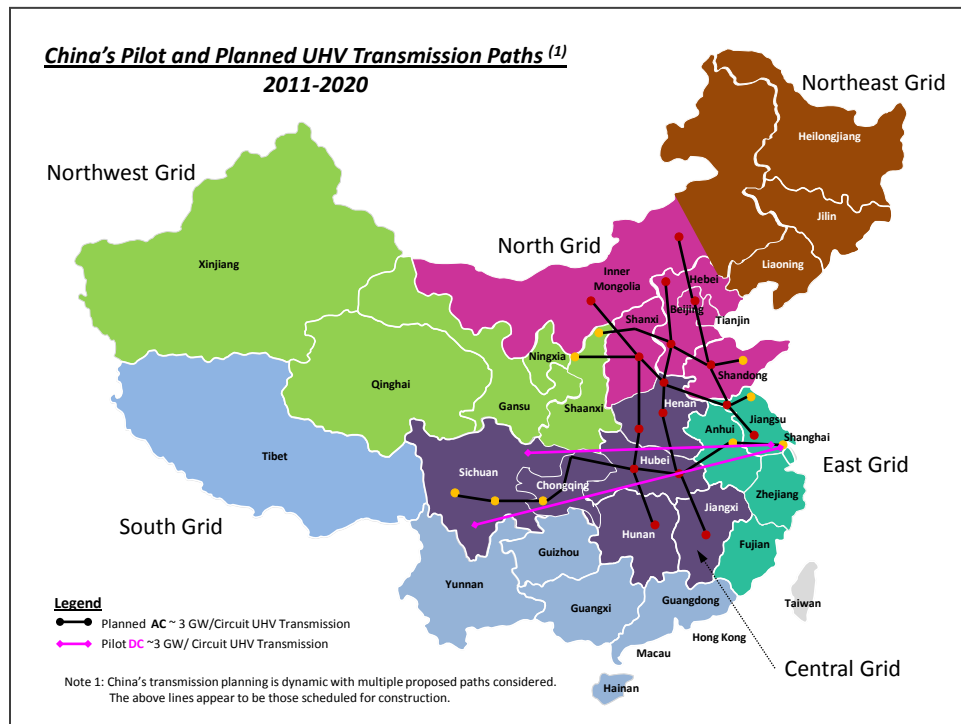
Source: National Bureau of Statistics of China and DBCCA analysis, 2011

In the near and medium term (until 2015), we believe China must develop more robust transmission resources linking the resource-rich northern regions to the workshops of the South while taking policy actions to encourage development of lower energy wind sources closer to major load centers. Such actions were explicitly sketched out in the 12th Five Year Plan. China has announced plans to invest RMB 500 billion (~USD \$80 billion) through 2015 for UHV and lower-voltage transmission grid expansion. By 2020, Min Li of Yuanta Securities estimates the total grid investment may approach RMB 675 billion (USD \$107 billion) on continued expansion. In the 2015-2020 period we believe China will finish an initial expansion of the transmission grid addressing many of the current bottlenecks that could involve the construction of up to 32,000 km of AC UHV lines and 18,000 km of DC UHV lines.

By 2020 China will, in our opinion, need a substantial new web of transmission lines to accommodate achieving targets for wind power and solar power development. Building a transmission system is a combination of civil and electrical engineering and requires time. We believe once China completes the first phase of transmission expansion, the new grid for inter-regional transmission will look like Figure 15, below. We note there are several various “transmission plans” that various representatives of State Grid of China has discussed publicly. While we believe the one depicted in Figure 15 to be the most likely, planners could certainly choose to add additional circuits in anticipation of generating capacity and load requirements.



Figure 15: China's Initial UHV Grid Expansion Program



Source: State Grid Corporation of China, Yuanta Securities, CEC and DBCCA analysis, 2011

Referring back to Figure 9 and considering China's long-term plans to develop both wind and solar power, we expect transmission to be an area for substantial investment for decades to come as both the length and number of transmission lines and capacity of those lines increases to accommodate ever more low-carbon electricity.

Transmission Needs, Provincial Business Realities

We believe a few points are worth consideration when thinking about the current transmission bottleneck. This topic offers interesting insights into provincial politics and planning processes in China.

From a simple business perspective, a transmission line is like a road. It has costs to construct and maintain and is limited by a maximum capacity. Not surprisingly, transmission planning aims to put in place enough capacity to convey enough power to cover peak conditions while also being well-utilized during off-peak times. Further, much of the inter-provincial transmission was built to accommodate the electricity produced by coal-fired power plants. In a symbiotic relationship, the output of the coal-fired power plant supported the economics of the transmission line while the existence of the transmission line (and its capacity to haul kWh) ensured the economic viability of the power plant. Further, output from the thermal power plants is steadier compared to wind power, making the transmission process easier to manage.

■ Seasonal Variation in Wind Energy

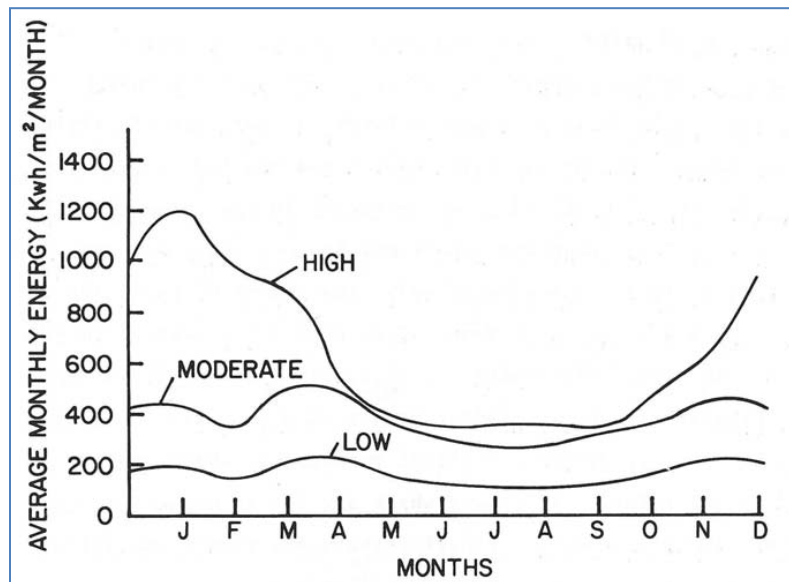
There is one additional complexity unique to China: many power plants serve the dual purpose of producing both electricity and heat for local communities. Thus, during the winter, the power plants often must run to satisfy their



Section III – Building Out The Grid

thermal heating obligations and thus also produce electricity. In doing so, the transmission becomes necessary as a way to deliver the electricity produced while satisfying thermal heating obligations. Since transmission lines were sized to accommodate these needs, the recent arrival of substantial and highly varying amounts of wind power presents significant problems. This is a real problem for China because the peak wind power season in the northern regions happens to be winter. Figure 16 depicts the typical seasonal variation in wind energy.

Figure 16: Best Wind Regions Best in Winter



Source: "Wind Energy Mission Analysis," General Electric Company, Valley Forge Space Center, Report No. 76, SDS4267, February 1977 and DBCCA analysis, 2011

Like a traffic jam on a highway, too much electricity production from too many sources (variable wind and less variable coal-fired electricity) results in an electrical traffic jam. To manage this, grid operators instruct wind power farms to curtail wind turbines in order to make transmission capacity available for "must run" coal-fired units so they can continue operation to satisfy thermal heating obligations. Such forced curtailment can have negative financial consequences for affected wind farms.

■ Provincial Competitive Dynamics

Putting aside the winter season "prime wind power vs. thermal heating" conundrum, provincial politics also complicate the process. Although State Grid Corporation of China is a national entity, the local grid officials are, operatively, strongly influenced by provincial government officials. To the extent that local "home province" power production requires transmission access and capacity, there are competitive dynamics that cause a certain resistance to taking transmission capacity away from local power producers (thermal or renewable) and making that capacity available to generation businesses from OTHER provinces. These dynamics flow from the provincial macroeconomic target process by which the national government manages China's economy. Consequently, precious transmission capacity can be husbanded for the output of local power producers while capacity outside the province that may have influence over transmission operations remains idle – despite the need for that remote power in yet other provinces. One way to address this problem would be the incorporation of power market models more commonly used outside China. While China is exploring power markets concepts, the transformation of the state-owned electricity industry is something that will, we believe, take considerable time.

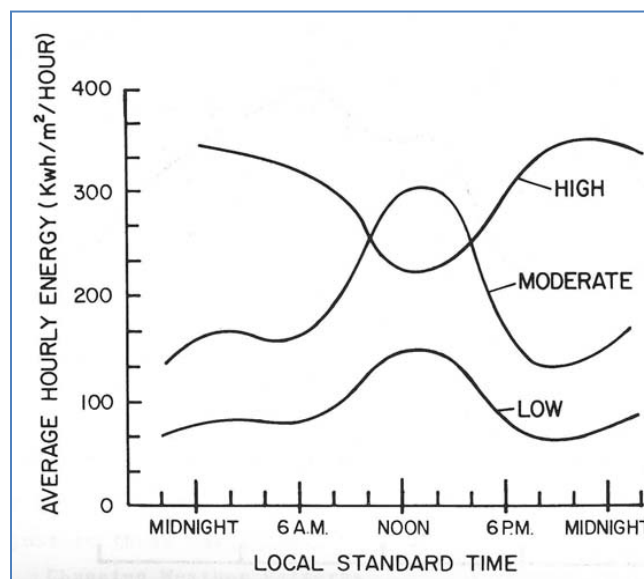


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■ Daily Wind Energy Variation Inconsistent with Peak Loads

While seasonal variation in wind energy influences the power delivery dynamic of the sector, constrained by grid transmission, daily variation in wind energy also causes short-term grid management problems. There are two important points to make. First, wind is a variable and difficult to predict resource. Such moment to moment variability results in varying electricity production which, in turn, complicates the marshalling and scheduling of all generation resources connected to the relevant transmission line. The second point is that wind does display a diurnal energy cycle often providing peak energy levels (wind speeds) late in the day for high energy wind regions after the peak in electricity demand has occurred. Conversely, moderate and low energy wind regions tend to deliver maximum wind energy at just before peak demand loads occur. This phenomenon is illustrated in Figure 17, below.

Figure 17: Wind Energy Ebbs and Flows During the Day



Source: "Wind Energy Mission Analysis," General Electric Company, Valley Forge Space Center, Report No. 76, SDS4267, February 1977 and DBCCA analysis, 2011

Thus the northern regions of China where the highest onshore wind energy regions are located could deliver peak output later than needed by the grid that is, for the time being, capacity constrained. Those lower wind energy regions are closer to the load sources and do not suffer the same degree of transmission constraint. Development of these areas is likely to be a major focus in the coming years. Although technically more difficult, inter-tidal and offshore wind regions are characterized by higher energy wind resources and are also close to load centers. We also expect develop to shift to these areas, although at a pace slower than in low energy onshore wind areas simply because of the technical and economic challenges of the offshore arena.

Natural Gas to Balance Variable Electricity Production from Renewables

As both transmission and wind and solar power capacity expand within China's energy infrastructure, we envision an opportunity for natural gas to play a grid stabilizing role, helping to support further renewable power development. The reason for this is gas turbines can be throttled up and down very quickly (in a matter of minutes) and can respond more easily to variations in wind power electricity production compared to coal-fired systems that require 30 minute or longer periods to materially change output levels.



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China's natural gas fields are conveniently located adjacent to major wind and solar regions and transmission corridors. Further, the major West-East gas transmission pipelines follow similarly convenient paths. Gas field locations are depicted in Figure 18 and West-East pipeline paths are located in Figure 19, below.

Figure 18: Gas Near High Energy Wind Regions



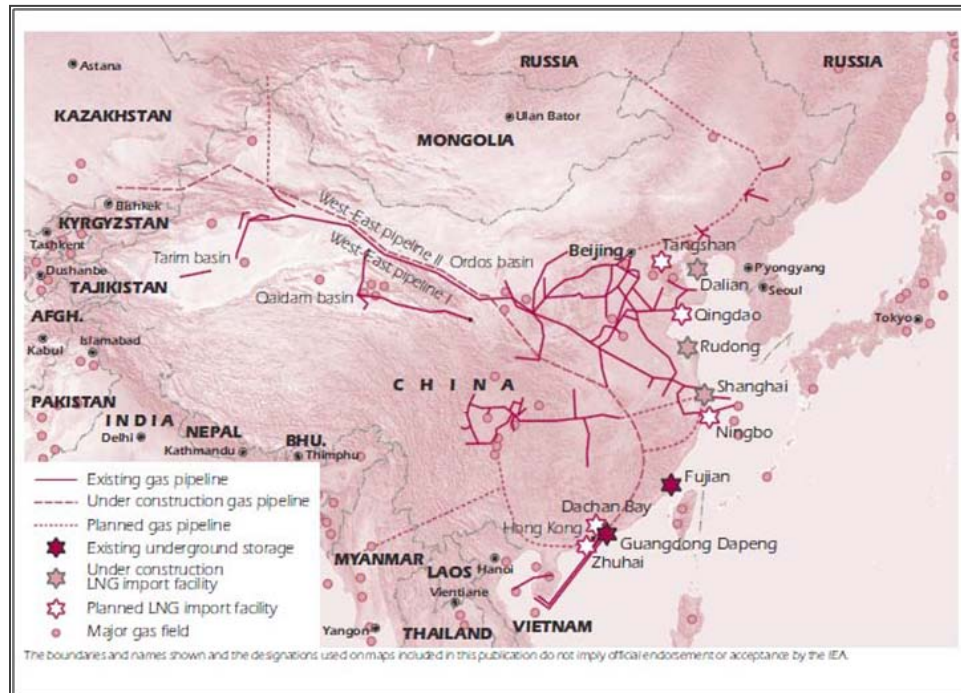
Source: "Natural Gas in China: Market Evolution and Strategy," Nobuyuki Higashi, International Energy Agency, 2009 and DBCCA Analysis 2011

Comparing Figure 18, with earlier provincial maps showing high wind energy regions, there is a clear proximity between gas and wind energy resources. Much of China's own gas flows from the Tarim, Ordos and Sichuan fields to the load centers in the East and Southeast. Further, as depicted in Figure 19, major pipelines carry China's gas along with major supplies of gas imported from Kazakhstan, Turkmenistan, Uzbekistan, Russia and Myanmar.



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Figure 19: Major Gas Pipelines Create Opportunities to Buffer Renewables Variability



Source: "Natural Gas in China: Market Evolution and Strategy," Nobuyuki Higashi, International Energy Agency, 2009 and DBCCA Analysis 2011

While the use of gas to buffer variability in wind and solar power electricity production may offer possible solutions to the management difficulties of a major transmission grid as large as China's, there are structural impediments to this strategy. China does not have enough domestic gas to fulfill its needs. Natural gas is a primary feedstock for industrial and chemical production. Further, policies enacted in 2007 by the NDRC prioritized the use of natural gas, ranking power generation as "confined" or lowest priority uses and providing gas to residential customers and vehicular customers a top priority. Table 12 summarizes the 2007 order.

Table 12: Prioritized Uses of Natural Gas

	Residential Sector	Industrial Fuel	Chemical Feedstock	Power Sector
Priority	- City residential - Public facilities - Natural gas vehicles			- Combined cooling/heat and power system
Allowance	- Centralized heating - Decentralized heating - Central air conditioning	- Substitution projects of oil and LPG - Substitution projects of coal with environmental and economical benefits - Interruptible consumers	- Low economic hydrogen projects - Low economic nitrogenous fertilizer projects	- Peak-shaving power generation in the area with sufficient supply
Confined			- Expansion of ammonia projects - Some chemical projects using methane	- Non-essential load-power generation



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Prohibited			- Methanol projects	- Base-load generation in the large-scale coal base area
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Source: "Natural Gas in China: Market Evolution and Strategy," Nobuyuki Higashi, International Energy Agency, 2009, NDRC and DBCCA Analysis 2011

In practical terms, the NDRC makes policy and can certainly revise policy. Although we have not undertaken an economics trade-off analysis of using natural gas to buffer renewable power variability, we suspect it may prove to be quite a cost efficient means to mitigate the transmission load balancing problems once China first solves transmission capacity constraints and addresses access management practices.



Section IV – DBCCA’s Wind and Solar Power Forecast

Section IV – DBCCA’s Wind and Solar Power Forecasts

IV.1 DBCCA Wind Power Forecast

We have prepared our forecast by both examining China’s policy environment and assessing what is practical and feasible within China’s policy framework. Further, we have examined and estimated China’s overall energy demand and shift toward higher electricity intensity (electricity use per GDP). With an aggregate electricity estimate, we then developed our forecast for renewable power development with an eye toward simultaneously achieving a variety of energy, electricity, fuel mix and capacity targets and goals.

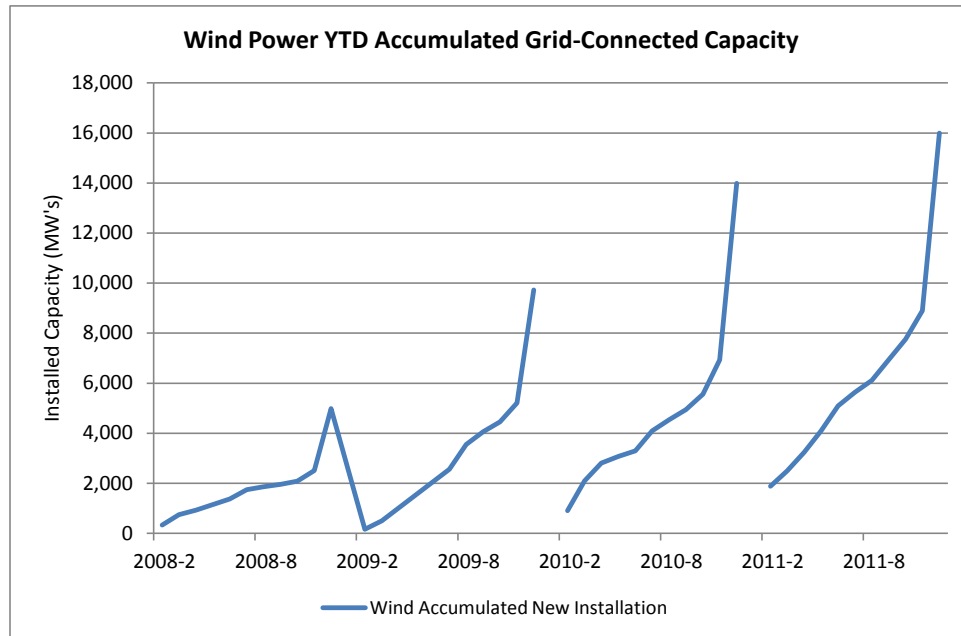
In the two following figures we present analyses of (1) our Base Case contrasted with (2) an Aggressive Build case. We examine the consequences of allowing growth of installed capacity to systematically exceed the pace at which wind power can be connected to the transmission grid. To clarify our analysis, we define the following concepts.

- **“Installed Capacity Base”** refers to wind power generation capacity that has been physically constructed, whether it is connected to the bulk transmission grid or not.
- **“Grid-Connected Base”** refers to wind capacity that has been constructed, certified for operation, connected to the grid and commissioned for the production of power delivered into the bulk transmission grid.
- **“Total Pool Awaiting Grid Connection”** refers to wind power capacity that has been constructed and is either being certified or awaiting connection to the bulk transmission system. GW’s in this category DO NOT produce electricity.
- **“Normal Pool Awaiting Grid Connection”** refers to the quantity of unconnected GW in the process of completing final certification and arranging for grid connection that at any given point in time may be considered “normal” as a result of building high levels of capacity. Assuming that (1) commissioning and grid connection times take approximately 6 months; and (2) 75% of new installations for Chinese wind occur in the second half of the year (see Figure 20, below), we estimate the “normal pool awaiting grid connection” to equal 75% of the annual installed capacity. Our approach suggests that only those turbines built in the first calendar half of any year are eligible for grid connection by the end of the same year. Those amounts constructed in the second half of the year are carried into the first half of the following year when we assume connection takes place.
- **“Overhang”** refers to that amount of GW awaiting grid connection IN EXCESS of the “normal pool awaiting grid connection” category. It is this category of surplus unconnected GW that the grid needs to absorb, and that creates a risk of slowing additions to the installed capacity base.



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Figure 20: Wind Power Annual Accumulated Newly Installed Grid-Connected Capacity (GW), Jan 2008 – Dec 2011 – Heavily Backend-loaded in the Second Half of the Year



Source: CEIC and DBCCA analysis, 2011

Figure 20, above, examines the cumulative intra-year pace of wind power installations from the beginning of 2008 through October 2011, the period for which data is available. Due to the nature of project timing, much capacity is completed (but not necessarily grid-connected) in the last few months of the year.

In preparing our forecast of Cumulative Installed Capacity vs. Grid Connected Capacity for wind power, we examined the current installed base (grid-connected and awaiting connection) and then, based on our policy driven, macroeconomic and energy forecasts developed our estimates for the amount of grid-connected capacity that could be absorbed by the transmission grid. Our DBCCA Base Case wind power forecast through 2020 is contingent upon a parallel expansion of the electricity transmission grid in order for economic and operational value to be harvested from prospective wind power development. Our DBCCA Base Case forecast can be found in Figure 21 below; third party wind power deal pipeline data can be found in [Appendix I](#). Given the outlook from the previous sections, we estimate that China will continue to build wind power through 2020, with 201 GW of grid-connected wind power capacity by that date. The distinction between “installed” vs. “grid-connected” capacity causes considerable confusion. China has not formally articulated a clear wind power target for 2020 although much commentary in the media and in energy policy research circles suggests that the government may be aiming for an approximate “200+” GW target by the end of 2020. Without detailed and precise commentary from the Chinese government, we cannot determine if such an unofficial target is “installed” or “grid-connected.” Assuming 2020 grid-connected capacity reaches 200 GW, such growth would represent a 20.5% annual compound average growth rate for the 2010-2020 period.

In our DBCCA Base Case, we recognize the constraints facing the transmission grid and work to match the pace of new wind turbine construction with the rate of grid connection. We assume the pace of grid connection will begin to speed up in the 2014 period as some new transmission lines become available. Assuming successful expansion of the electricity transmission grid occurs and a return to an annual installation program of 16 GW in 2015, we forecast



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annual installations increasing to a 20 GW per year in 2016, slowing slightly to 19 GW per year in 2017, and then settling to a steady 18 GW per year for the 2018-2020 period. We do not discount the notion that China could accelerate the pace of connection beyond 18 GW/year. Until we see more details on China’s transmission expansion plans, however, it is hard to justify substantially more interconnection of wind power than what is in our DBCCA Base Case.



Section IV – DBCCA's Wind and Solar Power Forecast

Base Case Forecast

Figure 21: DBCCA's Base Case Forecast of China's Wind Power Capacity by Category, 2010-2020 (GW)

Installed vs. Grid Connected Analysis - DBCCA Base Case		12th Five Year Plan Period					Cumulative Additions	13th Five Year Plan Period					Cumulative Additions
	2010	2011	2012	2013	2014	2015	2011-2015	2016	2017	2018	2019	2020	2011-2020
Plus													
Cumulative Installed Capacity Base (1), BOY	25.8	44.7	64.7	78.7	92.7	106.7		122.7	142.7	161.7	179.7	197.7	
Annual Incremental Installs	18.9	20.0	14.0	14.0	14.0	16.0	78.0	20.0	19.0	18.0	18.0	18.0	171.0
Equals													
Cumulative Installed Capacity Base (1), EOY	44.7	64.7	78.7	92.7	106.7	122.7		142.7	161.7	179.7	197.7	215.7	
Plus													
Cumulative GRID CONNECTED Base(2), BOY	17.6	31.0	47.0	63.0	79.0	95.0		111.0	129.0	147.0	165.0	183.0	
Annual GW Connected to Grid (3)	13.4	16.0	16.0	16.0	16.0	16.0	80.0	18.0	18.0	18.0	18.0	18.0	170.0
Equals													
Cumulative GRID CONNECTED Base(2), EOY	31.0	47.0	63.0	79.0	95.0	111.0		129.0	147.0	165.0	183.0	201.0	
Plus													
Total Pool of GW Awaiting Grid Connection(4), BOY	8.2	13.7	17.7	15.7	13.7	11.7		11.7	13.7	14.7	14.7	14.7	
Annual Additions from "Annual Incremental Installs"	18.9	20.0	14.0	14.0	14.0	16.0		20.0	19.0	18.0	18.0	18.0	
Minus													
Annual Incremental GW's Connected to Grid (3)	13.4	16.0	16.0	16.0	16.0	16.0		18.0	18.0	18.0	18.0	18.0	
Equals													
Total Pool of GW's Awaiting Grid Connection(4), EOY "Total Unconnected"	13.7	17.7	15.7	13.7	11.7	11.7		13.7	14.7	14.7	14.7	14.7	
Minus													
Normal Size of Pool Awaiting Connection (5)	14.2	15.0	10.5	10.5	10.5	12.0		15.0	14.3	13.5	13.5	13.5	
Equals													
"Overhang" (6)	-0.4	2.7	5.2	3.2	1.2	-0.3		-1.3	0.5	1.2	1.2	1.2	

Note:

1. "Installed Capacity Base" refers to wind power generation capacity that has been physically constructed, whether connected to the bulk transmission grid or not.
2. "Grid-Connected Base" refers to wind capacity that has been constructed, certified for operation, connected to the grid and commissioned for the production of power delivered into the bulk transmission grid.
3. Contingent upon successful electricity transmission grid capacity expansion becoming available in 2014 and thereafter.
4. "Total Pool Awaiting Grid Connection" refers to wind power capacity that has been constructed and is either being certified or awaiting connection to the bulk transmission system. This amount can be thought of as the total amount of GW's not yet connected to the transmission grid.
5. "Normal Pool Awaiting Grid Connection" refers to the quantity of unconnected GW that at any given point in time may be considered "normal" as a result of building high levels of capacity. We estimate this amount to be equal to 75% of the annual incremental installations.
6. "Overhang" refers to that amount of GW awaiting grid connection IN EXCESS of the targeted "normal pool" that should be awaiting connection at any point in time. The need for the grid to absorb a surplus or overhang of unconnected GW creates a risk of slowing additions to the Installed Capacity Base.

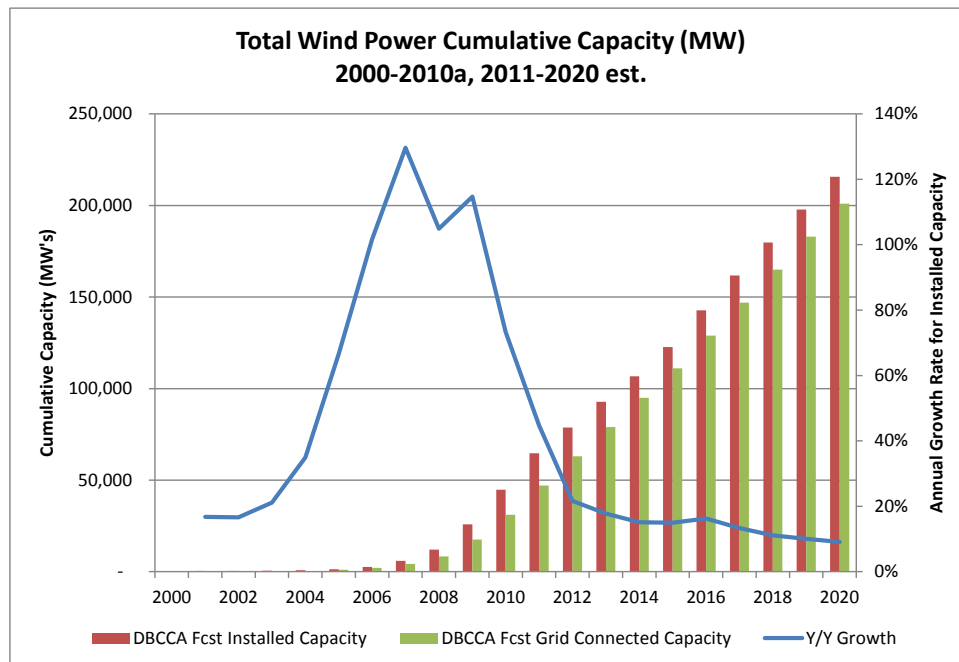
Source: National Bureau of Statistics of China, BNEF, and DBCCA analysis, 2011



Section IV – DBCCA’s Wind and Solar Power Forecast

We emphasize “connected to the grid” capacity, as we are most interested in the positive contribution wind power plays in de-carbonizing China’s energy system. As mentioned before, we believe an “overhang” in built yet unconnected capacity will serve to constrain new project construction during from 2011 into 2014. We do not believe that the “overhang” will have any impact on grid-connected capacity and, if anything, the presence of such a disruptive overhang could spur the pace of grid connections. We also forecast such overhang to diminish to zero (and, in fact, become negative, meaning the pool of unconnected capacity will be below the “normal” amount) once major grid expansion projects (e.g. new ultra high-voltage transmission lines) are completed by 2015.

Figure 22: Base Case Forecast - Near-term Connected Capacity Forecast Lags Installation



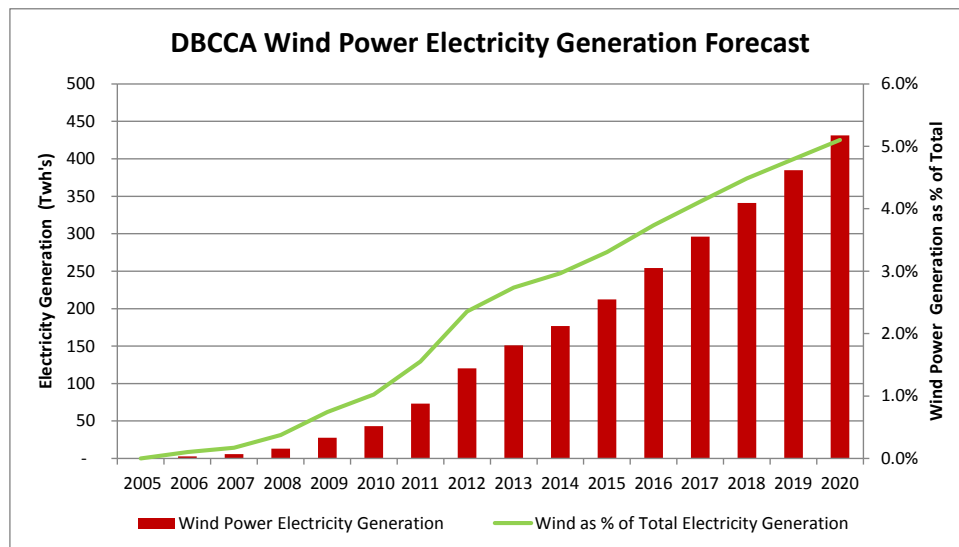
Source: China Wind Energy Association, National Bureau of Statistics of China and DBCCA analysis, 2011.

Based on our aggregate China primary energy supply, carbon emissions forecast, we believe our forecasted grid-connected wind power capacity could account for roughly 5% of total electricity produced in China in 2020. This compares to a current contribution of 1%. Figure 23 depicts the rapid increase in wind power electricity production.



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Figure 23: DBCCA Base Case Wind Power Electricity Production Through 2020



Source: DBCCA analysis, 2011.

Aggressive Case Forecast

Figure 24 (Aggressive Build Case) reflects what we think could happen if China and the industry were to expand the Installed Capacity Base at a sustained rate faster than the rate of grid connection we believe is achievable. As can be seen in Table 24, by 2020 there could be 44 GW of unconnected capacity in total. Assuming a normal amount of GW's per our assumptions for completed yet unconnected capacity awaiting connection, by 2020 a sizeable overhang of 29 GW could exist. This overhang is in addition to the normal pool of GW we estimate to be in the certification and commissioning/connection process at any point in time. *We believe the prospect of an expanding overhang of capacity sitting idle awaiting installation would serve as a materially undesirable trend from OEM equipment and project development investors' points of view.* The emergence of such a situation is not our expectation. We believe the industry and the government will demonstrate prudent planning and management of the wind power expansion program in order to avoid creation of such a sizeable overhang of wind turbines awaiting connection.



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Aggressive Build Forecast

Figure 24: DBCCA's "Aggressive Build" Forecast of China's Wind Power Capacity by Category, 2010-2020 (GW)

Installed vs. Grid Connected Analysis - Aggressive Build Case							Cumulative Additions 2011-2020	13th Five Year Plan Period					Cumulative Additions 2011-2020
	2010	2011	2012	2013	2014	2015		2016	2017	2018	2019	2020	
Plus													
Cumulative Installed Capacity Base (1), BOY	25.8	44.7	64.7	84.7	104.7	124.7		144.7	164.7	184.7	204.7	224.7	
Annual Incremental Installs	18.9	20.0	20.0	20.0	20.0	20.0	100.0	20.0	20.0	20.0	20.0	20.0	300.0
Equals													
Cumulative Installed Capacity Base (1), EOY	44.7	64.7	84.7	104.7	124.7	144.7		164.7	184.7	204.7	224.7	244.7	
Plus													
Cumulative GRID CONNECTED Base(2), BOY	17.6	31.0	47.0	63.0	79.0	95.0		111.0	129.0	147.0	165.0	183.0	
Annual GW Connected to Grid (3)	13.4	16.0	16.0	16.0	16.0	16.0	80.0	18.0	18.0	18.0	18.0	18.0	250.0
Equals													
Cumulative GRID CONNECTED Base(2), EOY	31.0	47.0	63.0	79.0	95.0	111.0		129.0	147.0	165.0	183.0	201.0	
Plus													
Total Pool of GW Awaiting Grid Connection(4), BOY	8.2	13.7	17.7	21.7	25.7	29.7		33.7	35.7	37.7	39.7	41.7	
Annual Additions from "Annual Incremental Installs"	18.9	20.0	20.0	20.0	20.0	20.0		20.0	20.0	20.0	20.0	20.0	
Minus													
Annual Incremental GW's Connected to Grid (3)	13.4	16.0	16.0	16.0	16.0	16.0		18.0	18.0	18.0	18.0	18.0	
Equals													
Total Pool of GW's Awaiting Grid Connection(4), EOY "Total Unconnected"	13.7	17.7	21.7	25.7	29.7	33.7		35.7	37.7	39.7	41.7	43.7	
Minus													
Normal Size of Pool Awaiting Connection (5)	14.2	15.0	15.0	15.0	15.0	15.0		15.0	15.0	15.0	15.0	15.0	
Equals													
"Overhang" (6)	-0.4	2.7	6.7	10.7	14.7	18.7		20.7	22.7	24.7	26.7	28.7	

Note:

1. "Installed Capacity Base" refers to wind power generation capacity that has been physically constructed, whether connected to the bulk transmission grid or not.
2. "Grid-Connected Base" refers to wind capacity that has been constructed, certified for operation, connected to the grid and commissioned for the production of power delivered into the bulk transmission grid.
3. Contingent upon successful electricity transmission grid capacity expansion becoming available in 2014 and thereafter.
4. "Total Pool Awaiting Grid Connection" refers to wind power capacity that has been constructed and is either being certified or awaiting connection to the bulk transmission system. This amount can be thought of as the total amount of GW's not yet connected to the transmission grid.
5. "Normal Pool Awaiting Grid Connection" refers to the quantity of unconnected GW that at any given point in time may be considered "normal" as a result of building high levels of capacity. We estimate this amount to be equal to 75% of the annual incremental installations..
6. "Overhang" refers to that amount of GW awaiting grid connection IN EXCESS of the targeted "normal pool" that should be awaiting connection at any point in time. The need for the grid to absorb a surplus or overhang of unconnected GW creates a risk of slowing additions to the Installed Capacity Base.

Source: National Bureau of Statistics of China, BNEF, and DBCCA analysis, 2011

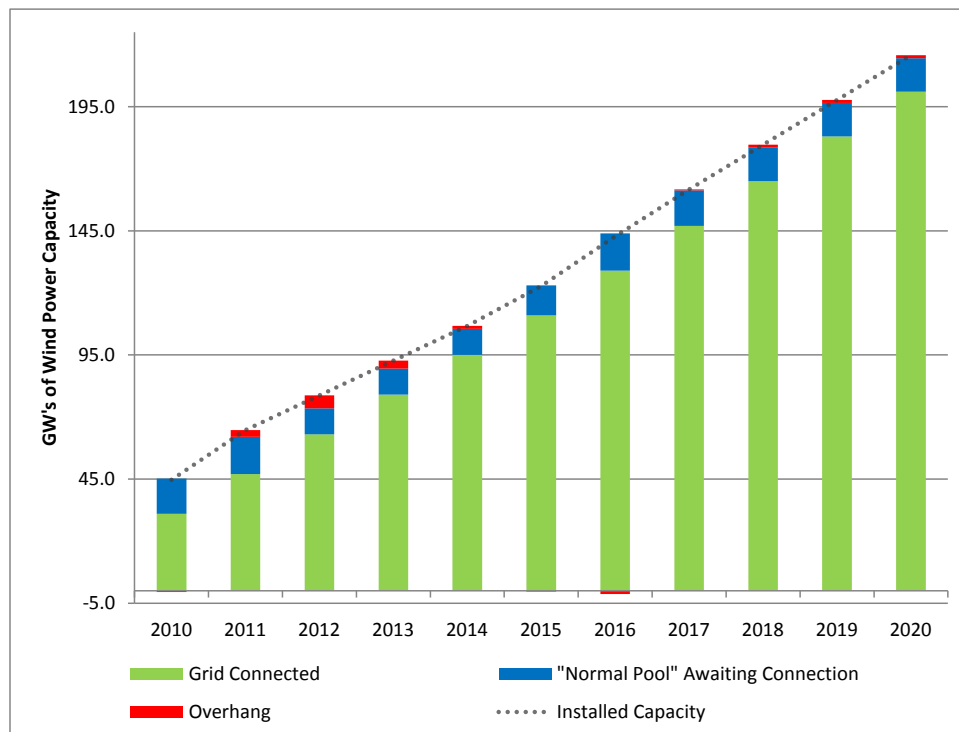


Section IV – DBCCA’s Wind and Solar Power Forecast

Comparing Overhang in DBCCA’s Base Case and Aggressive Build Scenarios

The Overhang: Putting aside grid connection difficulties and ensuing operational transmission capacity constraints, we estimate there will be a pool of “built but not connected” capacity at any point in time as wind farms go through their qualification testing and grid integration before being reclassified as “operational” from an electricity production perspective. We estimate the size of this normal pool awaiting grid connection to be equal to 75% of the annual installed capacity amount. Rapid construction and the current transmission bottlenecks are contributing to an expansion of this unconnected “overhang” of “installed” wind power compared to grid connected wind power. Based on our estimates, we estimate this overhang currently could be approximately 5 GW in our DBCCA Base Case and could swell to 29 GW in the Aggressive Build Scenario GW as depicted in Figures 21 and 24, above, unless China addresses interconnection delays and expedites transmission expansion. Figures 25 and 26, below illustrate the composition of the annual estimated cumulatively installed base of wind power in China under both our DBCCA Base Case forecast and Aggressive Build Scenarios.

Figure 25: DBCCA Base Case Wind Power Base Composition

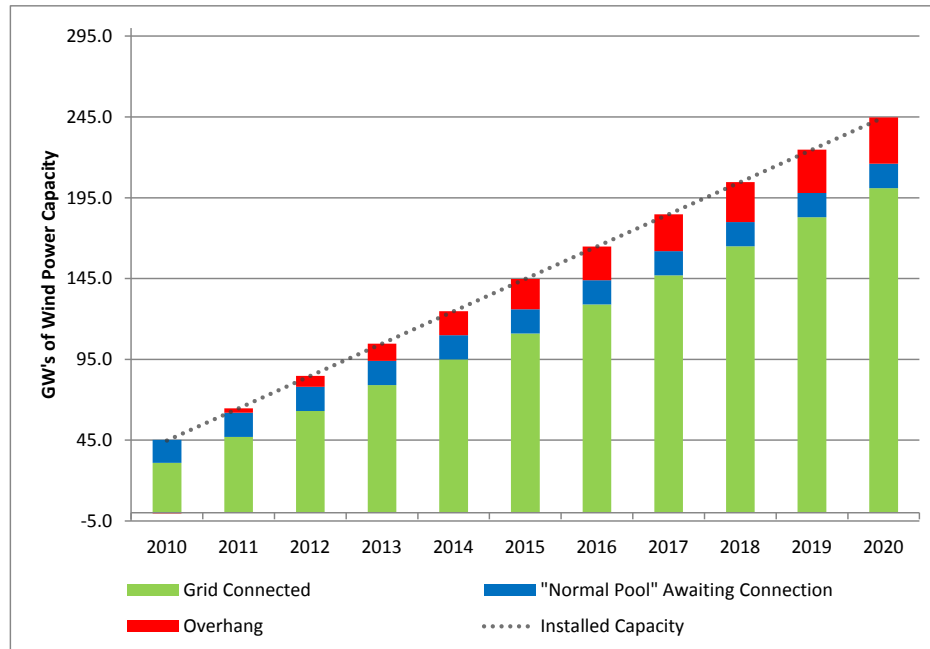


Source: DBCCA analysis, 2011.



Section IV – DBCCA’s Wind and Solar Power Forecast

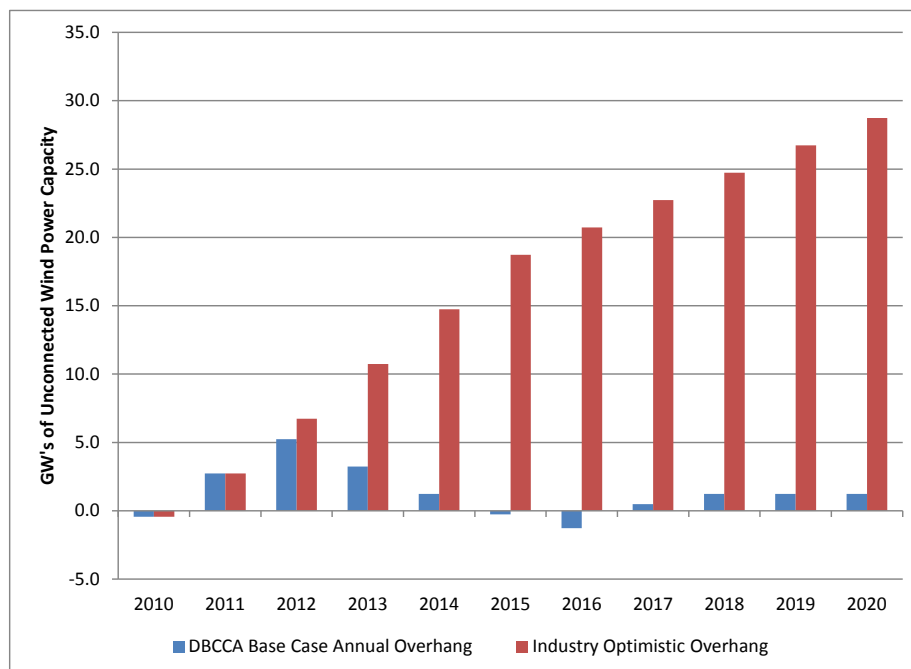
Figure 26: Aggressive Build Scenario Wind Power Base Composition



Source: DBCCA analysis, 2011.

Figure 27, below, draws the graphic comparison of the overhang amounts of our DBCCA Base Case and the Aggressive Build Scenario.

Figure 27: 29 GW of “Overhang” a Possibility



Source: DBCCA analysis, 2011.

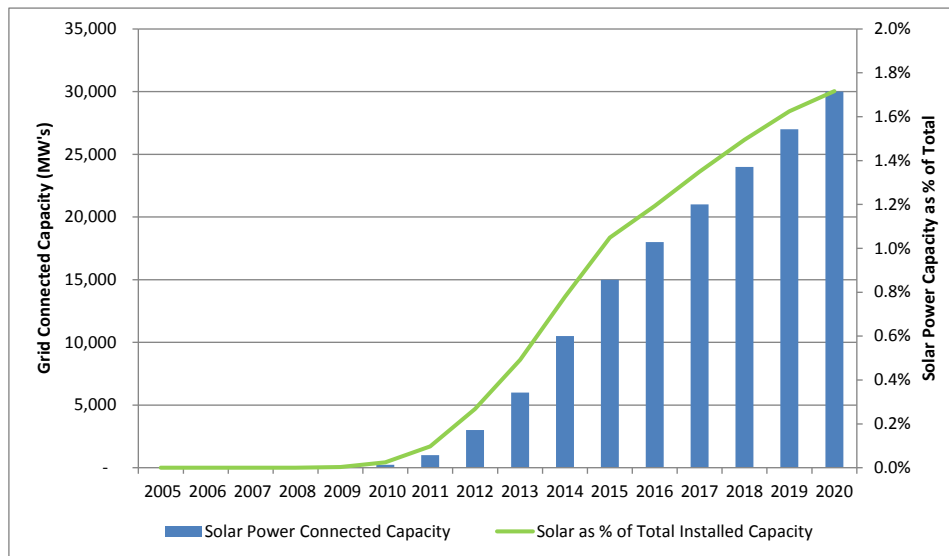


Section IV – DBCCA’s Wind and Solar Power Forecast

IV.II DBCCA Solar Power Forecast

In line with government targets, we estimate that China will continue to build solar power through 2020 by when we estimate at least 30 GW of solar power will be installed and connected to the transmission grid. As we did with our wind power forecast, we emphasize “connected to the grid” capacity, as we are most interested in the positive contribution solar power plays in de-carbonizing China’s energy system. Third party solar power deal pipeline data can be found in [Appendix I](#).

Figure 28: DBCCA’s Forecast of China’s Grid-connected Solar Power Capacity



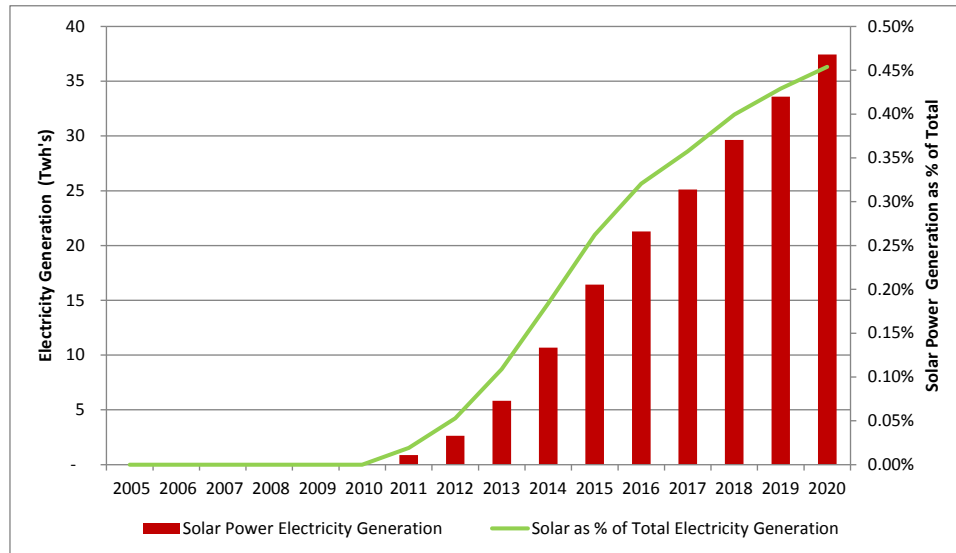
Source: DBCCA analysis, 2011.

Given the relatively remote location of the most attractive solar energy resource regions in China, we believe that completion of major transmission grid expansion will be necessary in order for China to extract the maximum benefits from solar power. Unlike in the case of wind power where natural gas resources lie in close proximity to wind farms and could, hypothetically, be relied upon to deliver stabilizing gas-fired power flows on the grid, the solar power areas may require additional gas pipeline development if the NDRC were to stabilize solar farms with gas turbines.



Section IV – DBCCA’s Wind and Solar Power Forecast

Figure 29: DBCCA Solar Power Electricity Production Through 2020



Source: DBCCA analysis, 2011.

While China has one single time zone, the east-west distances in the country are on par with the United States. As such, there is an approximate 2-3 hours difference in “solar time zones” between the eastern load centers and the western solar fields. Solar output tends to peak in the afternoon hours, slightly after peak load hours are likely to be experienced in the demand centers 2-3 “time zones” further to the east. We believe the time-shifting aspects of so remotely located grid-scale solar power will encourage China to focus more intently than most Western countries on grid-scale electricity storage systems. Being able to “bank” solar GWh and deliver this to the eastern regions as needed could make solar a unique contributor to China’s electricity system. By importing into the east stored electricity generated by solar power, China may be able to reduce coal load in the North and use the newly available transmission capacity to carry renewable wind power from the North to the South during peak wind production hours.



Appendix I – Wind and Solar “Third Party” Deal Pipelines

China’s Shifting Wind Pipeline

Although project pipelines are dynamic in nature, we believe that China’s commitment to continue supporting the sector’s growth for years to come is sincere, although contingent on major electricity transmission grid expansion for years to come. In March 2011, Azure International estimated a wind pipeline through 2015 of 97 GW, of which 56 GW was described as “imminent” with 28 GW already on OEM’s order books. By 2020, Azure estimated the pipeline to be approximately 285 GW. Table 1 summarizes Azure’s March 2011 assessment of the China wind power pipeline.

Table 1: March 2011 Pipeline Appeared Robust...

	2010 Existing	Azure International’s Near Term Pipeline(2015)	Azure International’s Long Term Pipeline(2020 ⁺)
Wind Power Capacity	45 GW	97 GW	285 GW
Unofficial Government Target	N/A	20 GW annual installation	200 ⁺ GW
Number of projects/sites	700 ⁺ operating projects	1000 ⁺ sites	1500 ⁺ site
Avg. wind turbine age	1 year	N/A	N/A

Source: Azure International (March 2011) and DBCCA analysis, 2011.

Comparing Azure’s March 2011 pipeline to more current estimates shows the effect of the overhang of built yet unconnected turbines. More current August 2011 pipeline data from Bloomberg’s New Energy Finance group suggests approximately 73 GW of incremental capacity additions in the 2012-2015 period of which 18 GW – 21 GW are planned for installation by the end of 2012. Table 2 provides a grid-based view of Bloomberg’s BNEF Group’s pipeline forecast through 2015. We attribute this reduction in the deal pipeline to both transmission grid constraints and a growing overhang of installed yet unconnected wind turbines combined with August 2011 material policy changes taking permitting authority away from provincial leadership and centralizing all permitting activity within the NDRC’s National Energy Board.

Table 2: Yet by August, Policy Actions to Cool the Market had Effect

	Aug 2011 Cumulative Installed Capacity	2015 New Additional Capacity Target	NDRC Pre-approved Capacity
North China Grid	15,342	23,688	8,565
Northeast China Grid	15,251	21,888	7,855
East China Grid	3,295	2,644	1,760
Central China Grid	630	3,677	1,480
South China Grid	1,667	2,843	1,460
Northwest China Grid	8,394	18,118	4,710
Total	44,579	72,859	25,830

Source: BNEF and DBCCA analysis, 2011

Having come through a period where the pace of new turbine construction exceeded the pace of grid connection, China must now absorb an overhang of built yet unconnected turbines (again, “overhang” representing a surplus of



Appendix I – Wind and Solar “Third Party” Deal Pipelines

installed-yet-unconnected turbines in excess of a “normal” pool approximately equal to 75% of the year’s annual incremental installed capacity) while simultaneously conducting necessary electricity transmission grid capacity expansion. For 2012, we think this overhang may be approximately 4 GW of capacity and thus may serve as a drag on 2012 new construction plans.

Solar Pipeline – 16 GW, Well Distributed

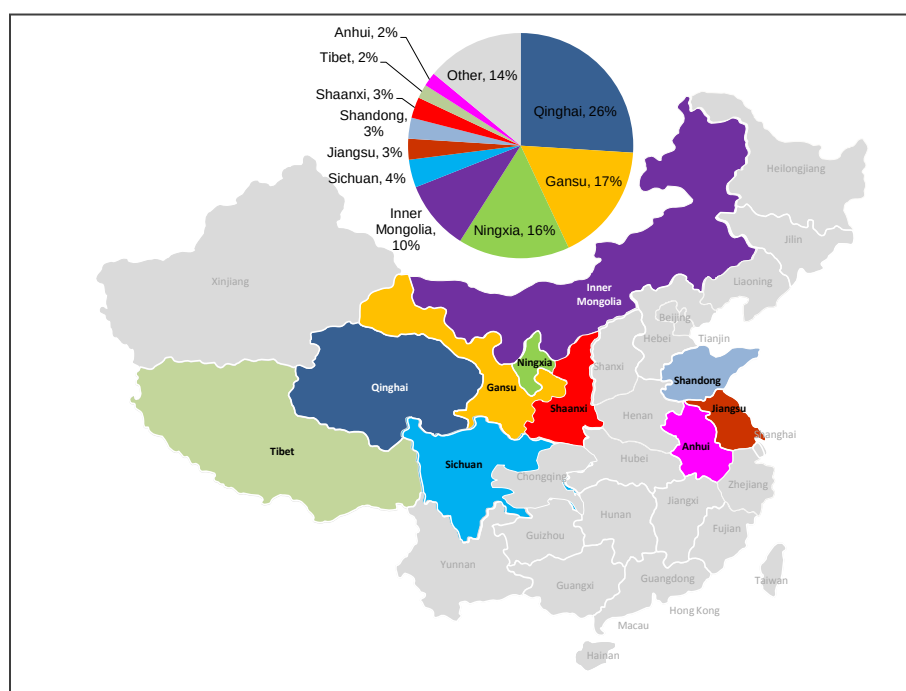
Both Bloomberg New Energy Finance and Solarbuzz estimate approximately 16 GW deal pipelines through the 2015 period. These fit with industry and government commentary that continues to point toward an increase to perhaps 15-20 GW by 2015 compared to the “up to 10 GW” target in the 12th Five Year Plan.

Table 3: BNEF Solar Pipeline segmented by Grid Regions

	Agreed Resource	Announced or Planning Begun	Permitted	Financing Secured or Under Construction	Commissioned		Total
					Partially	Fully	
North China Grid	995	1,441	33	471	17	52	3,008
Northeast China Grid	995	1,041	36	76	0	5	2,154
East China Grid	20	851	65	66	0	113	1,114
Central China Grid	0	935	3	65	0	18	1,020
South China Grid	0	477	0	26	101	45	649
Northwest China Grid	2,170	3,339	289	1,169	65	572	7,604
Total	4,180	8,084	426	1,873	182	804	15,549

Source: BNEF and DBCCA analysis, 2011.

Figure 1: Solarbuzz’ 16 GW China Pipeline Segmented by Provinces



Source: Solarbuzz and DBCCA analysis, 2011.



Appendix II – NREL’s China Wind Energy Resource Estimate

Appendix II – NREL’s China Wind Energy Resource Estimate (2008)

The United States Department of Energy’s National Renewable Energy Laboratory (“NREL”) in conjunction with China’s China Hydropower Engineering Consulting Group, conducted a resource estimate for selected portions of 25 of China’s 33 provincial departments. These aggregate lands surveyed accounted for approximately 48% of China’s total surface area (9.6 million km²) and of the lands surveyed (4.6 million km²), 58% of the surveyed region (2.7 million km²) was fully analyzed to determine aggregate wind energy potential. A similar exercise was undertaken for the coastal regions extending 20-30km from the shoreline. Wind energy levels were assessed with an array of 40m and 70 m survey towers for 366 day period drawn from daily data set spanning 15 years.

The wind energy resource survey did not assess how practical or economic it might be to develop wind power systems in all acreage measured and analyzed. The objective of the survey was to develop a high-level understanding of the wind energy resources rather than a precise estimate of economically developable resources. That being said, the survey estimates 3.2 TW of onshore wind energy resource assuming complete development of all surveyed areas without regard to cost or practicality assuming a 5 MW/km² installation estimate. Offshore resources are estimated to comprise 804 GW using similar assumptions of 100% of surveyed areas at 5 MW/km². Collectively, this survey suggests a total national wind resource of approximately 4 TW. We emphasize this estimate is a maximum theoretical limit as it takes into account neither technical nor economic feasibility. Nonetheless, as technology improves and costs decline, it appears that China could continue to mine the skies for decades to come.

Figure 2: Offshore Wind Energy Resource Estimates

Province	Moderate			Good to Excellent (Km2)			Moderate to Excellent Potential (MW)		
	Area (Km ²)	Potential (MW)	% Total National Potential	Good to excellent (Km2)	Potential (MW)	% Total National Potential	Total	% of Moderate	% of Good to Exc.
Guangdong	16,296	81,480	64.5%	25,493	127,465	19.3%	208,945	39%	61%
Shangdong	2,729	13,645	10.8%	23,782	118,910	18.0%	132,555	10%	90%
Zhejiang	3,449	17,245	0.1%	25,731	128,655	19.4%	145,900	12%	88%
Liaoning	1,585	7,925	6.3%	21,634	108,170	16.4%	116,095	7%	93%
Fujian	888	4,440	3.5%	16,505	82,525	12.5%	86,965	5%	95%
Jiangsu	955	4,775	3.8%	21,634	47,630	7.2%	52,405	9%	91%
Hebei	381	1,905	1.5%	5,551	27,755	4.2%	29,660	6%	94%
Shanghai	1,626	8,130	6.4%	2,678	13,390	2.0%	21,520	38%	62%
Tianjin	36	180	0.1%	1,404	7,020	1.1%	7,200	3%	98%
Guangxi	740	3,700	2.9%	0	0	0.0%	3,700	100%	0%
Total	28,685	143,425	100%	144,412	661,520	100%	804,945	18%	82%

Source: “China Wind Energy Resource Mapping Activity,” NREL, August 2008 and DBCCA analysis, 2011



Appendix II – NREL's China Wind Energy Resource Estimate

Figure 3: Onshore Wind Energy Resource Estimates

Province	Wind Class	Area (km ²) by Distance from Shore				Potential (MW) by Distance from Shore			
		0 - 10 km	10 - 20 km	> 20 km	Total	0 - 10 km	10 - 20 km	> 20 km	Total
Fujian	3	885	3	0	888	4,425	15	0	4,440
	4	878	1	0	879	4,390	5	0	4,395
	5	1,142	41	0	1,183	5,710	205	0	5,915
	6	3,049	727	132	3,908	15,245	3,635	660	19,540
	7	4,807	4,316	1,412	10,535	24,035	21,580	7,060	52,675
	Mod. to Good t	10,761	5,088	1,544	17,393	53,805	25,440	7,720	86,965
	Good t	9,876	5,085	1,544	16,505	49,380	25,425	7,720	82,525
Guangdong	3	12,115	4,128	53	16,296	60,575	20,640	265	81,480
	4	7,325	8,804	2,049	18,178	36,625	44,020	10,245	90,890
	5	1,650	3,050	148	4,848	8,250	15,250	740	24,240
	6	962	838	42	1,842	4,810	4,190	210	9,210
	7	111	479	35	625	555	2,395	175	3,125
	Mod. to Good t	22,163	17,299	2,327	41,789	110,815	86,495	11,635	208,945
	Good t	10,048	13,171	2,274	25,493	50,240	65,855	11,370	127,465
Guangxi	3	102	632	6	740	510	3,160	30	3,700
	4	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0
	Mod. to Good t	102	632	6	740	510	3,160	30	3,700
	Good t	0	0	0	0	0	0	0	0
Hebei	3	381	0	0	381	1,905	0	0	1,905
	4	595	442	0	1,037	2,975	2,210	0	5,185
	5	1,335	381	11	1,727	6,675	1,905	55	8,635
	6	392	1,741	654	2,787	1,960	8,705	3270	13,935
	7	0	0	0	0	0	0	0	0
	Mod. to Good t	2,703	2,564	665	5,932	13,515	12,820	3,325	29,660
	Good t	2,322	2,564	665	5,551	11,610	12,820	3,325	27,755
Jiangsu	3	954	1	0	955	4,770	5	0	4,775
	4	2,803	766	3	3,572	14,015	3,830	15	17,860
	5	1,807	3,741	406	5,954	9,035	18,705	2030	29,770
	6	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0
	Mod. to Good t	5,564	4,508	409	10,481	27,820	22,540	2,045	52,405
	Good t	4,610	4,507	409	9,526	23,050	22,535	2,045	47,630
Liaoning	3	1,584	1	0	1,585	7,920	5	0	7,925
	4	2,904	1,103	25	4,032	14,520	5,515	125	20,160
	5	5,815	2,948	76	8,839	29,075	14,740	380	44,195
	6	2367	6061	335	8,763	11,835	30,305	1675	43,815
	7	0	0	0	0	0	0	0	0
	Mod. to Good t	12,670	10,113	436	23,219	63,350	50,565	2,180	116,095
	Good t	11,086	10,112	436	21,634	55,430	50,560	2,180	108,170
Shandong	3	2,540	189	0	2,729	12,700	945	0	13,645
	4	3,549	2,394	49	5,992	17,745	11,970	245	29,960
	5	4,406	3,946	652	9,004	22,030	19,730	3260	45,020
	6	2683	5322	781	8,786	13,415	26,610	3905	43,930
	7	0	0	0	0	0	0	0	0
	Mod. to Good t	13,178	11,851	1,482	26,511	65,890	59,255	7,410	132,555
	Good t	10,638	11,662	1,482	23,782	53,190	58,310	7,410	118,910
Shanghai	3	1,169	372	85	1,626	5,845	1,860	425	8,130
	4	860	697	342	1,899	4,300	3,485	1,710	9,495
	5	73	590	113	776	365	2,950	565	3,880
	6	1	2	0	3	5	10	0	15
	7	0	0	0	0	0	0	0	0
	Mod. to Good t	2,103	1,661	540	4,304	10,515	8,305	2,700	21,520
	Good t	934	1,289	455	2,678	4,670	6,445	2,275	13,390
Tianjin	3	36	0	0	36	180	0	0	180
	4	164	0	0	164	820	0	0	820
	5	592	527	5	1,124	2,960	2,635	25	5,620
	6	84	32	0	116	420	160	0	580
	7	0	0	0	0	0	0	0	0
	Mod. to Good t	876	559	5	1,440	4,380	2,795	25	7,200
	Good t	840	559	5	1,404	4,200	2,795	25	7,020
Zhejiang	3	2,765	652	32	3,449	13,825	3,260	160	17,245
	4	2,610	577	349	3,536	13,050	2,885	1,745	17,680
	5	3,487	1,490	121	5,098	17,435	7,450	605	25,490
	6	6596	7745	2419	16,760	32,980	38,725	12095	83,800
	7	69	53	215	337	345	265	1075	1,685
	Mod. to Good t	15,527	10,517	3,136	29,180	77,635	52,585	15,680	145,900
	Good t	12,762	9,865	3,104	25,731	63,810	49,325	15,520	128,655
Total	3	22,531	5,978	176	28,685	112,655	29,890	880	143,425

Source: "China Wind Energy Resource Mapping Activity," NREL, August 2008 and DBCCA analysis, 2011



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