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China: West or East Wind

Getting the Incentives Right

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Abstract

With rapid development of wind power in China, the following three issues have become barriers for further scale-up: 1) concentration of wind farms in the Three-North region, which became significantly underutilized because of a limited capability of local power grids to off-take and consume wind-generated electricity and because of a lack of coordinated development of long-distance transmission lines to deliver electricity to load centers in the South and East regions; 2) increasing subsidies and, thus, a burden on final consumers; and 3) resistance of local authorities to develop new projects because the new value added tax policy reform. How to deal with these issues will have significant impact on the future development of wind in China. This note proposes a methodology to enhance a comprehensive approach by taking both generation and transmission into account in crafting the development plan and formulating the incentive policies, which may be useful in addressing these issues.

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China: West or East Wind

Getting the Incentives Right [1]

Yanqin Song and Noureddine Berrah

Key words: wind power concentration, increasing subsidy burden, VAT reform impact, cost and effectiveness

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Introduction

1. China has abundant renewable energy sources, including solar, hydropower, biomass, as well as wind. Since the late 1980s different incentive policies were developed to promote renewable energy with greater focus on wind in the North, Northwest, and Northeast regions (referred to hereafter as "Three-North;" see Figure 1). These policies played a very important role in increasing the development of renewable energy and creating a large market that propelled China's renewable energy industry to a leading position globally.

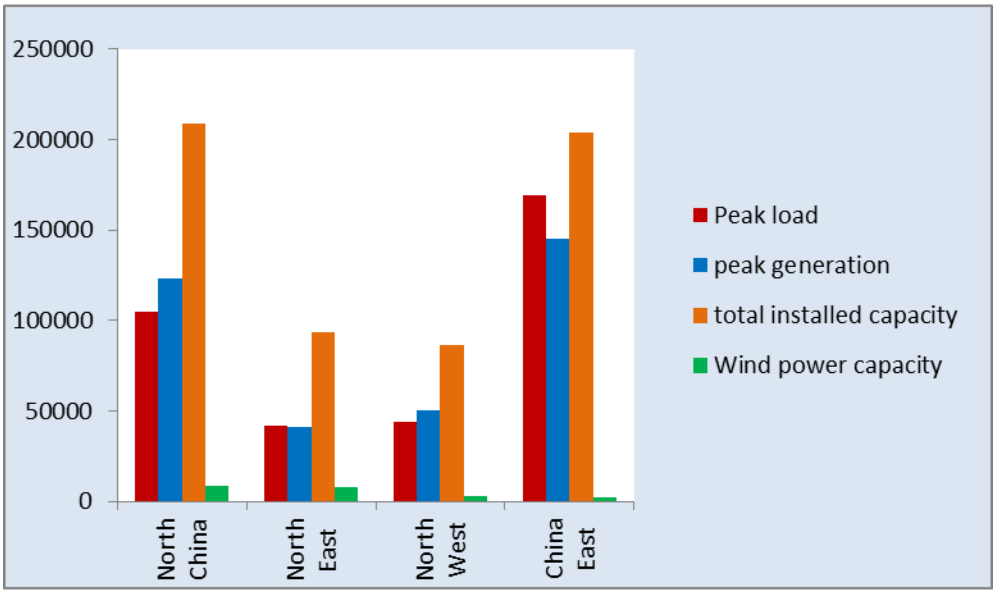

Figure 1: Wind Resources in Three-North, with Load and Capacity Distribution

Note: The figures in brackets are the installed capacity of wind in the region and its share in the total capacity in the whole country.

2. Despite their impact on the impressive growth in the renewable sector, these policies have been developed largely on a piecemeal basis and in some cases have created unintended effects that have led to the suboptimal development of renewable resources. Among all renewable energy technologies, wind power experienced the most rapid development and triggered a national debate about the drive for more ambitious development targets, the scale of subsidization, pricing, and taxation. Currently, following China's pragmatic reform and policy development approach, central government agencies are reviewing the results to further strengthen these policies to increase positive impacts and reduce the unintended negative effects.

3. This paper aims to demonstrate that the existing incentives, anchored by the wind FIT policy, favor the Three-North region and that, under present circumstances, there may be

more economic wind resources in the Southeast region. The paper first takes a quick look back at wind power development in China, then reviews the incentive policy structure, and evaluates some of the main impacts it has had on the wind power sector development. The paper especially focuses on the introduction of wind FIT in 2009 and VAT tax reforms, along with their effects on equipment manufacturers, developers, and local and central governments.

Chapter 1: Wind Power Development: A Quick Look Back

4. Grid-connected wind power development in China started in the early 1980s and lingered for more than two decades before surging forward during the 11th Five-Year Plan (FYP 2006–10). Installed capacity increased from almost nothing in 1980 to 4.2 MW in 1990, 344 MW in 2000, and 44 GW in 2010. Broadly, wind power capacity in China developed in four stages:

- Initial demonstration.
- Industrialization.
- Scaling up and turbine manufacturing localization supported by a concession program.
- Development of large-scale wind power bases supported by a FIT.

5. In the initial demonstration stage (1986–93), projects were implemented mostly for demonstration and for scientific research and development—that is, not for commercial purposes. Off-take prices for these projects were mostly aligned with the tariffs of local coal-fired plants, approved by the national and local price agencies and documented in PPAs between developers and grid companies. Off-take prices hovered around Y 0.28/kWh, which was a windfall for developers, since the turbines were mostly donated by international aid agencies through international cooperation projects.

6. The industrialization phase started in 1994, with the Chengfeng Plan of the State Planning Commission (SPC) and the Shuangjia Plan and Wind Turbine Localization Promotion Project of the State Economic and Trade Commission (SETC). Both introduced special policies to support domestic equipment manufacturing and to start commercial development. In 1994, the government mandated that grid companies facilitate the connection of wind farms and purchase all the electricity they generate. Off-take prices were calculated based on the "new plant/new price" policy, which ensured that revenues would enable developers to repay debt and secure reasonable profits. Off-take prices were agreed between the developers and grid companies, and approved by concerned price control agencies. This led to a wide range of tariffs—from RMB 0.38/kWh[2] to RMB 1.2/kWh[3].

7. During this stage, most of the wind farms were small (10 MW or less) and mostly developed by local grid companies or their associates. A general motivation was to improve their image and ensure approval of their conventional projects by local and/or national

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[2] Zhangbei Wind farm by China Energy Conservation Investment Company.

[3] Kuocangshan Wind Farm in Zhengkiang.

agencies. There was no mechanism to pass the incremental cost of wind electricity to end users, but the developers managed to cover incremental costs because they were insignificant compared to their revenues and profits. Because of this ad hoc approach, China failed to reach its 8th and 9th FYP development targets. The actual installed capacity by 2000 was only 344 MW compared to the central government's 1,000 MW target.

8. During the 8th and 9th FYPs, the SPC was responsible for new projects, and the SETC was in charge of retrofit and rehabilitation projects. This created confusion and allowed companies to take advantage of the loose and unclear institutional setup. For example, when seeking approval for a wind farm, developers would name it a new or a rehabilitation project depending on their relationship with the approving agency. This problem was addressed in 2003 when the SETC was merged with the SPC to create the National Development and Reform Commission (NDRC). This streamlined policy development processes, and the situation improved significantly.

9. In the third phase, to promote large scale wind power development, NDRC initiated the wind power concession program to introduce competition and rely on bid-based off-take prices. In 2003, it launched the first concession tender, mandating that turbine local content promote the country's wind industry. From 2003 to 2008, five concession tenders were organized; at first, there were 50 percent local content mandates, which were later increased to 70 percent. However, this requirement was removed because it was construed as a breach of World Trade Organization (WTO) rules. The electricity off-take price was theoretically determined by the winning bid price up to 30,000 hours of full load operation and at the average network electricity price for generation exceeding that amount. The contract was for 25 years. The lowest bid (later changed to the price closest to the average of the bidding price with the highest proportion of local content) was awarded the concession project.[4]

10. During this period, two major events significantly promoted wind power development in China: (a) China's commitment to significant wind power targets during the Renewable Energy Conferences in Bonn and Beijing in 2004 and 2005, respectively; and, more importantly, (b) the passage (February 28, 2005) and enactment (January 1, 2006) of the Renewable Energy Law. The law laid a solid foundation and provided unprecedented support to large-scale development of wind power in China. Additionally, higher targets were set by the government in the Renewable Energy Medium and Long Term Development Plan, published in 2007.

11. This legislation and the established policy framework provided incentive mechanisms for scaling up renewable energy—and in particular triggered an unprecedented development of wind power in China. By the end of 2008, the total installed wind power capacity had

[4] It must be noted that several developers or manufacturers, especially international ones, complained that the process was biased and bidding prices were influenced by statements made by high-level NDRC officials. These claims seem to be, at least partially, legitimate because many developers who had bid prices lower than the "informal cap prices" set by NDRC officials later received subsidies to improve the return on their projects.

reached 12,200 MW (see Figure 2), and developers began facing shortages of wind turbine supply. Many companies started investing in wind turbine manufacturing. By 2010, there were more than 80 manufacturers. The total capacity of turbines manufactured by Chinese companies in 2010 reached 10 GW.

12. Furthermore, another significant contributor to the fast growth of wind power in China was the reliance on the Clean Development Mechanism (CDM) to increase developers' revenues. Although there are no unambiguous statistics on the percentage of wind farm projects in China that applied for CDM registration, it is clear that a large number of the wind projects developed from 2005 applied for CDM and many of them were successfully registered by the CDM Executive Board of the United Nations Framework Convention on Climate Change (UNFCCC). Unit prices of Certified Emission Reductions (CERs) increased by US cent 1–1.5/kWh and indeed contributed to the wind power surge during this period.

13. In 2008, the CDM Executive Board of the UNFCCC reviewed and rejected 10 wind farm projects from China, stressing inconsistencies in the pricing policy that allowed wind farm developers in different regions to claim "additionality" for their projects. In response, the Climate Change Department of the NDRC and the Chinese Renewable Energy Industry Association (CREIA) argued that the prices were the result of competitive bidding and that differences were justified because pricing mechanisms were periodically adjusted to meet the wind power market's development needs. In the end, this event contributed to the transition from the wind concession program to the present FIT policy.

14. The fourth stage is characterized by (a) the introduction of the FIT policy in 2009; (b) the decision to develop seven 10 GW wind bases, six of them in the Three-North region; (c) the initiation of offshore demonstration projects; and (d) the increase of the 2020 national wind power development target to 200 GW.[5]

15. The NDRC (and later the National Energy Administration, NEA[6]) shifted from the wind concession program to the FIT as the main policy to support wind power development. The five rounds of the concession program provided sufficient experience and lessons and contributed to the formulation of the FIT policy. Furthermore, the Renewable Energy Law was amended in 2009 to mandate wind power off-take by grid companies. This new policy theoretically provided a stable and predictable market for potential investors and reduced market risks, since it ensured connection to the grid and off-take of all renewable generated electricity.

16. The established FIT scheme is differentiated into four groups by wind resource classification, based on the energy density at a 70 meter height: type I (higher than 510 W/m^2),

[5] This is the target was announced by National Energy Administration on July 7, 2012.

[6] The NEA consists of nine departments, including a Department of New Energy, which is responsible for formulating and implementing renewable energy development plans and industrial policies, for promoting institutional reform in the renewable energy sector, and for administering renewable energy sector.

type II (between 460 and 510 W/m^2), type III (between 390 and 460 W/m^2), and type IV (lower than 390 W/m^2). Each group was offered a fixed tariff: I—RMB 0.51/kWh, II—RMB 0.54/kWh, III—RMB 0.58/kWh, and IV—RMB 0.61/kWh. (See Table 1.)

Table 1: Category of Wind Energy Resources by Area

Category of wind energy resources area	Wind energy density at the height of 70 m (W/m^2)	Feed-in tariff (yuan/kWh)	Typical areas
Type I	>510	0.51	The areas in Inner Mongolia Autonomous Region, except Chifeng City, Tongliao City, Xing'an League, and Hulunbeier City; Urumuqi City of Xinjiang Uygur Autonomous Region, Yili Kazak Autonomous Prefecture, Changji Hui Ethnic Autonomous Prefecture, Kalamayi City, and Shihezi City.
Type II	460～510	0.54	Zhangjiakou City and Chengde City of Hebei Province; Chifeng City, Tongliao City, Xing'an League, and Hulunbeier City of Inner Mongolia Autonomous Region; Zhangye City, Jiayuguan City, and Jiuquan City of Gansu Province.
Type III	390～460	0.58	Baicheng City and Songyuan City of Jilin Province; Jixi City, Shuangyashan City, Qitaihe City, Shuihua City, Yichun City, Daxing'anling area of Heleijiang Province; the area of Gansu Province, except Zhangye City, Jiayuguan City and Jiuquan City; the areas in Xinjiang Uygur Autonomous Region, except Urumuqi City of Xinjiang Uygur Autonomous Region, Yili Kazak Autonomous Prefecture, Changji Hui Ethnic Autonomous Prefecture, Kalamayi City, and Shihezi City.; and Ningxia Hui Ethnic Autonomous Region.
Type IV	≤390	0.61	Other areas except Category I, Category II, Category III and IV.

17. To cover the renewable energy (including wind) incremental costs (wind generation cost minus the region's conventional power network average cost), China's Renewable Energy Law established a RMB 0.004/kWh[7] electricity surcharge on electricity consumption. Total surcharge revenues that accumulated from 2006 to 2010 amounted to roughly RMB 16 billion (US$2.54 billion), of which 70 percent were used for wind power subsidies.

18. According to the most recent wind power industry development report,[8] grid-connected wind capacity reached 44 GW, and annual wind electricity generation reached 50.1 TWh by the end of 2010. The 12th FYP increased the wind capacity target to 100 GW by 2015. The target for 2020 might be increased to 150 GW, 5 times the target announced in 2007 (see Figure 2).

[7] The surcharge increased to 0.008 RMB/kWh in 2012.

[8] "Wind Turbine Installed Capacity in 2010," Chinese Wind Energy Association.

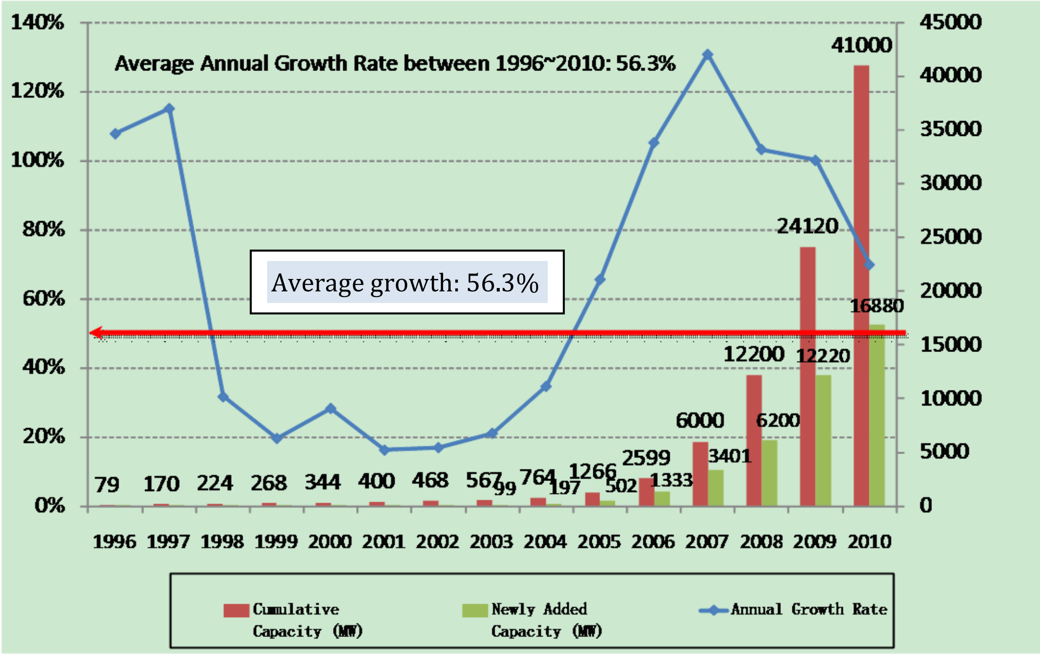

Figure 2: Development of the Wind Power Market in China

19. With the extraordinarily rapid development of wind, a series of issues arose:

- Concentration of the wind farms in the Three-North region, which became significantly underutilized (overall capacity factor was about 14 percent in 2010) because of a limited capability of local power grids to off-take and consume wind-generated electricity and because of a lack of coordinated development of long-distance transmission lines to deliver electricity to load centers in the South and East regions (750 MW[9] were denied connection to the grid).
- Increasing subsidies and, thus, a burden on final consumers.
- Resistance of local authorities to develop new projects because the new VAT policy reform.

These issues are described and discussed in the following chapter.

[9] State Electricity Regulatory Commission (SERC) report, 2011.

Chapter 2: Financial and Taxation Issues

Weak Performance of China's Wind Farms

20. The current regional FIT level is based primarily on considerations of resource endowments and the physical construction conditions. *Availability of local demand, which is important for local consumption, does not seem to have been taken into account adequately*. The FIT policy is intended to encourage development of good wind resources at a low generation cost. It indeed promoted the construction of wind power bases with a large capacity and strongly supported the local industry's development.

21. However, the rapid development of wind farms resulted in serious issues, especially with grid integration. The developers' enthusiasm and the number of wind farms continued to grow, while congestion became a serious problem and threats on grid safety and stability increased. In the 11th FYP, the installed capacity in Inner Mongolia increased from about 100 MW in 2005 to 10 GW in 2010, but there was no significant upgrade of the transmission capacity. Nationally by June 2010, the wind capacity not connected to the grid reached 750 MW, and this could increase significantly as capacity under construction amounted to about 16 GW. There are concerns also over suboptimal use of wind resources resulting from wake and micrositing issues. Usually for a large-scale wind farm in China, efficiency losses from wake are at least 2 percent.[10] The overall capacity factor of wind power is less than 15 percent, indicating a low level of efficiency. However, there are no studies that accurately assess these losses. Finally, grid companies refused to off-take wind-generated electricity for stated financial and/or institutional reasons. The worst case is in Inner Mongolia, which is taken as a case below. The discussion in the rest of this chapter focuses primarily on the Three-North region.

22. Wind power generation losses reached 2,760 GWh in 2009 and 2,770 GWh in the first half of 2010 nationwide, accounting for more than 10 percent of the total generation from wind (see Table 2). For the ease of the discussion, the total generation and generation loss in the whole year of 2010 is estimated by doubling the data in the first half of 2010. The losses are detailed as follows:

- Wind electricity generation losses in North China amounted to more than 1,500 GWh, accounting for about 57 percent of the wind power generation losses at the

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[10] According to the operational experience in California in the United States, the efficiency losses from the wake effect is about 10 percent on average (2 percent to 30 percent). In North China, the torrential characteristics of many wind farms are similar to those in California; therefore, they may have a similar wake effect ("China Electric Power," November 1998). However, this conclusion might underestimate the wake effect in China, since the size of North China's wind farms is much greater than California's and micrositing in China is less than optimal. In addition, wake and micrositing analysis was not part of the scope of the study, but the report refers to similar recommendations and further elaboration in the World Bank/ASTAE publication, "China: Meeting the Challenges of Offshore and Large-Scale Wind Power: Strategic Guidance" (ASTAE/World Bank: 2010).

national level, about 14 percent higher than the share of the region's total generation in the country's wind power generation (about 43 percent).

- Generation losses in Northwest China were not as significant as in North China. The total losses in 2010 amounted to 305 GWh, accounting for 11 percent of wind power losses at the national level. But because of the fast development of the wind base in Jiuquan, Gansu Province, generation losses are bound to become more and more serious in this region.
- At the provincial level, generation losses in Inner Mongolia amounted to about 2,100 GWh, accounting for 79 percent of the total generation losses at the national level (Inner Mongolia overlaps on both North China and Northeast Grid), about 44 percent higher than the share of the province's total generation in the country's wind power generation, which is about 35 percent.

23. The financial and environmental impact of the wind power generation losses were US$433 million in 2010, of which US$254 million were from environmental impacts and US$179 million from unrealized potential coal saving[11].

24. The estimate of the lost environmental benefits per ton of coal equivalent (TCE) is based on the following formula:

> Environmental benefit losses = [wind generation loss (kWh)*index of coal consumption (TCE) per unit of electricity generation on average in the network (g/kWh)]/1,000,000 * [index of TSP per TCE (t/TCE) * credit per unit of TSP (US$/t) + index of SO_2 per TCE(t/TCE) * credit per unit of SO_2 (US$/t) + index of NO_x per TCE(t/TCE) * credit per unit of NO_x (US$/t) + index of CO_2 per TCE(t/TCE) * credit per unit of CO_2 (US$/t)]
>
> *Total environmental benefit losses were estimated by multiplying the "environmental benefit losses per TCE" by the total coal consumption that could have been avoided if all wind-based electricity could have been used.*

The calculation is based on the following assumptions (see Table 2): Indexes of environmental pollution per TCE shown in Table 2 are derived from a SEPA (State Environment Protection Administration) study in collaboration with the World Bank completed in 2008 and the index of coal consumption (TCE) per unit of electricity generation on average in the network (g/kWh) is derived from the 2010 electricity yearbook.

[11] The actual financial and environmental losses

Table 2: Environmental Benefit per TCE and the Total Losses from Lost Wind-Based Generation, Three-North Region, 2010

Pollutants	Units	SEPA study	Pollution index per TCE(t)	Environmental benefit losses per TCE (US$/TCE)	Losses from lost generation (million US$)
TSP	US$/ton	5,801	0.017	98.617	183
SO_2	US$/ton	379	0.022	8.338	16
NO_x	US$/ton	269	0.01	2.69	5
CO_2	US$/ton	10	2.7	27	50
Total			2.749	137	254

Note: For coal, the price is US$100/TCE, and the coal consumption for power generation is 334 g/kWh.
Source: Beijing Energy Saving and Environment Protection Center and China's New Renewable Energy Target: The Green Leap Forward (ESMAP and the World Bank Policy Note).
Source: The benefit lost resulting from wind generation loss is based on the data in Table 3.

25. The wind generation losses in 2009 and 2010 in selected regions are in Table 3.

Table 3: National wind power generation loss in selected region, 2009 and 2010[12]

	On-grid generation (GWh)		Generation loss (GWh)		Share of generation loss as % of wind generation	
	2009	2010	2009	2010	2009	2010
Inner Mongolia	8,470	14,366	1,986	4,202	19.0	22.6
West	5,971	10,506	1,468	3,054	19.7	22.5
East	2,499	3,860	518	1,148	17.2	22.9
Jilin	2,009	2,852	194	520	8.8	15.4
Gansu	1,153	1,876	181	248	13.6	11.7
Heilongjiang	1,497	2,816	113	332	7.0	10.5
Liaoning	2,537	4,568	23	128	0.9	2.7
Hebei	2,333	4,604	264	122	10.2	2.6
Others	7,611	13,426	0	0	0.0	0.0
Total	25,610	44,508	2,761	5,552		

Note: Data for 2010 are estimated by multiplying the data in the first half of 2010 by 2[13].
Source: Inspection Report of Wind Power and Photovoltaic Generation, State Electricity Regulatory Commission (SERC), January 2011, and team's calculation.

[12] According to SERC's report, the generation losses are 12.3 TWh and 20 TWh in 2011 and 2012 respectively.

[13] According to statistics in SERC's report, the total wind power generation was 49.4 TWh. The generation losses was about 10 percent of it.

The calculated environmental losses are provided in Table 4.

Table 4: Estimated Unrealized Environmental Benefits from Wind Generation Losses in Selected Regions, 2009–2010

	Unrealized potential coal saving (US$ millions)		Unrealized environmental benefits (US$ millions)		Unrealized climate benefits (US$ millions)	
	2009	2010	2009	2010	2009	2010
Inner Mongolia	64.2	135.8	72.97	154.38	17.91	37.89
West	47.4	98.7	53.93	112.20	13.24	27.54
East	16.7	37.1	19.03	42.18	4.67	10.35
Jilin	6.3	16.8	7.13	19.10	1.75	4.69
Gansu	5.8	8.0	6.65	9.11	1.63	2.24
Heilongjiang	3.7	10.7	4.15	12.20	1.02	2.99
Liaoning	0.7	4.1	0.85	4.70	0.21	1.15
Hebei	8.5	3.9	9.70	4.48	2.38	1.10
Others	0	0	0.00	0.00	0.00	0.00
Total	89.2	179.4	101.40	203.98	24.89	50.07

Lack of Transmission Capacity

26. The regional and provincial grids failed to accommodate the rapid development of renewable energy and wind in particular. Access of renewable energy or wind-based electricity to the grid was constrained for recognized, but not comprehensively addressed, technical, financial, and institutional reasons. In Inner Mongolia by the end of 2010, for example, 60 wind farms were developed with an installed capacity (7,000 MW) that is more than 12 percent of its total power generation capacity (64,600 MW) (see Figure 3). This resulted in serious problems of wind power evacuation and system balancing because Inner Mongolia's electricity market was incapable of absorbing all generated electricity. Delivering electricity to the nearby North China grid is the only option for accommodating all generation during high wind periods. However, there are currently only two 500 kV lines, built during the 1990s, that are capable of delivering 4,300 MW from Inner Mongolia to the North China grid. During the daytime, the evacuation of wind capacity is not a serious issue. However, during winter nights, electricity generated by CHP (Combined Heat and Power Generation) plants has to be dispatched first to meet the high, space-heating demand. Since wind usually peaks during nighttime winter hours, wind electricity generated during these hours is unlikely to be dispatched because of grid constraints. Evacuation of electricity during high wind hours will, therefore, require building new or strengthening existing transmission lines. Expected wind development in Inner Mongolia requires major strengthening of the transmission system

to avoid generation losses more than economically justified. Other provinces, such as Gansu, Jilin, Heilongjiang, and Liaoning, are facing similar constraints.[14]

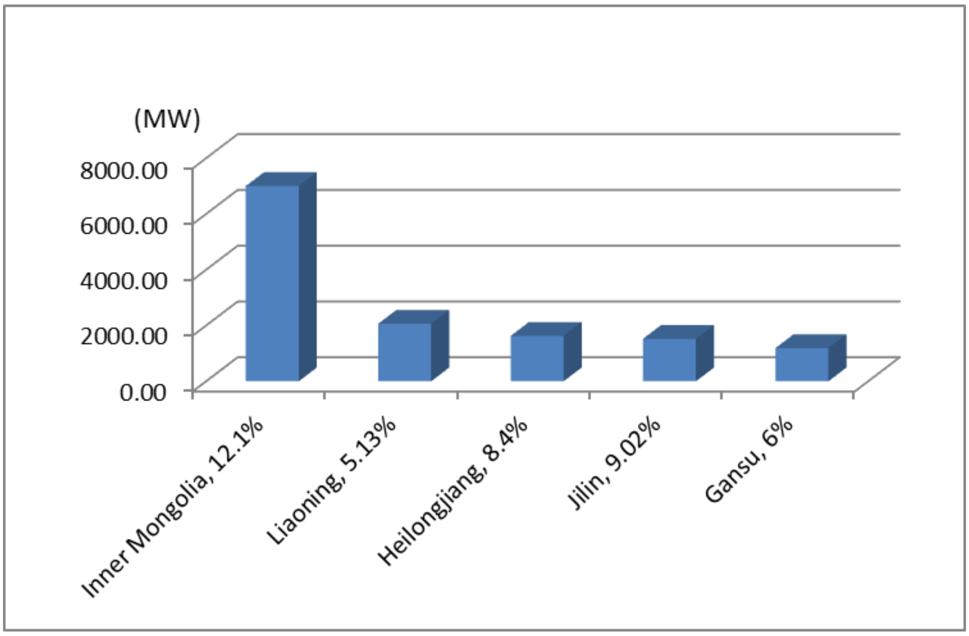

Figure 3: Distributions of Wind Power Capacity in the Three-North Provinces and Its Share of the Total Wind Power Installed Capacity in the Province

27. The concentration of wind capacity in Northwest China by developers attracted by a high FIT has created serious pressure on the underdeveloped grid which has also affected the quality of supply. This might be to the result of its intermittent nature but probably also the low quality of some locally manufactured turbines (see Figure 1 and Figure 3). Wind forecasting methods are not yet mastered and fully utilized, making it difficult for grid companies to prepare dispatch plans one or two days ahead to accommodate wind power outputs. In Jiuquan, for example, 5,000 MW of wind power capacity was installed at the end corner of the Gansu provincial grid, making load balancing and stable operation of the system very difficult, if not impossible. Peak load regulation deteriorated and power flow was practically impossible to control because of inadequate ancillary services and short-circuit limitations. Furthermore, it is planned to increase the site capacity during the 12th FYP, which would increase the pressure on the local grid and aggravate the existing problems if the grid is not strongly reinforced before commissioning any new capacity.

Increasing Subsidy Requirements

28. The Renewable Energy Law established an electricity surcharge collection and allocation system to cover the incremental costs of renewable energy power generation

[14] According to the survey done by SERC, the situation in 2011 was even worse. In the heating season in Three-North, because of guaranteeing the dispatch of CHP units, the generation losses of wind power account for 50 percent in the extreme case, which brings down the capacity factor to an even lower level.

compared to thermal power generation. Initially, a surcharge of RMB 0.001/kWh (2006) was added to provincial grid electricity prices. Because of the rapid development of renewable energy, wind in particular, the surcharge increased gradually up to RMB 0.008/kWh (2012). Total revenues accumulated from 2006 to 2011 amount to roughly RMB 16 billion (US$2.5 billion). The surcharge is transferred to a renewable energy fund, which supports the development of renewable energy. Wind subsidies captured more than 70 percent of the surcharge revenues during the same period resulting from the high growth of wind power capacity and generation. Even so, the collected surcharge is far from covering incremental costs of wind generation (see discussion below).

29. The planned increase of the total installed capacity of wind to 100 GW by 2015, mostly in Three-North, will require higher wind power subsidies. The subsidies needed for the wind electricity generation is estimated to rise from about RMB 15 billion in 2011 to about RMB 31 billion in 2015. This would require increasing the electricity surcharge on the same consumers to RMB 0.005/kWh[15] only for wind-generated electricity. Since the coal benchmark price[16] is unlikely to increase rapidly because of public sensitivity and government worries over inflation, the incremental cost will, therefore, remain high and the subsidy for wind electricity will require higher surcharge [17] (see Figure 4).

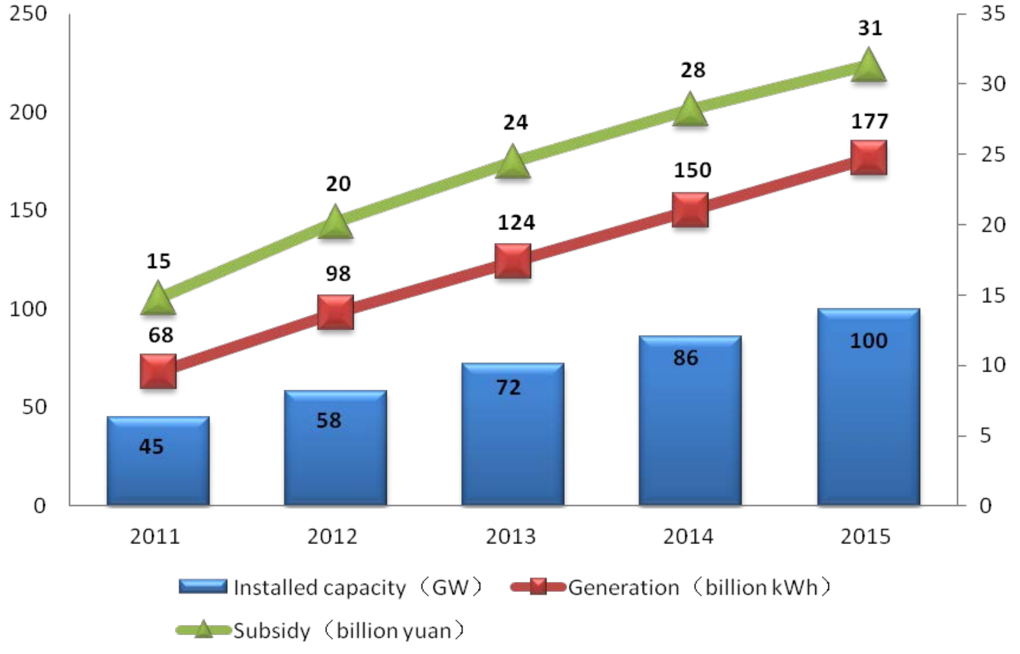

Figure 4: Growth of Expected Wind Subsidies

Note: The capacity factor will increase gradually from 15.2 percent to 17.7 percent from 2011 to 2015, and the subsidy will gradually decrease from RMB 0.217/kWh in 2011 to RMB 0.177/kWh in 2015. *Source:* The estimate was done by Energy Research Institute.

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[15] Total incremental cost of wind power divided by total electricity consumption (excluding Tibet and electricity for agriculture use).

[16] Benchmark price varies from province to province depending on the cost of power generation.

[17] Other factors may influence the demand for subsidy, such as turbine cost, transmission cost, and energy losses, which are beyond the scope of the discussion in this paper.

The 2009 VAT Reform Impact on Wind Power Industry

30. The concept of value added tax (VAT) reform and its impacts on the economy and the competitiveness of Chinese enterprises and consumers are well beyond the scope of this paper, since China is gradually reforming its VAT system to align it with international (European) practice defined below:

> *"Value added tax or VAT is an indirect tax, which is imposed on goods and services at each stage of production, starting from raw materials to final product. VAT is levied on the value additions at different stages of production. VAT is widely applied in the European countries. However, now a number of countries across the globe have adopted this tax system.*
>
> *Value added tax, also known as goods and services tax or GST proves to be beneficial for the government. Through implementation of this tax system, government can raise revenues invisibly, where the tax is not shown on the bill paid by the buyer. VAT is different from sales tax in various aspects. While sales tax is to be paid on the total value of the goods and services, VAT is levied on every exchange of the product, so that consumers do not have to carry the total cost of tax. However, VAT is generally not applied on export goods to avoid double taxation on the final product. However, if VAT is charged on export goods, the tax amount is usually refunded to the tax payer.*
>
> *The value added tax serves as the solution for different problems related to the sales tax system. Unlike sales tax, in VAT, there is provision for input tax credit or ITC. Because of the simplicity of the VAT system, the entire taxation system on consumer products and services has become easier. (Economy Watch)"*

31. In 2009, China implemented a VAT reform, which decreased the tax burden on wind farm developers,[18] but reduced the tax revenue to the local government. Some local governments responded by using their administrative authority to either force the wind farm developers to pay additional local fees, purchase equipment produced by local companies, or request that developers build equipment manufacturing facilities in their counties to mitigate their losses in tax resources. These measures could have negatively influenced the quality of the investment made. (See Figure 5.)

[18] It was noted that the impact of VAT reform on wind farm developers (in Type I area, it is about RMB 0.03/kWh) was taken into consideration when the FIT was determined. But the FIT is still very attractive to the developers, and the developers welcome the VAT reform.

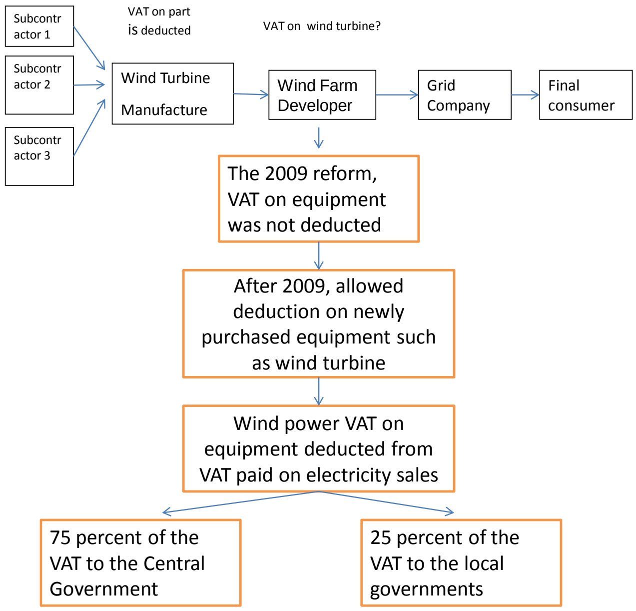


Figure 5: VAT Flow for a Typical Wind Farm Project

32. Given the high initial investment and low operation costs of wind power projects, the revised fiscal policy caused significant changes in government fiscal revenues. Under this new consumption-oriented taxation system, the deduction of the VAT associated with equipment purchased by wind farm developers largely decreased the VAT payments from developers to the local governments during the early years of operation, *but not necessarily over the lifetime of the wind farm*. Local governments appear to have overconcentrated on lost VAT revenues without taking into account the revenue impacts of large-scale wind power development.

33. Since 2009, wind farm investments averaged US$1.4 million/MW, tax included. Out of the total investment, the equipment cost has been US$1.175 million/MW, tax included. The following estimation of the impact of the VAT reform is based on the following assumptions:

- Investment cost for equipment: US$1.005 million/MW, before VAT (US$1.175 million/1.17).
- VAT per megawatt (eligible for deduction after the reform): US$171,000/MW (US$1.005 million * 17 percent).
- Electricity generation per megawatt: 2,200 MWh (1 MW * 2,200h[19])
- Tariff: RMB 0.51/kWh.
- Annual revenue per megawatt installed: US$171,600 (2,200 MWh * US$78/MWh).
- Total Annual VAT revenue per megawatt installed: US$14,586 (171,600 * 8.5 percent); 50 percent rebate for VAT of wind power (half of 17 percent);
- Local government share of VAT per megawatt per year: US$3,646 (14,586 * 25 percent); 25 percent of VAT goes to local government according to the regulation.

[19] Average In type I and II areas with about 10 percent generation losses.

Before January 1, 2009

Annual VAT revenue for the local government from every megawatt installed is US$3,646/MW (US$14,586 * 25 percent) with payment of 50 percent VAT on electricity sales from the date of commissioning.

After January 1, 2009

Each year the developer can deduct US$29,172/MW from the VAT paid on electricity sale (US$171,600 * 17 percent), since the total eligible deduction is US$171,000/MW. Therefore, the total deduction years are 5.9 (US$171,000/MW ÷ US$29,172/MW).

Since the share of the local government from VAT is US$3,646/MW each year, the total fiscal losses for the local government in 5.9 years amount to US$21,375/MW (US$3,646/MW * 5.9).

For a 100 MW wind farm, which is a common size in Northwest China, each year local VAT losses amount to US$364,600, and the total losses in 5.9 years will reach US$2,137,500.

After the deduction, VAT revenues collected by local governments in the remaining lifetime of the wind farm (14.1 years) amount to US$5,140,860.

After the fiscal policy reform, VAT revenues expected by local governments from wind power projects would at least be equal to or higher than the prereform level if wind power development is increased by 50 percent. The only issue is that in the first 5.9 years of the wind farm operation, there will be no VAT revenue income.[20]

Since the effectiveness of the reform, the development of the wind power industry kept a fast pace. At the end of 2008, the total installed capacity was 12,200 MW, while by the end of 2010, the total installed capacity had reached 44,000 MW.

[20] Local governments invented different kinds of fees to compensate their losses from VAT reform, such as the grassland recovery fee from the developers. Since the equipment price kept decreasing in last a few years, however, the negative and positive impacts generally offset each other. The developers were able to cover these fees while maintaining the same level of investment return. This paper only discusses the relationship between the impact of VAT reform on wind power development scale, which benefited from the VAT reform.

Chapter 3: Exploring Ways to Improve Efficiency and Cost Effectiveness

34. This chapter will focus on possible measures to address the issues discussed above:

- Concentration
- Subsidy affordability
- Taxation

Addressing Concentration Issues

35. In theory, there are three potential approaches to solve the concentration issue. The first is to absorb the power where it is produced. Since local absorption capacity is limited in Northwest and North China[21] (see Figure 1), this option is disregarded. The second option is to deliver the electricity to load centers in Southeast China through high-voltage, direct current (DC) or alternating current (AC) transmission lines. The third option is to build more wind capacity near the load centers in the Southeast region. The two latter issues are discussed further below.

36. To develop wind and deliver power in an effective way, it is necessary to take into account the cost of generation and the cost of transmission. If the transmission line is designed to deliver the full capacity, it could be underutilized because of intermittence issues related to wind generation. For a given capacity of wind, the transmission line needs to be designed to transmit the capacity that minimizes the cost of supply (generation plus delivery). This usually leads to designing the line to transmit only a certain percentage of the installed wind capacity. This percentage is labeled below as the "capacity ratio." The maximum share of the energy generated and delivered by the line is designated below as the "wind utilization rate."

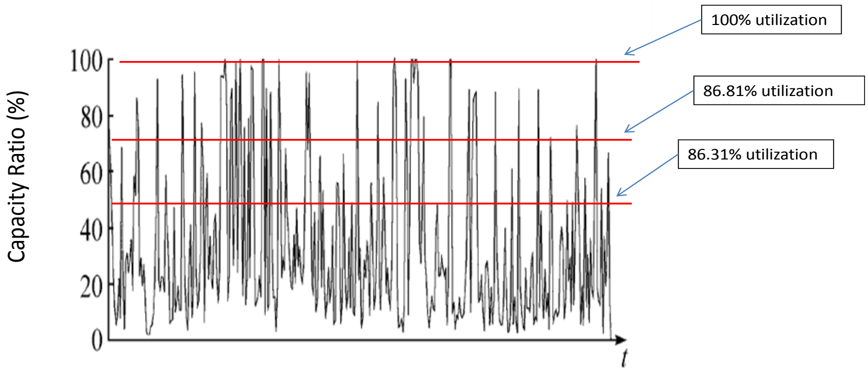
37. The China Electric Power Research Institute (CEPRI) carried out a study on the relationship between the wind resource utilization rate and the capacity ratio. The research results show that at the upper end of the wind speed distribution, the utilization rate decreases significantly more slowly than the capacity ratio (see Table 5 and Figure 6).

Table 5: Relationship between the Capacity Ratio and Generation Losses

(percent)

Capacity ratio	100	90	80	70	65	60	55	50
Resource utilization rate	100	99.86	99.57	86.81	95	82.68	89.80	86.31

[21] There are three routes (South, Middle, and North) of the program Sending Electricity from West to the East. The North route is to send electricity from Gansu and Ningxia, plus North Shanxi and West Inner Mongolia to East China. In 2010, the peak generation capacity in North West Grid was 50600 MW, while the peak load was 44210 MW, the surplus was 6390 MW; Also in 2010, the surplus in North China was 17988 MW; On the other hand it was short of supply in East China, the gap is 24150 MW.



Annual distribution of daily wind (speed) energy

Source: Gansu Electric Power Company

Figure 6: Relationship between the Capacity Ratio and the Resource Utilization Rate

38. The issue of grid connection and long-distance transmission associated with the emerging gigawatt-scale wind bases is complex. The CEPRI study suggests that further analysis and discussion on optimization are needed. According to the research results, a 100 percent utilization rate requires a transmission capacity equivalent to the wind generation capacity, while an 86.31 percent utilization rate can be reached with a transmission capacity of half the corresponding generation capacity.

39. The following optimization calculation for delivering a kilowatt of wind-generated electricity has been carried out based on the following formula:

Cost of delivering 1 kWh = Cost of generation of 1 kWh + cost of transmitting 1 kWh + cost of the unused generation[22]

The following are the assumptions in the calculation:
Unit cost for transmission line only for wind: RMB 0.20/kWh[23]
FIT: RMB 0.51/kWh
Generation cost: FIT * 2/3[24]

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[22] This is an extreme case, since part of the nontransmitted electricity can be used locally.

[23] According to data on electricity grids provided by experts, the total investment cost for a 2,000 km long 800 kV direct circuit line (for example, from Jiuquan, Gansu, to Jiangsu) is RMB 26.33 billion. The transmission capacity is 7.2 GW; therefore, the unit investment cost is RMB 3,658/kW. Taking this into account as part of the investment cost of a wind farm to calculate the FIT, and then comparing that with the FIT, RMB 0.51/kWh, the difference between the two is transmission cost, which is about RMB 0.20/kWh, assuming the full load generation time is 2,600 hours, the generation investment is RMB 8,000/kW, and the IRR is 8 percent.

Energy loss cost: (1-resource utilization rate) * FIT
(The resource utilization rate is given in Table 5 above.)

Table 6 below provides the results of the calculation of the generation costs, transmission costs, and lost generation costs for different capacity ratios varying from 100 to 50 percent.

Table 6: Detailed Calculation of the Generation Costs, Transmission Costs, and Energy Loss Costs

Capacity ratio (%)	Generation loss (%)	Energy lost (RMB/kWh)	Wind farm installed capacity	Wind power off-take (kWh)	Transmission cost share	Unit transmission cost (RMB/kWh)	Generation cost (RMB/kWh)
A	B	C = (B * 0.51)	D = (1/A)	E = C * (1-B)	F = (1/E)	G = 0.20*F	H = (2/3) * 0.51
100	0	0.000	1.00	1.00	1.00	0.20	0.340
90	0.14	0.001	1.11	1.11	0.90	0.18	0.340
80	0.43	0.002	1.25	1.24	0.80	0.16	0.340
70	3.19	0.016	1.43	1.38	0.72	0.14	0.340
65	5	0.026	1.54	1.46	0.68	0.14	0.340
60	7.32	0.037	1.67	1.54	0.65	0.13	0.340
55	10.20	0.052	1.82	1.63	0.61	0.12	0.340
50	13.69	0.070	2.00	1.73	0.58	0.12	0.340

40. The results of the calculation are provided in Table 7 and Figure 7. They show that the lowest delivery cost is reached for a capacity ratio of about 70 percent.

Table 7: Relationship between Capacity Ratio, Resource Utilization Rate, Generation Cost, Transmission Cost, and Energy Loss Cost

Capacity ratio (%)	100	90	80	70	65	60	55	50
Resource utilization rate (%)	100	99.86	99.57	86.81	95	82.68	89.80	86.31
Generation cost (yuan)	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340
Transmission cost (yuan)	0.200	0.180	0.161	0.145	0.137	0.129	0.122	0.116
Energy loss cost (yuan)	0.000	0.001	0.002	0.016	0.026	0.037	0.052	0.070
Total cost (yuan)	0.540	0.521	0.503	0.501	0.502	0.507	0.515	0.526

[24] FITs in all the four type areas are determined by the NEA with the following formula: FIT = Power Generation Cost + Tax + Profit (after tax), in which the generation cost is usually two-thirds of the FIT.

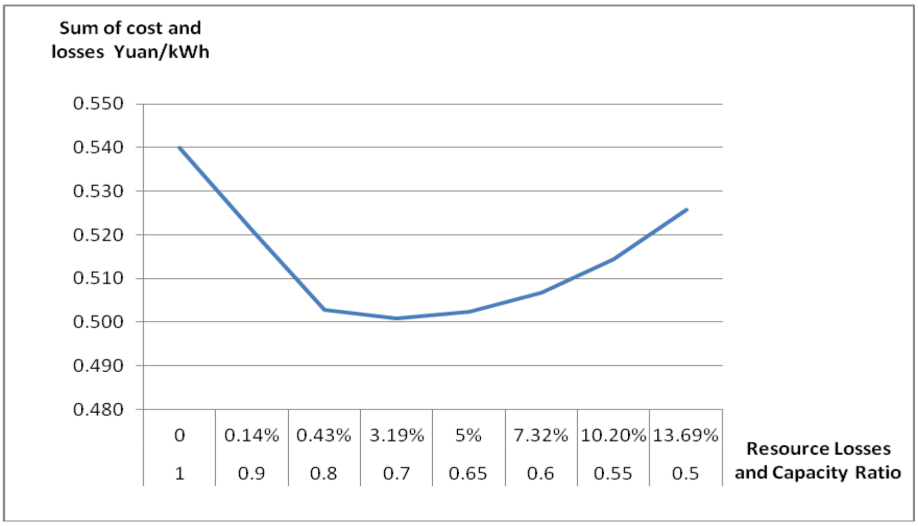

Figure 7: Relationship between Capacity Ratio, Resource Utilization Rate, and Costs

41. The constraint for further development of wind power in Northwest is the transmission capacity. According to the wind power development plan in Gansu Province, it is expected that 12.71 GW by 2015 and 20 GW by 2020 wind power will need to be delivered to eastern or central load centers.[25] These decisions need to be confirmed based on a rigorous optimization of resources.

42. If the evacuation lines from the Northwest are designed according to the optimum capacity ratio (70 percent; see Figure 7), the transmission cost of wind power would be RMB 0.14/kWh (the transmission cost corresponding to a capacity ratio of 100 percent is RMB 0.20/kWh). The total supply cost to the eastern load centers is equal to the FIT plus the transmission cost plus the cost of the energy losses, that is, RMB 0.666/kWh (0.51 + 0.14 + 0.016).[26]

43. Currently, the concentration of wind in the Northwest is mainly the result of a higher FIT. Under the current pricing policy and investment levels, most of the wind farms can generate higher internal rates of return (IRRs) than the benchmark 8 percent (see Appendix 1 for the assumptions used in this analysis)—except for the type IV area, where wind resources are not as good as they are in the Northwest.[27] The type I FIT is the lowest, but revenue levels of projects in this area are higher than projects in other areas. This provides a strong incentive to developers to develop projects in type I areas (see Figure 8*).* In Figure 8, IRRs at four different investment cost levels are presented. For each single investment cost level, the IRR in a good wind resource area is higher than the IRRs in poor wind resource areas (Type I >

[25] China Energy Daily (August 26, 2011).

[26] The case used here is Jiuquan, Gansu, which is in between the western part of Inner Mongolia and Xijiang, about the central part of the Northwest, therefore representing the average level of transmission cost.

[27] National guidance for electric power generation projects.

Type II > Type III > Type IV). It shows that there is less incentive to invest in those areas with comparatively poor wind resources.

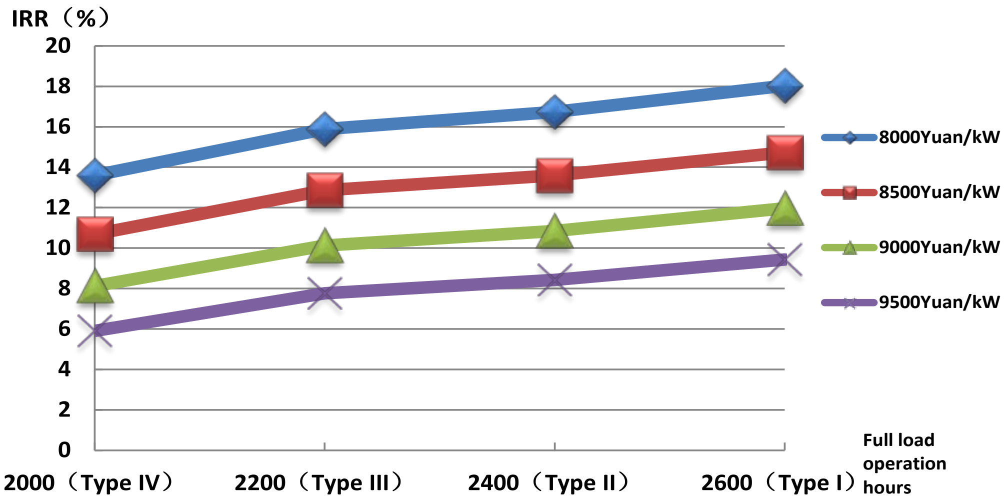

Figure 8: Rates of Return under Resource Conditions and Investment Cost

Note: The x axis represents the wind resource— annual full load operation hours.

44. **Projects[28] in types I, II, and III that usually realize generation losses have similar revenue levels to those in type IV that do not have generation losses.** As discussed previously, the generation losses happen primarily in Northwest. Assuming RMB 8,000/kW investment cost, a 5 percent generation loss in Type II area, and a 3 percent generation loss in Type III, the revenue of the projects in the type II and III areas is still higher than that in the type IV area. With the same investment cost assumption, but with a 10 percent generation loss and 2,600 full load generation hours, the project revenue is lower than in the type IV area. Under the same assumptions, but with 2,800[29] full load generation hours, the project revenue is higher than it is for projects in the type IV area that typically do not have generation losses. Table 8 and Figure 9 compare revenues of projects in Type IV with those in Types I, II, and III, and reveals relative revenue parity when taking into account generation losses.

Table 8: IRRs in Four Types of Areas with Different Level of Generation Losses

Full load operation hours	No generation losses	With generation losses
2,000 (Type IV)	**13.59**	13.59 (no loss)
2,200 (Type III)	15.88	14.75 (3% loss)
2,400 (Type II)	16.73	14.46 (5% loss)

[28] The majority of these projects are located in Inner Mongolia.

[29] In the same type of area, there is a range of full load operation hours, but one FIT. For those wind farms built in high full load operation hours sites, the revenue will be higher than wind farms built in lower full load operation hours sites in the same type of areas.

2,600 (Type I)	18.03	12.73 (10% loss)
2,800 (Type I)	22.81	16.89 (10% loss)

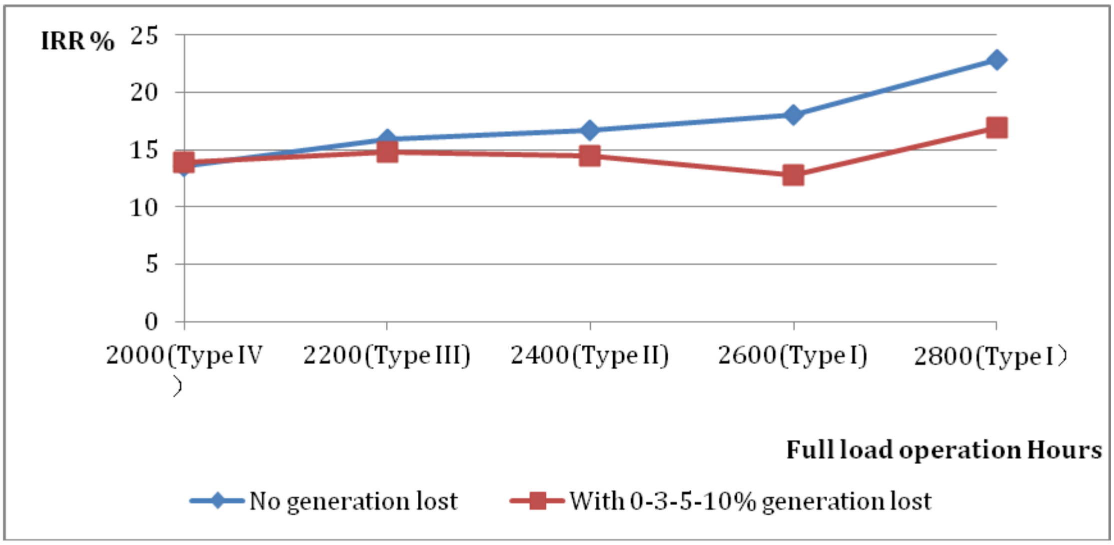

Figure 9: Comparison between Rates of Return for Nongeneration Loss and Different Levels of Generation Loss

45. The current tariff in the Southeast, usually Type IV, is RMB 0.61/kWh, which is RMB 0.056/kWh lower than the cost of delivering power from the Northwest, that is, RMB 0.666/kWh. Taking the environmental benefits (RMB 0.007/kWh)[30] into account, the FIT in the Southeast should be around RMB 0.673/kWh (not accounting for land availability and the higher cost in the eastern provinces). This could lead to more wind development closer to load centers and a reduction of transmission congestion.

46. The discussion in this chapter is only an illustration. The development of wind industry should be based on comprehensive analyses, taking into account supply and demand sides. It means that the development of generation, transmission, distribution, and utilization of wind power should be planned in a more coordinated manner to achieve optimal use of resources, cost effectiveness, and sustainable development of wind resources.

Addressing the Pressure on Subsidies

47. **Under the current FIT, wind farms in the Southeast receive the lowest subsidy; therefore, the incremental costs in the Southeast are less than they are in the Northwest.** According to the current policy, the tariff in Type I area is RMB 0.1/kWh lower than that of type IV. However, the benchmark price of desulfurized coal-fired power in type IV in the Southeast is higher than that in types I–III of the Northwest. Thus, the incremental cost in the Southeast is less than it is in Northwest. In this sense, there are two advantages to building wind farms in the Southeast: one is to reduce the current overconcentration of wind farm development in the Northwest, and the second is to reduce the level of subsidy.

[30] Calculated based on the data in Table 2 and Table 3.

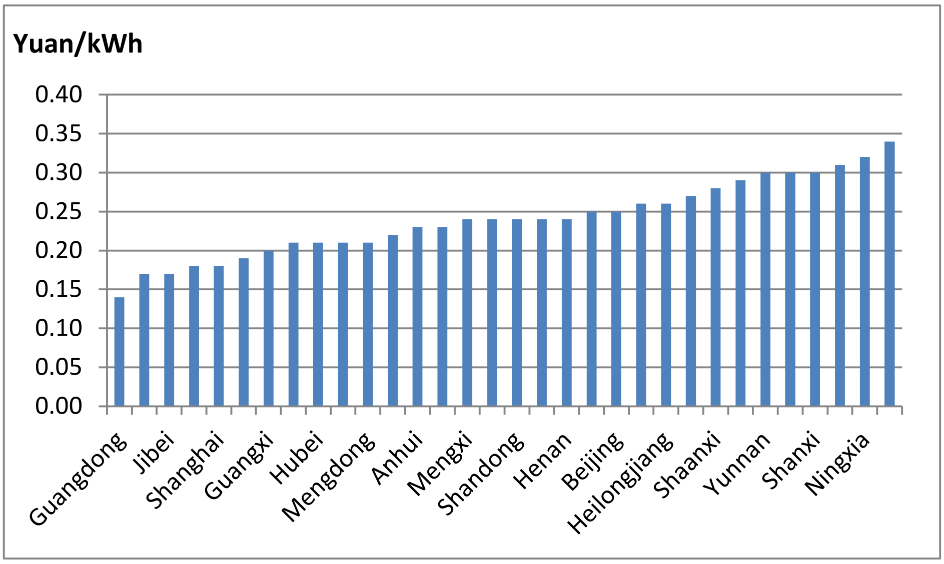

Figure 10: Wind Subsidies per Province by City and Region
(RMB/kWh)
Source: Based on the desulfurized coal-fired benchmark price in 2009.

48. According to the subsidy schedule from January to September 2010, the average subsidy in the whole country was RMB 0.224/kWh. The average subsidy for Inner Mongolia and Xinjiang, which are located in resource areas of type I, II, and III, was RMB 0.239/kWh. The average subsidy in other areas was RMB 0.195/kWh. The difference between the two was RMB 0.044/kWh (see Figure 10 and Table 9).

Table 9: Comparison of Subsidies in Different Regions

Wind resource zones	I、II、III	IV
Price (RMB/kWh)	0.51、0.54、0.58	0.61
Areas	Inner Mongolia, Xinjiang, North Hebei, Gansu, western Jilin, part of Heilongjiang, Ningxia	Other areas
Installed capacity (MW)	16,090	7,190
Generation subsidized (GWh)	21,300	9,700
Subsidy line of unit power (RMB/kWh)	0.239	0.195
Overall average subsidy line (RMB/kWh)	0.224	

49. In the Southeast, because the current tariff is RMB 0.61/kWh, developers of wind farms can secure financial internal rates of return (FIRRs) above 8 percent only when they realize equivalent full load operation hours above 1,800 for an investment level at RMB 8,000. The different FIT refers to a different economically exploitable wind resource:

For RMB 8,000/kW investment cost:

- When FIT RMB 0.61/kWh, 1,780 full load operation hours can secure an IRR of 8 percent;
- When FIT RMB 0.654/kWh, 1,660 full load operation hours can secure an IRR of 8 percent;
- When FIT RMB 0.673/kWh, 1,610 full load operation hours may secure an IRR of 8 percent.

Table 10 provides other estimates based on different investment cost assumptions.

Table 10: Full Load Operation Hours Needed to Keep IRR at 8%

Investment unit kW (RMB/kW)	8,000	8,500	9,000	9,500
Equivalent full load operation hours corresponding to 0.61 kWh	1,780	1,890	2,000	2,100
Equivalent full load operation hours corresponding to 0.654 kWh	1,660	1,760	1,860	1,970
Equivalent full load operation hours corresponding to 0.673 kWh	1,610	1,710	1,810	1,920

Note: Fixed IRR of 8%.

50. To realize the development target of 100 GW in 2015, there is a need to add 60 GW. It will require, under the current FIT regime, a subsidy of RMB 16.5 billion. Theoretically, if one tenth of the additional capacity, 6 GW, is installed in the Southeast rather than in the Northwest, as originally designed, savings would amount to about RMB 475 million[31] each year.

*6 GW * 1,800h * RMB 0.044/kWh = RMB 475 million*

This calculated savings assumes that the tariff remains RMB 0.61/kWh in the type IV area on the east coast. If the tariff was raised to RMB 0.654/kWh, with the same amount of subsidy, wind resources with lower full load operation hours (see Table 10) can be exploited. Furthermore, if the tariff was raised to RMB 0.673/kWh, which is equal to the delivery cost from Northwest to the east coast, resources with even lower full load operation hours could be developed, with the same amount of wind power, and extra subsidies would be needed of RMB 0.019/kWh (0.673–0.654).

The analysis above suggests that this approach is worthy for further, in-depth connection studies, for example, taking into account land acquisition costs, and comparing these to the building of long-distance transmission lines mainly for wind in the short term, which will involve transmission cost by RMB 0.14/kWh.

Addressing the Issue of Taxation

[31] Full load operation hours are considered to be 1,800 in the calculation.

51. On the one hand, local governments' fiscal income was negatively influenced by VAT reform. On the other hand, the wind power industry in China experienced rapid development in the last decade, and VAT revenue in most wind resource-rich places increased remarkably. Actions taken by local governments may have brought about local protectionism, which can generally lead to market distortions, installation of substandard equipment as developers try to absorb the costs of administrative measures, and harm the overall quality of projects.

52. The administrative measures adopted by local governments, to require the procurement of locally produced equipment and other fee-charging schemes that are aimed to compensate for VAT losses on equipment, should not be encouraged. Local governments seem to have disregarded the outcome that the new VAT policy will have, along with other government initiatives, of inducing wind development at a larger scale. VAT revenues expected by local governments from large-scale wind power projects would at least be equal to or higher than the prereform level if wind power development were increased by 50 percent. Moreover, some of these practices can threaten good supply chains and increase the overall costs of wind power generation, which are important for the long-term, sustainable development of the industry.

Conclusions

- The government's large-scale wind power development objectives should be twinned with a clear objective to deliver electricity at a minimum cost. Efficiency is contingent upon ensuring that wind farms are built in places where crucial requirements for success are present: the best resources, adequate project designs, use of proven turbines, regulatory clarity, adequate incentives, transmission capacity to deliver the electricity and, last but not least, appropriate operation and maintenance practices carried out by skilled and trained staff.

- The grid is crucial. International experience has been good in planning wind farm operational integration. However, grid connection and stability issues for gigawatt-scale wind bases, as envisaged in China, have no precedent anywhere in the world. Comprehensive connection studies with special attention to the optimum connection size and connection circuit layout should be undertaken with the involvement of all stakeholders.

- As large capacity operates at low efficiency in resource-rich Northern China, and because planning and construction of the grid network to off-take the electricity will take time, the government needs to consider readjusting the incentive mechanisms to guide the developers to invest in regions with high efficiency and as close as possible to load centers with an objective of achieving the lowest incremental cost.

53. Shifting part of the focus to the central and eastern regions in China by offering a higher feed-in price *can balance the wind power development pace in China and minimize the*

incremental cost for wind power development in the country, especially as wind resources in the Three-North region are further developed on a large scale and transmitted in bulk to the load centers.

- Some local governments are using their administrative authority to raise revenues from additional fees, and/or take on measures, such as forcing wind developers to purchase equipment produced by local companies and/or mandate developers to build manufacturing facilities in their counties to compensate tax losses they incurred after the last round of VAT reform. These initiatives should be discouraged because of their harmful impacts on the wind power industry. Local governments seem to disregard the outcome that the new VAT policy will have, along with other government initiatives, of inducing wind development on a larger scale. VAT revenues collected by local governments from wind power projects would at least be equal to or higher than the prereform level if wind power development were to increase by 50 percent.

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