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Center for International Climate and Environmental Research – Oslo
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From Non-market Support to Cost-Competetive Incentives

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Working Paper 2000:3
ISSN: 0804-452X

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December 22, 1999

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[1] This is a joint research project between the Institute for Techno-Economics and Energy System Analysis (ITEESA), Tsinghua University, China and the Center for International Climate and Environmental Research-Oslo (CICERO), Norway. Financial support is provided by the Research Council of Norway.

Abstract

This paper presents an overview of the development of wind energy in China. By examining the economics of windfarm development, it compares the economics of wind technology with other conventional energy technologies and analyzes the role of alternative policy instruments. Meanwhile, it identifies the major constraints of wind technology development and the defects of current non-market support from the government. It shows that the development of wind power will be directly subject to rational policy change, incentive mechanisms and institutional framework building. Particular importance is paid to market incentives to reach the objectives of commercialization and industrialization of wind power. The paper recommends some cost-competitive incentive measures and policies to drive the wind power market. It concludes that promising market incentives to speed up the development of wind energy include: (i) establish market competition mechanisms through standard power purchase agreement; (ii) adjust tax policies and government subsidies; (iii) stimulate investment incentive policies and regulations; and (iv) change governmental institutions and management modes.

Keywords: wind energy; policy incentive; commercialization; China

Contents

1 Introduction

China is endowed with rich wind resources. The amount of actual exploitable wind energy reserve is about 253GW. The development of wind energy began in the 1970s, initially focusing on the development of small wind turbines. The development of grid-connected wind power started from the late 1980s and the first windfarm was built in 1986. Since the beginning of the 1990s, wind power has experienced rapid development with average annual increase rate of about 60%. By the end of 1998, the total installed capacity of wind turbines in large-scale windfarms reached 223.6 MW with a total of 532 installed units.

The current development of wind power in China benefits greatly from high utility purchasing price. There are many factors which result in high generating costs and wind power prices, of which the three most important are: high initial investment of windfarm construction, short repayment time and high interest rate of loans, and over-estimation of operation costs during the calculation of wind generating costs and examination and approval of wind power prices. Like other countries, China has also designed favorable policies to advance the development of wind energy. Firstly, the former Ministry of Electric Power (MOEP) issued the *Regulation on the Management of Grid-connected Windfarms* in 1994, which requires that the purchasing price of wind power be based on the pricing principle of generating cost plus repayment of loan and interest, and reasonable profit. Tax deduction and exemption is another important option for government to support the development of wind power. For example, the Chinese government has stipulated a preferential tariff policy, which aims to support the import of wind turbines. Because of the limited funds for windfarm construction, the government also uses subsidy as an important policy instrument to support the building of windfarms. However, it is mainly non-market measures which have contributed to the current achievement of wind power development in China. In the long-term perspective, it would be difficult for wind power to compete with other energy technologies in such a situation. Thus, we should not wait for technological advancement to make wind generation cost-competitive. The development of wind energy should change from non-market-based support to cost-competitive incentive policies and measures and become commercialized in the market place.

The first part of this study offers an overview of the development of wind power in China, exploring the efforts of the government with the establishment of various incentive policies. In the following sections, a techno-economic assessment is carried out to estimate the generating cost and utility purchasing price of wind power. Through comparison with the costs of conventional power generation, such as hydropower or coal-fired power, particular emphasis is given to analysis of the reasons for high generating costs and high price of wind power generation. The study goes on to explore ways to reduce wind generating costs, and measures or policies to push forward commercialization of wind power generation, especially how to shift from current non-market support to market based cost-competitive incentives, as well as to discuss related policies, measures and institutional changes.

2 Wind Energy Development in China

2.1 Wind Energy Resource

The wind energy reserve in China is estimated in terms of the resource at a height of 10m above the ground, not on the whole aero-sphere or the sub-aerial space. The total available wind energy reserve at an altitude of 10m is 3,226 GW (He, 1996). This figure is also regarded as the maximum theoretical utilizable reserve. However, the actual available reserve is estimated at only 10% of the theoretical reserve. Taking the efficiency of wind conversion devices into consideration, the total actual available wind energy reserve at a height of 10m is 253 GW. Although the figure is big enough to imply that there is rich wind energy reserves in China, the actual wind energy reserve for economic exploitation (especially for wind farm development) needs to be further investigated. Table 1 shows wind energy reserve allocation by provinces (regions).

According to the main indicators of wind energy resource such as wind energy density, average effective speed and effective hours of wind speed, the wind resource of the whole country can be classified into four types: rich, moderate, marginal, and poor (See Figure 1).

Table 1. Wind energy reserve in some provinces (regions) in China

Province (Region)	Available Energy (GW)	Province (Region)	Available Energy (GW)
Inner Mongolia	61.78	Shandong	3.94
Xinjiang	34.33	Jiangxi	2.93
Heilongjiang	17.23	Jiangsu	2.38
Gansu	11.43	Guangdong	1.95
Jilin	6.38	Zhejiang	1.64
Hebei	6.12	Fujian	1.37
Liaoning	6.06	Hainan	0.64

Source: the original data is from the Meteorology Institute, the National Meteorology Bureau, China (He, 1996)

Regions with the richest wind potential are located in the north of Inner Mongolia Autonomous Region and the east of Heilongjiang Province, where annual average wind speed reaches 4~6 m/s, and a total of 5,000~6,000 hours per year when wind speed is in the range of 3~20 m/s. Along the coastal areas and nearby islands in southeastern China such as Zhejiang and Fujian Provinces, there is also rich wind energy potential, with average annual wind speed reaching 3~6 m/s, and wind speed in the range of 3~25 m/s occurring for more than 6,000 hours annually.

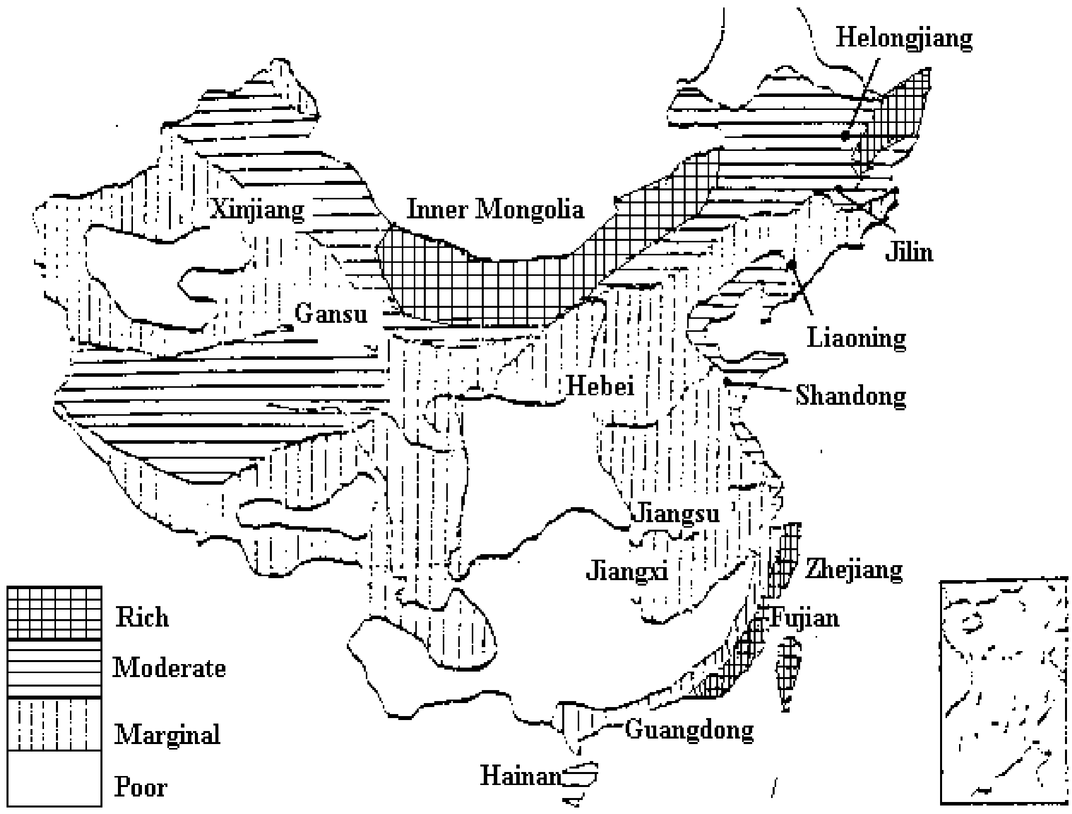

Figure 1. Distribution of wind resource in China
Source: Qiu D. X., Gu S.H., et al. (1992).

2.2 Wind Power Development: Past, Present and Future

2.2.1 Early Stage of Development

In the early 1970s, China began to develop wind energy with the primary purpose of supplying electricity to people living in rural areas, such as herdsmen and residents in remote pastoral areas or isolated islands (He,1996; Liu, 1998; Shen, 1996). The development of large-scale windfarms began in 1986. In April 1986, the first windfarm was built in Rongcheng County of eastern China's Shandong Province using equipment from Denmark. In October 1986, another pilot windfarm was built in Pingtan County of Fujian Province in southern China, supported by a grant from Belgium. After these two pilot projects, windfarms began to be built throughout China, mainly using imported wind turbines. The installed capacity of wind power increased rapidly year by year (He, 1996; Shi, 1994; Zang and Feng, 1998).

Since the beginning of the 1990s, the development of windfarms in China has achieved great success with an annual growth rate of about 60%. In 1990, the total installed capacity of wind turbines was only 4 MW with a maximum unit capacity of 200 kW, while by the end of 1998, the total installed capacity of wind power hit 223.6 MW with a maximum unit capacity of 600 kW. Table 2 and Figure 2 illustrate the development of wind power in China during the 1990s.

Table 2. Development of installed wind power generating capacity in China. MW.

YEAR	1990	1993	1994	1995	1996	1997	1998	1999*
Increased capacity of the year		10.5	14.8	6.8	21.4	109.2	56.9	95.56
Total installed capacity	4.0	14.5	29.3	36.1	57.5	166.7	223.6	319.16

Note: *--estimated.

Source: Statistics from the New Energy Development Division, Hydropower & New Energy Development Bureau, State Power Corporation of China.

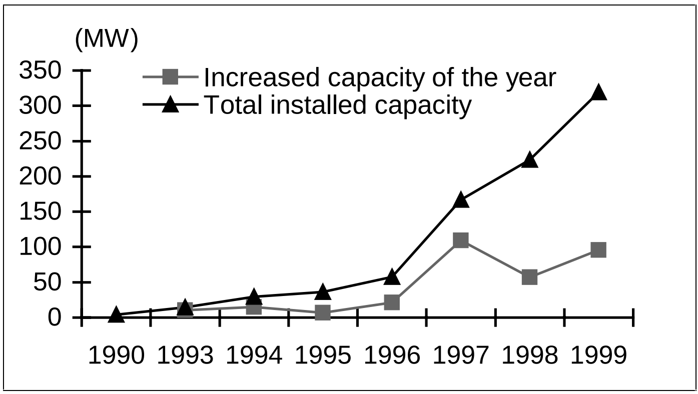

Figure 2. Wind power development in China

Source: Statistics from the New Energy Development Division, Hydropower & New Energy Development Bureau, State Power Corporation of China.

2.2.2 Current Situation

The installed capacity of wind power expanded from 166MW to 223.6 MW in 1998. Table 3 shows the details of total installed capacity of windfarms in China by the end of 1998. Currently there are 19 windfarms, among which several have a total installed capacity over 10 MW, for example, Dabancheng in Xinjiang, Nan'ao in Guangdong, Huitengxile in Inner Mongolia, Donggang in Liaoning, and Kuochangshan in Zhejiang.

Furthermore, additional projects are in progress. In 1999, there are 16 windfarms under development. It is predicted that the total installed capacity will reach 319.2 MW by the end of the year (Hydropower & New Energy Development Bureau of the State Power Corporation, 1998).

2.2.3 Future Development

The overall objective of large-scale future development of wind power has been well accepted by the government, because China needs cleaner energy. Wind energy is regarded as an alternative to traditional fossil fuel based energy systems. Wind power is perceived as a significant part of power generation in the future.

Table 3. Total installed capacity of windfarms in China in 1998

No.	*Province/Wind farm*	*Capacity of unit sets (kW)*	*Total capacity (kW)*
01	Xinjiang/Dabancheng No. 1	100~600	8,500
02	Xinjiang/Dabancheng No. 2	300~600	57,500
03	Xinjiang/Buerjin	150	1,050
04	Gansu/ Yumen	300	1,200
05	Inner Mongolia /Huitengxile	600	36,100
06	Inner Mongolia /Zurihe	100~300	4,200
07	Inner Mongolia/ Sangdu	55, 300	3,875
08	Inner Mongolia /Xilinhaote	250	1,000
09	Hebei /Zhangbei	275~600	9,850
10	Liaoning /Donggang	55~550	17,005
11	Liaoning /Hengshan	250	5,000
12	Shandong/Changdao	55	110
13	Shandong/Rongcen	55	165
14	Zhejiang /Sijiao	30	300
15	Zhejiang/ Kuochangshan	600	19,800
16	Zhejiang /Cangnan	55~500	1,255
17	Fujian /Pingtan	55~200	1,055
18	Guangdong Nan'ao	150~550	42,880
19	Hainan/Dongfang	55~600	8,755
	Total		**223,600**

Source: From the New Energy Development Division, Hydropower & New Energy Development Bureau, State Power Corporation of China.

Windfarm construction has been determined as a key area for investment during China's Ninth Five-Year Plan period (1995-2000). In order to realize the overall objective, related government departments have established targets for wind power development. The State Development and Planning Commission (SDPC) has set a target to install 400 MW and 1,000-1,100 MW of wind turbines by 2000 and 2010 respectively. The former Ministry of Electric Power (currently the State Power Corporation) and some regional electricity authorities and public utilities have also set targets for wind power development. Similarly, the State Economic and Trade Commission (SETC) has also formulated the *National Wind Power Development Plan (1999-2005)*. In the forthcoming *Industrial Development Plan for Renewable Energy (1999-2015)* also enacted by the SETC, wind power is one of the major energy technologies intended to reach the target of renewable energy development. Commercialization and industrialization of wind power will be the focus of future development and large-scale expansion. According to the current situation and development trend, it is estimated that possible targets for wind power are 500~600 MW, 1,000~1,500MW and 3,000MW by the end of 2000, 2005 and 2010 respectively (Hydropower Bureau of the State Power Corporation, 1998).

3 Techno-Economic Analysis of Wind Generation

There are many factors affecting the cost of wind power generation, such as investment, capital structure, government policy, management capacity and skills, etc. It is important to carry out a techno-economic analysis of wind generating systems to better understand these factors.

First, according to the actual situation in China, we make some basic assumptions to measure the cost of wind generation:

- the annual operation hours of a wind turbine are 2,500 h;
- the lifetime of a wind turbine is 20 years and the construction period of a windfarm is one year;
- total initial investment of a windfarm is US$ 1,000 (8,300 yuan)/kW[2];
- of the total investment, 20% comes from self-raised funds while the other 80% is provided through a domestic commercial loan at an interest rate of 7.56% and with a repayment period of 7 years;
- annual operating costs of a windfarm account for 5% of the total initial investment;
- the depreciation period of a wind turbine is 12.5 years;
- income tax is 33% and value added tax (VAT) is 17%.

Based on the above assumptions, we use the general economic assessment method to calculate the average financial cost of wind power generation (see Table 4). According to the table, the average cost of wind generation during the repayment period of the loan (years 1-7) is 0.551yuan/kWh (US$ 0.066/kWh), while it falls to 0.276 yuan/kWh (US$ 0.033/kWh) after repayment of the loan and interest, if taxes and profits are not taken into consideration. The static average cost of wind generation during the whole lifetime is only 0.372 yuan/kWh (US$ 0.045/kWh).

Table 4. Financial cost of wind power generation (yuan/kWh)

Item	Repayment period of loan	After repayment of loan and interest	Average cost of the whole lifetime
Depreciation	0.27	0.11	
Operating costs[1]	0.166	0.166	
Interest [2]	0.115	0	
Total	0.551	0.276	0.372

Note: [1] includes expenses for labor, maintenance, etc.
[2] Average value during the period.

However, the above calculation doesn't take the cost of self-raised funds into consideration. Moreover, the problem is that the depreciation is not enough to repay the loan, because it is very difficult to obtain a long-term loan with a repayment period over 10 years in China.

[2] The exchange rate for US dollar to Chinese yuan (RMB) is 1 US$ = 8.3 yuan.

In order to guarantee the profit of investors and finally to drive the development of wind energy, the only solution is to price wind power much higher, so as to guarantee investors or developers of windfarms the repayment of loan and interest. In 1994, the former Ministry of Electric Power (MOEP) issued the *Regulation on the Management of Grid-connected Windfarms.* According to the regulation, the grid network management authority should allow windfarms to connect with the power grid at the nearest points and purchase all electricity generated by windfarms. The purchasing price for wind power should be based on the pricing principle of generating cost plus repayment of loan and interest, and reasonable profit. If the price is higher than the average price of the grid, the difference should be shared throughout the grid, and the local utility should be responsible for purchasing wind power.

Under the pricing principle, it is possible for wind power to be priced very high. Table 5 shows the price of wind power under the above assumption, and on the basis of the pricing principle. It indicates that the average cost of wind generation during the repayment period of the loan accounts for 0.813 yuan/kWh (US$ 0.098/kWh), while it decreases to 0.266~0.319 yuan/kWh (US$ 0.027~0.038/kWh) after repayment of loan and interest, if value added tax (17%) is not taken into consideration. The static average cost of wind generation during the whole lifetime is about 0.372 yuan/kWh (US$ 0.04/kWh). However, once VAT is taken into consideration, the prices during the two periods reach 0.951 yuan/kWh (US$ 0.115/kWh) and 0.311~0.373 yuan/kWh (US$ 0.037~0.045/kWh) respectively. The static average cost of the whole operation period reaches 0.472 yuan/kWh (US$ 0.057/kWh). Of total costs including VAT during the repayment period, loan repayment and interest account for 52%, operating costs for 17%, and VAT 15%.

Table 5. Wind power generation price (yuan/kWh)

Item	Payback period of loan	After payback of loan and interest
Capital costs		
Payback of loan	*0.379*	*0*
Payback of self-raised funds	*0.053*	*0.053~0*
Profit for self-raised funds[1]	*0.100*	*0.100*
Interest	0.115	0
Subtotal	0.647	0.153~0.100
Operating costs	0.166	0.166
Total pre-tax cost	**0.813**	**0.319~0.266**
VAT (17%)	0.138	0.054~0.045
Total cost including VAT	**0.951**	**0.373~0.311**

Note: [1] Profit for self-raised fund is calculated at 15% of investment.

4 Barriers to Wind Development and Non-market Support from Government

4.1 High Utility Purchasing Prices of Wind Power

Table 6 shows the current utility purchasing prices for wind power in some windfarms. It indicates that there is great diversity in the price of wind power. Up to now, the highest price obtained is by Cangnan windfarm in Zhejiang Province (US$ 0.145/kWh), while the lowest is at Dabancheng No.1 windfarm in Xinjiang Autonomous Region (US$ 0.048/kWh). Generally, wind power prices fall into the range of US$ 0.07~0.11/kWh. Thus the wind power price in China is not falling into the normative range, and there are some problems that need to be solved. The most important one is that the utility purchasing prices for wind power are very high, so there is no competitive advantage for wind electricity compared with conventional power generation. This point can be seen clearly from Table 7, which compares wind power prices with coal-fired electricity prices in some provinces in 1997. It indicates that it is very difficult for wind energy to compete with conventional power generation at present.

Table 6. Utility purchasing prices of wind power in some windfarms of China in 1999

No.	Province/Wind farm	Maximum power price	
		(yuan/kWh)	(US$/kWh)
01	Xinjiang/Dabancheng No. 1	0.40	0.048
02	Xinjiang/ Dabancheng No. 2	0.66	0.080
03	Inner Mongolia /Huitengxile	0.609	0.073
04	Inner Mongolia /Zurihe	0.6094	0.073
05	Inner Mongolia/ Sangdu	0.609	0.073
06	Inner Mongolia /Xilinhaote	0.64786	0.078
07	Hebei /Zhangbei	0.984	0.119
08	Liaoning /Donggang	0.9154	0.110
09	Liaoning /Hengshan	0.90	0.108
10	Zhejiang/ Kuochangshan	1.20	0.145
11	Hainan/Dongfang	0.56	0.067
12	Guangdong Nan'ao No.1	0.74	0.089
13	Guangdong Nan'ao No.2	0.62	0.075
14	Fujian /Dongshan'aozishan*	0.46	0.055
15	Gansu/ Yumen	0.73	0.088
16	Jilin /Tongyu*	0.9	0.108
17	Shanghai/Chongming*	0.773	0.093

Note: *--under construction.
Source: Wang Y.T. (1999).

The high price of wind power is effective to guarantee investment recovery, but it will inevitably lead to unwillingness of the local electric grid to purchase from such sources. Because the local electricity utility has to depend on the improvement of the average electricity price paid by end-users to compensate its loss for purchasing wind power, it is not willing to support large-scale development of wind power, which perhaps causes obvious increases in the local electricity price. Furthermore, price regulation, which is more welcomed by windfarm developers while opposed by local electricity authorities, is the most powerful driving force at the early stage of windfarm development. It has gradually posed an obstacle to the development of wind energy. In addition, this policy has led to less motivation for windfarms to improve their management. Lack of experienced and qualified staff will in turn result in higher operation costs.

Table 7. Price comparison between wind power and coal-fired power in selected provinces of China in 1997(yuan/kWh)

Provinces	Coal-fired electricity		Wind electricity*	
	RMB	US$	RMB	US$
Xinjiang	0.32	0.039	0.698	0.084
Inner Mongolia	0.35	0.042	0.713	0.086
Liaoning	0.45	0.054	0.9-1.00	0.108-0.120
Shandong	0.45	0.054	0.80	0.096
Zhejiang	0.50	0.060	0.79	0.095
Fujian	0.55	0.066	0.79	0.095
Guangdong	0.60	0.072	0.77	0.093

Note: *--Average price for the windfarms in the province.
Source: Zhao et al. (1998).

4.2 Reasons for High Wind Generating Cost and Wind Power Price

There are many reasons for high generating cost and wind power price, among which three are the most important.

First, one main reason directly linked to high generating cost is high initial investment. Because most wind turbines installed in China's windfarms are imported, the initial investment of installed capacity in 1998 is as high as US$ 1,000/kWh. However, the initial investment of coal-fired power plants in 1996 was just US$ 651/kWh (5,404 yuan/kWh) while investment for hydropower in 1995 was about US$ 999.5/kWh (8,296 yuan/kW) and current nuclear power is about US$ 1000-2000/kWh. Without considering the capacity factors of equipment, wind power has equivalent initial investment with hydropower, but much higher than coal-fired power plants. As is well known, a wind turbine's capacity factor (about 0.30) is far less than other generating means, so actually the initial investment of wind power is far more than that of hydropower or coal-fired power.

Second, short lending time scales and high interest rates result in high capital costs during the repayment period of a loan. From Table 5, we can see that capital costs constitute half of the generating cost of wind power during the repayment period. Though the interest rate of short-term loans continues to decrease, commercial banks are not willing to provide long-term loans to investors. Generally, it is difficult to get a loan for the duration of over 10 years. The repayment period of loans for wind energy projects averages about 7-8 years with an interest rate of 7.56%.

Third, over-estimation of operation costs also contributes a little to high generating costs. In estimating wind generating costs, we assume operation costs are 5% of the total initial investment. On this basis, the operation costs of wind generation reach 0.166 yuan/kWh (US$ 0.02/kWh). Actually, the operation costs of wind power are about 2% of the total initial investment, so the average operation cost is just about 0.10 yuan/kWh (US$

0.012/kWh). Furthermore, over-estimation of initial investment also leads to over-estimation of operation cost.

4.3 Taxation Policy to Cut down Wind Power Price

Tax deduction and exemption provide an important option for government to cut the price of wind power to support its development. There are three types of taxes that have direct and powerful influence on the price of wind power, tariff, value added tax and income tax.

However, up to now, the government only implements a preferential tariff policy designed to support the import of wind turbines, without introducing any favorable rules or regulations in the field of VAT and income tax of wind energy.

From the early 1990s, the exemption of customs duty for imported wind turbines was put forward and finally approved by the government. In 1996, a new regulation for tariff diminution of wind turbines began to be put into practice. The duty rate for wind turbines was adjusted to 12%, and 3% for major components. However, the duty level was still kept at 6% in practice after various preferential treatments. Along with the customs duty, VAT at 17% and its surtax were also levied, so that the total import tax reached 26%. From 1998, the latest tariff regulation exempting customs duty on large-scale wind turbines was put into practice. It has reduced the cost of windfarm construction by about 15%. However, it has also seriously blocked the progress of localization of wind turbine production.

4.4 Government Subsidy to Make up Insufficient Capital Investment

Because of the high initial costs of investment, limited capital resources cannot meet the demand for wind energy development. Up to now, capital investment has mainly come from a few sources:

- Government finance or policy loans. For example, the SETC and SDPC, respectively, have sponsored a program to provide special loans for windfarm construction.
- Grants or preferential loans from foreign governments or international organizations. Most of these funds are soft loans with lower interest rates, and sometimes they are integrated with the sale of wind generating equipment. The annual amount of grants from foreign governments, such as Denmark, Germany, Netherlands, Spain, USA, etc., averages US$30~40 million. Similarly, some international organizations, such as the World Bank, also provide loans to promote the development of wind energy in China (a recent project).
- Direct investment and financing from foreign investors. Some foreign companies have shown interest in windfarm projects in China and are beginning to make investments.

Because of the limited funds for windfarm construction, the government uses subsidy as an important policy instrument to support the development of renewable energy, especially wind power. Currently, apart from providing subsidies for the loans of wind power projects, government aid also focuses on the following fields:

- subsidy or appropriation expenditure is provided to organizations engaged in R&D of renewable energy;

- budget allocations are made for tackling national or regional important key technical projects;
- financial support is given to some important scientific and technical demonstration projects and training;
- in some provinces, such as Inner Mongolia, Gansu, Qinghai, Xinjiang etc., local governments have established and implemented some subsidy policies for the diffusion of wind power (Zhang, 1999).

Unfortunately, comparing the potential of wind energy development, there is a big gap between demand and actual investment. Fundraising and financing are crucial elements to speed up wind energy development. On past trends, the growth rate of wind power development is on average about 60%. Current financial channels, such as government finance, foreign grants or preferential loans, cannot increase at the same rate. Unless a new investment mechanism (policy or regulation) is established and more financial channels opened up, it will be difficult to realize the target of wind energy development.

5 Defects of Non-market Support

From the above argument, we can see that currently the whole wind energy market is based upon governmental preferential policies, international grants or preferential loans, as well as governmental subsidies. Were these supports not available, the whole market would shrink rapidly.

Generally, wind energy has much poorer economics at the average grid-purchasing price of electricity. As a source of clean energy, however, it has great development potential and attractive prospects (Wu Y.D. 1998; Chen 1998). Thus, wind power needs high price policy to support its development, and has to depend on the improvement of its economics to be independent from government support in the future. In order to promote the development and diffusion of wind energy at such high cost and price, the government has issued a series of measures or policies to support the wind power market. However, these policies or measures are not based on economic incentives, but on non-market administrative measures, which entail some unavoidable defects.

1) Current price policy has no incentives to cut down the cost of investments and improve the management of windfarms, and it will impede the long-term development of wind power. In the early stage of development, the pricing regulation, which directly results in a high utility purchasing price of wind power, can stimulate greatly the enthusiasm of investors for wind energy. However, such high electricity prices will yield profits to windfarm developers from the beginning of the project. Such high profit based on high price places more burdens on power consumers. It has caused resistance from the public utilities. Because of lack of support from utilities, it is very hard for wind energy to achieve faster development. The high price policy can thus distort the original intention of wind energy development. High price may also damage long-term sustained development of wind power.

Because the investment activity of windfarm investors or developers aims at profit, management for the whole construction and operation period during the investment process will directly affect the benefits, and success of projects. Quality of management should be reflected in the costs of the project, generation and capital operation costs, etc. However, current price regulation, while not negating altogether such efforts, means that there is little incentive for windfarm owners to achieve better management of projects.

2) Over-intervention of government obstructs the building of market competition mechanism. Currently, most windfarms are subordinated to local electricity authorities, utilities or other governmental departments. The construction funds of these windfarms come fully, or at least partly, from grants or preferential loans from foreign governments or international organizations and the Chinese Government. Thus, construction, operation and management of windfarms are subject to government control; in particular the pricing principle of wind power seriously impedes wind energy projects from conducting themselves as businesses. Although it is difficult for wind power to compete fully with coal-generated power in the near future, it still needs to establish competitive mechanisms, even within wind power generation, through rational policies and measures. However, there are so far no effective and efficient market competition mechanisms.

3) Lack of effective investment policy or regulation. The reason for insufficient finance channels is not constraints on capital. It is mostly due to lack of relevant investment policy and regulations. Because investors are always able to foresee potential investment opportunities, once there is reasonable investment policy, which can reduce the risk in investment, windfarm projects will be able to attract investment.

4) Weakness in institutional framework and policy formulation for wind energy. Two points can be made concerning wind energy. First, the government lacks a single coherent and internally consistent policy; second, there is a lack of an institution to formulate policies and regulations, and the current institutional framework for doing so is complex and unwieldy. The responsibility of policy formulation appears to be shared by the State Development and Planning Commission (SDPC), the State Economic and Trade Commission (SETC) and the grid administration agencies, such as the State Power Corporation. One of the most important aspects of policy formulation is to make regulatory rules for the energy market. The current governance structure in China suffers from two deficiencies: first, the responsibility for wind energy policy is not clearly assigned to a single government institution; second, the State Power Corporation itself is engaged in policy formulation which may lead to favorable policies for itself.

6 From Non-market Support to Market Cost-competitive Incentives

6.1 Basic Prerequisite for Commercialization of Wind Energy

Generally, high pricing is intended to guarantee investment recovery, while it directly impedes large-scale diffusion of wind energy technologies. Practically, except where administrative pressure is applied, local utilities are reluctant to buy wind power with high price. Future large-scale development of wind power depends on commercialization of wind energy. Currently, wind power price is very high, although this is not true over the whole lifetime of wind power projects, because current wind power price includes high capital costs, and once the loan is paid back, the price of wind power will drop sharply. This is illustrated by the following calculation of the average 'whole life time' cost of wind power. It is based on the dynamic cash flow assessment method, and the following formula is used to calculate the wind generating cost (Qiu, 1997; Liu, 1998; Wei, 1999).

$$C_{kWh} = \frac{(C_F \times CRF + C_{OM} + C_R \times PVF \times CRF)}{N_{kW}}$$

Where,

- C_F = initial capital cost,
- C_{OM} = annual operating and maintenance costs,
- C_R = replacement costs (assuming there is no replacement for wind turbine system),
- PVF = present worth factor (based on discount rate i=10%),
- CRF = capital recovery factor (also based on discount rate i=10%), and
- N_{kW} = annual generation.

Based on the above calculation, the average cost of wind power during its whole lifetime is 0.56 yuan/kWh (US$ 0.067/kWh). Compared with the costs of conventional generating technologies (See Table 8), current wind power price is still not able to compete with them. However, if operation cost is estimated at 2% of the initial investment (5% is assumed in the above calculation), wind power price will be reduced to 0.46 yuan/kWh (US$ 0.055/kWh), which will be able to compete with nuclear power, but still higher than hydropower and coal-fired power. Because wind energy is non-polluting and renewable, it has external benefits (environmental benefits) compared with coal-fired power. It can be safely assumed that, even if the externality of wind energy are not taken into consideration, wind power will be able to compete with new coal-fired power in the near future (Zhao, 1998).

Table 8. Comparison of generating costs between wind power and other generating methods

Generating methods	Unit generating cost	
	yuan/kWh	US$/kWh
Coal	0.30	0.036
Nuclear	0.51	0.061
Hydro	0.28	0.034
Wind*	0.56	0.067

Note: If operation cost is estimated at 2% of the initial investment, wind power price will reduce to 0.46 yuan/kWh (US$ 0.055/kWh).

Source: calculated according to related information.

Wind energy has certain advantages in attracting investment. First, there is little risk in investing in a windfarm, if all the electricity it produces can be purchased by the grid, so only minimal sales and marketing efforts are required. Second, the construction of windfarms is fast, generally less than one year, so there will be power output from the second year, possibly even in the first year. Moreover, operation and management of windfarms are simpler than in coal-fired power plants, resulting in lower operation costs. With technological progress and innovation, generating costs of wind power will continue to drop. Therefore, there will be good prospects for the development of wind power. The key to realizing the commercialization of wind power lies in further reductions in initial investment and operation costs.

6.2 Localization of Wind Turbine Production

In order to reduce the initial investment cost of wind power, the current method is to exempt imported wind turbines from duty. However, the wind energy industry cannot rely on this measure forever. One effective way is to localize wind turbine production in order to reduce the initial investment cost of wind turbine. It is estimated that the production cost of wind turbines will decrease by 30%. (Wu G., 1999)

China's efforts on domestic production of wind turbines started in the 1980s. In 1982, the State Science and Technology Commission (SSTC) organized experts to investigate key technical problems in wind power generation. Meanwhile, China began to build its modern production capacity of wind turbines by importing technologies from abroad. By 1989, over 40 types of generating units ranging from 30kw to 200 kW had been developed and manufactured. In recent years, in order to improve and accelerate the development of wind generating technology, the government decided to attract advanced foreign technologies, then to absorb, digest, and make innovations, according to the local situation. Joint ventures were set up between local and foreign companies through technology transfer to jointly produce wind turbines. Xinjiang Wind Energy Corporation (XWEC) is an example, which has, to a large extent, realized the localization of 600 kW wind turbine technology through introducing, absorbing and digesting foreign advanced technology (Wu G., 1999).

However, production capacity is a basic condition to realize the domestic production of wind turbine. The key is not the production of wind turbines, but the establishment of a wind turbine market (Wang, 1999). The final target of localization of wind turbine production is to put domestic wind turbines into commercial operation. Thus, market incentive is the key for realizing the objective of domestic production of wind turbines.

However, from the outset, domestically produced wind turbines have to confront an unfair competition environment. There are two points concerning the unfairness of the market. First, the current policy exempts imported wind turbines from duty, and reduces that of imported components, which have a big impact on the domestic wind turbine industry. The Government is eager to adjust the duty to create a protective umbrella for the domestic industry. Second, current foreign government grants or preferential loans are often connected to sales of wind generation equipment of the donor country, which prevents domestic suppliers of wind generation equipment from bidding in the construction of windfarms. This will block the progress of domestic manufacture of wind turbines. Two ways can be adopted to overcome these barriers. One is to increase the domestic funds for windfarm construction and to set up incentives to increase the production capacity of domestic wind generation equipment. Another is to establish a whole set of quality measuring standards, auditing and certification systems for wind generation equipment and sectoral criteria, through which producers of wind generation equipment will have fair opportunities in bidding.

6.3 Cost-Competitive Incentives

Power supply in China is affected by the traditional command and control mode of the centrally planned economy, so the development of wind energy needs to change from a traditional concept and viewpoint, and to establish a set of incentive mechanisms as well as to improve the market competition environment.

6.3.1 Establishing a Market Competition Mechanism

The key to drive large-scale development and diffusion of wind power is how to set up a market mechanism for wind power generation, especially how to establish a fair environment for investment and competition.

Wind energy producers are hostages to their distributors, except in circumstances where they serve isolated markets, because they have to depend on grid connections to supply as well as to take power. It is particularly true with electricity producers where no storage is possible for wind power. Thus, there is no arrangement more important than the Power Purchase Agreement (PPA) through which wind energy is transferred to the intermediary between wind power producer and the ultimate consumer. The responsibilities and rights of the grid and windfarm owner can be made clear through the PPA. The PPA sets the terms by which power is marketed and/or exchanged. It sets the delivery location, power characteristics, price, quality, schedule, term of the agreement, and penalties for any failure to meet contracted terms.

There are two institutional barriers in creating PPAs. First, the distributor holds substantial market power over windfarms. The utility grid has many potential alternative sources of power, but the wind energy producer is uniquely dependent on the grid for its market. Consequently, there is little incentive for the distributor to enter into negotiations in good faith, and to share the economic surplus between the minimum cost of production and the value of the power to the grid. (The result is that most wind energy companies are mainly subordinated to the grid administrative bureaus.) Certainly, there is no incentive for the distributor to recognize the externalities from wind energy production and to pay a price higher than the avoided cost of power of equal value to its system from the least cost alternative source (Debra, 1996; Wei, 1999). Second, the negotiations over terms are exceedingly complex and expensive, with two knock-on effects. On the one hand, the expense itself is a barrier to even initiating an effort to establish a wind energy project; on the other hand, the uncertainty of the outcome makes it difficult to judge whether a project is feasible.

Both of these problems may be diminished with a uniform national policy on the transfer of power in the form of a required model PPA, subject to specific adjustments under specific conditions, but otherwise not to be modified. The model PPA should establish major terms of every agreement in the form of transparent formulas that could be applied in different situations. Most importantly, it would establish the duty of the distributors to negotiate with all potential wind power producers who sought connections with the grid.

The major difficulty in developing such a model agreement is to determine the price at which power is to be transferred. As noted above, there are typically substantial positive externalities associated with wind energy production. Further, wind energy is not financially attractive as compared to fossil fuel electricity production under current conditions. That the negative externalities of fossil fuel electricity production are not fully taken into account does not change this fact. Based on these facts, some observers often suggest that the price paid by the grid in the PPA should include a subsidy to the wind energy producer — that is, that the distributor should pay a price higher than the adjusted avoided cost of the power purchased. This practice would require the ultimate consumers of power to pay more for their service. They would be paying the financial cost of the externalities incorporated in wind energy production. While to a limited extent this approach seems roughly equitable, it has practical difficulties as well as advantages. The difficulties are that this places the distributor in the position of having an incentive to minimize its uptake of power, and to resist entering into agreements with wind energy producers. A relationship of mutual advantage is foreclosed, and the distributor will not be a satisfied and willing partner. The advantage is that the distributor becomes a low-cost tax collector that shifts funds from electricity consumers to cover a socially beneficial program. Another way is to make some institutional remedy or to formulate some government policies to reduce barriers, especially in price negotiation.

The establishment of the model agreement and consequently a market competition mechanism would substantially improve China's capacity to make effective use of wind energy resource.

6.3.2 Amendment to Taxation Policy and Government Subsidy

a) Tariff

Though tariff exemption can reduce windfarm construction costs and wind generating costs by 15%, it is not beneficial for the long-term development of the wind energy industry, especially for the wind turbine production industry. The government should gradually adjust the duty imposed on wind turbines, especially for the import of whole turbines, while keeping a low rate for components that cannot be manufactured domestically.

b) Value Added Tax on Power Production

Since the reform of the taxation system in 1994, windfarms have to turn over value added tax (VAT) at 17% to the tax authorities for wind power production. Wind power generation is not like other conventional power production (such as coal-fired), and with minimal fuel consumption, it is not able to offset or deduct fuel costs. This results in VAT representing a large proportion of generating costs. At present, for small hydropower, which has similar characteristics with wind power, VAT is levied at only 6%. Thus, there seems to be some unfairness for wind power. Many experts recommend reducing the current VAT rate to the same level as small hydropower.

c) Income Tax on Windfarms

Similarly, there are no income tax privileges for renewable energy projects in China. Wind generation is still charged income tax at 33%. However, there are enormous privileges for other types of production enterprises, such as foreign companies, joint ventures, high and new technology firms. To allow a better and fair development environment for wind energy, the government should, at least, grant wind power production enterprises the privilege of deducting partially the income tax burden, for example, levying only half of the current income tax rate.

d) Subsidy

As a major incentive, it would be better to provide subsidy for output of wind power, not for investment. Subsidy for investment has no incentive to improve the management of windfarms, while subsidy for output will stimulate wind energy developers to increase output and cut down generating costs. However, they must have enough subsidy funds while not just relying on government finance. The best solution is to set up different wind energy (perhaps renewables as a whole) development funds to provide subsidy for wind power production.

6.3.3 Investment Incentive Policy

Current investment in wind energy is usually coordinated under a government program. Unlike conventional energy projects, wind power projects do not have regular financial sources of allocation and loan. Once the original government and international funds decline, the domestic banks are reluctant to provide the required support to wind energy investors. This leads to a shortage of investment, and a consequent slow-down on wind project development.

Based on the "*New and Renewable Energy Development Program (1996-2010)*", the SETC is formulating the "*Industrial Development Plan for Renewable Energy Development (1998-2015)*", and will select wind energy as the priority area for new and renewable energy development. These guideline documents for renewable energy development will have great effects in promoting development and commercialization of wind energy. However, in order to encourage investment in the wind energy sector, the government still needs to address the following issues:

- standardize and simplify the approval procedure and contractual framework, i.e. through setting up a model PPA;
- establish market-based mechanisms, and learn from the experience of other countries;
- set up credit channels to wind energy developers.

7 Conclusions and Recommendations

Wind power producers faced with the uncertainty of deregulation and competitive price systems find investing in wind energy too risky. How to transfer from non-market support to market incentives is the ultimate objective for China to develop wind power. Such efforts are in progress, though they are perhaps insufficient. All the policies and measures discussed above have the potential to promote the commercialization of wind turbines, wind power generation and the wind energy industry as well as its industrialization, so a more rational policy environment becomes necessary to advance the development of wind energy.

Various specific targets for wind energy development have already been put forward and are continuously being revised. The forthcoming *Industrial Plan for Renewable Energy in China* enacted by the SETC will identify wind power as one of the main technologies to bring China a cleaner and sustainable energy development. To realize the wind energy development target, we have to reduce various institutional barriers. However, it is necessary to re-arrange the institutional framework, so that related government organizations have clear responsibilities for policy formulation. Though it seems to be difficult, because it failed to carry out institutional reform of government organizations related to renewable energy in 1998, the role of government does need to be redefined. In the past, the government role was predominantly on planning and coordination through the management and command and control of administrative power. Once the country moves towards the market mechanism, the role of government will need to be adjusted. In order to ensure the introduction of a cost-effective market for wind energy, the government should enhance, though not reduce, its role in market management. Cost-effective government planning and the collaboration between agencies and companies are important, while government role is required, for example, to issue licenses for wind turbine production, to regulate prices where competition does not exist, and to ensure power utilities, such as the State Power Corporation, do not abuse their market monopoly power. Related government departments should make joint efforts to:

- ✓ work out rational preferential policies or regulations, including tax, investment, subsidy and price, etc.;
- ✓ establish a fair, competitive market environment, especially for domestic wind turbine production;
- ✓ support public R&D of wind generation technology, and localization of wind turbine production;
- ✓ set up wind energy development funds to provide subsidy for wind generation;
- ✓ establish a national quality control, monitoring, and supervisory center for wind turbine development.

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