Steps towards a Wind Resource Concession Approach in China

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June 2003

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EXECUTIVE SUMMARY

Introduction

In the past, China has typically met its increased demands for electricity by burning more coal, but this has had very serious environmental consequences. The country has abundant wind resources, and the environmental benefits of utilizing this renewable resource are likely to be considerable. In order to spur its development, it has been proposed that the wind resource be treated much like oil or natural gas—and that Wind Resource Concessions (WRC) be established and granted to developers offering the most attractive bidding prices.

This report addresses the potential use of the WRC approach within China. Both the conventional energy business and renewable energy business are affected by WRC. Their concerns are described, and the single most problematic aspect of wind power development—its high cost with respect to alternatives—is then addressed. Wind power will require governmental support, and this report describes potential policy approaches for providing such support, and for developing the WRC program.

The Power Sector in China

China is among the world's richest countries in terms of absolute conventional energy resources. Unfortunately, however, crude oil and natural gas reserves are modest compared with those for coal and hydro. Coal's share has been decreasing, but it still represented 67% of the total primary energy consumption in 2001. The country has adopted an energy strategy that relies heavily upon domestic resources, and its resource base suggests that coal will therefore continue to be critically important.

In 1949, all electric power within the country came under state ownership and control, and it is China's centralized planning since that period that defined the conventional electric power sector within the country. Under centralized planning, the government sought to achieve a balance between electricity supply and demand, allocating resources to those industries, projects and regions deemed deserving of priority in order to meet national goals. The sector became characterized by the unfortunate features of centralized planning: chronic shortages and inefficiency.

China began its quest to adopt market-oriented reforms in the late 1970s, and shortly thereafter it adopted a series of reforms aimed at the electricity sector. The first set of reforms in the mid-1980s was targeted primarily at addressing chronic shortages brought about not only by centralized planning, but also by the immediate growth resulting from market reforms in the general economy. This reform allowed others besides the central government to invest in new capacity, and also raised electricity rates to provide capital for expansion.

A second round of reforms was carried out in the 1990s, a time when the country was moving further towards a market-oriented economy integrated with international capital flows, and began to address the question of efficiency. The country had developed sufficient generating capacity (despite very high economic growth rates), and even had surplus levels in various regions, brought about both by the development of new facilities and the closing of older, inefficient state-owned-enterprises. This surplus offered an opportunity to introduce economic dispatch pilot projects and other efficiency improvements, although it also brought about reluctance to meet the financial obligations for facilities constructed under shortage conditions.

A new round of reforms is currently underway. Following the British approach, the reforms seek to split generation from transmissions and distribution, and make it compatible with market-oriented supply. They also seek to move the central government into a role of regulator seeking to correct market failures, rather than as centralized planner allocating power sector resources.

Wind Resource Concessions

Like oil and natural gas, wind resources are geographically constrained energy resources, requiring further exploration/assessment for development. The wind resource is much more readily accessible than oil or natural gas reserves, and the resource assessments are both simpler from a technical viewpoint and much less expensive in economic terms. Both on-and off-shore sites are similarly appropriate for wind development. But other important characteristics are very different. Petroleum products are static, storable, fungible commodities sold in large-scale international markets,while wind power is dynamic, generates electricity intermittently, and requires localized consumption. Storage tends to be very expensive, and wind power typically produces electricity at a cost well above competing alternatives—even without considering the cost of storage technologies. Conceptually, then, while a WRC approach might be technically feasible, whether it would work in economic terms is much more problematic.

The Policy Setting for the WRC

Wind power has flourished in recent years in many countries, in spite of its higher price, because of specific governmental policies encouraging its development. It has been recognized that environmental and other externalities are not fully accounted for in direct market comparisons of power generating technologies, and conventional technologies have received (and continue to receive) considerable subsidies from governments.

While there are myriad forms of governmental assistance, the two most significant governmental support policies for renewable energy systems (RES) are those which:

- Offer **price-based** support, typically in the form of a feed-in tariff for the RES electric power; or

- Employ **quantity-based** obligations, which are often met through the trading of "green certificates" associated with RES power generation.

A similar price vs. quantity battle has already occurred within the pollution control arena. This is not surprising, since both pollution control and renewable energy programs are designed to utilize economic principles and mechanisms within a regulated environment, to accomplish environmental goals that would not otherwise occur in an unregulated setting.

At the beginning of 2002, three countries—Germany, Denmark and Spain—were responsible for about 84% of the E.U.'s installed capacity for wind power. Not surprisingly, all three countries had powerful price supports designed to encourage wind development. With price-level supports, the market responded with dramatic increases in wind power capacity. Wind developers and the environmental community obviously hailed such development, but there was a downside to this mechanism as well. Many argued that such price supports were extremely costly, and contrary to the E.U.'s idea of a liberalized, market-oriented approach to energy systems.

The quantity-based approach, on the other hand, typically relies on an "obligation" to use RES. This is usually mandated by the government in the form of a Renewable Portfolio Standard (RPS), or what in China has been called a Mandatory Market Share (MMS). Trading of green certificates associated with RES can help achieve that RPS/MMS in an economically efficient manner. These types of quantity-based systems have been employed successfully by individual states within the United States—but they typically require a rather sophisticated institutional structure to achieve such success.

Europeans have traditionally employed price-based systems for both pollution control and renewable energy systems, while the U.S. has tended towards the quantity-based approach. Recently, there has been a shift in Europe from price- towards quantity-based approaches for pollution control, but a much less successful one in the renewable energy area. China has also relied on price-oriented systems, and has virtually no experience with quantity-based ones.

The WRC assumes that eventually the private sector development of large-scale wind power units, backed by international financing, will lower the costs necessary to make this renewable resource economically competitive. It does not, however, deal with the short-term situation in which wind cannot compete with traditional fossil-fueled units. Some such financial support (whether price or quantity-based) will therefore be necessary in the short term, over and above (or perhaps as part of) the implementation of any WRC instrument.

Current WRC Status

Based upon a number of studies, the SDPC* issued draft guidelines for WRC pilot projects in November 2001, and then held a workshop in Guangdong that same month. The workshop was attended by more than 100 persons, including governmental officials, private sector developers, consultants, multilateral non-governmental organizations, local power officials, etc. The draft document indicated that it was applicable to wind projects greater than 50 MW, that the concession period would last for 20 years, and that the selection would be made through a tender open to both domestic and international investors. It suggested that the dominating criterion in the tender evaluation was the power tariff, but that the equipment purchasing plan, the financing plan, and the construction plan would all be taken into account. It also noted there would be requirements for local production, and that "purchasing equipment with a high local production rate would result in a high score in the evaluation."

After the workshop, Guangdong and Jiangsu projects were chosen as WRC pilot projects. Their provincial planning commissions prepared proposals, and these were submitted to SDPC for approval. In December of 2002, SDPC issued its approval documents for the two projects. These documents are only applicable to the two individual projects, and therefore do not constitute a final issuance of the WRC guidelines. However, some changes were made to the originally drafted material, including a doubly of project size (from 50 MW to 100 MW), and an extension of the concession period (from 20 years to 25 years). The approval documents also specified that the size of generator units must be larger than 600 KW. The concessions offers were made in April 2003 for both projects, and final bids are due in September. Panels will then have one month to evaluate these bids, and the concessions will be granted at that time.

A Proposed Policy Approach for the WRC

This document suggests that the WRC cannot be separated from the overall need for support of wind power, and that the nature of that support should change over time. It suggests that the WRC should change over time as well. The proposed policy transition is summarized in Table ES.1.

This presents a relatively measured, "learn-as-you-go" approach for developing wind power. It suggests that China should initially adopt a price-based support program in its early stages (i.e., 2003-2007), fostering industrial development in wind energy and focusing attention on capacity development within the wind power domain. This capacity development should address multiple requirements, including the development of policy incentives; assessments of the wind resource; formation of project development teams; governmental restructuring; project financing; and turbine manufacturing. There should be numerous relatively small-scale projects, designed as much to "prime the

* The State Development Planning Commission (SDPC) has recently been reorganized, and is now known as the National Development and Reform Commission (NDRC); for consistency over the time periods discussed in this report, the acronym SDPC has been used throughout.

pump" for that industry as to provide cost effective wind power, but really designed to give the country time to build up its institutional infrastructure in this area.

Table ES.1 Proposed Policy Transition for Wind Power Development in China

	2003-2007 Capacity Development	2008-2014 Market Development	Post 2015 RES Markets
Government Priority	Develop wind industry	Provide cost effective wind power	Regulatory support for full scale RES markets
Wind Power Project Size	Small (<40 MW)	Larger (40-150 MW)	Large (>100 MW)
Wind Resource Concessions	Narrowly defined, site-specific project development rights	Broader, with assessment risks taken on by bidders	Large scale tracts
Price-Based Support	Extensive National Program	Shift towards Provincial Governments	Lesser role
Quantity-Based Policies	Participation in CDM	Participation in CDM; Provincial level experimentation with RPS (with REC trading)	Participation in CDM; Further development of RPS (as needed) with REC trading

A second phase (2008-2014) would move towards market development, with larger-scale projects, more rigorously sited. The emphasis would shift from institution building towards more cost effective power delivery. More risks would be shifted towards the concessionaire, and in the latter stages, the government would begin to move more towards a market-oriented quantity approach, beginning RPS-type pilot projects in individual provinces or regions.

In the post–2015 period, after both the industrial and institutional frameworks have been developed and China has tapped into the experience of both European and U.S. market-based approaches, it would move towards a fully market-oriented system, one consistent with the rules and modalities of Clean Development Mechanism and other international environmental markets.

Several other salient features of such a transition are required:

- The support scheme should be national in scope, with a commitment to wean the nascent wind industry from donor and multilateral agency funding support;

- The nature of the concessions granted must change over time, beginning with narrow "project development rights" in the initial phase, but moving towards large-scale concession tracts similar to oil and natural gas concessions after 2015;

- Wind power requires an institutional "champion," given the task of increasing the installed capacity of this renewable resource and charged with implementing the WRC.

Next Steps for the Government

Europe and America have shown that it is possible to utilize governmental supports (whether price or quantity) to establish a significant market, and this in turn has led to significant decreases in cost for this technology. China's view of the WRC has tended to put cost reduction as the principal goal, envisioning that a viable market will develop accordingly. It aims to encourage larger and larger wind farms and units, attracting private sector financing—yet without having the regulatory, independent developers, or manufacturing infrastructure in place to support such reductions.

Given such a situation, the WRC program should instead proceed in the following manner:

- The WRC needs an institutional "champion," and such an organizational entity should have as its fundamental purpose the promotion of wind power generation within the electricity sector. Its tasks might include ensuring that existing regulations fostering the use of wind power are enforced; developing new regulations to foster its utilization; and developing standardized power purchase agreements, concession contracts, bidding materials, and similar documents for wind utilization.

- Governmental targets for wind power development should allow an initial capacity development stage, with more aggressive growth in later years, as the markets and institutional infrastructure develop. Based on the historical development of wind power in other countries, it would not be unreasonable to expect an additional 1 GW of installed wind capacity in China by 2005; 8-10 GW by 2010; and 12-15 GW by 2015.

- While cost efficiencies depend upon large-scale turbines and project sizes, China's near-term needs are more oriented towards RES market development within the power sector. Thus, the development of numerous smaller-scale projects, in a wide range of settings, from a diverse number of developers should be encouraged. These might still be accomplished utilizing larger turbines sizes, since the development and manufacture of larger, more cost effective wind turbines within the country are clearly warranted. But there should be a no project size thresholds within the WRC guidance.

- In order to support project development expertise and experience, attempts should be made to minimize risks for developers in the early stages of WRC development. The uncertainty of the Power Purchase Agreement arrangements in the power sector needs to be overcome, and guarantees for wind power should rest with the national government, not the grid company or even the province at this stage. Recognizing the burden that this imposes on the government, a system benefit charge or comparable mechanism could serve to help garner funds for such purposes. Supporting numerous small wind farms should also help to minimize the financial risks associated with any individual project.

- The wind resource assessment is critical for the WRC, and should be pursued through three different strategies during the three stages of wind power development noted above. In the first stage, developers would rely on government-supported data collection (as in existing pilot projects), but a pricing mechanism could be used to compensate for resource data uncertainty. The initial emphasis in this stage is on developing expertise within the country to perform such resource assessments. In stage two, organizations employing internationally accepted standards could collect the data, but would not be allowed to take part in the bidding. In stage three, wind developers would independently be responsible for all resource assessments.

- Aside from general guidelines designed to ensure compatible bids, grid connection issues are a bilateral technical concern and can be addressed within the PPAs, rather than within the WRC framework.

- The government obviously has an interest in furthering the manufacture of larger-scale turbines within China, but this should not be a "blanket" policy applicable for all WRC projects. Localized turbine manufacturing is a key component of driving down wind power costs in China, and steps to encourage the market for such turbines are better served in initial stages by fostering competitive efforts across a range of domestic and joint venture entities, rather than a narrow subsidy for certain selected facilities or units.

- A variety of other factors affect implementation of the WRC, including the time period needed for approvals (e.g., tariffs, local land use, etc.); penalty periods; the role of governmental agents in the bidding process; the measurement of "local content"; project selection criteria; etc. Most of these factors are not unique to wind projects, but will be found in virtually any power sector development project. The key point for implementation of the WRC in its early stages is to try to minimize uncertainty and risk for project developers. As developers (and governmental authorities) gain confidence in the WRC process, the larger scale, market driven opportunities will develop over time.

1. 0 Introduction

The rapid economic growth rates in China require a supporting energy infrastructure, and historically China has met increased demands for electricity by burning more coal. Environmental concerns at the local, regional and international level have shifted attention to cleaner, renewable energy resources such as wind energy. Wind energy was the fastest growing energy technology in the 1990s, in terms of growth of installed capacity per technology. By the end of 2002, more than 31,000 MW of wind power generating capacity has been installed worldwide. By the end of that same year, approximately 460 MW of capacity had been installed in China, a level that lies well below that of developed countries like Germany (>12,000 MW) or the U.S. (>4600 MW), or even other large developing countries such as India (>1700 MW).[1] The Tenth Five-Year Plan calls for more than a three-fold increase in such wind power capacity by the year 2005.

China has abundant wind resources, and the environmental benefits of utilizing this renewable resource are likely to be considerable. Professor Timothy Brennand of the University of East Anglia (U.K.) therefore proposed that a Wind Resource Concession (WRC) policy mechanism be employed in the country in order to spur its development. The United Nations Development Programme (UNDP) provided support to analyze this idea, and Brennand prepared a report published in 2000 entitled *Concessions for Wind Power Plants: A New Approach to Sustainable Energy Development in China.*[2]

The word "concession" can be used to cover a rather broad range of applications. At its base lies the idea that a government or company or some other entity will grant a certain type of "privilege"—typically the use of land, or the unique right to sell goods or services—to a specific "holder" (i.e., concessionaire). In practice, for wind energy development, this usually means the right to construct a wind farm at a particularly lucrative site, or perhaps the ability to sell power generated in a specific region at an especially rewarding price. As discussed below, countries such as Argentina and Morocco have already adopted such wind concession approaches.

What was unique about Brennand's WRC proposal for China was its ambitious scale. He argued that large-scale wind projects were necessary to bring about the next major reduction in wind-generation costs. He thus analyzed the economics of a 500 MW concession bid, and argued for concession tracts of a hundred square kilometers or more—capable of supporting a 1000 MW or more of electic power generation.

This report has a much more tractable goal. It reviews the need for renewabl energy systems in China, and on-going efforts to develop a concession approach. It then maps out a strategy for accomplishing such a "transitional" WRC program. It does so by addressing the single most important element hindering wind power development in China—its high price—from a policy perspective, and then provides an implementation plan for WRC.

After this introductory chapter, Chapter 2 discusses the potential role of wind energy in China. It outlines the characteristics of the country's coal-based system, as well as the wind resources available to overcome the problems evident as a result of the existing approach.

Chapter 3 lays out the findings of the Brennand report, along with that of another energy expert retained by UNDP to analyze the WRC, Professor Ni Weidou of Tsinghua University in Beijing. The Ni report, also published in 2000 and entitled *A New Approach for Wind Power Development: Final Report*,[3] addressed some of the implementation concerns associated with utilizing the WRC approach in China.

There are three principal stakeholders with interests affected by WRC: the conventional energy business; the renewable energy business; and the so-called "political field." Chapter 4 tackles the first two stakeholders, while Chapter 5 addresses the political implications of the policy issue. It is primarily concerned about the single most difficult aspect of wind power development—its high cost with respect to alternatives. This chapter acknowledges that wind power will require governmental support, and describes potential policy approaches for providing such support.

Chapter 6 outlines the existing status of the WRC program, including proposed WRC guidelines and pilot projects currently under development. Chapter 7 proposes a broad development path for wind power in China, with three stages lasting into a post-2015 period, and including the implementation of a modified WRC program. Chapter 8 is more specific, focuses on the near term, and lists some "next steps for the government" to take to implement the modified WRC. Chapter 9 presents the conclusions of the report.

While "full-scale" implementation of the WRC as Brennand initially envisioned it may be some years away, such an approach nonetheless offers a useful means of developing renewable energy systems in China. It offers an important alternative to the coal-based future so often predicted, a future that carries ominous environmental implications for the Chinese people and the world. Given the country's projected economic growth rates and energy needs, and the important environmental benefits associated with this renewable energy technology, wind power and the WRC deserve special attention in order to help bring about a sustainable energy future within China.

2.0 Wind Energy in China

2.1 China's Energy System

China is among the world's richest countries in terms of absolute conventional energy resources. It ranks first in the world in hydropower resources, third in proven coal reserves, tenth in proven oil reserves, and eighteenth in proven natural gas reserves. Its total reserves of these four energy resources amount to 10.7% of the world's reserves (if measured by energy content), which puts the country in third place overall.

Despite these apparent riches, the country faces a number of disadvantages:

- The country has a huge population, and consequently its per capita energy reserves are only at 51% of the world's average.
- The mix of its reserves is seriously imbalanced. Crude oil and natural gas reserves are modest compared with those for coal and hydro. The world's oil and natural gas reserves represent 25.3% of the total energy resource reserves, but in China the corresponding share is merely 4%. This poses a big problem for the energy supply and demand response, and raises important national policy concerns about the independence and security of its energy supply;
- Major energy resources are geographically distributed far away from the major industrial centers, as well as the major population. Generally, coal reserves are located in the northwest, oil and natural gas in the far west and southwest, and 70% of the hydropower resource is in the southwest. In the east and coastal areas of the country, where most of the population and industrial infrastructure are located, energy resources are relatively scarce.
- Except for coal, exploitation of these energy resources has generally been quite low and underdeveloped. Thus, for example, China has used only 6.6% of its total exploitable hydropower resource.[4]

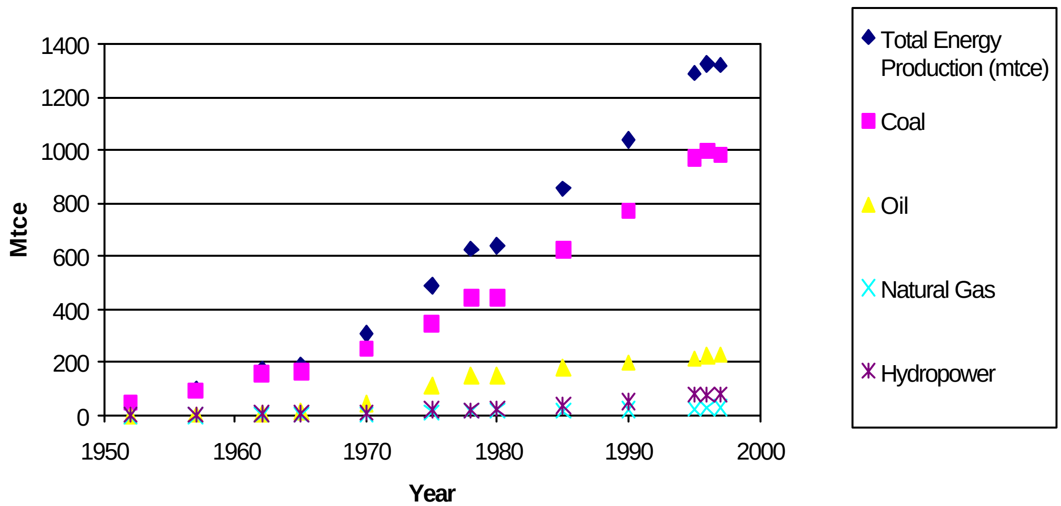
After the formation of the People's Republic of China in 1949, the nation's energy system development can be categorized into three distinct phases: before the economic reform in 1978; 1979 to 1997; and 1998 to present.

Generally, the first two stages were characterized by a severe shortage of energy supply. The significant difference between the two stages is that during the first stage, the development policy and economy were strictly central planned, and the economy and consequently energy consumption were relatively limited in scale. During the second stage, there was a booming economy and increased energy demand, and the policy and economy developed under a so-called "socialist market mechanism."

The year 1997 marked a significant milestone in Chinese energy development, because for the first time the nation's energy supply had a surplus, coupled with relatively high economic growth. Shortly thereafter, the government declared that the economy had departed from a history of energy scarcity.[5]

At the time of the nation's formation, total annual energy output was approximately 23.74 million tce, and this was predominantly accomplished using coal (i.e., 96.3%). Per capita electricity use was 10 kWh/year.[6]

Figure 2.1 Historical Record of Primary Energy Production by Fuel Type



Source: China Statistical Year Book, 2002.

There has been a consistent (yet arguably insufficient) decrease in the share of coal in the total primary energy production mix, as indicated in Figure 2.1. The slightly anomalous data around 1980 represents a failed effort to further this shift. Based upon false and overoptimistic forecasts about the nation's oil reserves, the government launched a campaign to replace coal-fired boilers (primarily at power plants) with oil-fired ones. It soon determined that both the oil production facilities and the actual levels of oil reserves could not satisfy such an ambitious and unrealistic plan, and so a reverse campaign was initiated, with the predictable resulting chaos and a loss of valuable capital resources.

Prior to the mid 1980's, the most agonizing shortage of energy supplies was from the lack of coal mining and transportation capacity. In order to relieve this pain, the government allowed the private sector to enter the coal production and transportation business, which quickly and effectively boosted the national coal supply. From mid 1980's, underdeveloped power capacity became the major concern of national energy development strategy (as was stated in the national guideline during the period, "take electricity power development as the pivot in energy construction.").[7] A comparable adjustment to draw non-state-owned and international capital investment was made, and, as in the coal industry, power generation capacity increased significantly.

By the end of 1997, Chinese national energy supply for the first time in the nation's history exceeded the national energy demand, with a healthy and fast growing economy in place.

Today, China is the world's second largest energy consumer (after the United States), and the third largest primary energy producer (following the U.S. and Russia). Its energy consumption accounts for approximately one tenth of the world's total, and its supply and demand structure is unique for a number of reasons:

- Although coal's share has been decreasing, it still represents 67% of the total primary energy consumption, a figure more than 2.5 times higher than the world's average.[8]
- Fully 88.6% of China's energy use is provided by the domestic resources. This reflects the government's consistent emphasis on self-reliance for meeting energy needs. Even after the adoption of economic reforms and "opening up" policies, this strategy has not been changed. Given the country's energy resources, heavy reliance on coal is the country's sole means of implementing such a strategy.[9]
- China has an unusually high share of industrial energy use (57.9%[10]) in comparison with OECD countries (29.9%) or the world average (34.7%). This reflects both the low energy efficiency of the Chinese industrial sector and the underdevelopment of other (i.e., service) sectors. For example, the iron, steel and chemical industries alone require about half of total industrial fuel demand. One of the most steel intensive economies in the world, Chinese steel makers use on average a third more energy per tonne of output than their US counterparts.

With a huge, rapidly expanding yet low efficiency energy system, in which coal plays (and will continue to play) the dominant role, China today faces a serious challenge of energy related—or more precisely coal-related—environmental problems.

Five of the world's ten most polluted metropolises are Chinese.[11] In 2001, 67% of all cities failed to meet the Class II criteria of the Chinese National Ambient Air Quality Standards (CNAAQS) in annual average, and 40 percent had one or more pollutant with a concentration higher than Class III.[12] China became the world's largest SO_2 producer in 1995.[13] With an ongoing expansion, more than 40% of the nation's land is suffering from acid rain with annual levels below 5.6 pH, primarily because of coal consumption related SO_2 emissions.[14]

Research has been undertaken to determine the costs of national environmental damage, including a comprehensive study conducted by the World Bank in 1995.[15] According to this study, the total damage inflicted was $44.88 billion US, equivalent to 7.1% of the total GDP in that same year.

The public is increasingly concerned about the poor state of the environment. A survey conducted in early 2001 of 15,000 persons throughout the country found that 68% were willing to accept higher taxes for a cleaner environment, and 49% declared that environmental protection is China's greatest problem, topping such concerns as crime, overpopulation, unemployment, education and social insurance.[16]

A number of studies have now been done to predict the future development of China's energy system.[17] According to virtually all of the business-as-usual (BAU) scenarios, China will continue to be the world's largest coal user throughout the first half of the century, and the total primary energy consumption will remain second to the U.S.—but the gap between the two countries will narrow over time. Two studies analyzing the period beyond 2030 suggest that in that decade (i.e., 2030's), CO_2 emissions from China's energy consumption will exceed those of the U.S., and China will become the world's largest emitter.[18]

These studies also indicated, however, showed that there is great potential for mitigating the BAU greenhouse gas (GHG) emissions, by switching the energy infrastructure from a coal-dominated system to a cleaner one. In this evolutionary process, renewable energy could play a significant role, especially over the long run. According to the World Bank, renewable energy has the second largest potential (after energy conservation) in reducing CO_2 emissions, and could account for 30% of total GHG emission reduction by the year 2020.[19]

Over a longer time span, the role of renewable energy could be even more important. In two other (government and IIASA) studies, ecologically driven scenarios predict that by the year 2050, renewable energy technologies such as wind, solar, and commercial biomass could represent 30-35% of total primary energy use in China.[20] Together with increased oil and natural gas consumption, these could cut coal's share to 27-30% of primary energy use,[21] and reduce emissions of CO_2, SO_2, and other air pollutants by 35-55%.

2.2 Wind Resources in China

Amongst renewable energy technologies, wind power has been shown to be a practical choice, both in terms of its technological and commercial maturity, and economic competitiveness.[22] As one of the most promising renewable energy options, it could therefore have an important role to play in improving the sustainability of Chinese energy system.

In 1981, the National Meteorological Bureau of China conducted the first nation-wide wind resource investigation, and the result of its survey was publicized in the book *National Wind Resource Regional Division*. Later, in 1987, the Bureau organized a more detailed survey in the eastern coastal areas, as well as the northwestern, northern, and northeastern regions of the country. During that project, additional monitoring stations were employed, the data sampling methodology was refined, and contour maps of wind energy intensity, as well as the tally of cumulative hours at various levels of wind speed, were prepared for the major provinces and autonomous regions. Key provinces and individual cities have also conducted more detailed, substantiated surveys, and have composed their own local wind energy distribution maps.[23]

These surveys have indicated that the exploitable wind resources in China are huge.[24] Even though there is much uncertainty, it has been suggested that China has the third largest exploitable wind resource in the world, following only Russia and the United States.[25]

In 1995, a national wind resource assessment report prepared by the Chinese Meteorological Research Institute estimated that the total wind energy reserve at 10 meters height is 3226 GW.[26] Based upon a very rough estimate, the exploitable wind resource was estimated to be 250 GW, a figure that represents some 78% of the total power generating capacity installed within the country at the end of 2002.

The assessment criteria and regional division of wind reserves are outlined in Table 2.1 and 2.2.

Table 2.1 National Wind Resources in China

Criteria	Richest	Sound	Exploitable	Poor
Effective Wind Intensity (W/m^2, al)	>200	200~150	150~50	<50
Number of Hours/al of >3m/s	>5000	5000~4000	4000~2000	<2000
Number of Hours/al of >6m/s	>2200	2200~1500	1500~350	<350
Share of national territory (%)	8	18	50	24

Source: CNE, 2003

The richest wind resource regions are located in the eastern coastal areas and in the islands there. Wind energy intensity is well above 200W/sq. m; 6 m/s and above wind speeds occur for more than 4000 hours; and 3 m/s and above wind speeds for more than 7000-8000 hours. Fifty kilometers inland, however, the suitability of the wind resource diminishes rapidly.[27]

Well-endowed wind resource regions are found in Inner Mongolia and Northern Gansu, where wind energy intensities are in the 200-300 W/m^2 range; winds of 6 plus m/s speed occur for more than 2000 hours, and 3 or more m/s speed for more than 5000 hours. These areas cover a significant amount of the territory.

Exploitable resources can be found in the eastern regions of Heilongjiang, and in Jilin, Shandong and Liaoning (along the eastern coastal regions), where there are $200w/m^2$ or more; and 3000 plus hours of 6 m/s winds, and 5000-7000 hours of 3 m/s winds.

Another area with rich wind resources is the Qinghai and Tibetan plateau, although the air density there is as low as 67% of the sea level.

From Table 2.2, it can be seen that the wind resources are primarily distributed in two large wind belts: a Coastal wind belt and a Northern wind belt stretching from Xinjiang through Gansu to the plateau of Inner Mongolia.[28]

Table 2.2 Selected Provincial Wind Resources (GW)

Province	Wind Resource	Province	Wind Resource
Inner Mongolia	61.78	Shandong	3.01
Xinjiang	31.33	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	0.54

Source: P. Shi, 1999

To date, no national resource mapping has been conducted to determine the economically exploitable resource and its geographical distribution, and the lack of such a database has proven to be a problem in developing wind power projects.[29] Fortunately, however, such a resource mapping project is currently underway, and the GIS database should be completed in 2004.[30]

2.3 Wind Power Development

The experimental application of small sized windmills began in the country during the 1950's, and continued into the 1960's. Nonetheless, formally organized R&D of small scale (i.e., < 1KW), off-grid wind power equipment was only initiated in the late 1980's, under the coordination of then State Science and Technology Commission. This was followed by pilot, demonstration, and dissemination programs coordinated by the State Planning Commission, primarily in Inner Mongolia.

During the 1980's, the priority was shifted to grid-connected wind development, and attention was focused on R&D and technology transfer for larger size wind power technologies and equipment. Later, pilot and demonstration projects of grid connected wind farms were set up in Shandong (55 KW units), Xinjiang (100 KW and 150 KW units), and Inner Mongolia (100 KW units), utilizing Danish and American equipment. A national wind industry association was set up, and some large, state-owned-enterprises (SOEs) became involved in developing domestic manufacturing capacity.

During the 1990's (and especially after 1994, when the then Ministry of Electric Power issued a new policy on wind power tariffs), grid connected wind farm development continued to grow. Total installed capacity increased from 20 MW in 1990 to 460 MW at the end of 2002.

In general, the development of small sized, off-grid wind power has been relatively successful. Today, the application of small wind power generators (100W- 1.5 KW) has been fully commercialized, and China is the world's largest microturbine wind market. Approximately 156, 000 sets (with a total capacity of 18.1 MW) are in use, mostly by Inner Mongolia herdsmen. Given that this market has matured, there seems little opportunity for substantial further development.[31]

However, the potential for on-grid applications remains relatively untapped, and this is the subject of the remaining chapters in this report.

3.0 The Concept of a Wind Resource Concession

Oil and natural gas are geographically constrained resources, and certain of these geographical areas are more "lucrative" for resource development than others. Governments have the power to restrict access to the resource, and to allow exclusive rights for its development. They routinely do so for oil and natural gas, issuing large-scale tract "concessions" (often consisting of thousands of square kilometers), in both on-shore and offshore locations. Private sector entities bid for the rights to develop the resource under such concessions, and are willing to invest additional funds in both exploration and resource mapping as part of their developmental efforts, in order that they might identify the best potential resource extraction arrangements. Could such an arrange also work for wind resource development?

Wind resources are similarly geographically constrained energy resources, requiring further exploration/assessment for development. The wind resource is much more readily accessible than oil or natural gas reserves, and the resource assessments are both simpler from a technical viewpoint and much less expensive in economic terms. Both on-and off-shore sites are similarly appropriate for wind development.

But while wind energy shares such characteristics with oil and/or natural gas, it also has important characteristics which are starkly different. Perhaps most importantly, petroleum products are static, storable, fungible commodities sold in large-scale international markets. Wind power is dynamic, generates electricity intermittently, and requires localized consumption. Storage tends to be very expensive, and wind power typically produces electricity at a cost well above competing alternatives—even without considering the cost of storage technologies.

Conceptually, then, while one might agree that such an approach is technically feasible, whether WRC would work in economic terms is much more problematic. This has not stopped other countries from experimenting with various aspects of the concept, however.

3.1 Experience with Wind Concessions

No country around the world has implemented WRC of the type and/or size of the concessions proposed by Brennand. Given the fluid nature of the term, however, a number of countries have issued what are commonly referred to as "concessions" that could attract wind power development.[32] These include, for example:

Argentina. In conjunction with the World Bank and GEF, Argentina has developed an off-grid concession approach to provide RES electricity to rural areas. The project, known as Proyecto de Energia Renovable en el Mercado Electrico Rural (PERMER), was designed to provide electricity to about 70,000 households and 1,100 public services, and was expected to cost about $120 million.[33] This program was subsequently delayed by the Argentine economic crisis, however, and its pressures to reduce fiscal expenditures.

Questions were also raised about the long-term sustainability of the program, once the initial grants and loan funding were exhausted.[34] A WRI study of Argentina's market-driven electricity sector reform concluded that "federal efforts to provide rural electricity services require greater subsidies, and concession designs that go beyond tweaking the existing models…."[35]

Morocco. Morocco depends on imports for more than 90% of its energy needs, and accordingly has developed a strategic plan to develop renewable energies.[36] With more than 3500 kilometers of coastline, and some of the best wind power development sites in the world, the country intends to utilize this resource. The national utility company Office National de l'Electricité (ONE) plans to establish two major wind farms, one in the northern part of the country, and another in the south. The wind farms will have a total capacity of 200 MW. Under a production concession scheme, ONE established a list of pre-qualified firms, and scheduled offers to be issued in early 2003. Construction is to begin in 2004, and wind power service will be provided in 2005. The wind farms will be developed by the concessionaire, and ONE committed that it would: a) grant 20 years of operation to the developer; and b) offer a long term PPA. At the end of this period, the facilities will be transferred to ONE. This process is designed to introduce competition into project development, and will serve to move the national utility towards a more market-oriented position. Although labeled a "production concession," in most respects this development represents a power sector tendering arrangement.

Egypt. Egypt has excellent wind resource in the Suez Bay, and the government hopes to utilize WRC to develop the wind power there. As a first step, an eighty square kilometer parcel of land located north of Zafarana City has been designated for wind power development. The total capacity is estimated to be 600 MW. The national public utility company has built a transmission line to the center of the area, and the area will be divided into several blocks that will be opened for bidding. The first phase is proceeding with two projects under development, using bilateral funding from Denmark and Germany. As above, this project currently represents a move towards introducing competition into wind power development, rather than a full-scale WRC as envisioned by Brennand.

3.2 The Brennand Report

Brennand noted in the preamble of his report that it had three principal aims:

- To bring a new policy instrument capable of accelerating the development of renewable energy to the attention of energy authorities;
- To get large scale investors to consider much larger projects than had been the norm to date; and
- To encourage a mechanism that could exert strong downward pressure on wind generation costs.

Although Brennand noted that concessions are routinely employed in other energy and mineral sectors, he was very careful to note the distinctions: "The parallels drawn with the petroleum and natural gas sectors are not to be taken too literally since the economic driving forces are entirely different in magnitude and the markets cannot be compared."[37]

His WRC approach would encourage private sector investment in a manner that would help to address the biggest hurdle associated with wind power—its high cost relative to coal-based production. Wind power generation costs are highly dependent upon two factors. First, since the energy in the wind is a function of the cube of its speed, small differences in average wind from site to site can nevertheless translate into significant differences in power production, and thus in costs. Second, the size of the production system also plays a key role in wind power, with significant economies of scale evident in production costs.

His report suggests that it will be necessary to move towards very large power plants, in order to make the approach economically viable. As noted earlier, he analyzed the economics of a very large (0.5 GW) facility, and showed that even that would not be competitive at the present time. The report encourages the development of policies to foster even larger (i.e., 1.0 GW) plants in individual concession areas.

Brennand's WRC approach might thus be summarized as a prospective policy mechanism that would encourage private sector firms to put very, very large wind units in exactly the best locations. By doing so, it would enable them to drive down costs, and thus make this type of renewable energy investment a viable alternative to coal-based production. If private sector spending for very, very large units in exactly the right places represents what one might consider an "ideal" situation for wind development in China, then one might consider:

A. *Where are the "right places"?*

As noted earlier, China has "world class" winds along the coastal regions of Guangdong and Fujian, and excellent sources in parts of Inner Mongolia, Xinjiang, Shandong, Liaoning and Zhejiang provinces. The country's wind energy potential ranks among the world's best, with approximately 250 gigawatts of exploitable resources available at the 10-meter level. Since the wind profile typically increases with height, and larger facilities target winds at 50 meters or higher, the real potential resource base is probably much larger. The status of the country's general resource base is thus reasonably well known. UNDP currently has a project underway that will provide a GIS database for this information, and the overall resource data will be readily accessible.

As one moves from the country level to WRC tract and then facility levels, however, the data becomes much less adequate for the tasks at hand. The resource surveys necessary to establish tracts appropriate for WRC have not yet been accomplished. At the facility level, there has been some individual site data collected for various specific site evaluations, but—as noted earlier—it is assumed that those operating within the WRC would still have to thoroughly explore facility siting characteristics within the concession areas. The site selection process also depends upon factors other than the wind resource (e.g., the proximity to transmission lines, other development in the area, etc.).

Thus, from the developers' viewpoint, China looks like it has a promising wind resource, and the general areas for potential development are known. But given the key importance of even small differentials in wind speed, the specific "right places" are not yet known.

B. *What is the "right size"?*

The WRC envisions very, very large facilities, but China's wind power has not yet developed in this manner. As suggested above, there are approximately 140,000 small turbines in the country, and China has been the world leader in the manufacture of these units. Most are in the 100 to 3000 watt range, and are used in households and small commercial and village applications. Only in the last several years has China begun to manufacture medium size units (in the 600 to 750 kW range), usually in conjunction with foreign licensing or joint ventures. These require relatively few outside components, but demand has been low because imported units range have a reputation for higher quality, and tend to be more cost effective.[38]

Even larger units are now being installed in Europe and the U.S., and 1500 kW units currently represent the state-of-the-art.[39] It is these larger units that are driving the on-going reduction in wind energy costs. The cost of producing electricity from wind has dropped by more than 80% in the past two decades, and a wind energy trade association claims that a large plant (50 MW and up) at an excellent site (20 mph average wind speeds) could now deliver power for about 3¢/kWh.[40]

The Brennand report is not quite as optimistic, and its evaluation of a very large wind concession (0.5 GW) in China found that positive cash flows would require an electricity price above 6¢/kWh, and that commercial rates of return would require at least 8¢/kWh. The report noted: "these outcomes would not generate bidding interest."[41] However, it was nevertheless sanguine about future projects within China for two reasons: 1) costs should continue to drop over time; and 2) when China is able to manufacture the larger turbines that meet international quality standards, it should be able to reduce turbine production costs by a further 25-30%.

C. *Where is the private sector investment?*

Given its high costs, private-sector investment in wind power has not played a significant role to date. Governments around the world have determined that environmental and other characteristics associated with this renewable resource deserve consideration, however, and wind power has flourished in other countries because of policies encouraging its development. There are myriad forms of governmental assistance, including research and development funds, tax credits or rebates for turbine purchases, favorable terms for grid access, etc.

The WRC itself is a policy mechanism that would appear to require little in the way of governmental spending. But Brennand's determination that even a 500 MW facility would not be cost-competitive suggests that the WRC policy alone would not increase wind power production at the present time. He is clear about this economic picture, and recognizes that the WRC will also require other levels of governmental support. His conclusions lead off with a series of statements including the words "government-led," "political will," "charge on all consumers," "price support," etc. These issues are fully addressed in the following chapter.

3.3. The Ni Report

While the Brennand report presents the "big picture" about WRC, it also recognized that the proposed policy would raise a number of implementation issues within China. The Ni report was designed to address a number of these concerns. It, too, presents information about the country's wind resources and foreign wind power development experience, as well as a cost assessment and a discussion of WRC barriers and market concerns.

The Ni report covers a wide range of implementation issues, but Chapter 3 summarizes concerns in several areas:

- *The high price*. China's wind power is even more expensive than that in foreign countries, since much of the equipment is imported, and a lack of adequate personnel for management and maintenance has increased O&M costs.

- *Availability of capital*. Virtually all financing is coordinated through the power corporations, and there are very few sources of capital not associated with either the government or international donors.

- *Manufacturing and service capabilities*. Low levels of demand for domestic turbines and poor response from domestic R&D have hampered the industry's development.

- *Institutional arrangements*. A "balkanized," decentralized governmental responsibility for wind power hinders its development.

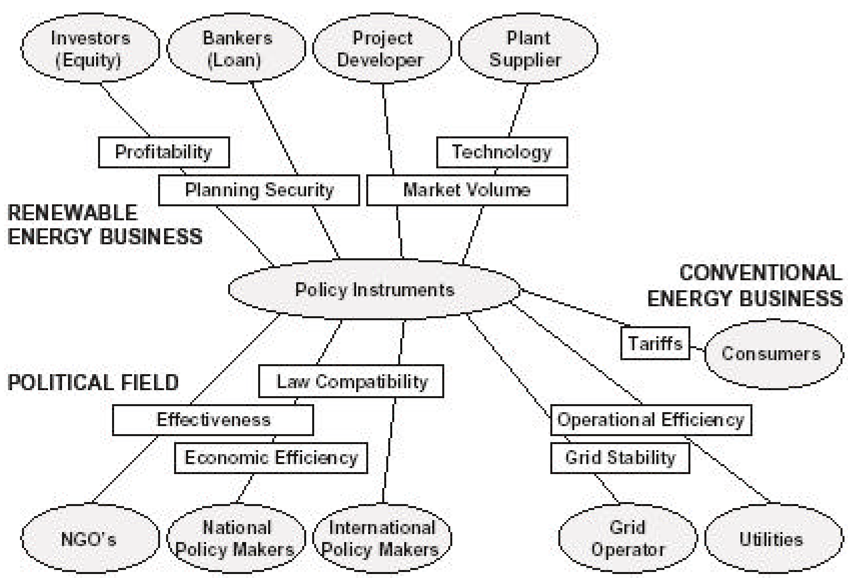
- *Lack of private-sector competition*. The above factors, and equipment selection dictated by donors, has limited private sector competition in this industry.

The report also cites the novelty of the WRC, and a lack of institutional support for wind power development within the country. The following chapter focuses on the principal stakeholders who will be affected by WRC, and their role in wind power development in the country.

4.0 The Concerns of Principal Stakeholders

A recent *Energy Policy* paper which addressed the evaluation of policy instruments designed to foster wind energy development projects (such as the WRC) suggested that analysts have tended to ignore and neglect the interests of important stakeholder groups.[42] The authors proposed a "more integrated evaluation approach" which would take into account interests in three broad areas: the conventional energy business; the renewable energy business; and the political field, as outlined in Figure 4.1.

Figure 4.1 Principal Stakeholder Interests in RES Policy Instruments



Source: Enzensberger et al, 2002

This chapter addresses the first two elements within this framework. The "political field" aspects of the policy instrument development are then addressed within the following chapter.

4.1 The Conventional Energy Business in China

The power sector has an extensive history, going back to the establishment of the first power generation station in Shanghai in 1882. In 1949, when the People's Republic of China was born, the country had only 1.85 GW of generation capacity and an annual per capita power use less than 10 kWh.[43] At the present time, China has the world's second largest electricity system, with 338 GW installed capacity and 1478 TWh generation in 2001. The power industry has been growing at an average annual growth rate of 11.5% (in terms of increased capacity), although much of this growth has occurred within recent decades.

Like its general energy system, the power sector in China is dominated by coal-fired power plants, which accounted for 78% of the total generation in 2000 (see Table 4.1).[44] According to the Tenth Five Year Plan, however, development priorities will be shifted in the future from the construction of coal fired generation plants to hydro power, gas turbines, and grid extension.[45]

Table 4.1 Mix of Power Generation in 2000

	Electricity (TWh)	%
Coal	1081	78
Oil	46	3.3
Natural Gas	19	1.4
Nuclear	17	1.2
Hydro	222	16
Other Renewables	2	0.1
Total	1387	100

Source: CERS, 2002

In 1949, there were only 6,500 km of transmission lines. Today, the grid covers all of the cities, townships, and most rural areas. By the end of 1999, the 220kV transmission lines extended 495,123 km, and at the 500kV level, transmission lines (including DC lines) covered 22,927 km.[46]

There are 16 power networks in China listed in Table 4.2 below, and shown in Figure 4.2 above, although these have undergone considerable reorganization in recent years. In May 1990, the then Ministry of Energy decided to build the China Southern Power Corporation, which included YNPN, GZPN, GXPN, and GDPN; later, when Hainan Province was formed, HNPN was added. Also, later in the decade, Chongqing was separated from Sichuan Province. In early 2003, the grids from the above five southern provinces noted above were merged into the China Southern Power Grid Corporation. Thus, the sixteen networks listed have now been consolidated into six inter-provincial grids and six independent provincial grids.

4.1.1. Institution and Administration

In 1949, when the power industry was nationalized, it became a vertically integrated entity in terms of both administration and business operation, and was exclusively state-

Figure 4.2 Power Networks in China

owned. The power administration agency within the central government simultaneously played multiple roles, serving as decision maker for all aspects of national strategies, policies, planning, and regulations; sole investor for system expansion; and director of all system operations. The local electric bureaus (i.e., the local branches of the state's power administration) functioned in a similar manner, performing both governmental and business operations functions. Despite numerous rounds of reshuffling and restructuring undertaken within the industry, this fundamental feature did not change until the first serious reforms were undertaken in the mid-1980s.[47]

Until very recently, governmental control within the sector occurred through a highly centralized decision process, utilizing a supply and demand balancing mechanism. Prices of electricity, like those for most other products in the nation, were only utilized for accounting purposes, and did not reflect the real variation of supply and demand in the marketplace. They did not affect the allocation of resources.

The power sector was divided into planning units featuring both vertical (industrial) lines, and horizontal (geographical) blocks. The national development plan was made incrementally in five-year segments. During the planning process, economic growth and

Table 4.2 Characteristics of China's Power Networks

Abbreviation	Name	Location	Installed Capacity (MW 1999)	Electricity Production (bkWh 1999)
NEPN	Northeast	Heilongjiang, Jilin, Liaoning Province and east part of Inner Mongolia Autonomous region	39543.9	144.892
NCPN	North China	Beijing,Tianjin,Hebei,Shanxi, & west part of Inner Mongolia Autonomous Region	40716.2	192.235
NWPN	Northwest	Shanxi, Gansu, Qinghai & Ninxia Region	18021.9	73.614
CCPN	China Center	Henan, Hubei, Hunan and Jiangxi Provinces.	43365.4	167.322
ECPN	East China	Shanghai city , Jiangsu, Zheijiang and Anhui Provinces	51986.4	226.890
SDPN	Shandong	Shandong Province	18017.8	91.205
FJPN	Fujian	Fujian Province	9657.4	35.600
SCPN	Sichuan	Sichuan Province	14670.1	44.953
CQPN	Chongqing	Chongqing City	3182.3	13.218
XJAR	Xinjiang Autonomous Region	Administered by NCPN	2144.0	11.492
HNPN	Hainan	Hainan Province	1663.6	3.865
GDPN	Guangdong	Guangdong Province	30333.7	114.004
GXPN	Guangxi	Guangxi Province	5953.0	24.423
YNPN	Yunnan	Yunnan Province	6340.8	26.805
GZPN	Guizhou	Guizhou Province	5518.8	27.063
XZAR	Tibet	Tibet Autonomous Region	159.0	.305

electricity demand were projected for the next five years, and based upon these projections, SDPC and its local branches determined new generation and transmission projects. SDPC then coordinated with other relevant governmental agencies to site the new projects, allocate capital funds, determine equipment specification and manufacturers, fuel types and suppliers, supervise the construction and appoint management. Once completed, the project would be transferred to SETC, which worked as the management of day-to-day operations, allocating annual and quarterly quotas among power plants, and controlling the dispatching of generated electricity. When electricity was in short supply, SETC also allocated consumption quotas among end users. Hence, the government controlled and operated everything from long term planning, project development and construction, down to the daily power generation and dispatching.[48]

A. First Phase of Reform (1985~1997)

One of the chief characteristics of the centralized planning period was a chronic shortage of electricity supply. In order to draw sufficient investment to tackle the severe on-going shortages, the State Council issued the *Provisional Regulation on Encouraging Fund Raising for Power Construction and Adopting Multi- Rate Tariff* in 1985. This allowed local governments, the private sector, and foreign entities to provide investment capital for power generation. In order to encourage such investment, a so called "new electricity new price" (or rate of return tariff) was set forth, giving a guaranteed 12-15% rate of return. The government tried to transform its inter-provincial and provincial power bureaus into modern, market-oriented businesses by introducing western accounting systems and by requiring the bureaus to become financially self-supporting. By 1997, a number of Chinese power generation companies were listed in the New York Stock Market and in other international stock markets.

Through this period of reform, the previously state owned power sector underwent considerable change, and some 50% of its generation capacity was owned by non-state investors by 1997. The reform successfully channeled badly needed financial resources into the industry, and as a result, the chronic nation wide power supply shortage was eliminated. In that same year, power supplies exceeded demand for the first time.

However, the reforms during this period did not solve all problems. The state monopoly was broken, but the state still controlled half of the generation capacity, and the entire transmission grid. It still served as both regulator and business operator, and was able to inflict various kinds of discriminatory treatment upon the IPPs, especially in the surplus market environment. Since many of the IPPs were owned by local governments, the reforms gave rise to serious regionalist favoritism, which hindered inter-provincial electricity trading and the economic optimization of power sector resources. The reforms also did not change the fact that pricing was predetermined by the government, did not reflect market conditions, and was not representative of the true costs of power production.

B. Second Phase of Reform (1997~2002)

The major objective of the second phase of reform was to sever the intertwined elements of regulation and business operations. In 1997, the then Ministry of Power was dismantled, and its business operational responsibilities were given to the newly established State Power Corporation (SPC). After this reshuffling, SPC became a real and pure power company, comparable in many respects to governmentally owned utilities in many other countries.

The other governmental responsibilities were assigned to SETC, SDPC, and the Ministry of Finance (MOF). SETC became responsible for setting the industry's planning regulations, as well as economic and technical policies and standards; supervising the industry's operations and management; and ensuring the balanced dispatch and distribution of electricity. SDPC was responsible for stipulating the developmental strategy and the geographical distribution of large-scale construction projects; allocating the national fiscal budget on infrastructure; and regulating electricity prices. MOF became responsible for stipulating financial management regulations; supervising their proper implementation; and managing state-held equity to ensure its optimal return.[49]

However, even after these reforms, a number of lingering issues remained unresolved:

- *Underdeveloped market mechanism:* The government still employed its administrative command and control measures as the major instrument of regulating the industry (project approval, predetermined price, etc.), distorting market signals and resulting in inefficient practices. Even after the formation of SPC, its undisturbed vertical (generation, transmission, distribution and retail) operations and monopoly continued to impede the formation of fully developed competition.
- *Market division and regionalism*: The electricity market in China is basically divided by administrative region, which makes inter-provincial trade extremely difficult. Given the distance between primary energy sources (in north-west China) and the principal power load (in south-east China), this issue continues to be significant. It is also one of the principal institutional barriers impeding the use of clean and renewable energy resources within the country.
- *Ineffective investment incentive and price regulation*: Long term PPAs based upon tariffs guaranteeing high rates-of-return were very successful in drawing investment to alleviate supply shortages in the late 1980's and early 1990's. These PPAs presented a problem, however, in an era when supply exceeded demand.

C. On-going Reforms

At the national level, SETC has recently been dismantled, and many of its governmental/regulatory functions have been taken over by the former SDPC. (As noted earlier, SDPC itself has been reorganized as well, and is now known as the National

Development and Reform Commission [NDRC]). Other portions of SETC have become corporate entities.

Within the power sector, other on-going reforms are designed to address the above noted and other sectoral concerns. At its base, a general policy of the reform is to separate generation from transmission and distribution, in order to break an existing monopoly and encourage competition. This should both improve efficiency and reduce costs. A related goal of the reform is to expand the role of electric power within the economy, and serve to integrate the grid throughout the country. Furthermore, the reform is expected to address environmental externalities. Within the national power system, an equivalent environmental "price" for emissions from power generation should be established, and it is anticipated that mechanisms encouraging the development of clean (renewable) power sources will be introduced. Electricity will be supplied directly to large users by power generation enterprises under certain pilot projects, changing the monopolistic pattern of the past.

According to the reform program: both generation and network enterprises will be restructured; feed-in price competition will be practiced; operating rules for the power market will be established; governmental oversight and regulatory mechanisms created; regional power markets instituted; and new power pricing mechanisms put into place. Because the government is extremely wary about causing disruptions within the power sector and the overall economy, no timetable has been publicized. However, utility policy analysts believe that the transitional phase will take at least 5-7 years.[50] The resulting power market system, although remaining under the supervision of the government, should operate independently of it, in a fair, competitive, open, orderly and vigorous manner.

4.1.2 Restructuring

In December 2002, portions of the state owned generation capacity were divided into five companies, each with an average generating capacity of approximately 30,000 MW. The five companies are: the Huaneng Group; Huadian Power; Guodian Power; Datang Power Group; and the China Power Investment Company. Four other design and construction entities were also created during the restructuring.

Before the power sector reform, all sixteen power networks were administrated by the SPC. Afterwards, the national grid system was divided into two grid companies: the State Power Grid Corporation and the Southern China Power Grid Corporation.

The State Power Grid Corporation will be a national venture, and will represent investors of the power networks originally administered by the SPC. It will be responsible for forming five regional Power Network limited companies (or incorporated companies) in Northern (including SDPN); Northeastern (including east Inner Mongolia); Northwestern; Eastern (including FJPN) and Central China (including CQPN and SCPN). The Power Corporation of Tibet will also be administered by the State Power Grid Corporation. The Southern China Power Grid Corporation will be composed of GDPN, HNPN, YNPN, GZPN and GXPN. This Corporation will be founded with shares accorded by the ratio of net assets of each of the individual power networks making up the new corporation.

A State Electric Regulatory Commission (SERC) was also set up in March, 2003. It is anticipated that reform will now focus on developing a market mechanism and regulatory system, gradually set up price competition for dispatching and operations, establishing a new pricing system, and stipulating how environmental factors will affect electricity pricing.

4.1.3 Pricing

Ameliorating the power pricing mechanism is a key element of the power system reform. Under the new pricing mechanism, the power price will have three components: a feed-in price, a transmission/distribution price, and a sales price. Competition will be introduced into the generation sector to establish the feed-in price. Then, considering such factors as efficiency, cost restrictions and system development, the government will determine price rules for transmission/distribution pricing. Given these factors, a realistic and appropriate final sales price will be determined. As the keystone of the reform package, the transformation of the pricing system is receiving special attention.[51],

The feed-in tariff will itself consist of two components (an electricity price and a capacity price), and a series of issues including price correlations, trading systems, price system designs, etc. are currently being analyzed to determine how such a reform might be implemented. It is anticipated that prices based upon rate of return calculations will continue to be used in competition for connections during the transitional period, before the two component feed-in tariff is adopted.

4.1.4 Impact of Power Sector Reform on Wind Projects

The construction of Chinese wind farms was started by the mandate of the then Ministry of Electric Power with the objective of promoting adoption of clean power technologies. Pushed by the ministry, the local utility administrations had to set up wind power development companies within their administrative framework, and this gave rise to (still existing) monopoly ownership. Most of the wind farms were built by using governmental grants and international bilateral loans, which meant that the feed-in price was relatively low in the beginning. For example, the wind farms' feed-in tariff was as low as 0.2 RMB/kWh in Xinjiang. There was no regulation in place to control the pricing process between the grids and the wind farms, as wind farms were preponderantly owned by the utility companies.

As shown in Figure 4.3, the current power price system consists of a feed-in tariff, a grid sales price, and an inter-grid supply price.[52] The feed-in tariff is the price paid by provincial or larger than provincial power companies to independent power plants (including joint venture, raised fund plants, etc). The price is determined on a plant-specific (or even unit specific) basis, at the "new electricity, new price" (i.e., the "rate of return price"). For those plants dispatched by the provincial (or larger than provincial) grid, the price is approved by SDPC; for those plants dispatched by the grid beneath the provincial level, the price is approved solely by the provincial price bureau. The PPA sets the feed-in tariff, and represents the legally binding relationship between the power plant and the grid.

For those plants built by the state before 1985 (as well as those built by the state between 1985-1992), there is no independent feed-in tariff. These plants collect the direct operational cost (i.e., without investment payback) according to the catalogue price published by the state.

The retail price is the price charged to end-users when they buy electricity from the provincial power company (or an independent distribution company), and is uniform within each province. The wholesale price is the price charged to the independent distribution company when it purchases electricity from the provincial power company, and this is also uniform within one province. These retail and wholesale prices are called the "catalogue" price, and are stipulated and published by SDPC. Catalogue price adjustments can occur only after the provincial power company submits a proposal to SDPC, and SDPC can approve all or part of the price adjustment.

In 1994, the then Ministry of Electric Power issued *Regulation of Wind Power Grid Connection and Operation*, which stipulated that:[53]

- The ministry was in charge of all aspects of the administration, supervision, and direction of wind farms' planning, construction, management, and operation;
- Grids should allow wind farms to connect near the project site, and should purchase the project's total generation output. The wind farms should sign a connection contract with the grid;
- Feed-in tariffs should be determined based upon: generation costs + interest payments + rational profit.[54] Cost differences above the grid's average feed-in tariff should be covered by the whole grid.

This has been the major regulation followed by utility companies and wind developers in making the feed-in tariff arrangement, and it did play a positive role in increasing wind power capacity from 29 MW in 1994 to more than 400 MW in 2002. Nevertheless, the regulation has some serious problems.

First, the regulation did not specify the exact scope implied by the key word "grid". Accordingly, local administrations (e.g., utility companies in charge of grid connections and the purchase of generation; planning commissions in charge of project approval; provincial price bureaus in charge of the electricity sales price; etc.) could explain it at will as referring to the district, or provincial, or regional-level grid. This made it extremely difficult for wind farms (especially larger sized ones) to be built in locales where there might be a sound resource, but the local grid was relatively small and could not solely afford the price difference. Provincial price bureaus tend to control the sales price quite tightly, and have not allowed price recovery at and above provincial level grids.

Second, the rate of return pricing is a typical case of decision making under asymmetric information, in which the government has insufficient information to determine the "real" costs and rational profits of the wind farms, and the wind farms themselves have no incentives to reduce their costs. In order to address this problem, the government can try to make the approval process more strict and difficult for newcomers. But, as comparable experience with conventional power plants' construction has shown, the government's effort are usually in vain, and result in a so-called "backward price driven phenomena" (i.e., the government loses control of capital and operational costs, and the resulting feed-in tariff). The required annual renewal of the feed-in tariff also increases market risks for potential outsiders.

It seems likely that today's on-going reform will also inflict certain transitional pains upon wind power development. As the grid is separated from generation, the chronically underdeveloped and financially unhealthy grid will have to increase its profitability. The experience of the pilot phase suggests that it is unlikely that the grids will attempt to cover the extra costs associated with wind power, as they sometimes did before. Institutionally, there are many critical policy issues that have to be addressed during the reform, and wind power development may not be a high priority during this transition.

However, over the longer run, the inclusion of environmental considerations in power sector decision-making should play an important role in the development of wind power within the country.

4.2 The Wind Energy Business in China

4.2.1 Current Status

China's wind farms at the end of 2002 reflect the resource conditions noted earlier, with wind power facilities distributed primarily within the two major wind belts (i.e., a Northern/Western belt with approximately two-thirds of the nation's installed wind capacity, and an Eastern Coastal belt with the remaining third).

Despite the country's abundant resources and more rapid development after 1994, Chinese wind farms only compose a very modest percentage in the world's total. Its share only changed from 1% in 1995 to 1.7% in 2001, a relatively insignificant improvement. Its growth rate does not match that of Europe, ands also lags behind India, which had a significant increase in the mid 1990's during the so-called "India Boom".

4.2.2 Size of Wind Farms and Turbines

Even though the average unit size of wind turbines in China cannot match levels found in Europe (1278 KW in Germany in 2001, for instance), it has nonetheless increased significantly in recent years. In 2001, the average unit size in China was 492 KW, which is well above the outside world's general impression about the unit sizes being employed in Chinese wind power development.[55]

However, the scale of wind farms in China is relatively small. By 2001, there were twenty-seven wind farms in the country, with an average capacity of 14.8 MW. More than half of these wind farms had an installed capacity less than 10 MW, while in Germany, the typical size was 20-50 MW, and in U.S. it was even larger (i.e., 50 MW and above).[56] These small sizes contribute to poor economic ratings in China when compared with E.U. and U.S. facilities.

It can be seen in Table 4.3 that the actual installed capacities of wind power are typically a very small fraction of the total installed capacity within the power network. The largest percentage of wind power (at 3.4%) is located in the Xinjiang Autonomous Region. The carrying capacity of the power network does not appear to be a barrier to the development of wind power in China at the present time, or within the foreseeable future.

After the recent restructuring, all but one of the formerly SPC-owned wind farms (which account for more than 50% of the nation's current wind power capacity) were assigned to Longyuan, a renewable energy developer under one of the five generation companies; the remaining SPC-owned wind farm went to Huaneng, another one of the five generation companies.

4.2.3 Ownership and Turbine Market Share

Chinese wind farms have been overwhelmingly developed and owned by the nation's power sector, i.e., the state owned electric power companies, power administrative bureaus, power distribution companies, and the wind power development companies set up by those companies and bureaus. Most of these owners are provincial level and local level companies. Nevertheless a new trend occurred in the late 1990s, encouraged by the SDPC's "Ride the Wind" Program. More and more foreign commercial investment entered the market in the form of joint ventures with local counterparts, although this has not yet captured a significant share of installed capacity.

Despite years of efforts put into the promotion of domestic manufacturing capability, Chinese wind farms primarily use equipment from abroad, especially turbines manufactured in Denmark and Germany. In 1998, Danish turbines accounted for more than three-quarters of total installed capacity; and less than 1% was manufactured domestically (see Table 4.5). Even after the push of the "Ride the Wind" Program, Chinese turbines (and joint venture units, or turbines with domestic components) only represented 5% of installed capacity in 2001.[57]

Figure 4.3 Current Power Pricing System

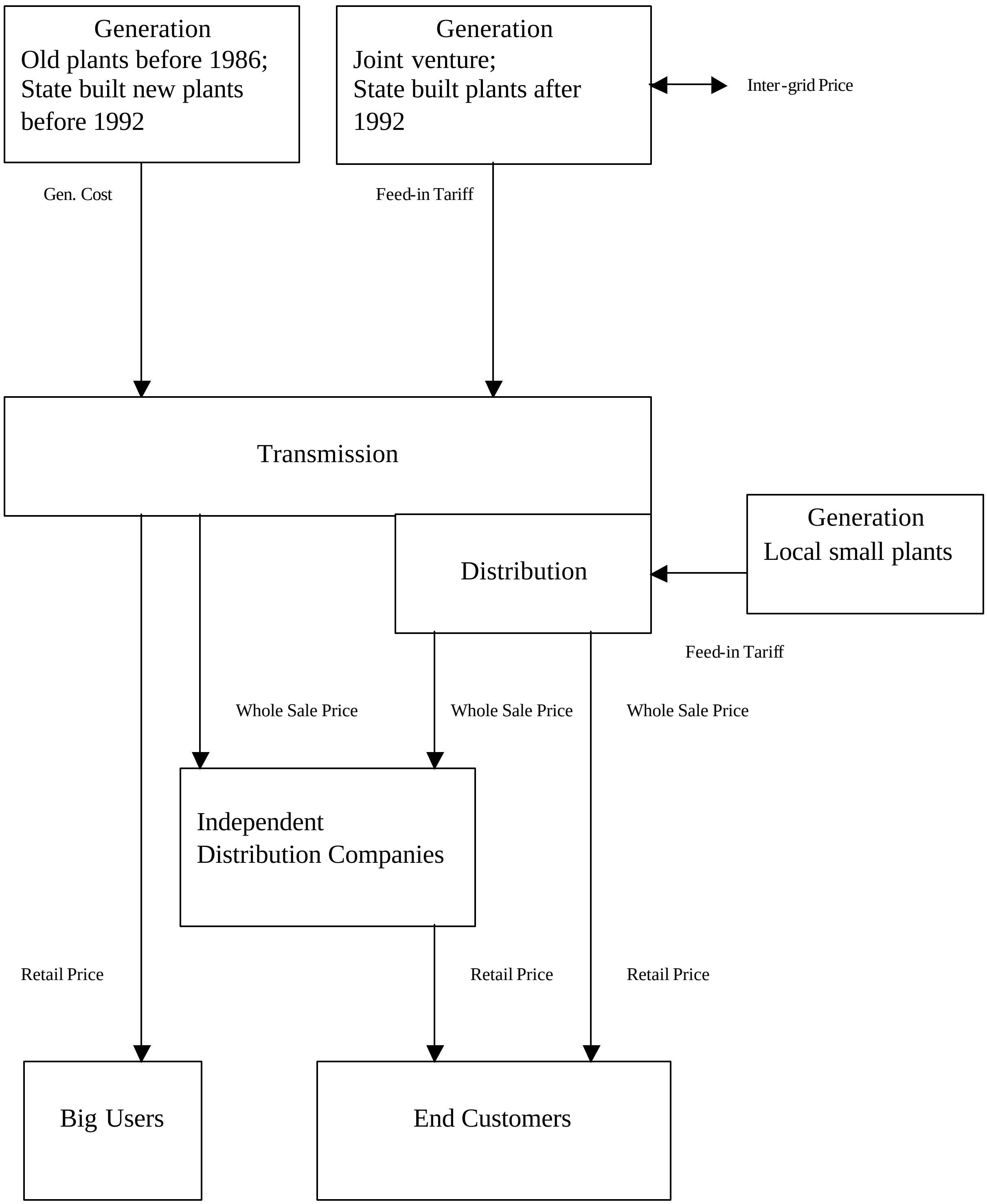


Table 4.3 Wind Power Capacities and Availability in Power Networks

	Power Network	Total Installed capacity (MW)	Installed capacity of wind power (MW)	Percentage of wind power in power network (%)	Available wind energy[b] (MW)	Percentage of wind resource utilized (%)
State Power Network Corporation	NCPN	40716.2	60.3	0.15	71756	0.084
	NEPN	39543.9	82.5	0.21	29661	0.278
	ECPN	51986.4	30.4	0.06	6516	0.467
	CCPN	43365.4	0	0.	12568	0.000
	NWPN	18021.9	1.2	0.01	39470	0.003
	FJPN	9657.4	13.1	0.14	1372	0.955
	SDPN	18017.8	5.7	0.03	3936	0.145
	CQPN	3182.3	0	0.	--[a]	--[a]
	SCPN	14670.1	0	0.	4358	0
	XJAR	2144.0	73.0	3.40	38255	0.191
	XZAR	159.0	0	0	40008	0
Southward Power Network	GDPN	30333.7	70.0	0.23	1950	3.590
	GXPN	5953.0	0	0.	1681	0
	HNPN	1663.6	8.8	0.53	640	1.375
	GZPN	5518.8	0	0.	1006	--
	YNPN	6340.8	0	0	3666	--
			344.8		256843	0.134

[a]CQPN is included in SCPN in the final two columns.
[b]*Sources: http://www.xjwind.com*

Table 4.4 Installed Wind Capacities in Selected Years (MW)

	1995	1999	2000	2001
Europe	**2518**			**16362**
Germany	1136			8100
Denmark	619			2417
Spain	145			3175
Holland	236			483
UK	200			477
Sweden	67			264
Italy	25			560
Greece	28			273
North America	**1676**			**4440**
US	1655			4280
Canada	21			200
South America	**11**			**2162**
Asia & Pacific	**626**	**1403**	**1795**	**2162**
China	44		361	399.9[58]
India	565			1426
Middle East & Africa	**13**			**203**
World Total	**4844**	**13455**	**17706**	**23309**

Source: Ackermann, 2002

4.2.4 Technology and Operational Performance[59]

Two types of wind power unit are being used in Chinese wind units: a) adjustable blade span units; and b) fixed blade span units. The former are lighter, more efficient in making use of wind blow, but are more expensive and require more sophisticated construction, installation, and maintenance techniques. The latter ones are cheaper, simpler in structure, but are heavier and have a lower utility.[60] Generally, Chinese wind

Table 4.5 Wind Turbine Market Share in China (by capacity)

Country	Manufacturer	Share (%)
Denmark		
	Vestas	24
	Micon	23
	Nordtank	15
	Bonus	14
Germany		
	Nordex	5
	HSW	3
US		
	Zond	10
China	all	1
Other countries		5

Source: H. Zhou et al, 2003

mills have relatively poor technical and economic performance characteristics. The average capacity factor for Chinese wind farms is below 20% (i.e., less than 1750 hours/year).[61]

Although there are some cases of good performance (e.g., Dabancheng II in Xinjiang Autonomous Region has the nationally highest capacity factor at 36~39%, and its annual tally of hours in operation is 3200~3400[62]), most of the other units are performing at much lower efficiencies in terms of capacity factor and operating time.

A typical case is in Inner Mongolia. That region has the largest number of wind farms, and the second largest capacity among all the provinces and autonomous regions. In 1996, the average capacity factor was 17.8%, while the world's advanced operations are as high as 50%. Reasons for this include: a) the resource condition, which reflects poor mapping and siting practices; b) poor operations and maintenance practices; c) low turbine generation efficiency; and d) the grid's inability to accept electricity generated by the wind farms.[63] These poor performance characteristics occurred in both domestic and imported units. The relative contribution of these factors is not known, although one might surmise that the contribution of items c) and d) should be relatively low (the imported units, primarily from Denmark, have enjoyed a solid reputation for stable and efficient performance, both in China and abroad; and wind power represents only 0.094% of capacity in the Inner Mongolia power grid, which should pose no challenge for the power dispatching center and transmission lines).

For most domestic units, the situation appears much worse. Many sources have acknowledged the common disadvantage of domestic units, primarily due to the high frequency of breakdown, instability and unreliability of performance, and high maintenance. Many simply cannot be put into operation on a reliable basis.[64] However, at least one domestic manufacturer[65] suggests that the newly developed 600KW units have already improved in this respect. Though there are some operational records to support this statement, the time period has not yet been long enough to fully verify it.

4.2.5 Financing

It has been stated that "Chinese wind farms were predominately driven by international aid programs, despite government programs to promote wind energy"[66], but both forms of support have in fact played an important role. By the end of 1997, 1.75 billion RMB was spent on wind farm construction, resulting in 166.5 MW of installed capacity. Of that total, 41% was obtained from abroad in the form of bilateral soft loans and grants, and the remaining 59% was from the Chinese government, through its renewable energy development programs (i.e., the "Double Plus" preferable bank loans from SETC; SDPC "Ride the Wind" bank loans executed by the China Energy Conservation Investment Corporation; pilot and demonstration funds from SDPC; and R&D grant provided by MOST).[67] Noticeably absent was private sector funding, from China or abroad. This was undoubtedly due to the high financial risks, the institutional uncertainty, the poor economics of wind power generation, and the lack of policy incentives designed to encourage private sector wind power development.

4.2.6 R&D and Domestic Manufacturing

China has long been aware of the importance of developing its domestic manufacturing facilities in order to make wind power cost-effective and competitive with conventional power technologies. While efforts has been made to further such objectives, the outcome has nevertheless been disappointing.

In the Seventh Five Year Plan Period (FYPP 1986 - 1990), China began to fund wind power equipment R&D through the then State Science and Technology Commission. Three million RMB in grants were provided to assist in developing what were then world-class 200 KW and 300 KW units. An additional seven million RMB were provided in the Eighth FYPP, and another 10 million RMB in the Ninth FYPP.[68] Units developed by the Zhejiang Mechanical and Electrical Research Institute (ZMERI) and the Nanjing High Speed Gear Box Manufacturer (NHSBM) remain in the experimental and pilot phase, and the first batch of five units (two 300 KW units by NHSBM and three 250 KW units by ZMERI) were sold for project development as late as 2000. These units are still not in full operation because of frequent operational failures.[69] Meanwhile, commercially employed units elsewhere in the world are now typically in the 1500 KW range.

Learning from this, the government changed its strategy, and two new approaches were introduced. In the Ninth FYPP, SETC began to fund (through its “Double Plus” Program) the purchase of manufacturing technologies from abroad. Chinese R&D institutions and manufacturers have bought 600 KW manufacturing technologies from Austria (Pier) and Germany (Jacobs), and the resulting products have been sold to some wind farms. The results of this approach have been controversial. The manufacturers have declared it a success, though they have acknowledged that improvements needed to be made in quality control and computer software (e.g., AUTOCAD)[70]. Others have suggested that this approach has not proved satisfactory, and that integrated design is the weakest link.[71]

A second idea emerged in SDPC’s “Ride the Wind” Program, which basically supported joint ventures between foreign manufacturers and Chinese integration factories through a public bidding offer. As a result of this effort, the German company Nordex Black-Durr and Spanish MADE were chosen from abroad, and the Xian Aero-Motor Company and China First Tractor Machine Manufacturer were identified within China. The products from these two (respective) joint ventures have been sold to newly built wind farms.

4.2.7 Economics

A number of studies have now been undertaken to determine the economic viability of Chinese wind farm projects.[72] In 1996, the World Bank conducted a comprehensive analysis, and addressed costs at Huitengxile in Inner Mongolia and at Nanao Island in Guangdong Province.[73] Base load least cost options were identified through optimization planning for the North-Eastern China Grid (where Huitengxile was to be connected), and the annualized costs (including capacity, energy, and transmission/ distribution extension costs) were calculated to be 0.32 RMB/kWh there. This was assumed to be the avoided cost of the wind farm, and represented the potential feed-in tariff for a wind project located there. Assuming a relatively high capacity factor (i.e., 38.6%) and full operation in the first year, the financial IRR for total investment was calculated to be 10%. A comparable analysis for Nanao Island resulted in an IRR of 7%. Another analysis by Liu et al showed that the unit cost of wind power is almost twice as high as that of coal fired power (i.e., 0.56 vs. 0.30 RMB/kWh).[74] Given the factors discussed above, the true cost of wind power in China is clearly well above international norms, and prospective developers face many potential concerns.

4.2.8 The Developers Perspective

From the perspective of a wind power project developer, the situation in China has several important characteristics: a) the assessment of the wind resource; b) project development criteria; c) agreement negotiation; d) financing; e) equipment purchases; f) operations and management; and g) electricity sales.

A. Wind resource assessment

The wind resource is clearly the most important physical parameter for a wind farm, and it is assessed on the basis of yearly speed, monthly speed, functional density, etc. For a wind farm, the most important parameter is the annual blowing hours of effective wind speed. Wind resources have a great influence on the economics of wind farms, as Table 4.6 suggests:

Table 4.6 Influence of Wind Resource on Power Price[75]

Annual blow hours of effective wind speed	2000	2200	2400	2500	2600	2700	2800	2900	3000
Power cost (yuan/kWh)	0.650	0.591	0.542	0.520	0.500	0.481	0.464	0.448	0.433

At present, China lacks complete and accurate data about its wind resources, which are important to wind developers. Existing resource data have been determined from approximately 900 weather stations located across the country. These data are important for the development and strategic planning of wind resources, but they are not sufficient for the construction of wind farms on a commercial scale. Two facts make the situation even more dire: a) There are no clear requirements for anemometry standards in China. Anemometers are not certified, and there are no definitive stipulations about the location or the number of metering points, nor of the necessary data collection period. The reliability of existing data cannot, therefore, be guaranteed. b) The annual blowing hours of effective wind speed that are reported are sometimes higher than actual, in order to foster project development. Given such situations, data about wind resources are usually not credible.

A first important consideration for wind developers is therefore to gain reliable anemometric data concerning the wind resource. As discussed in a later section, this might be accomplished under the WRC by: a) relying on existing data, but using a pricing mechanism to compensate for resource data uncertainty; b) entrusting anemometry data collection to an internationally accepted organization that did not take part in the bidding; and c) allowing wind developers themselves to collect the data.

Each of these approaches has advantages and disadvantages, but the approach employed under the WRC might change over time, as developers and data collection organizations gain experience and confidence in the resource assessments.

B. Project development criteria

In the past, the price of wind power has been determined according to the principle of a "pay back" price. That assessed price was merely submitted to the government in order to obtain project approval. Under that rule, the investors' revenue rate was fixed, and wind developers faced no risk. Such a pricing mechanism contributed nothing to cost reduction, because the wind power developers had no incentive to do so.

Under the WRC, however, the assessed price will be used for bidding purposes. Each individual developer will estimate its bidding price, and this in turn will depend upon the criteria specified for project development. The government (or organization representing the government) will have a "ceiling" price, and tenders above that ceiling will not be considered. Since there is competition, wind project developers will try to reduce their costs in meeting the development criteria in order to win.

Potential wind developers will want to ensure that the tender process under the WRC is open, just, and equitable. They will also be concerned that the selection process rules are followed. China has formulated some laws, such as the "Law on Tender Offer and Bidding of the People's Republic of China" on January 1, 2000, which are designed to provide such guarantees. Developers are also concerned that all necessary approvals be made in a timely manner, and the SDPC has promised that all approval processes will be finished within 45 working days. But developers will nonetheless want assurances that such laws and regulations will be fully implemented.

C. Agreement negotiations

When a developer has won the bid and the final price of wind power has been approved by the government, a number of agreements must be signed. Under the WRC, these would typically include the concession contract and the power purchase agreement (PPA). Other contracts may also be negotiated with local governments concerning land use, site access, etc.

In the concession contract, the developers' obligations must be determined and specified. For example, wind resource assessments; the size of the development; development implementation plans; etc. should be included. Issues relating to project administration, project cost and recovery, ownerships of assets, taxes, etc. are also usually stipulated within the contract. Furthermore, the developer's resource assessment and operational risks are also spelled out. On the other side, developers must be assured that the governmental or power sector signatory body, whether a functional section of the local government or a company (or agent) authorized by the local government, is able to represent that entity, and uphold the guarantees included in the concession contract. A significant level of discussion in meetings addressing the WRC focused on the question: "Who is standing behind the contract?" A draft WRC concession contract has already been prepared, and is included within the Ni report.

One question raised in discussions about the WRC in China concerns "ownership" of the wind resource, and whether developers might be required to pay fees or royalties for it. Since wind power is not currently economically viable, and requires government support, such discussions are currently moot. In the future, however, if production costs were significantly reduced, then such a discussion might theoretically become relevant—

although there are no documented cases of any such arrangements, and such additional costs would act as a deterrent to the development of renewable energy systems.

For wind developers, the power purchase agreement (PPA) is a crucial document. It is an agreement between the developers and the power network companies, and specifies the pricing arrangement and conditions for power sales. The power grid company must guarantee that all electricity produced by wind power is purchased, and the term of the PPA is usually 15-20 years. The WRC pilot agreements specified a 25 year period for wind purchases. As discussed in a later section, developers' experience with PPAs in China has not always been positive. If China seeks private sector financing and development for wind power within its power sector, then the implementation of PPAs plays a central role in providing the necessary assurance of a financial return on such investment.

D. Financing

Financing has been one of the principal problems hindering the development of wind power in China. The initial investment required for a wind project is typically about 8000 yuan/kW, and the development of wind power on a large scale would therefore require considerable sums of capital investment.

In the past, wind developers have been wind power companies that were subordinated directly to (or controlled by) the State Power Company. SPC has had relatively little interest in this type of generation, and its investment history reflects that fact. Thus much of the investment in wind power has come from loans from foreign governments or international organizations. Such investment would not be sufficient for large-scale development of wind power in China, however, and it will be necessary to widen financing channels for that to occur.

Under the WRC, developers can seek financing from any domestic and/or international source. Only a small part of the investment (typically 20-30%) is in the form of equity capital; the remainder will be borrowed. But wind developers encounter a number of problems in arranging such financing. Banks tend to believe that the wind power industry has a high level of risk, while the revenue stream isn't particularly large. They are therefore often reluctant to provide loans to wind power projects. Second, even if loans are provided, such loans often have high interest rates and relatively short repayment periods (i.e., much shorter than for thermal and hydro power plants). It has been estimated that the cost of wind power could be decreased by about 20% by extending the repayment term from 5-8 years to 15 years. Third, the banks usually have other (better) investment alternatives than wind project developments, and have historically been reluctant to provide such financing to developers.

E. Equipment Purchases

Wind turbines, the principal equipment in a wind farm, can be imported or produced locally. The wind turbines in existing power generation wind farms in China are typically foreign products, particularly in those cases where the investment was provided by foreign governments. The level of technology in domestic wind turbines currently lags behind that in the developed world, and Brennand considered localized wind turbine manufacturing essential to its large-scale development in the country.

WRC could accelerate local production of wind turbines, since developers would prefer to buy less expensive units. However, developers are also very concerned about performance as well as price, and here (as noted above) the domestic product cannot match foreign products. Historically, the better performance of imported wind systems has more than offset their higher price. This creates a vicious circle, since without orders, local manufacturers cannot improve their performance. In order to overcome this problem, it has been suggested that the government could:

- Protect locally produced equipment through customs duties and value added tax (VAT);
- Prescribe that certain parts of the units (e.g., generators) must be locally made;
- Prescribe a local production rate (e.g., 40%) for the number of whole units.

These latter two approaches could encourage localized production, but they might conflict with the rules of WTO and do not follow "market-oriented" thinking. Concession projects are often designed to achieve specific (i.e., non-market) purposes, however, and one of these purposes could be the development of local manufacturing for this product.

F. Operations and management

Once the wind farm has been constructed, there are both operational and operating cost concerns. Given a specific wind resource, electricity production is first determined by the operating condition of the wind turbines. In this respect, most of the existing wind farms in China are not operating very well. It often takes a long time to diagnose wind turbine problems, and since most wind turbines are imported, spare parts are often not available. There are often long waits for foreign experts to perform repairs.

The attitude of the power network is also a factor influencing the actual amount of electricity sold. If developers are required to dispatch power according to load peaks and valleys, they cannot generate their maximum levels. Although the government has regulatory measures promising that all of the electricity generated by wind power developers will be purchased, the power network may reject doing so (especially since deregulation has now increased the focus on costs).

There is no fuel cost for wind, so the principal components of operating costs include labor, maintenance and management costs. These should decrease under the wind farm scales envisioned under Brennand's WRC proposal. Improving the management of Chinese wind farms is a key task. In the past, wind farms have depended upon state-operated power companies, and management techniques were more often based upon administrative requirements than market-oriented price signals.

G. Electricity sales

Existing wind farms can sell electricity to the power network, since the current owners of most exiting wind farms have been linked to the SPC, and typically have relatively close relations with the power networks. However, for new independent developers, there may be a problem because of the higher price.

The price of wind power is higher than that of coal fired thermal power throughout the country, and this price burden has usually been shared throughout the local provincial power network. Given the very small installed capacity of wind power at the present time, this hasn't presented much of a problem. As the installed capacity increases, however, the issue of burden sharing becomes a more significant policy concern.

In Inner Mongolia, the total capacity of the power network is quite small, and burden sharing has already become an important issue. Inner Mongolia has rich wind resources, but localized burden sharing acts as a considerable constraint on its development. The cost of coal-fired power there is about 0.20 yuan/kWh, while the cost of wind power is more than 0.50 yuan/kWh. This gap is too large to be met within the limited power grid capacity in Inner Mongolia, and a rise in price could subsequently influence the region's economic development.[76] Local governments are therefore not active in promoting the development of wind power.

Similarly, in Zhangbei, the price of wind power was as high as 1.04 yuan/kWh in 1997, but is 0.65 yuan/kWh now. That wind farm was developed under the SPC, but given the restructuring and such prices, there appears to be little interest in further development at that site at the present time.

4.2.9 Impact of Reform on Wind Power Developers

The on-going reforms could present further transitional difficulties for wind power developers. When the grid has been separated from generation, the chronically underdeveloped and financially unhealthy grids will have to increase their profitability. During the pilot phases of reform, cutting the feed-in tariff through competition was found to be difficult, and there seems little likelihood for the grids to assume the extra costs of wind power by themselves (as was sometimes done before).

Institutionally, the regulatory system is far from developed, and the roles of the State Electricity Regulatory Commission and the newly reorganized SDPC (i.e., the NDRC) are not yet clearly defined. Under such conditions, issues of financial and political risk loom large for project developers, regardless of new wind power policies. Even when the regulatory structure has been defined, there are many critical policy issues that have to be tackled during the initial stages of reform. Wind power development will face considerable competition in terms of regulatory priorities.

Over the longer run, however, the consideration of environmental factors and the development of a more rigorous, institutionally strong power sector will ultimately bode well for wind power developers.

5.0 The Policy Setting for WRC

5.1 Administration

In China, the administration of wind power development has been conducted at three levels: a) the central government, b) the provincial government; and c) the county government. Amongst these three, the central government has played the dominant role.

At the national level, under the State Council, which is the executing branch of the government, several commissions and ministries work together to take the major responsibility of wind power administration.[77] In addition to the power sector reforms, the national government arrangements have also undergone very recent change, which makes the descriptive aspects of administration rather difficult to convey.

In principle, the State Development Planning Commission (SDPC) was in charge of the national macro economic planning, and large sized infrastructures construction. Under its Department of Infrastructure, wind power development was managed by means of national development planning, project approval, and budget allocation. The Price Bureau was in charge of wind power feed-in tariff approval. SDPC also supervised project financing and international cooperation. The recently reorganized SDPC will continue to perform these functions.

The State Economic and Trade Commission (SETC) was responsible for national industrial operations and technical renovations. Under the Department of Resource Conservation and Integrated Utilization, SETC supported wind power development in terms of commercialization and fostering domestic manufacturing capabilities. SETC was recently abolished, and it is anticipated that most of these activities will be assumed by the newly formed State Electricity Regulatory Commission.

The Ministry of Science and Technology (MOST) is in charge of the administration and planning of R&D activities, as well as technology transfer from abroad. It has been involved in wind power development primarily through the provision of venture capital.

The State Electricity Regulatory Commission (SERC) was formed in March 2003 to supervise market competition within the power industry, and also to issue licenses to environmentally qualified operators. It expects to launch a pilot power pooling arrangement in two regions, and will also oversee the distribution of power from energy-rich to energy-poor regions. Many anticipate that this is the first public utility regulatory body, and that comparable institutional arrangements will be developed for oil, natural gas, and water.[78]

Each of these agencies has branches at the provincial and county level, carrying out the duties of organizing specific projects and developing supplementary policies and regulations within their authority.

The actual inter-relationships and coordination amongst these agencies are far from being clear-cut, even though they are officially stipulated. Though some observers believe that the agencies have collaborated with each other in an effective manner,[79] the overwhelming opinion is that the situation is far from ideal in terms of efficiency and effectiveness of decision-making. The agencies themselves have concurred with this latter opinion.[80]

5.2 Overview of China's Wind Power Development Strategies

In terms of their scope of magnitude, geographical coverage, as well as degree of applicability and implementation, the strategies and policies concerning wind power development can be categorized into three hierarchies: a) directives and guidance; b) programs, plans and regulations; and c) specific incentives.[81]

5.2.1 Directives and Guidance

These include:

- Ten Measures to Chinese Environment and Development, State Council, 1992;
- China Agenda 21, State Council, 1994;
- 1996–2010 New and Renewable Energy Development Guideline, SDPC, SSTC and MOST, 1995;
- Electric Power Law; and
- National Energy Development Plan for the Tenth Five-Year Plan Period, SDPC, 2000

Among these laws and guidance documents, it was stressed that renewable energy will be "the base for future energy system", and "will prioritize the exploitation of renewable energy in national energy development strategy". In 2000, SDPC, for the first time in the nation's history, included bio-environment protection into the national energy strategy, and declared "the optimization of energy system will be the top priority for future energy development".

In the above-mentioned 1995 guideline (which many believe to be the most comprehensive policy document by the GOC on renewable energy development to date), grid-connected wind power was listed as one of the three top priority renewable energy technologies for support.* The Electric Power Law provided some legal basis for wind power grid connections. Provision No. 5 states that the "government encourages and supports renewable power generation"; Provision. No. 22 that "utilities should allow IPPs to operate"; Provision No. 37 that "the power plants with the same quality of electricity will be treated equally regarding feed-in tariff'; and Provision 47 that "GOC will provide favorable treatment to rural electrification."

5.2.2 Programs, Plans, and Regulations

* The other two are photovoltaics and biomass.

These include:

- Ride the Wind Program, SDPC, 1996;
- Regulation of Wind Power Grid Connection and Operation, SPC, 1994;
- 1996–2010 Renewable Energy Prioritized Projects, MOST, 1995; and
- The Tenth FYPP Renewable Energy Commercialization Plan, SETC, 2000

SDPC initiated its *Ride the Wind* program in 1996. [82] Its main objectives were to draw foreign investment in order to establish joint ventures, introduce new technology, and to make the domestic components share as much as 60% of the large sized turbines. It used some 200 MW of prospective project development as leverage to attract such foreign investment. The program was also designed to support domestic R&D capabilities, focusing these projects on manufacturing issues associated with the production of large-sized turbines.

Program activities included determining the major models of future large-sized wind turbine manufacturing in China, based upon an evaluation of the existing situation and the country's products and comparative advantage; screening and identifying two assembly factories for national recognition and assistance; helping these factories master the core technologies for making the large-sized units (and supported by the national R&D budget); and establishing joint ventures, while requiring the foreign partners to provide manufacturing technologies. To date, the two joint ventures have been established and put into operation, but their products are still not providing steady and reliable performance. The economic performance of the two joint ventures has also been unsatisfactory.

In addition to such development programs, the regulation of feed-in tariff for power plants in China is determined by governmental authorities addressing price administration. The electricity pricing system is a rather complicated and convoluted one. The feed-in tariff varies from plant to plant (or even unit-by-unit within the same plant), depending upon geographical location, ownership, age, source of investment, etc.

In 1994, the then Ministry of Electric Power (with SDPC and MOST later concurring) issued *Regulation of Wind Power Grid Connection and Operation,* discussed in Section 4.1.4. Until very recently, this has been the major regulation followed by utility companies and wind developers in making the feed-in tariff arrangement.

5.2.3 Specific Incentives

This category includes specific incentives (offered by both the central and local governments) to provide financial aid that would offset the high costs associated with wind power projects. These have included:

- *Subsidies*. Subsidies have long been one of the major measures adopted by GOC to support wind power applications. Currently applied subsidies include: a)

Overhead subsidies. In order to promote and disseminate renewable energy technologies, a special management network was established throughout the country, and administrations at different level provide overhead budget support as well as funds to conduct such activities as programming and planning, assist pilot and demonstration projects, etc.; b) R&D subsidies. A major channel for wind power R&D funding is through SDPC's and MOST's annual special budgets. MOST typically input some 15 million RMB annually. The government also provides financial aid to other academic and research institutions to conduct wind technologies R&D activities; and c) Loan interest subsidies. From 1996, the central government began to subsidize 50% of the interest cost of the commercial bank loan for renewable energy projects.

- *Lower Taxes*: In the past, some wind power projects have had a VAT as low as 6% (by qualifying as a small-scale taxpayer), but currently the rate is 8.5%, half of the normal rate of 17%.

- *Tax Credits*. Wind power developers have a number of potential tax credits available, including: a) Income Taxes. The base line income tax rate in China is 33%, but businesses can receive favorable tax treatment if: 1) it is located in a minority autonomous region; 2) it is a high tech business (15%); 3) it is located within a poor region; 4) it is a joint venture (i.e., these are free of tax in the first two years, and are taxed at 50% of the base line rate for the following 3 years). b) Tax Credit for Imported Equipment. The tax levies on imported equipment are custom tariffs, value added taxes (VAT), and the VAT annex (i.e., the VATA, used for city construction and education funding). The custom tariff is 3% on wind turbine spare parts, and 6% on a complete wind turbine (i.e., much lower compared with the average levy on imported goods of 23%). There are no tax credits on VAT and VATA for imported equipment.

- *Low Interest Bank Loans*. Beginning in 1996, the central government set up an annual 120–130 million RMB bank loan quota, especially designed for rural and renewable energy investment. Through SETC, the government also provided subsidies for 50% of the loan's interest costs. To date, almost 1 billion RMB of this low interest bank loan has been utilized in the construction of wind farms and domestic manufacturing plants.

The impacts of a variety of preferential financing incentives, preferential taxation incentives, and various mixtures of such measures for wind power development in China were recently analyzed in a report funded by the Energy Foundation.[83] MOST, SDPC and SETC all participated in this report, which was designed to evaluate incentive policies to promote the development of China's wind industry, and its commercialization. The report determined that "there is no single [incentive] policy that has prominent influence" except for a "preferential pricing policy."[84] It suggested that such a pricing policy "appears to be very effective and certainly merits further discussion."[85] Given the key role that such pricing measures have played in other countries, and their potentially significant role within China, the following sections of this WRC report focus on the economic framework of such a pricing approach, along with the principal alternative means of providing such support.

5.3 Price vs. Quantity Policy Mechanisms

As noted earlier, wind power energy currently costs about twice as much as coal-based capacity in China, and it simply cannot compete with fossil fuel alternatives at the present time. This is also the case in the rest of the world, where conventional technologies typically have lower costs than wind power. Yet more than 6,000 MW of wind power were installed worldwide in 2001, a one-year increase of 31%. By itself, the U.S. state of Texas was responsible for 915 MW, more new wind capacity than had ever been added in the whole United States in any single year.

The seeming discrepancy between these cost and growth statements arises from the fact that governments around the world have determined that environmental and other characteristics associated with this renewable resource deserve consideration. Wind power has flourished because of governmental policies encouraging its development.

While there are myriad forms of governmental assistance noted above (and further discussed in another Packard/Energy Foundation report addressing renewable energy development in China[86]), the two most significant governmental support policies for renewable energy systems (RES) are those which:

- Offer **price-based** support, typically in the form of a feed-in tariff for the RES electric power; or

- Employ **quantity-based** obligations, which are often met through the trading of "green certificates" associated with RES power generation.

A similar price vs. quantity battle has occurred within the pollution control arena. The former mechanism is similar in many respects to a price-based tax on pollution (i.e., Pigouvian taxation), and the latter to a quantity-based constraint on emissions, with market trading employed to reach the goal (i.e., emissions trading). This is not surprising, since both pollution control and renewable energy programs are designed to utilize economic principles and mechanisms within a regulated environment, to accomplish environmental goals that would not otherwise occur in an unregulated setting.

The remainder of this chapter first examines that pollution control experience, and then renewable energy program experience, in a numbers of other countries around the world. The two programs are inextricably linked, since the similarity of their goals may result in overlap. For example, the design of markets in renewable energy credits (REC) established to support wind power could have implications for the greenhouse gas markets established under the Kyoto Protocol's "flexibility mechanisms," depending upon whether the carbon dioxide is bundled or unbundled within the definition of the REC.

With the fundamentals of such governmental support programs established, it then addresses price vs. quantity mechanisms under the WRC, followed by a discussion of their utilization within a Chinese context. The chapter concludes with an analysis of the linkages to other broader market-oriented policies (e.g., the Clean Development Mechanism and carbon markets), which could play an important role in wind power development.

5.3.1 Price vs. Quantity for Pollution Control

Societies have traditionally developed pollution control regulation based on an approach very compatible with an engineering worldview: governments set environmental goals, typically in the form of environmental quality standards setting ambient pollutant limits, and then accomplishes them by instituting prohibitions and/or technology-oriented requirements (i.e., emission standards, design standards, etc.) to achieve and maintain the desired pollutant levels. This is often called the "command/control" approach to pollution control.

Economists have offered an alternative regulatory approach in recent decades, however. Instead of employing environmental quality standards, governments would ideally set environmental goals at the point where marginal costs (MC) equal marginal benefits (MB). All of the concerns about public health, ecosystem damage, visibility, etc. could theoretically be incorporated into these curves. And since there is no "invisible hand" that guides society to the point where MC=MB, economists have also developed alternative regulatory means to achieve it.

Instead of technology-oriented approaches, economists offer two alternatives. A price-based mechanism was developed by the English economist Arthur Pigou in his classic text *The Economics of Welfare* in 1920, and pollution taxes are therefore referred to as Pigouvian taxation.[87] A quantity-based approach was suggested by Professor John Dales of the University of Toronto in 1968, in his book entitled *Pollution, Property and Prices*.[88] Although from an efficiency viewpoint these price and quantity mechanisms are different sides of the same coin, there are important differences in their application—particularly within the political arena.

Over recent decades, much of the world has garnered experience with the price-based tax approach for pollution control. This has occurred primarily in the wastewater/water pollution control area, and much of the initial experience occurred because of the favorable revenue collection characteristics of such a tax. Governments initially collected revenues at relatively low tax rates – too low to affect pollution behavior. Over time, however, as the tax rates rose, they began to have an effect on the levels of pollution emitted. There has never been political support for such mechanisms in the U.S., although they have similarly been employed (at very low tax rates) to collect revenue. The American political characteristics of property rights, markets, and minimizing wealth transfers to the public sector have led to a focus instead on quantity-based regulation.

The first move towards quantity-based program occurred in the mid-1970s, when the U.S. EPA adopted its Emissions Trading Program (ETP). This approach grafted an economic mechanism allowing marginal cost thinking onto the traditional command/control system. It did not abandon the environmental quality goals originally set, nor the command/control requirements employed to reach those goals; rather, the ETP allowed emission sources to utilize less expensive methods for meeting those same environmental goals. Then, in 1990, Congress moved closer to Dales' economic thinking, by adopting a quantity-based approach to control acid rain. In the late 1990s, the same quantity-based mechanism was employed to tackle the problem of tropospheric ozone, through the NOx Budget and similar city and regional markets.[89]

Most European and other industrialized countries were initially skeptical of Dales quantity-based approach, and even environmental economists displayed a preference for Pigouvian taxation.[90] A major international shift, however, occurred in COP 2 in Geneva in 1996, when the U.S. laid out a position calling for "realistic, verifiable and binding" targets for greenhouse gas pollutants, but noted that "international emissions trading must be part of any future regime."[91] This subsequently laid the groundwork for the quantity-based approach adopted in the Kyoto Protocol the following year.

Since that time, the European Union and numerous price-oriented countries have become enthusiastic proponents of the Kyoto quantity-based approach. The EU has introduced plans to start a carbon-trading scheme in 2005, and individual European countries such as the U.K. and Denmark have already adopted emissions trading programs.[92] Others are closely studying the idea.

There is now a nascent market in carbon credits, with more than a dozen organizations acting as "brokers" and/or exchanges; other entities willing to "certify" the credits (even before Kyoto Protocol rules are firmly established); and individual firms specializing in carbon sequestering and "sink" credits. Deals worth more than $100 million have been transacted since 1996, and more than 65 of these trades have been for quantities greater than 1,000 metric tonnes of CO_2 equivalent.[93] The credits themselves typically sell for between $0.60 and $3.00 per metric tonne of CO_2 equivalent.

5.3.2 Price vs. Quantity for Renewable Energy

A comparable policy debate is evident in the title of a recent article in the journal *New Energy*: "Political Prices or Political Quantities? A Comparison of Renewable Energy Support Systems."[94] Renewable energy systems are not yet able to directly compete on an economic basis with conventional energy systems in most parts of the world (although they can sometimes do so in remote, outlying areas not connected to the grid). Nonetheless, it is recognized that environmental and other externalities are not fully accounted for in such direct comparisons, and conventional technologies have received (and continue to receive) considerable subsidies from governments. If new, environmentally promising renewable energy technologies have qualities that deserve societal support, then a policy question arises how governments might provide it in an economically efficient manner. Not surprisingly, the debate occurs along price vs. quantity lines.

The European Wind Energy Association noted that in the year 2001, 4,500 MW of wind power capacity was added to European electricity grids, an increase of more than 35% for this type of energy. Germany topped the list, adding approximately 2,650 MW, bringing total German wind power capacity to 8,750 MW. Fully half of all European wind power capacity in Europe at the beginning of 2002 was located in that single country. Spain was the second largest market in 2001, installing more than 1000 MW. That country is now the second largest European market for wind power, with more than 3,300 MW of total capacity installed. Denmark dropped from second to third, with a total installed capacity of more than 2,400 MW. Together, these three countries are responsible for about 84% of the E.U.'s installed capacity for wind power.[95]

Not surprisingly, all three countries have had powerful price supports designed to encourage wind development. Germany's Electricity Feed Law, first introduced in 1991, required electric utilities to purchase renewable energy at guaranteed prices equal to 90 percent of retail prices. In 1997, wind units were obtaining 0.1715 Deutsche Mark ($0.105) per kilowatt-hour for the life of the plant—obviously a significant incentive for development.[96] Denmark's Windmill Law required that its electric utilities purchase output from private wind turbine owners at 85 percent of the consumer price for electricity, with a comparable 1997 figure of 0.62 Kroner ($0.09) per kWh.[97] The Danish wind market has also been strengthened by a combination of production subsidies, a carbon tax, and various tax credits.[98]

In Spain, under a 1997 law, all RES are paid a guaranteed price set between 80 and 90% of the average sale price of electricity. Spanish wind units have two means of receiving payment: one varies each year according to a government decree, and a second is based upon the average market "pool" price of electricity, with an added variable environmental premium (again determined by the government). Wind producers can choose between the two.

The recent growth figures indicate the success of such price-based supports, but even they do not convey all of the on-going activity. A ministerial order published in France in April 2000 imposed an obligation on EDF and independent distribution system operators to buy electricity generated by renewable energy systems, and a December 2000 order established size criteria for the obligation. The purchase conditions for wind power plants were issued in June 2001, with an attractive feed-in pricing structure (83.8 Euros/MWh for the first five years, and an operation-time-dependent price for the next ten years), and the results have been impressive. The French government had an objective of establishing a base of more than 5,000 MW of wind power in 2010, but by October 2001, it had already received offers for 13,000 MW. Project offers have continued to come in since that time, and limited grid capacity is now a major factor affecting wind power development in the country.[99]

While such feed-in tariffs are not necessarily "fixed," the price-level supports are nonetheless quite high, and the market has therefore responded with dramatic increases in wind power capacity. Wind developers and the environmental community obviously hailed such development. But Denmark's wind production subsidy alone was costing more than 0.5 billion Kroner ($80 million) by 1998, and was rapidly increasing as new capacity was being brought on-line. Many have argued that such price supports are extremely costly, and are contrary to the E.U.'s idea of a liberalized, market-oriented approach to energy systems.

In such a setting, attention has begun to focus on the alternative policy mechanism, the quantity-based approach. The Netherlands introduced a "green certificate" system in January 1998. It was developed by the electricity sector (not the government) within the framework of their Environmental Action Plan. It set a voluntary target of producing 1,700 GWh for the year 2000, and Green Labels were produced to match voluntary demand in the market. In 2001, a Green Certificates Body (GCB) was established (by government decree) in the Dutch transmission system operator. The GCB ensures that a corresponding quantity of electricity has been generated by renewable sources. Certificate holders are then exempted from the regulatory energy tax. Since that initial European effort, green certificate schemes have also been established, or are under development, in Austria, Belgium, Denmark, Italy, Sweden and the UK.

One key policy question in such schemes is the source of the "demand" for the green certificates. As noted with the initial Dutch program, one source can be the voluntary actions of consumers who wish to purchase environmentally attractive energy. Such an approach has been adopted in many places around the world, often under the title "green electricity" or "green power." As an example, consumers can choose their electricity supplier at the retail level in a number of U.S. states, and many have chosen to purchase electricity generated from renewable sources. One such retail supplier, the Green Mountain Energy Company, has 500,000 customers in six U.S. states. It sells power at a premium price, and ensures its customers that their purchases were indeed generated by renewable energy sources through a "Green-e" certification system operated by the Center for Resource Solutions (CRS) in California. In another example, one can also go to the Internet and purchase Pure Wind[sm] Certificates, issued by the PG&E National Energy Group. For $40, the purchaser can acquire all of the environmental attributes associated with the generation of one MWh of electricity generated by the firm at its 11.5 MW wind facility in Madison County, New York.[100] Such voluntary schemes can work, but they usually do not produce the quantity of power generation sought by governments and RES advocates. In the U.S., there are about 160 green-pricing programs run by utilities, and they have a market share of about 1%.[101]

Governments can increase the quantity of RES in the marketplace by instituting a Renewable Portfolio Standard (RPS), or what in China has been labeled a mandatory market share (MMS). In such a program, the RPS/MMS (or "quota," or "obligation") constitutes the demand in the renewable energy market, while the projects employed to create the certificates/credits generate the supply. These markets are just as artificial as that for pollution allowances or credits. In both cases, the marketplace demand is created by governmental fiat.

In the U.S., the Senate passed a bill in April 2002 calling for a federal RPS calling for ten percent of electric power in 2020 to be generated by renewable sources.[102] The Department of Energy predicts that the 10 percent RPS would lead to a fivefold increase in wind power generation than a reference case (i.e., without the RPS). Coal utilization is expected to decrease by 5%, as firms shift to co-firing biomass in their existing coal-fired units[103] to meet the mandated target.

While such a federal RPS has not yet been fully adopted in the U.S., such efforts are nonetheless proceeding in individual states. Eleven states have developed state-level RPS through January 2003, and three have developed renewable portfolio "goals."[104] Most attention has been focused on the state of Texas, because, as noted earlier, that one state added 915 MW of wind power in 2001. It did so through an RPS in the Texas Public Utility Restructuring Act, mandating that 2,000 MW of new renewable capacity be added in the state by the year 2009. This new demand would be met through a quantity-based Renewable Energy Credit (REC) market program, to ensure that the capacity was added in an economically efficient manner. Texas thus offers an example of a successful quantity-based approach, comparable to the successful price-based systems in Europe noted earlier.

In order to determine why the Texas program was such a success, the Lawrence Berkeley Lab (LBL) examined the state's approach in a preliminary assessment. It found that several components of the Texas RPS contributed, including: a) strong political support and regulatory commitment; b) predictable, long-term purchase obligations; c) credible and automatic enforcement; d) flexibility mechanisms (i.e., a long "true-up" period, REC banking, etc.); d) certificate (REC) trading; e) favorable transmission rules and siting processes; and f) the production tax credit.[105] The LBL determined that some of the other state RPS programs do not exhibit such characteristics, and thus "may do little to instill confidence in the renewable energy industry."[106]

Approximately four years ago, the European Parliament also called for such binding RPS-type targets for all European countries. In the final negotiated compromise, these mandates instead became "National Indicative Targets" for renewable energy in 2010.[107] Individual country targets range from 5.7% in Luxembourg to 78.1% in Austria, with a European-wide goal of 22.0%. While the full-scale RPS has not been adopted for Europe as a whole, a number of individual countries are nonetheless proceeding in such a direction.

The Renewables Obligation and the Renewables Obligation (Scotland), introduced on 1 April 2002, place such a legal obligation on all licensed electricity suppliers in the U.K.[108] They will have to provide 3% of their sales in such a manner in the period to March 2003, rising to 10.4% for the year ending March 2011. Renewable obligation certificates (ROCs) are issued to the generators by the Office of Gas and Electricity Markets (Ofgem), and these can be traded to meet the RES obligation.

In Italy, Legislative Decree no. 79/99, commonly referred to as the Bersani Decree, requires that producers and traders must possess (and subsequently file) at least 2% of the total energy produced/used in the previous year. Tradable green certificates issued by the national grid company GRTN can be employed to meet this requirement. The trading scheme will coincide with an electricity exchange to be run by the Gestore del Marcato Elettrico, a subsidiary of the GRTN.[109] Other European countries—Austria, Belgium, and Sweden—are similarly introducing green certificate trading programs backed by RPS-type mandates.

In addition, two pan-European programs have attempted to foster such market-oriented systems. The Renewable Electricity Certificate Trading project (RECerT) simulated trading in Tradable Green Certificates (TGCs) over a live, real-time, internet-enabled trading platform. The project, which spanned an eighteen-month period, had more than 140 participants from 27 partners in 16 countries. It concluded:

> "Assuming that markets are competitive and function correctly, a TGC_{el} [i.e., electricity *T*radable *G*reen *C*ertificate] system is more cost-efficient and effective in achieving RES-E targets for EU Member States than a feed-in tariff system."[110]

Similarly, the Renewable Energy Certificate System (RECS) is an industry-led, independent initiative launched in 1999, whose goal is to promote international trade in renewable energy certificates. RECS believes that international harmonization of the certificate trade is achievable, and would deliver larger benefits than disconnected, individual national initiatives.[111] RECS began with voluntary efforts in individual countries, but is now moving towards an international marketplace through its "Association of Issuing Bodies" (AIB). RECS has 135 organizations participating in its program, from 20 different countries,[112] and it notes that the AIB is on its way to becoming legally established in a number of European countries.[113]

Interestingly, like the transformation from price- to quantity-based mechanisms in pollution control, Europe has also become a battleground for a similar price to quantity transition—but the transition for renewable energy has not been proceeding quite as smoothly.

Recognizing that its price supports were costing the country considerable sums, Denmark decided to make the transition from feed-in price-based support to a green certificate quantity-based market program in 1999. In part, this was seen as a means of getting the government out of an increasing budgetary problem. As Morthorst notes:

> "In the green certificate model the renewable production subsidy is converted from being paid out of the public budget to be paid directly by the Danish electricity consumers. Thus, almost as important as the environmental aspects is the release of the Government from the pretty heavy burden of subsidizing renewable technologies…"[114]

Combined with this budgetary shift, the green certificate program also has the important effect of shifting risks (both financial and political) from the government onto the wind power developer.

Not surprisingly, wind power developers were fiercely opposed to any such move away from price supports and towards a quantity-based market-oriented scheme. The Danish

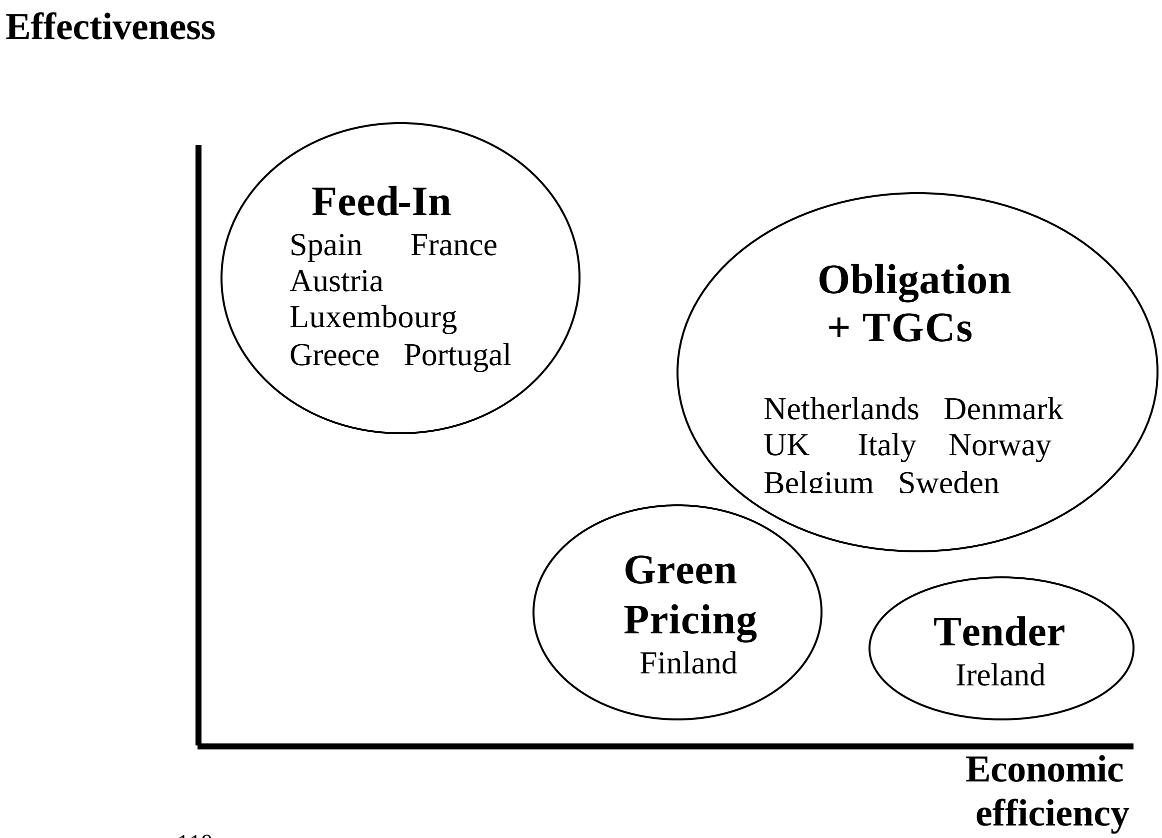
Wind Energy Association identified nine "basic flaws" in the proposed green certificate program, with the first three containing such terms as "built-in instability", "unstable" and "expectations of multiple market collapses…."[115] Their concern was not misplaced—development of the domestic and international markets was indeed quite slow, and the subject of considerable uncertainty. New project development plummeted as the industry was weaned from its price supports, and moved into an uncertain market. Denmark installed 600 MW in the year 2000 (based primarily on orders established under the price support regime), but only 117 MW in the following year—and much of that was also based upon previous orders. Many of the major wind turbine manufacturers received no Danish orders in the first half of the year. In Parliament hearings in September, the industry convinced the government that the quantity-based scheme was impractical (at least over the short term), and the new market-oriented system was placed on indefinite hold.

Similarly, the Swedish Energy Organization's National Association, SERO, called the proposed Swedish green certificates program "a catastrophe for wind power and small hydropower."[116] Sweden's plan, scheduled to be launched in early 2003, has been designed to increase electricity production from renewable sources by 10 TWh from 2003 to 2010. Instead of focusing on market risks, however, the Swedish Association of Wind Power Equipment Suppliers anticipated that much of the new renewable capacity would not come from wind, small hydropower, or solar units, but rather by substituting biomass for coal in existing coal-fired stations. This would require very little capital investment, and the market price of the green certificates would reflect this fact. The development of new wind power capacity would therefore almost certainly suffer, at least in the short term (until around the year 2008, according to the report).[117]

The Swedish report is more sanguine about the role of international green certificate trading, however, and even the Danish wind industry recognizes that such a trading scheme might ultimately be appropriate—but under a harmonized EU system rather than individualized country efforts. It has been suggested that such a harmonized effort is not likely to be implemented before 2010, however.[118]

The RECerT program mentioned earlier sought to summarize expected support mechanisms for renewable electricity within Europe over the coming years, and developed the plot outlined in Figure 5.1.

Figure 5.1 Future RES Support Programs in Europe



Source: RECerT[119]

This figure shows that six countries (including France) will probably continue with price-oriented feed-in mechanisms, while seven (including both Denmark and Sweden) will move towards a quantity-oriented obligation/TGC program. Germany currently has a strong feed-in tariff, and nothing in the report suggests that it is likely to modify that approach, even though its future approach is not identified in the figure. Two other approaches, a voluntary green electricity system in Finland and a tender system in Ireland, are not quite as rigorous as the obligation/TGC approach, but can be considered as introductory steps towards the quantity-oriented mechanism.

This figure suggests that the European community is likely to be split in the near term, with approximately half utilizing price supports, and the other half utilizing quantity-based systems. Given the increased economic efficiency recognized in the figure for the obligation/TGC and the pan-European efforts noted above, the long-term future probably lies in that general direction (especially given the budgetary impacts of high price supports). Wind development in the U.S. will probably follow the quantity-based approach as well, in both the short and long term.

Such Q-based markets for renewable energy are not easy to establish, however. The evaluation of the Texas RPS program noted that not all U.S. states were proceeding as successfully, and that political support, regulatory commitment, and predictable, long-term purchase obligations played a key role in their success. Introducing such institutional factors on an international basis may prove especially daunting.

5.3.4 Price vs. Quantity for WRC

The Brennand report recognizes that wind power facilities are not yet able to compete with coal-fired power plants, and that further support will be necessary. The report states: "the price support needed to commercialize wind farms has reduced very considerable but has not broken through the fossil-fuel barrier."[120] Thus, support for wind power is economically necessary, even if the WRC is adopted.

The exact form of that support does not appear to be a critical factor for the WRC, however. Brennand suggests that "the concession approach does not require any novel fiscal or pricing innovations," and all that it is designed to do is simply provide "a structured basis for promoting wind energy…"[121] In theory, either price or quantity-based systems could work, as long as the support is provided.

The report recognizes that price supports encourage a large amount of development, and also local ownership, and these are both factors that the WRC program is hoping to foster. The implementation of bidding for WRCs may be affected under price supports, however. Documents must be developed outlining WRC bidding procedures, and one obvious parameter that could be a target for the bid is the price of electricity produced. If the government chose to encourage stronger development of the industry through a fixed feed-in tariff, then Brennand suggests that the potential for conflict might be overcome by inviting bidding on the basis of two variables:

a) a discount off the fixed payment, and/or
b) a curtailment of the period over which the fixed payment would apply.

But quantity-based systems also have their own attractions, including the important fact that market-oriented competition applies downward pressure on costs and prices. This may help make renewable options more vigorously competitive with conventional, fossil-fired technologies. Such competitive pressures are not readily evident in price support schemes. Brennand suggests that an RPS is appropriate "in the grid area or areas where the concession bidding scheme is to be introduced,"[122] and the quantity-based approach is also more clearly aligned with the WRC idea of bringing in a market orientation, private sector funding, and international project development skills to the power sector.

Brennand notes that neither price nor quantity support systems have ever been applied to concession arrangements at the scale envisioned in his report.[123] He concludes by suggesting that the price-based system "will cost the grids users more, but may well be a preferred route for initial rounds, and to accelerate the establishment of strong, competing, local manufacturing of wind turbines."[124] But, "in the longer term, competitive systems would seem to be more appropriate."[125] Thus, Brennand calls for a shift from price to quantity instruments over time.

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5.3.5 Price vs. Quantity in China

Like European countries, China has historically tended towards employing price-oriented mechanisms in regulated environments where it utilized economic approaches. It has virtually no experience in utilizing quantity-oriented ones.

China's pollution control efforts make this case evident. Like other countries, it, too, initially adopted a command/control regulatory approach (i.e., as an element of its centralized planning process), and subsequently modified it to include economic mechanisms (i.e., its pollution levy system [PLS], adopted in the late 1970s). The PLS was designed to target those emission sources not in compliance, and collected a fee based on each kilogram of pollution above the level targeted by command/control. It was thus not a full-fledged Pigouvian tax (since it applied only to excess emissions), but was rather designed to encourage compliance in an economic manner. It might similarly be viewed as an incremental efficiency improvement over command/control regulations, laying the groundwork for a priced-oriented economic approach.

There have subsequently been attempts to revise the levy system, and to bring it closer to the economic ideal of Pigouvian taxation. These revisions include collecting fees on all emissions, not just "excess" ones; increasing the levy rates; and adjusting the emissions to account for pollution equivalency and geographical considerations. Pilot projects to assess the effects of such revisions began in Hangzhou, Zhengzhou, and Jilin in 1998.[126] Many problems remain, however. It has been suggested that only about 50% of the total levy fees are actually collected; the fees have fallen behind inflation (since they are not indexed); township and village enterprises (TVEs) are not well represented; and levy fees are well below the marginal cost of pollution control (and even below the operating costs of control equipment). Emission sources thus sometimes shut down their control equipment and pay the pollution levy, and the new revenue stream to the local EPB may mute criticism of this practice.

In recent years, there has been some interest developing about the potential for Q-based pollution control systems in China. One of the most important reasons for this, of course, is the current quantity-based approach of the Kyoto Protocol, and the role that China will play in the international market for carbon credits (as discussed below).

But even at the national level, there have been a number of projects designed to explore and examine the potential role of emissions trading and other comparable quantity-based approaches. The Asian Development Bank supported an initial exploratory project of this approach, including analyses in Shaanxi Province and other locations. It is currently funding an evaluation of emissions trading to address acid rain concerns in Shanxi and Anhui Provinces, and its efforts in Taiyuan are raising international attention.[127] Other organizations have identified at least nine case studies where the emissions trading approach has been applied, in as many provinces.[128]

The Chinese government has also indicated an interest in applying such quantity-based mechanisms at the national level to address the problem of acid rain. In late 1999, SEPA conducted a workshop in conjunction with the U.S. EPA, whose program noted: "with the development and perfection of a market-oriented economy in China, it is worth exploring how operational market mechanisms might utilize the power of markets in controlling SO_2 pollution ands improving environmental quality."[129] At the conclusion of the workshop, the two national regulatory agencies agreed to work collaboratively on a feasibility study addressing such an approach.

Whether such quantity-based approaches in the pollution control area will become feasible in China remains to be seen, given the considerable "rule of law" compliance issues still evident, and the uncertain status of property rights within the country. As noted below, the influence of international trends towards such systems, the country's recent accession to the WTO, and its own on-going development towards a market-oriented economy may encourage such pollution control developments.

In the renewable energy area, China is currently pursuing small-scale, incremental steps along both economic paths. On the price side, China has determined to offer favorable prices for wind power generation. It has mandated that utilities purchase power generated by wind units, but, as the Energy Foundation report notes: "SDPC could start with implementation rules for the renewable energy regulations that already exist. One example is the requirement of utilities to purchase wind-generated electricity, a rule that is not currently followed or enforced."[130]

The country has not developed a fixed, high feed-in tariff at the national level to foster the development of wind power, but instead provides favorable power purchase agreements (PPAs) on a project-specific basis, spreading out the burden of the higher prices over the grid. But the status of PPA agreements currently presents a significant concern for foreign investors in China.

Meizhou Wan, for example, is a 725 MW coal-fired power plant in Fujian Province. The first power station in China to receive limited recourse, private-sector financing from ADB, the $700 million facility was developed on build-operate-transfer (BOT) principles, and was the first fully foreign-owned power project to receive approvals from the State Council and the State Planning Commission.[131] It was also the first international power station in China to receive both direct equity investment and debt financing from the Asian Development Bank.[132] The owners held a 20-year PPA with the Fujian Provincial Electric Power Bureau, yet the province apparently backed away from the PPA when the facility was completed,[133] because there was no longer a power shortage in that area.

The "burden-sharing" of high price PPAs for wind power has also become problematic. In May, 1998, China received World Bank/GEF loans under the China Renewable Energy Development Project (REDP) to build five wind farms: 100 MW at Huitingxile in Inner Mongolia; 50 MW at Zhangbei in Hebei Province; 20 MW at Pingtan in Fujian Province; and 20 MW at two sites in Shanghai. Unfortunately, however, the Huitingxile, Zhangbei and Pingtan facilities ran into problems when the State Power Corporation of China (SPCC) decided to dissolve the North Power China Grid (NCPG), breaking it down into smaller, provincial grids. As the project restructuring document noted in deleting 170 of the proposed 190 MW: "[the higher price] could not be spread over the regional grids. This created difficulties in concluding PPAs with the provinces, especially for the large windfarms in the REDP."[134] This same document suggested that such problems highlighted the need for a national, rather than grid or project-oriented policy framework.

On the quantity-based side, the 10th Five Year Plan includes a proposal for a mandated market share/trading mechanism for renewable energy. The World Bank and GEF are supporting such an approach under the China Renewable Energy Scale-Up Program (CRESP), under the Strategic Partnership for Renewable Energy. Although this program is still on going, RPS has not been able to garner any political support in recent months, given both the uncertainty about the electric power restructuring and the recognition that an RPS would ultimately bring about higher costs—the exact opposite intention of the restructuring efforts.

5.3.6 Linkage to CDM and Carbon Markets

The physical characteristics of electricity in a power grid make it impossible to track the linkage between a specific producer and a specific end user. Thus, even if a customer is willing to pay more for "green" electricity generated by wind farms or solar panels, it is not possible to ensure that the specific electrons delivered to them were generated in such a manner.

But under the "green certificate" approach, an approved RES such as a wind power unit can be considered to produce two individual products: a) the electricity; and b) an "environmental" commodity of some type represented by the green certificate. A powerful characteristic of this approach is that these two commodities can then be sold in two different markets. The electricity itself is traded and consumed locally, and its price is typically based upon traditionally regulated tariffs. The environmental benefits reflected in the certificates, on the other hand, can be sold in local, national or even international markets, depending upon how the commodity itself is defined, and how it is certified. As such, its value can be determined by open market forces, and the income derived from such a commodity could prove useful in providing funds for the project development itself.

As noted earlier, quantity-based markets have already been established for pollution control. The development of an RES might be considered a "pollution control" effort itself, if it displaces some alternative pollution-generating energy facility. It is exactly this approach that is encouraged under the Kyoto Protocol. The alternative facility is considered a part of the baseline, and the new RES generates pollution reductions, which can then be sold in an international marketplace.

The Kyoto protocol has three “flexibility mechanisms” designed to establish such an international marketplace. The industrialized developed countries (i.e., the so-called Annex I countries) have agreed to specific levels of reductions below their 1990 emissions level, and must thus achieve a specific carbon budget. Under the “international emissions trading” (IET) flexibility mechanism, they can buy or sell parts of this budget to each other in the form of “assigned amount units” (AAUs). Under the accords agreed in COP 7 at Marrakesh, they can also utilize “removal units” (RMUs) based upon improvements made in carbon sinks and land use changes.

Project-level greenhouse gas improvements over a “what would have happened” baseline will also be allowed, in two contexts: a) trades between the Annex I countries; b) and trades between Annex I countries and developing countries. The former fall under a “joint implementation” (JI) flexibility mechanism, and the credits are called “emission reduction units” (ERUs). Such ERUs might be generated, for example, by a Japanese firm making an energy efficiency investment in an Eastern European facility. The latter trading system is designed to provide a means for developing countries to participate in efforts to reduce global warming, even though they have not agreed to any emissions budgets, and to help them achieve sustainable development. This flexibility mechanism is known as the Clean Development Mechanism (CDM), and offers “certified emission reductions” (CERs) associated with individual projects. These might include, for example, a German firm arranging to build a wind power facility in China. The market in CERs is thus an important consideration in this WRC project.

China’s potential role in the CDM has drawn considerable attention in recent years. In some pre-Bonn (i.e., COP 6 *bis*) analyses, Woerdman examined potential markets evolving from the Kyoto Protocol flexibility mechanisms, and suggested that “CDM is about 3 times as cheap as JI, and about 6 times as cheap as IET.”[135] Countries such as China would thus be well situated to benefit under the development of such carbon markets. Edmonds et al. found that China alone could gain about $4 billion in 2010 from the carbon-trading market, and the other non-Annex I countries combined would gain a similar amount.[136] Zhang estimated that China could capture fully 60% of the CDM market by itself,[137] leading some to analysts to cynically suggest that CDM as an acronym really stood for a “China Development Mechanism.”

Events since Bonn and Marrakesh have dampened this enthusiasm, in a number of respects. First, and perhaps most importantly, the withdrawal of the U.S. from the Kyoto Protocol significantly dropped the demand (and hence the price) of carbon credits in the marketplace. The technical compromises at Marrakesh necessary to accomplish political agreement also had the effect of easing demand for CDM credits, and many believe that CERs will be “crowded out” by the relatively cheap carbon credits available from Russia and Ukraine, at least in the short term. Thus, the market in carbon credits will be much smaller, and generate much less revenue, for energy projects in developing countries such as China.

Nonetheless, there has been continued interest on the part of bilateral and multilateral donors on implementing this flexibility mechanism. Several CDM projects are currently underway in China, addressing:

- Power sector projects (funded by the World Bank, Germany and Switzerland);
- Provincial-level energy efficiency and renewable energy projects (funded by the Asian Development Bank);
- Transportation and carbon sequestering projects (funded by Canada);
- Energy conservation and others (funded by UN Foundation and UNDP).[138]

The development of wind power facilities under a wind resource concession could generate CERs under the CDM, and these carbon credits could then be sold in international markets.

Since the green certificates discussed above represented some type of "environmental commodity" associated with the wind power facility, then an obvious policy question arises whether such carbon is already "bundled" within the green certificate, or whether it can be "unbundled" and sold in the CDM marketplace. This issue has received considerable attention in both the US[139] and Europe[140].

The principal advantage of unbundling multiple environmental attributes stems, of course, from its ability to deliver multiple income streams to a renewable energy project. This could be important, given that RES projects tend to be expensive when compared to other greenhouse gas and/or pollution control options, and many RES projects are only marginally profitable in any event.

There are a number of disadvantages, however. Even under a straightforward green certificate transaction, there exists the possibility of "double counting." This might occur, for example, if one MWh of wind power is sold to two customers, or if one customer used that MWh to meet two regulatory requirements (e.g., an RPS and pollution control requirement). The certification, verification, and certificate tracking systems must be designed to ensure that such actions do not occur.

Under an unbundled scenario, the opportunities for such double counting increase, perhaps significantly. The Center for Resource Solutions has conducted an extensive analysis of the forms of double counting,[141] and suggests that these would fall in a category labeled "partial double sale." CRS identifies both actual and perceived partial double sales that could occur. For example, a perceived double counting might occur when a green certificate customer purchases the certificate because of global warming concerns, yet is not aware that the carbon credit has been sold separately, and that their action therefore has no climate change value. Here again, prevention relies primarily upon tight regulatory oversight of transactions, and adequate information to the customer. Other problems might occur as well, particularly in regulatory areas where pollution control markets already exist. In the U.S., for example, both SO_2 and NOx markets already exist, and any claimed reduction in these pollutants from RES offsetting fossil-fueled power generation may not occur unless their pollutant allowances are also retired;

otherwise, the corresponding pollutant reduction might just be sold to another emission source.

Whether it is worthwhile to bundle or unbundled depends ultimately upon the goals of the governmental program. For example, a country might decide to support RES in order to foster technological development in the energy field; to develop an electric grid that is resilient and has a greater mix of energy technologies; and to improve environmental conditions in urban areas. If environmental benefits associated with GHG control plays a relatively small role in the country's thinking, then it might be readily willing to unbundle the carbon, and sell it in international markets. On the other hand, if global climate change could be considered a central reason for that support, then it would be probably remain tightly bundled.

In the Texas REC system, all of the environmental attributes associated with the RES are bundled, and remain with the REC.[142] This has been the case with most of the RPS developed to date. Some have held that such tight control needlessly restricts markets, however, and that the reasons for unbundling discussed above are legitimate. One suggested compromise has been to provide only "bundled" products to retail consumers and small energy users, while giving larger, more sophisticated clients the additional flexibility associated with specialized, unbundled emission-reduction instruments.[143]

6.0 Current Status of WRC

6.1 Background of the WRC Initiative in China

At the turn of the century, after almost a decade and a half of development, China had built up several hundred megawatts of wind power capacity. But these figures fell far short of both governmental plans and international expectations, given the nation's excellent resource conditions and the significant amounts of funding supplied by the government for wind power development.

A number of analyses have been made to explore the reasons for this unsatisfactory performance. Y.C. Huang, the nation's former Minister of Energy, suggested that the major impediment against large-scale wind power development was the fact that wind power's feed-in tariff was not yet economically competitive. For instance, the SDPC approved feed-in tariff of wind power in Inner Mongolia in 2002 was 1.047 RMB/KWh, a level about three times as high as that of local coal-fired power.[144] According to Professor Ni's report noted earlier, the principal problems go beyond the high feed-in tariff to include financing difficulties, poor manufacturing capacity, uncertainty and low efficiency in administration and institutional arrangement, and a lack of competition.

The unique characteristic of current wind farm development in China is that most of the existing facilities are owned by power utility companies, who do not have any particularly strong reasons to try to drive down costs. As Professor Ni's report suggests: "There is no competition in wind farm construction and operation. Power sector basically monopolized the investment, operation, and management, it is hard for other players to get involved, which fundamentally hinders the cost reduction of wind power, impede the healthy and large scale development of wind power."[145] Breaking such a monopoly and reducing costs by introducing competition became a major concern, and new policy options began to be explored.

In 1999, Professor Timothy Brennand of the University of East Anglia (U.K.) presented a report entitled *Concession for Windfarms: A New Approach to Wind Energy Development* at CCICED (China Council for International Cooperation on Environment and Development), a high level international advisory panel to the Chinese government. This report introduced the idea of utilizing WRC within the country. Although the report was schematic as far as implementation was concerned, it did outline the WRC's basic concept, process, relationship among WRC certificate holder, grid, and market, and possible institutional arrangements.

About the same time, wind power development was suffering because a power supply surplus had developed in most areas of the country. This made high-priced wind power even less competitive. For three years, SDPC halted the approval of new wind power projects. Meanwhile, however, the idea of utilizing WRC began to be taken seriously, and several additional policy analyses on this topic were conducted.

6.2 Policy Analysis and Preparation

In the period 2000 to 2002, three policy studies were conducted by Chinese policy analysts. The first study (Professor Ni's report) was undertaken at Tsinghua University, and SPC and ERI were involved in the research. The study summarized the major impediments of wind power development in China, discussed the concept and framework of WRC, and highlighted the significance of WRC in introducing competition, reducing cost, and promoting domestic manufacturing capability. A key aspect of the study was that it included, for the first time, the basic contents of a sample WRC agreement.

A second, more-detailed study was led by ERI.[146] Both China Hydro Consultants Company and the SPC Research Center participated in this research, and an SDPC officer worked as advisor as well. It comprehensively analyzed the practices of oil and natural gas concessions, BOT power projects, the U.K. NFFO wind power project bidding process, and WRC in Morocco and Egypt, and analyzed their suitability for Chinese WRC practices. According to this study, the WRC was designed to tackle a number of problems: 1) current policies and incentives have not received satisfactory results, and cannot support large-scale wind power development; 2) the current power purchase agreements between grids and wind farms, and their feed-in tariffs, have not reflected real costs, and have hindered price reductions; 3) the low quality and poor performance of local turbines have resulted in a turbine market dominated by imported equipment, which was a major reason for high costs, and this also hindered competition; and 4) the uncertainty of market warranties (i.e., yearly negotiations for feed in tariffs, rather than long term PPAs) and difficulties in offsetting the price difference (i.e., cost sharing of the grids).

The ERI study suggested that the main objective of the WRC is to introduce competition and improve the current rate of return pricing method. The main commitments that would be made by the government are: 1) an obligation to purchase all of the electricity generated by the wind farms; 2) an agreement that wind units would not have to compete with conventional power plants for dispatching; and 3) an agreement on long term PPA pricing (although, as discussed below, the nature of this specific commitment is rather nebulous). The study suggested that the high wind power price should be offset by the regional grid company, instead of by the provincial power company, and SDPC should allow the grid company raise its sales price particularly for the wind power generation.

ERI's analysis recognized that current laws and the legislative environment was not specific and powerful enough for WRC implementation, especially with respective to the electricity purchase and pricing, so it suggested that a special law be established for WRC. The study also proposed other supplemental policies such as long term (15 years) loans, tax credits, etc. It outlined the contents of a potential WRC agreement and PPA, and also specified a WRC bidding procedure.

During the study, the team conducted field investigations, and identified Huilai in Guangdong Province and Rudong in Jiangsu Province as potential candidates for WRC pilot projects, each with 100+ MW installations. The team also suggested that some projects in Fujian Province could be chosen as secondary candidates.

During 2002, a third study concerning WRC was made by Guangdong's provincial research team about the Province's pilot project.[147] This study did not raise any new issues or problems beyond the scope of those addressed in the first two studies.

In addition to these Chinese analyses, Brennand issued a report in 2000 summarizing his UNDP efforts (as discussed earlier in Chapter 3). This current report, also supported by UNDP, has been designed to follow up on both the Brennand and Ni efforts.

6.3. Draft WRC Guidelines and Approval Documents for Pilot Projects

Based upon these studies (and especially the one led by ERI), SDPC drafted a four-page document, dated November 22, 2001, labeled "draft, for discussion," and entitled "Administration Procedures on Wind Power Concession Pilot Project."[148] The document had ten sections (including Purpose, Definition, Scope of Tender, etc.), with a seventh section termed "Concession Agreement." This had subsections on project binding conditions, the construction period, the concession period, owner's responsibilities and obligations, the governmental commitment, and the power purchase agreement.

The draft document indicated that it was applicable to wind projects greater than 50 MW, that the concession period would last for 20 years, and that the selection would be made through a tender open to both domestic and international investors. It suggested that the dominating criterion in the tender evaluation wais the power tariff, but that the equipment purchasing plan, the financing plan, and the construction plan would all be taken into account. It also noted there would be requirements for local production, and that "purchasing equipment with a high local production rate would result in a high score in the evaluation." No specific evaluation criteria were given, however.

A workshop was held in Guangdong in November 2001 to discuss this document, and it was attended by more than 100 persons, including governmental officials, private sector developers, consultants, multilateral non-governmental organizations, local power officials, etc.

In the workshop, participants raised a number of points:

- While the English version of the document included the words "pilot project" in its title, the Chinese version did not. SDPC agreed that the document was intended to apply for all projects in the future, not just pilot projects (i.e., the word "pilot" was stricken).

- The question was raised whether the wind power concession rules would apply to all wind projects. SDPC responded that this was only one means of developing wind projects, and that other (i.e., non-WRC) alternatives were still applicable.

- The wind power concession definition section (Section 2) contains the sentence: “The government shall commit to purchase all electricity to be produced from the project,” and an extensive discussion ensued about what the term “the government” meant. The initial SDPC answer was that this was the provincial government, but concerns were raised that there should be a linkage between the guarantor and the institutional entity: a) with control over the monies (i.e., the tariff); b) that appoints the government agent (see immediately below); or c) which controls the power company.

- Section 4 outlines the role of an agent performing WRC tasks on behalf of the government, but goes on to state: “the agent shall…take all obligations of the government.” This was viewed as troublesome, since it would appear to shift any commitments from the governmental entity to an appointed agent.

- Section 5 outlines an SDPC approval requirement, and there was considerable discussion about this process. Developers were very concerned about the length of time such approvals could take, but SDPC responded that it should only take approximately one month. A suggestion was made to include such time constraints within the procedures text, but SDPC noted that their approval processes were guided by administrative law.

- In that same section, Provincial or other governments would prepare project information for approval, including wind resource measurement data. Developers asked whether the government would guarantee such data. SDPC stated that any “resource risks” would lie with the developer. The developers indicated that they would require at least twelve months of on-site measurements, since international banks would not provide project financing with anything less than these amounts of data. SDPC indicated that it thought six months of data from government-certified monitoring equipment should be sufficient. Developers responded that six-months of monitoring might be fine for one-yuan/kWh power prices, but that the ability to lower the tariff depended upon confidence in knowing the resource risks.

- The Concession Agreement section contains the statement: “The point for wind farm to connect with the transmission networks is selected to be the nearest transformer,” and goes on to discuss the interconnection procedures. Developers liked the language in the procedures document, suggesting that it clearly put the onus for any such required upgrades on the transmission system, but the local utility demurred, stating that any new source should instead meet grid-system interconnect requirements.

- A similar discussion focused on the nature of the power generated, the stability of the grid, and reactive power. The power company was clearly concerned about taking on additional system requirements, while developers indicated that they could provide whatever conditions were sought, as long as they were compensated accordingly.

- The construction period begins on the date of the concession agreement signing, and penalties could be accrued if the works are not completed in a two-year period. Developers were extremely concerned about any approval processes included during that time period (e.g., for tariffs, local land use, etc.), since they would have absolutely no control over such time elements.

- Questions about the preferable taxation policies and VAT provisions focused primarily upon whether domestic bidders might become disadvantaged.

After the workshop, the Guangdong and Jiangsu projects were chosen as the pilot projects, and the provincial planning commissions began to prepare the pilot project proposals, and submitted to SDPC for approval. In December of 2002, SDPC issued its approval documents for the two projects. These documents are only applicable to the two individual projects, and therefore do not constitute a final issuance of the WRC guidelines. However, some changes were made to the originally drafted material:

- The size of the wind farm was doubled from 50 MW to 100 MW, and the concession period was extended from 20 years to 25 years;

- Documents specified that the size of generator units must be larger than 600 KW;

- Instead of connecting at the "closest transformer," as in the draft guidelines, the new WRC approval documents specified the "designated grid connection point"; no further explanations or specifications were offered;

- The share of local equipments must be no less than 50%;

- The feed-in tariff has a so-called "two-phase price" scheme. For a period up to 30,000 hours[149], the feed in tariff will be the bidding price; after 30,000 hours, it will be the "then average feed-in tariff of the power market." No further explanation was given about the definition of this "power market."

- The total amount of electricity will be purchased by the "local grid company[150]" at the price specified above, and "the effect of wind power feed-in price to the sales price will be taken into account of provincial power price scheme".

- "Bidding price will be the major evaluation criterion, meanwhile the share of local equipment will be taken into account, and the tender promised the lowest feed-in tariff and the most local equipment will win the project."

- The bidding procedure will be led by SDPC, jointly with the provincial planning commission and "other related agencies." A bidding company will typically be employed for document preparation and similar related tasks.

- The governmental agent will be the one "designated by the provincial government". According to SDPC, the Guangdong Provincial Government has already appointed its provincial planning commission as its governmental agent. Jiangsu Province has not yet decided, but it will most likely also appoint its provincial planning commission.

- The construction period is 2 years; unlike the guidelines, there is no mention of a potential one-year extension.

Although these pilot project approval documents have furthered the WRC guideline process, some critical issues remained unsolved.

Perhaps the most pressing problem is the presumably high feed-in tariff and unclear pricing arrangements. Under the newly initiated power sector reform, grid companies have been separated from generation companies. As profit-driven businesses, they are no longer willing to assume previous responsibilities for developing renewable energy. Since the current reform has not yet set up any correlated adjustment mechanisms between the feed in tariffs and the sales price, the grid will continue to view high priced wind power quite skeptically. If it is not allowed (by the local price administration and SDPC) to increase its sales price proportionally, the grid will have to cover the costs of wind power by itself. This crucial issue was not clear in the approval documents, reflecting no doubt unresolved issues amongst the SDPC (i.e., especially its Infrastructure Department and Price Department), local governments, national and southern grid companies, and provincial grid companies. Given the unprecedented large scale of the pilot projects, as soon as high bidding prices do occur, severe and painful negotiations between the parties will begin. This is probably the reason why, as many have pointed out, there is no mandatory contract included in the WRC process between the government and the grid company.

Another concern that has been raised is the lack of technical criteria about the grid connection, and the fact that no specifications have been included about the quality of the wind power source. According to some wind power technical experts, Chinese power grids (unlike their European and American counterparts) are relatively weak in terms of robustness, and dispatching capabilities. They may not be able to handle significant amounts of low quality, interruptible wind power, creating reactive power, voltage decrease and system stability problems. This might cause a lot of trouble in future operations.

Finally, local governments may also have reasons to be wary of the WRC concept. Some expressed concerns about having to bear extra costs associated with building roads to remote wind development locations. Others were concerned about making commitments for long term warranties in the PPA for wind power, when such commitments for conventional power plant construction have been strictly prohibited by the State Council. Although the grid companies will purchase the wind power generated, there is an implied commitment from the provincial authorities, and the long term PPA will result in a shift of market risks from the developer to the grid/government (since the current arrangements call for yearly price adjustments).

6.4. Future Plans of SDPC

SDPC realizes that there are uncertainties and unsolved issues in WRC practice, yet it remains enthusiastic about the idea. Instead of waiting for all power sector issues to be resolved in the reform process before adopting WRC, it has chosen instead to proceed with pilot projects, and will judge the results accordingly, and try to solve problems as they arise.

SDPC believes that WRC is likely to be a feasible approach for replacing the long adopted rate of return pricing method, which proved unsuccessful in the past, and unsustainable within the context of power sector reform. SDPC also views WRC as a means of determining the real cost of wind power in a system where there is asymmetric information about such costs.

If the pilot projects go well, and everything remains under control, SDPC plans to copy the approach in more provinces, at a larger scope—"more than ten projects", according to one SDPC official. However, the uncertainties also offer considerable opportunities for WRC "failure"—when, in fact, such failure would not necessarily be associated with the WRC concept, but rather the institutional arrangement in which it was implemented.

6.5 Current Status of Proposed WRC Projects

6.5.1. Guangdong Project

The price differential between thermal power and wind power in Guangdong Province is the smallest in China; there are abundant wind resources; and the economic growth rate is high, providing both relatively high levels of income and a need for further electric power. For these reasons, the potential for wind power development in the Guangdong region has received considerable attention from the Chinese government. In the past, the Guangdong Power Network (GDPN) was under the jurisdiction of the Guangdong Provincial Government, and alone among the power networks was independent of the State Power Corp. Such flexibility provided yet another reason to consider wind power development within the region.

The GDPN has numerous connections with other power networks, and as early as in 1979, it was connected with the system belonging to China Light and Power of Hong Kong, and supplied electricity to Macao. In the mid-1980s, it was connected with the power system of the Guangxi Zhuang Autonomous Region, and in the early 1990s with the power systems of Yunnan and Guizhou. The third phase of that network expansion, bringing power from the west to the fast-growing east, broke ground in November 2001.[151]

There are currently two on-grid wind farms in Guangdong Province, with a total installed capacity of 70.08 MW, from 153 sets of wind turbines. One wind farm is located in Nan'ao, and has an installed capacity of 56.88 MW and 131 wind turbines. The other is located in Huilai County, and has an installed capacity of 13.2MW, and 22 wind turbines. At the provincial level, the install capacity of wind power in Guangdong is the second largest, just less than that in Xinjiang.

The bidding document for a new Guangdong WRC project has been prepared (in both Chinese and English) by the bidding company, Chinese Mechanical Equipment Import and Export Corporation. This was completed and publicized in April 2003. According to SDPC's plan, tenderers have 5-6 months before submitting their bidding proposals. An evaluation panel will then be organized (led by the provincial planning commission), consisting of administrative personnel, consultants on law, economics, finance, and power sector issues, and this panel will take approximately one month to identify the winner. SDPC is confident that the construction can begin before the end of 2003.

The provincial planning commission has been appointed by the provincial government as the governmental agent. The newly established Southern China Grid Company has not yet articulated its attitude about the price arrangement within the PPA, and this remains perhaps the major uncertainty in the project. Though not yet clarified, it is believed that the high price will be covered by only the provincial grid, rather than the whole Southern China grid (as suggested in both the Ni and ERI reports).

According to an analysis and calculations made by the Guangdong Provincial Technical Economic Research Development Center[152], the bidding price will not be below 0.5 RMB/kWh, as many had anticipated (and hoped).

Six companies have now bought the bidding document, including one foreign company (Huarui). Many developers have been concerned about the high preparation costs, especially given the uncertainty of the project. Because the one-year of resource data provided by the local government for the tender is not considered sufficient, it is estimated that a further 2 million RMB will be necessary to consolidate the information about the resource condition. According to the requirements of the WRC procedure, one percent of the total investment will be given to the local government as a development fee; another one percent to the bidding agent; and the winner must put forward another 10% as the guaranty of contract compliance. Considering that project financing will require no less than 20% equity, the costs for developers will therefore be substantial. They are worried that if the bidding prices are high, the government will rescind the concession, and there will be no way that they will be able to recover their preparation costs.

6.5.2. Jiangsu Project

Another pilot project for the WRC is planned in Jiangsu Province. Jiangsu is rich in wind resources, with exploitable resources of more than 2 GW. There are no wind farms in

Jiangsu Province now, however, although anemometry work began in 1998, and these data have made a WRC pilot project feasible.

The provincial power network in Jiangsu is a part of the East China Power Network (ECPN). In Wudong County, where the WRC pilot project is to be located, there are no power sources, and electricity demands must be supplied by the provincial power network. The wind farm will be located near the load center, and it will be easy to connect with the power grids.

Economic development in Jiangsu Province has been rapid, so the ability to bear a higher power price is also relatively strong. Furthermore, the provincial government of Jiangsu has developed a number of preferential policies to support the development of wind power (with respect to financing, taxes, feed-in tariffs, etc.).

The pilot project of WRC in Jiangsu is currently in a situation similar to that of Guangdong. The governmental agent has not been appointed, however, and there appeared a number of questions raised by the provincial grid company about the PPA commitment.

6.5.3. Fujiang Project

The Fujian Provincial Government is said to be very supportive about the proposed WRC project (at least in part because it hopes to promote the province's wind turbine manufacturing industry), but its proposal was turned down (at least temporarily) by SDPC because of the lack of sufficient power demand within the province. The resource conditions there are believed to be superior to the approved Guangdong and Jiangsu projects, however.

7.0 Proposed Policy Approach for the WRC

Implementation of the wind resource concession in China is framed by two important characteristics:

- The WRC only indirectly deals with the principal problem of wind power development in China—its high price when compared with conventional alternatives. It does so by assuming that eventually the private sector development of large-scale wind power units, backed by international financing, will lower the costs necessary to make this renewable resource economically competitive. It does not, however, deal with the short-term situation in which wind cannot compete with traditional fossil-fueled units. Some sort of "support" will therefore be necessary in the short term, over and above (or perhaps as part of) the implementation of any WRC instrument.

- The "concession" approach itself is a rather flexible instrument, which might cover a range from small-scale governmental "deals" for project development to large-scale bidding for resource tracts covering thousands of square kilometers and capable of generating hundreds (or even thousands) of megawatts of electric power. Brennand clearly envisioned (and analyzed) the latter approach, but the former is not precluded.

With regards to the first item, it would appear that the WRC is ambiguous, and could be implemented under either price- or quantity-based governmental supports. Brennand mentions the need for both—although he does state that price supports might be preferable in the early stages in order to favor the development of a wind industry.

The development of such a high technology, environmentally friendly industry is one that many countries obviously share. Based upon studies in Denmark, it has been estimated that 17 person-years of employment are created for every MW of wind energy manufactured, and about 5 person-years for every MW installed.[153] Given such numbers, the European Wind Energy Association and Greenpeace, hoping to promote wind generation of 12% of the world's electricity supply by 2020, suggest that China could be employing almost a quarter of a million persons in a localized industry by that time.[154]

Denmark currently has a 50% market share of wind turbines worldwide, but fully 70% of all wind power generation in the world today is located within Europe, and 84% of that is found in only three countries—Germany, Denmark and Spain.[155] These countries are precisely the ones that have developed strong price supports. Not surprisingly, the outside world sees a direct linkage between national energy policy and industrial policy within these countries.

The failure of the much-touted MITI industrial policy model in Japan has made many economists leery about governmental-directed efforts to target industrial success, and nowhere is such skepticism more deserved than in China. The country is currently making the difficult transition from a centrally planned to a market-oriented economy, and calls to provide special subsidies and/or governmental favoritism to industries—no matter how well meaning, or how good the cause—are met with special wariness.

Wind development supporters often try to keep their distance from avowed advocacy of such industrial policy approaches. Danish wind industry representatives claim that there was never any "clever, co-ordinated, long term political planning," and that, instead, Denmark was simply lucky in terms of timing and in hitting the commercially right technology.[156] Academics have similarly proposed that Danish governmental wind support was never a "means-ends, rational choice activity," but rather a "process of policy learning." This included vision building, institutional learning, organizational learning, and a co-evolving and diversified linkage between goals, instruments, relevant knowledge and institutions. NGOs and local energy offices, the traditional electric system, the nascent turbine industry and the government all played a part, and in some sense the provision of support became "a testing ground for new forms of democratic participation in technical as well as policy development."[157] And even if there were extra costs for society in these countries, it has been argued that the economic valuation of the reduced environmental impacts associated with the renewable energy more than compensates for the additional wind power support.[158]

Whether or not one might deem a strong support program as falling under the banner of "industrial policy," it does seem clear that China's existing wind industry is unable to meet the demands of significant wind development. As in other countries, this technology needs governmental support in the short term in order to grow, and the price mechanism has shown that it can accomplish this successfully. It has been suggested that price supports may have dynamic efficiency advantages over more market-oriented policy approaches.[159] China also has historically relied upon price mechanisms, and has virtually no experience with quantity-based instruments.

Based upon such factors, and consistent with Brennand's reasoning, China should adopt a price-based support program in its early stages, fostering industrial development and allowing a period for institutional capacity development. Such capacity development should address multiple aspects of wind power development, including the establishment of legal infrastructure and policy incentives; assessments of the wind resource; formation of project development teams; governmental power sector restructuring; project financing; and turbine manufacturing. Eventually, however, it should move towards the more market-oriented quantity approach, following the same type of transition that is currently occurring within Europe, but in a later time period.

It might do so in the following manner:

7.1 2003–2007: Capacity Development

The EWEA/Greenpeace report suggests that 2004 could be the "takeoff year" for large-scale wind power development in China,[160] but given the problems identified in the Ni report and recent slow progress, this seems somewhat optimistic. Previously, wind developers have become somewhat disillusioned with the country's progress, and industry observers have labeled the country a "perennial 'also ran.'"[161] "China continues to prove a great disappointment," notes one trade piece, and "…almost any future projections by governmental ministries will be heavily discounted by the wind industry."[162] Last year's authoritative BTM annual survey *International Wind Energy Development* characterized China's status as "slow," and suggested that the reasons for this were primarily institutional.[163]

Given this situation, and the numerous previous calls to address institutional issues within the Chinese government (readily evident within the Ni report and others[164]), it is apparent then that the first order of business is to bring the country's "institutional house" into order. If WRC is ever to become a viable policy instrument, it must have an institutional champion that has sufficient power and authority to bring it into existence and implement it on a national level. The current power sector restructuring offers an opportunity for the creation of exactly such an entity.

Perhaps most importantly, however, the initial focus of this organization should be the development of a broad, project development scheme designed to bring market-oriented wind power experience to a wide range of institutions, throughout the country. Germany has found that its strong support program has encouraged wind power development even in areas of lesser wind speed, and these initial projects in China should be small-scale, designed as much to "prime the pump" of the country's wind turbine industry and to foster institutional development as to provide cost effective electrical power. Although the SDPC's draft guidelines for WRC are applicable only for projects greater than 50 MW, numerous smaller projects should be included in this early phase. Although the loss of scale efficiencies is recognized, such projects would ensure that the financial risk associated with any individual project effort would be small, and—as one developer's interview suggested to us—it would help to remove the intense political pressure that normally accompanies large-scale development projects.

This should be a national support program, utilizing national resources. The country must decide to adopt such a program for its own sake, and accordingly must begin to limit wind power's dependency on foreign donors and multilateral agencies for support. The relatively small-scale project sizes envisioned in this early phase should be awarded on the basis of competitive bidding. Although individual project sizes might be small, the bid technology requirements could be fashioned to obtain experience over a range of turbine sizes. It is also here where the second defining characteristic of the WRC comes into consideration. Virtually any privileged project arrangement can be termed a "concession," and the ability to narrowly define the site, the nature of the wind resource assessment, the technology to be employed, or various other project parameters would be useful in these early-stage projects. Concessions would thus narrowly represent little more than specific "project development rights" at a specified site.

Although WTO non-discrimination principles do not allow discrimination between 'like' products or services on the basis of their country of origin, one might expect that a mix of domestic, joint venture, and foreign developers would respond to these concession offers.

The country could use this phase of development to meet its Tenth Five Year Plan commitment of providing 1500 MW by 2005, and continue such efforts in following years until both the institutions and wind industry capabilities are more firmly established.

7.2 2008–2014: Market Development

With an institutional base established, the developing Chinese wind industry should be in a position to move towards larger scale projects. These too would still require price supports, but the focus on larger project and unit sizes would dictate an increasing attention to the wind resource for site selection. These projects would also rely on a tendering system, although the concept of the "concession" should be broadened in this phase to shift the wind resource assessment task (and attendant risks) onto the bidder.

As the projects increase in size and sites become better, production costs associated with wind power should be dropping (both nationally and internationally), and the "burden sharing" associated wind power should also shift during this phase, away from the national government and towards the grid region/provincial level in which the power is generated and used.

With the more mature institutional infrastructure (within both the government and the restructured power sector), there should be much less emphasis on developing the wind industry, and more attention paid to providing cost effective power services.

China should also watch the development of quantity-based markets for renewable energy, particularly as these go into effect on a broader scale in Europe (perhaps in the latter part of this decade?). In the early years of the next decade (i.e., near the end of its second phase of development), China should then begin to experiment with a quantity-based renewable energy system within a specific province or regional grid. Such a quota should be opened to all renewable energy systems, not just wind power.

7.3 Post-2015: RES Markets

With a mature regulatory infrastructure, more than a dozen years of experience with a restructured power sector, and a Chinese renewable energy industry developed through price supports, it would then be time to move this industry further towards a market orientation, and the type of WRC envisioned in Brennand's report.

Andersen et al have examined the development of wind power since the early 1960s, and then tried to extrapolate how such development might continue through 2030.[165] Such an exercise is fraught with peril, recognizing the potential for new ideas or technological shifts that might radically change a given technology. They note, however, that all of the imaginable concepts of wind turbines were available in the early 1960s, and that "no really new concepts have been developed since then, and only a few concepts have a significant market share today." They suggest that the technology of the future will increase design flexibility along three fronts (structural, drive trains and controls), and that a greater availability of both concepts and designs will be offered during this decade, as the market expands and new companies seek to establish themselves. Over time, however, as the market matures, only a few concepts (and companies) would establish a dominant position. Their view is essentially one of incremental technological change, with at least one more scale up of turbine units, into the 4-6 MW range.[166]

China is obviously in a "catch-up" position now with respect to its wind turbine manufacturing. It has the capability to manufacture 660 KW units, but does not yet manufacture the 1500 KW units that are now the norm in most developed country applications. Given the expected dynamism of the wind power industry over the coming decade, the expected large scale growth of this technology, the domestic need for an environmentally acceptable alternative to coal, and China's ability to manufacture high technology goods at low cost all suggest that the country is very well positioned to capture long term advantage. The capacity development and market development stages outlined above should provide China with a basis for doing so, and for developing the large turbine manufacturing capabilities necessary for the RES market evident after 2015.

In that post-2015 world, the principal question is whether wind will need the "artificial markets" of an RPS or quota system, or whether it will be able to fully compete against conventional technologies. If China has managed to reform its environmental program, and has fully "internalized" pollution externalities, then the latter would probably be the case. More likely, however, its environmental program will face considerable difficulties in making adjustments for a variety of structural and contextual reasons.[167] The country will continue to face economic development pressures, even if its spectacular growth rates continue. It is also likely to come under increasing pressure from the international community to more actively participate in the international framework for climate change mitigation, perhaps by becoming an Annex I member, or at a minimum by expanding the role of CDM within the country.

In such a setting, it seems likely that a transition from a price- to a quantity-based regulatory support program, coupled with the WRC, would be appropriate. At that time, China could decide whether it should bundle or unbundled the carbon in its REC. Like any other component of an energy project (e.g., turbine, fuel, etc.), such pollutant externalities emitted or avoided will increasingly be viewed as commodities in the international marketplace. The rules of that market will help shape such a regulatory decision (even though, in the current situation, it would likely seek to unbundled the carbon).

The principal characteristics of this proposed developmental path are summarized in Table 7.1.

Table 7.1 Proposed Policy Transition for Wind Power Development in China

	2003-2007 Capacity Development	2008-2014 Market Development	Post 2015 RES Markets
Government Priority	Develop wind industry	Provide cost effective wind power	Regulatory support for full scale RES markets
Wind Power Project Size	Small (<40 MW)	Larger (40-150 MW)	Large (>100 MW)
Wind Resource Concessions	Narrowly defined, site-specific project development rights	Broader, with assessment risks taken on by bidders	Large scale tracts
Price-Based Support	Extensive National Program	Shift towards Provincial Governments	Lesser role
Quantity-Based Policies	Participation in CDM	Participation in CDM; Provincial level experimentation with RPS (with REC trading)	Participation in CDM; Further development of RPS (as needed) with REC trading

8.0 Next Steps for the Government

Establishing such a WRC program will take the government in a slightly different direction than current governmental WRC efforts described in Chapter 6. It suggests that steps should be taken in a number of specific areas:

8.1 Wind Development Targets

A measure of the institutional "balkanization" that has affected wind power development within China is the plethora of targets for installed capacity that have been developed by different institutions and organizations, for different purposes. The Tenth Five Year Plan set a target of at last 1500 MW for wind power by the year 2005, but this was later revised to 1200 MW for both wind power and solar energy. The State Power Corporation had set a wind power target of 1000 MW for the year 2000, but this figure was not achieved. In 2001, SETC developed plans that called for industrial development that would result in 3000 MW by 2005, 4900 MW by 2010, and 7000 MW by 2015.[168]

Bringing consistency and a cohesive development plan for wind power development is obviously one of the key elements of the capacity development efforts in the first stage described above. It is also apparent that such goals are both appropriate and indispensable for such development tasks, since they convey the nature of the proposed development effort and indicate the magnitude of the resources required. While the final targets would be set as part of that institutional capacity building, the development effort should be significant enough to foster market expansion and provide a basis for growth. Based on the historical development of wind power in other countries, it would not be unreasonable to expect an additional 1 GW of installed wind capacity in China by 2005; 8-10 GW by 2010; and 12-15 GW by 2015.

8.2 Price Supports

As noted in the previous chapter, the WRC doesn't really deal with the principal problem associated with wind power development in China, its high price compared with conventional alternatives. This is particularly true in a country where the extensive environmental externalities (i.e., pollution) associated with conventional coal-fired units are not penalized or monetized, and hence do not enter the capacity expansion decision.

The WRC assumes that private sector development of large-scale wind power units will lower costs. This may ultimately become true, but it not likely to happen in the immediate future in China, and some sort of governmental support will be necessary, at least during that short term period.

The existing WRC program suggests that a winning developer will be offered a long term PPA, with a feed in tariff specified at the bidding price for the first 30,000 hours, and at a "power market" price thereafter. From the developer's perspective, however, several immediate questions arise:

a) *Who is providing the guarantee?* The PPA is with the newly formed regional grid company, but the experience of independent developers in China is fraught with problems associated with such agreements. PPAs in areas with excess power supplies have been abrogated even for coal-based generation, and this is clearly a bigger risk for wind generators. The grid company is trying to become a profit-oriented company, and will obviously be reluctant to pay rates far above competing alternatives, in spite of its contractual obligations. As noted above, there are also indications that the higher prices must be recouped from the provincial grid (rather than the larger, regional grid).

b) *How will the grid recoup its high wind prices?* The grid will pay for its obligations to the developer through the monies it collects from retail sales. The reformed procedures on how these retail rates will be set are not yet established, however, and there will be considerable pressure to keep them low. The control of retail power prices has always been a serious political issue, and the government has worried that increased power prices could have both economic and political repercussions. Given the enormous pressure already imposed by both the power sector reform and a tightening power market, there will probably be little room for significant subsidies within the retail price. If the grid companies are squeezed, receiving low retail rates but forced to subsidize the higher generating costs associated with wind, these pressures would ultimately be shifted to the wind power developers.

c) *What is the "power market" which will define returns after the initial 30,000 hours?* This is currently undefined under the WRC, and independent developers would try to shift these unknown risks by front-loading the bid (i.e., recovering any costs within the initial period).

All of these factors increase the developers' uncertainties and risks, and will tend to increase the bidding price. If they are expected to build large, 100+ MW facilities, there will be considerable amounts of capital at risk. Accordingly, the WRC is unlikely to accomplish its immediate goal of lowering the price associated with wind power.

A WRC program consistent with that outlined in the previous chapter would take a different approach. It would seek to minimize risks for wind power developers at this stage of development, although it would do so for much smaller wind farms—recognizing the considerable financial burden this imposes upon the government. In Europe this has been done directly with high feed in tariffs, and in the U.S. with production tax credits. Liu et al propose funding similarly based upon production (instead of initial investment), perhaps using a carbon tax or green electricity pricing scheme to offset the financial impacts on the government.[169] A system benefit charge or comparable levy could also serve to garner funds for such purposes.[170] The uncertainty of the PPA arrangement in the existing WRC program needs to be overcome, however, and the guarantees for it must rest with the national government, not the grid company or even the province at this stage. Whether the national government becomes involved in developer/grid company PPA negotiations; offers direct production guarantees to the developer (based upon unit availability); or enters into other WRC concession arrangements with the developer might be explored in a variety of pilot projects over the next year or two.

8.3 Wind Resource Assessments

Wind resource assessments are a crucial part of the WRC. These data are extremely important for developers, since the whole financial viability of developing a project at a specific site depends upon them. Unfortunately, though, Chinese wind resource data are relatively poor, for a variety of reasons (e.g., lack of anemometry standards, lack of measurement criteria, misleading data reported in order to encourage development, etc.).

In the initial WRC guidelines, six months of data were considered sufficient. Developers balked, suggesting that at least one year of commercial-quality data were necessary to determine resource risks. One year of data was provided by local authorities in Guangdong for the pilot site, but developers were apparently not satisfied with these data, and planned to make additional resource assessment efforts.

Since gathering reliable anemometric data concerning the wind resource is so critical for the WRC, a number of alternatives warrant attention:

- Relying on existing data, but using a pricing mechanism to compensate for resources data uncertainty. For example, the power price might be divided into a capacity price and an energy price. The capacity price might be determined according to basic annual blowing hours of effective wind speed that could then be guaranteed (guaranteed electricity production). This part of price could be used to cover the capital cost of wind farms. The energy price is the price of electricity production above the guaranteed level, which might equal the average power price on-grid. Given the uncertainty of the wind resource determination, the income associated with this part of the electricity production would be uncertain. If the wind resources are good, then developers might earn extra profit, while the power network loses little because the price of the wind power is the same as the network price. If the wind resource isn't very good, then developers would still cover their investment with the capacity price, so they would face little resource risk.

- Entrusting anemometry data collection to an internationally accepted organization that did not take part in the bidding. All potential bidders could pay part of the data collection costs for such an organization. The organization would then provide reliable anemometric data for one year for all potential bidders. Total costs would be lowered in this option, because there would be no duplication of effort.

- Allowing wind developers themselves to collect the data. A one-year period could be given to potential wind developers before any bidding is conducted, and during that period they might obtain any on-site data desired. Developers themselves would thus pay for any data collection costs, and these data costs might be considered an expenditure of the project in the winning bid. Costs incurred in losing bids would not be compensated. Under such conditions, developers themselves might organize collective monitoring efforts.

These three alternatives would be roughly appropriate for the three stages of wind power and WRC development outlined in the previous chapter. During the first stage, as wind resource assessment techniques and data are being developed within the country, and the initial wind farm sizes are relatively small, less sophisticated data could be used for siting purposes. This would be a capacity development stage, in which Chinese organizations were learning to perform the resource assessments, and gaining experience. All such learning efforts should be designed and performed to meet international standards. Risks for developers should be minimized during this period, corresponding with the attempts noted above to minimize PPA risks, and such a pricing mechanism can be employed to do so.

During the second phase, as the units got larger, and precise siting became more important, it would be expected that all resource assessment work could be performed to international standards by Chinese organizations. They would have gained sufficient experience collecting and analyzing such data during the first phase of development.

During the third, fully market-oriented phase, developers would be responsible for their own resource assessment. They could spend whatever they wanted to justify the resource basis for their WRC bid.

One other note of caution, however. According to some observers, in response to the on-going power sector reform, local governments have already begun to allocate the most promising wind power sites to their own local companies. If this is true, it makes the sustainability of the WRC approach questionable, if the most suitable resources are not available for bid.

8.4 Grid Connections

In the current WRC approach, there is no discussion about the technical issues associated with grid connections, and no specifications about the quality of the wind power source (e.g., power factor supplement). The concession documents now suggests that the connection will be at "the designated grid connection point" instead of the "closest transformer," a shift that favors the grid company. But there are no terms associated with power quality or reactive power concerns.

With respect to technical connection issues, developers were worried about compensation for such matters, and also worried that such connection issues could be used as obstacles by recalcitrant power system officials.

The utilities (i.e., now grid companies) recognized that wind power represented a relatively minor fraction of power within the grid, and was likely to remain so for the foreseeable future. They were concerned about system stability, although they too realized that this was primarily a technical matter, and could be readily addressed. They believed that any system adjustments made to accommodate wind power additions should be covered by the new generators, however, while those new developers worried that such costs would make their already high-priced power even more expensive.

Other than having general guidelines designed to ensure that all bids are compatible, grid connection issues are a bilateral technical concern and can be addressed within the PPAs, rather than within the WRC framework. To the extent that enforcement of the PPA is a contentious issue, this might affect development. But in this case, the greater risks would appear to lie with the grid rather than the developer, and there would be appear to be little reason to try to address such concerns through the WRC. If it became clear that grid companies were attempting to use this technical issue to avoid WRC obligations altogether, then such action might be warranted.

8.5 Regulatory Considerations

The lack of a comprehensive and integrated renewable energy policy framework and legislation has been a chronic issue for wind power development in China. It is complicated by the fact that the national government has recently undergone a restructuring, and at the same time, the country is undergoing power sector reform. There has been an attempt to move both the national economy and power sector entities towards a market orientation, a position inimical for the development of a technology that cannot currently compete on market terms.

Europe and America have shown that it is possible to utilize governmental supports (whether price or quantity) to establish a significant market, building up the capabilities of its turbine manufacturers and wind development specialists. This in turn has led to significant decreases in cost for this technology, and eventually it should lead to competitive pricing. China's view of the WRC seems to be one of attempting to put cost reduction as the principal goal, hoping that a viable market will develop accordingly. It aims to encourage larger and larger wind farms and units, attracting private sector financing—yet the regulatory, independent development, and manufacturing infrastructure required to support such reductions is not currently in place.

China is well positioned to develop a dynamic, cost competitive wind power industry, one that could contribute significantly to the country's power sector, employment and environmental needs. But the key word here is "develop;" this will not happen overnight, and the technology cannot yet compete with lower-priced conventional alternatives. It will require governmental support, patience, and a developmental path that focuses initially on market development rather than sharp price reductions.

The compatibility of WRC with the on-going power sector reform is critical to its success. Luckily, the concession approach is one that is malleable, and easily adapted towards such an approach. It will be required in several areas:

Institutional development.

The WRC needs an institutional "champion." Such an organizational entity (which might, for example, be a new office within the newly formed SERC) should have as its fundamental purpose the promotion of wind power generation within the electricity sector. Its tasks might include:

- Ensuring that existing regulations fostering the use of wind power are enforced;
- Developing new regulations to foster its utilization;
- Developing standardized power purchase agreements, concession contracts, bidding materials, and similar documents for wind utilization;
- Developing wind generation capacity within each of the sub-regional grid system;
- Serving as an institutional base for coordinating governmental efforts on the WRC; and
- Tracking the localization of wind turbine production;

As noted earlier, however, its most important role initially should be the development of a broad, project development scheme designed to bring market-oriented wind power experience to a wide range of institutions, throughout the country.

One such model of an institution which has successfully encouraged price-based development of wind power is Spain's Instituto para la Diversificación y Ahorro de la Energía. (IDAE). This is a publicly owned, business-structured entity whose function is to encourage energy efficiency and a diverse mix of energy sources, including renewables. It gives technical advice to financial institutions regarding energy projects, and provides technical and financial support to renewable energy projects through third-party finance, shareholdings in joint-stock companies, and cooperation agreements leading to demonstration projects. It has also been active in promoting the utilization of Spanish technologies in other countries.[171]

Unit and Project Size.

While it is clear that cost efficiencies depend upon large-scale turbines and project sizes, China's near-term needs are more oriented towards RES market development within the power sector. Accordingly, the WRC should be modified to encourage numerous smaller-scale projects, in a wide range of settings, from a diverse number of developers. The 100 MW threshold in the existing pilot projects, and even the 50 MW threshold in the draft guidelines, should therefore be dropped. There are some relatively small-scale projects currently underway (e.g., the 20 MW World Bank/GEF facility in Shanghai), and more such projects should be encouraged. No project thresholds are necessary in WRC guidance.

The government obviously has an interest in furthering the manufacture of larger-scale turbines within China, and bringing the industry towards international standards. It might therefore be appropriate to characterize unit sizes within specific projects (as was done for the pilot projects in Guangdong and Jiangsu), but this should not be a "blanket" policy applicable for all WRC projects. The development of a viable turbine manufacturing industry calls for a more flexible approach, with support available across a broader range of sizes, at least within the first period of development.

Other WRC factors.

A variety of other factors affect implementation of the WRC, and were discussed in the Guangdong workshop during the development of SDPC's guidelines. These include the time period needed for approvals (e.g., tariffs, local land use, etc.); penalty periods; the role of governmental agents in the bidding process; the measurement of "local content"; project selection criteria; etc. Most of these factors are not unique to wind projects, but would be found in virtually any power sector development project.

As China moves towards market-oriented project development, such factors will no doubt become standardized. As noted earlier, some are already addressed by administrative regulations and law. The key point for implementation of the WRC in its early stages is to try to minimize uncertainty and risk for project developers. Enforcement of PPA agreements is crucial, as is enforcement of the provision that the grid should take all of the wind power produced. If the WRC starts with smaller, less financially risky projects, the costs of providing such guarantees will not be great. As developers (and governmental authorities) gain confidence in the WRC process, the larger scale, market driven opportunities will develop over time.

9.0 Conclusions

The wind resource concession idea has been proposed as a renewable energy policy mechanism designed to move China towards a state of affairs in which private sector power developers would utilize international commercial financing to invest in large, base-loaded, state-of-the-art wind units, employing turbines manufactured within China, meeting international quality standards but at a price perhaps 20-30% lower than market rates.

Given the important environmental benefits that would accompany such conditions, it is apparent that such a mechanism deserves attention. However, it is also apparent that such an approach represents a very different wind power program from the one that currently exists within China. The current system relies primarily on relatively small turbine units, manufactured domestically, often for localized consumption by residential/commercial units on an intermittent basis; or else slightly larger (often imported) units for power generation linked to the nearby grid. The country does not yet manufacture the 1.5 MW units that now represent state-of-the-art in most wind power applications in Europe and the U.S.

While the WRC might help, it seems unlikely that the WRC program alone would be able to accomplish such a major transition. This is because the WRC only indirectly addresses the most important problem with wind power—its high price. The scale economies and siting advantages garnered through WRC alone will not overcome the fact that these units cannot currently compete with fossil-fueled alternatives. The wind units will require governmental support.

Introducing governmental support means that institutional factors will play a critical role, and the WRC program must be considered within the broader context of developing China's renewable energy program. Both price and quantity mechanisms are available to provide such support, but institutional problems have already been blamed as the principal reasons behind China's slow development of its wind resource. Addressing the form of support also means tackling the country's institutional infrastructure.

This report therefore presents a relatively measured, "learn-as-you-go" approach for developing wind power. It suggests that China should initially adopt a price-based support program in its early stages (i.e., 2003-2007), fostering industrial development in wind energy and investing in capacity development. There should be numerous relatively small-scale projects, designed as much to "prime the pump" for that industry as to provide cost effective wind power, but really designed to give the country time to build up its institutional infrastructure in this area.

A second phase (2008-2014) would move towards larger-scale projects, more rigorously sited. The emphasis would begin to shift from institution building towards more cost effective power delivery and market development. More risks would be shifted towards the concessionaire, and in the latter stages, the government would begin to move more towards a market-oriented quantity approach, beginning RPS-type pilot projects in individual provinces or regions.

In the post–2015 period, after both the industrial and institutional frameworks have been developed and China has tapped into the experience of both European and U.S. market-based approaches, it would move towards a fully market-oriented system, one consistent with the rules and modalities of CDM and other international environmental markets.

Several other salient features of such a transition are required:

- The support scheme should be national in scope, with a commitment to wean the nascent wind industry from donor and multilateral agency funding support;

- The nature of the concessions granted must change over time, beginning with narrow "project development rights" in the initial phase, but moving towards large-scale concession tracts similar to oil and natural gas concessions after 2015;

- Wind power requires an institutional "champion," given the task of increasing the installed capacity of this renewable resource and charged with implementing the WRC.

While the WRC is technically feasible, future progress in wind power development in China will depend more upon the institutional framework in which it is implemented than any technical characteristics of the policy mechanism. Governmental support at the national level is necessary, and the means of providing such support has been contentious in all countries. China should aim to make the transition from price- to quantity-oriented support over time, when it has developed both the manufacturing and institutional capacity to do so. If it follows such a plan, then China will be well situated to assume a dominant position in this important renewable energy industry in the future—one which will help the country meet its growing energy needs in a sustainable manner, serve to reduce its unwelcome reliance on coal, and provide an environmentally appropriate livelihood for hundreds of thousands of its citizens.

Endnotes

[1] Ackermann, T. and Soder, L., 2002.
[2] Brennand, T.P., 2000.
[3] Ni, W. et al, 2000.
[4] MOE, 1997.
[5] ERI, 1999.
[6] Ministry of Energy, 1990.
[7] ERI, 1999.
[8] CERS, 2002
[9] China became the net oil importer in 1993. The growth in the number of private vehicles, as well as the shift away from coal in the residential and service sectors, makes the broader energy supply question very unclear (ERI, 1999). This has spurred an ongoing debate about the directions of policy, but a consensus remains that the dominance of coal will not be quickly undone.
[10] in 1999. (CERS, 2002).
[11] K.He et al., 2002.
[12] World Bank, 2002. According to the definition of CANNQS, Class II means the minimum requirement of long period of exposure without harmful impact to the human body, and Class III refers to that of short time exposure without harm
[13] ERI, 1999.
[14] ERI, 1999.
[15] Cited in He, K. et al, 2002.
[16] World Bank, 2002
[17] IEA, 2002; Nakicenovic, N. et al, 1998; MOST, 2000; U.S. Dept. of Energy, 2002; Gan, L., 1998; Rose, A. et al., 1996; Zhang, Z., 2000; Bach, W. et al,1998; VanVuuren, D. et al., 2003; Larson. E. et al., 2003; Wu, Z. et al., 1997; DRI-WEFA, 2002; ERI, 1999; MOE, 1997; World Bank, 1996; and Logan, J., 2001.
[18] N. Nakicenovic et al, 1998; and MOST, 2000.
[19] World Bank, 1996.
[20] MOST, 2000 and N. Nakicenovic et al, 1998.
[21] Some experts view these levels as extremely optimistic, and believe that it is unlikely that China's coal consumption will drop below 50% within the foreseeable future.
[22] MOST, 2002; and E. Cassedy, 2000.
[23] He, D., 1999.
[24] World Bank, 1996
[25] Wu, J., 2002.
[26] ERI, 1995; and CNE, 2003.
[27] ERI, 1995:
[28] Shi, P., 1999.
[29] MOST, 2002.
[30] UNDP, 2002.
[31] Zhang, Z.M., 2002.
[32] Zhuang X. et al, 2001.
[33] Covarrubias, A. J. and Reiche, K., 2000.
[34] Bouille, D. et al, 2001a.
[35] Bouille, D. et al, 2001b.
[36] Center for Renewable Energy Development (Morocco), 2001.
[37] Ibid., p. 10.
[38] Lew, D. and Logan, J., 2001.
[39] Ackermann T. and Soder, L., 2002, p. 73.
[40] AWEA, 2001.
[41] Brennand, T., 2000, p. 66.
[42] Enzensberger, N. et al., 2002.
[43] Zhang, C., 2003; and MOE, 1990.

[44] CERS, 2002.
[45] SDPC, 2002.
[46] See http://www.sp.com.cn.
[47] Energy Foundation, 2002.
[48] Zhang, C., 2003; and Feng, F., 2003.
[49] Feng, F., 2003.
[50] Ibid.
[51] Energy Foundation, 2002.
[52] Feng, F., 2003.
[53] SDPC and MOST later concurred with these requirements.
[54] This is the so-called "rate of return" price.
[55] Ibid. suggests that Chinese wind mills are predominately smaller ones.
[56] Ibid.
[57] Zhou, H. et al, 2003.
[58] Ackermann, T. and Soder, L., 2002
[59] An investigation of wind farm operation performance was made by SDPC in 1999 throughout China, but these data are not yet available.
[60] CNE, 2003.
[61] Zhou, H. et al, 2002.
[62] Shi, P., 1999.
[63] Zhou, H. et al, 2002.
[64] Zhou, H. et al, 2003; Zhou, H., 2000; and He, D., 1999.
[65] Wu, G. et al, 2001.
[66] Ackermann, T. and Soder, L., 2002.
[67] Zhou. H. et al, 2002; and P. Shi, 1999.
[68] Zhou, H. et al, 2002.
[69] Ibid.
[70] Wu, G., 2001.
[71] He, D., 1999.
[72] Wu, J., 2002; Han, Y. et al, 1999; Han, Y. et al, 1996; CNE, 2003; Gao, H., 2000; World Bank, 1996; and Liu, W. et al, 2002.
[73] World Bank, 1996.
[74] W. Liu et al, 2002. Some important factors in this analysis (e.g., size of wind farm, discount rates, etc.) are not identified, however, and the operating costs figures (i.e., real O&M costs only 2% of capital costs) seem rather low.
[75] Ni, W. et al, 2000.
[76] Qi Laisheng, General Director of Inner Mongolia Wind Power Company, estimates that the power price of the entire network would increase about 0.02 yuan/kWh if the installed capacity of wind power were increased to 100 MW.
[77] CCRE, 2002.
[78] "Regulator Sets Target…," 2003.
[79] For example, see World Bank, 1996.
[80] Zhang, Z. et al, 2001; Zhang, Z.M. et al, 2002; Liu, W. et al, 2002; Raufer, R. and Wang, S.J., 2002; Gan, L., 2003; Zhou, H., 2000; and Zhao, J., 1998.
[81] Zhao, J. et al, 1998.
[82] SDPC, 1999.
[83] Zhang, Z.M. et al, 2002.
[84] Ibid., p. 214.
[85] Ibid.
[86] Zhang, Z.M. et al, 2000.
[87] Pigou, A.C., 1920.
[88] Dales, J.H., 1968.
[89] See Raufer, R., 1998, for a discussion of these programs.
[90] Robert Nelson noted the support of environmental economists for Pigouvian taxation over quantity-based approaches, and suggested: "In part, this seems to have been a case of simply picking the wrong horse. But

it is also likely that professional economists in the environmental field were aware of at least some of the practical advantages of a market permit system, but simply could not accept its ideological implications." See Nelson, R., 1987, p. 70.
[91] FCCC/CP/1996/15, p. 48.
[92] Denmark launched a power sector emissions trading (ET) program on July 1, 2000; the U.K. launched an ET program on 14 August 2001.
[93] Rosenzweig, R. et al, 2002.
[94] Hvelplund, F., 2001.
[95] European Wind Energy Association, "Another Record Year for European Wind Power," 20 Feb. 2002.
[96] Guey-Lee, L., 1998. Since April 2000, Germany's renewables law lays out declining rather than fixed feed-in tariffs (Ondraczek, J., 2002).
[97] Guey-Lee, L., 1998.
[98] Morthorst, P., 1999.
[99] Belhomme, R., 2002.
[100] http://www.purewind.net/certificate_form.html
[101] Lobsenz, G., 2002.
[102] Note that even though the Senate passed this bill, it would not have become law unless it was also approved by House of Representative members (who had no RPS in their version of the energy bill), and also signed by the U.S. President.
[103] U.S. Dept. of Energy, 2002.
[104] As of January, 2003; see Database of State Incentives for Renewable Energy (DSIRE), (2003). The eleven RPS states are AZ, CT, IA, ME, MA, NV, NJ, NM, PA, TX, and WI; the three states with goals are HI, IL and MN.
[105] Wiser, R. and Langniss, O., 2001.
[106] Ibid., p. 16.
[107] "European Renewable Electricity…", 2002.
[108] Office of Gas and Electricity Markets, 2002.
[109] Salvaderi, L., 2002.
[110] Energy for Sustainable Development, Ltd., 2001
[111] Eurelectric, 2000, p. 31.
[112] RECS, 2002.
[113] Ibid.
[114] Morthorst, P.E., 2000, p. 156.
[115] Krohn, S., 2001a.
[116] Krohn, S., 2001b.
[117] Ibid.
[118] Krohn, S., 2002a.
[119] Energy for Sustainable Development, Ltd., 2001, p. 41.
[120] Brennand, 2000, p. 43.
[121] Ibid., p. 32.
[122] Ibid., p. 43.
[123] Ibid., p. 44.
[124] Ibid.
[125] Ibid., p. 12.
[126] Bohm, R.A.et al, 1998.
[127] "A Great Leap Forward," 2002; R. Morganstern et al, 2002.
[128] Fernando, P. N. et al, 1999.
[129] SEPA (China) and EPA (U.S.), 1999.
[130] Zhang, Z.M. et al, 2000, p. 77.
[131] The project is owned by the Fujian Pacific Electric Company, a consortium that includes InterGen (i.e., Royal Dutch Shell and Bechtel Group joint venture) [45%]; Hong Kong-based Lippo China Resources Limited [25%]; El Paso Energy [24.8%]; and the Asian Development Bank [5.2%].
[132] InterGen, 2001.
[133] "China Electricity Reform…," 2002.
[134] Sumi, Y., 2001.

[135] Woerdman, E., 2000.
[136] Edmonds, J., et al, 1999.
[137] Zhang, Z.X., 2000.
[138] U.S. Embassy, 2002.
[139] Center for Resource Solutions, 2001.
[140] Eurelectric, 2000.
[141] CRS, 2001.
[142] *Green Power Newsletter*, 2001.
[143] Ibid.; CRS, op. cit., p. 38.
[144] according to F. Feng, 2003.
[145] Ni, W. et al, 2000.
[146] Zhuang, X. et al, 2002.
[147] Zeng, L.M., 2002.
[148] A 1½ page document entitled "Preferential Policies on Wind Power Concession," was also distributed, and labeled "for discussion," but not dated. It presents an overview of the wind power situation in China, introduces the wind power concession idea, and then outlines three preferential policies for wind power concession projects: a) a 20 year operating period and 15+ year loans; b) preferential tax and VAT provisions; and c) favorable power tariffs and price adjustment mechanisms. There was a suggestion in the meeting that preferential treatment should be extended towards all renewable projects, not just wind power concession projects, but the discussions concerning this document were brief, and primarily reiterated the points noted above for the Procedures document.
[149] The 30,000 hours represents an amount of power production rather than chronological time, and reflects the total power produced (in kWh) divided by the nominal power rating of the facility (in kw).
[150] According to SDPC, in the two pilot projects, it will be the provincial (rather than regional) grid companies who will sign the PPA with winning developers.
[151] An, W.Y. and Zhan, L.S., 2001.
[152] Zeng, L.M., 2002.
[153] Krohn, S., 1998.
[154] EWEA and Greenpeace, 2002.
[155] Ackermann, T. and Soder, L., 2002, pp. 74 and 75.
[156] Krohn, S., 2002.
[157] Gregersen, B. and Johnson, B., 2000.
[158] Krewitt, W. and Nitsch, J., 2003.
[159] Menanteau, P. et al, 2003.
[160] EWEA/Greenpeace, 2002, p. 35.
[161] Gipe, P., 2002b.
[162] Gipe, P., 2002a.
[163] BTM Consult ApS, 2001, p. 6.
[164] See, for example, Gan, L., 1999; and Liu, W. et al., 2002.
[165] Andersen, P. and Jensen, P., 2000.
[166] Ibid., p. 157.
[167] Sims, H., 1999.
[168] Gu, S. and Liu, H., 2001.
[169] Liu, W. et al, 2002.
[170] Zhang, Z. M. et al, 2000.
[171] See www.idae.es

Bibliography

"A Great Leap Forward," (2002). *The Economist*, May 11, p. 75.

Ackermann, T. and Soder, L., (2002). "An Overview of Wind Energy Status 2002," *Renewable and Sustainable Energy Reviews*, 6, 67-128.

American Wind Energy Association (AWEA), (2001). "Wind Energy's Costs Hit New Low," press release, March 6.

An, W.Y. and Zhan, L.S., (2001). "Third Phase of Electric Project Kicks Off" and "Gigantic Network Mapped Out," *China Daily*, Dec. 5.

Andersen, P.D. and Jensen, P.H., (2000). "Wind Energy Today and in the 21st Century," *International J. Global Energy Issues*, 13:1-3.

Bach, W., et al, (1998). "China's Key Role in Climate Protection," *Energy*, 23:4, 253-270.

Belhomme, R., (2002). "Wind Power Development in France," presented at the IEEE Winter Meeting, New York, NY, January.

Bohm, R.A., Ge, C., Russell, M., Wang, J., and Yang, J., (1998). "Environmental Taxes: China's Bold Initiative," *Environment*, September.

Bouille, D., Dubrovsky, H. and Maurer, C., (2001a). "Argentina: Market-Driven Reform of the Electricity Sector, in *Power Politics*, World Resources Institute, Washington, DC.

Bouille, D., Dubrovsky, H. and Maurer, C., (2001b). *Reform of the Electric Power Sector in Developing Countries: Case Study of Argentina*, World Resources Institute, Washington, DC, March.

Brennand, T.P., *Concessions for Wind Power Plants: A New Approach to Sustainable Energy Development in China*, UNDP/University of East Anglia Report, U.K., 2000.

BTM Consult ApS, (2001). *International Wind Energy Development: World Market Update 2000*, Ringkobing, Denmark, March.

Cassedy, E., (2000). *Prospects for Sustainable Energy, A Critical Assessment*, Cambridge University Press.

Center for Renewable Energy Development (Morocco), (2001). *National Strategic Plan for the Development of Renewable Energies*, Ministry of Industry, Commerce, Energy and Mines, Kingdom of Morocco, Marrakech, October.

Center for Resource Solutions (CRS), (2001). *Renewable Energy Credits Trading: The Potential and the Pitfalls*, San Francisco, CA, at http://www.resource-solutions.org/CRSprograms/trec/trc.pdf.

China Commercialization of Renewable Energy (CCRE), (2002). "Renewable Energy Institutional Framework, at http://www.ccre.com.cn/Chinese/BG.htm (in Chinese).

"China Electricity Reform Will Reassure Foreign Investors," (2002). *Power Engineering International*, March 11.

China Energy Research Society (CERS), (2002). *Energy Policy Research*, Issue No. 1, Beijing.

China National Statistical Bureau, (2003). China Statistical Yearbook 2002, China Statistical Press, Beijing.

China New Energy (CNE), (2002). "Wind Resource in China," at http://www.newenergy.org.cn.

China New Energy (CNE), (2003). "Wind Power," at http://www.newenergy.org.cn.

Covarrubias, A. J. and Reiche, K., (2000). "A Case Study on Exclusive Concessions for Rural Off-Grid Service in Argentina," Chapter 10 in Energy Services for the World's Poor, World Bank, Washington, DC, at http://www.worldbank.org/html/fpd/esmap/ energy_report2000/ch10.pdf.

Dales, J.H., (1968). *Pollution, Property & Prices*, Univ. of Toronto Press, Toronto, Canada.

Data Resources Inc. (DRI) and Wharton Econometric Forecasting Associates (WEFA), (2002). *Asia Energy Prospect*, at http://www.globalinsight.com.

Database of State Incentives for Renewable Energy (DSIRE), (2003). at http://www.dsireusa.org.

Edmonds, J., Scott, M., Roop, J., and MacCracken, C., (1999). *International Emissions Trading and Global Climate Change: Impacts on the Costs of Greenhouse Gas Mitigation,* Report for the Pew Center on Global Climate Change, Washington, DC, December.

Energy for Sustainable Development, Ltd. (2001). *The European Renewable Electricity Certificate Trading Project (RECerT): Final Technical Report*, September; at http://recert.energyprojects.net/.

Energy Foundation, (2002). *Chinese Power Sector Reform and Sustainability Strategy*, Beijing, China, at http://www.efchina.org/chinese/home.cfm.

Energy Research Institute (ERI). (1995). Wind Energy Background Report, Beijing.

Energy Research Institute (ERI), (1999). China Mid and Long Terms Energy Strategy, China Planning Press, Beijing.

Enzensberger, N., Wietschel, M. and Rentz, O., (2002). "Policy Instruments Fostering Wind Energy Projects—A Multi-perspective Evaluation Approach," *Energy Policy*, July.

Eurelectric, (2000). "Market Mechanism for Supporting Renewable Energies: Tradable RES Certificates," Report # 2000-900-0081; at http://www.eurelectric.org.

"European Renewable Electricity Directive: The Final Version," (2002). *Wind Directions*, January, pp. 10-11

European Wind Energy Association (EWEA) and Greenpeace, (2002). *WindForce12: A Blueprint to Achieve 12% of the World's Electricity from Wind Power by 2020*, May, at http://www.ewea.org/doc/WindForce12.pdf.

Feng, F., (2003). *Power System Reform: Separation of Generation and Grid, Price Competition for Connection*, Development Research Center (DRC), State Council, China; unpublished report.

Fernando, P. N., Huq, A., Abeygunawardena, P., Anderson, R., and Barba, R., (1999). *Emissions Trading in the Energy Sector: Opportunities for the People's Republic of China*, ADB, Manila, September.

Gan, L., (1998). "Energy Development and Environmental Constraints in China," *Energy Policy*, 26:2, 119-128.

Gan, L., (1999). "Wind Energy Development and Dissemination in China: Prospects and Constraints in an Institutional Context," *Sinosphere V. 2, Spring Issue*, at http://www.chinaenvironment.net/sino/

Gao, H., (2000). The Analysis of Chinese Wind Power Price, Vestas China, at http://www.opet.net.cn.

Gipe, P. (2002a). "Wind Booming Worldwide,"March 28; at http://www.chelseagreen.com/Wind/articles/BTMUpdateRev.htm.

Gipe, P., (2002b). "Soaring to New Heights: The World Wind Energy Market," *Renewable Energy World*, July/August; at http://www.jxj.com/magsandj/rew/2002_04/wind_energy.html.

Green Power Newsletter, (2001). No. 8, July.

Gregersen, B. and Johnson, B., (2000). "Towards a Policy Learning Perspective on the Danish Wind-power Innovation System," paper to be presented at 3rd POSTI International Conference on Policy Agendas for Sustainable Technical Innovation, London (Draft), Nov., at http://www.esst.uio.no/posti/workshops/gregers.pdf

Gu, S. and Liu, H., (Eds.), (2001). *2002-2015: New Energy and Renewable Energy Industrial Development Plan*, China Economy Press, Beijing.

Guey-Lee, L., (1998). "Wind Energy Developments: Incentives in Selected Countries," at www.eia.doe.gov/cneaf/solar.renewables/rea_issues/windart.html.

Han, Y. et al., (1996). "Feasibility Study of Wind Energy Potential in China," *Renewable Energy*, 1, 1996, pp 810-818.

Han, Y. et al., (1999). "Wind Energy Development in China—Reality and Market Forces," *Renewable Energy*, 16, 965-969.

He, D., (1999) "Wind Energy Development and Prospective," *Solar Energy Journal (Special Edition)*, Beijing.

He, K. et al, (2002). "Urban Air Pollution in China," *Annual Rev. of Energy and Environment*. 27, 397-431.

Hvelplund, F., (2001). "Political Prices or Political Quantities? A Comparison of Renewable Energy Support Systems," *New Energy*, May, 18-23.

InterGen. (2001). Press release, February 16; at http://www.intergen.com/021601pr.html.

International Energy Agency (IEA), (1999). Chinese Energy Security, at http://www.iea.org/index.html

International Energy Agency (IEA), (2000). China's Energy Development Trend, at http://www.iea.org/index.html

International Energy Agency (IEA), (2002). World Energy Outlook 2002, at http://www.iea.org/index.html

Krewitt, W. and Nitsch, J., (2003). "The German Renewable Energy Sources Act—an investment into the future pays off already today," *Renewable Energy*, 28, forthcoming.

Krohn, S., (1998). *Creating a Local Wind Industry: Experience from Four European Countries*, May.

Krohn, S., (2001a). "An Industry View of a Proposed Danish Green Certificate Market," Paper presented at Copenhagen Workshop on Tradables, 10-11 September, at http://wwww.windpower.dk/articles/busiview.htm.

Krohn, S., (2001b). "Swedish Green Certificate Plans Could Halt Wind," at http://www.windpower.org/news/swedish.htm.

Krohn, S., (2002a). "Wind Energy Policy in Denmark: Status 2002," at http://www.windpower.org/articles/energypo.htm.

Krohn, S., (2002b). "Wind Energy Policy in Denmark: 25 Years of Success—What Now?", Feb.; at http://www.windpower.org/articles/whatnow.htm.

Larson, E. et al, (2003). "Future Implication of China's Energy-Technology Choices," *Energy Policy*, in press.

Lew, D. and Logan, J., (2001). "Energizing China's Wind Power Sector," http://www.pnl.gov/china/ChinaWnd.htm

Li, Y.M., (2003). Interview of Li (Director of Dep. Of Infrastructure, SDPC, Office Director of National Power Sector Reform), China Power News Net, at http://www.cec.org.cn/news/

Liu, W. et al, (2002). "Cost Competitive Incentives for Wind Energy Development in China: Institutional Dynamics and Policy Changes," *Energy Policy*, 30, 753-765

Lobsenz, G., (2002). "Green Mountain To Utilities: Let's Tango," *The Energy Daily*, 30:53, March 19.

Logan, J., (2001). An Update on Recent China's Energy Consumption, at http://www.pnl.gov/china/engenvup.pdf.

Menanteau, P., Finon, D., and Lamy, M., (2003). "Prices versus quantities: choosing policies for promoting the development of renewable energy," *Energy Policy*, (in press).

Ministry of Energy (MOE), (1990). China Energy Industry 40 Years Statistics, MOE, Beijing.

Ministry of Energy (MOE), (1997). China Energy Strategy Study, China Electric Power Press, Beijing.

Ministry of Science and Technology (MOST), (2000). *Study on Chinese National Future Energy Development Strategy*, Beijing.

Morganstern, R. et al, (2002). "Demonstrating Emissions Trading in Taiyuan, China," *Resources*, 148, Summer, pp. 7-11.

Morthorst, P., (1999). "Policy Instruments for Regulating the Development of Wind Power in a Liberated Electricity Market," at http://www.risoe.dk/sys/esy/renewable/policy_instr_pub_b.pdf.

Morthorst, P., (2000). "Windpower: Status and Development Possibilities," Solar Energy 2000; Sixth International Summer School Lectures, Klagenfurt, Austria; at http://www.ebd.lth.se/avd%20ebd/main/Summerschool/Lectures/lect-n-morthorst.pdf

Nakicenovic, N., et al, (1998). *Global Energy Perspectives*, IIASA, Cambridge Univ. Press.

Nelson, R., (1987). "The Economics Profession and the Making of Public Policy," *J. of Economics Literature*, 25.

Ni, W. D. et al, (2000). *A New Approach for Wind Power Development: Final Report*, Tsinghua University, Beijing, July.

Office of Gas and Electricity Markets, (U.K.) (2002). "Guidelines on Green Supply Offerings," April, at http://www.ofgem.gov.uk/docs2002/31green_supply_offerings_guidelines.pdf.

Ondraczek, J., personal communication, 2002.

Pigou, A.C., (1920). *The Economics of Welfare*, Macmillan & Co., Ltd., London.

Raufer, R., (1998). *Pollution Markets in a Green Country Town: Urban Environmental Management in Transition*, Praeger Publishers, Westport, CT.

Raufer, R. and Wang, S. J., (2002). "Wind Resource Concession Approach in China," *IEEE Power Engineering Review*, 22:9, 12-18

"Regulator Sets Target for China's Power Sector Reform," (2003). *People's Daily*, March 26.

Renewable Energy Certificate System (RECS), (2002). Press No. 4., January, at. http://www.recs.org.

Rose, A. et al, (1996). "Global Warming Policy, Energy, and the Chinese Economy," *Resource and Energy Economics*, 18, 31-63.

Rosenzweig, R., Varilek, M., and Janssen, J., (2002). *The Emerging International Greenhouse Gas Market*, Pew Center on Global Climate Change, Washington, DC, March.

Salvaderi, L., (2002). "Accomplishments and Challenges for Wind Power in the Italian Generation System; A Perspective from a Major Player: Edens Spa," IEEE Winter Meeting, New York, NY, January.

Shi, P., (1999). "Chinese Wind Energy Development," *Solar Energy Journal (Special Edition)*, Beijing.

Sims, H., (1999). "One-fifth of the Sky: China's Environmental Stewardship," *World Development*, 27:7.

State Development Planning Commission (SDPC), (1999). *White Paper on Renewable Energy Development*, China Planning Press, Beijing.

State Development Planning Commission (SDPC), (2002). Tenth Five-Year Plan, Beijing, at http://dp.cei.gov.cn.

State Environmental Protection Agency (SEPA, China) and Environmental Protection Agency (EPA, U.S.), (1999). W*orkshop on the Feasibility of Using Market Mechanisms to Achieve Sulfur Dioxide Emissions Reductions in China*, Beijing, China, Nov. 15-18.

Sumi, Y., (2001). Memorandum Re: Restructuring the China Renewable Energy Development Project (CN-PE-46829 and CN-GE-38121), World Bank, May 1.

United Nations Development Programme (UNDP), (2002). Capacity Building for the Rapid Commercialization of Renewable Energy in China, Project. No. CPR/97/G31, at http://www.unchina.org/undp/modules.php?op=modload&name=News&file=article&sid=26&mode=thread&order=0&thold=0

U.S. Dept. of Energy, (2002). "Impacts of a 10-Percent Renewable Portfolio Standard," EIA, SR/OIAF/2002-03, February.

U.S. Dept. of Energy, (2002). Annual Energy Outlook 2002, DOE/EIA-0484 (2002), at http://www.eia.doe.gov/oiaf/ieo/index.html

U.S. Embassy, (2002). *Beijing Environment, Science and Technology Update*, January 11.

Van Vuuren, D. et al, (2003). "Energy and Emission Scenarios for China in the 21st Century, Exploration of Baseline Development and Mitigation Options," *Energy Policy*, 31, 369-387.

Wiser, R. and Langniss, O., (2001). *The Renewables Portfolio Standard in Texas: An Early Assessment*, Lawrence Berkeley National Laboratory, LBNL-49107, November, at http://eetd.lbl.gov/ea/EMS/reports/49107.pdf.

Woerdman, E., (2000). "Implementing the Kyoto Protocol: Why JI and CDM Show More Promise Than International Emissions Trading," *Energy Policy*, 28.

World Bank, (1994). *Issues and Options of GHG Emission in China*, World Bank, Washington DC.

World Bank, (1996). *China: Renewable Energy for Electric Power,* Report No. 15592-CHA, Washington, DC.

World Bank, (2002). *Environmental Challenge in China*. ECON Report No. 34/02, Project No. 36190, Washington, DC.

Wu, G. et al, (2001). "Domestication of Wind Turbine," Xinjiang Wind Power Company, at http://www.newenergy.org.cn.

Wu, J., et al, (2002). "Wind Energy Investigation Report," Beijing Guodian Northern China Power Engineering Company, at http://www.nckm.com.

Wu, Z. et al, (1997). "Mitigation Assessment Results and Priorities for China's Energy Sector," *Applied Energy*, 56:3/4, 237-251.

Zeng, L.M., (2002). *The Policy Research of WRC in Guangdong*, Guangdong Provincial Technological and Science Research Center, Guangdong Province, China.

Zhang, C., (2003). Reform of the Chinese Electric Power Sector: Economics and Institutions, Working Paper #3, CESP, Stanford Univ., CA.

Zhang, Z. H., (2000). "Can China Afford to Commit Itself an Emission Cap?: An Economic and Political Analysis," *Energy Economics*, 22, 587-614.

Zhang, Z.M. et al, (2000). *China Renewable Energy: Challenges and Potential*, EF China, Beijing, China, at http://www.efchina.org/chinese/home.cfm

Zhang, Z.M. et al, (2002). *The Incentive Policy Research of Economy on Wind Power Generation in China,* China Environmental Science Press, Beijing.

Zhang, Z.X., (2000). "Estimating the Size of the Potential Market for the Kyoto Flexibility Mechanisms," *Environmental Economics Working Paper Series*, (http://www.ssrn.com/update/ern/ern_enviro.html), January 19.

Zhao, J. et al, (1998). Study on Chinese Renewable Energy Development Economic Incentives, Chinese Environmental Press, Beijing, China

Zhou, H., (2000). Wind Power Prospective, at www.energy-China.com

Zhou, H. et al, (2002). China Wind Farm Construction and Prediction, at www.energy-China.com

Zhuang, X., et al, (2001). WRC Method and Policy, Energy Research Institute, SDPC, Beijing.