Evaluation of Policies Designed to Promote the Commercialization of Wind Power Technology in China

Executive Summary

By analyzing the economics and regulatory environments of wind power in countries where the industry is well established, the present paper makes preliminary recommendations for creating a commercially self-sustaining wind power industry in China.

The paper concludes that wind power will compete effectively with electricity generated from conventional energy resources in China once the installed capacity of wind power exceeds around 3500 megawatts, or slightly over 1% of total generation capacity. To reduce wind power prices to a commercialization target price commensurate with power generated from conventional sources, it is estimated that social investment of about 6.6 billion Yuan (US$800 million) will be required. Assuming operating periods for wind projects of 20 years, and a buy-down period lasting 10 years more, additional expenditures would total around 220 million Yuan (US$27 million) per year.

Various incentive policies are discussed for generating this investment, summarized in detail below. They are evaluated in terms of their economic costs and benefits, as well as in terms of the projected feasibility of their implementation with respect to bureaucratic and institutional hurdles.

One of the basic aims of developing a renewables-based power industry is to gradually replace old, polluting fossil-fuel plants with non-polluting forms of generation while continuing to meet projected electricity demand. The principal barrier to entry for renewables, including wind, is the relatively higher cost of power generated compared with conventional sources. Market conditions developed in other countries to stimulate growth in the wind power industry have aimed to reduce or remove this barrier to entry. As such, they serve as models for China. In North America and Europe, where the wind power industry presently is most highly developed, legislation has been used to require power companies to purchase a certain proportion of their electricity from small power providers or from renewable sources at fixed prices. This legislative approach typically has been combined with the establishment of preferential financing channels for renewable generation projects, such as capital awards, production awards, tax credits, government incentives, small usage-based surcharges to consumers, preferential pricing systems, and renewable energy certificates.

Having conducted a general review of various kinds of policy instruments, the present paper aims to apply approaches developed elsewhere to China. From a legislative point of view, the Chinese situation presents new challenges to the development of wind power because China's governmental structure differs from those of its North American and European counterparts to an extent that they may not serve as very effective models. Rather than focus on the political angle, however, the present paper turns to a microeconomic analysis, using as a context China's relatively well-developed financial structures of taxation, money-lending and governmental incentives, which bear moderately close resemblance to those in other wind power-producing countries.

The on-grid price gap between wind power and coal-fired power in China is roughly 0.3 Yuan per kilowatt-hour—comparable to, if not somewhat higher than, price differences elsewhere in the world. This price gap is calculated by estimating the average on-grid prices of coal-fired power and wind power across China. The latter estimate proves somewhat more complex, not least because the price of wind power varies according to its use rate, that is, the number of hours per year that wind turbines turn. Coal-fired power plants, by contrast, usually serve base load and therefore are in operation most of the time.

The policy goal with respect to commercializing China's wind power industry is to reduce the on-grid price of wind power to a target price equivalent to or less than the on-grid price of coal-fired power—that is, to bridge the price gap. The present paper presents a series of hypothetical policy mixes, containing different kinds of incentives, tax breaks, preferential pricing, preferential loan conditions and other instruments, and performs cost-benefit analyses on each of them to determine a combination of measures that would achieve the goal. Whereas single measures would in principle be the easiest to implement, it is found that only combinations of measures are able to close the gap.

Table 7-38 Summary of cost-benefit analyses of incentive policies for the development of wind power in China, based on a 2000 on-grid price of 0.64 Yuan per kilowatt-hour. The benefit-to-cost ratio is estimated in comparison to coal-fired power plants. Once wind power becomes as cheap as coal-fired power in China (roughly 0.35 Yuan/kWh), wind power would be expected to become commercially viable. An incentive policy is often considered to be economically attractive when the benefit-to-cost ratio is greater than or equal to one and less viable when the ratio is less than one. Policies with larger ratios are considered more economically beneficial than those with smaller ratios. Under the present analysis, only the last two policy combinations in the table reach the 0.35 Yuan/kWh target price.

Policy code	Description of incentives	On-grid power price (Yuan/kWh)	Percent reduction from 2000 price of wind power _	Wind farms compared with Coal-fired power plants	
				Net benefit (million Yuan)	Benefit-to-cost ratio
—	No incentive (control case)	0.64	0.0	—	—
S1.3	3-year interest allowance loan	0.61	4.7	6.5	1.02
S1.5	Prolong repayment period to 15 years	0.51	21	–47.9	0.85
S2.2	VAT exemption	0.61	4.4	–53.0	0.81
S3.1	o 3-year interest allowance loan o Prolong repayment period to 15 years	0.48	25	–146	0.64
S3.9	o 3-year interest allowance loan o Prolong repayment period to 15 years o Exemption from import duties o Reduction in VAT	0.44	32	–291	0.38
S3.12	o 3-year interest allowance loan o Prolong repayment period to 15 years o Exemption from import duty o Reduction in VAT o Reduction in income tax	0.44	32	–314	0.36
S3.14	o 3-year interest allowance loan o Prolong repayment period to 15 years o Exemption from import duty o Exemption from VAT o 2-year deduction in income tax o 3-year exemption from income tax	0.39	39	–478	0.15
S3.16	o Prolong repayment period to 15 years o Exemption from import duty o Exemption from VAT o 2-year deduction in income tax o 3-year exemption from income tax o Maintain investment levels below 7500Yuan/kW o Increase annual power generation time to	0.35	46	–360	0.21

Policy code	Description of incentives	On-grid power price (Yuan/kWh)	Percent reduction from 2000 price of wind power _	Wind farms compared with Coal-fired power plants	
				Net benefit (million Yuan)	Benefit-to-cost ratio
	2600 hours				
S4.1	Subsidy on wind power prices to equalize them with coal-fired power prices	0.35	45	–615	0.26

The benefit-to-cost ratios identified in the table do not, at first glance, appear attractive. However, this analysis fails to consider the full benefits of wind power generation, and specifically fails to acknowledge the potential cost reductions in this technology over time. Therefore, in tandem with valuing policy instruments, the paper presents an analysis of projected economies of scale for a Chinese wind power industry. It outlines a growth cycle for the industry, progressing from research and development, through technology demonstration to equipment manufacturing and deployment. Production costs early in an industry's life typically can be higher than at maturity. The wind power industry in China would be expected to go through a buy-down stage where the government would absorb the higher initial costs. This sort of buy-down effectively reduces or eliminates a major barrier to commercialization.

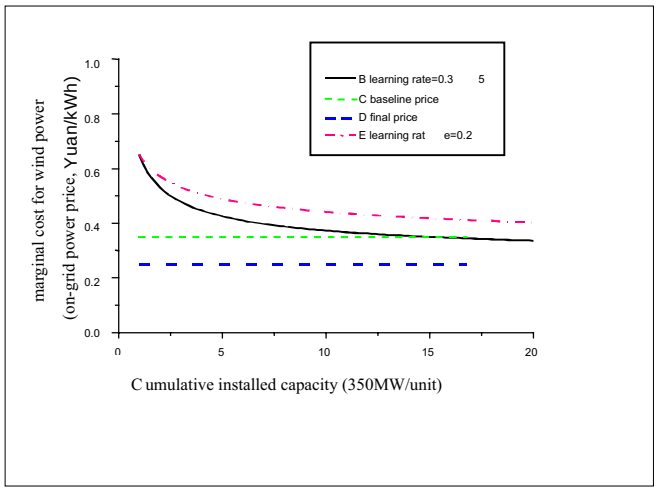
Once deployment is under way, the increasing scale of an industry would be expected to gradually lower production costs. This trend is described by a formula relating the long-term marginal cost of wind power (L) to the rate at which the minimum possible cost of wind power is approached as the industry expands in scale.

$$L = A + BN^{-\beta} \qquad (1)$$

where
L is the long-term marginal cost of wind power
A is the minimum cost that could ultimately be reached
B is the difference between the initial cost and the final cost
N is the cumulative installed wind power capacity.
_ is an offset factor, which is determined by the rate of cost reduction under different sales conditions.

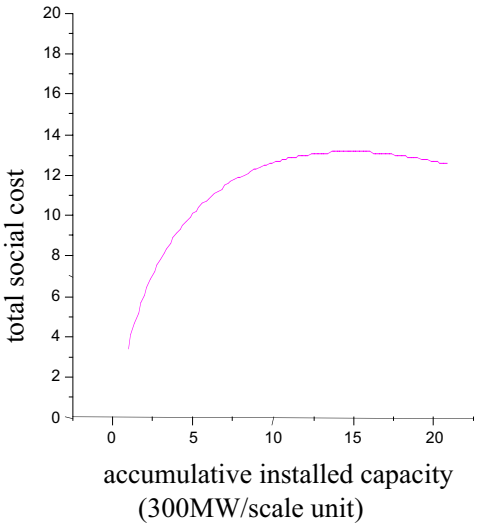
Based on China's initial scale of its wind power industry, and using the U.S. experience as a model, the present paper estimates a size of the industry at which the lowest possible cost of wind power would be approached. This size is estimated at around 3500 megawatts of cumulative installed capacity, as shown in the graph below.

Fig. 8.4 The so-called 'learning curve' for wind power in China, showing the rate at which the marginal cost of wind power (in Yuan per kWh) decreases as the cumulative installed capacity increases (solid line, B in the legend). The target price for commercialization of wind power—equivalent to the average on-grid price of coal-fired power—is estimated at 0.35 Yuan / kWh (small dotted line, C in the legend). The learning curve approaches the target price in the region of 3500 MW of cumulative installed capacity.



Using this result as a baseline and combining it with estimates of generation efficiency, the paper goes on to estimate the social cost of developing the required capacity for commercialization. As the figure below shows, this cost peaks at around 1.3 billion Yuan per year, coinciding with attainment of the commercialization capacity of 3500 MW.

Fig. 8-5 Estimate of annual social expenses, in hundreds of millions of Yuan, during the buy-down stage of the development of a Chinese wind power industry.



In conclusion, the paper articulates three general policy approaches for commercializing wind power in China.

1. The cost could be shared by the whole of society. In this approach, the extra cost of wind power would be added to the total cost of all power on the grid, and the per-kWh price of all types of power on China's provincial grids would be calculated again after the additional price of wind power had been distributed among them all. If this approach were taken, the average price of electricity for consumers would increase by barely a thousandth of a Yuan per kWh and hence go virtually undetected.
2. The extra cost of wind power could be subsidized directly by state funds, or compensated through a combination of tax exemptions and investment subsidies. These methods are not always easy to implement. Investment subsidies in particular can become especially complex to administer.
3. A wind power fund could be established by the government and contracts would be awarded to developers who bid for the lowest subsidies per unit of generation capacity installed. The fund could be assembled from a variety of sources, such as state funds, funding from a lottery or bond system, pollution charges, an extra electricity usage charge to consumers, and even from societies and individuals.

Of these three methods, the first is considered the most feasible. However, to keep price increases as low as possible, additional measures may be taken, such as extending repayment periods on financing for wind power developments, exempting imported turbine parts from value-added tax, and creating deductions or exemptions from value-added tax and income tax on revenues from the sale of wind power.

Competition for investment in wind power also is a critical factor. China would have to introduce competition mechanisms where few presently exist, such as opening development projects to bids from investors, awarding bids based on the on-grid price of power produced after a wind farm had been completed, and establishing mechanisms for distributing extra costs of wind power among consumers.

If the first policy approach is to be taken then it would be vital that a responsible and efficient organization be established to promote the policy and manage its implementation. Provincial power grid corporations would not be appropriate vehicles for this role: it must be independent. The organization's responsibilities would include, but not necessarily be limited to, the following:

- Drawing up and implementing local wind power plans in accordance with the National Wind Power Plan.
- Compiling data needed to make annual adjustments to the market price of wind power, as well as calculating a new price, obtaining approval from the State Power Corporation, and putting it into practice.
- Supervising and measuring the development of wind farms and their connection to the grid.
- Supervising and measuring the purchase of wind power generated by local power corporations.
- Organizing bidding for wind farm projects.