Energy Policy 38 (2010) 1872–1878

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

China's renewable energy policy: Commitments and challenges

Feng Wang [a], Haitao Yin [b,c,*], Shoude Li [b]

[a] School of Public Economics and Administration, Shanghai University of Finance and Economics, 777 Guoding Road, Shanghai 200433, China
[b] Antai College of Economics and Management, Shanghai Jiao Tong University, 535 Fahua Zhen Road, Shanghai 200052, China
[c] Erb Institute for Global Sustainable Enterprise, University of Michigan, Ann Arbor, MI 48109, USA

ARTICLE INFO

Article history:
Received 30 September 2009
Accepted 23 November 2009
Available online 16 December 2009

Keywords:
Renewable energy
Electricity
China

ABSTRACT

The passing of the Renewable Energy Law (REL) in 2005 demonstrated China's commitment to renewable energy development. In the 3 years after the REL, China's renewable electricity capacity grew rapidly. From 2006 to 2008, China's wind capacity installation more than doubled every year for 3 years in a row. However, three facts prevent us from being optimistic about China's renewable electricity future. First, considered as a share of total capacity, renewable electricity capacity is decreasing instead of increasing. This is due simply to the rapid growth of fossil fuel capacity. Second, a significant amount of renewable generation capacity is wasted because it is not connected to the electricity grid. Finally, renewable electricity plants are running at a low level of efficiency. Based on an in-depth analysis of China's existing renewable energy policy, we suggest that these challenges should be dealt with by introducing a market-based mandatory renewable portfolio requirement coupled with strong regulatory monitoring of grid enterprises.

1. Introduction

It is widely recognized that stopping global warming is a battle which cannot be won without China's participation. China's energy consumption relies heavily on fossil fuels. In 2007, fossil fuels accounted for nearly 93% of total energy consumption in China, of which about 75% came from coal (NBSC, 2008). As China's energy consumption has increased rapidly in recent years, greenhouse gas emissions have skyrocketed. On 19 June 2007, the Netherlands Environmental Assessment Agency announced that China's 2006 CO_2 emissions had surpassed those of the US, making China the largest carbon emitter (Ma and He, 2008). Auffhammer and Carson (2008) have projected that the increase in Chinese emissions by 2010 will be several times larger than reductions embodied in the Kyoto Protocol unless there are substantial changes in China's energy policies.

With mounting pressure for carbon reduction, China is standing at a crossroads for determining its future energy policies. Without a doubt, low carbon will be the watchword for these policies. There are three primary ways to cut back carbon emissions: slowing economic growth, reducing energy intensity, and developing renewable energy.

Scholars have repeatedly observed that production expansion is the major force driving the growth of China's energy consumption (such as Shiu and Lam, 2004; Yuan et al., 2008). However, it is not an option for China to cut its energy consumption and carbon emissions at the cost of economic growth. China has set its development goal at the rate of a 7.2% increase in gross domestic product (GDP) per annum between 2000 and 2020 (Yang, 2008). At this rate of growth, China will have to rely on the remaining two ways to cut carbon emissions: reducing energy intensity and increasing the share of renewable energy. Zhang et al. (2006) have found that the potential for further reduction in carbon intensity through improved generation efficiency appears to be low. Zhao et al. (2009) reported that China's energy intensity has continuously increased since 1998, reversing the previous trend. Therefore, in order to achieve the goal of carbon reduction, policy makers and scholars have shown a growing interest in the development of renewable energy and its substitution for fossil fuels, especially coal.

In spite of some renewable energy programs established as early as the mid-1990s (Ma and He, 2008; Zhang et al., 2009), development of renewable energy did not become a *policy* issue until 2005. On 28 February 2005, the Renewable Energy Law (REL) was passed by the National People's Congress, marking a new stage of renewable energy development in China. Since the REL was introduced, a number of supporting regulations and guidelines have been put into place to implement the law. This paper provides a critical review of the major measures to stimulate renewable energy development that are contained in these laws, regulations, and administrative guidelines, and examines their impact. Different from previous studies on China's renewable energy policy (for example, REN21, 2009; Zhang et al., 2009), the focus of this paper is not to describe various policy instruments

* Corresponding author at: Antai College of Economics and Management, Shanghai Jiao Tong University, 535 Fahua Zhen Road, Shanghai 200052, China. Tel./fax: +86 21 52302519.
E-mail address: htyin@sjtu.edu.cn (H. Yin).

0301-4215/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2009.11.065

but to analyze the incentives these policies have created for renewable energy investment. Impacts of these policies are evaluated based on available data. Comparisons with US key renewable energy policies are also discussed.

In this paper, we focus on the electricity sector for two reasons. First, the different areas of renewable energy development – for example, residential heating, transportation fuel, and electricity generation – demand different policy treatments. It is hard to offer an in-depth analysis of one area while trying to cover all of them. Second, China's electricity sector accounted for almost 50% of coal consumption in 2006. Without substantial policy changes, coal consumption by the electricity sector is expected to increase from 24.9 quadrillion Btu in 2006 to 57.3 quadrillion Btu (or 58% of total coal consumption) by 2030, an average rate of increase of 3.5% per year (U.S. EIA, 2009). Therefore, the electricity sector is the most important sector in determining whether China can successfully reduce its reliance on fossil fuels and thus cut carbon emissions.

The paper proceeds as follows. Section 2 offers a brief review of the specific goals and measures that existing laws, regulations, and guidelines have set up to encourage investment in renewable electricity. Section 3 describes the development of renewable electricity in the past few years, particularly since the passage of the REL, and identifies the key challenges for existing renewable energy policy. To put matters in perspective, comparisons with the US are presented when necessary. In Section 4, we propose measures that would complement existing policies, measures that we believe would promote renewable electricity development more effectively and efficiently, namely, market-based mandatory renewable portfolio requirements coupled with strong regulatory monitoring of grid enterprises. Section 5 concludes the paper.

2. Existing policies for renewable electricity development in China

2.1. Goals for renewable electricity development

Article 4 of the REL requires that a goal for the amount of renewable energy in China's energy portfolio be established. Based on this requirement, a series of administrative orders and guidelines, most notably the *Eleventh Five-Year Plan for Renewable Energy Development* (EFYPRED) and the *Mid- and Long-Term Plan for Renewable Energy Development* (MLTPRED), were published to specify what the goal ought to be. According to the MLTPRED, renewable energy should account for 10% of total energy consumption in China by 2010 and 20% by 2020, an increase from 7.1% in 2005. The growth target in each category is summarized in Table 1.

As demonstrated in Table 1, the goal for total renewable energy capacity by 2010 is 300 million tce, of which 248.24 million tce are to come from renewable electricity. Therefore, the development of renewable electricity is crucial to meeting the growth targets for renewable energy in the near future. It is worth noting that hydroelectric, regardless its capacity, is counted as renewable energy. In the 2010 and 2020 targets, hydroelectric represents 80% of all renewable capacity. For non-hydroelectric capacity, the goal is for non-hydro renewable generation to account for 1% of all grid-connected electricity generation by 2010 and 3% by 2020. Electricity investors whose total capacity exceeds 5000 MW shall get 3% of their total capacity from non-hydro renewable sources by 2010 and 8% by 2020 (MLTPRED).

2.2. Measures for renewable electricity development

2.2.1. Guaranteed grid access and cross-subsidization

The REL set up guaranteed grid access and cross-subsidization as primary means to ensure that renewable electricity plants recover their operation costs. Article 14 stipulates that enterprises that operate electricity grids – the State Power Grid and the China South Power Grid – shall sign agreements with approved renewable electricity generators to purchase all grid-connected electricity they generate. The State Electricity Regulatory Commission (SERC) published executive order No. 25, *Rules for Grid Enterprises to Purchase all Renewable Electricity*, in 2007, which restated and detailed grid enterprises' responsibility for purchasing all grid-connected renewable electricity.

The price at which grid operators purchase renewable electricity is not decided by the market, but follows government-guided prices. For wind electricity, the wholesale price is set based on bid prices for the wind project that come out of

Table 1
Goals for renewable energy development.
Sources: The Eleventh Five-Year Plan for Renewable Energy Development (March, 2008); the Mid- and Long-Term Plan for Renewable Energy Development (August, 2007).

Renewable Energy	2005	Goal for 2010	Goal for 2020
Electricity (MW)	113,580	205,875	
Hydroelectric (MW)	110,000	190,000	300,000
Grid-connected wind (MW)	1260	10,000	30,000
Distributed wind (MW)	250	75	
Solar (MW)	70	300	1800
Biomass (MW)	2000	5500	30,000
Biogas supply (million M^3)	80,000	19,000	44,000
Household biogas (million M^3)	18,000	15,000	30,000
Livestock farm biogas (stations)		4700	
Biogas from industrial effluents (stations)		1600	
Heating			
Solar water heaters (million M^2)	80	150	300
Geothermal heat, etc. (1000 tce)	2000	4000	12,,000
Solar cookers (1000 stations)		1000	
Fuel			
Bio-ethanol (1000 tons)	1020	3000	10,000
Bio-diesel (1000 tons)	50	200	2000
Solid biomass fuel (1000 tons)		1000	50,000
Total (1000 tce)	166,000	300,000	

a government-organized tendering process. For biomass, solar, and other renewable electricity generation, prices are set by the government based on a rule similar to the "rate of return" principle: that is, cost plus a reasonable return on capital. Without a doubt, these prices are much higher than that for fossil fuel electricity. The purpose of guaranteed grid access at a government-set price is to ensure a market for renewable electricity. The cost of renewable electricity generation is still significantly higher than fossil fuel generation (Cherni and Kentish, 2007). If renewable power plants were required to compete with fossil fuel power plants on price for grid access, investors would have no incentive to invest in renewable energy development.

In return for ensuring open grid access for renewable electricity, grid enterprises are allowed to recover the cost above purchasing conventional electricity through cross-subsidization. According to Article 20 of the REL and the "*Renewable Electricity Pricing and Financing*" published by the National Development and Reform Committee (NDRC) in 2006, grid enterprises may recover from their customers (1) expenses for getting renewable electricity connected to the grid, and (2) the difference between expenses for purchasing renewable electricity and those for purchasing fossil fuel electricity of the same amount.

2.2.2. A public fund for renewable energy development

Public subsidies for renewable energy development existed long before the REL. For example, in 1999, the State Council set up an innovation fund of 1 billion RMB for small- and medium-sized technical enterprises; the purpose of the fund was to support energy efficiency and renewable energy by means of grants and preferential loans. About 1000 projects have obtained support from this fund (Cherni and Kentish, 2007). The Department of Resource Conservation and Utilization of the former State Economic and Trade Committee provided low-interest loans from the state budget to support the industrial development of renewable energy (NREL, 2009). Some local Governments, such as that of the Inner Mongolia Autonomous Region, have used income tax revenues to support local renewable energy development (Cherni and Kentish, 2007).

However, before the REL, these subsidies were provided on an ad hoc basis, and were subject to changes of policy priority. Article 24 of the REL establishes a long-term, stable subsidization system that requires the central government to set up a public fund for renewable energy development. The fund is financed with general tax revenue. In 2006, the NDRC published "Guidelines for Using the Public Fund for Renewable Energy Development." These guidelines list three priorities. One is support for renewable electricity generation (including wind, solar, and ocean). The other two priorities are research on energy sources able to replace oil, and support for the use of renewable energy by the heating-and-cooling systems of buildings. The public fund can be used in two forms. First, it can be issued as a grant. Recipients of such grants use the funds for renewable energy research and development. Second, it can be used to subsidize loan interest. Eligible renewable projects may obtain public funds to pay part of its loan interest.

2.2.3. Other economic incentives

The REL of 2005 also set up other economic incentives to support renewable energy investment. Article 25 encourages financial institutions to provide preferential loans to eligible renewable energy development projects. Article 26 states that the government shall provide tax benefits to eligible renewable projects. So far, neither SERC nor NDRC has published administrative orders or guidelines for implementing these measures. As a result, preferential loans and tax benefits have been used in an ad hoc and very limited manner (Zhang et al., 2009). The only nationwide tax policy favorable to renewable energy development at present is administrative order No. 2001-198, which was issued by the Ministry of Finance (MOF) and the State Administration of Taxation in December 2001 (MOF and SAT, 2001), 4 years before the REL. According to this order, the value-added tax for using municipal solid waste for power generation shall be collected first and later refunded. The value-added tax rate for wind power was reduced from 17% to 8.5% (MOF and SAT, 2001). This taxation policy has, in general, not provided sufficient support for renewable electricity generation (NREL, 2009), which is evidenced by Fig. 1 and Fig. 2, which show that wind electricity capacity did not change from 2001 until the introduction of the REL.

Customs duty exemption or reduction is also given to imported renewable energy power generation equipment and to parts considered to be high-tech. According to the NREL (2009), in the 1980s and early 1990s, applications to reduce or exempt customs duties on the main components of wind turbines, on the turbines themselves, and on photovoltaic modules imported with international assistance, were all approved, so that the actual duties paid were very low. However, there is no specific government document that clearly codifies

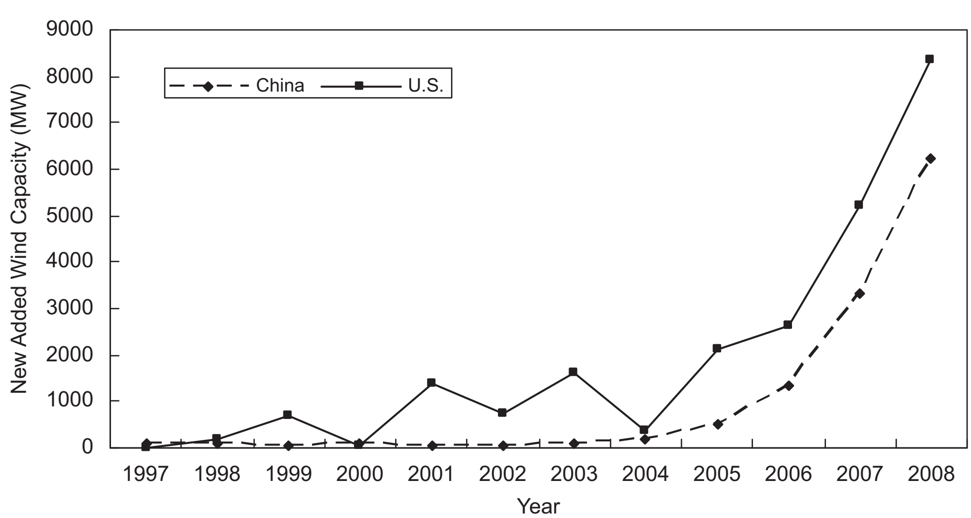

Fig. 1. New added wind capacity in China and the US.
Sources: US Energy Information Agency website (www.eia.doe.gov); Shi (2007, 2008, 2009); China Energy Statistical Yearbook 1997–2009.

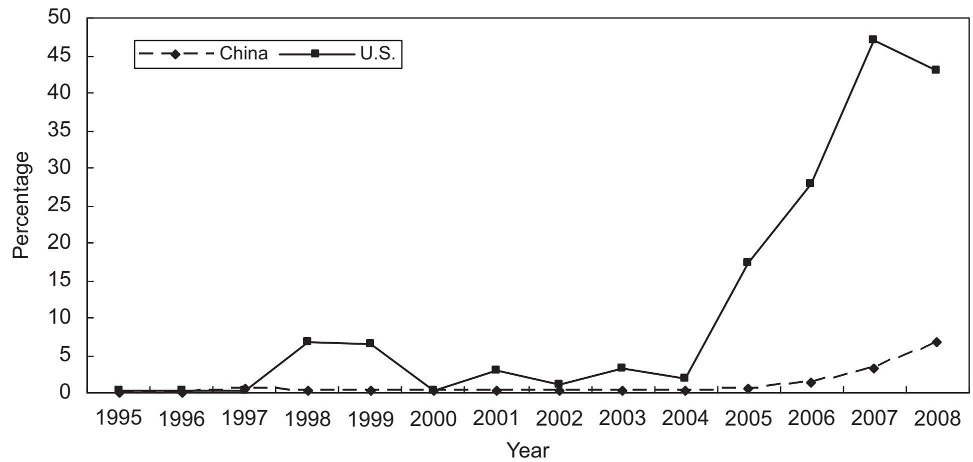

Fig. 2. New added wind electricity capacity as a share of total capacity installation in China and the US.
Sources: US Energy Information Agency website (www.eia.doe.gov); Shi (2007, 2008, 2009); China Energy Statistical Yearbook 1997–2009.

these duty benefits, and they are given on a case-by-case basis. As the need to promote the development of domestic wind technology increases, these customs duty benefits are likely to disappear. In 2005, the NDRC published *Some Requirements for Wind Farm Development*, which clearly stated that 70% of wind power equipment must be produced domestically. Wind farms that cannot fulfill this requirement may not be built. All the imported wind equipment must pay the custom duty set by law.

3. Renewable electricity development after the Renewable Energy Law

Since 2006, China has joined the United States in becoming a very dynamic wind market (see Fig. 1). From 2006 to 2008, China's wind capacity installation more than doubled every year for 3 years in a row. In 2008, China's new wind capacity installation ranked second only to the US. Total wind capacity reached 12 GW, surpassing India for the first time and taking the lead in Asia (WWEA, 2009).

This development is encouraging and suggests that the impact of the 2005 REL on renewable electricity development was positive. However, another aspect of the current situation prevents us from being optimistic about China's renewable energy future. Fig. 2 shows new added wind electricity capacity as a share of total capacity installation in China and the US from 1995 to 2008. In the past 2 years, wind has accounted for about 45% of the total new electricity capacity installation in the US, and all renewable energy accounts for more than 50%. In contrast, in China, only about 6% of new electricity capacity has come from wind.

According to *Audit Reports on Implementation of Policies Regarding Renewable Electricity Pricing and Sales*, published by the SERC in 2008, from the end of 2005 to the end of 2007, although renewable electricity capacity and generation increased by 30.6% and 20.6%, respectively, renewable electricity capacity considered as a share of total capacity decreased by 1.37%, and renewable electricity as a share of total electricity generation decreased by 1.23% (SERC, 2008). This decrease was due mainly to the fact that the development of renewable electricity other than wind power, notably hydroelectric, was much slower than traditional fossil fuel electricity generation. This suggests that in spite of the rapid development of renewable power, China's electricity generation still relies heavily on fossil fuel. Without significant changes, this trend is likely to continue, and fossil fuel generation's share of total electricity generation will increase rather than decrease. As a result, carbon emissions will continue to grow with the increased demand for electricity.

A second issue accompanying the rapid growth of China's renewable electricity capacity is the difficulty of feeding renewable power into the grid. It is reported that about one-third of wind generation capacity is not connected to the grid (Wang, 2009). The key reason is that grid enterprises are reluctant to build grids connecting wind power plants to the main grid network, even though required to do so by the REL and by SERC executive order 25. In its audits of renewable electricity pricing and sales, the SERC reported that it is commonplace for grid enterprises to refuse or delay building or expanding grids to connect to renewable power plants. As a result, a significant amount of wind generation capacity, especially in the provinces of Hebei and Gansu, was wasted (SERC, 2008). Some renewable power plants (for example, wind power plants in Inner Mongolia Autonomous Region, Heilongjiang Province, and Jilin Province; and hydroelectric power plants in Qinghai Province and Jiangxi Province) have had no choice but to build connecting grids themselves or to share the costs, which is a violation of the REL and SERC executive order 25 (SERC, 2008).

Another challenge for China's renewable electricity development is its low operation efficiency. In 2007, with wind generation capacity of 16,596 MW, the US produced 34.45 million MWh of electricity (EIA, 2007). In contrast, in China, wind power plants of 5,610 MW only contributed 5.36 million MWh of electricity (SERC, 2008). That is, 1 MW capacity produced 2,076 MWh of electricity in the US per year but only 955 MWh in China. Assuming that wind plants that are not connected to power grid do not generate electricity at all, the electricity produced by 1 MW capacity in China is about 1433 MWh, still significantly lower than the US Low operation efficiency may be due to many reasons, but it surely can be improved through appropriate policy intervention. We will return to this point in the next section.

In sum, the development of renewable electricity in China in the past 3 years offers clear evidence of the Chinese government's strong commitment to clean energy; the growth of renewable electricity generation capacity has been greatly boosted. This development is encouraging. However, in the meantime we have also seen many of the challenges which China must confront.

First, only a very small percentage of new electricity capacity is currently coming from renewable sources. China's new electricity generation capacity is still coming predominately from fossil fuels. As a result, renewable electricity capacity and generation considered as a share of total capacity and generation decreased instead of increased. With this fact in view, we have a reason for not being optimistic about China's carbon emission future. Second, grid enterprises are reluctant to build new grids connecting wind power plants to the main grid network, which results in a waste of installed wind capacity and reduces investors' incentives to develop renewable electricity. Third, compared to their US counterparts, China's renewable electricity plants are running at low efficiency, which impairs their contribution to meeting overall electricity demand. These difficulties are unlikely to be resolved without appropriate policy treatments, to which we turn in the next section.

4. Policy suggestions for a better renewable energy future in China

4.1. Strengthen policy incentives for power companies through a mandatory renewable portfolio requirement

China has set a clear goal for renewable energy development. But it is not clear how this goal can be achieved. Electricity companies have no legal obligation to invest in renewable energy. Although the MLTPRED states that electricity investors who own capacity of 5000 MW and above shall get 3% of their total capacity from non-hydro renewable energy by 2010 and 8% by 2020, these goals are suggestive rather than mandatory. In the past, wind and other forms of renewable electricity development have been driven mainly by administrative plans instead of by internal strategic choices stemming from the market. Since 2002, the State Commission of Development and Reform has initiated the Wind Power Concession Bidding Project and developed several 100 MW and larger wind projects (Zhang et al., 2009). A significant portion of the 4 trillion RMB economic stimulus package is also devoted to renewable energy development.

It is open to question whether this approach, whereby firms develop voluntarily unless included in administrative plans, is sustainable and can affect China's reliance on fossil fuels. A mandatory system similar to the US's renewable portfolio standards (RPS) may therefore be desirable. In the US as of April 2009, 30 states and the District of Columbia have passed an RPS. An RPS requires all electricity generators (or retailers) to demonstrate that they have supported a certain amount of renewable electricity generation. For example, if the goal is set at 3% in a year, an electricity generator (or retailer) that supplies 1000 MWh electricity must prove that it has supported 30 MWh of renewable electricity generation in that year. This is a legal requirement. The electricity generator (or retailer) will be fined if it fails to comply with this requirement. The fine is normally set much higher than market price for renewable electricity (50 USD per MWh and adjusted each year for inflation). Thus, an RPS is a mandate which electricity suppliers have to comply with, rather than a voluntary choice. With RPS, developing renewable electricity in a cost-effective manner is an element every electricity supplier must integrate into its business plan.

In the future, China may consider imposing mandatory renewable portfolio requirements on all electricity companies. By increasing the requirement over time, this policy could help shift China's energy reliance on fossil fuels toward renewable energy.

4.2. Establish a market-based renewable portfolio requirement

One concern related to imposing a mandatory renewable portfolio requirement on all electricity companies is that electricity companies in areas with few renewable resources might have to pay a prohibitively high cost to fulfill the requirement. In order to have renewable electricity developed in the most cost-effective manner, a market-based portfolio requirement, similar to the cap-and-trade scheme, is necessary.

In the US, most RPSs have a market element. Instead of developing renewable generation capacity on their own, electricity companies are offered an alternative way to comply with the mandatory requirement—by buying Renewable Energy Credits (RECs). An REC is a certificate of proof that one MWh of electricity has been generated by a renewable energy source. RECs can be traded freely on the market. An electricity company in an area poor in renewable energy resources can purchase RECs from those with rich renewable resources. As such, every electricity company pays to support renewable energy development, and renewable electricity is produced by the most cost-effective power plants.

As discussed in Section 3, one difficulty with China's renewable energy development is its low efficiency. Part of efficiency loss is a result of existing pricing schemes. Currently, the price for renewable electricity is primarily determined by the government instead of the market. Price is normally set at a level so that the cost is fully recovered and "reasonable" return is ensured. This pricing mechanism offers little incentive for firms to improve efficiency because profit is more related to the size of investment than high efficiency (Crew and Kleindorfer, 2002). With such a pricing scheme, firms have no incentive to invest in Research and Development. This is a crucial drawback for China's current renewable energy policy considering the high cost of renewable generation and rapid technology progress worldwide.

To some extent, a market mechanism such as REC-trading could fix this problem. Renewable electricity generators compete on the REC market and therefore have an incentive to lower generation costs. In order to lower costs, firms would invest in management efficiency and technology progress.

4.3. Strengthen regulation and monitoring of grid enterprises

In 2002, the vertical monopoly of the State Power Corporation was dismantled. Total assets were divided into 11 new corporations including two grid operators, five independent power producers, and four auxiliary corporations (Ma and He, 2008). The two grid enterprises – the State Power Grid and the China South Power Grid – are still *de facto* state-owned monopolies in their own regions.

Grid connectivity has become the major constraint for China's renewable electricity development (REN21, 2009). Grid enterprises have little incentive to build and expand grids to connect to producers of renewable electricity. First, most renewable power plants are located in remote areas. Connecting them with the main power grid requires significant investment. Second, because renewable electricity accounted for only a small share of total electricity generation, grid enterprises have little incentive to invest in innovation (REN21, 2009).Third, as the higher cost of renewable generation is to be recovered from consumers, electricity price will increase as more renewable electricity is fed into the grid. As long as the consumer demand curve is not inelastic, grid enterprises will bear part of the costs. Lastly but not the least, renewable power is very sensitive to seasonal and climate change, and may cause grid instability and increase the complexity of grid management.

As the monopoly status of grid enterprises is not likely to change in the near future, the Chinese government needs to strengthen its monitoring of them to ensure that renewable electricity has guaranteed grid access as required by the REL. In the meanwhile, public funds for renewable energy development should tilt toward supporting grid construction and research on improving grid compatibility with renewable power.

4.4. Guarantee the electricity consumer's right of choice

China's existing renewable policy focuses on the supply side and ignores the other side of the market: consumers. Currently, as a result of heightened environmental consciousness, more and more consumers, including industrial and commercial users, are willing to pay a higher price for renewable electricity. For example, Wal-Mart China has set as its goal "to be supplied 100% by renewable energy" (Wal-Mart China, 2009).

Currently, consumers' green purchasing power has not been effectively tapped in China. The REL encourages electricity consumers to purchase renewable electricity at a higher price. However, again, no administrative orders or guidelines have been issued to make sure that electricity consumers can get renewable electricity when they ask for it. That is to say, utilities have no obligation to offer their customers the choice of buying green electricity—a situation quite different from that in the US, where a mandatory green power option has been implemented in several states.[1] The mandatory green power option has proven to be a powerful tool for encouraging renewable development (Adelaja and Hailu, 2008; Kneifel, 2008; Menz and Vachon, 2006; Yin and Powers, 2009). With this policy, all utilities in the state are required by law to offer its customers the choice of opting to buy green power. If Chinese electricity companies were required to offer renewable electricity if asked, the purchasing power of millions of green consumers would create additional market incentives and pressure for electricity companies to development renewable energy.

5. Conclusion

The REL of 2005 marked a new stage for renewable energy development in China. The last 3 years have witnessed a rapid growth of renewable electricity capacity, which demonstrates China's commitment to renewable energy development and the positive impact of the REL. However, three facts prevent us from being optimistic about China's renewable energy future. First, renewable electricity capacity as a share of total capacity has decreased instead of increasing (SERC, 2008). This is due simply to the rapid growth of fossil fuel generation. Second, it is reported that about one third of wind generation capacity is wasted because sources are not connected to the grid (Wang, 2009. Third, renewable electricity plants are running at a low efficiency level. As demonstrated in Section 3, the amount of electricity that is generated with 1 MW of wind capacity in China is significantly lower than that in the US.

These three problems are likely to persist unless there are substantive policy changes. We have suggested the introduction of a market-based mandatory renewable portfolio requirement coupled with strong regulatory monitoring of grid enterprises. Mandatory requirements on electricity companies could force them to make renewable electricity development an integral part of their strategic considerations. Market-based compliance mechanisms are intended to find the cheapest way to generate renewable electricity and to create incentives for power producers to improve their efficiency. Strong regulatory monitoring of grid enterprises is intended to ensure grid access for renewable power producers.

This paper illustrates the necessity of developing a market-based mandatory renewable portfolio requirement in China. Future research should look into the design of such a requirement. Lessons have already been learned from the development and design of renewable portfolio policies in the US and Europe (such as Berry and Jaccard, 2001; Wiser and Barbose, 2008; Wiser et al., 2007; Wiser et al., 2005). China's renewable portfolio policy may of course be different in many respects because of China's existing regulatory and industry structure in the electricity sector.

[1] Eight states, including Colorado, Delaware, Iowa, Montana, New Mexico, Oregon, Virginia, and Washington, have implemented statewide mandatory green power options. With this policy, electric utilities are required to offer customers the option of buying electricity generated from renewable resources. If the customers of one electric utility requested a certain amount of renewable electricity and paid for it, at the end of the year, this utility had to demonstrate that it had supported this amount of renewable electricity generation in the form of generating renewable power themselves, purchasing renewable power from independent power producers (IPPs) or purchasing renewable energy credits (RECs) from a renewable energy provider certified by a state public utilities commission. This policy can be implemented through different mechanisms, which have been explored by (Kotchena and Moore, 2007).

References

Adelaja, S.J., Hailu, Y.G., 2008. Effects of renewable portfolio standards and other state policies on wind industry development in the US mimeo, Michigan State University.

Auffhammer, M., Carson, R.T., 2008. Forecasting the path of China's CO_2 emissions using province-level information. Journal of Environmental Economics and Management 55 (3), 229–247.

Berry, T., Jaccard, M., 2001. The renewable portfolio standard: design considerations and an implementation survey. Energy Policy 29 (4), 263–277.

Cherni, J.A., Kentish, J., 2007. Renewable energy policy and electricity market reforms in China. Energy Policy 35, 3616–3629.

Crew, M.A., Kleindorfer, P.R., 2002. Regulatory economics: twenty years of progress? Journal of Regulatory Economics 21 (1), 5–22.

EIA, 2007. United States Renewable Electricity Profile 2007 Edition. Energy Information Administration. Retrieved May 21, 2009 〈http://www.eia.doe.gov/cneaf/solar.renewables/page/state_profiles/us.html〉.

Kneifel, J., 2008. Effects of state government policies on electricity capacity from non-hydropower renewable sources. mimeo, University of Florida.

Kotchena, M.J., Moore, M.R., 2007. Private provision of environmental public goods: household participation in green-electricity programs. Journal of Environmental Economics and Management 53, 1–16.

Ma, C., He, L., 2008. From state monopoly to renewable portfolio: restructuring China's electric utility. Energy Policy 36 (5), 1697–1711.

Menz, F.C., Vachon, S., 2006. The effectiveness of different policy regimes for promoting wind power: experience from the States. Energy Policy 34 (14), 1786–1796.

MOF and SAT, 2001. In: Adjustment of Value-Added Tax for Some Resource Comprehensive Utilization Products. Ministry of Finance and the State Administration of Taxation.

NBSC, 2008. In: China Statistics Yearbook of 2008. National Bureau of Statistics of China.

NREL, 2009. Renewable energy policy in China: financial incentives. National Renewable Energy Laboratory. Retrieved May 17, 2009 〈http://www.nrel.gov/docs/fy04osti/36045.pdf〉.

REN21, 2009. Recommendations for Improving the Effectiveness of Renewable Energy Policies in China. Retrieved November 12, 2009 〈http://www.ren21.net/news/news38.asp〉.

SERC, 2008. Audit Reports on Implementation of Policies Regarding Renewable Electricity Pricing and Sales. State Electricity Regulatory Committee. Retrieved August 8, 2009 〈http://www.serc.gov.cn/zwgk/jggg/200901/t20090120_10879.htm〉.

Shi, P., 2007. Statistics of China's Wind Electricity Capacity Installation in 2006. Retrieved September 5, 2009 〈http://www.cwea.org.cn/download/display_list.asp?cid=2〉.

Shi, P., 2008. Statistics of China's Wind Electricity Capacity Installation in 2007. Retrieved September 5, 2009 〈http://www.cwea.org.cn/upload/20080324.pdf〉.

Shi, P., 2009. Statistics of China's Wind Electricity Capacity Installation in 2008. Retrieved September 5, 2009 〈http:/www.cwea.org.cn/download/display_list.asp?cid=2〉.

Shiu, A., Lam, P.L., 2004. Electricity consumption and economic growth in China. Energy policy 32 (1), 47–54.

U.S. EIA, 2009. In: International Energy Outlook 2009. United States Energy Information Agency.

Wal-Mart China, 2009. Wal-Mart China corporate social responsibility. Retrieved August 8, 2009 〈http://www.wal-martchina.com/english/community/community.htm〉.
Wang, L., 2009. One third of wind generation capacity in China is disconnected from grid (in Chinese). China Power. Retrieved June 12, 2009 〈www.chinapower.com.cn/newsarticle/1094/new1094077.asp〉.
Wiser, R., Barbose, G., 2008. In: Renewable Portfolio Standards in the United States—A Status Report with Data Through 2007. Lawrence Berkeley National Laboratory.
Wiser, R., Namovicz, C., Gielecki, M., Smith, R., 2007. The Experience with Renewable Portfolio Standards in the United States. The Electricity Journal 20 (4), 8–20.
Wiser, R., Porter, K.F., Grace, R., 2005. Evaluating experience with renewable portfolio standards in the United States. Mitigation and Adaptation Strategies for Global Change 10, 237–263.
WWEA, 2009. World Wind Energy Report 2008. World Wind Energy Association. Retrieved August 8, 2009 〈http://www.wwindea.org/home/index.php?option=com_content&task=view&id=226&Itemid=43〉.
Yang, M., 2008. China's energy efficiency target 2010. Energy Policy 36, 561–570.
Yin, H., Powers, N., 2009. Do state renewable portfolio standards promote in-state renewable. Energy Policy, in press, doi:10.1016/j.enpol.2009.10.067.
Yuan, J.H., Kang, J.G., Zhao, C.H., Hu, Z.G., 2008. Energy consumption and economic growth: evidence from China at both aggregated and disaggregated levels. Energy Economics 30, 3077–3094.
Zhang, C., Shukla, P.R., Victor, D.G., Heller, T.C., Biswas, D., Nag, T., 2006. Baselines for carbon emissions in the Indian and Chinese power sectors: implications for international carbon trading. Energy Policy 34 (14), 1900–1917.
Zhang, P., Yang, Y., Shi, J., Zheng, Y., Wang, L., Li, X., 2009. Opportunities and challenges for renewable energy policy in China. Renewable & Sustainable Energy Reviews 13 (2), 439–449.
Zhao, X., Ma, C., Hong, D., 2009. Why did China's energy intensity increase during 1998–2006: decomposition and policy analysis. Energy Policy, in press, doi:10.1016/j.enpol.2009.11.019.