Some Recommendations for Improving Renewable Energy Policies in China*

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Renewable energy is the one of the most promising solutions for environmental protection and energy deficiency. Since 2005, the Chinese government has put forward a number of measures in promoting renewable energy. This paper presents those renewable energy policies in China and illustrates their achievements and limits. Comparing the renewable energy policies in Europe and US, feed-in-tariffs and quotas are two main measures that are adopted by western countries. A detailed performance review of feed-in-tariffs and quotas is examined by using effectiveness and efficiency as criteria. The enlightenments to improve renewable policies in China include strengthening compliance with quotas, developing priority dispatch and technical standards for interconnection, putting forward a more advanced feed-in-tariff system, and ultimately guaranteeing the electricity consumer's right of choice.

Keywords: feed-in-tariffs, renewable power quotas, priority dispatch, distributed generation

Introduction

Since 2006, China has experienced a rapid growth in its renewable energy resources, particularly wind power, placing it among the world's leading countries, in terms of renewable energy installation and generation. This growth was greatly enabled by the renewable energy policy framework created by its landmark *Renewable Energy Law*, passed in 2005 and amended in 2009, which established key policies including: national renewable energy targets; a mandatory connection and purchase policy; a national feed-in tariff (FIT) system; and arrangements for cost-sharing and funding of renewable energy incentives.

This paper describes the mechanisms established by the *Renewable Energy Law* and its implementing regulations, as well as the challenges China continues to face in improving its renewable energy policy framework to improve integration and utilization of renewable energy sources. It also provides a comparison of the Chinese renewable energy policy framework with those in the European Union (EU) and United States and examines the effectiveness and efficiency of FITs and quotas by using Europe as an example. Later, the paper provides recommendations for improving implementation of the *Renewable Energy Law*, with regard to implementing a renewable power quota system and priority dispatch policy, developing technical standards for

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connection of renewable resources with the grid, development of a more advanced FIT system, and central-local coordination of renewable energy development.

Renewable Energy Policies in China

Establishment of a National Level Renewable Energy Target

On February 28, 2005, the Standing Committee of the National People's Congress promulgated the *Renewable Energy Law*, which became effective on January 1, 2006 (National People's Congress, 2005). As stated in the law, the purpose of the *Renewable Energy Law* is to promote the development and utilization of renewable energy, increase energy supplies, improve the energy structure, guarantee energy security, protect the environment, and realize economically and socially sustainable development. The law stated that renewable energy development and utilization would be treated as a priority area for energy development and defined renewable energy to include wind, solar, hydro, biomass, geothermal, ocean, and other non-fossil energy. Subsequent regulations have clarified that biomass power includes agricultural and forest waste-generated power, as well as waste-to-energy power and sludge gas power projects (Ministry of Finance [MOF], National Development and Reform Commission [NDRC], & National Energy Agency, 2012).

In 2007, the State Council released the mid- and long-term development plan for renewable energy, which set targets for meeting 10% of China's primary energy consumption from renewable energy sources, including hydropower, wind, and solar by 2010 and 15% by 2020. The mid- and long-term development plan for renewable energy also sets specific installed capacity targets for 2010 and 2020 for various renewable power technologies, including hydropower, wind, and solar (see Table 1). The 2020 installed capacity target for wind power, 30 GW, was already met by 2010, highlighting the challenges in setting targets for rapidly expanding renewable technologies.

Table 1

Installed Capacity Targets for Renewable and Other Power in the 2007 Mid- and Long-term Development Plan for Renewable Energy

	2010 Targets	2020 Targets
Hydropower	190 GW	300 GW
Wind power	5 GW	30 GW
Solar electricity	300 MW	1.8 GW
Biomass power	4 GW	24 GW
Power from livestock and industrial methane	1 GW	3 GW
Waste-to-power	500 MW	3 GW

Source: NDRC (2008).

In 2008, NDRC released the renewable energy plan for the eleventh five-year period, which reiterated the target of reaching 10% of energy consumption from renewable sources by 2010, the final year of the *Eleventh Five-year Plan* (NDRC, 2008). The *Eleventh Five-year Renewable Energy Plan* also sets out target indicators for the installed capacity and generation to be met by various technologies, including hydro, wind, photo voltaic, and biomass power (NDRC, 2008).

Use of a Renewable Power Quota System to Address Challenges in the Implementing Renewable Power Targets

However, gaps in implementation and in the clarity of the targets remained, for example, by 2010, only

seven out of 14 power companies and two of the grid companies have met their 2010 targets of obtaining 3% of installed capacity and 1% of generation, respectively, from non-hydro renewables. The government has sought to address these challenges by setting out more specific generation-based renewable power quotas, akin to renewable portfolio standards (RPS), for grid companies, power generators, and provincial-level governments in draft *Regulations for Management of Renewable Power Quotas* issued by the National Energy Administration (NEA) on May 2, 2012.

The draft *Renewable Power Quota Regulations* has renewable power targets for 2015 for three types of entities:

(1) The largest 14 generators, which accounted for 66% of China's annual power generation (2786 TWh) and had 28 GW of renewable capacity installed in 2010, will be required to generate an average of 6.5% of their total electricity generation from non-hydro renewable sources by 2015. At the end of 2010, the 14 power companies generated an average of just 1.34% (37.3 TWh) of their power generation from renewables, so this will mean increasing generation from renewable sources to 276 TWh of their forecasted total 4,235 TWh total generation in 2015. Although the NEA has not defined a 2020 target, Bloomberg New Energy Finance has calculated that it could be as high as 10% based on an extrapolation of the current level of generation and the 2015 target;

(2) The four grid companies will be required to purchase a certain percentage of their total generation from non-hydro renewable generators in their area. The targets are 4.8% for State Grid, 3.2% for Southern Grid, 14.9% for Inner Mongolia Power Grid (covering Inner Mongolia West), and 9.9% for Shaanxi Provincial Power Grid (covering 30% of Shaanxi);

(3) All provinces and the four provincial-level municipalities will have their own non-hydro renewable electricity consumption targets in order to ensure that generators and grid companies in their jurisdictions implement the quotas. These targets are to be included in local government plans for energy development and power generation. There are four tiers of targets, ranging from a low of 1% of total energy consumption for Zhejiang, Hubei, Guangxi, Chongqing, and Hainan, to 15% of total energy consumption for Inner Mongolia West and East (wind resource rich provinces). The average renewable energy consumption target across all of the provinces is 5%.

The draft *Renewable Power Quota Regulations* requires generators and grid companies to meet their compliance targets in 2015 and 2020, not on an annual basis. However, they are required to report their progress in meeting these targets to the local branch of the NEA on a monthly basis. The local branch of the NEA reports progress in their jurisdiction to the NEA, which evaluates the progress of each generator, grid company and provincial/municipal government. After a six-month evaluation period, the NEA will publish a report on the performance in meeting the quota targets. No penalty for non-compliance has been set in the regulations, but progress in meeting the renewable power quota targets will be used by the central government in their performance evaluations of state-owned generators, grid companies, and provincial/municipal governments.

The Mandatory Connection and Purchase Policy

Article 14 of the original *Renewable Energy Law* required grid companies to connect and purchase all of the renewable power generated within their coverage area. This mandatory connection and purchase policy was a landmark provision, because it ensured that there would be a market for the electricity generated by

renewable sources and helped foster the clear long-term market demand that is needed for investment in large-scale energy infrastructure projects.

In 2007, the State Electricity Regulatory Commission (SERC) issued the *Measures on Grid Company Full Purchase of Electricity from Renewable Energy (Full Purchase Measures)*:

- require grid companies to promptly provide connection services to the renewable generator;
- establish a “priority dispatch” system, in which renewable generators are given priority in the electricity dispatching sequence to guarantee the requirements of the mandatory connection and purchase policy;
- allow the power dispatcher to manage the renewable power generator in cases where grid stability is threatened. If this occurs, the grid company must promptly notify the renewable generator in writing with an explanation and include an estimation of the non-purchased volume. The grid operator must also report the incident including the reasons for taking action and the corrective measures taken to SERC, which will supervise these measures;
- include a penalty provision in the event of grid company non-compliance with the mandatory connection and purchase policy.

Despite the provisions and the 2005 *Renewable Energy Law*, it became clear that grid companies were not complying fully with their obligations to connect and purchase all renewable power. However, there have been no reported cases of SERC exercising its discretion to impose penalties on grid companies for non-compliance, possibly because of a reluctance to enforce penalties in instances where the grid company did not purchase wind electricity, because of concerns over the possible destabilization that doing so could have on the grid.

Require Renewable Generators to Meet Technical Standards

The 2009 amendments sought to improve the implementation of the mandatory connection and purchase policy by balancing the responsibility that renewable power generators have to meet technical standards for on-grid electricity with the grid companies’ obligation to connect and purchase all renewable power. The original 2005 law simply required grid companies to purchase without condition all renewable power available for purchase; the 2009 amendments limit grid companies’ responsibility to purchase renewable power only from those renewable power generators that meet certain technical requirements for connection. By including technical standards for connection, the generators and the grid companies are now mutually responsible for ensuring grid stability. Article 11 of the *Renewable Energy Law* states that the State Council standardization body shall establish and issue renewable power grid connection technical standards and other national renewable energy technical product standards.

However, as the SERC noted in a 2011 report, wind power technical standards have been delayed, including national wind power grid connection technical standards and associated standards for collection, connection, and monitoring of wind power (SERC, 2011). The lack of these standards has threatened the safe operation of the grid. In particular, the 2011 SERC report examined the increasing number of major incidents of wind turbines suddenly and unexpectedly going off-line on the grid, causing grid disturbances, noting that there were 80 such incidents in 2010, rising to 193 in the first eight months of 2011 (54 of which involved 100-500 MW going off-line and 12 of which involved over 500 MW going off-line).

Priority Dispatch of Renewable Power

Article 14 of the 2009 *Renewable Energy Law* requires the NEA, SERC, and MOF to set priority dispatch regulations that will give priority to renewable power generators in the electricity dispatch sequence. This

meets the requirement in the 2007 *Full Purchase Measures* that electricity dispatchers give priority to renewable generators in accordance with the relevant national regulations regarding dispatch. Although national regulations regarding dispatch have not yet been issued, a trial “efficiency dispatch” policy was announced in late 2007 pursuant to the *Energy Conservation Law* (State Council, 2007a). Under this policy, the loading order of power-generating units was set based on the level of pollution emitted from the generating unit, with zero-emissions units being dispatched first and the highest emission units being dispatched last. The efficiency dispatch policy is an innovative policy that departs from the general practice in China and most of the rest of the world, in which the dispatch sequence is based on dispatching the units generating electricity at the lowest average cost first.

The trial efficiency dispatch policy started with five provincial pilot projects in Jiangsu, Henan, Sichuan, Guangdong, and Guizhou. These pilot projects were relatively successful and provided provincial and central government officials with priority dispatch experience, paving the way for its inclusion in the amendments to the *Renewable Energy Law*. In Guizhou, for example, a total of 1.35 million tons of standard coal equivalent were saved from January 2008 to September 2008, as a result of the trial dispatch policy (International Energy Network, 2008). Nevertheless, a number of technical and financial issues still exist, for example, one problem is that combined heat and power (CHP) coal-fired power plants are the primary source of heating used in Northern China during the winter months and are considered “must-dispatch” resources to provide heating to citizens. Thus, in practice, CHP power plants are given priority in the dispatch sequence, although wind and other renewable resources would otherwise be given that priority because of their lower emissions. Coal-fired power and hydropower are limited in their ability to match the variable generation patterns of renewable power. Increasing the dispatch of renewable power sources will require the construction of more flexible and active generation sources that can be quickly increased or slowed down to meet peak load or frequency needs, such as natural gas power plants or pumped hydro-electricity storage systems.

FITs and Cost Sharing Measures

FITs guarantee a price that the grid company will pay to the renewable generator, in order to ensure that developers of more expensive renewable generation sources can recover their costs and earn an appropriate profit. Concession programs provide the government with valuable experience in setting an appropriate FIT that is neither too high and thus an inefficient use of public funds, nor too low and thus insufficient to create adequate incentives for investments in renewable technologies. Once a FIT has been set, any further projects permitted through concession bidding cannot exceed the national FIT. The additional cost of the FIT over and above the price of conventional coal-fired power is paid with funds collected through a national electricity surcharge for renewable energy.

In 2006, the NDRC issued the *Interim Measures on Renewable Energy Electricity Prices and Cost Sharing Management (Cost Sharing Measures)*, which directed NDRC’s pricing department to set a nationwide renewable surcharge levied on electricity users at a uniform rate based on the users’ consumption of electricity (NDRC, 2006). The surcharge was set at an initial rate of 0.001 RMB /kWh in May 2006, but with the increase in wind, solar, and biomass power projects and the associated costs of FIT subsidies, the surcharge has had to be increased to 0.002 RMB/kWh for industrial/commercial customers in July 2008 (staying at 0.004 RMB/kWh for residential customers), 0.004RMB/kWh for industrial/commercial customers in November 2009, and most recently, 0.008 RMB for both industrial/commercial and residential customers in December 2011.

Renewable Energy Development Fund

Under the 2009 amendments, the new renewable energy development fund includes both the renewable energy surcharges collected from grid companies and it specified in the original *Renewable Energy Law*, which is funded through central government budget allocations and supports the following activities:

- (1) science and technology research, standard setting and demonstration projects supporting renewables development;
- (2) renewable energy programs for use in agricultural and herding areas;
- (3) construction of independent renewable electricity systems in remote areas and islands;
- (4) renewable energy resource exploration, evaluation, and related information systems;
- (5) promoting the localization of manufacturing for renewable energy equipment (MOF & Finance and Construction Department, 2006).

Projects seeking funding for research and development are required to apply through the national “863” and “973” high-technology development research programs under the Ministry of Science and Technology, which have a long history of funding advanced scientific research in a variety of areas (Osnos, 2009).

In July 2010, MOF appropriated special funds of 200,000,000 CNY to foster the development of ocean energy development for the first time. The funds were issued by the State Oceanic Administration (SOA) to several large scale projects led by some large state-owned enterprise such as CNOOC, Huaneng, Datang, Longyuan, etc. and dozens of research projects in ocean renewable energy development. Participation of enterprises is considered the most significant step to the road of commercialization of ocean renewable energy. This event is considered to be a milestone for China’s ocean energy development and the funds will be evaluated every year thereafter.

Challenges China Continues to Face in Improving its Renewable Energy Policy Framework

Integration Problem of Renewable Power Into the Grid

About 25% to 30% of China’s erected wind turbines are not connected to the grid at any one time, although most eventually will be connected. The lower performance of Chinese wind farms is the reflection of a number of challenges that renewables development has faced in China in recent years, including:

- long delays in connecting wind farms to the grid, due to a lack of coordination between wind farm and grid development planning, as well as a lack of incentives for grid companies to connect to renewables generators;
- lower conversion efficiency of domestic turbines compared to international manufacturers;
- poor integration of wind farms with the grid and grid company curtailment of wind-generated electricity, due to concerns that wind-generated electricity might destabilize the grid.

Low Operating Efficiency

Wind power doubled in capacity each year during the four year period from 2006 to 2009, and wind has grown from a mere 1.3 GW at the end of 2005 to 62.4 GW (grid and non-grid connected turbines) by the end of 2011, which helps China to surpass the US as the country with the most installed wind capacity in the world. However, China’s rapid growth in wind power has been accompanied by significant growing pains, which have exposed areas in which the renewable policy framework can be improved, for example, although China’s installed wind capacity has grown at a rapid rate, the actual amount of electricity generated from the installed

wind turbines has been less impressive. Both China and the US had about 47 GW of grid-connected wind power at the end of 2011, but the US generated 120 terawatt hours (TWh) from its 47 GW of wind farms, while China generated only 74 TWh with the same grid-connected capacity. The difference in performance between US and Chinese wind farms was reflected in the differences between the average capacity factors of US and Chinese wind farms, with US wind farms achieving a 29% capacity factor and Chinese wind farms reaching just 22% in 2011 (Romankiewicz, 2012).

Weakness and Incompleteness in Incentive System

When it comes to China's subsidy to renewable energy investment projects, small scope and little amount are the very foremost problems. Except the project of Delivering Power to Village, most subsidies are symbolic and are less than 10% of the total investment; besides, these subsidies tend to be jammed in their transmission to the lower level of units, making it difficult to reach the lower level of units smoothly. China's force in supporting renewable energy through taxation methods is fairly weak the actual taxation of most renewable energy projects is quite close to that of conventional energy, some even higher than that of conventional energy. This could not present the favorable conditions and policies for renewable energy.

Even as the surcharge rose from 0.001/kW in 2006 to 0.008/kW in 2011, there was a short fall of RMB 1.4 billion in 2010 and RMB 22 billion in 2011. Even with the most recent 0.008 RMB rate, an analysis of the forecasted wind, biomass power, and solar PV FIT payments through 2020 has found that accumulative RMB 710 billion of renewables subsidies will be required from 2011 to 2020 at current subsidy levels, and that the RMB 0.008/kWh surcharge is not sufficient to cover these costs. This suggests that the government will need to raise the surcharge (e.g., to 0.01 RMB/kWh in 2013) or reduce the level of the FITs for certain technologies.

Inadequate Investment in the Technical Research and Development for Renewable Energy

Renewable energy is a technology-intensive and fund-intensive industry. Currently, China has ranked top in terms of investment on renewable energy; the investment reached 0.6 bn USD in 2005, but very small proportion were applied in technical research and development. As statistics shows, China's investment on the research and development of renewable energy took up only 0.045% of the total GDP (gross domestic product), while EU member countries' investment accounted for 2% of the GDP, which is about 44 times higher than that of China. China's technical research and development in renewable energy lack adequate investment, leading to the fact the some advanced techniques and equipment depend much upon importation, for instance, 70% of the wind energy power generation machinery group came from importation in 2005, which is the most important reason why the cost remained high; spathic-silicon materials and raw materials for photovoltaic cell must depend upon importation, leaving the industrial development at a slow pace and its future not so promising.

Comparisons With the EU and US Renewable Energy Policy Frameworks

EU's Renewable Energy Legal and Policy Framework

Based on the roadmap and a public consultation, the EU in 2009 adopted a new comprehensive renewable energy directive (the 2009 renewable energy directive), covering renewable energy in the electricity, transportation, and heating and cooling sectors, and setting mandatory targets for EU member states based on the overall targets of obtaining 20% of gross final energy consumption from renewables and 10% of transportation fuels from renewable fuels by 2020 (European Parliament and European Council, 2009). The

directive requires member states to implement measures to support the development of renewable energy to meet their renewable energy targets. The 20% renewables target is a part of a larger “20 to 20 to 20” energy and climate package adopted by the European Commission in December 2008 which aims to reduce EU greenhouse gas emissions by 20% from 1990 levels, increase renewables to 20% of final energy consumption, and reduce primary energy consumption by 20% of projected 2020 levels through energy efficiency, all by 2020 (European Commission, 2010).

In allocating the 20% mandatory renewable energy target to individual EU member states, the 2009 renewable energy directive notes that the starting point, the renewable energy potential, and the energy mix of each member state vary, and that it is thus appropriate to share the required total increase in the use of energy from renewable sources on the basis of an equal increase in each member state’s share weighted by their GDP, modulated to reflect their starting points, and by accounting in terms of gross final consumption of energy, with account being taken of member states’ past efforts with regard to the use of energy from renewable sources. The targets set for each of the 27 member states range from 10% (Malta) to 49% (Sweden)

With regard to grid connection, the 2009 renewable energy directive states that, subject to requirements relating to maintaining the reliability and safety of the grid, member states shall provide renewable energy sources with priority or guaranteed access to the grid and also provide them with priority dispatch. Member states are to take measures to minimize the curtailment of renewable electricity generators; if significant measures are taken to curtail renewable generators in order to protect the security of the system, member states are to ensure that the responsible system operators report the curtailment measures to the relevant competent authority and the corrective measures they intend to take to prevent inappropriate curtailments.

In Germany, the *Renewable Energy Sources Act* (Erneuerbare Energien Gesetz or EEG) provides for differential FITs based on the cost of generation of various renewable energy sources (solar, offshore and onshore wind, geothermal, hydro, biomass and landfill gas, sewage gas, and mine gas (Retrieved from www.erneuerbare-energien.de/files/pdfs/allgemein/application/pdf/eeg_2009_en.pdf). The level of FIT payments are also differentiated by project size, with lower payments made to larger projects to account for their greater profitability, due to economies of scale and to encourage smaller distributed generation as well as larger utility-scale projects. The German system also provides for tariff degression in most cases, whereby the amount of the FIT available for a particular renewable energy source is lowered over time based on expected cost reductions in the technology; FITs for rapidly developing technologies, such as solar and offshore wind, have a greater decreasing rate, since their costs are expected to drop more quickly than more mature renewable technologies such as wind and hydro (Couture, Cory, & Williams, 2010).

United States’ Renewable Energy Legal and Policy Framework

Compared to the EU and China, the United States presently has relatively less national guidance and policy support to promote the deployment of renewable energy, with no mandatory national targets for renewable energy and no national FITs or renewable energy standards (RES), although national RES legislation has been proposed in congress several times in the last decade.

Instead, at the federal level, the primary means for promoting the deployment of renewable energy has been through federal production and ITC, and more recently under the *American Recovery and Reinvestment Act*, through a direct cash grant program known as the “1603 Treasury Grant” program. The Production Tax Credit (PTC) program was first established under the *Energy Policy Act* of 1992 and in 2010 provided

qualifying renewable energy project owners with a tax credit of \$22 per MWh of electricity generated for wind, closed-loop biomass, and geothermal, or \$11 per MWh for open-loop biomass, qualified hydroelectric, landfill gas, municipal solid waste, marine, and hydrokinetic power. The incentive is production-based, such that the more electricity that is generated, the greater the tax credit gained. The PTC generally lasts for a period of 10 years, with the value of the tax credit provided rising for inflation (Bolinger, Wiser, Cory, & James, 2009). The investment tax credit (ITC), created in the *Energy Policy Act* of 2005, reduces federal income taxes for qualified renewable energy project owners based on the capital investment value of the project, and in 2010 provided a 30% tax credit for solar, small wind, and fuel cells, and 10% for geothermal, CHP, and micro turbines, subject to certain maximum incentives.

With the economic downturn in 2008, banks which had previously used their investments in renewables projects to take advantage of the PTC found their future profitability uncertain, making investments using the PTC less attractive and leading to a sharp downturn in the availability of tax equity capital. In order to avoid a sudden downturn in investments in renewable energy, the *American Recovery and Reinvestment Act* of 2009 created a new “1603 Treasury Grant” program, providing qualified project developers with cash grants equivalent to 30% of the capital expenditure of a project in lieu of production or ITC. The first cash grants were issued in September 2009 and the program has managed to provide an incentive for project investors sufficient to avoid a serious reduction in renewable energy investment. The “1603 Treasury Grant” was extended in December 2010 for an additional year.

As a result of the relative lack of a consistent renewable energy policy framework at the federal level, much of the policy support for renewable energy in the United States has taken place at the state level, through RPS and, to a lesser extent and more recently, state FITs. As of May 2010, 29 states plus the District of Columbia have established RPS, which set a mandatory target for a utility to obtain a certain percentage of its retail electricity sales (or generating capacity) from renewable energy sources or purchasing renewable energy credits. In addition, six states have non-binding renewable energy goals (Database of State Incentives for Renewables & Efficiency, 2010). California has been one of the most ambitious RES in the nation: Investor owned utilities are required to reach an additional 1% of retail sales per year from renewable sources, with a target of 20% by 2010, and all utilities are required to achieve 33% of their electricity from renewables by 2020 (Retrieved from www.lw.com/Resources.aspx?page=FirmPublicationDetail&publication=3769).

Effectiveness and Efficiency of FITs and Quotas in the Europe

FITs are generation-based and price-driven incentives. The price per unit of electricity that a utility, supplier, or grid operator is legally obligated to pay for electricity from renewable energy sources in the electricity (RES-E) producers is determined by the system. Thus, a federal (or provincial) government regulates the tariff rate. It usually takes the form of either a fixed amount of money paid for RES-E production, or an additional premium on top of the electricity market price paid to RES-E producers. Besides the level of the tariff, its guaranteed duration represents an important parameter for an appraisal of the actual financial incentive. FITs allow technology-specific promotion as well as an acknowledgement of future cost-reductions by applying dynamic decreasing tariffs.

Figure 1 gives an overview on the economic level of FITs for electricity from onshore wind between 2003 and 2005. It can be seen at a glance that the range is rather broad. In 2005, it varied between about 60 and 90 EUR/MWh which is mainly due to differences in wind conditions in different countries.

Figure 1. Example: Level of fixed FITs for electricity from wind onshore in some European countries. Source: Held, Haas, and Ragwitz (2006).

Quota obligations based on tradable green certificates (TGCs) are generation-based and quantity-driven instruments. The government defines targets for RES-E deployment and obliges a particular party of the electricity supply-chain (e.g. generator, wholesaler, and consumer) with their fulfillment. Once defined, a parallel market for renewable energy certificates is established and their price is set following demand and supply conditions (forced by the obligation). Hence, for RES-E producers, financial support may arise from selling certificates in addition to the revenues from selling electricity on the power market. With respect to technology-specific promotion in TGC systems, this is also possible in principle.

Quota-based systems are now in place in six EU countries, in the U.S. as RPS in about 20 states (and the District of Columbia) and also in Japan. Figure 2 gives a comparative overview on the prices of TGC in the last years. The most important perception is that with the exception of UK, no recognizable decrease took place.

Figure 2. Comparison of premium support level: Value of TGCs. Source: Ragwitz et al. (2007).

Reviewing the two renewable policies described above, the core question is whether these policies have been successful or not. To assess the success, the most important criteria are:

- effectiveness: Did the policies lead to a significant increase in deployment of capacities from renewable energy resources in the electricity (RES-E) in relation to the additional potential? The effectiveness indicator measures the relation of the new generated electricity within a certain time period compared to the corresponding potential of the technologies;
- economic efficiency: What was the absolute support level compared to the actual generation costs of RES-E generators and what was the trend in support over time? How is the net support level of RES-E generation consistent with the corresponding effectiveness indicator?

Effectiveness of Policy Instruments

Firstly, the effectiveness of policy instruments is analyzed by looking at the quantities installed. Figure 3 depicts the policy effectiveness for electricity generation from all “new” RES from 1998 to 2005 measured in the incremental amount of RES-E per year and capita. Clearly, it was highest in Denmark with about twice as high renewable electricity deployed than the next ranked countries Finland, Sweden, Spain, and Germany. It should be noticed, however, that since 2003, the net increase in wind power capacity has been close to zero in Denmark. It is of interest that among these countries, quite different promotion schemes exist: a quota-based TGC system in Sweden, investment incentives in Finland, and FITs in the other countries.

Figure 3. Policy effectiveness of support measures for electricity from “new” RES (excl. hydro) measured in additional kWh per year and capita for the period from 1998 to 2005 in the EU. Sources: Harmelink, Voogt, and Cremer (2006).

It is clearly noted that countries with FITs as support scheme achieved higher effectiveness compared to countries with a quota/TGC system or other incentives. Denmark achieved the highest effectiveness among all member states, but again it has to be mentioned that hardly any new generation plants have been installed in recent years, whereas the opposite happened in Germany and Portugal, with a strong increase in the recent past.

Among the new member states, Hungary and Poland have implemented the most efficient strategies in order to promote “new” renewable energy sources. Since Figure 4 depicts the effectiveness indicator for the total renewable electricity, the following figures demonstrate the effectiveness by technology.

Figure 4. Policy effectiveness of total RES-E support for the period from 1998 to 2005 measured in yearly additional electricity generation in comparison to the remaining additional available potential for each EU-27 member state. Sources: Harmelink et al. (2006).

Economic Efficiency

In this context, three aspects are of interest: absolute support levels, total costs to society, and dynamics of the technology. As an indicator in the following, the support levels are compared for wind power in the EU-27 specifically.

Figure 5 shows that the support level and the generation costs are mostly very close. Countries with rather high average generation costs frequently show a higher support level. A clear deviation from this rule can be found in the three quota systems in Belgium, Italy, and the UK, for which the support is presently significantly higher than the generation costs. The reasons for the higher support level expressed by the current green certificate prices may differ. Main reasons are risk premiums, immature TGC markets, and too short validity times of certificates (Italy and Belgium). For Finland, the level of support for wind onshore is too low to initiate any steady growth in capacity.

Figure 6 and 7 illustrate a comparatively overview of the ranges of TGC prices and premium FITs in selected EU-27 countries. With the exception of Sweden, the TGC prices are much higher than the premium received by the investors, if guaranteed FITs are eligible, explaining also the high level of support in these countries as it is demonstrated in Figure 6. Additionally, a trend towards more efficient designs in FITs in the recent past becomes obvious. However, this trend has not yet been noticed in quota markets based on TGCs.

Figure 5. Wind onshore: Support level ranges (average to maximum support) in EU countries in 2006 (average tariffs are indicative) compared to the long-term marginal generation costs (minimum to average costs)—Support level is normalized to 15 years. Source: Ragwitz et al. (2007).

Figure 6. Comparison of premium support level: FIT-premium support. Source: Van Der Linden et al. (2006).

Figure 7. Comparison of premium support level Value of TGCs. Source: van der Linden et al. (2006).

Comparison of Effectiveness and Financial Indicators

It is often argued that the reason for higher capacities installed is a higher support level. Although it should be noted that the resource endowments of RES vary depending on each country, as can be seen from Figure 7, actually the opposite is true. The countries with highest support levels—Belgium and Italy—are among those with the lowest specific deployment. Meanwhile, high FITs especially in Germany are often named as the main driver for investments especially in wind energy. However, the support level in Spain and Germany is not particularly high compared with other countries analysed here.

Figure 8 compares the effectiveness indicator, defined as new generated electricity within one year to the additional potential of RES-E, to the net support level of total RES-E technologies, excluding hydro plants between 2005 and 2006. Notable are that higher efficient countries as Austria, Germany, Portugal, or Spain have introduced FITs, whereas countries with less effectiveness and high support, as Italy, Belgium, and UK operate a quota system.

Figure 8. Effectiveness vs. net costs of promotion programs for electricity from RES in EU-27 countries (2005–2006). Source: Ragwitz et al. (2007).

As a general conclusion, it can be stated that the investigated feed-in systems are effective at a relatively low producer profit. In contrast, it can be observed that the present quota systems only achieve rather low effectiveness at comparably high profit margins. It is important to know that these quota systems are relatively new instruments in all the countries currently using them. Therefore, the observed behavior might still be characterised by significant transient effects.

Recommendations for Enforcement of the Renewable Energy Law

Implementation of the Renewable Power Quota System

Interactions between the renewable power quotas and FITs. Given that the quotas will be implemented in a policy framework which already uses FITs to promote the development of renewable power sources, Chinese policymakers will need to consider how the new renewable power quotas will interact with the FIT system. Although countries around the world have tended to rely on one or the other policy to incentivize

renewables growth, i.e., either requiring utilities to meet a quantitative target for renewables as a share of total energy or electricity consumption or guaranteeing a price for electricity from renewable, the policies can complement and support each other (Cory, Couture, & Kreycik, 2009; Azuela & Barroso, 2011), for example, the level at which China's various FITs are set may incentivize some forms of renewables development over others; developers, for example, based on the higher value of the FIT and other reasons, may prefer to develop solar PV over biomass power. This may affect the costs for the government in paying for FIT payments as developers, grid companies, and provinces seek to meet their renewable power quotas.

Tracking compliance with the renewable power quotas and piloting REC trading programs. The draft *Renewable Power Quota Regulations* does not provide for trading of renewable energy certificates. This makes sense, given that China will need to gain experience with tracking progress in meeting the quotas by generators, grid companies, and provincial-level governments. The draft requires generators and grid companies to report their progress on a monthly basis and requires the NEA to publish a report on the performance in meeting the quota targets. To ensure timely and accurate filing, the NEA's report should be made public and that generators, grid companies, and provincial-level governments will be subject to substantial penalties for submitting false or misleading information. Cross-checking the data submitted by each of the entities within a jurisdiction will also help to ensure the integrity of generation data for both the renewable power quota system and the FIT payments system.

In the future, a REC trading system could allow grid companies and generators to trade renewable energy credits depending on the excess or shortfall in meeting their quotas. A trading mechanism could increase economic efficiency in meeting renewable generation targets by increasing the flexibility of grid companies and generators to meet their targets. It would allow grid companies and generators in areas with less renewable resources, such as Beijing and Shanghai, to meet their target obligations by purchasing RECs from areas with rich renewable resources, such as Inner Mongolia. However, an adequate legal and regulatory infrastructure must be in place and reliable generation data must be available for such a trading scheme to be successful and to prevent gaming of the system. While it may be premature to institute a nationwide REC trading scheme in the near-term, a pilot trading scheme could be developed to help lay the groundwork for implementing a national trading system in the mid to long term.

Strengthening compliance with the quotas through sufficiently strong penalties. The draft *Renewable Power Quota Regulations* does not specify a penalty for non-compliance in meeting renewable power quotas, but progress in meeting the renewable power quota targets will be used by the central government in their performance evaluations of state-owned generators, grid companies, and provincial/municipal governments. Performance evaluations of government officials—which determine whether officials are rewarded or penalized, based on their performance in meeting economic, social, and environmental targets—have proven to be one of the most effective tools for implementing China's centrally determined targets at the provincial and local level. Beginning in the *Eleventh Five-year Plan*, the target responsibility and evaluation system has been used to effectively motivate government officials and state-owned enterprises to meet the energy intensity and pollution reduction targets assigned to them (State Council, 2007b). This system will be helpful in motivating generators, grid companies, and provincial officials to meet their renewable power quota targets. However, the target responsibility and evaluation system alone may not be sufficient to ensure compliance with the renewable power quotas.

Priority Dispatch, Defining Conditions for Permissible Curtailment, and Development of Technical Standards

Grid operation issues raised by priority dispatch. China has experimented with priority dispatch in five provinces since 2007. The implementation of priority dispatch can be technically difficult, because of the general non-storability of electricity and the intermittent nature of renewable energy resources. Since electricity generated by a wind farm typically cannot be stored for future use, it must be dispatched entirely at the moment it is produced, even if this occurs during a period of low demand. The dispatcher must meet energy demand with a sufficient amount of energy supply even as demand fluctuates throughout a single day. If, for example, a wind farm is the first power generator in the dispatch sequence, the dispatcher will need to know the exact amount of wind power being produced as soon as possible in order to successfully match power supply and demand; otherwise, priority dispatch could lead to power outages and compromise the stability of the entire grid network.

Defining permissible curtailment conditions and appropriate compensation to generators. Germany's priority dispatch experience could be useful for China in considering how to set its own policy. Under the 2008 amendments to the *German Renewable Energy Sources Act*, grid system operators must immediately and as a priority purchase, transmit and distribute the entire available quantity of electricity from renewable energy sources (Retrieved from www.erneuerbare-energien.de/files/pdfs/allgemein/application/pdf/eeg_2009_en.pdf). However, as a result of these amendments, the priority connection and purchase system was changed from an unconditional system to a conditional one, in which there are exceptions in certain defined circumstances by which the grid is permitted to take technical control over installations connected to the grid. As a result of these changes, grid companies are now permitted to force the curtailment of power generated from renewable facilities with a capacity of over 100 kW, if all of the following conditions are met:

- (1) The grid would otherwise be overloaded, if curtailment were not to take place;
- (2) The grid has ensured that the largest possible quantity of electricity from renewable sources and CHP is already being purchased;
- (3) The grid has reported the current situation to the relevant region of the grid system.

Notably, the German law includes a hardship clause which states that even if the grid is permitted to curtail generation in situations that meet the above three requirements, the grid is still required to compensate the renewable generator for the curtailment, on the basis of either a negotiated price or, in the event an agreement cannot be reached, the FIT price minus the expenses saved by the generator as a result of the curtailment.

Developing technical standards for interconnection. Developing compulsory national standards for wind, solar, and other renewable interconnection can help improve grid stability as well as promote the development of renewable technologies. The development of national grid codes in the United States has helped to advance wind turbine technologies that ultimately make it easier to integrate wind projects into the grid (Federal Energy Regulatory Commission, 2005). Although grid standards around the world vary in many respects, there are certain common features of successful grid standards for wind power in the United States and Europe. In addition to low voltage ride through (LVRT) capability, which is mandatory in China at the end of 2011, other grid codes around the world require that wind turbines have certain technical capabilities to maximize grid stability, such as the capability to (1) maintain a particular power factor and (2) remote supervisory control and data acquisition (SCADA) capability.

Developing a More Advanced FIT System and Distributed Generation Policies

Besides using FITs to support renewables development, China should consider developing more advanced FIT schedules, for example, China could consider including tariff degression in its FIT schedules for various technologies, similar to Germany, based on the best available estimate of the declining costs of renewable technologies. Current FIT schedules do not provide any detail on how the on-grid price may be adjusted in the future: China's solar photovoltaic FIT set in July 2011, for example, simply states that the government will adjust the tariff in the future based on changes in investment capital and technological improvements. Providing a tariff degression schedule would provide generators, grid companies, and manufacturers with a better idea of future subsidy support and allow them to better plan for future renewables development. It would also help the government to control the costs associated with FIT subsidies for renewable power development. China could also consider setting a reasonable cap on the total payments made for FITs for particular technologies on an annual basis, in order to avoid overly rapid development and promote a more sustainable development model. This could help China to avoid the recent boom-bust growth patterns seen in some EU countries, which provided generous FITs for solar photovoltaic, but then greatly reduced the subsidies following the economic downturn.

China could also differentiate FIT payments based on project size, with higher payments made to smaller projects to encourage the development of distributed generation. China is in fact developing draft distributed generation regulations, which could expand the use of renewable technologies, particularly solar photovoltaic, in cities, including industrial, commercial, and residential rooftop appliances. The draft distributed generation regulations foresee the implementation of net metering as well as FIT and installation incentives for distributed generation sources. Developing distributed renewable electricity sources would help to complement China's focus on larger, utility scale renewables projects, and could reduce the need to build transmission capacity from China's wind and solar resource rich western areas to its eastern electricity demand centers by developing models favoring localized production and consumption of renewable electricity.

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.

Currently, consumers' green purchasing power has not been effectively tapped in China. The *Renewable Energy Law* 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. The mandatory green power option has proven to be a powerful tool for encouraging renewable development. 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, the purchasing power of millions of green consumers would create additional market incentives and pressure for electricity companies to development renewable energy.

Conclusions

China has achieved remarkable improvement for its renewable energy resources, since it firstly enacted *Renewable Energy Law* in 2005. About seven relevant policies have been put forward, which include

feed-in-tariffs, quotas, priority dispatch, technical standards, mandatory connection and purchase, and etc.. However, the government also faces a few challenges such as the integration problem of renewable power into the grid, and low operating efficiency during implementation. The motivation of this paper is to provide insightful recommendations for improving the current renewable energy policies in China. By comparing renewable energy policy frameworks in the EU and United States, feed-in-tariffs and quotas are two main measures that are adopted by western countries. After a detailed performance review of those two policies in effectiveness and efficiency, the significance of policy interactions between feed-in-tariffs and quotas is straightforward. More specifically, the government is advised to strengthen compliance with quotas and pilot renewable energy certificates, develop priority dispatch and technical standards for interconnection, put forward a more advanced feed-in-tariff system and distributed generation policy, and ultimately guarantee the electricity consumer's right of choice.

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