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# Review of wind power tariff policies in China

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## HIGHLIGHTS

- Key components to exam China's wind power.
- Evaluation of Europe could be helpful.
- China has to remove institutional barrier.

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## ABSTRACT

In the past 20 years, China has paid significant attention to wind power. Onshore wind power in China has experienced tremendous growth since 2005, and offshore wind power development has been on-going since 2009. In 2010, with a total installed wind power capacity of 41.8 GW, China surpassed the U.S. as the country with the biggest wind power capacity in the world. By comparing the wind power situations of three typical countries, Germany, Spain, and Denmark, this paper provides a comprehensive evaluation and insights into the prospects of China's wind power development. The analysis is carried out in four aspects including technology, wind resources, administration and time/space frame. We conclude that both German and Spanish have been growing rapidly in onshore capacity since policy improvements were made. In Denmark, large financial subsidies flow to foreign markets with power exports, creating inverse cost-benefit ratios. Incentives are in place for German and Danish offshore wind power, while China will have to remove institutional barriers to enable a leap in wind power development. In China, cross-subsidies are provided from thermal power (coal-fired power generation) in order to limit thermal power while encouraging wind power. However, the mass installation of wind power capacity completely relies on power subsidies. Furthermore, our study illustrates that capacity growth should not be the only consideration for wind power development. It is more important to do a comprehensive evaluation of multi-sectorial efforts in order to achieve long-term development.



## 1. Introduction

In consideration of China's rapid economic growth and its $CO_2$ emission reduction goals for 2020, it is urgent to raise the share of renewable energy (i.e., make the transition from thermal power to clean energy). For instance, China's wind power capacity increased from 4,200 kW in 1980 to 41.8 GW in 2010. China surpassed Germany and Spain in 2009, and then surpassed the 40.2 GW capacity of the U.S. in 2010 to be ranked number one in the world in total wind power capacity. As shown in Fig. 1, the annual rate of capacity increase from 2000 to 2010 was around 50%. China will have 150–230 GW of installed wind power capacity by 2020 (Global Wind Energy Council (GWEC), 2009).

This paper aims to investigate whether existing supportive policies are optimal for assisting China's wind power capacity growth, which is a popular topic that receives high attention from worldwide researchers. Most voices nowadays encourage China to increase wind capacity from different aspects, for instance, Li, H. Guo, S. and Wang, B. have pointed out the importance of on-shore wind power technical innovations in terms of accelerating capacity growth, whereas He, J., Zhao, X., and Yang, S. raised their supportive recommendations of developing off-shore wind farms. The argument of this paper is that capacity growth should not be the only objective of China's wind power development at this stage, since neither policy schemes nor technology are completely built to fit in China's scenario. The focus of this paper is on policy scheme development in terms of tariff instruments, specifically,

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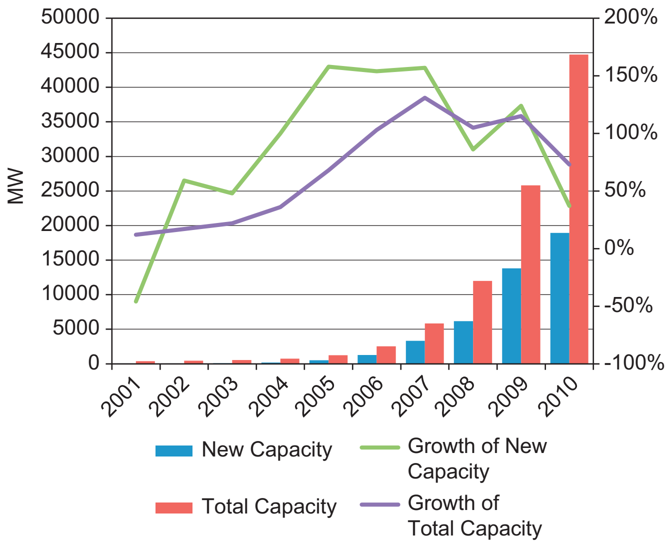


**Fig. 1.** China's wind capacity growth from 2000 to 2010.
*Source*: China wind power outlook 2010 (2011).

feed-in tariffs, which are charges paid by a power transmission company to a power generation company. The paper will evaluate the advantages and disadvantages of China's current feed-in tariffs on wind power and investigate the extent to which the feed-in tariff policy has facilitated the sector's sustainable growth. International experience with onshore and offshore wind power will be useful in answering these questions. Section 2 of this paper reviews the literature pertinent to the earliest-adopting countries, which started wind power development in Europe in the 1980s. The methodology described in Section 3 includes both conceptual and analytical frameworks. Section 4 evaluates China's wind power sector, and conclusions and policy recommendations are provided in Section 5.

## 2. Experiences with feed-in tariffs in Europe and China

Modern systems for wind power utilization were introduced to the world approximately 30 years ago. Since then, tariff-based stimulating policies have played a significant role in accelerating the development of wind power. Both Europe and the U.S. have received substantial recognition for wind power development; however, because each individual state in the U.S. has its own regulations, this paper considers only European cases as reference points. In China, unlike Europe, government intervention plays a large role in promoting wind power development.

### *2.1. Onshore wind power*

In this section, we shall focus on Germany, Spain and Denmark, all of which started developing wind power in the 1990s and introduced policy reforms around 2000. With the support of improved wind policies, Germany and Spain have achieved favourable environments for wind power development. Denmark, on the other hand, experienced a large decrease in development because of ineffective financial incentives.

#### *2.1.1. Germany*

In 2011, Germany had 27.214 GW of wind capacity, which was the largest in Europe, represented 14% of global capacity (GWEC, 2011). Wind power promises to provide 30% of Germany's renewable energy supply in 2020, and 60% in 2050. Moreover, wind power is expected to produce 30–40% of the total electricity supply in 2050. A feed-in tariff, called the Electricity Feed Law, was introduced in Germany in 1991. It was replaced by the Renewable Energy Sources Act ("EEG" in German) in 2000. The initial Electricity Feed Law was essentially a test of a feed-in tariff, since Germany was among the first countries to connect wind energy into the electric grid. The purpose at that time was to stimulate further development of the wind industry. The EEG, which was applied to the wind power market when the stimulation strategy was more mature, mainly considered wind resources and technology as the two determinants of tariffs. In term of grid connections, power from renewable resources had priority over power from traditional resources.

The 2000 EEG introduced a fixed tariff, effective for a period of between five and 20 years. After that period, it could be reduced to a basic level. The year limit depended on local wind resources. In areas with good wind conditions, wind farms would receive the initial fixed tariff for fewer years. For areas with less wind resource, wind farms could receive the fixed tariff for longer periods. To increase turbine installation efficiency, the EEG cancelled compensation for locations with a yield of less than 60% of the reference wind resource (GWEC, 2009).

As shown in Fig. 2, wind power development remained at a very low level in the 1990s and then increased steadily after 2000. Policy incentives played a large role in this process. Instead of simply enabling development of wind farms to meet the 2020 and 2050 targets, the EEG maximized the advantages of wind farm locations and resource availability. It set the "reference yield" as a benchmark to determine the period of the initial tariff before the transition to more beneficial rates, based on the level of wind resource.

Both fixed and basic tariffs have annual reduction rates. Driven by technology improvements, the tariff for a wind project developed in the year following the introduction of a new feed-in rate could be reduced by a certain percentage (GWEC, 2009: *p.* 11). Advances in wind power technologies bring down the investment cost and, accordingly, the tariff rate decreases year after year. However, since the tariff is determined by both technology and wind resources, it can increase again if the wind resources of a particular year are poor. For example, the 2009 tariff went up because of the lack of wind resources that year.

#### *2.1.2. Spain*

In the 1990s, Spanish wind power development was targeted for improvement. A new policy mechanism was implemented in 1997, and growth in power generation capacity mainly occurred after 2000. Fig. 3 shows the growth trend of Spanish onshore

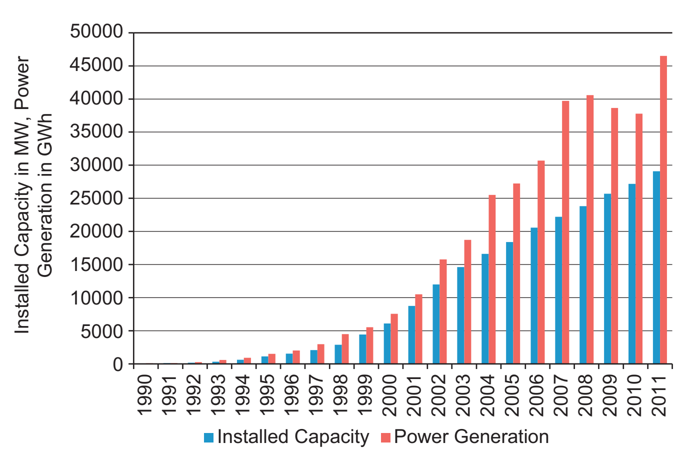


**Fig. 2.** Wind power capacity growth in Germany from 1990 to 2011.
*Source*: Böhme (2012).

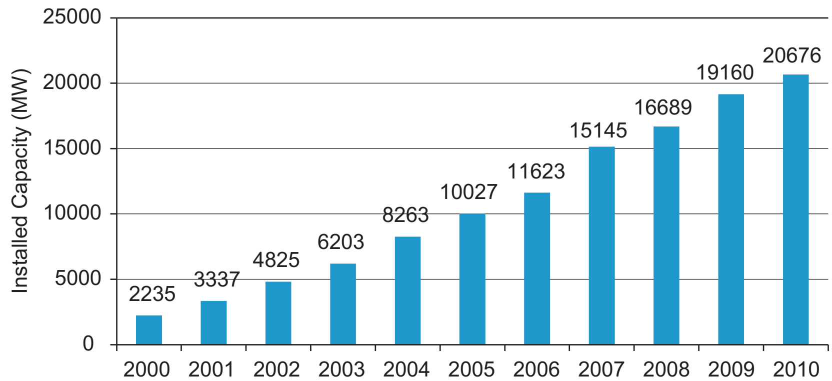


**Fig. 3.** Wind power capacity growth in Spain from 2000 to 2010.
*Source*: Global Wind Energy Council, 2011.

wind power from 2000 onward. In 2004, the policy was modified by the Royal Decrees, which also made changes in the wind tariff system in both 2004 and 2007 (GWEC, 2009). In Spain, the main determinant of tariff is technology, with a close focus on wind predictions. Under Spanish regulations (Alejo, 2011), wind-farm owners sell their power to the grid and must predict how much wind power they will be contributing. The wind-farm owners need to pay penalties for inaccurate prediction. In other national markets, wind farm owners are not penalized for prediction errors. However, the burden that this requirement places upon companies has turned into an advantage by leading to more accurate and reliable predictions. Spanish companies have taken the lead in microsite prediction—forecasting what will happen at a specific turbine, given the meteorological conditions.

The 1997 Electricity Power Act allowed small- and medium-size power plants to choose either a fixed rate or a premium rate plus the market price. The selection remains in effect for one year, and then wind power producers may choose whether to stay with the selected plan or change to the other option. In 2004, Royal Decree 436/2004 stated that wind tariffs should be based on a certain percentage of the average electricity sector tariff ("TMR" in Spanish). Although the TMR level changes every year, the wind tariff has generally been approximately 80%–90% of the TMR.

In 2007, Royal Decree 661/2007 changed the wind tariff policy by introducing two new features: use of the Consumer Price Index (CPI) and the detailed adjustment of rates. The use of the CPI initiated the linkage of the tariff with the real-time price of electricity. The regulation sector also released a correction factor of $\pm 0.25\%$ in order to benefit both end users and small- and medium-size power companies. In the end, although the rate increases slightly each year, the tariff generally remains stable, and the utility companies are able to tolerate a certain degree of annual inflation.

### *2.1.3. Denmark*

Wind energy in Denmark has proved to be an expensive way to reduce $CO_2$ emissions: it saves 2.4 million tons of $CO_2$ per year, under a subsidy averaging $128 per ton of $CO_2$ (CEPOS, 2009). Denmark ranks 9th in the world in cumulative wind capacity. However, it has experienced difficulties since 2000 because of the unstable policy support given to wind power development. The case of Denmark shows the sensitivity of capacity growth to stimulation policy.

In the 1990s, the Danish government released policies that were very supportive to wind power, and which caused rapid capacity growth in the initial period. Under heavy subsidies, there were more than 4000 wind turbines in Denmark in 2000, two-thirds more than in Britain although Denmark was only a fifth the size of Britain (GWEC, 2009). Danish installed wind capacity was 343 MW (76% of total capacity installed in Western Europe), with an average growth rate of 21%. However, the original subsidies were too high, and became a tax burden on consumers. In order to stimulate industrial consumption of renewable energy, taxes were adjusted such that the utility tax for Danish households was 2.5 times higher than the industrial utility tax. Denmark has the world's highest tax burden, and taxes and charges on electricity for household consumers are the highest in the EU 25. Consequently, in 2001, the newly elected Danish government reformed the subsidy policies related to wind power development.

Fig. 4 shows the significant growth trend in Danish wind power capacity from 1990 to 2011, a period that bridged across the 2001 policy reform. In the 1990s, wind power capacity grew rapidly at an average rate of more than 500 MW per year, while the industry received very strong support from government. In the 2000s, the capacity increase stalled because of the sudden elimination of beneficial policy. For instance, the installed wind capacity in 2000 was 637 MW, but it suddenly dropped to 107 MW in 2001 (with a substantial rebound in 2002) caused by uncertainties about the policy, and in the years from 2004 to 2008, there were barely any capacity increases in Denmark. This phenomenon clearly shows the influence of tariff policy on capacity growth.

The 2000 policy introduced major changes in wind power subsidies: newly installed turbines still received a fixed tariff of 4.4 cents/kW h, but no further subsidies. For existing turbines, the tariff remained the same, but the subsidy (3.6 cents/kW h) remained in effect only for very limited hours. Furthermore, from 2003 onward, all renewable energy immediately received the market price. Financial subsidies were replaced with "green certificates." At the same time, in order to share the cost of the wind power subsidy, the energy price for consumers was raised to the highest in Europe (more than twice the British price). This change led to a public anti-wind-power campaign, in which the government was pressured to explore other renewable sources.

Policy support for wind power in Denmark was obviously over-beneficial in the 1990s, enabling a high growth rate at the beginning but leading to a policy reversal in the 2000s. Over-beneficial tariff incentives do not necessarily help achieve $CO_2$ reductions. According to CEPOS (2009), the cost of Danish wind power capacity to consumers is exacerbated by the country's inability to use surplus electricity. Nearly all the excess wind-derived power is exported to neighbouring countries, further depressing the price. Subsidies paid through taxation are also

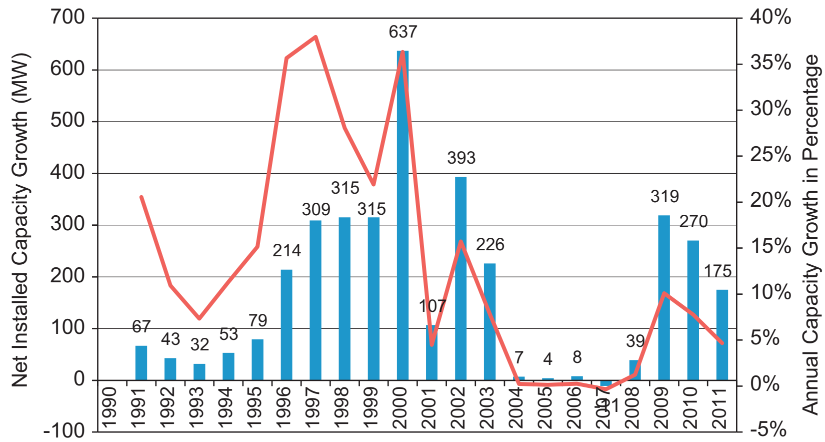


**Fig. 4.** Wind power growth in Denmark from 1990 to 2011.
*Source*: Global wind energy council, 2012.

gone with the power exports. This excessive support is obviously unsustainable: it helped Danish wind power development reach a short-term peak, but tax refunds and output subsidies soon became heavy burdens on the budget (Morthorst, 1999: *p.* 11). While the Danish government wished to encourage capacity growth, over-investments in the early stages of wind power development were not effective.

### 2.1.4. *China*

Both Germany and Spain are emphasizing the technology factor. Germany additionally considers the sizes of power producers, while Spain relies on technical support of wind forecasting, which is another way to maximize resources. In the case of China, there are very limited policy incentives based on either technology or resource distribution, but considerable emphasis on financial investments, which is very similar to the Danish policy of focusing on heavy subsidies. China has three financial sources for its subsidies: the clean development mechanism (CDM), governmental subsidies, and electricity sales. CDM provides a large amount of international financial aid, with each kW h of wind power receiving 8 cents (CNY) in subsidies but the CDM funding criteria exclude many domestic wind projects. In contrast, governmental subsidies are a major force in accelerating the development of wind power. In 2010, China invested 103 billion CNY, at 32.72% annual growth, representing 26.14% of its total power sector investment (Cheng et al., 2011). Fig. 5 shows that Chinese wind power subsidies grew rapidly from 2002 (138 million CNY) to 2008 (2.38 billion CNY).

In China, part of the profit from thermal power is used to subsidize wind power. In 2009, such cross-subsidies for renewable energy were raised from 0.2 cent/kW h to 0.4 cent/kW h, and in 2011, the thermal power charge was increased by 2.6 cents/kW h to support another increase in the cross-subsidy to 0.8 cent/kW h.

Since 2006, tariff rates have been determined on the basis of bidding. Provinces with rich wind resources, such as Inner Mongolia, Jilin, and Gansu, adjusted tariffs inside each province based on the lowest-cost bids for building new wind power projects. As a result, the annual growth of China's wind power market reached 60% in 2006, followed by three consecutive years (2007–2009) of more than 100% growth in installed capacity (GWEC, 2009).

In 2009, the national development and reform commission (NDRC; see Li et al., 2011) released NDRC Pricing Reg. (2009) 1906, which divided China's onshore wind resource into four categories and each category has a different benchmark tariff. The government applied "price floor", which means the result of bidding is limited to a certain minimum price, to prevent the price

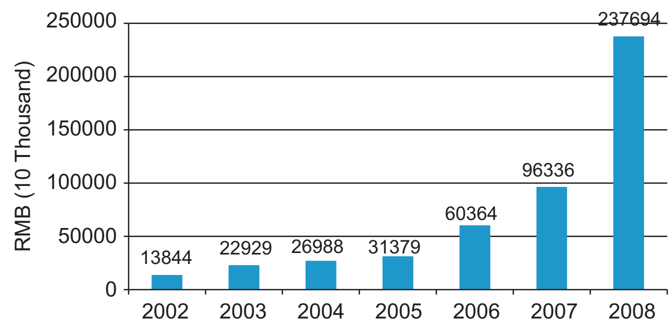


**Fig. 5.** China's wind power subsidy growth from 2002 to 2008.
*Source*: Xia and Song (2009).

from going below the cost (China Renewable Energy Committee, 2009). As shown in Fig. 6 and Table 1, floor prices of the four categories vary from 0.51 to 0.61 CNY/kW h, reflecting the concept that the better the average wind conditions, the lower the tariff level should be.

## 2.2. *Offshore wind power*

Offshore wind power has advantages in comparison with onshore wind power. For instance, wind tends to blow more consistently over the ocean than on land, coastal regions are generally denser with respect to energy consumption, impact on the landscape is minimized, and noise sources are further away from residential areas. On the other hand, high installation and maintenance costs, plus lack of expertise and experience, are currently major concerns for offshore wind power development. In most countries, offshore wind power systems are implemented by large companies because of the high cost of investment and long period of financial return. Europe has around 10 years of experience in developing offshore wind power, while China has only 1–2 years. Worldwide, offshore wind capacity growth is still in a testing period, with the potential for further improvement. In this section, we will look only at Germany and Denmark as case studies, since Spanish offshore wind power development is at a disadvantage because the majority of wind companies there are small or medium-size.

### 2.2.1. *Europe*

Globally, ten European countries are in leading positions in the development of offshore wind capacity. Fig. 7 shows the general

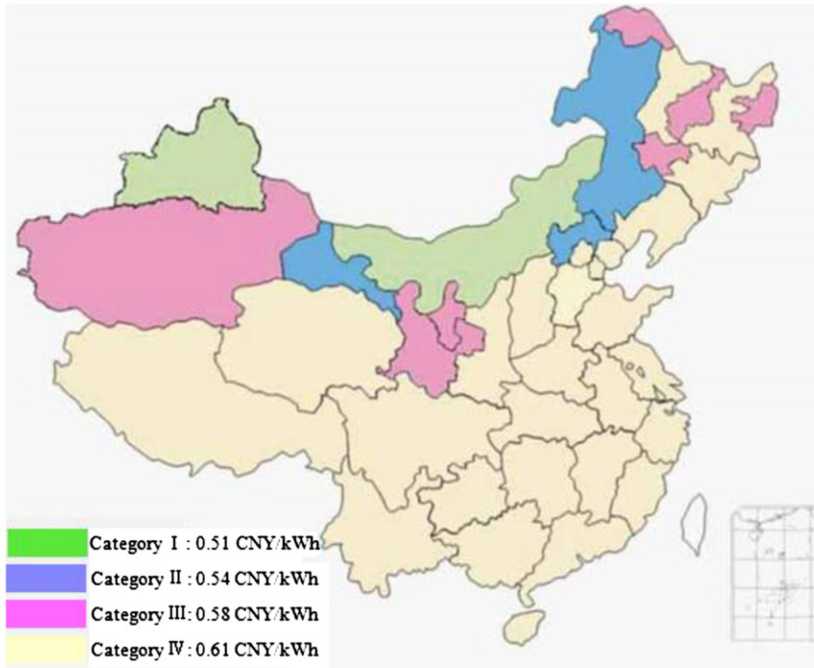


**Fig. 6.** Benchmark feed-in tariffs for onshore wind power (Jiang et al., 2011).

**Table 1**
Benchmark feed-in Tariffs, in CNY/kW h, for onshore wind power (Jiang et al., 2011).

| Resource zone | Benchmark feed-in tariff (CNY/kW h) | Administrative areas included |
|---|---|---|
| Category I | 0.51 | **Inner mongolia autonomous region except**: Chifeng, Tongliao, Xing'anmeng, Hulunbeier; **xinjiang uygur autonomous region**: Urumqi, Yili, Karamay, Shihezi |
| Category II | 0.54 | **Hebei province**: Zhangjiakou, Chengde; **inner mongolia autonomous region**: Chifeng, Tongliao, Xing'anmeng, Hulunbeier; **Gansu province**: Zhangye, Jiayuguan, Jiuquan |
| Category III | 0.58 | **Jilin province**: Baicheng, Songyuan; **Heilongjiang province**: Jixi, Shuangyashan, Qitaihe, Suihua, Yichun, Daxinganling region, **Gansu province except**: Zhangye, Jiayuguan, Jiuquan, Xinjiang **autonomous region except**: Urumqi, Yili, Changji, Karamay, Shihezi, **Ningxia Hui autonomous region** |
| Category IV | 0.61 | Other parts of China not mentioned above |

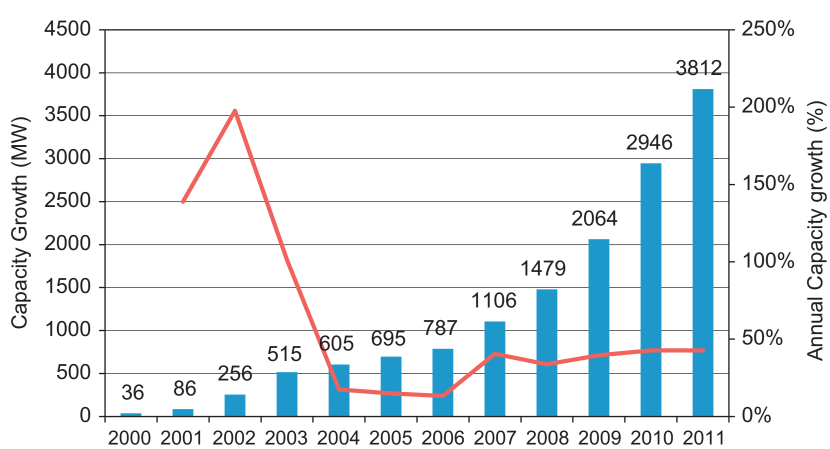


**Fig. 7.** Off-Shore wind power capacity growth in EU(10) from 2000 to 2010.
*Source*: Global wind energy council, 2009.

trend of offshore wind power growth in the ''EU 10'' from 2000 to 2011. In the first four years, the annual growth rate exceeded 100%. After 2004, it decreased, but remained at about 30%. The peak in the rate of capacity growth in 2002 is because of Denmark's high capacity growth in the early 2000s, which was a lagging result (2- to 3-year contraction period) of the above-mentioned Danish policies favouring domestic wind power. In 2011, the offshore wind power capacity in the EU 10 reached

3812 MW, which was roughly 10% of the total EU wind power capacity. A total of 14 TWh of electricity was produced by these offshore wind farms in 2011, covering 0.4% of the EU 25's total power consumption (EWEA, 2012).

The growth of offshore wind power reflects the effectiveness of policy incentives. In most countries that have both onshore and offshore wind farms, simplified administrative processes should be supplemented by micro-adjustments to address the details. For offshore farms, policy incentives are mostly focused on technologies because wind resources are sufficient. High construction cost is the major weakness of offshore wind farms. A common solution to this problem is the application of benchmarking prices to both onshore and offshore power.

In Germany, the price for offshore wind power is subsidized at a rate of 91 Euros per MWh for the first 12 years and 61.9 Euros per MWh for the next 8 years. For onshore wind power, the rate is 83.6 Euros per MWh for the first 5 years and 52.8 Euros per MWh for the next 15 years (EWEA, 2012). Data show that Germany had an increase of 108 MW in offshore wind capacity out of a total of 1,493 MW of wind power in 2010 (GWEC, 2011). The federal government paid more attention to offshore wind power after the Fukushima nuclear accident in Japan. Governmental planning calls for 7.6 GW of installed offshore capacity by 2020 and as much as 26 GW by 2030.

Denmark expanded its wind capacity growth from onshore to offshore farms in the early 2000s, at a time when wind capacity was growing rapidly. Offshore wind power is comparatively expensive and poses risks for construction and operations because of wave levels and water depth. Learning from the recent history of governmental support for onshore wind power, bidders and regulators accepted the idea of fixed feed-in tariffs over a lifetime of 50,000 full-load hours for offshore turbines. Conditions at Danish offshore platforms vary, so a tender system is applied to establish offshore tariffs, while the onshore tariff is 68 Euros per MWh for the first 15 years. In 2020–2025, the average offshore capacity factor will be 40% of total Danish wind power (EWEA, 2012). Administrative systems for wind bidders are also being simplified. Successful bidders could receive licenses directly from governmental regulators.

#### 2.2.2. *Offshore wind power development in China*

China has two operating offshore wind farms as of 2012: the Donghai Bridge wind farm near Shanghai has a 102 MW capacity, and the Jiangsu Rudong county wind showcase has a 201 MW capacity. The NDRC initiated offshore wind development planning in 2005, which is relatively late compared to Europe. However, offshore wind power in China is experiencing very rapid development owing to strong governmental support. In 2009, the national energy administration (NEA) required each east-coast province to estimate its potential for developing offshore wind power. In 2010, the NEA released interim regulations and requirements for offshore wind development, including the bidding procedures for offshore feed-in tariffs. In the same year, the first round of concession bidding started in 11 coastal provinces. In 2011, China already had 209 MW of offshore wind power capacity. Furthermore, 24 offshore wind farms have been approved for construction in the 12th five-year plan (FYP). By 2015, China will have 5 GW of offshore wind capacity; by 2020, offshore wind capacity should reach 30 GW (He et al., 2011).

The lack of coherent regulation between different governmental sectors is a major reason for delaying approved offshore wind projects. According to He et al. (2011), four of the tariff bid-winners in October 2010 voluntarily waived their projects. For instance, the sea area for Dongtai's offshore wind farm was claimed to be an ocean reserve after the NDRC gave approval for construction of 200 MW of capacity. Similar cases demonstrating the lack of integrated planning could have a huge negative influence on further offshore wind power development.

## 3. Methodology

Feed-in tariffs are currently the prevailing instrument worldwide for encouraging wind power development, followed by rebates, tax incentives, tendering systems, and green tariffs (Haas et al., 2004: p. 3). Morthorst (1999) identified five key areas as the most important indicators for evaluating the process of wind power development: these are investment certainty, effectiveness, efficiency, market competition, and administrative demands.

- **Investment certainty** refers to the high level of certainty for independent investors (wind power producers) who are guaranteed a fixed price for each kW h of power that is connected into the grid. In the cases of Germany, Spain and Denmark, investment certainty only applied to a short period rather than long-term because the feed-in tariff was continuously changed. It has been proven to be very difficult for any country to identify the right policy in the early stages.
- **Effectiveness** is the degree to which tariff policy helps promote renewable electricity. It is important to determine the optimal level of subsidies for the most suitable investment in wind power. An overly high subsidy could be a potential threat to funding sources. The effectiveness level is very sensitive to the tariff set, production costs, administrative procedures and natural conditions (Morthorst, 1999). The experiences of Germany and Spain show that tariff policies can evolve from less-effective scenarios to more-effective ones after policy reform. Since wind power has great future potential, it is still too early to claim that current German and Spanish tariff policies are the most mature and effective ones. Denmark's situation, on the other hand, shows the sensitivity of wind power to policy support: capacity was growing rapidly when subsidies were strong, but failed quickly once the beneficial policies were discontinued.
- Whereas effectiveness applies at the macro level, **efficiency** applies at the micro level. The experiences of Europe indicate that efficiency refers to whether a policy contributes to capacity growth or technology development, or helps to keep tariff rates at reasonable levels. Morthorst (1999) argues that policy usually fails to be efficient because of two factors: feed-in tariffs are determined by a single regulatory governmental department, and/or there is no direct competition under feed-in tariffs.
- **Market competition** encourages wind power producers to evolve to adopt a market mechanism. As previously discussed, the most market-driven country is Spain. In comparison with countries where oligopolies dominate the market, thousands of small- and medium-scale wind companies in Spain clearly contribute to the transparency and fairness of market competition. However, at this very early stage of development, a wind power tariff does not have the ability to make the price directly competitive with thermal power. In other words, rushing into the competitive market before maturity could reduce "efficiency." Market competition has not been achieved in any countries yet, although there are significant trends in that direction.
- Feed-in tariffs should have clear and transparent **administrative demands** that specify the extent to which the government should be involved in regulation or deregulation of tariff management. The Chinese characteristics of top-down control are suitable for state-owned enterprises; on the other hand, most European countries, such as Germany and Spain, are working on deregulation processes in an attempt to make the transition to a market mechanism. Meanwhile, Denmark represents the case of

having a simplified administrative system enabling bidders to receive licenses for offshore wind power.

Investment is a major pushing force for accelerating wind power development, which should be implemented with effective and efficient policy guidance. "Effectiveness" views the situation from the macro level; meanwhile, "efficiency" tackles the problems from the ground level. The role of government is to find a balance between interventional controls and deregulation based on market mechanisms. At this stage, wind power requires policy supports, but it should be evolving in the direction of market mechanisms for long-term sustainable development.

The above conceptual framework was designed for renewable energy as a whole. In order to evaluate wind power for the particular case of China, we have to narrow down Morthorst's conceptual framework to a more focused analytical model, which can be summarized by four indicators: **Technology, wind resources, administration,** and **time/space frame.** Market competition is not used due to the lack of market mechanisms in China.

- Haas et al. (2004) indicated that different countries may require varying types of policy support, but a common strategy in wind power development is to enhance the **technology** factor. According to Morthorst (1999), technology stimulation is considered as increasing the efficiency of wind power. Higher efficiency would enable a system to provide more electricity with a limited amount of available capacity. The German EEG was a successful policy reform that actively applied technology incentives. Spanish policy reform was another case of shifting investment towards technology for wind power development. Both countries accomplished significant progress in developing wind technologies.
- Morthorst (1999) pays considerable attention to **wind resources**. Wind resources should be the core consideration for policy making. This indicator contains two parts: first, the level of resource availability on a certain geographic scale; and second, access to maximum wind resources should also be considered in this criterion. For countries with imbalanced wind resources, policy guidance needs to play a more important role in comparison with those countries that have sufficient wind resources. For example, Germany introduces policy restrictions on certain locations to avoid over-installation, while Spain is more flexible and maximizes potential wind resources through wind power forecasting and penalty mechanisms.
- The third indicator that determines policy effectiveness is **administration**. It is important to consider whether the purpose of policy-making is being fulfilled; the degree to which the implemented policy addresses each component of the most challenging issues; and whether the government plans to transfer the development method from top-down state intervention to deregulated competitive market mechanisms.
- Lastly, the **time/space frame** is another essential factor that should be considered during the process of evaluating the policy. The suitability of tariff policy should be tested over a certain amount of time. Long-term examination could reveal weaknesses and allow the introduction of appropriate strategic solutions in a local context. During the evaluation process, one should bear in mind whether the policy adjustment has been in effect long enough to judge the results domestically.

## 4. Evaluations of China's wind policy

It is generally recognised that China and the three European countries discussed above have actively improved their wind power policies via policy reforms. Like Germany, China has a strong focus on wind resource optimization. China also learned from Spain by incorporating "price floor" (benchmark) economic theory into its policies; on the other hand, China is heavily relying on strong financial subsidies, which recall the failure of Danish wind power development after the 2000 policy reform.

The commonality between China and Denmark reveals a financial threat to the future development of China's wind power sector. Because of the large amount of top-down investment, extravagant subsidies may exist. The risk to China's wind power sustainability has been a concern of researchers both at home and abroad. At the moment, China's wind power capacity represents a small percentage of its overall energy capacity (3.27%, as shown in Fig. 8); however, in the long term, the promise of generous and constant prices could be a threat to the government's ability to subsidize a large amount of wind power capacity.

Table 2 is a policy comparison between Germany, Spain, Denmark and China. Our objective is to find models for China's policy improvements via an analytical framework. First of all, the technology barrier is a major challenge for China's wind power improvement efforts. Despite the great amount of installed capacity, a large proportion of wind power capacity has yet to be connected to the grid because of grid access bottlenecks. The percentage of China's grid-connected capacity is extremely low in comparison with European levels. Non-grid capacities in Europe are usually around 10%, but China has more than 30% in non-grid capacity. For instance, an average of only 22.9 GW of Chinese wind power was grid-connected in 2010, although China had a total capacity of 41.8 GW (Electric Industries Statistics, 2010). The purpose of financial support is to foster the overall effectiveness of wind power consumption; however, the high volume of subsidies has only helped China to increase mass production, with little technology improvement. Without policy incentives, there is little investment flowing to technology innovations. A typical technical barrier for wind power is power storage technology. Most of the wind resources are present at night, while the peak demands usually occur between 10 am and 3 pm (GWEC, 2009).

Furthermore, offshore wind turbines face a global technical barrier. According to He et al. (2011), offshore wind turbines require high reliability to handle waves higher than 10 m, which is the limit for sending human workers and workboats to repair damage. This issue is of more concern for China than for European countries because the Chinese shore is widely open to the ocean, with wave and wind levels generally higher than those in the waters bordering most of Europe. On the other hand, this technical barrier reveals that China needs more independent knowledge and property rights with respect to wind power

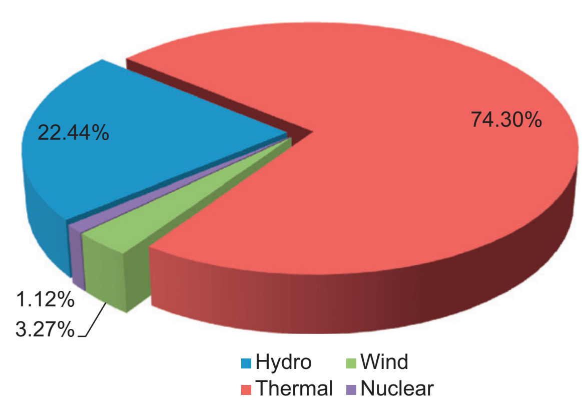


**Fig. 8.** China's 2010 power capacity distribution by energy type.
*Source*: Energy technology and economics (2011).

**Table 2**
Policy comparison of feed-in tariffs in Germany, Spain, Denmark and China.

| | Germany | Spain | Denmark | China |
|---|---|---|---|---|
| **Technology** | 10% Non-grid connection; Significant policy incentives | 10% Non-grid connection; Significant policy incentives, technology focusing on power predictions | 10% Non-grid connection; no significant policy incentives | 30% Non-grid connection; no significant policy incentives |
| **Wind Resources** | Subsidies are based on detailed locational factors. | Wind resource was measured by detailed technical predictions; penalty mechanism is introduced to guarantee the accuracy. | N/A | Four benchmark categories, varying from 0.51 CNY/kW h to 0.61 CNY/kW h |
| **Administration** | Simplified approval process; top-down and bottom-up policy-making process; market involvement; ''reference yield'' as benchmark; governmental subsidies for small-scale power companies (2 cents/kW h of profits) | Simplified approval process; top-down and bottom-up policy-making process; favourable for small and medium businesses; CPI engagement | Simplified approval process; top-down and bottom-up policy-making process; domestic and foreign marketing involvements; power producers immediately received market price after 2003, when financial subsidies were replaced with ''green certificates'' | Complicated approval process (lack of governmental sectorial integration); highly regulated; no market involvement (state-owned wind companies) |
| **Time/Space Frame** | Onshore: 20 years in total, 10-year testing period. Off-shore: 10 years' experience | Onshore: 20 years in total, 8-year testing period. Insignificant offshore power development | Onshore: 20 years in total, 8-year testing period. Offshore: 10 years' experience | Onshore: 6 years in total, testing period N/A. Offshore: 1–2 years' experience |

equipment. Relying on technology transfer permits and limited imports will not solve this problem.

Concerning the second criterion, wind resources are one of the key indicators that Morthorst (1999) emphasizes. Wind power policy in Germany successfully optimizes the use of wind resources, while Spanish prediction technologies accurately measure wind power levels and allow regulation by the penalty mechanism, which is another way to increase power stability and reliability. China has relatively abundant wind resources because of its large land mass and long coastline. According to estimates by the China meteorological administration (see Xia and Song, 2009), based on the relatively low height of 10 m above the ground, the theoretically exploitable offshore wind resource represents a potential power generation capacity of 4,350 GW, and the technically exploitable wind resource is 297 GW. In 2007, it has been shown that the total technically exploitable onshore wind resource was around 1,000 GW (Xia and Song, 2009).

The system of four ''rate-level benchmarks'' can be seen as a significant improvement in China's resource use. The four categories of wind tariffs generally match well with the geographic locations of wind resources. However, on a global scale, obviously Germany determines tariffs at a much finer level of detail, while China's four rate benchmarks are focused on the national level at the moment. Nevertheless, the trend of Chinese resource policy is in a positive direction, with further regulations to be developed in the future.

According to Morthorst (1999), tariffs failed to be efficient for two reasons: (1) Feed-in tariffs were determined by a specific regulatory department; and (2) costs for wind power were not based on direct competition with thermal power. These observations reveal weaknesses within regulatory systems that closely match China's problem: that is, the development strategy in China was heavily reliant on state intervention alone, without bottom-up input; the central government distributed its FYP wind power objectives to the provinces without clear knowledge of the ground-level challenges. As a result, wind power development at this stage has become target-oriented, instead of shifting the load in a practical manner from traditional power generation to renewables.

It is generally agreed that ''administrative demands'' should give way to ''market competition'' in the long-term development context. Wind power is not ready to replace traditional energy types at this point; governmental support will still play an important role during the transition period. China is not the only country that relies heavily on state intervention. The three European countries discussed above are also highly concerned about whether market mechanisms are ready to enable the shift away from thermal power. Nowadays, state regulations play a major role in the renewable-energy policies of many countries. For instance, Germany has tariff subsidies for small-scale wind power through the Renewable Energy Law, which states that the wind tariff is 6 cents/kW h, while the end price is 4 cents/kW h. Thus, every kW h of wind power that the producer sells to the grid earns a 2-cent profit (GWEC, 2009). Europe could open up its markets at the EU level before entering the global market; China, in contrast, has no such smaller-scale ''practice'' platform. Nevertheless, since wind power is gradually accounting for a greater fraction of energy production, an awareness of transitioning to market competition as a tool for long-term growth is highly encouraged.

However, regulators should have a willingness to be self-critical; that is, to examine whether policy adjustments are at the right scale and in the right direction. During this process, government-led development is unlikely to result in comprehensive policy guidance, since it only provides one perspective on the solutions; other participants should be more involved to provide better evaluations. For instance, since renewable generation increased by 50% in 2010, 0.4-cent (CNY)/kW h wind subsidy would not be sufficient to cover the cost, (Electric Industries Statistics, 2010). With 0.4-cent/kW h subsidies, 257.2 billion CNY would be accumulated for renewables in the period from 2009 to 2020; with 0.8 cent/kW h, more than 500 billion CNY would be accumulated; and more than 600 billion CNY would be accumulated if the subsidies were higher than 1 cent/kW h. Clearly, the requirement for raising subsidies in response to accelerated power capacity is not sustainable; quantitative subsidies would not be a long-term solution for releasing financial pressures.

The administrative support for European offshore wind power is comparatively more market- driven, while in the case of China, government is still playing a major role in leading the wind market. Spain is understood to have the most market-driven system compared with the other two cases. With thousands of small- and medium-size wind companies having nationwide coverage, Spain has the second-largest wind power capacity in Europe. Wind power in China has mainly been provided by larger-scale wind companies, with a limited number of medium-size ones, creating a situation very similar to that of Germany. It therefore behoves China to consider wind resources as an important arena for policy improvements.

The market-led development of wind power should not devolve into a "price war"; instead, distinctive technologies and patents should be the major price-determining factors. The tariffs for China's four new offshore wind projects will be 0.78, 0.71, 0.69, and 0.68 CNY/kW h, respectively. These are very close to onshore wind tariffs, although the cost of offshore wind projects is usually twice that of onshore projects (He et al., 2011). In the case of Europe, developers inclusively involved with turbine manufactures, and companies with elite technologies are enabled to have higher market penetration. According to the EWEA (2012), five companies—SSE renewable (28%), RWE (22%), DONG (19%), Vattenfall (13%), and ENBW (6%)—shared 88% of European offshore capacity in 2011 because of accumulative technologies. The "price war" circumstance reveals the weakness that offshore wind power in China features very limited engagement of Chinese intellectual property; rather, the operation is highly reliant on governmental subsidies. The current tariff for the Donghai bridge offshore wind project is 0.978 CNY/kW h, but that project would require 1.2 CNY/kW h to achieve fiscal balance (He et al., 2011).

The time/space frame underscores another weakness of China's wind development policy. Most of the European countries spent 10 years or more on testing technologies and finding suitable policies for their domestic markets. As discussed in the previous sections, both Germany and Spain initiated wind power in the 1990s, but mass capacity growth did not occur until the 2000s. In comparison, China only had 6–7 years of experience for onshore and 1–2 years for offshore wind development, which should have been part of the testing period for policy development and improvement. It is predictable that China has a long way to go, unavoidably making more policy changes in the future. Onshore wind power development in China from 2002 to 2009 was at a level similar to Europe's in the 1990s, whereas China's offshore wind power development is still at an immature stage. Aiming at high capacity growth this early in the life cycle of China's wind power development would not be beneficial for wind power in the long run. Impractical policies may be inadvertently implemented, since the development of China's wind power is still at an early stage. China is geographically larger than European countries, and it contains more robust wind resources. Theoretically, China should be expected to spend more time exploring and examining its options to determine what policies would be most suitable.

After China's onshore feed-in tariff policy was developed, it was adjusted for application to offshore wind power. However, it is premature to apply the feed-in tariff to offshore wind power at the moment, since there is considerable room for improvement. Predictably, when offshore power capacity is growing rapidly, its grid-connection capability is a more severe challenge.

To summarize the above analysis, in comparison with Europe, China does not have detailed and market-driven policies; it also lacks policy guidance to encourage technology enhancement. In fact, it appears that China is emulating the Danish experience. China is geographically bigger, and provides larger subsidies, than European countries; the recent policy reforms increased investment levels to meet the capacity requirements, instead of encouraging technology improvements. As a result, cross-subsidies rose twice in the three years from 2009 to 2011. Predictably, they will be forced to rise again in the near future, since capacity is growing at such a fast pace, and the cost of thermal power will be raised accordingly again.

## 5. Conclusions and recommendations

The previous sections identified some problems that China's wind sector is experiencing, including the lack of technology stimulation policies, unnecessary funding support through cross-subsidies, and the need for improvement in administrative schemes. Four general recommendations are provided below.

- First, as wind power capacity has grown, it has been increasingly recognized that a major obstacle to renewable energy development is the power-subsidy financing method. China's wind sector is currently growing very rapidly because of strong financial subsidies. A financial burden will arise in the long run if technical efficiency does not improve. In the future, the mass production of wind power capacity will require larger subsidies than thermal power. Therefore, subsidies will have to be further increased. Challenges will still remain for long-term development because, at the same time, in order to afford the increasing subsidies, the government would have to charge higher rates to end-users for thermal power. This situation would create a vicious cycle for power subsidies. The Danish case shows that this scenario could not last for long. It is therefore a strategic imperative to shift the policy from a capacity-oriented stimulation mechanism to a technology-oriented one. For instance, subsidies should be based on integrated grid-connected capacity instead of installed capacity.
- Second, quantitative data do not necessarily represent the full picture of empirical practice. It is true that China currently has the largest wind power capacity in the world, surpassing that of the U.S., and it is still the fastest-growing country in this respect. However, quantitative performance data do not reveal the weakness of low grid-connected capacity. As discussed in the above sections, non-grid-connected wind power in most European countries represents around 10% of total capacity; in China, total installed capacity in 2010 was 41.8 GW, while total grid-connected capacity that year was 22.9 GW; i.e., more than 30% of capacity was not connected to transmission lines. It is therefore necessary for multiple stakeholders to be involved in the decision-making process to help avoid or reduce such problems. Technical improvements and policies with more detailed resource distributions would help China to be more efficient in wind power delivery.
- Third, top-down intervention should be integrated with grass-roots support. The combined efforts of both top-down and grass-roots stakeholders could lead to more suitable regulations. Successful efforts are characterized by the cooperation of all stakeholders to achieve a common objective; ground-level problems are easily revealed via bottom-up input. The decision-making process is heavily controlled by the authorities in China, with a lack of feedback from the ground. Policy design should be a shared effort among all relevant social sectors. Simply relying on one sector makes it very hard to achieve comprehensive and suitable results. It would be very helpful if tariff policies could be determined jointly by all governmental sectors and other participants.
- Lastly, offshore wind power in China is still at an immature stage of its life cycle. At this stage, policy makers should focus on institutional improvements and R&D investments instead of rushing into high capacity growth. The initial macro-guidance established the nature of offshore wind power as a showcase, owing to the immaturity of both policy schemes and independent technical properties. Moreover, the provisions of the 12th FYP accelerated the speed of capacity growth, although offshore wind power is still in a testing period. A lack of solid and suitably directed policy development in the early stages will result in inefficient investments and other threats to future power generation. The regulatory sector should aim for sustainable policies. Early investment in capacity growth while the system is immature is a high-risk and low-return approach.

Although China is not ready to open its renewable-energy sector to market forces, policy guidance should be devised to lead regulations in a market-driven direction. The three European countries discussed here did not confront completely free markets; however, they are approaching market-driven policies. China's wind power is still in its initial stages, and is not ready to replace thermal power. Policy supports should play a key role in leading its growth. Wind power in China is considered young in comparison with Europe. At this stage, China should learn from European experience. Simply increasing subsidy levels may be helpful to release the cost pressure in the short run; it does not solve the problem for long-term development. All-around technical and instrumental improvements are urgently required and can only be realized in a sound and meaningful policy environment.

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