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The impact of Chinese carbon emission trading scheme (ETS) on low carbon energy (LCE) investment

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HIGHLIGHTS

- The impact of Chinese emission trading scheme on low carbon energy investment is assessed.
- A real-option based investment decision model under uncertainty is built and employed.
- Key variables and features of ETS influencing wind power investment are explored.
- Chinese carbon ETS cannot support low carbon energy investment on its own.
- Other policy measures complementing ETS are still needed and should be coordinated.

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ABSTRACT

China is planning to introduce emission trading scheme (ETS) to decrease CO_2 emission. As low carbon energy (LCE) will play a pivotal role in reducing CO_2 emissions, our paper is to assess the extent and the conditions under which a carbon ETS can deliver LCE investment in China. We chose wind technology as a case study and a real-option based model was built to explore the impact of a number of variables and design features on investment decisions, e.g. carbon and electricity price, carbon market risk, carbon price floor and ceiling and on-grid ratio. We compute critical values of these variables and features and explore trade-offs among them. According to our work, a carbon ETS has a significant effect on wind power plant investment although it cannot support investment in wind power on its own. Carbon price stabilization mechanisms such as carbon price floor can significantly improve the effect of carbon ETS but the critical floor to support investment is still much higher than the carbon price in China pilot ETSs. Our results show that other policy measures will be needed to promote low-carbon energy development in China.

1. Introduction

As the world's largest greenhouse gas emitter, China has introduced a number of policies to tackle its emissions responsible for climate change. For example, in 2009 China committed to reduce its 2005 carbon intensity by 40–45% by 2020 and the target of carbon emission peaking in 2030 has recently been proposed. In order to minimize the costs of meeting these targets, market-based policy instruments, such as emission trading schemes (ETSs) (National Development and Reform Commission (NDRC), 2012)[1] are being introduced. Currently seven pilot ETSs are operating in five cities and two provinces, i.e. Shenzhen, Beijing, Shanghai, Tianjin, Chongqing, Guangdong and Hubei, as part of the 12th Five-Year-Plan (2011–2015) (PRC, 2011; NDRC, 2011), with these areas accounting for about 18% of the country's total population and 27% of the national GDP in 2010 (Lo, 2012). In December 2014, "Regulation Measures on National Carbon Emission Trading in China" were issued by NDRC as part of the process to introduce a national carbon trading legislation. Detailed rules on ETS design are currently under discussion with the aim of announcing a unified national scheme in 2017, which would be refined during 13th Five-Year plan as experience from the pilot ETSs accumulates.

As low carbon energy (LCE) is expected to play a fundamental role in reducing long-term CO_2 emissions, it becomes important to explore how a national Chinese ETS would affect the LCE development and whether it can provide a strong incentive for investment in LCEs. Wind power is a key LCE in China, and deployment

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[1] During the 11 Five-Year Plan (2006–2010), to realize the energy intensity reduction target, China paid giant cost with the command and control policy instrument being employed, and some provinces were even forced to shut down their industrial capacity towards the end of 2010 to meet their assigned energy-saving targets. With this experience, China is becoming more interested in market-based strategies for GHG control (Lo, 2012).

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of wind power is delivering increased energy supply, diversification in the energy mix, reduction of GHG emissions, and improvement in air quality and energy security. In addition, China is endowed with very large wind resources, namely 23.8 TW onshore and 2 TW offshore (Zhao et al., 2013a), and there's still great potential for the future development. At last, wind-utilization technology is relatively mature and it is the closest to being cost-competitive with established fossil fuel technologies, so from the evaluation results of wind power investment, the implication on other LCEs could be inferred. For the reasons referred above, we chose wind technology among LCEs as a case study, and the potential impact of the ETS on wind power plant investment is explored.

The Chinese government has taken considerable steps to promote development of wind power, including mandatory measures and financial support. The Renewable Energy Law, introduced in 2006, and the "Long-term Development Plan for Renewable Energy", introduced in 2007, played a fundamental role in accelerating the development of the wind power investment. In 2009 the NDRC passed the "Notice on Improving Power Price Policy of Wind Power Accessed to the Grids" introducing feed-in tariffs with rates varying according to wind resource quality and investment conditions.[2] As part of this policy, China was divided into four wind resource areas, and different benchmark prices, ranging from 0.51 RMB/kWh (0.082 USD/kWh) to 0.61 RMB/kWh (0.098 USD/kWh) have been established.[3] This was a considerable change from the tender pricing system which had been responsible for very low prices paid to wind generators (Zhao et al., 2013a). In addition to national policies, the international clean development mechanism (CDM) has played a role in promoting the development of the Chinese wind power industry by providing additional funding through the sales of the Certified Emissions Reductions (CERs) (Wen and Qian, 2007; Zhang et al., 2009).

Considerable challenges remain to promote the development of the Chinese wind industry, despite the support of domestic policies and international CDM. Low access to the power grid has remained a major obstacle to the deployment of wind power in China (Zeng et al., 2013), with the gap between installed capacity and capacity connected to the grid being about 30%, i.e. almost one turbine out of three installed currently sits idle and left unutilized (Li et al., 2013). In addition, the large deficit in the Renewable Energy Development Fund, i.e.14 billion RMB (2.24 billion USD) at the end of 2014 implies that wind power investors cannot rely on the timing payment of the feed-in tariffs (China Economic Net, 2014). In terms of CDM, as a result of over allocation of emission quotas in the EU ETS, outbreak of the financial crisis and faster than expected growth in renewable energy (Mo and Zhu, 2014), international carbon price is relatively low, implying that the need for CERs is limited and CER revenues lower than expected (Pechak et al., 2011). In addition, revenues from CDM are particularly uncertain as some of the Chinese wind power CDM projects have recently been refused certification by the United Nations Executive Board (EB), as they questioned the additionality of these projects and whether CDM revenues are needed to make investments viable (Zhao et al., 2013b). This fact casts doubts on the sustainability of this revenue stream for Chinese wind power investors.

Against this background, the Chinese national ETS may provide new incentives for the wind power development, as wind power plant investors can apply for the so-called Chinese CER (CCER) projects, granting certificates which can be used to offset CO_2 emission in the Chinese ETS pilots (NDRC, 2014). Until March 2015, 45 wind power CCER projects have been approved by the NDRC, i.e. about 30% of the total CCER projects (Sino Carbon, 2015). Although ETSs provide a carbon price signal, potentially encouraging investments in wind power plant (Stavins, 2001), the effect of carbon ETS may be hampered by low price and excessive price volatility. This has been shown to be the case according to experience from the EU ETS and results from a number of simulation studies (Grubb and Neuhoff, 2006; Hoffman, 2007; Blanco and Rodrigues, 2008; Rogge et al., 2011; Mo et al., 2012; Gulbrandsen and Senqvist, 2013; Löfgren et al., 2014; Mo and Zhu, 2014).

The aim of our paper is to assess the extent and the conditions under which a carbon ETS can deliver investment in wind power in China. As far as we are aware this is the first time that the impact of the China ETS on the wind power investment is explored through a real option theory model which enables us to assess implications of possible policy design, importance of renewable energy policy, and the coordination of the two policies to promote renewable energy deployment in China. Real option theory enable us to take into consideration the value of the option to defer investments in a wind plant, the flexibility in the timing of the investment and the uncertainty characterizing the decision to invest. As Chinese carbon market and related policies face considerable uncertainty, ability to decide the timing of investments is a considerably important feature in the investment decision process. Our approach is particularly suited to model situation in which decisions are affected by stochastic variables like the carbon price. On the contrary, feed-in tariffs, which are not explicitly taken into account in our work, are deterministic policies, i.e. the rate is fixed in advance although it may change based on known schedule. Our model enables us to explore the impact of a number of variables and design features on investment decisions and investment timing, such as carbon and electricity price, carbon market risk, carbon price floor and ceiling and on-grid ratio. In a number of instances we explore trade-off between these features and derive policy insights. Our paper is structured as follows. Section 2 places our article within the literature discussing the policy landscape in China and assessing the impact of policy to stimulate the development of the Chinese wind power industry. Section 3 described the modelling methodology used in our research (more details can be found in the Appendix). Section 4 discusses the results from our simulations and Section 5 summarizes the findings from our study and discusses policy implications.

2. Literature review

A number of papers have recently discussed Chinese policies related to wind energy and their impact on capacity deployment and electricity production, especially after feed-in tariffs were introduced in 2009. Since 2005 China has achieved considerable progress in terms of wind power deployment. Total installed capacity has increased from 1 GW in 2005 to 115 GW in 2014 but it is strongly concentrated in a handful of regions, namely Inner Mongolia (20% of the total capacity), Gansu and Hebei (9% each) and Xinjiang (8%) (CWEA, 2014). Availability of wind resources has clearly a role to play in this pattern but unfortunately this concentration of wind plants has generated a number of problems as the regions above are far from important electricity demand centres and from the local existing electrical power grid which is also reported to be weak, therefore constraining the possibility to connect a considerable number of wind plants (Ling and Cai, 2012). On a more positive note, Lewis (2010) points out that south-eastern coastal areas have also very good wind resources, i.e. 5000–7000 usable hours per year with the advantage of being closer to demand centres. Although other land uses may compete

[2] The tariffs are funded through the renewable energy development fund with financial resources collected through increases in the electricity sale price of thermal power.

[3] The exchange rate we used in this paper is as follow, 1USD=6.24RMB, which is observed on February 12th, 2015.