Energy Policy 63 (2013) 97–100

Contents lists available at ScienceDirect

Energy Policy

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

Communication

# The value of holding scarce wind resource—A cause of overinvestment in wind power capacity in China

Xuemei Liu*

*Department of Economics, California State University, 1250 Bellflower Blvd., Long Beach, CA 90840, USA*

ARTICLE INFO

*Article history:*
Received 30 July 2012
Accepted 10 August 2013
Available online 28 August 2013

*Keywords:*
Overinvestment
Wind power capacity
China

ABSTRACT

China's wind power capacity has increased dramatically in recent years, but about 30% of the installed capacity sits idle, so overinvestment in wind power capacity seems to be a serious problem. This paper explores reasons for the overinvestment. The economic analysis shows that, given uncertain future policy on wind power, it is optimal for power companies to invest more than the amount in a certain world. A part of the “overinvestment” has a real value, which can be interpreted as the value of holding scarce wind resource. This value exists because the wind-rich sites with convenient locations to connect to the grids are scarce resource, and also because the specific government policies that are essential for promoting wind power are uncertain in the future. This value should be taken into account in the investment decision, but it results in the phenomenon of “overinvestment”. The concept of the value of holding scarce resource can be generally applied to the resources that are scarce and for which the future policy is uncertain.



## 1. Introduction

China's wind power capacity has increased dramatically in the past several years and ranks first in the world since 2011 (NDRC, 2011). By the end of 2009, 423 wind farms had been constructed, with 20,367 installed wind turbines, and the cumulative installed capacity of wind turbines increased to 24,120 MW (Yu et al., 2011). By the end of 2011, the total installed wind power capacity in China reached 62.73 GW (Wu et al., 2013).

The investment in wind power capacity has been mainly driven by government policies. So far the unit cost of wind electricity is still too high for most wind farms to make profits. Thus, profits cannot be the driving force for the investment in wind capacity. Since 2005, the central government has issued a number of policies, including the Renewable Energy Law (NPC, 2005), Renewable Energy Pricing and Cost Sharing Management and Trial Methods (NDRC, 2006), the Mid- and Long-Term Development Plan for Renewable Energy (NDRC, 2007). These policies use instruments such as favorable pool purchase pricing of wind power, tax exemption and reduction, and financial subsidies (Fang et al., 2012) to stimulate the investment in wind power. As a consequence, China's wind power capacity doubled every year for five consecutive years from 2005 to 2009.

* Corresponding author. Tel.: +1 562 985 4832.
*E-mail address:* xuemei.liu@csulb.edu

0301-4215/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.enpol.2013.08.044

However, the rapid increase results in overinvestment in wind power capacity. Due to the limited capacities of the grid and transmission, only 62.51% of the wind capacity installed in 2009 was connected to the grid (Fang et al., 2012). By 2010, about 30% of the total installed capacity had not been integrated with the grid (Zhao et al., 2012). Currently about 20 GW generating capacity cannot be absorbed (Wu et al., 2013). About 30% of the installed wind capacity sits idle (Chinese News, 2012). Nevertheless, new wind farms continue to be built.

Although it is obvious that the investment in wind capacity in China has been stimulated by government policies, the reasons behind the overinvestment have not been well explored. There are some studies in the literature discussing the difficulties and barriers of getting good returns on the investment in wind capacity, such as inadequate grid infrastructure, waste in wind power development, wind farm outages, low capacity factors and low quality turbines (Cyranoski, 2009; Han et al., 2009; Li, 2010; Liao et al., 2010; Liu and Kokko, 2010; Rutkowski, 2010; Wang, 2010; Young et al., 2010; Yu et al., 2009). Nevertheless, it has rarely been addressed and discussed why the overinvestment has occurred in China given so many difficulties and barriers.

This paper attempts to contribute to the energy policy literature by exploring the reasons for the overinvestment in wind power capacity. The huge gap between the investment in wind capacity and the actual generation of wind power may be partially explained by technological uncertainties. Without sufficient and accurate wind resource assessments, many wind farms built in China cannot generate as much electricity as anticipated

(Zhang et al., 2009). In addition, although Chinese enterprises have mastered the technology to produce small-scale turbines, the domestic technology to produce large-scale turbines is still immature (Yu and Qu, 2010). Many of the wind turbine design systems are transferred from foreign companies, with no databases or know-how. As a result, wind turbines cannot be customized to meet the specific requirements of the wind resource in China, so they do not operate as well as expected (Zhang et al., 2009). Given these uncertainties, it is difficult for investors to make accurate predictions about how much electricity can be generated from a certain amount of wind capacity, and thus it may result in the gap between the investment in wind capacity and the actual generation of electricity.

In addition to the technological uncertainties, are there any other causes for the overinvestment? Is it possible for power companies to overinvest in wind capacity on purpose? In other words, is it in their interest to invest more in wind power capacity than what they need to reach a certain target of electricity generation? These questions are motivated by the fact that the specific government policies that are essential for promoting wind power are uncertain in the future. For examples, the "Renewable Energy Law", issued in 2005, states that 15% of the national energy consumption is to be sourced from renewable energy by 2020; in addition, large state-owned power companies will be obliged to ensure that wind power accounts for at least 5% of their total energy output by the same year (Lema and Ruby, 2007). However, this law is very abstract and does not have details on how it will be implemented in 2020. Since the political and economic changes in China have been enormous in the past thirty years, and are expected to continue in the future, it is uncertain whether the obligation of wind power will be really imposed on power companies by 2020. In case it will be imposed, it is uncertain whether the government will adopt command-and-control approaches (restrictive regulation) such as a nonmarketable quota system or incentive-based policy instruments such as a tradable quota system. If the government adopts a nonmarketable quota system, all power companies will have to use their own wind farms to generate wind power to meet the quota requirement. If the government adopts a tradable quota system, some power companies may meet the requirement by purchasing wind power from other companies. In that case, building wind farms is not the only choice, and thus some power companies may not bother to invest in wind power capacity. Since different policy instruments have very different impacts, the uncertainty of government policy must have some influence on the companies' investment decision.

Does the overinvestment have anything to do with policy uncertainty? If yes, how does policy uncertainty affect the investment decision and result in overinvestment? These questions are explored in this paper. The study is conducted with a simple economic model. The paper is organized as follows. Section 2 presents the setup of the model and the analytical result. Section 3 applies the result to the current Chinese situation and discusses about the concept of the value of holding scarce wind resource as well as how the value affects the investment decision. Conclusions are presented in Section 4.

## 2. The model

This paper analyzes the impact of policy uncertainty on the investment in wind capacity by looking at a typical firm's behavior. The majority of the investors in wind capacity in China are State Owned Enterprises (SOEs). By the end of 2008, nearly 90% of installed wind capacity was invested by SOEs, and 97% of the wind concession projects were developed by SOEs (Wang et al., 2010). Thus the firm in this model is assumed to be a SOE.

For simplicity, it is assumed there are two periods: investment is made only in the first period and wind electricity is generated only in the second period. The firm invests in constructing wind farms and installing wind turbines in the first period without knowing whether a nonmarketable quota will be adopted in the future. The second period can be interpreted as a whole sequence of further periods. If there is no restrictive regulation in the second period, then the firm will produce the amount of wind power as it normally does. If a nonmarketable quota system is imposed in the second period, the firm will have to comply with the regulation and produce the amount of wind power to meet the quota requirement. It is assumed that no new investment is made in the second period. Although there are sufficient sites where wind farms can be built, the wind-rich sites with convenient locations to connect to the grids are scarce resource. Once the wind-rich sites are acquired by some firms in the first period, they will not be available for other firms to build wind farms in the second period. Thus, a firm that does not acquire wind-rich sites and construct wind farms on the sites in the first period will have little chance to find a good site to construct a wind farm in the second period.

When the firm makes a decision on the investment in the first period, it maximizes the net benefit derived from the investment. The net benefit is the difference between the total benefits and total costs. The total benefits, received only in the second period, consist of two parts: direct benefits and indirect benefits. The direct benefits include the monetary return of producing and selling wind powered electricity in the second period, and the non-monetary benefits that the firm as a SOE must take into consideration, such as the local government's goal of increasing employment, production, tax revenue and growth rates, as addressed in Liu and Kokko (2010).

The indirect benefit is derived from complying with the regulation. If no restrictive regulation is imposed in the second period, then the indirect benefit is zero. If a nonmarketable quota system is imposed in the second period but the firm does not have enough wind power capacity to meet the requirement of wind electricity, then the firm will be punished. Since the relevant policies have no details about the punishment, it is not clear how the SOEs will be punished for not being able to fulfill the obligation. The punishment may take the form of monetary penalty as well as non-monetary punishment. For example, the chief executives of SOEs, who are actually government officials and can move freely back and forth into government positions, are likely to be punished in the form of losing their future promotion opportunities or even losing their current positions. Thus the indirect benefit is the avoided loss from not being able to comply with the regulation.

Let $u$ represent the investment in the first period, $M(u)$ represent the direct benefits and $N(u)$ represent the indirect benefit. Both benefit functions are assumed to be continuous, concave and twice differentiable in investment. Let $p$ represent the firm's predicted probability that a nonmarketable quota will be imposed in the second period, so the probability of obtaining zero indirect benefit is 1-$p$. Then the expected value of the indirect benefit is $pN(u)$.

The cost of investment is the economic cost of constructing wind farms and installing wind turbines in the first period. For simplicity, it is assumed that the operation and maintenance costs in the second period are proportional to the investment cost in the first period, and can be collected into the investment cost. Let $C(u)$ represent the investment cost function, which is assumed to be continuous, convex and twice differentiable in investment.

The firm is assumed to choose the level of investment to maximize its expected present value of the net benefit, which is the difference between the total benefits and total costs:

$$\max_u r[M(u)+pN(u)]-C(u)$$

where $r$ represents the discounting factor.