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Financial risks for green electricity investors and producers in a tradable green certificate market

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Abstract

This paper analyzes financial risks in a market for tradable green certificates (TGC) from two perspectives; existing renewable producers and potential investors in new renewable electricity generation capacity. The equilibrium pricing mechanism for a consumer-based TGC market is described and a market with wind turbines as the sole renewable technology is analyzed. In this framework, TGC prices and fluctuations in production from wind turbines will be negatively correlated and, as a result, TGC price fluctuations can actually help decrease the total financial risk. Based on this recognition, analytical expressions for revenue-variance-minimizing trading strategies are derived and an analysis of the demand and supply for financial hedging is used to show that forward contracts will be traded at a risk premium.

JEL: D80; G18; O20; Q28

Keywords: Tradable green certificates; Financial risk; Forward contracts

1. Introduction

Following the global trend towards market-based systems for electricity trading, a number of countries are considering tradable green certificate (TGC) markets as a way of introducing market-based support schemes for renewable energy technologies. TGC markets in various forms are under consideration or actual implementation in a number of European countries, e.g. the Netherlands, Denmark, Sweden, Italy, the UK, etc. However, the specific design varies significantly across countries. An important distinction is whether the obligation to purchase green certificates rests on the consumer or producer. In this paper, we primarily consider the suggested Danish system, which is a consumer based one. The primary element of the Danish TGC market is an obligation on consumers to buy an amount of certificates corresponding to a percentage or quota of their total electricity consumption during a specified time period, e.g. one calendar year. Each supplier of renewable (green) electricity will receive a certificate for each unit of electricity produced and, given the fixed quota, it is then left to competition on the supply side to find the appropriate certificate price.

In spite of the market label, the TGC system is a specific form of quantity regulation. A demand for green electricity is created, but it is based on a quota defined by the Government rather than directly on the individual consumer's desire for electricity from renewable sources. A tendering system is another example of quantity regulation. But here, the price paid to renewable producers is typically fixed for a number of years ahead. The new and innovative part of the TGC concept is the dynamic price setting mechanism that results from creating a market for a tradable good (in this case a financial product called a green certificate). A detailed description of consumer-based TGC systems can be found in Amundsen and Mortensen (2001), Morthorst (2000), Schaeffer et al. (1999), Jensen and Skytte (2002a), Jensen and Skytte (2002b), Morthorst (2000) and Fristrup (2002).

This paper contributes to the ongoing discussion about TGC market design by analyzing the effects that a consumer-based TGC system will have on the financial risks for wind-turbine owners. Wind turbines are assumed to make up the entire supply side of the market, i.e. other renewable sources are supported either

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through separate technology specific TGC markets or other political instruments. In the proposed Danish system[1] it is likely that the supply side will attempt to form cartels, however, we assume that legal action will prevent such action and we have based the market analysis on perfect competition. With perfect competition, the pricing mechanism is based on the assumption that long-run marginal costs (LRMC) of the marginal renewable investor minus the expected price of electricity will equal the expected TGC price in equilibrium.

Two main factors will affect equilibrium in the framework described above. The short-term (annual) effects of these factors are analyzed by looking at trading strategies for existing producers, whereas the long-term effects are analyzed by looking at the risk premium required by investors. The first factor concerns the amount of information about the shape of supply and demand curves available to investors and producers. In a TGC system, potential investors need this information in order to evaluate future prices and expected return on the investment. Similarly, existing producers need the information to construct an optimal bidding strategy in the market. The second factor concerns the volume risk that arises because the average wind conditions fluctuate between the annual periods. Fluctuations in the wind regime imply that the amount of electricity, and thus also the number of certificates produced, are both stochastic variables. Because of this volume risk, the effect of signing fixed-price forward contracts, both in the TGC market and in the physical electricity market, is more ambiguous for a wind-turbine owner than for a power producer who can control production volume.

A liquid forward market plays an essential role in attracting new investors to a commodity market. Since the main goal of a TGC market is to obtain cost-efficient deployment of renewable capacity, it is important to analyze the role of such contracts for hedging purposes. Assuming that revenue is the essential parameter for investors, and that utility can be expressed in a mean variance framework, we derive analytical expressions for variance-minimizing portfolios of forward contracts. To illustrate the implications of stochastic production volume, the strategies are subsequently compared to those of producers with a deterministic production volume. Finally, we analyze the demand for hedging on both the supply and demand side of the TGC market and conclude that forward contracts will have an inherent tendency to trade at a risk premium, i.e. at a price above the expected spot price.

[1] Our point of departure is the proposed Danish system but most conclusions will be valid in other similar systems.

2. The price-setting mechanism in a TGC market

In this section, the pricing mechanism for a perfectly competitive consumer-based TGC market is described. The pricing mechanism constitutes a necessary basis for an analysis of the financial risks implied by the introduction of such a market. As described in detail below, it is crucial that at equilibrium a new entrant in the TGC market produces the marginal unit, and we therefore distinguish between existing and new capacity. Assuming perfect competition, new entrants will supply at the LRMC. LRMC is defined here as the price required by an investor in order to supply an additional unit of renewable capacity. It is therefore an average cost that encompasses short-run marginal costs (SRMC), average per unit repayment of fixed costs, and an average per unit risk premium. SRMC is defined as the variable costs of production, and in the case of a wind turbine this is simply the operation and maintenance (O&M) cost.

In addition to trading financial certificates, the wind-turbine owner will also sell the produced power on the physical market for electricity. This represents an additional income and the price, thus obtained, in this market must therefore be subtracted from the LRMC in order to derive a supply curve in the TGC market. It is important to note that by using the LRMC curve as part of the supply curve to form an equilibrium price in a single annual period (see Fig. 1), we are implicitly assuming that this equilibrium price equals the expected average equilibrium price during the lifetime of the investment. We shall make this assumption in the following, because it eases the illustration of market equilibrium considerably without affecting the results presented.

Fig. 1 illustrates market equilibrium in the proposed Danish TGC system. In this system, the obligation to buy certificates is an annual one, where each consumer must purchase certificates corresponding to a fraction of his/her annual power consumption (we use the term "quota" in this paper), or pay a predefined penalty[2] for the deficit.

With perfect competition price will equal SRMC if existing renewable generators can cover the demand for certificates. In practice, the SRMC of running a wind turbine is always lower than the electricity price received on the physical market implying that in this case the certificate price should be zero. For the TGC system to function properly, the quota must therefore be set at a level, which ensures that the marginal unit is a new

[2] This penalty is effectively a price cap in the market. The proposed Danish system also includes a minimum price cap. This minimum cap has been suggested to ensure that, as a minimum, all turbine owners receive the CO_2-reduction credit that was given to all renewable power producers in the previous system.