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Emissions trading and investment decisions in the power sector—a case study in Finland

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Abstract

Organizations, which consider investment in or divestment of power production licences/capacity within the European Community, are exposed to the impacts of the European Union Emission allowance Trading Scheme (EU ETS). In this paper, the consequences of the EU ETS on investment decisions are explored in a country-specific setting in Finland. First, we review the general mechanisms through which the EU ETS influences size, timing and cashflows of an investment. Next, we discuss the projected changes in Finnish power producers' investment environment and examine the financial impacts due to the EU ETS on a case investment decision, a hypothetical condensing power plant (250 MW_e). The standard discounted cash flow (DCF) analysis is extended to take into account the value of two real options: the option to wait and the option to alter operating scale. In a quantitative investment appraisal, the impact of emissions trading not only depends on the expected level of allowance prices, but also on their volatility and correlation with electricity and fuel prices. The case study shows that the uncertainty regarding the allocation of emission allowances is critical in a quantitative investment appraisal of fossil fuel-fired power plants.

Keywords: Emissions trading; Investment; Power generation

1. Introduction

On 13 October 2003, the Directive 2003/87/EC of the European Parliament and of the Council establishing a carbon dioxide (CO_2) emission allowance trading scheme (EU ETS) within the Community entered into force. The directive creates a framework for emissions trading and gives guidance on the details of the trading scheme, such as the allocation method and penalties, until 2012.

The European Union is expected to need some 650 GW of new power capacity and to replace some 330 GW of existing power stations over the next 30 years (IEA, 2003a). The economic lifetime of an investment in power capacity typically ranges from 20–40 years (OECD NEA/IEA, 1998). Within the EU ETS, the value of emission allowances can affect the cashflows of a power plant during its entire lifetime. In particular, there is a considerable and fundamental price risk ("what is the value of an allowance? will trading continue?") (see e.g. Springer and Varilek, 2004). The character of the price risk is somewhat different from that of fuels or electricity, which can be considered "genuine necessities" and are already traded in large volumes. IEA (2003b, p. 31) characterizes the price risk as "potentially critical". Any investor within the Community considering investment or divestment of power production licences or capacity, be it a green-field plant, a retrofit of an existing plant or an acquisition, should therefore be interested in the impacts of the allowance trading scheme.

Implications of the EU ETS for investment decisions in the power sector have been discussed on a European

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scale e.g. by Reinaud (2003) and de Leyva and Lekander (2003). In this paper, the impacts of the EU ETS on investment decisions are explored in a more detailed regional setting in Finland. We consider a single-firm optimization problem using an exogenous, stochastic price model,[1] and back the modelling results with an analysis of the investment environment. Section 2 provides a brief review on the general mechanisms through which emissions trading affects size, timing and cashflows of an investment decision. Section 3 explores the projected changes in the Finnish power producers' investment environment. Section 4 examines the financial impacts due to the EU ETS on a case investment decision, a hypothetical 250 MW_e condensing power plant. We extend the broadly used discounted cash flow (DCF) analysis to better reflect the value of two real options:[2] the option to wait and the option to alter operating scale. Finally, some conclusions are drawn.

2. Emissions trading in power investment decisions

Size and timing of the initial investment together with the subsequent annual cashflows mainly determine the financial performance of a power investment. Flexibility in timing gives the investor a valuable *option to wait* for new information. The standard models of irreversible investment under uncertainty show that the value of this option increases with a higher degree of uncertainty in the operating environment (McDonald and Siegel, 1986). As the EU ETS introduces new price risks for capacity investments, it should thus contribute to this direction. On the other hand, it has been argued that emissions trading as such does not reduce a firm's incentive to invest in abatement capital, such as renewable technologies, relative to e.g. emission taxes, since the most important uncertainty factor—the abatement cost uncertainty—is there irrespective of the regulatory instrument (Zhao, 2003).

In addition to the option to wait, investors may also have an *option to stage the investment*: instead of committing to a "lump" project, the investor may implement several smaller projects sequentially. However, this typically results in higher unit costs. It has been argued that a higher uncertainty, e.g. due to emissions trading, may nevertheless cause the investor to prefer the smaller project(s) to the lump project (e.g. Dixit and Pindyck, 1994, pp. 51–54). Kort et al. (2004) have recently called this intuitively appealing result into question. They argue that a higher uncertainty makes the lump investment more attractive relative to the sequential investment.

The cumulative cashflow, *CF*, for a thermal power plant in any selected period can be calculated from:

$$CF = \int P(t)S(t)\,\mathrm{d}t - C_f, \qquad (1)$$

where $P(t)$ is the output capacity (in MW) of the plant at time t, $S(t)$ is the spark spread (in €/MWh) of the plant at time t, and C_f is the fixed cost. The spark spread comprises thus both variable revenues and costs per unit of output. It is a widely used variable for option-based power plant valuations (Deng et al., 2001; Deng and Oren, 2003; Hsu, 1998; Näsäkkälä and Fleten, 2004; Tseng and Barz, 2002).

If Eq. (1) is simplified so that the plant produces electricity only, when $S(t)$ is positive, and always with its maximum capacity P_{max}, we obtain

$$CF = P_{max} \int max\,[S(t), 0]\,\mathrm{d}t - C_f. \qquad (2)$$

Eq. (2) somewhat overestimates revenues due to the technical constraints omitted (Deng and Oren, 2003; Tseng and Barz, 2002).

Emissions trading is likely to impact *CF* through four mechanisms:

- emissions trading will have an impact on *existing cost categories*, such as fuel costs and thus affect the spark spread, $S(t)$. It has been estimated that producer price of coal and oil would decrease compared to a baseline scenario (Holtsmark, 2003; Holtsmark and Mæstad, 2002). Expectations on the impacts on gas producer prices in Europe due to the EU ETS are diverse: while e.g. Holtsmark (2003) projects a decrease in prices, e.g. de Leyva and Lekander (2003) and Reinaud (2003) expect an opposite market reaction. A detailed regional bottom-up analysis in Finland clearly shows that under a free allocation of allowances the demand on gas on the market will increase, which should thus result in a corresponding price increase (Electrowatt-Ekono, 2003). Similarly, the improved competitiveness of biomass is likely to increase its market price. In addition to fuel costs, it has also been identified that emissions trading can cause a pressure to modify the existing energy taxes (see Section 3.2.2).
- emissions trading introduces new costs hence reducing S and increasing C_f. The most important is likely to be the value of surrendered emission allowances. For example, the spark spread for a condensing power plant within the EU ETS can be presented as follows:

$$S = p_e - \frac{p_f}{\eta} - \frac{e_f}{\eta} p_{\mathrm{CO_2}} - \psi, \qquad (3)$$

where p_e is the market price of electricity, p_f is the market price of fuel, $p_{\mathrm{CO_2}}$ is the market price of emission allowances, η is the thermal efficiency of the plant, and e_f is the emission factor of the fuel.

[1] See Ventosa et al. (2004) for a taxonomy on electricity market models.

[2] For an overview on real options, see Trigeorgis (1995).