CO_2 Price Dynamics: The Implications of EU Emissions Trading for Electricity Prices & Operations

J.P.M. Sijm, S.J.A. Bakker, Y. Chen, H.W. Harmsen, and W. Lise

***Abstract*—The experience with CO_2 trading and allowances prices in the last year is reviewed, with a focus on the factors influencing the price of electricity in EU countries. A statistical analysis investigates the relationship between the large increases in electricity prices experienced in 2005 and their relationship to CO_2 prices. In addition, a market simulation analysis using the COMPETES model [2] is performed to assess the extent to which profit-maximizing generators, some of which possess market power, might pass on the opportunity cost of allowances to consumers. The paper concludes by reviewing possible options for policy makers to address the possible adverse implications of price increases caused by CO_2 trading.**

***Index Terms*—CO_2 emissions trading, Economics, Market power, European Union, Electricity Prices**

I. Introduction

SINCE January 2005, the EU Emissions Trading Scheme (EU ETS) has been in force. A major point of controversy and political sensitivity concerns the potential impact of free allocation of emissions allowances on the price of electricity and the resulting implications for power producers, consumers and policy makers as illustrated by ongoing discussions throughout the EU in professional journals, popular media and political arenas. In addition, in 2006, Member States and the European Commission have to decide on this allocation of emission allowances for the second trading period (2008-12), including the option to auction a part of these allowances. Overall, some 10 billion emission allowances of 1 tonne CO_2 each will be allocated for this period. At current prices, this represents a social value of more than 200 billion Euros, about half of which will be allocated to the power sector.

Against this background, the key objectives of the study [1] summarized in this paper include:

- To present a structured overview and qualitative analysis of the underlying, major factors determining the impact of EU emissions trading on the price of electricity.
- To assess the extent of passing through CO_2 costs of freely allocated emission allowances to power prices in Germany and the Netherlands by means of empirical and statistical analyses.
- To provide a quantitative analysis of the potential implications of the EU ETS for power prices in the countries of continental North-Western Europe (Belgium, France, Germany and the Netherlands) by means of the so-called COMPETES model.
- To indicate the socio-economic implications of passing through carbon costs of emissions trading to the price of electricity for major power producers and consumers, including options and strategies for policy makers to address potential adverse implications.

In order to achieve these objectives, the study summarized here has followed a broad approach, including four analytical methodologies:

- Interviews with stakeholders in the power sector of the Netherlands, including major power producers and large industrial consumers of electricity.
- Empirical and statistical analyses of trends in prices of fuels, CO_2 and electricity in Germany and the Netherlands over the period January-July 2005.
- Analyses by means of the COMPETES model [2] of the implications of emissions trading on power prices, generators' profits and other issues related to the wholesale power market in four countries of continental North-Western Europe (Belgium, France, Germany and the Netherlands).
- A survey of the theoretical and empirical literature, notably on the determinants of the impact of emissions trading on the price of electricity. The major results of these analytical approaches and their policy implications are discussed below.

II. Empirical and Statistical Analyses

Trends in prices of electricity, fuels and CO_2 emission allowances have been analysed for Germany and the Netherlands over the period January-July 2005. Based on these trends, rates

J.P.M. Sijm, S.J.A. Bakker, and W. Lise are with the Policy Studies Unit of the Netherlands Energy Centre (ECN), Amsterdam, The Netherlands (sijm@ecn.nl, bakker@ecn.nl, lise@ecn.nl); Y. Chen is with the Dept. of Geography & Environmental Engineering of The Johns Hopkins University, Baltimore, MD, USA (yschen@jhu.edu); and H.W. Harmsen is with Carbonmetrics, Inc., Utrecht, the Netherlands (henk@carbonmetrics.com).

of passing through CO_2 costs in power prices have been analysed for four cases

The major findings of the empirical and statistical estimates of the pass-through rates in Germany and the Netherlands include:

- Given the (autoregressive) character of the power price data, the Prais-Winston method provides most likely better estimates of the pass-through rates than the OLS approach. For the Netherlands, the PW estimates vary between 44 and 47 percent and for Germany between 42 and 69 percent.
- By means of a simple regression-line method ECN has estimated pass-through rates varying from 46 to 73 percent for Germany and from 39 to 55 percent for the Netherlands.
- In addition, ECN has estimated the absolute amounts of CO_2 costs passed through to power prices, based on an average price on the EU ETS market of 15.3 €/MWh over the period January-July 2005. For Germany, these amounts vary from 5.9 €/MWh during the off-peak period to 9.5 €/MWh during the peak load hours (both coal-based cases). For the Netherlands, these amounts vary from 2.8 €/MWh during the peak load period (gas-based case) to 7.2 €/MWh during the off-peak hours (coal-based case). The amount for the gas-based case in the Netherlands is relatively low because the carbon intensity of gas-generated power is much lower (about half) than coal-generated power, while the passing-through rate for gas is relatively low (probably because the gas prices have been very volatile and rapidly rising during the period considered, while coal prices have been rather stable). Moreover, the passing through rate for gas during the peak hours in the Netherlands is likely underestimated due to the underlying assumptions used.

It should be emphasised, however, that these rates and amounts of passing through CO2 costs do not necessarily apply to all installations during all load periods considered. On the contrary, notably in the Netherlands there is a major share of gas installations that must run during off-peak hours, even if it is not profitable, as seems to be the case under forward 2006 price conditions. Under these conditions, such price-following installations are not able to cover the opportunity costs of grandfathered allowances, let alone to realise 'windfall profits' due to emissions trading. On the other hand, it should be recognised that besides potential revenues from heat production these installations may earn significant profits during peak load hours (when prices are relatively high) and that without emissions trading power prices might have been lower during the off-peak hours given the average pass-through rates and the average high CO_2 prices considered.

III. COMPETES MODEL FINDINGS

COMPETES is basically a model to simulate and analyse the impact of strategic behaviour of large producers on the wholesale market under different market structure scenarios (varying from perfect competition to oligopolistic and monopolistic market conditions) [2]. As part of the present study, it has been used to analyse the implications of emissions trading for power prices, firm profits and other issues related to the wholesale power market in four countries of continental North-western Europe (i.e. Belgium, France, Germany and the Netherlands). The major findings of the COMPETES model analyses include:

- Power prices increase significantly due to CO_2 emissions trading under all scenarios considered. In case of a CO_2 price of 20 €/tonne, these increases are generally highest in Germany (13-19 €/MWh) and lowest in France (1-5 €/MWh), with an intermediate position for Belgium (2-14 €/MWh) and the Netherlands (9-11 €/MWh). For these EU4 countries, on average, the increase in power prices is estimated at 6-12 €/MWh, i.e. an increase of about 13-39 percent compared to the power prices before emissions trading.
- Estimates of the pass-through rates are generally high. Most of these rates vary between 60 and 80 percent, depending on the country, market structure, demand elasticity and CO_2 price considered.
- Emissions trading in general and the free allocation of emission allowances have a major impact on business profits of major power companies. Even if it is assumed that these companies have to buy all their CO_2 emission allowances on the market, profits increase significantly under most scenarios (mainly due to the fact that carbon-extensive generators benefit from higher power prices set by carbon-intensive generators). However, power companies receive most of their emission allowances free of charge while part of the opportunity costs of these allowances are passed through into higher power prices, leading to so-called 'windfall profits'. As a result, total business profits increase by some 6-98 percent, depending on the scenario and CO_2 price considered. These figures, however, have to be treated with due care as they refer to model scenario analyses rather than facts of life.

IV. DETERMINANTS OF THE IMPACT OF EMISSIONS TRADING ON POWER PRICES

The impact of EU emissions trading on the price of electricity is determined by three major factors:

- the price of carbon in the EU ETS market,
- the carbon intensity of power production,
- the level of passing through carbon costs.

With regard to the third factor, the so-called 'pass-through rate', a distinction should be made between the extent to which producers add on the opportunity costs of CO_2 emission allowances to their other, marginal costs when making production or trading decisions ('add-on rate') and the extent to which CO_2 allowances costs ultimately work on power prices that are determined by a complex set of market forces ('work-on rate'). Even if the add-on rate is 100 percent, the work-on rate may be (far) less than 100 percent due to a variety of reasons. In general, these reasons include:

- A change in the merit order of the power supply curve due to rising CO_2 costs.
- A change in power demand due to higher ETS-induced power prices.
- The incidence of market power by monopolistic or oligopolistic generators.
- A decline in the gross margin to cover fixed investment costs and/or a decline in oligopolistic mark-ups due to the free allocation of emission allowances.
- A restriction in ETS-induced power price increases by means of regulation or voluntary agreement.
- The incidence of outside competition, for instance by non-fossil generators.
- The development and adoption of carbon-saving technologies induced by changes in carbon prices.
- Other reasons or factors such as the updating of National Allocation Plans or the incidence of non-optimal behaviour among power producers, market imperfections, time lags or other constraints, including (i) the incidence of risks, uncertainties, lack of information, and the immaturity or lack of transparency of the carbon market (ii) the incidence of rapidly rising CO_2/fuel (i.e. gas) prices, and (iii) the incidence of other production constraints, such as a lack of a flexible and liquid gas market.

V. Policy implications

The EU ETS is a cap and trade system based primarily on a free allocation of a fixed amount of emission allowances, often denoted as grandfathering. If applied equally to existing and new fossil-fuel installations, however, such an allocation system may have two opposite effects on power prices with significant different implications for power producers, consumers and policy makers:

- A price increasing effect due to the passing through of the opportunity costs of grandfathering.
- A price compensating or neutralising effect of grandfathering due to its subsidisation of fixed investment costs.

The first grandfathering effect implies that profit maximising producers pass through ('add-on') the opportunity costs of CO_2 emission allowances to their other (short-term) marginal costs when taking production or trading decisions. If this would be the only effect of grandfathering, this would mean that these costs would be passed-through ('work-on') to power prices. As a result costs of CO_2 emissions would be internalised by higher power prices, leading to a more efficient or more optimal situation from a social welfare point of view, including less CO_2 emissions due to (i) less power sales, if power demand is price elastic, and/or (ii) a change in the merit order, if the costs are high enough to effectuate such a change.

In addition, however, passing through of opportunity costs of grandfathering would imply higher power prices for all consumers, including households, small firms, power-intensive industries and other major electricity users. If power-intensive industries are hardly able to pass through the higher costs into their outlet prices due to outside competition or high elastic demand response it would imply that these industries are faced by less profits, less production, less employment and a shift in investment, production and trade opportunities to locations outside the EU ETS (including 'carbon leakage'). Finally, a free allocation of emission allowances implies a transfer of wealth from consumers to producers (called 'economic rent' or 'windfall profits').

On the other hand, the second grandfathering effect implies a lump-sum subsidy to an installation that lowers the fixed investment costs of power generation, which under certain conditions results in a neutralisation of the increase in power prices due to the passing through of the opportunity costs of CO_2 emission allowances. If fully effective, it would mean that power prices, on balance, would not change and, hence, that certain potential adverse effects of higher power prices would not occur. However, it would also imply that external costs of CO_2 emissions would not be internalised through higher prices, leading to a less efficient situation from a social welfare point of view. This means that total CO_2 emissions by the power sector are not significantly decreased through lower demand or by large changes in the generation mix since neither output prices nor the total average costs of generation technologies would change significantly. As a result, emission reductions elsewhere have to be increased to meet overall environmental targets.

In fact, if grandfathering is applied equally to existing and new investments it leads, on the one hand, to an internalisation of external CO_2 emission costs due to the passing through of these costs into higher power prices, on the other hand, this effect may be nullified by the implicit lump-sum subsidy to fixed investment costs due to grandfathering, with the subsidy being higher if the investment is more carbon-intensive. Hence, the impact of grandfathering on emissions reduction may be small, while it encourages investments in carbon intensive generation capacity. Such a contradictory or even perverse approach may be questioned from a consistent and cost-effective environmental policy point of view.

The impact of the second effect of grandfathering will only be effective up to a certain CO_2 price level and in a (long-term equilibrium) situation in which generation capacity is scarce and actually enlarged by investment in new capacity. However, regardless whether and to which extent the first effect of grandfathering will be fully or partially neutralised by the second effect, there will always be a trade-off between these effects with regard to their implications for power producers, consumers and society at large. Either the second effect will not or only partly neutralise the first effect, meaning that on balance power prices will increase, leading to beneficial implications on the one side (less CO_2 emissions by the power sector) and to adverse implications on the other (higher costs to power-intensive industries and other consumers; windfall profits to generators). Or the second effect will fully neutralise the first effect, meaning that on balance power prices will not increase, thereby avoiding not only the adverse implications of higher power prices but also the beneficial implications mentioned above.

In order to address the adverse implications of grandfathering, the study [1] summarized in this paper discusses a wide variety of power options and strategies. These options and strategies include:

- indirect allocation of emission allowances
- auctioning
- regulation
- benchmarking with ex-post allocation adjustments
- limiting the price level of a CO_2 emission allowance
- encouraging competition in the power sector
- abolishing grandfathering to new investments
- taxation
- state aid
- other long-term options such as broadening the climate coalition or encouraging carbonsaving technologies in the power sector
- strategies at the level of power consuming industries such as energy saving, stringent power contract negotiations, or self-generation of electricity.

However, there seems to be no ideal option or package of options to address these implications as each option has its specific pros and cons. Overall, auctioning seems to be a better option than grandfathering or an ex-post benchmarking system. While auctioning would raise power prices by the costs of the CO_2 allowances, it would have several beneficial effects, including (i) avoiding windfall profits among producers, (ii) enhancing environmental-economic efficiencies by internalising the external costs of CO_2 emissions into the power price, (iii) raising public revenues that could be used to mitigate potential drawbacks of rising power prices, and (iv) treating incumbents and newcomers equally while avoiding potential distortions of new investment decisions.

In the end, however, allocation of economic rents is a political issue belonging to the world of policy makers.

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VI. References

[1] Sijm, J.P.M., S.J.A. Bakker, Y. Chen, H.W. Harmsen, and W. Lise, "The implications of EU emissions trading for the price of electricity," ECN-C—05-081, 2005, www.ecn.nl/library/reports/2005/c05081.html

[2] Hobbs, B.F. and F. Rijkers (2004): 'Strategic Generation with Conjectured Transmission Price Responses in a Mixed Transmission System I: Formulation', IEEE Transactions on Power Systems, Vol. 19, No. 2, pp. 707-717

Biographies

Jos Sijm is a senior economist at the Energy Research Centre of the Netherlands (ECN). He holds a Ph.D. in development economics from the Tinbergen Institute (Erasmus University Rotterdam). He has been actively involved in a large variety of research projects dealing with energy and climate policy issues, including the implementation of the EU Emissions Trading Scheme.

Stefan Bakkeris a researcher energy and climate policy at ECN. He has a Bachelor degree in Chemical Engineering and a Master degree in Environmental Science. His work focuses on international climate policy issues notably research projects regarding the implementation of the Kyoto flexible mechanisms, the EU Emissions Trading Scheme, and post-2012 climate policy strategies.

Yihsu Chen received his Master degree from the Harvard School of Public Health in 1999 and is now a Ph.D. candidate in the Dept. of Geography & Environmental Engineering of The Johns Hopkins University. His B.S. is in Environmental Science at Tunghai University in Taiwan.

Henk Harmsen obtained his Master degree in Environmental Management from the Imperial College at Wye, University of London. He has worked for the United Nations, KPMG and ECN. At present, he runs his own consultancy bureau, Carbonmetrics, dealing with environmental and climate policy issues.

Wietze Lise is economic researcher at ECN, working in the Energy Markets and International Climate Policy group of the Policy Studies department, which he joined in 2005. He received his Ph.D. (Economics) degree from the Delhi School of Economics, India, in 1999 and his MSc (Applied Mathematics) from Twente University, Enschede, the Netherlands in 1992.