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Emissions trading: Impact on electricity prices and energy-intensive industries


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Emissions Trading: Impact on Electricity Prices and Energy-Intensive Industries

Under the EU-wide Emission Trading Scheme (ETS), CO₂ allowances have thus far been allocated largely free of charge. This paper presents a didactic synthesis on the impact of the ETS and argues that such a cost-free allocation will lead to an increase in electricity prices even when strong competition prevails in electricity markets. Electricity prices are also likely to increase as a consequence of the environmentally desirable fuel switch from coal to natural gas in the power sector when certificates are entirely auctioned in the power sector as of 2013. This tendency may be attenuated, but not outweighed, by the price decrease of CO₂ allowances over the long term.

The European Union’s CO₂ emission target, stipulated in the Kyoto Protocol, aims at an emission reduction of 8% relative to 1990 between 2008 and 2012. The EU-wide emissions trading scheme (ETS), established in 2005, is a key pillar of the European Commission’s strategy to achieve this target. As documented in the environmental economics literature, emissions trading schemes are an economically efficient means to achieve exogenously set emission reduction targets. Although the alternative of CO₂ taxation would be an equally cost-effective measure, its associated emissions reductions emerge endogenously as the market adjusts to higher CO₂ costs. Thus, a CO₂ tax does not ultimately ensure the achievement of a given reduction target.

After the introduction of the ETS, European electricity prices increased along with those of the emission certificates, alternatively called allowances or permits. This correlation instigated an intense debate concerning the distributive and welfare implications of the ETS, particularly in Germany. Confusion reigned among consumers as to why they faced an increase in prices and, ultimately, in electricity bills despite the cost-free allocation of CO₂ certificates in the majority of EU countries. Fuelled by the media and political posturing, it was commonly suspected that electricity suppliers used the introduction of this climate policy instrument as a pretext for increasing electricity prices, and hence, their profits. It was further alleged that this outcome could be prevented if electricity markets were more competitive.

While providing for a didactic synthesis on the impacts of the ETS, this paper sets out to demonstrate why both of these conclusions are mistaken. Rational economic behaviour by power producers was bound to lead to an increase in electricity prices, in spite of the cost-free allocation of CO₂ certificates based on historical emissions, commonly called grandfathering, and irrespective of whether strong or weak competition prevails on electricity markets. Indeed, price increases for electricity are even desirable from an economic and environmental perspective, as this induces consumers to reduce their demand for electricity. Just such a price increase was predicted by economists prior to the introduction of the ETS.

The authors thank Joachim Schmidt and five anonymous reviewers for valuable comments and suggestions.

3 T. Tietenberg, op. cit., p. 410.
portunity cost in price setting would be completely igno-
rant of the functioning of a market economy.

If certificates are grandfathered, rather than auctioned, the ETS-induced price increases of outputs such as elec-
tricity lead to considerably higher revenues at no addi-
tional cost – that is, to windfall profits. Our estimations for
Germany’s power sector indicate that these windfall profits
may be substantial, a conclusion that is substantiated by
Sijm et al.\(^5\) for the case of the Netherlands’ power sector, as
well as by Chen et al.\(^6\) for northwest Europe. With a CO\(_2\) tax,
by contrast, it would be the government, rather than private
firms, that would receive the increased payments by con-
sumers. It therefore may well be justified for governments
to extract some of these windfall profits via certificate auc-
tioning, as stipulated by the European Commission for the
third trading period (2013-2020). As of 2013, all certificates
required by the European electricity producers will be auc-
tioned.

It is commonly argued, however, that the abrupt transition
to auctioning may endanger the competitive position of
energy-intensive industries in Europe by imposing the CO\(_2\)
cost upon them, even though these industries already suf-
f er from the indirect cost originating from the ETS-induced
electricity price increases. This is all the more important as
it is probable that long-term electricity prices will increase
due to the power sector’s environmentally desirable fu-
el switch to natural gas, which will be triggered when the
certificates are auctioned. This likely increase in electric-
ity prices due to the forced retirement of coal-fired power
plants and investments in new gas-fired power plants may
be attenuated, but not outweighed, by the long-term price
decrease of CO\(_2\) allowances following the emissions reduc-
tions in the electricity sector.

Using the empirical example of electricity production,
we demonstrate in the subsequent section that passing
through the value of grandfathered certificates to output
prices is in perfect accord with rational economic behaviour
and, hence, is no indication of a lack of competition. Then,
we appraise the magnitude of the windfall profits accru-
ing to Germany’s power sector before shifting attention to other
energy-intensive sectors. While empirical evidence on the
impacts of the ETS is scant, the findings reviewed here cast
doubt on the efficacy of the ETS as an instrument to reduce
global emissions as long as the other major industrial and

transition countries reject integration into a comprehensive
global emissions trading system.\(^7\)

**CO\(_2\)** Certificates, Electricity Prices and Market Power

Electricity markets follow the same economic laws as
other markets but with some important particularities. Two key properties of electricity are that, first, it cannot
be stored at low cost in large quantities and, second, its
demand is highly price inelastic in the short term but sub-
ject to substantial temporal fluctuations. These properties
imply a high degree of volatility in electricity prices. In the
public debate, these substantial fluctuations are frequent-
ly misinterpreted as a sign of weak competition among
electricity producers. In a similar vein, public scepticism
was also aroused by the ETS-induced increase in elec-
tricity prices following the largely cost-free allocation of
CO\(_2\) emission allowances.

Neither phenomenon, however, can be taken as an indi-
cator for the presence of market power.\(^8\) Rather, the elec-
tricity price-raising impact of certificates would also arise
under perfect competition. Regardless of whether cer-
tificates are distributed at no cost or are purchased, they
have a value that can be observed on a daily basis at ex-
changes such as the Leipzig Power Exchange. Because
of the possibility to sell certificates at their market price, a
rational electricity supplier will only produce a megawatt
hour (MWh) of electricity if the profit from electricity gen-
eration is at least as high as the revenue that would be
garnered from selling the otherwise required certificates
in the market. The electricity price that a rational supplier
therefore requests should cover both production and op-
portunity costs, where in this case the opportunity cost
originates from the value of the certificates.

Although opportunity costs are not incurred in the same
sense as the actual costs associated with inputs to elec-
tricity production, such as natural gas, this kind of cost is
nevertheless equally price relevant: Irrespective of wheth-
er an emission allowance has been obtained via grand-
fathering or through an auction, the electricity producer
always has the option of selling it at the exchange rather
than actually using it in the production process. Indeed,
as illustrated in the following, the fact that electricity price-

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5 J. Sijm, K. Neuhoff, Y. Chen: CO\(_2\) cost pass through and wind-
fall profits in the power sector, in: Climate Policy, Vol. 6, No. 1, 2006,
pp. 49-72, here p. 49.

6 Y. Chen, J. Sijm, B.F. Hobbs, W. Lise: Implications of CO\(_2\) emis-
sions trading for short-run electricity market outcomes in northwest
Europe, in: Journal of Regulatory Economics, Vol. 34, No. 3, 2008,
pp. 251-281.

7 See e.g. C. Böhringer, C. Fischer, K.E. Rosendahl: The Global
Effects of Subglobal Climate Policies. Symposium Distributional As-
pects of Energy and Climate Policy, in: The B.E. Journal of Economic

8 Market power is defined as the ability of a producer to raise the price
above the level that would prevail under full competition. In the ideal
situation of full competition, all market participants are “price takers”
and have no ability whatsoever to influence the price. In this theoretic
ideal, prices equal the marginal costs of production.
es reflect this option is independent of whether individual suppliers can exercise market power\(^9\) and of the allocation mechanism in place, whether this is grandfathering, auctioning or some mixture of the two.

It is a fallacy to attribute the pass-through of allowance prices to market power because the extent of this pass-through is a function of the supply and demand elasticities, even in the case of perfect competition. According to economic theory, the degree to which firms’ higher production costs are passed on to consumers depends on the relative price elasticities of supply and demand. Given the notoriously price-inelastic demand for electricity\(^10\), it is reasonable to surmise that CO\(_2\) prices would largely be passed on to consumers, even if perfect competition prevailed in the electricity production sector.

That the intensity of competition plays a secondary role in the pass-through of CO\(_2\) prices is demonstrated by a simulation exercise for Belgium, France, Germany and the Netherlands.\(^11\) The decisive factor is instead seen in the distinct mix of fuels used for electricity production, which differs substantially across these countries (see Table 1). According to the simulation results, a plausible CO\(_2\) price of €20/tonne would have a particularly strong effect in raising electricity prices only in Germany, where the price increase of electricity would lie between €13 and €19/MWh.

\(^{9}\) The suggestions by politicians, consumers and cartel offices that electricity producers not include the value of grandfathered certificates in electricity prices are fundamentally at odds with free market principles. Were the electricity sector forced to do so, rational electricity producers would reduce production, thereby driving up electricity prices to the point that the sale of certificates would become the unattractive alternative relative to production. As a result, market laws ensure the inclusion of the certificates’ value in the electricity price even in the presence of command and control measures. In short, the widely held view that the inclusion of allowance values in electricity prices can be regarded as an indicator of the absence of competition among utilities is misplaced.

\(^{10}\) E.R. Branch: Short Run Income Elasticity of Demand for Residential Electricity Using Consumer Expenditure Survey Data, in: Energy Journal, Vol. 14, No. 4, 1993, pp. 111-121, here 111, for example, estimates the electricity price elasticity in the USA to be \(-0.2\). Accordingly, a price increase of 10% would be accompanied by a decrease in electricity consumption of 2%. In a review of the literature from E.R. Branch, op. cit. p. 119), the electricity price elasticity in the USA ranges from \(-0.11\) to \(-0.55\). In contrast to electricity, individual mobility demand seems to be much more elastic. An international survey of empirical studies by P. Goodwin, J. Dargay, M. Hanly: Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review, in: Transport Reviews, Vol. 24, No. 3, 2004, pp. 275-292, cites fuel price elasticities varying between \(-0.89\) and \(-0.04\). For Germany, specifically, M. Frondel, N. Ritter, C.M. Schmidt: Germany’s solar cell promotion: Dark clouds on the horizon, in: Energy Policy, Vol. 36, No. 11, 2008, pp. 4198-4204 and M. Frondel, C. Vance: Do High Oil Prices Matter? Evidence on the Mobility Behavior of German Households, in: Environmental and Resource Economics, Vol. 43, No. 1 2009, pp. 81-94 find fairly high elasticities ranging between \(-0.6\) and \(-0.4\).

\(^{11}\) J. Sijm et al., op. cit., p. 61.

### Table 1

<table>
<thead>
<tr>
<th></th>
<th>Germany</th>
<th>France</th>
<th>Belgium</th>
<th>Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear Power</td>
<td>22.6</td>
<td>75.6</td>
<td>52.0</td>
<td>3.7</td>
</tr>
<tr>
<td>Hydro Power</td>
<td>3.9</td>
<td>11.4</td>
<td>2.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Wind Power</td>
<td>6.3</td>
<td>1.4</td>
<td>1.1</td>
<td>4.1</td>
</tr>
<tr>
<td>Coal</td>
<td>44.3</td>
<td>5.1</td>
<td>6.7</td>
<td>23.4</td>
</tr>
<tr>
<td>Oil</td>
<td>2.1</td>
<td>1.1</td>
<td>0.8</td>
<td>1.2</td>
</tr>
<tr>
<td>Gas</td>
<td>12.9</td>
<td>4.1</td>
<td>31.9</td>
<td>60.4</td>
</tr>
<tr>
<td>Others</td>
<td>7.8</td>
<td>1.2</td>
<td>5.6</td>
<td>7.0</td>
</tr>
</tbody>
</table>


The corresponding price increase in France is considerably lower, ranging between €1 and €5/MWh, while it lies in an intermediate range between €9 and €11/MWh for the Netherlands, depending on whether the market structure is assumed to be oligopolistic, monopolistic or fully competitive and on whether the calculation specifies demand which is completely inelastic or moderately elastic.

Given that the various generation technologies imply different CO\(_2\) emissions per MWh and therefore distinct opportunity costs, these results are not surprising in light of the fuel mix in the electricity production of these countries. While France relies on CO\(_2\)-free nuclear power for roughly 75% of its electricity generation,\(^12\) gas-fired plants with comparably low CO\(_2\) emissions are dominant in the Netherlands, owing to the country’s gas deposits. In Germany, by contrast, electricity prices are largely determined by coal-fired plants. Accordingly, the EU-wide prices for CO\(_2\) allowances increase electricity prices more in Germany than in countries with less carbon-intensive electricity production, an effect that will be exacerbated by Germany’s nuclear phase-out by 2022. EU-wide uniform CO\(_2\) prices will continue to have disparate effects on the electricity prices in the individual countries until there is a sufficiently integrated electricity market in Europe. This, however, is unlikely to be achieved in the foreseeable future, given inadequate cross-country network capacities.

### The Magnitude of Windfall Profits

Given the observed electricity price increases in the aftermath of the ETS introduction, it is of interest to provide a crude estimate of the magnitude of associated windfall profits. Although the data required for precise calculations...
Nuclear power, in particular, does not cause any CO₂ emissions and, hence, does not suffer at all from penalising CO₂. It is therefore reasonable to surmise that a large share of windfall profits can be ascribed to CO₂-free nuclear power generation. This is in line with Sijm et al.¹⁵, who conclude that given their high share of nuclear power in total generation, Électricité de France (EdF) and Germany’s E.ON may benefit most from emissions trading, even if electricity producers have to buy all their allowances. Note that even without ETS, both nuclear and hydro power benefit from their lower variable unit production costs relative to coal (see Figure 1).

Using the electricity production data for Germany presented in Table 2, the windfall profits attributed to nuclear-based electricity production in 2006 were on the order of €2.3 billion. This estimate is obtained by multiplying 167.5 million MWh of nuclear power by the price increase of €13.9/MWh, which results from the assumed 80% pass-through of CO₂ costs for brown coal-based electricity production. Additional windfall profits accrue to electricity production from hydro power, which also incurs no CO₂ costs. In 2006, 27.9 million MWh of electricity were produced from hydro power. If it is again assumed that the CO₂ opportunity cost is €13.9/MWh, the estimated windfall profits associated with hydro power amount to another €0.4 billion. In short, the CO₂-free electricity production from nuclear and hydro power alone may have accounted for some €2.7 billion of the windfall profits realised by German electricity producers in 2006, illustrating the enormous economic significance of the ETS.

While nuclear, hydro and brown coal power plants are typically employed to satisfy base-load demand, the higher cost of production in brown coal power plants usually determines the electricity price in base-load times.¹⁴ Hence, under the ETS regime it is the additional CO₂ cost of electricity production from brown coal that increases base-load prices, irrespective of whether electricity is produced from brown coal, nuclear or hydro power.

While benefitting from these ETS-induced price increases, electricity sources with lower CO₂ emissions than brown coal also incur less additional cost from any CO₂ penalty. Nuclear power, in particular, does not cause any CO₂ emissions and, hence, does not suffer at all from penalising CO₂. It is therefore reasonable to surmise that a large share of windfall profits can be ascribed to CO₂-free nuclear power generation. This is in line with Sijm et al.¹⁵, who conclude that given their high share of nuclear power in total generation, Électricité de France (EdF) and Germany’s E.ON may benefit most from emissions trading, even if electricity producers have to buy all their allowances. Note that even without ETS, both nuclear and hydro power benefit from their lower variable unit production costs relative to coal (see Figure 1).

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In addition to nuclear and hydro power plants, the CO₂-free electricity production by wind power and other renewable energy technologies – generously supported by Ger-

### Table 2

<table>
<thead>
<tr>
<th>Gross Electricity Production in 2006 in Germany</th>
<th>million MWh</th>
<th>Shares</th>
<th>t CO₂/MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear Power</td>
<td>167.4</td>
<td>26.3%</td>
<td>0.000</td>
</tr>
<tr>
<td>Brown Coal</td>
<td>152.0</td>
<td>23.9%</td>
<td>1.003</td>
</tr>
<tr>
<td>Hard Coal</td>
<td>136.0</td>
<td>21.4%</td>
<td>0.924</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>73.5</td>
<td>11.6%</td>
<td>0.470</td>
</tr>
<tr>
<td>Hydro Power</td>
<td>27.9</td>
<td>4.4%</td>
<td>0.000</td>
</tr>
<tr>
<td>Wind Power</td>
<td>30.5</td>
<td>4.8%</td>
<td>0.000</td>
</tr>
<tr>
<td>Biomass, etc.</td>
<td>38.0</td>
<td>6.0%</td>
<td>0.000</td>
</tr>
<tr>
<td>Others</td>
<td>10.5</td>
<td>1.7%</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>635.8</td>
<td>100.0%</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: CO₂ emissions factors are taken from M. Klobasa, M. Ragwitz: Gutachten zur CO₂-Minderung im Stromsektor durch den Einsatz erneuerbarer Energien, Fraunhofer Institut für System- und Innovationsforschung, Karlsruhe 2005, p. 20.


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¹³ J. Sijm et al., op. cit., p. 67.
¹⁵ J. Sijm et al., op. cit., p. 63.
man electricity consumers on the basis of the Renewable Energy Sources Act\(^\text{16}\) – also leads to windfall profits for conventional electricity producers.

Not least, even the CO\(_2\)-intensive electricity production from brown and hard coal profits from the cost-free allocation of certificates. Assuming for the sake of simplicity that the producers of brown coal-based electricity were to have received all required emission permits without any charge, the windfall profits resulting from the production of 152.0 million MWh of electricity produced from brown coal in 2006 would have hypothetically added up to €2.1 billion, again assuming the extra CO\(_2\) cost to be €13.9/ MWh. Of course, the €2.1 billion figure overestimates the true windfall profits of coal-based electricity production, as there were some moderate CO\(_2\) abatement obligations in the first trading period (2005-2007).\(^\text{17}\)

**Impacts on Energy-Intensive Industries**

By certificate auctioning, such windfall profits could be diminished. This possibility is one of the primary reasons why in the second trading period (2008-2012) German electricity producers must purchase almost 9% of the certificates that are allocated to the sectors participating in the ETS.\(^\text{18}\) This is close to the auctioning limit of 10% that is stipulated by the European Commission for the second trading period. For the third trading period (2013-2020), the Commission decided to expand the extent of the auction to cover 100% of all certificates required by European electricity producers.

This may adversely affect the electricity-producing sector, as well as many other industry sectors, as further electricity price increases can be expected to accompany a full auctioning. This consequence appears to be likely given the current CO\(_2\) cost pass-through rates of less than 100%.\(^\text{19}\) The incapability of producers of brown coal-based electricity to pass through the entire CO\(_2\) cost to electricity prices would lead to losses under a complete auctioning. This is illustrated by Figure 2, which shows that with an imperfect pass-through of the CO\(_2\) cost, the total cost of brown coal-based electricity production is not completely covered by the prevailing electricity price level.

A study of the UK electricity sector initiated by the Carbon Trust\(^\text{20}\) confirms this potential auction outcome: without free allowance allocation, the sector incurs losses under a scenario that presumes CO\(_2\) prices of €25/tonne. This level appears to be realistic given the price range of up to €30/tonne that has been observed thus far for ETS emissions certificates. To avoid losses, it may well be expected that producers would seek to push electricity prices higher by reducing supply.

Without a doubt, emission-intensive plants, such as those producing electricity from brown and hard coal, incur large CO\(_2\) costs from complete auctioning, thereby triggering the environmentally desirable conversion from high to low-emission technologies. In the short run, European electricity producers involved in the ETS would increase their utilisation of existing gas power plants in place of coal power plants. Over the long term, a complete auctioning would most likely accelerate the retirement of coal power plants and the installation of new gas-fired plants. According to the Carbon Trust\(^\text{21}\), this is the main abatement option for the EU electricity sector. The investment cost and higher operating costs of the new gas-fired power plants will put upward pressure on electricity prices. A February 2008 paper by the Swiss bank UBS predicts that 43% of Europe’s coal-fired power generation will be converted to gas.\(^\text{22}\)

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\(^{17}\) According to Germany’s National Allocation Plan (NAP1), in the first trading period (2005-2007) existing plants were forced to undertake a CO\(_2\) reduction of 2.91% relative to the historical emission level, resulting in a need to purchase additional allowances.

\(^{18}\) In fact, the purchase of 9% of the total number of allowances that are allocated to the German sectors participating in the ETS covers 40 million tonnes of the annual CO\(_2\) emission volume of 453.1 million tonnes allowed by the European Commission for the second trading period (NAP2 2007, p. 20), with the German electricity sector responsible for about 70% of the overall CO\(_2\) volume emitted by the German industries involved in the ETS.

\(^{19}\) J. Sijm et al., op. cit, p. 67.


\(^{21}\) Carbon Trust, op. cit., p. 12.

prices over the long term but will increase long-term gas demand and, hence, the prices of gas and electricity in general. This would result in further pressure on European industries, which already face relatively high electricity prices compared with North America and non-EU European countries such as Norway and Switzerland (Table 3). These long-term effects of a complete auctioning on power prices and on the competitive position of European industry have received scant attention in both empirical studies and theory. Despite the substantial economic repercussions to be expected from the ETS, there are few empirical analyses that explore the effects of the higher electricity prices from emissions trading on the energy-intensive industries in Europe. A particularly conspicuous research lacuna concerns the effects of a complete auctioning, though a major reason for this is that to date no complete auctioning system has been put into practice. In the USA, for example, one of the first countries to use an emissions trading system, certificates have been almost exclusively grandfathered on the basis of historical emissions.

Besides the Carbon Trust study on the implications of the ETS for the competitiveness of European industrial sectors, one of the few relevant studies is the “Report on International Competitiveness”27, which was commissioned by the Directorate-General for the Environment of the European Commission and carried out by Ecofys and McKinsey. Because both studies do not consider future developments of Europe’s power sector, their results reflect the short-term effects of the ETS. With a complete auctioning of certificates, however, it is most likely that the fuel mix of European power generation would change significantly, with substantially higher demand for natural gas and increasing gas and electricity prices as potential consequences. There is apparently no empirical study that addresses these long-term issues, and the report from Ecofys and McKinsey is no exception. Nevertheless, this study shows that even under the assumptions of small-scale auctioning accompanied by a grandfathering of 95% of allowances and a

Table 3
Electricity Prices for Industries (2002-2009)
in US cents per kWh

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>11.03</td>
<td>16.1</td>
<td>21.0</td>
<td>27.6</td>
</tr>
<tr>
<td>Germany</td>
<td>4.9</td>
<td>7.7</td>
<td>9.4</td>
<td>13.5</td>
</tr>
<tr>
<td>UK</td>
<td>5.2</td>
<td>6.7</td>
<td>11.7</td>
<td>13.4</td>
</tr>
<tr>
<td>France</td>
<td>3.7</td>
<td>5.0</td>
<td>5.1</td>
<td>10.7</td>
</tr>
<tr>
<td>Switzerland</td>
<td>7.0</td>
<td>8.4</td>
<td>8.0</td>
<td>9.4</td>
</tr>
<tr>
<td>USA</td>
<td>4.8</td>
<td>5.3</td>
<td>6.2</td>
<td>6.8</td>
</tr>
<tr>
<td>Norway</td>
<td>3.1</td>
<td>4.3</td>
<td>5.5</td>
<td>5.9</td>
</tr>
<tr>
<td>Canada</td>
<td>3.9</td>
<td>4.9</td>
<td>5.9</td>
<td>5.9</td>
</tr>
<tr>
<td>Japan</td>
<td>11.5</td>
<td>12.7</td>
<td>11.7</td>
<td>15.8</td>
</tr>
</tbody>
</table>


A CO\textsubscript{2} price of €20, the impact of CO\textsubscript{2} penalties on electricity prices could be substantial for energy-intensive industry sectors.

Among the most greatly affected would be the highly electricity-intensive aluminium producers, despite the fact that they have not been involved in the ETS so far. Although not directly affected by CO\textsubscript{2} cost, this sector is indirectly impacted by the ETS-induced electricity price increases. Its migration to countries with low electricity prices, such as the Gulf States of the Middle East or Iceland, would clearly be accelerated by an auctioning system. Small et al., for instance, reach this conclusion for Great Britain as well as for Europe in general. Their study shows that aluminium production on the island would already be completely abandoned at a CO\textsubscript{2} price of €15/tonne even if all allowances were grandfathered. Similar consequences could be expected for other electricity-intensive industries, such as copper production.

For this reason, Ecofys and McKinsey conclude that for energy-intensive industry sectors – and only those sectors are involved in the ETS – the “possibility of production shifts and CO\textsubscript{2} leakage is real”. In other words, the ETS-induced burden placed on energy-intensive European industries leads to a transfer of emissions to other countries that have no such climate protection costs. The emissions reduction within the EU would then be offset by emissions increases outside the EU, a phenomenon commonly referred to as the leakage effect.
to as carbon leakage,\textsuperscript{32} which is conventionally defined as the change in foreign emissions as a share of domestic emissions reduction. Of particular concern is leakage to emerging countries that lack comparable environmental regulation.\textsuperscript{33}

Three drivers account for carbon leakage. First, high-polluting industries may relocate outside the EU. Second, imports of pollution-intensive goods may diminish production within Europe. Third, a substantial reduction of the energy demand in countries with strongly curbed emissions could lead to lower energy prices worldwide, which would in turn increase demand for fossil fuels in the remaining countries. While sceptics argue against overestimating the carbon leakage effect, given that environmental regulations are but one of many factors determining firm location, the possibility of resettlement must nevertheless be acknowledged.\textsuperscript{34}

The possibility that the importation of pollution-intensive goods could curb European production and not decrease global emissions accordingly appears to be of high relevance. For example, using a trade model for homogeneous goods with high transportation costs and under the assumptions of 90\% grandfathering of allowances and a CO\textsubscript{2} price of €20/tonne, Demailly and Quirion\textsuperscript{35} find leakage effects of 50\% in the cement industry, a sector that accounts for around 5\% of global anthropogenic CO\textsubscript{2} emissions. In other words, roughly half of the emission-savings would be offset by cement imports from non-EU countries, with a corresponding decrease in cement production within the EU as a result.\textsuperscript{36} This decreased production would not imply a reduction in profits, however, because the EU cement industry could sell its unused allowances, 90\% of which were obtained for free. But if these certificates were auctioned at a rate of 50\% or higher, the study finds that the cement industry would have to contend with substantial cuts in profits.

The variety of leakage rates resulting from various studies using CGE (computable general equilibrium) models is considerable, ranging from 10-30\% on the low end\textsuperscript{37} to rates above 100\% for oligopolistic market structures.\textsuperscript{38} For individual sectors, calculated leakage rates can be much higher than the average rates.\textsuperscript{39} In response to carbon leakage concerns, several OECD countries are proposing trade-related measures, such as border carbon adjustments (BCAs), to complement their climate policies. BCAs require importers to purchase emissions allowances in proportion to the emissions embodied in the foreign production of goods, whereas on the other side they would give rebates to exported goods, depending on a benchmark of their emissions intensity. These rebates keep domestic goods competitive on world markets. The EU has so far used preferential allocation of grandfathered allowances to allay concerns about losing profits to foreign competitors, whereas the USA, Australia and New Zealand propose output-based rebating as another form of free allocation to offset most of the carbon cost increases to their energy-intensive, trade-exposed industry sectors.

Such measures, however, are controversial. Some analysts believe that they may harm industries in developing countries while minimally mitigating total carbon emissions. Others argue that these trade policy measures are disguised restrictions to trade, intended primarily to protect the competitiveness of domestic industries in OECD countries.\textsuperscript{40} Missing from much of the debate on trade-related measures, though, is a broader understanding of the effects of climate policies that are implemented unilaterally or sub-globally.

Using a CGE modelling framework, Böhringer, Fischer and Rosendahl\textsuperscript{41} investigate how unilateral and sub-global climate policies implemented in either the EU or the USA, or in both regions, affect the global distribution of economic and environmental outcomes and how these outcomes may be altered by complementary anti-leakage policies. With a leakage rate of up to 28\%, carbon leakage is highest if only the EU countries reduce their emissions, whereas

\begin{footnotesize}
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\item 33 C. Böhringer et al., op. cit., p. 1.
\item 36 According to M. Grubb, K. Neuhoff: Allocation and Competitiveness in the EU Emissions Trading Scheme: Policy Overview, in: Climate Policy, Vol. 6, 2006, pp. 7-30, here p. 12, this high leakage rate can be explained by the large output price increases due to ETS-induced CO\textsubscript{2} costs that tend to “overcome the barriers that have traditionally kept foreign imports out”.
\item 40 C. Böhringer et al., op. cit., p. 1
\item 41 C. Böhringer et al., op. cit.
\item 42 Ibid., pp. 18-19.
\end{itemize}
\end{footnotesize}
the leakage rates are lower than 10% if only the USA reduces emissions. An important reason for this discrepancy is that imports and exports in the USA constitute a smaller share of the economy than in the EU. Another reason for the higher leakage with a unilateral EU climate policy is that this region's energy-intensive industries are less carbon-intensive than those in the USA. While the net effect of anti-leakage policies on worldwide abatement costs is moderate, none of the countervailing policies reduce leakage rates very much.43

**Summary and Conclusions**

One of the key points emerging from our review of the EU’s experience with emissions trading is the potential for adverse economic repercussions from unilateral climate policies. Based on the theory of finance, unilateral action may lead to not only a reduction of other countries’ incentives to diminish greenhouse gas emissions44, thereby compromising the EU’s bargaining position in global climate negotiations45, but also to large carbon leakage effects, whereby production is shifted to countries lacking stringent climate protection regimes.

These considerations may have been reason enough for the European Commission to avoid the abrupt transition from the current 10% auctioning to a 100% auctioning of certificates beginning in 2013. Instead, the share of permits that must be auctioned by the industry sectors other than electricity will be increased successively, from 20% in 2013 to 70% in 2020.46 With a complete auctioning, after all, the competitive position of energy-intensive EU industries facing strong international competition would suffer relative to their counterparts in countries without comparable environmental costs, with detrimental effects on economic growth, income and employment.47 In addition to ETS-induced electricity price increases, frequently called indirect CO2 cost, the direct production cost increases resulting from auctioning may generate a heavy burden for energy-intensive industry sectors, such as the cement industry or copper and aluminium producers.

The Commission’s decision on the exceptional 100% grandfathering of allowances for the most efficient 10% of firms in those industries that would suffer from carbon leakage48 does not create additional incentives to reduce emissions beyond those already reflected in the ETS-induced higher electricity prices. Nevertheless, these non-electricity sectors should be completely exempted from the auctioning of certificates as long as all other major industrial and transition countries abstain from serious climate protection measures and reject integration into a comprehensive global emissions trading system.

It bears particular emphasis that the future obligation for European electricity producers to purchase all certificates beginning in 2013 may have serious long-term consequences, in that it may trigger a substantial increase in the EU’s demand for natural gas. In the long run, this may ultimately lead to higher electricity prices via increasing gas prices, as well as greater reliance on gas imports, in particular from Russia.49 Not only would a complete auctioning thus undermine the EU’s endeavour to improve its energy security situation, it could also result in dramatic changes in countries such as Poland, whose electricity production largely rests on coal-fired plants. Coal-based production currently accounts for 93.1% of total Polish electricity generation.49 Although there is the exceptional rule of an annually increasing auctioning share for the electricity sectors of several new Member States such as Poland, electricity is anticipated to become much more expensive in these EU countries when full auctioning is prescribed in 2020.

This is all the more relevant as it bears noting that after 2012, a substantial reduction in emissions will be required if compliance with the ambitious European climate protection goals set for 2020 is to be achieved. To reach the EU target of a 20% reduction relative to 1990 by 2020, the European Commission will uniformly reduce the overall emission cap for the ETS sectors by 1.74% per annum, beginning with the year 2010.49 This would yield a CO2 emission reduction in the ETS sectors of 21% relative to 2005, a drastic cut compared to the EU’s Kyoto target of an 8% reduction relative to 1990 between 2008 and 2012. The most likely consequences would be higher certificate prices, thereby making electricity even more expensive.

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43 C. Böhringer et al., p. 29.
48 These are industries that would incur additional carbon cost of at least 5% of their value added and face a trade intensity of at least 10%. If either of these so-called carbon leakage risk criteria exceeds the threshold of 30%, this risk is regarded as permanent for such an industry, giving rise to an unconditional grandfathering of permits for such industries in the future (BMU, op. cit.). Yet, only those firms among the 10% of the most efficient in their sector receive 100% of the permits for free. As a consequence, very inefficient firms in sectors suffering from carbon leakage may need to auction a substantial share of permits, which may easily exceed the share of permits freely allocated to them.
49 D. Helm, op. cit., p. 37.