Differentiation and dynamics of competitiveness impacts from the EU ETS

Misato Sato,* Michael Grubb, Jim Cust, Katie Chan, Anna Korppoo, Pablo Ceppi

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Abstract

We summarises the main factors that differentiate impacts of the EU ETS on profitability and market share. By examining sampling a range of sectors, we present some simple metrics and indicators to help judge the nature of potential impacts. We also consider briefly the mitigation response to these impacts by sectors, and how they may evolve over time. The broad conclusion confirms the *aggregate* findings presented in the existing literature - most participating sectors are likely to profit under the current ETS structure out to 2012 at the cost of a modest loss of market share, but this may not hold for individual companies and regions. The period 2008-12 can assist participating sectors to build experience and financial reserves for longer term technology investments and diversification, providing the continuation and basic principles of the EU ETS post-2012 is quickly defined and incentives are in place for sectors to pursue this.

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Emissions trading, industrial competitiveness, spillovers, allowance allocation, perverse incentives

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* Corresponding author: Electricity Policy Research Group (EPRG), Faculty of Economics, University of Cambridge, Austin Robinson Building, Sidgwick Avenue, Cambridge CB3 9DE U.K., Tel: +44 1223335288. misato.sato@econ.cam.ac.uk

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1. INTRODUCTION

The EU Emissions Trading Scheme (EU ETS) was launched in January 2005 to cap CO_2 emissions from heavy industry in Europe. It is by far the largest ETS, covering 45% of Europe's total CO_2 emissions released from 11,500 installations of the energy intensive sectors. Its major role in establishing a price for carbon has been an achievement of global significance, and the EU ETS is often noted as the most ambitious climate policy implemented to date. At the same time, the scheme faces important challenges that potentially undermine its environmental effectiveness and credible survival beyond 2012, of which addressing the issue of industrial competitiveness is one.

Concern about loss of industrial competitiveness is one of the main obstacles to governments adopting stringent climate policies. It is feared that policies applied to domestic energy-intensive sectors facing competition from firms located in regions without climate policy could reduce their international competitiveness both in terms of loss of profitability and loss of market share.[1]
Although the stated aim of an emissions trading scheme is to cap industry's emissions at minimum mitigation costs such that it affects its competitiveness the least, industrial competitiveness impact remains a contentious issue surrounding Europe's unilateral implementation of the ETS. [2]

The analytics of competitiveness impacts of the EU ETS - more specifically, the ability of the free-allocation approach to address competitiveness loss - has been explored from different perspectives in the literature. Principles of how in the short run, sectors within the EU ETS are likely to adjust price and output, have been set out by the work of The Carbon Trust (2004), The Carbon Trust (2005), Reinaud (2005), Smale et al. (2006) and McKinsey and Ecofys (2006). They have presented numerical results of how as a consequence, the participating industries on a sector scale are likely to be over-compensated by existing high proportions of allowances that are being allocated for free.

These conclusions have been supported by studies of the power sector using both empirical and model simulation approaches. For example, the empirics relating to cost pass-through and wind-fall profits has been examined in depth in electricity pricing (Sijm, Bakker et al. 2005; Sijm, Chen et al. 2006;

[1] As pointed out by Demailly and Quirion (2006), to distinguish and disentangle these two effects is vital to discussions, as is demonstrated throughout this paper.
[2] The economic rationale behind a cap and trade system, applied to a large number of installations belonging to heterogeneous sectors, is that the price of allowances acts to equate marginal costs of abatement across all sources. If the allowance price is higher than a source's marginal costs of abatement, they will reduce their emissions in order to avoid the cost of purchasing an additional allowance, or in order to sell an additional allowance.

Sijm, Neuhoff et al. 2006). Sectoral analyses have estimated the impact of a CO_2 price on both profits and output using detailed global sector simulation models (Quirion 2003; Hidalgo, Szabo et al. 2005; Demailly and Quirion 2006; Szabo, Hidalgo et al. 2006, Palmer et al., 2006). Emerging from the literature are also insights into the dynamics and tensions between two dimensions of competitiveness. That is, tensions between A) short-run profit maximisation that involves marginal cost pricing, CO_2 cost pass-through and output restriction and B) maintaining market share in the long-run by pricing below marginal cost but above average cost.

Although studies examining short-term competitiveness impacts of the EU ETS conclude that in general, sectors in aggregate will profit from the scheme by passing through CO_2 costs to product prices and adjusting supply, they mask effects experienced on an individual firm or sectoral level and provide little insights into the distributional consequences of the scheme (McKinsey and Ecofys, 2006; Palmer et al., 2006).

In contrast to modelling approaches that necessarily simplify, the objective of this paper is the opposite; here focuses upon the "real-world" features that differentiate impact of EU ETS within and across sectors including heterogeneity between countries, firms, production processes, and scope for abatement technologies. By examining sample sectors both within and outside the EU ETS, we present some general metrics and indicators to help judge the nature of potential impacts on price, potential profit or loss, and market share. Our analysis gives strong support for a sector-specific allocation to better address industrial competitiveness in the EU ETS.

Our analysis makes some progress to answer key questions facing the development of the EU ETS:

- Can general principles and indicators be extracted that may help understand the likely impact of the EU ETS on different sectors, both within and outside the EU ETS?
- To what extent may the risk of perverse incentives in electricity (as studied by Neuhoff (2006)) apply to other key sectors in the EU ETS?
- To what extent can insights relating to leakage from an exceptionally detailed study of cement (Demailly and Quirion 2006) be extrapolated to deepen understanding of the likely impacts of EU ETS on market share of other key energy-intensive EU ETS sectors?
- How far can such results be generalised across companies, sectors and regions within Europe?
- How significant may be mitigation options and what implications may this have for structural design over time?
- How may these and other impacts evolve over time?

The organisation of the paper is as follows. Section 2 briefly reviews the wider literature on competitiveness issues of climate policy. In Section 3, we begin by providing a summary of the key factors that differentiate impacts of the EU ETS on industrial exposure, drawing upon the basic insights derived from Smale et al (2006) and McKinsey and Ecofys (2006), then extend this analysis to develop and apply indices to a wide range of sectors' value at stake and marginal costs impacts. Section 4 relates the general principles extrapolated from the analyses in Section 3 to the issue of timing and considers how impacts on sectors evolve over time. Section 5 then describes heterogeneous characteristics within sectors that differentiate EU ETS impacts. The final section offers conclusions.

Throughout this paper, "short-run" refers to timescales up to five years, and "long-run" indicates a post 2012 timescale over which strategic decisions on allocation of new investment start to bear fruit.

2. COMPETITIVENESS: BACKGROUND and LITERATURE REVIEW

The debate about industrial competitiveness impact of the EU ETS forms an important part of wider discussions on the spill-over effects from climate policy, that is, the effects of abatement measures taken in one country or a group of countries on sectors in other countries. In theory, the first order impacts on prices (change in profits) drives secondary industrial competitiveness impacts such as re-location in the longer term. Spillover effects explored in the literature also include carbon leakage[3] (Kuik and Gerlagh 2003), impact on energy prices (Barnett, Dessai et al. 2004; Pershing and Tudela 2004), and positive spillovers such as impacts on sustainable development (Kemfert 2002; Gundimeda 2004) and technology spillovers (Rosendahl 2004; Sijm, Kuik et al. 2004).

The implication of international trade theory is that the imposition of a CO_2 constraint in one country reduces the cost-effectiveness and hence the competitiveness of its CO_2 intensive sectors exposed to international trade. At the country level, competitiveness is maintained in the long-run as exchange rates adjust to compensate for the loss of competitiveness. However, it is misleading to discuss competitiveness on a country level because a household or transportation in one country does not 'compete' with their counterpart in another country, hence the concept of nationwide competitiveness is ill-

[3] Measured by the increase in CO_2 emissions in outside countries where abatement actions are being undertaken.

defined in economics (Krugman 1994; Babiker, P. Criqui et al. 2003). Rather, competitiveness is a concept relevant at a firm or sector level. Implementation of a uniform CO_2 emission price impacts sectoral competition, by reducing competitive advantage of CO_2 intensive sectors, and shifting advantage to less CO_2 intensive sectors. In addition, for a CO_2 intensive sector producing internationally traded goods such as steel, firms that are subjected to high CO_2 market prices may lose competitiveness, at the gain of firms in regions without CO_2 mitigation policies.

In general, little evidence is observed in the empirical literature to support the hypothesis that climate policy has yet had large adverse effects on competitiveness (IPCC 2001; Zhang and Baranzini 2004). In their survey of spillover effects and competitiveness, Sijm et al (2004) compares results of empirical studies on the issue of relocation energy-industries and finds no satisfactory explanation for the different outcomes between empirical studies. They conclude that if a relation between climate policy and relocation could exist, then it is statistically weak and insufficient for policy making. A statistical analysis carried out on four energy-intensive sectors in nine OECD countries by Baron and ECOEnergy (1997) estimate an average 3% increase in production costs from a CO_2 tax of $100/tC, supporting these conclusions.

Conclusions derived from modeling analysis are more diverse. The IPCC Third Assessment Report (IPCC 2001) reviews studies that use CGE models with exogenous technological change to estimate spillover effects (measured in the form of leakage rates) resulting from implementation of the first-period Kyoto commitments through uniform carbon taxes. It reports estimated leakage rates range from 5-20% (increase in CO_2 emissions outside of Annex I divided by reductions in Annex I). Grubb et al (2002) argue that such models overstate costs because they do not account for global diffusion of induced technological change, which has been demonstrated to have central importance in relation to climate change by Grubler et al. (1999), Gritsevskyi and Nakicenovic (2000) and others. On the other extreme, much higher leakage rates were reported by Babiker (2005), using a global CGE model for 7 regions, 7 goods and 3 industry with increasing returns to scale and strategic behaviour in energy-intensive industry. Depending on assumptions made, the model's estimates range from 25% (with increasing returns) to over 100% leakage rates that imply large loss of competitiveness in the OECD region.

Over recent years, reflecting the surging interest in industrial competitiveness among governments and industry stakeholders with the implementation of the EU ETS in Europe, a new body of competitiveness literature has emerged with focus on competitiveness in the context of an ETS (Quirion 2003; The Carbon Trust 2004; Hidalgo, Szabo et al. 2005; Reinaud 2005; The Carbon

Trust 2005; Demailly and Quirion 2006; Smale, M et al. 2006; Szabo, Hidalgo et al. 2006; McKinsey and Ecofys, 2006). These studies using sector simulation models of varying degrees of complexity consistently estimate that impact of EU ETS on global competitive distortions are low for all sectors. A literature review and discussions of EU ETS competitiveness in a wider context (macroeconomic impacts such as on employment) is provided Oberndofer et al (2006). Studies using detailed sectoral models (e.g. Quirion 2003, Demailly and Quirion 2006) have, in addition, provided insights into the way in which under profit-maximisation, allocation methodology affects competitive impacts. In addition, Johnston (2006) considers the legal implications of free-allocation and profit-making.

3. SUMMARY OF SECTORAL ECONOMIC IMPACTS FROM EU ETS

3.1 Key determinants of industrial exposure

The three main factors determining a sector's inherent potential exposure to the EU ETS are: i) energy intensity; ii) ability to pass cost increases through to prices; and iii) opportunity to abate carbon.

Figure 1 shows a conceptual matrix, broadly classifying various sectors according to the likely impacts of the EU ETS, when measured in what are considered the two primary dimensions of competitive exposure: potential value at stake as indicated by energy intensity, and ability to pass cost changes through into prices. For sectors like ferrous metals that fall under the category 'at risk', high international exposure constrains their ability to pass on costs, even though they may not lose out in the short term. Although electricity is energy intensive, because of its high ability to pass on costs, this sector has high potential to gain from the EU ETS. As suggested by Demailly and Quirion (2006), whilst 'inland' cement manufactures protected by transport costs can similarly be considered as having the potential to gain, the same may not be true for coastal cement producers exposed to the threat of imports.[4]

[4] The GEO trade model used in this study divides the world into over 7,000 areas, of which 1,600 areas are identified real sea harbours and more 'land harbours' are represented in order to compute realistic transportation costs.

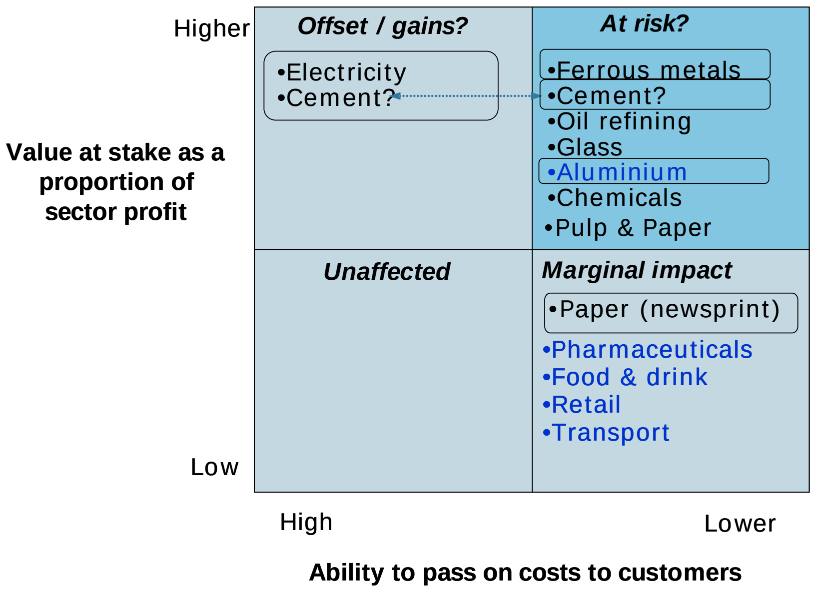

Figure 1- Classification of industrial sectors according to exposure

3.2 'Value at stake' and marginal cost impacts

To translate the general principles underlying Figure 1 into quantitative insights, in Figure 2 and 3 we develop and apply indices to a wide range of sectors, illustrated with reference to 2004 UK data.[5]

The biggest single constraint on ability to pass CO_2-related costs on to customers is foreign competition from regions outside the EU ETS region, and the simplest measure of this is the existing degree of trade intensity. This forms the x-axis in Figure 2 (see figure notes for definition). Obviously this is an imperfect indicator, and in response to large price differentials could change substantially over time; but it remains by far the most plausible aggregate indicator of the barriers to large scale imports and exports. The quite exceptional position of Aluminium, as noted in Smale (2006), is readily apparent – its trade intensity is almost twice that of any other sector.

[5] Results for one sector in particular (pulp and paper) is highly unrepresentative from a European perspective - UK accounted for 6.1% total paper production and almost nont for total pulp production by country in CEPI (Confederation of European Paper Industry) in 2005 (CEPI, 2005). Germany, Sweden and Finland are the largest producers and together account for 46.1% of total paper production and 62.8% of total pulp production.

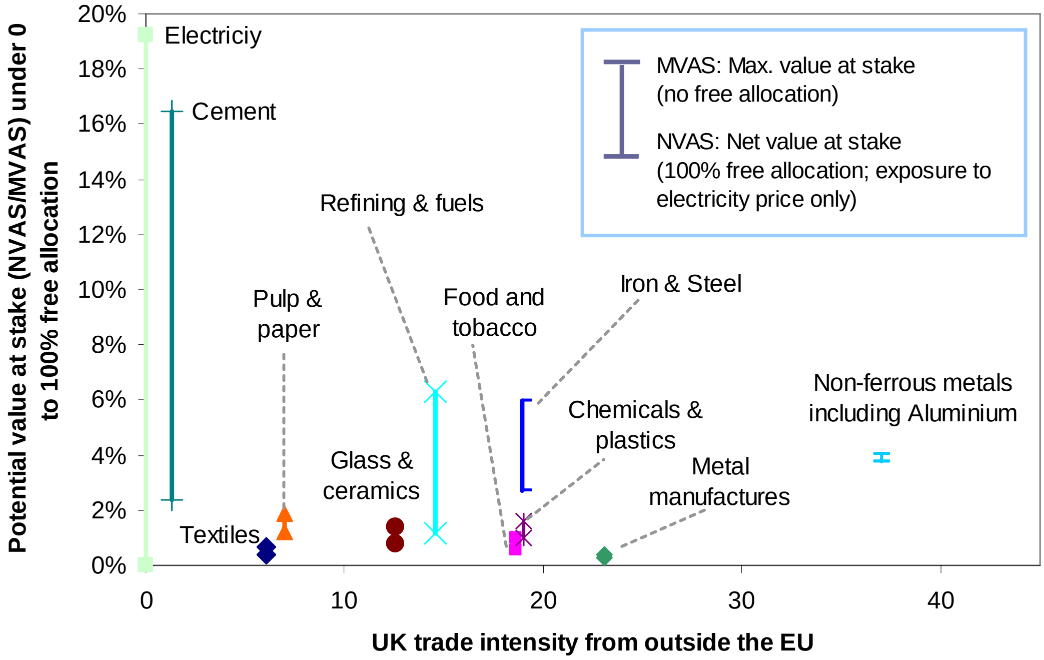

Figure 2 - **Net Value At Stake relative to UK trade intensity from outside the EU.**[6]

Notes: Upper end of range indicates zero free allocation, and lower end of range indicates 100% free allowances (effect of €10/MWh electricity price increase to sectors). Assumes allowance price of €15/tCO_2 and no CO_2 price pass through in sector. Trade intensity here is defined as the value of imports from non-EU countries as a proportion of the total supply in the UK minus the value of exports to non-EU countries as a proportion of total demand in the UK.

The vertical axis combines the full range of potential indices of *net value at stake* (NVAS), which we define as the net impact of the EU ETS on sector costs relative to sector value-added. The lower end shows the impact if the sector participates in the EU ETS and receives free allocations equal to its "business-as-usual" emissions, and takes no abatement action: the NVAS then represents the sector's exposure to indirect costs through electricity price impacts only. The upper end shows the impact if there were no free allocations – equivalent to 100% purchase on markets or auctioning at the market price. The chart shows results for a carbon price of 15€/t CO_2 and an electricity pass-through resulting in wholesale electricity cost increase of €10/MWh. Scaling the electricity price would move the lower point of the bars

[6] Own calculations based on following data Sources: Energy consumption data adapted from DTI Energy Statistics Publications "Table 4.6: Detailed industrial energy consumption, by fuel, 2004" available from http://www.dti.gov.uk/energy/statistics/publications/energy-consumption/industrial-tables/page18171.html. Trade and demand/supply data adapted from UK National Statistics' United Kingdom Input-Output Analyses 2006 Edition available from http://www.statistics.gov.uk/about/methodology_by_theme/inputoutput/. Fuel inputs for electricity generation taken from DTI's DUKES 5.1.1 available at http://www.dti.gov.uk/energy/statistics/source/electricity/page18527.html. Cement process emissions calculated as 0.45t CO_2/t cement as with Cembureau (1999).

in direct proportion; scaling the carbon price would scale the height of each bar.

The significance of the upper level (no free allocation) is that *it also gives an indication of the impact on marginal cost* of any fixed allocation. As long as production of more or less output is not accompanied by any change in free allowances, it faces the full cost of extra allowances, or the opportunity cost of not selling allowances. In addition, since in general firms maximise profits by pricing at or close to the marginal cost of last unit produced, the upper level gives a rough indication of the corresponding potential impact on output prices (relative to value-added). As emphasised in previous modelling studies, such behaviour will in general lead to large profit gains from the EU ETS – but at the expenses of a cost differential that could increasingly lead to loss of market share to foreign imports in the longer term.

Sectors outside of the EU ETS would face the cost impact at the bottom of each bar (electricity price exposure) and an equivalent incentive to change the price of their products; there would be no divergence between average and marginal costs, and no resulting scope for profiting from such divergence. [7]

The first striking feature of the graph is that Cement, Refining & Fuels, Iron and Steel and Non-ferrous metals (principally Aluminium) stand out for their high potential value-at-stake. The wide ranges for the former three reflect their high intensity of direct carbon emissions relative to electricity; the narrow bar for Aluminium reflects its dependence on electrical processes, that sometimes result in it being termed "solid electricity". If sectors receive 100% free allocation, aluminium is not only twice as exposed in trade terms, but it faces the highest impact of all sector on net value at stake (3.7%) – its degree of exposure is wholly unique. [8] Profits in the Iron and Steel and Cement sectors are also relatively sensitive to electricity price, with 2.7% and 2.4% NVAS respectively. For Refining which uses hardly any electricity from the grid, 100% free allocation reduces its NVAS to barely 1.1% of its total value-added.

However, zero free allocation – or pricing at the marginal (opportunity) cost – gives a very different picture for these three sectors. Cement, with an NVAS

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[7] Note that this is a complementary treatment to that presented in the Carbon Trust analysis (Carbon Trust, 2004) which focused on the variation in value at stake for a range of electricity price pass through and a modest range of allocation cutbacks (0-10%). The intent in Figs 2 and 3 here is to give an insight also into the marginal cost impacts that can drive imports under profit-maximising behaviour. Also the chart in Carbon Trust (2004) was indexed on total sector turnover, rather than value-added.

[8] Electricity costs for aluminium production average a quarter of operating costs, with 95% of electricity used for smelting stage (equivalent to 80% of emissions of all primary production of aluminium).

impact of 16% of its total value-added then stands out. The equivalent NVAS impact on Refining & Fuels, and Iron & Steel, is about 6% each. For the UK, no other EU ETS sector in aggregate has NVAS impacts above 2% even for zero free allocation. High CO_2 intensity per unit of profit may explain the high leakage rate associated with profit-maximisation in Demailly and Quirion (2006): differential simply become so large that barriers that traditionally hold foreign imports away and exports competitive are overcome over time.

More explicit price indices are considered below. In Figure 3 we show the same NVAS range data for UK industrial sectors, but this is set against the import intensity *from other EU* countries. Although the EU ETS should have a similar impact on prices everywhere in Europe, in practice the degree of electricity cost impacts may vary and the sector structures and associated carbon intensities may differ between different countries as discussed in section 4.1 below.

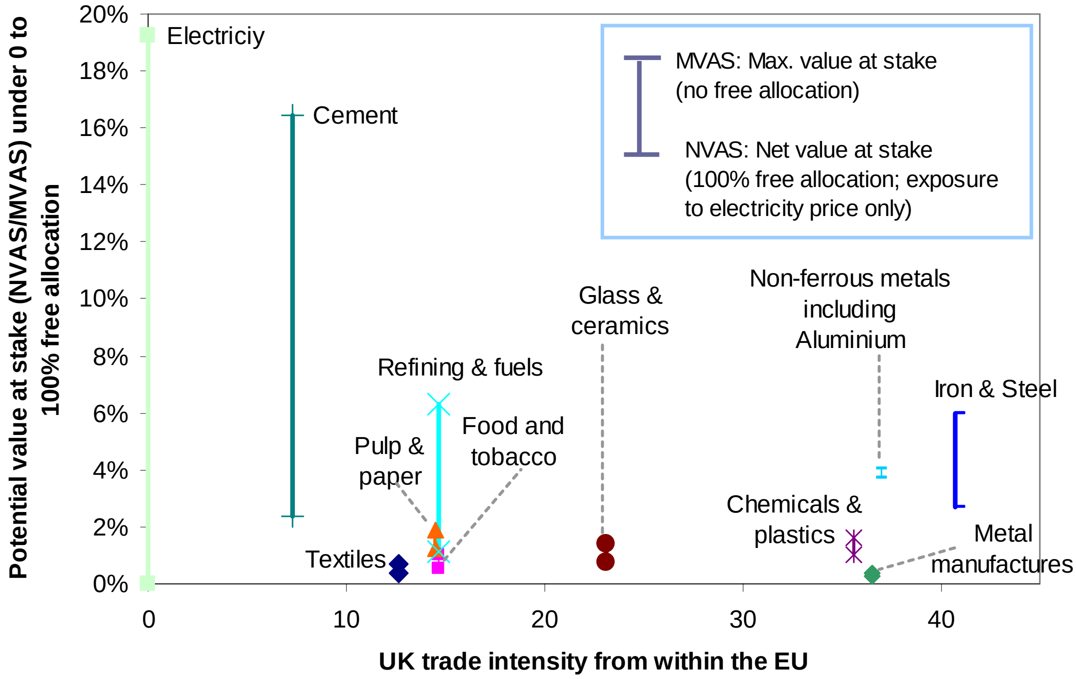


Figure 3 **Net Value At Stake relative to UK trade intensity from within the EU**

Notes: See Figure 2 notes for assumptions and data sources. Trade intensity here is defined as the value of imports from EU countries as a proportion of the total supply in the UK minus the value of exports to EU countries as a proportion of total demand in the UK.

Moreover, the intensity of trade *within* Europe gives an insight into the potential degree of concern about differential allocations between countries. The most sensitive sectors from this standpoint, for UK companies, are Iron and Steel, Refining and Fuels, and Cement. Chemicals and Aluminium again also shows high trade intensity, with sensitivity likely to be as much on electricity differences (for participating installations) as on allocation differentials.

It is apparent from the static analysis here that differentials in level of exposure to international trade and net value at stake imply that potential competitiveness impacts are widely differentiated across sectors. Yet a common theme across allocation plans in Phase I and II of the EU Emissions Trading Scheme was the limited nature of differentiation between sectors. Many plans treated virtually all sectors the same, by allocating according to their expected 'business-as-usual' needs, with the result that some sectors (electricity) are over-compensated more than others. The implication in the longer term perspective is explored in the following section.

4. OPTIONS FOR SECTOR-SPECIFIC ADJUSTMENTS OVER TIME

4.1 A case for a sector-specific approach post-2012

Separating the two distinct effects potentially experienced by companies provide the key to understanding competitiveness impacts over time:

1. change in profits (from one-off gains in economic value from free-allowances, and from short-term adjustments to output and product prices)
2. change in market share

Whilst most covered sectors have so far profited from the former, traded sectors are at the same time are faced with potential adverse impact on market share in the long-run due to leakage. Leakage results from two distinct effects: A) plant closures in Europe and B) additional capacity outside of Europe to service market growth.

The magnitude and timing of market share loss will depend on various factors including the degree of production and price adjustments, degree of exposure to international trade and expectations about allocation cut-backs in the future. The extent to which a company is concerned about long-term market share loss may also reflect in pricing strategies exercised today – unlike power generation, traded sectors are likely to avoid aggressive marginal pricing strategies.

To gain a sense of the dynamic impacts on the market, Table 1 below report results adapted from the Oxera (2005) analyses. Using a Cournot model of the impacts on net values at stake, and the percentage increase in product price required to maintain profits for UK industrial sectors, for moderate '2010' and more severe '2020' scenarios.

		Net value at stake (%of current EBITDA)*		Product price rise required to keep profits flat (% of current price)	
		2010**	**2020****	**2010****	**2020****
		€15/5%	**€30/15%**	**€15/5%**	**€30/15%**
EU ETS Sectors	**Cement**	22%	55%	5%	9%
	Steel	11%	29%	1.5%	4%
	Newsprint	1%	3%	<0.1%	0.6%
	Petroleum	0.5%	0.5%	0.1%	0.3%
Non-EU ETS Sectors	**Aluminium**	60%	150%	Unable to maintain current profits	
	Car manufacture	1%	3%	<0.1%	0.1%
	Brewing	1%	2.5%	<0.1%	<0.1%
	Grocery Retail	0.5%	1%	<0.1%	<0.1%
	Hotels	2%	5%	0.4%	0.5%

Table 1 – EU ETS Sectors Net Value-at-Stake and price rise required to maintain profitability of key energy-intensive sectors under the most demanding scenarios.

*Notes: *As in Section 3, NVAS is defined as increase in total costs after allowance allocation divided by original EBITDA.** EU ETS price are assumed to be 15 €/tCO₂ and 30€/tCO₂ for 2010 and 2020 scenarios respectively. In both Scenarios, allocation cut back is assumed at 1%pa from 2005, hence 5% cut-back for 2010, and 15% cut-back for 2020. Includes both direct and indirect EU-ETS effects. Also takes into account the overlap between the different instruments used to regulate emissions from these sectors i.e. the UK Climate Change Levy and the UK Climate Change Agreement. CCL does not include revenue recycling. CCL is assumed to stay constant for both scenarios (in contrast to 2020 scenario in Oxera (2005) which includes a doubling of CCL effect).*

Sources: Oxera (2005) and The Carbon Trust (2005).

Under the scenario set out to 2010, the product price uplift required to maintain profits is relatively small for most EU ETS sectors, relative to other factors that determine competitive positions such as transport costs, price fluctuations and international differentials. However, this does not hold if stringency of climate policies increase in line with targets for emissions reductions over time. The price increase required for cement and to a lesser degree steel, become large under the more severe 2020 scenario at 9% and 4% respectively. This suggests severe limitations to free-allocation as an approach to protecting the competitiveness of these sectors, and the need for alternative approaches. These results are consistent with leakage rates found under scenario using allocation by grandfathering, in the study using a detailed models of the EU cement sector taking account of transport costs (Demailly and Quirion 2006).

For the non-EU ETS sectors, the results also confirm the conclusions of the analysis in Section 3, that the UK aluminium producers' competitive position is severely at risk if reliant on electricity input from the national grid. For both measures, the impact on newsprint, petroleum, car manufacturing and brewing is extremely small.

Thus the general application of free-allocation across all sectors represents a crude and near-term way to addresses competitiveness issue in the EU ETS. As stringency of climate policies are increased over time in line with targets for emissions reductions, distributional consequences too will become magnified. While most sectors, and particularly the power generation sector profits from it in the short-run, it does not offer solutions to problems in the long-run for sectors like iron & steel and cement, or sectors severely affected by indirect impacts of the EU ETS (in the form of raised electricity prices) such as aluminium. This suggests that in extending the EU ETS beyond Phase 2 (2008-12), serious consideration may have to be given to these sectors with respect to allocation if key competing nations are not taking equivalent action.

4.2 Options to address competitiveness issues post-2012

To sustain the EU ETS in the long term as an instrument that helps to (a) decarbonise European industry as efficiently as possible, including avoidance of allocation-based distortions (b) avoid large transfer payments between sectors or between consumers and industrial sectors; and (c) protects the competitiveness of European industry in the absence of comprehensive global participation is one of daunting complexity. The four main strands of options for moving the scheme forward explored in the literature and in general policy discussions are summarised here.

Firstly, in theory, combining free-allocation with auction and revenue recycling can allow compensation at minimum costs whist raising revenues that can be directed towards redistributional purposes. Auctioning allowances also has the advantage of minimise distortions in the EU ETS (Neuhoff, Keats et al. 2006). Hepburn et al (2006) has argued that greater use of auctioning is likely to be a part of solutions for energy intensive sectors and there are signs in the NAP 2 debate that allocation is indeed moving in this direction.

Secondly, output-based allocation (whereby firms are allocated allowances according in proportion to production) in theory reduces product prices and increases production relative to the grandfathering approach. Because it avoids putting constraints on output, this approach is frequently advocated by industrialists (Eurofer, 2005; Cembreau 2006). Indeed, studies using sector models to quantify impacts (Burtraw, Palmer et al. 2001; Quirion 2003; Demailly and Quirion) estimate that compared with allocation by grandfathering or auctioning, impact on leakage of production (fall in domestic production and rise in imports) to non-EU regions is less under out-put based allocation, and profits are also less.[9] However, CO_2 abatement is also less under this approach because by linking allocation to output, no CO_2 scarcity rent is created.

Global sectoral agreements covering sectors with high international exposure, is discussed widely in the literature (Groenenberg, Phylipsen et al. 2001; Thomas, Cameron et al. 2004; Bosi and Ellis 2005; Watson, Newman et al. 2005; Schmidt, Helm et al. 2006). It represents probably the 'first best' solution (excepting a comprehensive global agreement on the equivalent use of economic instruments) but is obviously a highly ambitious target which moreover probably could not be expected to arise for all sectors of concern simultaneously.

Finally, the use of border tax adjustments (bta) to protect competitiveness whilst maintain the core principle of reflecting full carbon costs has been explored in the literature (Biermann and Brohm 2003; Ismer and Neuhoff 2004; Saddler and Muller et al. 2006; Demailly and Quirion 2006), and recently in high level political debates in France and Australia.

4.3 Beyond the sector-level analysis

So far, analysis using sector-average data has illuminated the need to account for cross-sectoral difference in further analysis of competitiveness. However, sectoral level analyses can mask significant differences between regions and processes within one sector. We now turn to examine more closely the potential differences between companies, processes and countries in Europe, and how these might affect findings in key sectors. We focus upon those EU ETS sectors - electricity, cement, iron and steel, and pulp and paper - which have both high potential cost exposure, and big diversity in terms of the carbon intensity or exposure of their operations.

[9] Quirion (2003) also finds that total production costs (the proxy for employment in European iron and steel sector) rises slightly as reductions in production level is more than offset by increased abatement measures.

5. DIFFERENTIATION WITHIN SECTORS

5.1 Electricity generation sector

As noted previously, the ability of the power generation sector to profit from the EU ETS despite its energy intensive nature of production is attributed to the price inelastic nature of electricity demand, the low trade intensity and hence high ability to pass through CO_2 opportunity costs to electricity prices. In line with theory, empirical studies on cost pass-through such as that by Sijm et al. (2006) on the German and Dutch electricity sector observe high pass through rates, ranging between 40 and 120% of CO_2 costs. [10]

However, as partly captured by the range of cost pass through rates estimated by Sijm et al (2006), impacts of EU ETS and the ability to profit will vary across electricity generators. There are major differences in profit performance at the individual firm level due to the differences in technology portfolios (and corresponding CO_2 intensity of generation), market size and structure, institutional structures, regulatory regimes and demand patterns, all of which potentially affect pricing strategies hence firm profits.

5.1.1 Diversity of processes and their carbon intensity

The technology portfolios of firms vary widely in the generation sector (e.g. coal, gas, nuclear, hydro and renewables). Each plant for these technologies also has different cost structures and carbon intensity. For example, UK generating companies diverge enormously in their carbon intensity as shown on the left hand side of Figure 4. Although the sector as a whole passes through costs to the level expected in an national competitive environment, and will benefit from the EU ETS, different companies are affected differently due to the changes in merit order induced by the EU ETS. As modeling results using the Oxera electricity wholesale market model show (right hand side of Figure 4), generators with a relatively high CO_2 intensity are likely to become less competitive following the scheme's introduction. Specifically, two companies are predicted to see their operating profit decrease even with 90% sector pass through, that leads to a 14% increase of wholesale price induced by the EU ETS. These represent companies with marginal coal plant at risk of losing infra-marginal rent and hence market share. By the same token, other companies would increase their operating profits by more than the average.

[10] In theory a profit maximising power generator adds the costs of CO_2 emission allowances to its other marginal (variable) costs when making (short-term) production or trading decisions, hence pass on the cost of CO_2 allowances onto product prices, even if allowances are allocated to them for fee (Burtraw et al., 2002, 2005; Reinaud, 2003). This is because as long as allowances can be sold on the market for a positive price, using allowances to cover its emissions carries an opportunity cost. Due to the nature of inelastic demand and national markets, the electricity sector has a unique ability to pass on CO_2 costs to its consumers.

Hence the results show a large diversity of earnings impacts attributable to the EU ETS. The results are not related only to carbon intensity, due to the complexity of the electricity market operation.

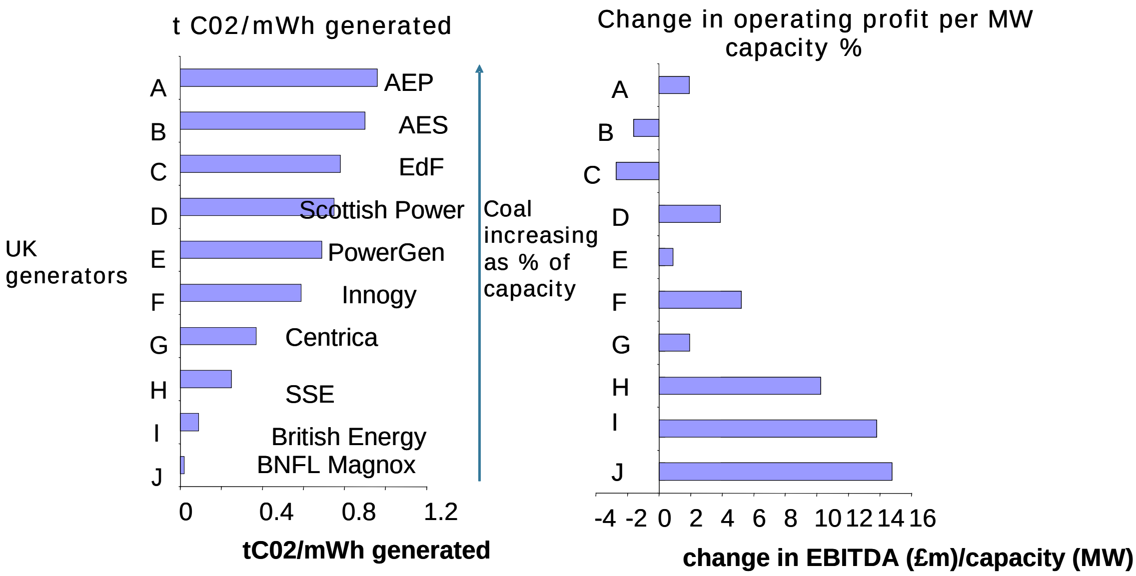


Figure 4 - Impact of EU ETS on net earnings of different electricity companies in the UK

Note: Innogy now trades in the UK under the RWE brand.
Source: Results from OXERA electricity sector dispatch model, Scenario 2 EU ETS assumptions with 90% sector cost pass-through.

5.1.2 Diversity across Europe

As shown in Figure 5, carbon intensity of electricity production varies widely across Europe. Peak is dominated by relatively inefficient coal power in Greece and on the other extreme are France and Sweden characterised by almost no fossil systems. As power sector allocation reflects historic emissions under most NAPs, if we assume competitive national markets and a 100% cost pass through rate, firms in countries with high intensity of generation are expected to profit more from free allowance allocation than those with low carbon intensity.[11] The reverse would be true would be true if high levels of electricity trade tended to levelise prices across the EU.

[11] Since less efficient power plants provide peaking and hence set wholesale prices in a pool system, in a country where peaking power stations are coal fired, the price rise due to EUA cost pass through are correspondingly larger.

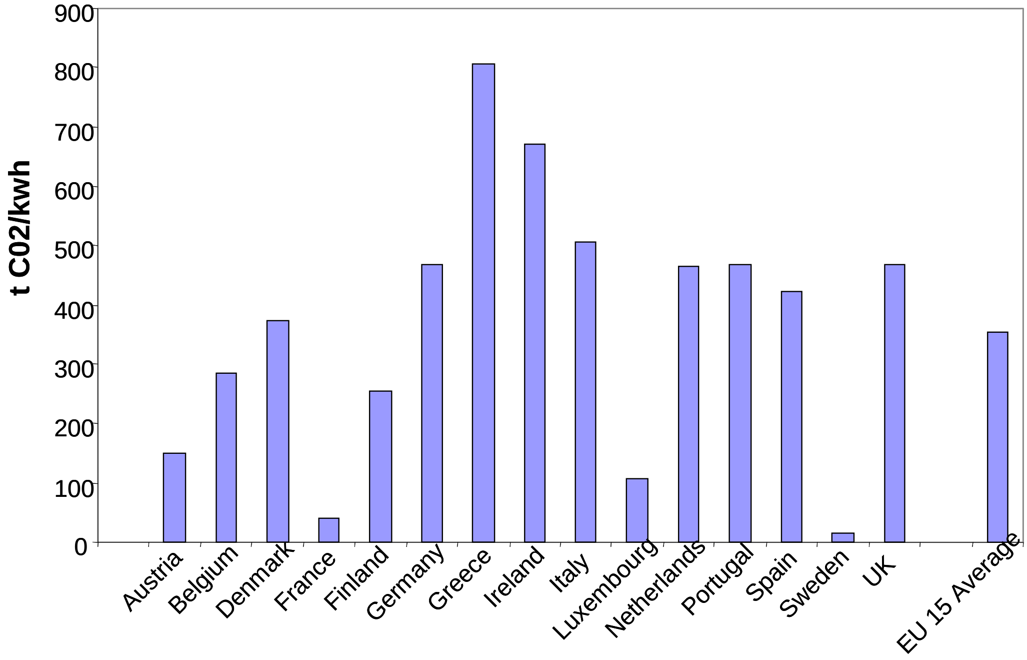


Figure 5 - Carbon intensity of power production in EU countries (total: fossil and non-fossil).

Notes: Peak is dominated by relatively inefficient coal power in Greece. France and Sweden characterised by almost no fossil systems. EU 15 average is close to 100tC/kWh (350tCO2/kWh)

Sources: IISI, OECD

However, such effects will be moderated by regional differences in ownership structures, level of concentration in the market and regulatory regime. For example, fixed retail prices as in France and contractual arrangements limit firms' ability to reflect CO_2 costs in electricity price. Theses differences may explain why profit-making differs considerably between power companies in different countries.

5.1.3 Mitigation Options

In the short-run, carbon-intensive generators can reduce their exposure to the EU ETS by retrofitting energy efficiency measures or adopting more advanced technologies, without switching technology. For example, replacing a coal-fired steam turbine with pulverised-coal technology can achieve 27% emissions reductions and replacing a single cycle gas turbine with CCGT brings 36% reductions. Dramatic reductions in the carbon intensity of electricity generation necessitate shifting firms' portfolio of generation assets towards lower carbon technologies, such as CCGT, nuclear, renewables, biological sequestration and CCS. For example, combined cycle gas turbines

(CCGT) are on average three times more CO_2 efficient than coal/lignite fired power plants (350 kg CO_2/MWh compared to 900-1,100 kg CO_2/MWh).

Resource and technical potentials for mitigation in the power sector are large in most Member States, however, economic potentials vary across power generators according to technology portfolios and policy environment (e.g. level of R&D support and deployment policies).

5.1.4 Free allocation and perverse incentives from the EU ETS

As argued by Neuhoff et al. (2006), repeated or new entrant free-allocation in the power sector can give perverse incentives. For example, it can encourage existing heavy emitters to continue operation of a plant beyond its efficient life-time and produce excessive output and emissions in order to increase allocation under future allocation plans. These perverse effects distort not only static but also dynamic efficiency, counteracting objectives of the overall climate policy framework within which the EU ETS exists. Basing free-allocation on a uniform sectoral benchmark can reduce but not remove perverse incentives. As touched upon in section 3.4, increasing the level of allocation by auction in NAP2s furthermore addresses concerns about windfall profits to the electricity generation sector resulting from the EU ETS.

5.2 Cement

Modelling results of the UK cement sector by Smale et al. (2006) estimate that EU ETS could have positive impact on profits: 13% and 25% change in EBITDA for CO_2 price assumptions of €15/tCO_2 and €30/tCO_2 respectively. The results to a large extent reflect the fact that despite having the highest CO_2 emissions per unit of profit out of all EU ETS sectors, cement producers can retain price differentials due to high on-land transport costs for cement and hence low trade intensity.

Detailed analysis on the EU ETS impact on the European cement industry, using a model that takes more detailed account of foreign competition and transport costs by Demailly and Quirion (2006) gives additional insight. Whist they support the conclusion that cement manufacturers profit from grandfathered allowances, they also address the dynamic tension between profit maximisation in the short-run and losing market shares to imports in the long run. This study explores output based allocation as an alternative approach to addressing competitiveness issues, which we come back to towards the end of this section. Walker (2006) attempts to test the validity of the EU cement sector's cost pass-through abilities, but finds results to be inconclusive.

Here we fist examine heterogeneities among cement producers (such as the notable high exposure of producers located on costal regions) that differentiate competitiveness impact within the sector, which are overlooked in Smale et al. (2006).

5.2.1 Diversity of processes and their carbon intensity

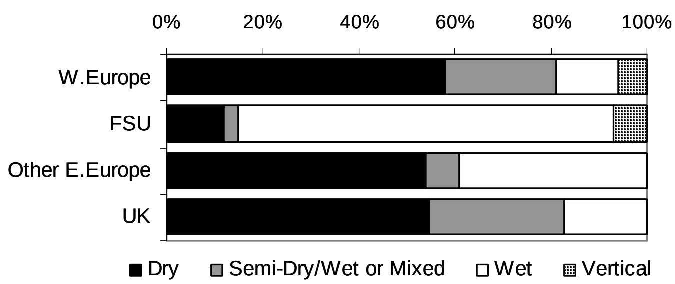
Although cement is considered largely a homogeneous product, carbon intensities can vary widely from a low 0.19tC/tonne cement in Western Europe, 0.17tC/tonne in Japan, to 0.24tC/tonne in China and the United states (Worrell, Price et al. 2001).

By far the largest proportion of energy consumed in cement manufacture consists of fuel that is used to heat the kiln used for clinker production. Vertical kilns are the oldest and least efficient technology used today, and have been replaced by rotary kilns in most of the developed world. Rotary kilns technology is further divided into four types – wet, semi-wet, semi-dry and dry – the latter being the most modern and least energy-intensive process. Compared with plants using a long-wet kiln, dry preheater/ precalciner kiln require 45% less energy input.

Given the high sunk costs (cement production plants have operational lifetime of 30 years or more), product homogeneity and high degree of process-emissions, there is a case for some free allocation in order to moderate differentials in the degree of exposure to the EU ETS due to different production process. However, perverse incentives can result from different approaches to free allocation as discussed below.

5.2.2 Diversity across Europe

Figure 6 shows kiln technology by region in Europe in the mid 1990s, production volume and the corresponding CO_2 emissions.



	Emission factor ($t\ CO_2/t$)	Total Production (Mt)
Spain	0.76	26.7
Italy	0.75	33.2
Germany	0.68	36.1
France	0.62	21.2
W. Europe	0.71	181.9
Japan	0.62	91.6
China	0.88	423
US	0.89	77.9
FSU/E. Europe	0.79	100.7

Figure 6 Kiln Type (%) and production for cement, by region

Source: Adapted from Worrell, Price et al. (2001), Humphreys, M..et al. (2002), and CEMBUREAU (2000)

It is not possible to draw conclusions on relative exposure of cement sector by country due to lack of available data on variations in production processes (% kiln types) and emission factors by EU country.

In general, however, due to its high transport costs[12], cement import is a localised issue. Specifically, cement producers located in coastal and boarder regions are expected to emerge as a distinct group with high exposure to world prices of cement and hence competitiveness impacts from the EU ETS. With increased GHG mitigation costs, imports from North Africa are expected to increase into Southern Europe. In reality, there exist other trade barriers that protect costal European cement manufacturers. For example, EU firms may attempt to insulate home markets from foreign competitors by dominating available port capacity to restrict importers' access port facilities.

5.2.3 Mitigation Options

In the short to medium run, emissions in cement production can be reduced by three channels: improving energy efficiency of the process; switching from high to low carbon fuels and the use of blended cement (with reduced clinker content).

a) Energy efficiency

Energy efficiency improvements have contributed significantly towards CO_2 reductions in cement production historically. For example, shifts to new processes[13], conversion from direct to indirect firing, improved recovery from coolers, installation of roller presses, optimization of the clinker cooler, improvement of preheating efficiency, improved burners as well as process control and management systems have been identified as having significant impact (Humphreys, M. et al. 2002). The same study estimates potential energy efficiency reductions of 11% in the US cement industry corresponding to 5% reductions in CO_2.

b) Fuel-switching

Unlike aluminum, over 90% of the energy used in the cement production originate from fuels and only 5-10% of the primary energy consumption is electricity. Where carbon intensive fuel is used at present, large mitigation

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[12] For a tonne of cement is sold around €80 at the exit of a plant in France, it costs €10 to transport it by road over 100km (Demailly and Quirion, 2006)

[13] In the longer term, shifts in production to modern efficient dry kilns offers opportunities to bring down carbon intensity of production significantly. In addition, research has been conducted on the reduction of carbon dioxide emissions through carbon dioxide removal, whereby CO_2 is separated during or after the production process and subsequently stored or disposed of outside the atmosphere. However, at this stage of research it is not clear whether this technique can be applied to cement production facilities (The Carbon Trust, 2004).

opportunities exist in fuel-switching e.g. waste-derived alternative fuels may reduce CO_2 emissions by 0.1 to 0.5 kg/kg cement produced compared to current used production techniques using fossil fuels and at the same time diminish the disposal of waste material. However, such efforts may not be sufficiently rewarded by the EU ETS, as it achieves emission reductions in economic sectors that are not covered by the ETS i.e. waste disposal and incineration.

c) Blended cement

Almost all CO_2 emissions embodied in cement originate from clinker production, of which 60% is process related to the decarbonisation of lime, and 40% are fuel-related (Holcim 2006). Increasing the additives in cement (i.e. the use of blended cement) such as blast furnace slags, flyash from coal-fired power stations, and volcanic material reduces the amount of clinker needed (Josa et al., 2004). Clinker-to-cement ratios in 1994 show a range of 80% in Japan and 81% in Western Europe, 88% in the USA and 96% in Korea (Worrell, Price et al. 2001). Globally, the average clinker ratio dropped from over 80% in 1990 to 77% in 2005 (Holcim 2006). However, the availability of suitable additives differs between regions. Current applications of blended cement varies widely from country to country, being relatively high in Europe and low in the U.S. and U.K.

Technical potential of mitigation options vary across production processes, and the degree of to which uptake is incentivised is also influenced by A) allocation volume and methodology used for CO_2 allowance, and B) other existing 'clean air' policies in each Member State.

5.2.4 *Free allocation and perverse incentives from the EU ETS*

Due to the relative homogeneity of cement products and processes (compared to other sectors) and the high proportion of process-emissions that are difficult to mitigate with current processes, there is pressure to cushion allocation against potential production increase with generous levels of free-allocation. However, there are risks in these moves away from the full carbon price incentives inherent in the current design. For example, *ex-post* allocations based on output per tonne of cement would in practice have to be indexed on production of clinker, to prevent companies simply importing this most energy-intensive part of the production process (Demailly and Quirion, 2006). Alternatively, some industry groups have argued for the complete omission of process emissions from the ETS as a 'stop-gap' measure. Because there are major uncertainties about production and the extent to which emissions cannot be avoided, eliminating process emissions may make the cap more effective (Schleicher, 2006). Such a system – or indeed, *ex-post* output based allocation – would however remove incentives either for substitution of products (e.g. wood for cement in construction), or for truly radical production technology changes.[14]

5.3 Iron and Steel

In general, studies quantifying competitiveness impacts on the iron and steel sector (Carbon Trust, 2004; Carbon Trust, 2005; Smale et al., 2006; Demailly and Quirion, 2006; and McKinsey and Ecofys, 2006) estimate limited short-run impact. Iron and steel is relatively more exposed to international trade compared with cement – relative to the 184 Mtons of long and flat products produced in the EU25, around 10.8% is imported and 11.25% is exported (McKinsey and Ecofys, 2006). However, product differentiation allows for price differentiation to a certain degree. [15] In the Smale et al. (2006) study modelling cold rolled steel manufacture as a representative homogeneous product, when the allowance price is 15€/t CO_2, short-run marginal production cost increase by 8%, while production output will decrease by 2.1%. It also estimates that steel manufacturers are able to pass on 65% of their marginal cost increases to consumers.

Results for the steel sector are highly scenario-dependent, however, and indeed, the iron and steel industry is characterised by complexities on many dimensions which likely differentiate competitiveness impacts within the sector: A) multiple products (substitution possibilities and price structures?); B) multiple processes (varied cost structures and abatement opportunities); C) varying levels of price elasticity of demand for imports/exports; D) large firms and imperfect competition in the sector[16].

5.3.1 Diversity of products, processes and their carbon intensity

i) Product differentiation

Unlike cement, steel is not a homogeneous product; steel grades and quality vary to satisfy a wide range of applications including construction, automotive, packaging, appliances, and manufacturing industries. These varying products and grades are manufactured using different steelmaking pathways between the integrated process (BOF), and the alternative steelmaking process utilising the electric arc furnace (EAF). To some extent,

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[14] In the cement sector, a possible example might be the 'carbonsafe' proposals for producing cement through catalytic processes, with the carbon for the cement absorbed from the atmosphere rather through crushing of rocks (http://www.tececo.com/projects.carbonsafe.php). If feasible, this would ultimately turn cement production from being one of the biggest sources of CO2 emissions into being one of the biggest 'sinks'. Allocation approaches that protect the cement sector from the carbon intensity of clinker production and the associated process emissions, however, would largely remove the incentive for the industry to explore or invest in such processes.

[15] The level of international competition and product homogeneity is considerably greater for the manufacture of hot rolled steel manufacture, compared with cold rolled steel.

[16] The top ten companies account for 28% of total world steel production (IISI, 2005).

product differentiation in the steel sector provides steel firms in the EU with profits despite a high cost base (World Steel Dynamics, 2006). However, evidence of considerable trade flow within the EU and rising imports from China suggests continuing product differentiation and its ability to sustain price differentials in the long run is highly uncertain. The industry in general is not built around niche markets.

ii) Process differentiation

Two process routes are used for iron and steel production. In the primary or BOF route, CO_2 is emitted through a series of processes to produce hot metal (during the conversion of coal to coke or in blast furnaces). Similar to process emissions in cement production, CO_2 is also a by-product of chemical reactions throughout the iron making process, including the reduction of iron ore to iron, reduction of materials from coke input, and limestone reduction for sulphur removal in the molten iron[17].

The secondary route of producing steel involves melting scrap metal using electrodes in an electric arc furnace (EAF). The EAF route uses only 30-40% of energy used in the primary route but almost all energy input is sourced from electricity, hence CO_2 emissions is a function of source of electricity.[18] To a large extent, the process determines the final product e.g. stainless steel is produced using EAF.

As allocation under existing NAPs account only for direct CO_2 emissions of iron and steel production, whereas integrated plants receive free allocation for emissions generated from the production of coke, molten iron, and crude steel, EAF plants do not receive allowances for indirect energy inputs. Basing allocation on historic emission therefore protects the carbon intensive steel producers, whist EAF steel production remains similarly exposed to competitiveness impacts along with downstream industries like Aluminium, due to its high vulnerability to indirect impact of increased electricity prices. The study by McKinsey and Ecofys (2006) addresses the differentiation between BOF and EAF in terms of both cost pass thorough ability and relative reliance on direct and indirect energy inputs.

5.3.2 Diversity across Europe

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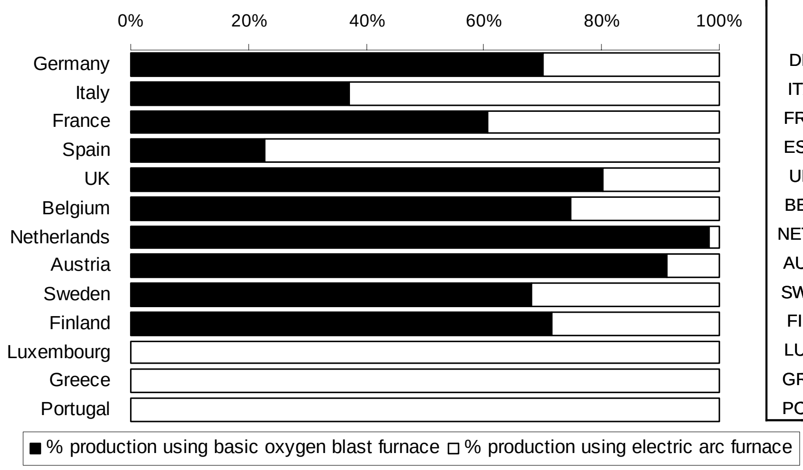
[17] On average, a tonne of steel produced using BF consumes around 400kg of coke and around 300kWh electricity.

[18] On average, a tonne of steel produced using the integrated route in the OECD has an emission factor of 2.2 t CO_2/t, of which fossil fuels accounts for 2.1 t CO_2/t and electricity accounts for only 0.1 t $CO_2$2/t. In contrast, the emission factor for steel produced using the EAF process is 0.5 t CO_2/t, of which electricity accounts for 0.3 t CO_2/t (Watson et al, 2005).

The product mix and hence production routes are largely driven by the economics of input materials for production. This explains to a large extent, the international variation in the ratio between the primary and secondary production routes, and the corresponding rate of CO_2 tonnage emitted per unit of steel output as shown in Figure 7.



	Emission factor (t CO2/t)	Total Production ('000 tonnes)
DE	0.88	44,809
ITA	0.59	26,832
FRA	0.80	19,758
ESP	0.46	16,094
UK	0.97	13,268
BEL	0.92	11,135
NETH	1.13	6,572
AUS	1.07	6,262
SWE	0.86	5,708
FIN	0.89	4,766
LUX	0.26	2,675
GRE	0.26	1,701
POR	0.26	730

Figure 7 Comparison of Carbon Dioxide Generation and Method of Steel Production in 2003

Source: Data from The Carbon Trust based on IISI, OECD.

Integrated steelmaking pathways are dependent on availability of coal and iron ore, while the secondary route relies heavily on scrap steel availability. High sunk costs and the volatility of world scrap supply and prices also constrain the substitutability of the two production processes.

5.3.3 Mitigation options

Iron and steel is one of the most energy intensive manufacturing sectors and accounts for an estimated 5.2% of total global GHG emissions (Watson, Newman et al. 2005). The production processes involves a series of batch processes, generating various fuel and heat by-products throughout the process. There are a wide variety energy retrofit and other efficiency I mproving options including by-product heat, energy and process gas recovery, reducing loss of heat, process integration, and efficient design of furnaces. In addition, fuel-switching in integrated steel plants (e.g. instead of coke, Direct Reduced Iron technology utilises chemical reactions and natural gas to produce molten iron) can significantly reduce emissions.

Mitigation potentials in the industry have been estimated by several authors. In an examination of 47 energy efficiency improvements in the US iron and steel sector, Worrell et al (2001) found a technical potential of 24% efficiency improvements out to 2010, and a economic potential of 18% using a 30% discount rate. De Beer et al (2001), using a discount rate of 4% estimate the cost-effective potential in EU-15 out to 2010 to be 10.2% (18 Mt CO_2/yr) compared with baseline emissions. In addition, technical potentials of around 15 Mt CO_2/yr for eight energy saving technologies in 2030 in Western Europe are estimated by Tanaka et al (2006) using the Monte Carlo approach. Adopting such technologies offer steel makers the opportunity to reduce exposure to EU ETS competitiveness impacts.

However, the economic potential for energy efficiency improvements varies widely across individual plants, depending on plant configurations and on local markets for fuels, heat and electricity (Watson, Newman et al. 2005).

The European iron and steel sector, in partnership with international steel producers, suppliers and academics, is also addressing post-Kyoto issues through the €44m, partly EC-funded, Ultra Low CO_2 Steelmaking (ULCOS) Initiative. This multi-phased project focuses on developing technological innovations for the integrated method of steel production including smelting reduction processes that will eliminate the requirement of coke, which is an energy-intensive product that produces CO_2 in the coke-making and iron-making processes. Another project within this initiative is research into CO_2 capture and storage; this particular project is seen as an essential method for ULCOS to meet its CO_2 reduction targets (House of Commons Select Committee 2005). Such RD&D efforts by OECD steelmakers, including EU manufacturers, are essential in order to develop sustainable innovations for steel production based on finite resources and the global competitive market of the iron and steel sector.

5.3.4 *Free allocation and perverse incentives from the EU ETS*

As mentioned above, under existing NAPs that index allocation to historic emissions rewards high emitters (i.e. integrated steel mills) with larger allowances, whilst the lower CO_2-emitting EAF process receives less. Furthermore, a study by Entec and NERA Economic Consulting (2005) has noted perverse incentives resulting from allocation methods: because downstream operations such as cold rolling and annealing are unaccounted for in the current scheme, there is an incentive to 'leak' gases produced from upstream operations such as blast furnaces and from basic oxygen steelmaking and utilised for its energy content in these downstream operations. However, these issues have since been addressed according to subsequent publications (DTI, 2005).

Like cement, some industry groups have put forward for output-based allocation scheme based upon cost pass-through abilities and value at stake as a proportion of sector profit. This, as supported by modelling studies quantifying impacts on the steel sector (Burtraw, Palmer et al. 2001; Quirion 2003) provides incentives for firms to maintain production levels and hence reduces leakage. However, these models consistently estimate that compared with allocation by grandfathering of auctioning, the iron and steel sector profits less with output-based allocation. Because no CO_2 scarcity rent is created, CO_2 costs are not internalised into decision-making, and are not reflected in product prices. This means that there is less incentive for intermediate and final consumers to switch to less polluting products. If allocation is generous and output increases, then steel prices will fall.

As Figure 3 shows, large volumes of iron and steel products are traded within the EU, hence it is important that allocation methodology is harmonised across MS.

5.4 Pulp and paper

Although analysis on the UK newsprint production in (Smale, M. et al. 2006) estimates the EU ETS cause very small impact, this result may not be applicable sector and EU wide for the following reasons: newsprint represents only a small proportion of production in the sector, its raw material basis and production technologies are not representative of the whole EU, and the P&P industry in the UK is extremely small relative to Scandinavian or central European countries. Nonetheless, two essential cross-cutting features of P&P are reflected in the results. Firstly, with high levels of use of on-site Combined Heat and Power (CHP) generation based on waste as fuel, production costs is relatively less exposed to increased electricity prices. At the same time, the market for paper and pulp is highly globalised, hence producers have limited opportunity to pass on costs to product prices.

5.4.1 Diversity of product, processes and carbon intensity

Comparing the energy efficiency and CO_2 factors of pulp and paper plants internationally is difficult as product mixes and energy supplies differ dramatically between plants and countries (Siitonen and Ahtila 2002). The sector is characterised by: multiple production technologies (mechanical and chemical pulping); different product types (pulp, newsprint, fine papers, packaging, and sanitary and household); multiple raw materials (wood and recycled fibre); and energy as a side product in some of the production technologies (chemical pulping produce waste liquor, and heat recovery with mechanical pulping)(Phylipsen, Blok et al. 1998).

Whereas some production processes are self-sufficient of energy supply (chemical pulping) and might even produce surplus, others (mechanical pulping, fine paper when not integrated with chemical pulping) require significant external supply of energy, especially electricity. Recycled fibre based paper production is much less energy intensive process than wood based paper production (Siitonen and Ahtila 2002). Table 2 summarises the differences in carbon intensity between pulp and paper production technologies.

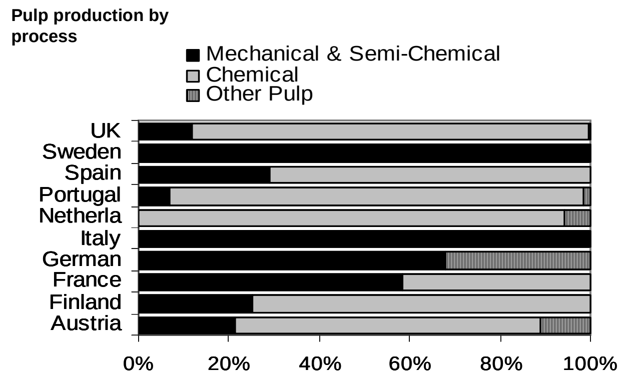
Industry	Indirect CO2 emissions	Direct CO2 emissions	Total CO2 emissions
Chemical pulp	0.07	0.04	0.12
Chemical P&P	0.62	0.00	0.62
Mechanical P&P	1.03	0.00	1.03
Thermo-mech.P&P	0.12	0.02	0.14
Recovered fibre P&P	0.27	0.34	0.61

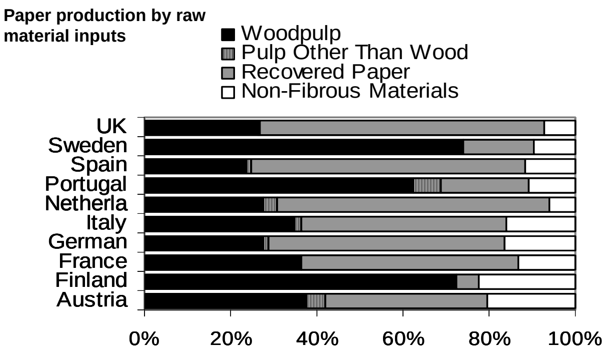
Table 2 Carbon intensity in pulp and paper production, tons of CO2 per ton of pulp/paper produced.

Source: McKinsey and Ecofys (2006), p.32.

5.4.2 Diversity across Europe

Europe is divided into countries where wood material is available and allows large scale production (Scandinavia) and where most paper is produced by recycled fibre or imported pulp (rest of Europe). As shown in Figure 8, Scandinavian countries produce large volumes of high quality products for export (using highly energy efficient processes) while Central Europe has smaller and less efficient facilities for local consumption. In addition to Scandinavia, Germany is a significant paper producer in Central Europe (Commission 2001).





Pulp & Paper Sector

	Emission factor (t CO2/t)	Total Production* ('000 tonnes)
UK	-	-
SWE	0.19	15696
ESP	0.61	6924
PT	0.29	2755
NL	-	-
ITA	0.81	9756
GER	0.73	20987
FRA	0.44	11152
FIN	0.43	16700
AUS	0.54	5334

*Sum of paper and market pulp production

Figure 8 - Pulp and Paper production of selected EU countries in 2002

Source: adapted from CEPI Annual Statistics 2002 & Finnish Forestries Industries federation.

Exposure to import is unevenly divided between plants and EU countries as some products are produced for domestic or local markets while others are mainly exported. The largest producers, namely Finland and Sweden, export a significant share, almost 1/3 of total production outside the EU, while the EU remains the most important market (Swedish Forest Industries Federation 2005). Competitiveness impacts from EU ETS concerns in the pulp and paper sector therefore affect Scandinavia more than rest of Europe, as the share of the sector of GDP is high (Kemppi, Honkatukia et al. 2002).

5.4.3 Mitigation Options

There are three main avenues for reducing CO_2 emissions in the sector:

1) Saving energy by new modes of operation: improvements of skills and motivation of personnel; energy audits; process integration; monitoring and control; and modern financing mechanisms of energy conservation such as Energy Saving Companies.
2) New technology: Introduction of more energy efficient technologies; and electrical devices with low energy consumption (Siitonen and Ahtila 2002). Also gasification of fuels, especially bio fuels, provides emission reductions.
3) Fuel switching can be an importance source of emission reductions. Practical examples include further introduction of CHP and increasing energy sourced from renewable energy sources.

Many of these grouped potentials, particularly those involving fuel switching and increasing CHP capacity, have already been used in Scandinavia, but large potentials remain in Central Europe. The fact that own CHP capacity reduces the exposure to electricity price rises (The Carbon Trust 2004) has also been largely recognised. In Scandinavia, CHP is already common amongst pulp producers as a result of the supply of waste liquor that can be used as a fuel. Such bio fuels are carbon neutral that can allow some of the received allocation to be sold in the EU ETS.

Most of the pulp and paper firms in Finland own significant shares of electricity producing companies which contributes to the lower electricity prices for them (Siitonen and Ahtila 2002; Korppoo unpublished). Similarly, large industrial energy users may be able to negotiate a lower electricity price based on long-term contracts with low carbon producers receiving windfall profits as their production costs have not increased in line with electricity prices (The Carbon Trust 2004).

The instability of carbon price contributes to the difficulty of investment planning while the energy intensity of the sector makes the sector vulnerable to the influence of the EU ETS. Operating outside the EU and self-sufficiency of energy can protect the sector from the negative impacts of the EU ETS. One additional concern is the influence of carbon pricing to the availability of wood raw material for pulp production as carbon costs may encourage using the carbon neutral wood as a fuel rather than as raw material of paper (McKinsey and Ecofys, p.33; CEPI 2003).

5.4.4 *Free allocation and perverse incentives from the EU ETS*
The pulp and paper market is global (Kemppi, Honkatukia et al. 2002; CEPI 2003) and pricing is competitive due to fairly low concentration of the sector (McKinsey and Ecofys 2006, p.33) which increases the sensitivity of the sector to competition from outside the EU where carbon is not priced. Consequently, European pulp and paper producers have limited ability to pass through CO_2 prices to product prices, however, this varies between products. According to the same study, 50% of the expected increased costs of chemical pulp production can be passed on to the customer while the respective figure for paper is 0-20%, and 0-0.7% for recovered pulp.

The EU ETS is expected to influence the division of markets between pulp and paper producers inside and outside the EU as the carbon cost, especially those linked to increasing electricity prices, is not added to prices outside the EU (McKinsey and Ecofys 2006, p.33; CEPI 2003). This competitive advantage for producers from outside the EU, especially from the US, worries EU producers.

McKinsey and Ecofys (2006, p. 36) has estimated that the short and mid-term effect of the EU ETS on competitiveness (assuming 95% free allocation of allowances) is reflected as the following net cost increases: 0% for chemical market pulp, 1.2-1.9% for recovered fibre, 0.6-1.1% for paper produced of chemical pulp, 3.1-4.2% for paper produced of mechanical pulp and 4.7-6.2% for paper produced of thermo-mechanical pulp. These figures illustrate the uneven influence of the EU ETS on different pulp and paper production technologies.

Complexity of the sector makes the competitiveness issues, and incentive issues difficult to conceptualise. For instance, the UK newsprint producers argue that integrated producers of pulp and paper (mainly in Scandinavia) have a competitive advantage as they are able to use the waste stream of their pulp production as a carbon neutral source of energy (The Carbon Trust 2004). It is true that for instance Finnish pulp and paper industry is self-sufficient of heat, and produces some 40% of its electricity demand (Siitonen and Ahtila

2002). But as the scale of production is much larger in Scandinavia than in the UK, the dramatically less energy intensive process based on recycled fibre cannot be used as the main supply of raw material which is possible in the smaller scale production in Central Europe. Consequently, the additional cost of carbon has much smaller impact on producers using recycled fibre in Central Europe.

Business actors around Europe have argued that early action, which refers to investments in advanced low carbon technologies such as efficient production processes, CHP and bio fuels, has not been recognised in the national allocation of emitting rights (Kylä-Harakka-Ruonala 2004; The Carbon Trust 2004). Even withholding from updating technology in order to increase the EU ETS allocation was suggested as means to protect business from carbon costs by one Finnish pulp and paper producer. It seems that NAPs address this problem different ways which may influence competitiveness of companies inside the EU. However, such early action has certainly protected the sector from the EU ETS as the plants supplied by renewable energy sources require no emitting rights, and any allocation under EU ETS would provide an additional source of revenues. However, competitiveness between EU and non-EU producers is more relevant than the influence of National Allocation Plans to the competitiveness between EU countries.

Moreover, as there is competition between EU producers, it is important that the method of national allocation is similar in all member states (The Carbon Trust 2004).

6. CONCLUSIONS

This paper has summarised cross-cutting factors that differentiate impacts of the EU ETS on profitability and market share, drawing upon the basic insights derived from modelling studies of individual sectors (Smale et al. 2006); that most sectors participating in the EU ETS and in particular the power generation sector will profit under the current structure out to 2012, but for trade sectors, this comes at the cost of a modest loss of market share.

However, conclusions from aggregated analysis mask differences in exposure experienced on an individual firm or sectoral level. Through examining sample sectors, this paper sheds light on the underlying factors that differentiate impacts.

First, to translate the general principles of cross-sectoral differentiation into quantitative insights, we develop and apply indices to a wide range of sectors.

The indices developed with reference to 2004 UK data in Figures 2 and 3 illustrate that sectors vary widely in their:

- potential net value at stake if sectors receive 0% to 100% free allocation, due to differences in sector EU ETS costs relative to sector value-added;
- ability to apply marginal pricing (pass thorough EUA costs to product prices) because of varying exposure to international trade;
- exposure to indirect costs through electricity price impacts only.

Under the existing scheme where EU ETS sectors receive free allocation similar to BAU levels and no sectors receive compensation for indirect electricity price rise impacts, Non-ferrous metals (principally Aluminium) stand out for their high exposure, not only in potential value-at-stake terms but also in their exposure. Due to their relatively high exposure to indirect electricity impacts, the potential for exposure is also high for the iron and steel sector if the scheme moves towards zero free allocation. However, if sectors receive 100% free allocation, potential net value at stake is low - below 3% - for all sectors except Aluminium.

A closer look into the EU ETS sectors in Section 5 has shown differentiated competitive impacts within sectors across production processes and across regions. Across processes, both the differences in the degree of reliance on electricity input from the grid as well as the range and scope of mitigation options are in some cases considerable. Furthermore, perverse incentives that result from methods of free allocation have been identified in most EU ETS sectors.

To secure efficient mitigation investments by heavy industry requires at least the continuation and basic principles of the EU ETS post-2012. Providing that this is quickly clarified, the period 2008-12 can, under the current terms of the EU ETS, assist the participating sectors to build up experience and financial reserves that can assist them with longer term technology-related investments, and diversification, providing the incentives are in place for them to peruse this. However to strengthen the scheme beyond 2012, significant changes to allocation methodology will be required, taking account of differentiated impacts outlined in this paper.

REFERENCES

Babiker, H. (2005). "Climate change policy, market structure, and carbon leakage." Journal of International Economics **65**: 421-445.

Babiker, M. H., P. Criqui, et al. (2003). "Assessing the Impact of Carbon Tax Differentiation in the European Union." Environmental Modeling and Assessment **8**(3): 187-197.

Barnett, J., S. Dessai, et al. (2004). "Will OPEC lose from the Kyoto Protocol?" Energy Policy **32 (2004)** 2077-2088.

Baron, R. and ECON-Energy (1997). Economic/fiscal instruments: competitiveness issues related to carbon/energy taxation. *Policies and Measures for Common Action Working Paper 14*. A. I. E. G. o. t. UNFCCC. Paris, OECD/IEA.

Biermann, F. and R. Brohm (2003). Implementing the Kyoto Protocol without the United States: The Strategic Role of Energy Tax Adjustments at the Border, Working Paper of the Global Governance Project.

Bosi, M. and J. Ellis (2005). Exploring Options for "Sectoral Crediting Mechanisms". OECD Environment Directorate, IEA. Paris, OECD/IEA.

Burtraw, D., K. Palmer, et al. (2001). "The Effect of Allowance Allocation on the Cost of Carbon Emissions Trading." RFF Discussion Papers **01-30**.

Cembureau (1999). Environmental Benefits of Using Alternative Fuels in Cement Production: A Life Cycle Approach. Brussels, Cembureau.

CEMBUREAU (2000). "Best Available Techniques" for the Cement Industry, CEMBUREAU.

Cembureau, 2006. Climate Change – CO2 Emissions Trading: Points of Convergence within the Cement Industry. Position paper, available at: http://www.cembureau.be/Cem_warehouse/POINTS%20OF%20CONVERGENCE%20WITHIN%20THE%20CEMENT%20INDUSTRY.PDF

CEPI (2003). The European Paper Industry's Views and Action Plan on Climate Change. C. o. E. P. Industries.

CEPI (Confederation of European Paper Industries) (2002). Annual Statistics 2002 European Pulp and Paper Industry, CEPI

CEPI (Confederation of European Paper Industries) (2005). Annual Statistics 2005 European Pulp and Paper Industry, CEPI.

Commission, E. (2001). Intergrated Pollution Prevention and Control. Reference Document on Best Available Techniques in the Pulp and Paper Industry. E. Commission. Brussels.

de Beer, J., D. Phylipsen, et al. (2001). "Economic Evaluation of Carbon Dioxide and Nitrous Oxide Emission Reductions in Industry in the EU." Final Report. Ecofys, Utrecht. accessible at: http://europa. eu. int/comm/environment/enveco/climate_change/sectoral.

Demailly, D. and P. Quirion (2006). "CO2 abatement, competitiveness and leakage in the European cement industry under the EU ETS: Grandfathering vs. output-based allocation." Climate Policy **6**(1).

Demailly, D. and P. Quirion (2006). Leakage from climate policies and border tax adjustment: Lessons from a geographic model of the cement industry, CIRED.

Entec and NERA (2005). EU Emissions Trading Scheme Benchmark Research for Phase 2. DTI.

Eurofer, 2005. The greenhouse gas challenge: how the EU steel industry competitiveness could be affected? Position paper, available at http://www.eurofer.org/positionpaper/compet/OECD12-01-2005doc.pdf

Gritsevskyi, A. and Nakicenovic (2000). "Modelling uncertainty of induced technological change." Energy Policy **28**: 907-921.

Groenenberg, H., D. Phylipsen, et al. (2001). "Differentiating commitments world wide: global differentiation of GHG emissions reductions based on the Triptych approach - a preliminary assessment." Energy Policy **29**: 1007-1030.
Grubb, M., C. Hope, et al. (2002). "Climatic Implications of the Kyoto Protocol: The Contribution of International Spillover." Climatic Change **54**: 11-28.
Grubler, A., N. Nakicenovic, et al. (1999). " Dynamics of energy technologies and global change." Energy Policy **27**(5): 247-280(34).
Gundimeda, H. (2004). "How 'sustainable' is the 'sustainable development objective' of CDM in developing countries like India?" Forest Policy and Economics **6**: 329-343.
Hidalgo, I., L. Szabo, et al. (2005). "Technological prospects and CO2 emission trading analyses in the iron and steel industry: A global model." Energy **30**: 583-610.
Holcim (2006) "Resource Utilization and CO2." http://www.holcim.com/CORP/EN/oid/47529/module/gnm50/jsp/templates/editorial/editorial.html **Volume**, DOI:
House of Commons Select Committee (2005). Memorandum from Corus. Science and Technology - Memoranda. H. o. Commons.
Humphreys, K., M. M., et al. (2002). Toward a Sustainable Cement Industry: Substudy 8: Climate Change. W. B. C. f. S. Development. Battelle.
IPCC (2001). IPCC Third Assessment Report 2001.
Ismer, R. and K. Neuhoff (2004). Border tax adjustments: a feasible way to address nonparticipation in emission trading. Cambridge working papers in economics ; CWPE 0409. Cambridge, Department of Applied Economics.
Johnston, A. (2006). "Free allocation of allowances under the EU Emissions Trading System – legal issues." Climate Policy **6**(1).
Kemfert, C. (2002). "An Integrated Assessment Model of Economy-Energy-Climate – The Model Wiagem." Integrated Assessment **3**(4): 281-298.
Kemppi, H., J. Honkatukia, et al. (2002). EU-laajuisen päästökaupan toteuttamisvaihtoehdot ja vaikutukset Suomen kannalta. V. G. I. f. E. Research.
Korppoo, A. (unpublished). Drivers and barriers to modernisation of Russian pulp and paper industry. . Centre for Environmental Policy, Faculty of Natural Sciences. London, Imperial College London. **Phd**.
Krugman, P. (1994). "Competitiveness: a dangerous obsession." Foreign Affarirs **73**(2).
Kuik, O. and R. Gerlagh (2003). "Trade Liberalization and carbon Leakage." The Energy Journal **24**(3): 97-120.
Kylä-Harakka-Ruonala (2004). Teollisuus ja ilmastopolitiikan eri vaiheet. T. energiankatsaus.
Martin, N., E. Worrell, et al. (1999). Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the U.S. Cement Industry. . Berkeley, Lawrence Berkeley Natl. Lab.
McKinsey & Company and Ecofys (2006). EU ETS Review: Report on International Competitiveness. Conducted for European Commission DG Environment.
Neuhoff, K., K. Keats, et al. (2006). "Allocation, incentives and distortions: the impact of EU ETS emissions allowance allocations to the electricity sector." Climate Policy **6**(1).
Oberndofer et al. (2006): The Impacts of the European Emissions Trading Scheme on Competitiveness and Employment in Europe - A Literature Review (A

report commissioned by World Wide Fund for Nature - WWF)

Oxera (2004). CO2 emissions trading: How will it affect UK industry? Report prepared for the Carbon Trust. Oxford.

Oxera (2005). The Economic Impact of Carbon Policies on UK Companies. Report prepared for The Carbon Trust. Oxford.

Palmer, K., Burtraw, D., Kahn, D., 2006. Simple Rules for Targeting CO2 Allowance Allocations to Compensate Firms, Climate Policy, 6 (5), forthcoming.

Pershing, J. and F. Tudela (2004). A Long-Term Target: Framing the Climate Effort. Beyond Kyoto: Advancing the international effort against climate change, PEW Center on Global Climate Change.

Phylipsen, G. J. M., K. Blok, et al. (1998). Handbook on International Comparisons of Energy Efficiency in the Manufacturing Industry, Department of Science, Technology and Society. Utrecht University.

Quirion, P. (2003). Allocation of CO2 allowances and competitiveness: A case study of the European iron and steel industry. CORE Environmental Seminar, Louvain-la-neuve.

Reinaud, J. (2005). "Industrial Competitiveness Under the European Union Emissions Trading Scheme." IEA Information Paper.

Rosendahl, K. (2004). "Cost-effective environmental policy: implications of induced technological change." Journal of Environmental Economics and Management **48**(3): 1099-1121.

Saddler, H., F. Muller, C. Cuevas (2006). "Competitiveness and Carbon Pricing Border adjustments for greenhouse policies", The Australia Institute Discussion Paper 86.

Schleicher, S. (2006)

Schmidt, J., N. Helm, et al. (2006). "Sector-based Approach to the Post-2012 Climate Change Policy Architecture." Centre for Clean Air Policy, FAD Working Papers.

Siitonen, S. and P. Ahtila (2002). Possibilities of Reducing CO2 Emissions in the Finnish Forest Industry. F. F. I. Federation. Helsinki.

Sijm, J. P. M., S. J. A. Bakker, et al. (2005). CO2 Price Dynamics: The implications of EU emissions trading for the price of electricity. Petten, Energy Resaerch Centre of the Netherlands.

Sijm, J. P. M., Y. Chen, et al. (2006). CO2 Price Dynamics: A Follow-up Analysis of the Implications of EU Emissions Trading for the Price of Electricity. Petten, The Netherlands, Energy Research Council of The Netherlands.

Sijm, J. P. M., O. J. Kuik, et al. (2004). *Spillovers of Climate Policy An assessment of the incidence of carbon leakage and induced technological change due to CO2 abatement measures*. Netherlands Research Programme on Climate Change Scientific Assessment and Policy Analysis, ECN.

Sijm, J. P. M., K. Neuhoff, et al. (2006). "CO2 cost pass through and windfall profits in the power sector." Climate Policy **6**(1).

Smale, R., H. M, et al. (2006). "The impact of CO2 emissions trading on firm profits and market prices." Climate Policy **6**(1).

Swedish Forest Industries Federation (2005). Pulp and Paper Statistics. Stockholm.

Szabo, L., I. Hidalgo, et al. (2006). "CO2 emission trading within the European Union and Annex B countries: the cement industry case." Energy Policy **34**: 72-87.

Szabo, L. s., I. Hidalgo, et al. (2006). "CO2 emission trading within the European Union and Annex B countries: the cement industry case." Energy Policy **34**: 72-87.

Tanaka, K., R. Matsuhashi, et al. (2006). "CO2 Reduction Potential by Energy Efficient Technology in Energy Intensive Industry." Retrieved 17 October 2006, from http://eneken.ieej.or.jp/en/data/pdf/324.pdf.

The Carbon Trust (2004). The European Emissions Trading Scheme: Implications for Inducstrial Competitiveness, The Carbon Trust.

The Carbon Trust (2004). The European Emissions Trading Scheme: Implications for Industrial Competitiveness. United Kingdom, The Carbon Trust.

The Carbon Trust (2005). The UK climate change programme: potential evolution for the business and public sector, The Carbon Trust.

Thomas, C. D., A. Cameron, et al. (2004). "Extinction risk from climate change." Nature **427**: 145-148.

Walker, N. (2006): Concrete Evidence? An Empirical Approach to Quantify the Impact of EU Emissions Trading on Cement Industry Competitiveness.

Watson, C., J. Newman, et al. (2005). Can Transnational sectoral agreements help reduce Greenhouse Gas Emissions? Round Table on Sustainable Development. Paris, OECD.

Worrell, E., L. Price, et al. (2001). "Energy efficiency and carbon dioxide emissions reduction opportunities in the US iron and steel sector." Energy **26**(5): 513-536.

Worrell, E., L. Price, et al. (2001). "Carbon Dioxide Emissions From The Global Cement Industry." Annual Review of Energy and the Environment **26**: 303-329.

Zhang, X. and A. Baranzini (2004). "What do we know about carbon taxes? An inquiry into their impacts on competitiveness and distribution of income " *Energy Policy* **32 (2004)**: 507-518.