Competitiveness Effects of Environmental Tax Reforms

COMETR

Publishable Final Report
to the European Commission, DG Research
and DG Taxation and Customs Union
(Summary report)

NERI, University of Aarhus (Denmark)
Cambridge Econometrics (UK)
ESRI (Ireland)
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Abstract:	COMETR provides an ex-post assessment of experiences and competitiveness impacts of using carbon-energy taxes as an instrument of an Environmental Tax Reform (ETR), which shifts the tax burden and helps reduce the carbon emissions that cause global warming. COMETR: reviews the experience in ETR in seven EU Member States (Denmark, Germany, Netherlands, Finland, Slovenia, Sweden and UK); analyses world market conditions for a set of energy-intensive sectors, as a framework for considering competitiveness effects; analyses the effects of ETR on sector-specific energy usage and carbon emissions in Member States with carbon-energy taxes introduced on industry; presents a macroeconomic analysis of the competitiveness effects of ETR for individual Member States as well as for the EU as a whole; provides ex-post figures for environmental decoupling and assesses carbon leakage; reviews mitigation and compensation mechanisms for energy-intensive industries.
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COMETR
Overview of deliverables

The final report contains the following deliverables from the COMETR project – it is these deliverables which are summarised in the present publishable final report (summary report).

WP1

Mikael Skou Andersen, ***Environmental tax reform and the competitiveness issue,*** **Aarhus: NERI.**

Stefan Speck, ***Overview of environmental tax reforms in EU member states,*** **Aarhus: NERI.**

WP2:

John Fitz Gerald, Mary Keeney and Sue Scott, ***Analysis of world market conditions for energy-intensive sectors as a framework for considering competitiveness effects,*** **Dublin: ESRI.**

WP3:

Anders Ryelund, ***Improvements in energy efficiency and gross carbon-energy tax burdens in eight energy-intensive and less energy-intensive sectors: a sub-sector perspective,*** **Aarhus: NERI.**

Martin Enevoldsen, Anders Ryelund and Mikael Skou Andersen, ***The impact of energy taxes on competitiveness, output and exports: a panel regression study of 56 European industry sectors,*** **Aarhus: NERI.**

Alexandra Miltner and Roger Salmons, ***Assessment of the impacts of environmental tax reforms on the competitiveness of selected industrial sectors,*** **London: PSI.**

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WP4:

Terry Barker, Sudhir Junankar, Hector Pollitt and Philip Summerton, ***The effects of environmental tax reform on international competitiveness in the European Union: modelling with E3ME,*** **Cambridge: CAMECON**

WP5:

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Terry Barker, Sudhir Junankar, Hector Pollitt and Philip Summerton, ***Carbon leakage: Analysis within an E3ME framework,*** **Cambridge: CAMECON.**

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WP6:

Mikael Skou Andersen and Stefan Speck, ***Environmental tax reforms in Europe: Stabilisation, mitigation and compensation,*** **Aarhus: NERI.**

The complete final report is available at http://www.dmu.dk/COMETR

COMETR WP 1

Environmental Tax Reforms in Europe

by

Mikael Skou Andersen, NERI

Seven EU member states have implemented tax reforms which to some extent shift the tax burden from taxation of labour to taxation of carbon-energy. The member states and the initial year of the tax reform[1] are as follows:

1. Sweden (1990)
2. Denmark (1993)
3. Netherlands (1996)
4. Finland (1997)
5. Slovenia (1997)
6. Germany (1999)
7. UK (2001)

The reforms include tax shifts toward energy and transport taxes, as well as in some cases a restructuring of energy taxes to reflect better their carbon emissions. While the scale of the tax shifts differs between member states, altogether these tax reforms are assessed to have shifted tax revenues for more than 25 billion euros annually in Europe. It is mainly labour which has experienced the lighter tax burden.

While the resulting reductions in carbon emissions are documented in several studies (Clinch et. al., 2006, Speck et. al., 2006; Enevoldsen et. al., 2007), concerns remain as to whether the broader effects for economic growth, competitiveness and employment are also beneficial. The COMETR project has addressed this difficult and sensitive issue by means of a range of methods and research techniques. COMETR has taken its point of departure in official definitions of competitiveness as established by the EU and OECD.[2] The aim of the COMETR project has been to provide an evaluation from an ex-post perspective on the impacts of ETR on competitiveness, in particular that of energy-intensive industries.

The underlying philosophy of environmental tax reform was expressed by former Commission President Jacques Delors in the famous White Paper on Growth, Competitiveness and Employment (Commission, 1993), which recommended taxing 'bads' rather than 'goods' (labour) in order to achieve a double dividend. While the

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[1] According to Slovenia's report to UNFCC its carbon-energy taxation is part of a broader green tax reform (Republic of Slovenia, 2002: 40), but Slovenia mainly restructured its energy taxes to include a carbon component.

[2] The European Commission defines competitiveness as 'a sustained rise in the standards of living of a nation and as low a level of involuntary employment as possible' (EC, 2004). OECD states that competitiveness denotes 'the degree to which a country can, under free and fair market conditions, produce goods and services which meet the test of international markets, while simultaneously maintaining and expanding the real incomes of its people over the longer term'.

first dividend (improved environmental conditions) is long-term in nature, a second and more immediate dividend was expected to arise as a result of a tax shift from labour to pollution. This second dividend, according to the philosophy, would bring increased social welfare; the principal route of effects being an increase in employment as labour costs lower and while costs of fossil fuels increase.

There has been ample criticism of these assertions in economics and taxation literature. Goulder (1995) has suggested that the double dividend cannot be taken for granted but depends on the specific distortionary properties of the tax that is replaced by energy taxation. Bovenberg and de Mooij (1994) warned that energy taxes could cause *inflationary* effects, as wage earners would demand compensation for increased power and heating costs.

The response from the architects of environmental tax reform (ETR) to these critics has been to emphasize the role and design of **revenue recycling**; when energy taxes are used to replace employers' social security contributions, no inflationary push is caused, as a highly distortionary labour market tax is replaced. Indeed this approach has been the red thread in member state ETRs.

A complication arises with energy-intensive companies, because the compensation they receive via the reduction in social security contributions does not fully match the additional energy costs. They may have a small labour stock, while they consume large amounts of energy. Their sensitivity depends on the degree to which they use carbon-intensive fuels. In member states such as Sweden, Finland and Slovenia the energy-intensive industries benefit from the availability of hydropower and nuclear power, and so are less sensitive to carbon-based energy taxes. However, in most member states complicated schemes have been designed to balance, cap or reduce the tax burden of energy-intensive industries. Exemptions present a complex regulatory taxation mesh that distorts not only the desired impacts of energy taxation, but also poses a threat to fair terms of competition. According to EU law such exemptions constitute state aid and must be approved by the European authorities, thus helping to control member state concessions to energy-intensive industries.

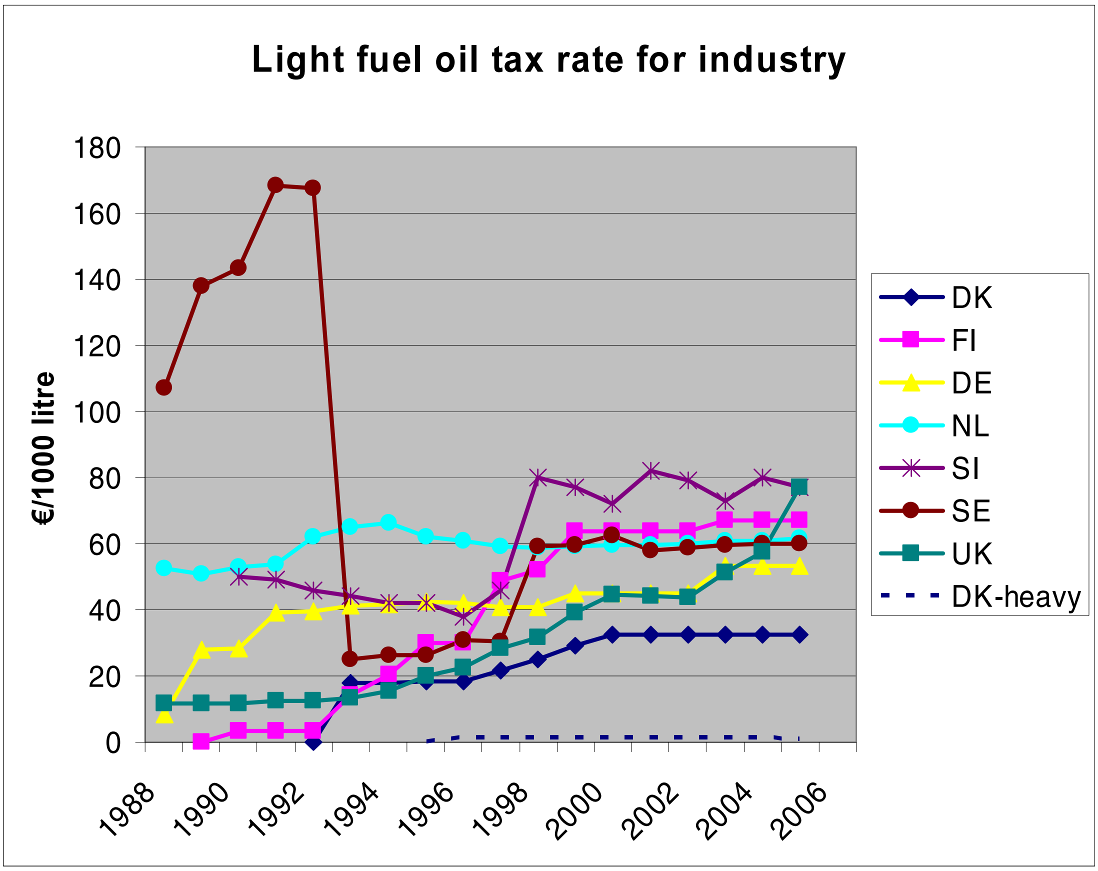
ETR changes the relative costs of the products produced by all companies and in particular by energy-intensive companies – and the taxation debate has been followed by speculations concerning the extent to which energy-intensive industries can either reduce their energy consumption or switch the fuel input to less carbon-intensive sources. While many energy-intensive industries maintain that they have already minimised their fossil fuel use to an efficient level, proponents of ETR cite studies and claim that further energy savings can be attained, in particular in response to energy taxation (e.g. DeCanio, 1998; Porter and van der Linde, 1995).

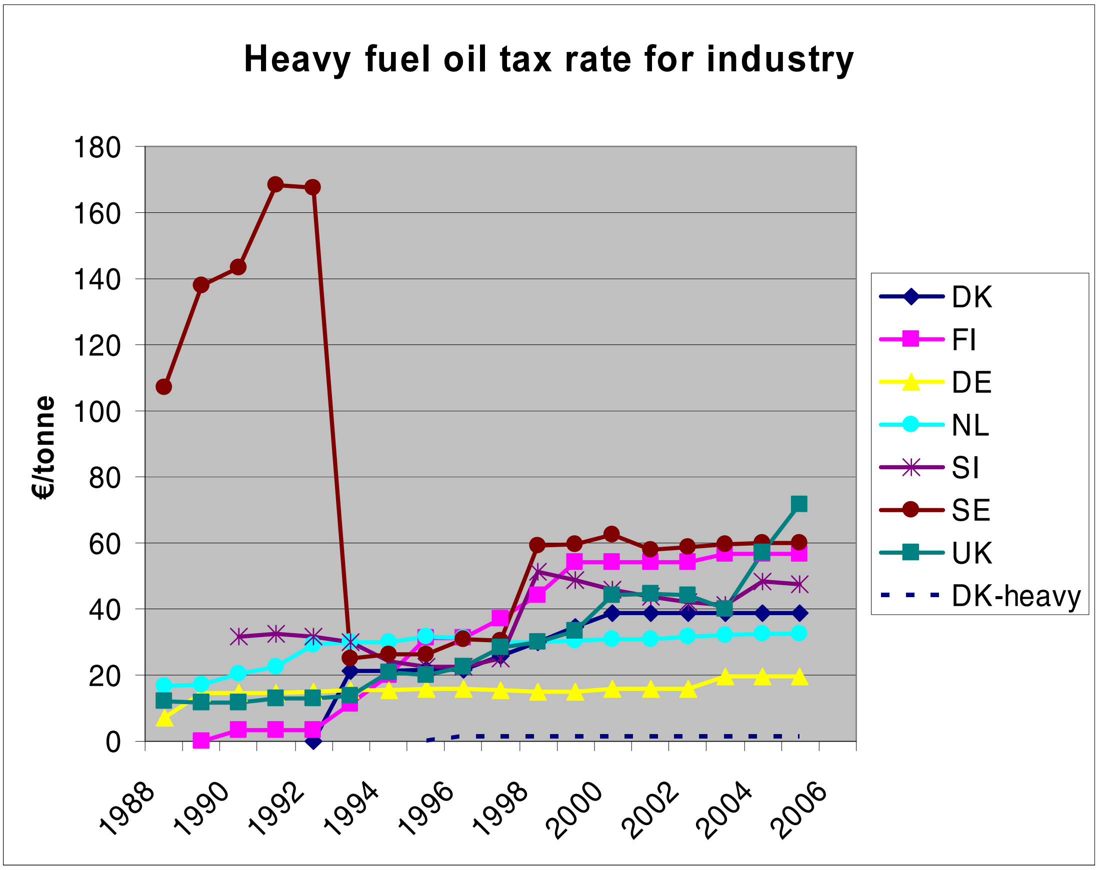
However, the 'Porter hypothesis' (Porter, 1991) boldly states that a pressure to innovate caused by energy taxes in fact will facilitate improved competitiveness, if not of the individual company then of the economy at large. If for specific producers fuels cannot be switched or efficiency not be improved, the changed relative prices will favour other producers, and to the extent that such producers are innovative overall competitiveness of the economy may in fact improve. However, this hypothesis as well as the extent to which the losers of such transitions will respond with carbon leakage rather than with innovation, i.e. relocation to non-ETR countries, remains a controversial issue which connects with broader questions and patterns of globalisation of industrial production, and raises concerns about the need for border-tax adjustments.

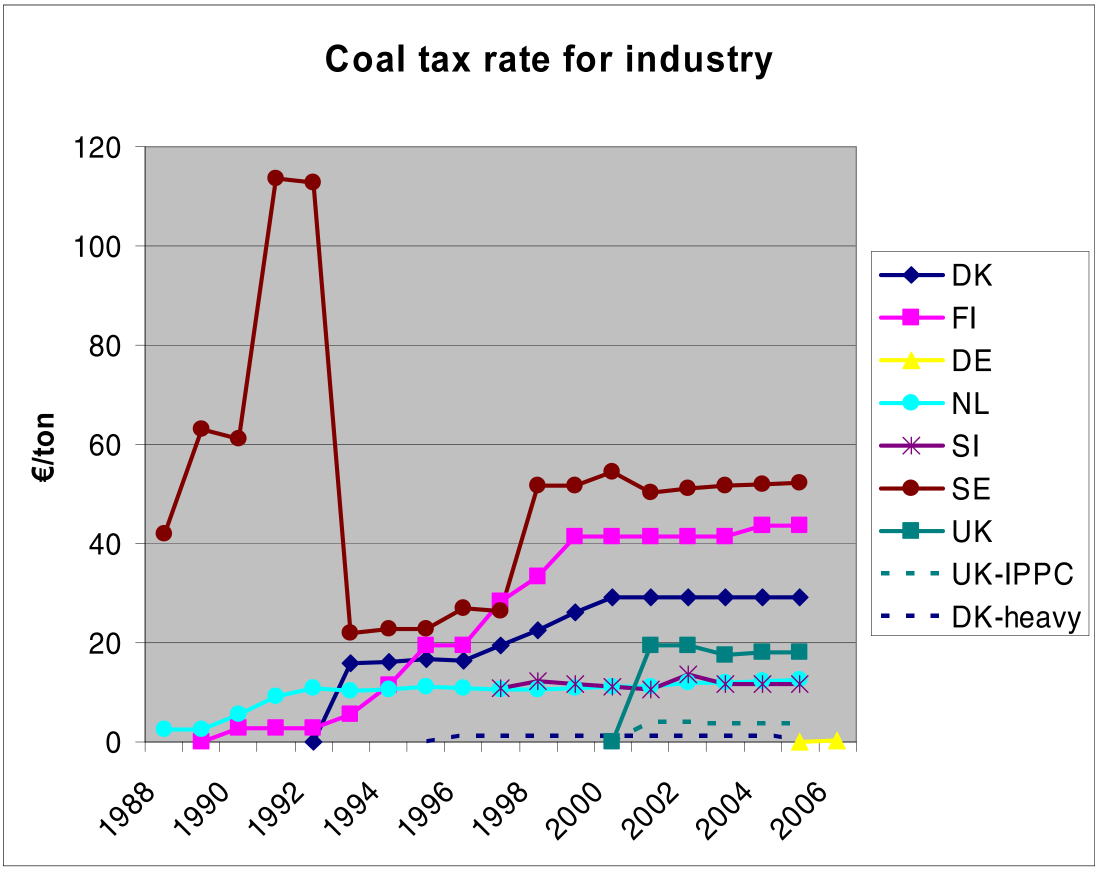
The purpose of the COMETR project has been to study the impacts of ETR on competitiveness using a range of approaches and research techniques. As a stepping stone in this aim the COMETR project has built a unique database of sector-specific energy prices and taxes for a range of energy-intensive industries. Basically, four different research approaches have been employed to investigate the competitiveness impacts of ETR;

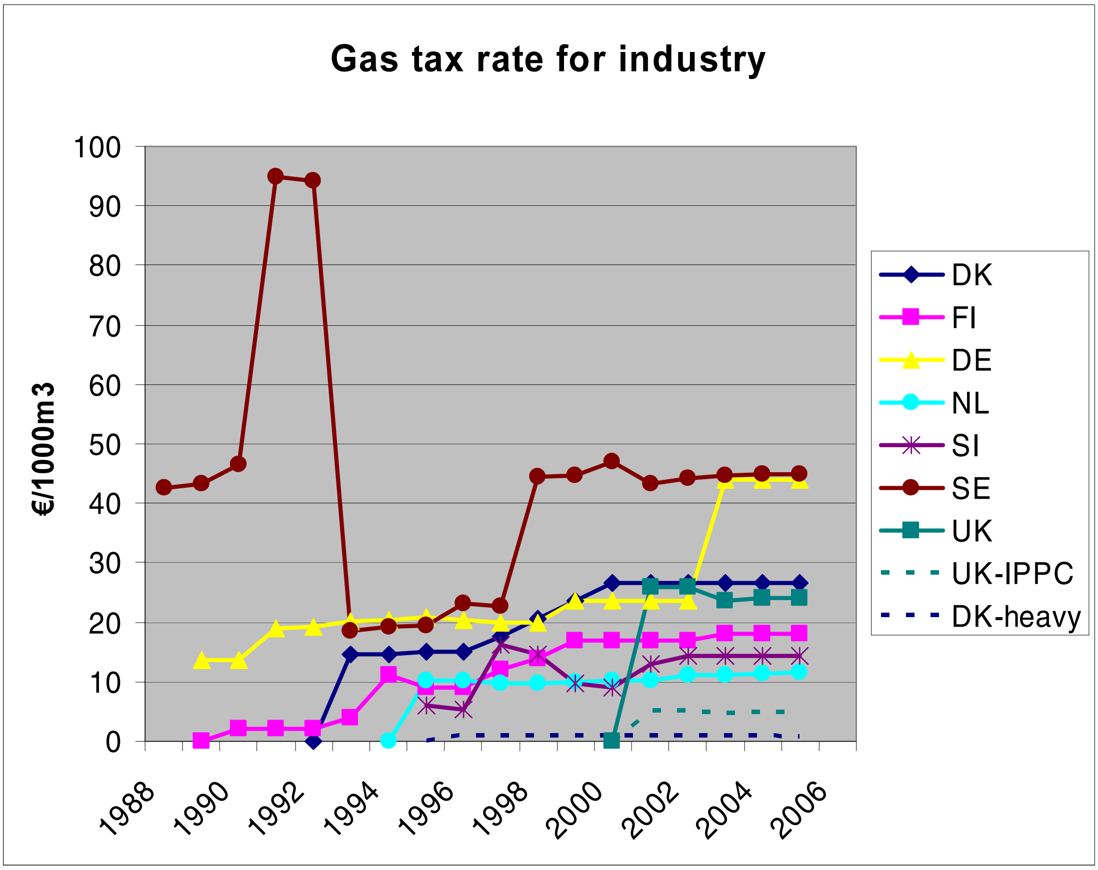
- indicators of changes in unit energy costs as a result of ETR
- bottom-up analysis of energy cost changes relative to changes in competitiveness
- macro-economic modelling in an ex-post perspective by means of the E3ME-model
- case studies and interviews in energy-intensive industries

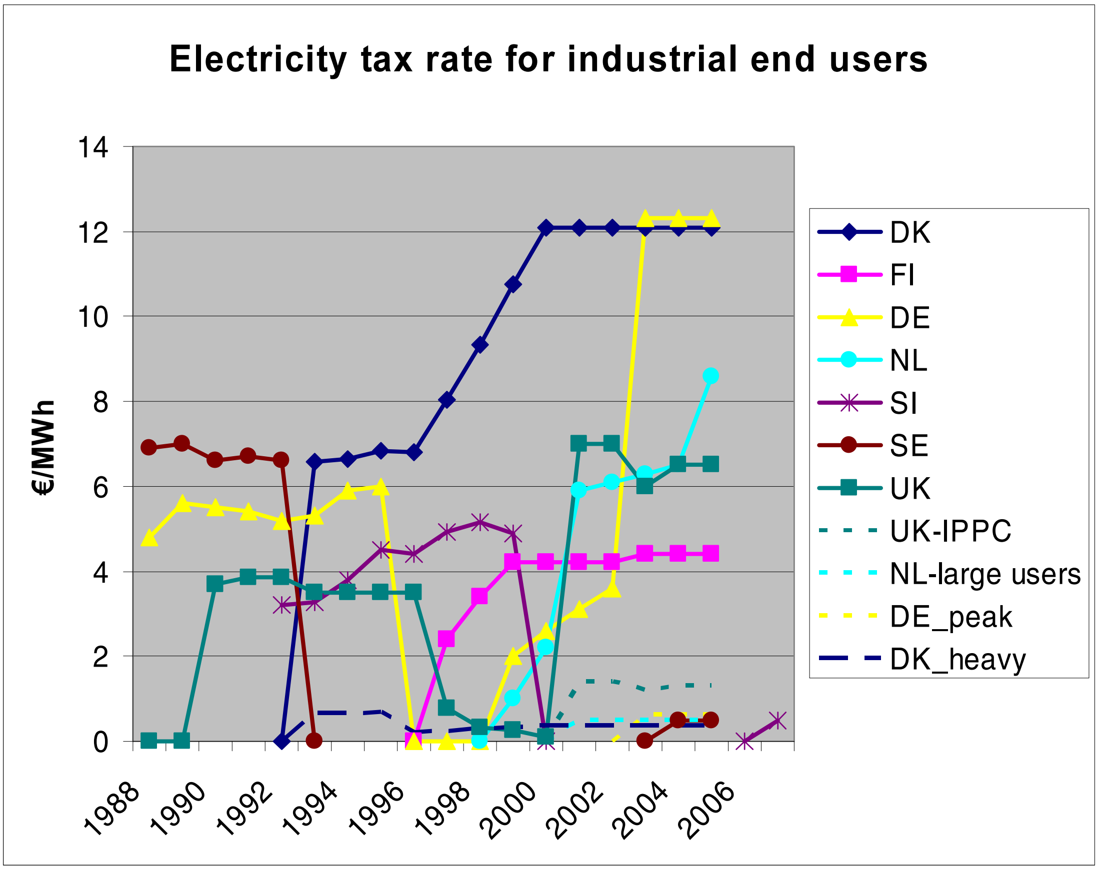
The following figures provide an overview of the time-series for **industry tax rates** (current prices) and **unit energy costs** established as part of the COMETR project. The initially rather high Swedish tax rate would translate into a 10-12 US dollar per barrel oil tax.

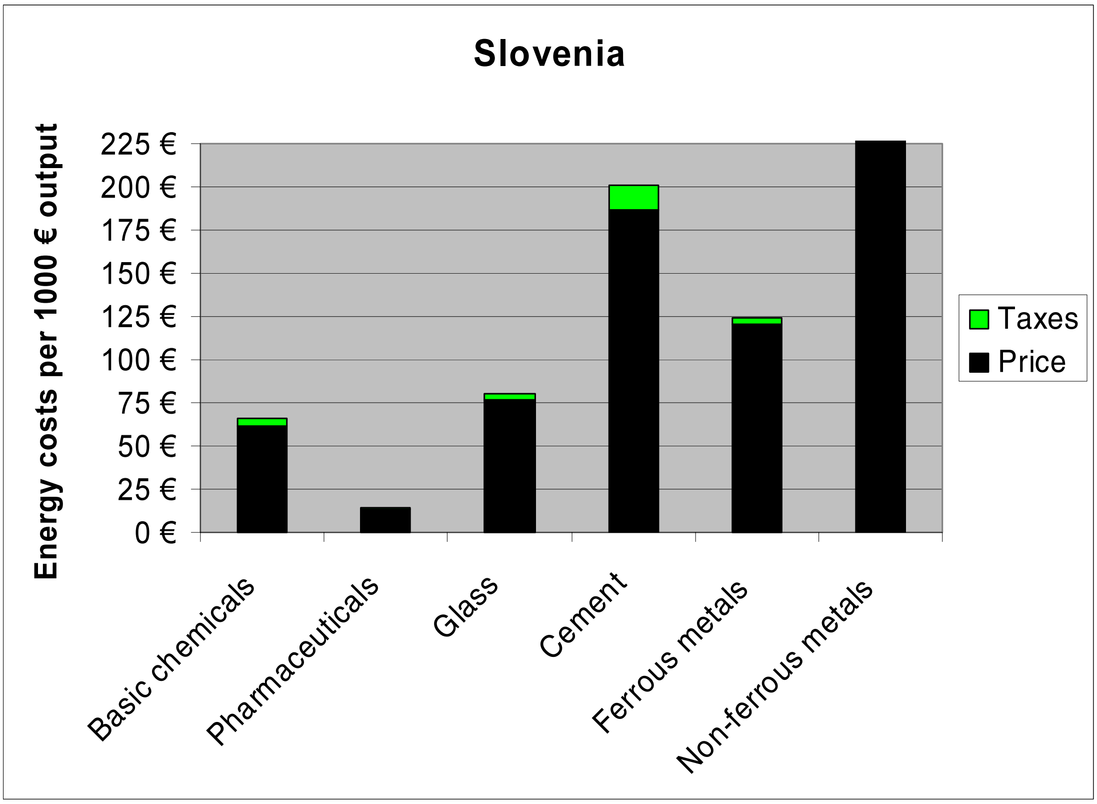


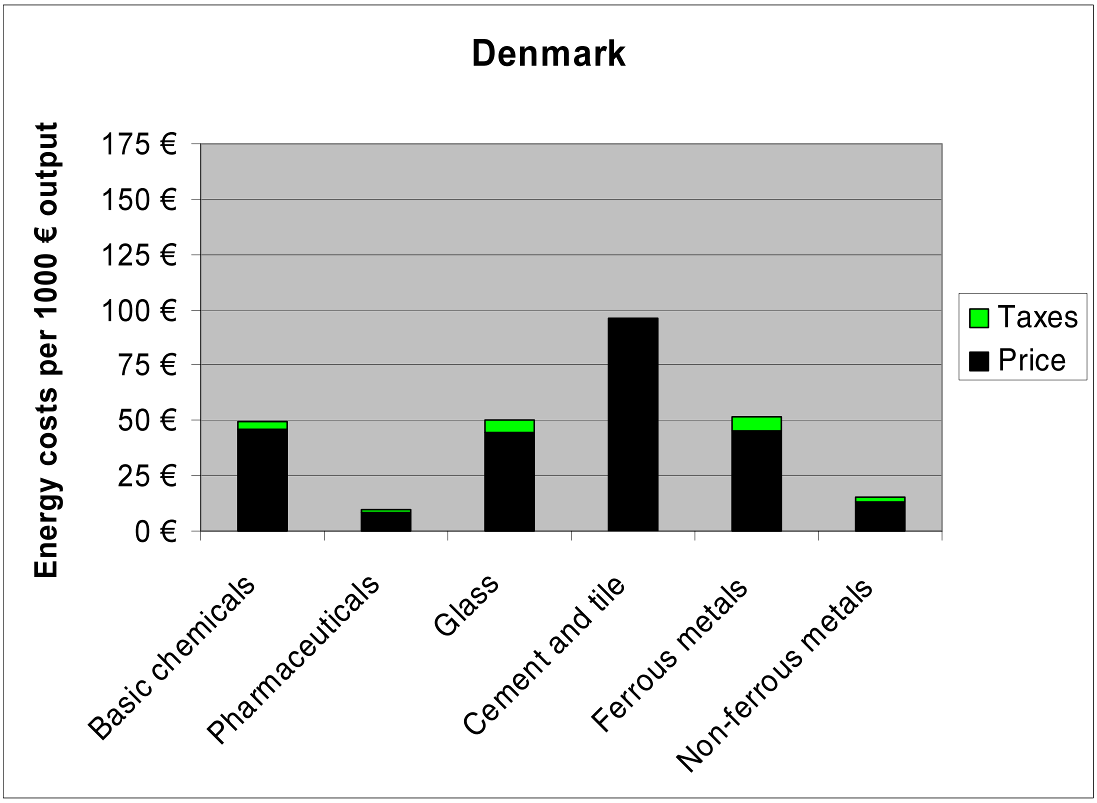

Heavy fuel oil tax rate for industry
€/tonne
180
160
140
120
100
80
60
40
20
0
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
DK
FI
DE
NL
SI
SE
UK
DK-heavy

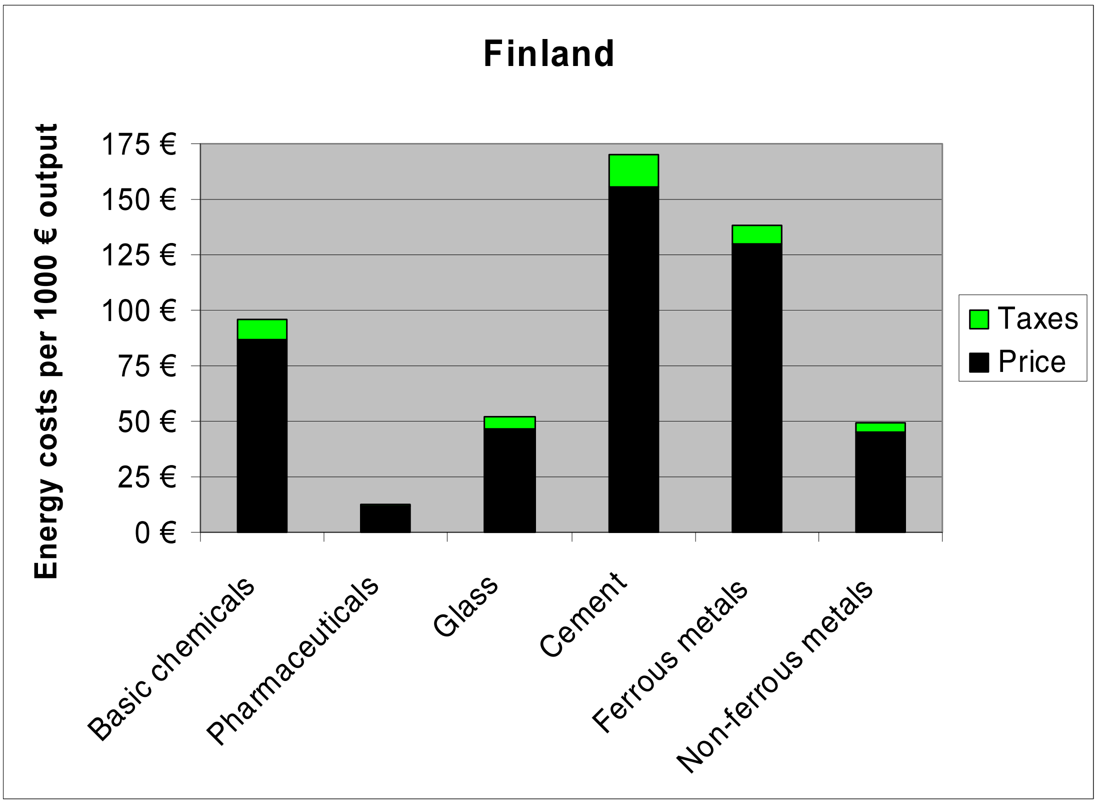

Coal tax rate for industry
€/ton
120
100
80
60
40
20
0
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
DK
FI
DE
NL
SI
SE
UK
UK-IPPC
DK-heavy

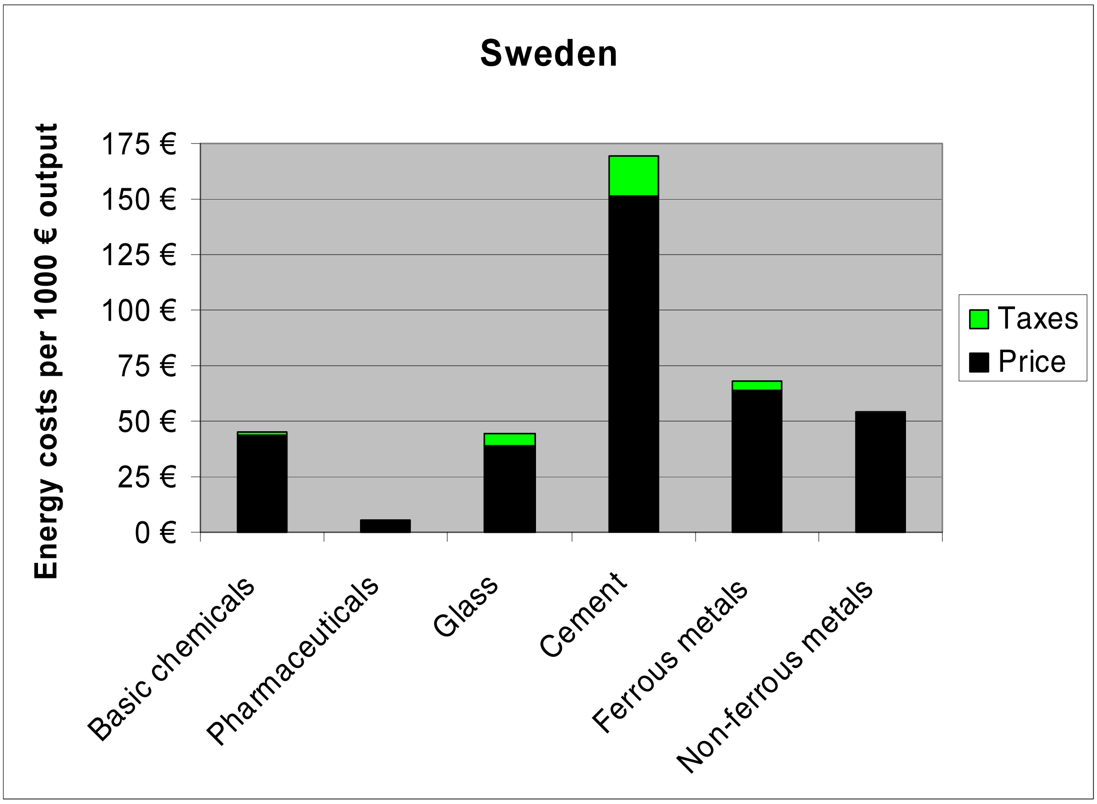

Gas tax rate for industry
€/1000m3
100
90
80
70
60
50
40
30
20
10
0
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
DK
FI
DE
NL
SI
SE
UK
UK-IPPC
DK-heavy

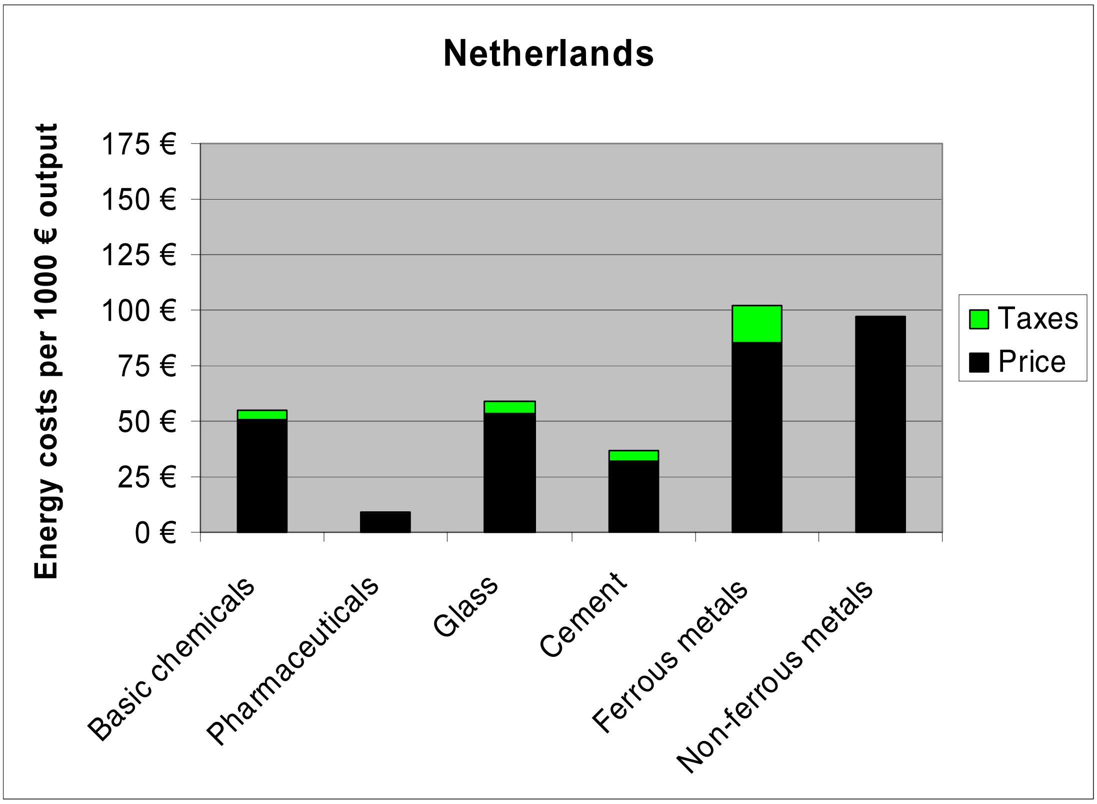

Electricity tax rate for industrial end users
€/MWh
14
12
10
8
6
4
2
0
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
DK
FI
DE
NL
SI
SE
UK
UK-IPPC
NL-large users
DE_peak
DK_heavy

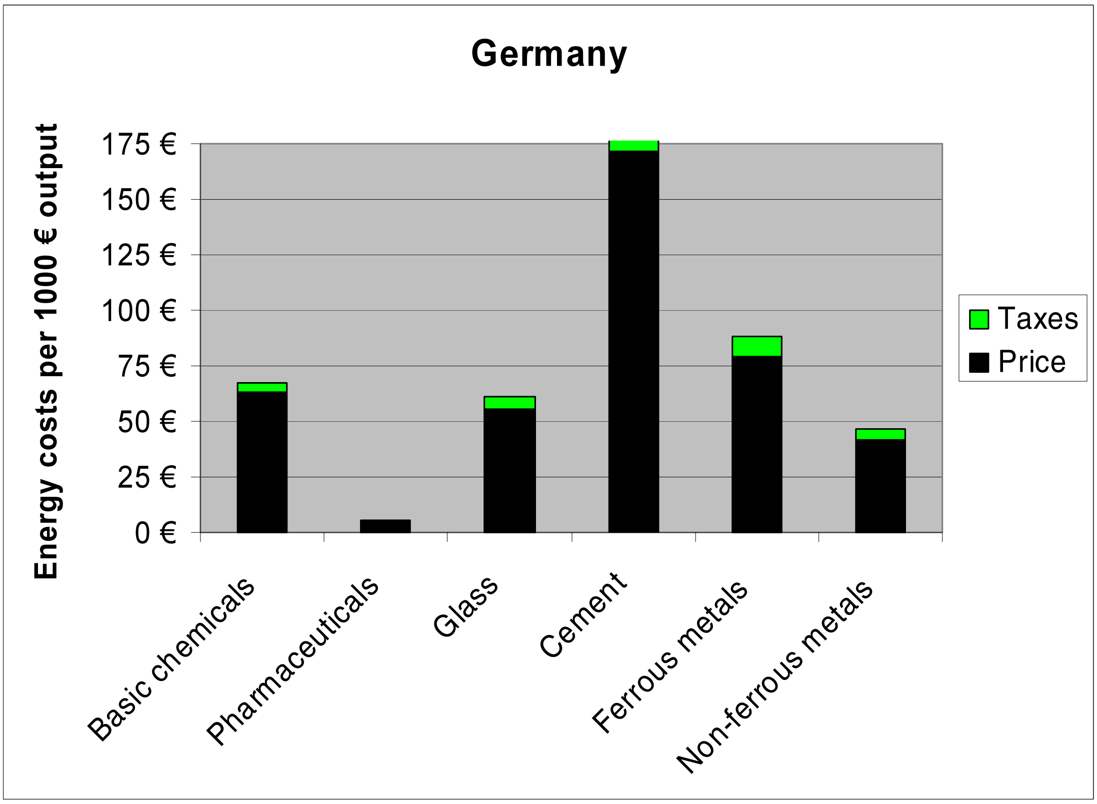

Slovenia
Energy costs per 1000 € output
225 €
200 €
175 €
150 €
125 €
100 €
75 €
50 €
25 €
0 €
Basic chemicals
Pharmaceuticals
Glass
Cement
Ferrous metals
Non-ferrous metals
Taxes
Price

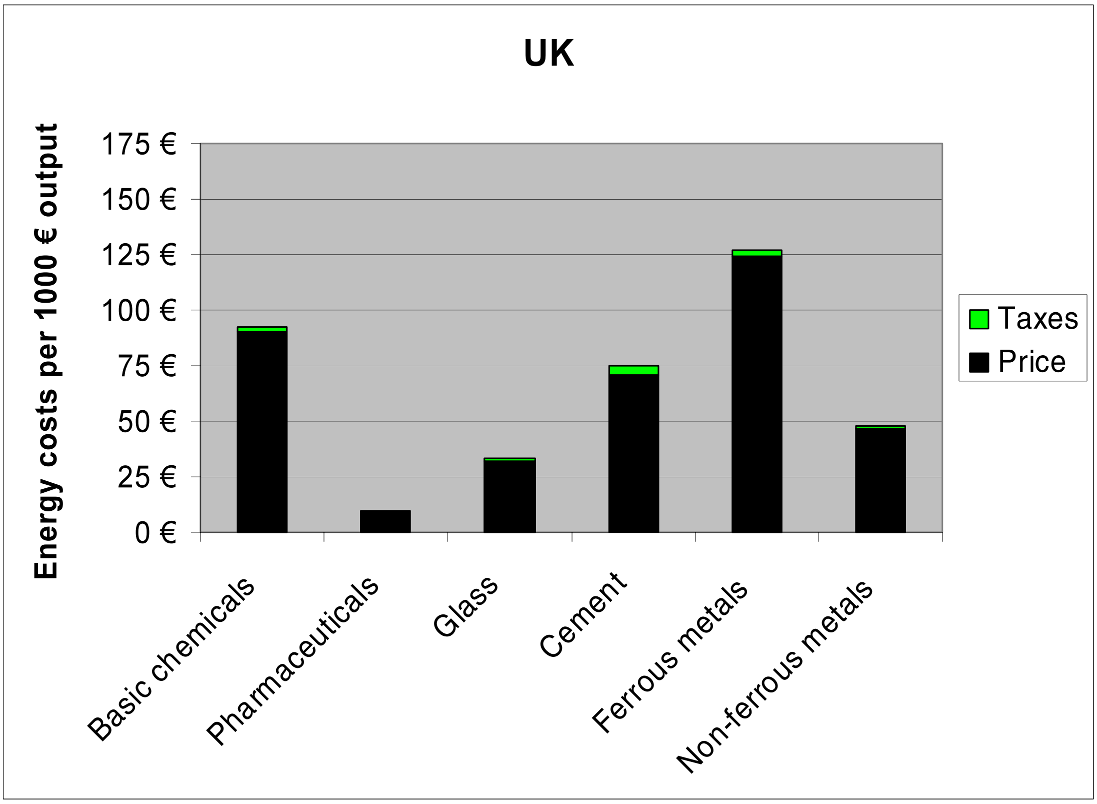

Denmark
Energy costs per 1000 € output
175 €
150 €
125 €
100 €
75 €
50 €
25 €
0 €
Basic chemicals
Pharmaceuticals
Glass
Cement and tile
Ferrous metals
Non-ferrous metals
Taxes
Price


Finland
Energy costs per 1000 € output
175 €
150 €
125 €
100 €
75 €
50 €
25 €
0 €
Basic chemicals
Pharmaceuticals
Glass
Cement
Ferrous metals
Non-ferrous metals
Taxes
Price


Sweden
Energy costs per 1000 € output
175 €
150 €
125 €
100 €
75 €
50 €
25 €
0 €
Basic chemicals
Pharmaceuticals
Glass
Cement
Ferrous metals
Non-ferrous metals
Taxes
Price


Netherlands
Energy costs per 1000 € output
175 €
150 €
125 €
100 €
75 €
50 €
25 €
0 €
Basic chemicals
Pharmaceuticals
Glass
Cement
Ferrous metals
Non-ferrous metals
Taxes
Price


Germany
Energy costs per 1000 € output
175 €
150 €
125 €
100 €
75 €
50 €
25 €
0 €
Basic chemicals
Pharmaceuticals
Glass
Cement
Ferrous metals
Non-ferrous metals
Taxes
Price



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COMETR WP 2

The market: structure and sector vulnerability

by

John Fitz Gerald and Sue Scott, ESRI

Which sectors are potentially vulnerable?
Are they exposed to global competition?

Competitiveness and vulnerability to competition are defined in several ways. This makes it difficult to assess the implications for the manufacturing sector of the introduction of environmental tax reform (ETR), especially the carbon or energy taxes aspect. The present work package looks at the market and structure in which manufacturing sectors have to compete and investigates the two questions posed above, in two main parts.

The first part uses the traditional measures, such as energy intensity, to measure vulnerability, and a screening process is subsequently undertaken in order to select those manufacturing sectors that are potentially vulnerable. In the second part the selected sectors are subjected to an analysis that helps us to understand the kind of market in which they operate and it throws light on the important and insufficiently addressed issue of market power. The point is that a sector may be highly affected by carbon/energy taxes, but ability to pass on these costs in its selling price gives rise to less concern than if the sector has to meet the world price and has to absorb the tax increase. There are also other options such as relocation, technical adjustment and mitigation policies to help sectors adapt and these are touched on in the discussion.

Screening for sectors that are potentially vulnerable under ETR

Screening of all manufacturing sectors at the NACE 2-digit level was undertaken in order to identify sectors that might be vulnerable. For each sector, calculations were undertaken of energy expenditure shares (of value added, gross output and operating surplus); labour's share of value added; exports as a share of total output; imports as a share of supply on the domestic market, and of the shares of exports going to EU and non-EU destinations. Using each of these various measures the sectors could be ranked and allocated to categories of high, medium and low vulnerability. A key measure is energy intensity as this determines the amount of tax due under ETR.

Representation of sectors with low labour intensity was necessary as these could be vulnerable under ETR where revenues were recycled to reduce labour taxes. They could find themselves "under compensated". After consultation with project partners, seven sectors were selected as potentially vulnerable that would be subjected to detailed analysis in the COMETR study. Geographic relevance was taken into account in the selection, such as the importance of wood and paper in the Scandinavian ETR countries (the countries that introduced ETR being Denmark, Germany, Finland, Netherlands, Sweden and the UK). Selected sectors are as follows:

Table 2.1 Seven potentially vulnerable sectors selected for further study

	NACE code	Intensity Energy	Labour	Export	Import
Food and beverages	15	high	low	low	low
Pulp, paper and board	21	high	medium	low	low
Wood and wood products	20	medium	low	low	low
Basic chemicals excl. pharmaceuticals	24 less 24.4	high	low	high	high
Pharmaceuticals	24.4	low	low	high	high
Non-metallic mineral products	26	high	medium	low	low
Basic metals	27	high	high	medium	medium

Source: WP 2 Table 2.1, footnotes apply. This table applies to the UK, where the sectors were ranked by intensities and split into three groups, high, medium and low intensity.

Some observations noted in the study are worth mentioning, focusing on the nineties when ETR was in full swing. It appears that there is much variation in unit energy costs between countries within a sector. Take basic metals in 1998, for example, unit energy costs could amount to about a third (of gross value added) in Finland, compared to less than ten per cent in the UK. Unit energy costs in the wood and paper sector were also highly varied across countries.

By contrast there appears to be more consistency within countries. A country that has high unit energy costs in one sector tends to have high unit energy costs in many other sectors as well. Germany and the Netherlands provide good examples. At the other end of the scale, Denmark and then the UK have fairly consistently lower unit energy costs. A ranking according to unit energy cost in the following table shows this.

Table 2.2 Ranking of countries according to unit energy cost (GVA basis) within each sector (1998, 1=most intensive country; 6=least intensive country)

1998	Wood and Paper	Pharma-ceuticals	Basic Chemicals	Non-met mineral products	Basic Metals	Food, Beverages & Tobacco	Total Gross Manuf. Output
Denmark	6	6	6	6	5	3	5
Germany	3	2	2	2	1	1	3
Finland	1	4	4	3	2	5	1
Netherlands	4	1	1	4	3	4	2
Sweden	2	3	3	1	4	2	6
UK	5	5	5	5	6	6	4

Source: Cambridge Econometrics E3ME database.

As for unit labour costs, the UK and Denmark were found to have relatively high unit labour costs across the selected sectors, which can be important for ETR, depending on how the revenues are recycled.

An indication of international competitiveness can also be gained by the export and import intensities of the sectors identified. As expected, WP 2 saw strong, and growing, export intensities in wood and wood products from Finland and Sweden. Export intensities were in the 80 per cent range by 1998 for these two countries, but around 20 per cent or less for the others. Pharmaceuticals are heavily traded, exports reaching 80 per cent or more in the cases of Sweden and Denmark. Basic metals are exceptionally highly traded in the cases of Sweden and Finland, and growing.

At the lower end of trade intensity, the food and beverages sector is rather low in export intensity, with Denmark and the Netherlands at the higher end of the countries studied. Non-metallic mineral products have relatively low trade intensity, at around 20 per cent, though rising to around 40 per cent in 1998 in the cases of Sweden, Denmark and Finland.

Are they exposed to global competition – do they have market power?

The effects of competition hinge on whether or not the selected sectors can pass on increases in costs, such as the cost increases due to the introduction of carbon or energy taxes. In effect do they have market power, or are they price takers who have to be able to match the world price or else go out of business in this jurisdiction? Sectors that have no market power can be particularly vulnerable to an ETR policy, unless the revenue recycling mitigates the damage, or technical and other options are favourable.

To answer this question, price determination was investigated in each of the selected sectors in each of the ETR countries for which data were available. The influence of domestic costs as against world prices was then tested. Two polar cases of the pricing of domestic manufacturing output can be posited, where prices are either:

- externally determined, and the sector is a price-taker, or
- determined as a mark-up on domestic costs, and the sector is a price-setter.

In the latter case the sector is less exposed to competitive pressures and can be said to have market power. It is less vulnerable in the event of the introduction of the tax element of ETR, such as a carbon or energy tax, as the tax can be passed on. If on the other hand the former case holds and prices for the sector's product are externally determined, then that sector could indeed be vulnerable in the event of the introduction of a carbon/energy tax, in the absence of mitigating or other options. Such options might include revenue recycling or technological adaptations that it can undertake. A mixture of the two polar cases above is also a possibility.

Pursuing this line of reasoning the following model could therefore be estimated:

$$p_i = \alpha_0 + \alpha_1 mc_i + \alpha_2 p^f_i$$

where p_i is the domestic output price, mc_i is the domestic marginal cost, and p^f_i is the foreign or world price. Estimation enables one to test for evidence that prices are either set domestically i.e. according to domestic costs, or otherwise set by the foreign price. In the results from this equation estimated from the data, three separate outcomes are of interest: that only the coefficient α_1 on domestic costs is significant and non-zero, only α_2 is significant so that domestic costs do not drive the prices set by the sector and only the external price situation matters, or thirdly a mixture of the two.

The equation above is taken to be a long-run price relationship and a lagged response to price change is allowed (by an error-correction representation). A synopsis of the results is given in Table 2.3 for two sectors taken from each extreme of results.

Table 2.3 Modelling the domestic output price - with the US price and then German price representing the foreign price.[1]

-Adjustment speed λ -Domestic cost -Foreign price -Fit: Adjusted R^2	BASIC METALS		NON-METALLIC MINERAL PRODUCTS	
	US price	German price	US price	German price
Denmark	-0.062** 0.174 0.643*** 0.323	-0.156*** 0.079* 0.866*** 0.500	0.009 1.377 -0.920 0.540	-0.234*** 0.513*** 0.139 0.211
Germany	-0.149 0.270 1.246 0.598	..	-0.022 0.079 -0.327 0.498	..
Finland	-0.116*** 0.375*** 0.301*** 0.600	-0.136*** 0.194** 0.516*** 0.643	-0.048** 0.278** 0.056 0.410	-0.315*** 0.419*** 0.053** 0.227
Netherlands	-0.083** 0.300*** 0.405*** 0.508	-0.139*** 0.146** 0.665*** 0.605	-0.016 0.124 0.134 0.395	-0.177*** 0.406*** 0.412*** 0.178
Sweden	-0.038* 0.410* 0.711** 0.634	-0.124*** 0.047 0.942*** 0.830	-0.002 -8.456 0.027 0.727	-0.176* 0.716*** 0.018 0.257
UK	-0.055*** 0.329*** 0.267* 0.700	-0.115*** 0.229*** 0.476*** 0.830	-0.035*** 0.352*** 0.260 0.730	-0.167** 0.518*** -0.000 0.216
RESULT (no. of significant price determinants in sector)	**4 Domestic 5 US**	**4 Domestic 5 German**	**2 Domestic 0 US**	**4 Domestic 2 German**

1 Using US$ exchange rates and DM exchange rates, and imposing Purchasing Power Parity.
* Significant at 10%, ** Significant at 5%, *** Significant at 1% level.
The modelling used quarterly data from 1975 to 2004 inclusive, taken from OECD and Eurostat.
Source WP 2 Table 2.5a and 2.5b.

The results are given in a set of four figures for each sector in each country. The first, λ, is the speed of price adjustment; the second indicates the influence of domestic cost (domestic wage rates) in the long run; the third indicates the influence of the 'foreign' output price in the long run, which in the first column is the US price, and in the second column it is the German price, acting in the manner of an 'EU price'. The fourth figure is the measure of fit. As mentioned results are shown here for just two of the selected sectors, that emerge at opposite extremes of the pricing power spectrum. These are the basic metals sector which judging from the results has least pricing power and non-metallic minerals which has most pricing power.

Basic Metals

In the basic metals sector the US price has a strong and significant influence on output prices except in the case of Germany. An even stronger external price effect is found when using the German price as the external price, but this sector is evidently a price-taker on world markets as results indicate that this sector's pricing is the most responsive to both sets of external prices. The German price is a more important determinant of the output price and far outweighs the influence of domestic costs, which are of lesser significance and in fact insignificant in the case of Sweden under the German price. This indicates that environmental tax reform consistently applied across the EU would limit the effect on competitiveness. The adjustment coefficient suggests a relatively strong and significant stable long-run pattern of response across all the countries studied.

Non-metallic Mineral Products

This sector is not highly traded and the US price, when used to represent the foreign price, is nowhere significant in explaining movements in the sector's output price. In the UK in particular the model shows domestic costs as a determinant. If the sector responds to any foreign price, it is likely to respond to the German or 'European' price. This reflects the low trade shares on the world market owing to the bulky nature of the product and its high weight-to-value ratio.

In the final column, however, where the external price is represented by the German price, the outcome is an inferior fit and the German price is only significant in the Netherlands and to a minor extent in Finland. Domestic costs on the other hand significantly determine a substantial portion of this sector's output price in all countries investigated. To the extent that the external price is at all significant, the fact of it being the German price indicates that a carbon-energy tax applied EU-wide would not create significant competitive disadvantage, given that the rest of the EU would face a similar tax.

Implications for ETR

The main points to note from the analysis of pricing power are:

1. The model performed overall well statistically.
2. It gave plausible results.
3. The mainly better explanatory power of the German as opposed to the US price has important policy implications and suggests that an EU-wide ETR would have advantages.
4. According to the extent that they are price-takers, sectors can be informally ranked according to vulnerability on international markets.

This ranking, based on the relative strengths of the foreign price as opposed to domestic cost in determining the output price is shown here. The ranking, starting with the most vulnerable sector, which we saw above to be basic metals, is as follows:

Table 2.4 Sectors ranked by vulnerability on pricing

Basic metals	(most vulnerable)
Paper and paper products	
Wood and wood products	
Chemicals	
Food, beverages and tobacco	
Non-metallic mineral products	(least vulnerable)

These measurements of price-setting power bring an important dimension to bear in the assessment of a sector's vulnerability under ETR. It also has a bearing on the debate concerning foreign direct investment and carbon leakage, which features strongly in discussions about carbon/energy taxes. From a survey of the literature on the pollution haven hypothesis it emerged that relocation of production is a possible outcome of the introduction of environmental regulations. This is not a surprising finding, though there is considerable debate on the methods used to investigate it, and the effect is usually small in any event. This brings the advantages of ETR over environmental regulations into focus, because revenues in ETR are available that can help to prevent industrial relocation. This is provided that the revenue recycling is designed and targeted carefully.

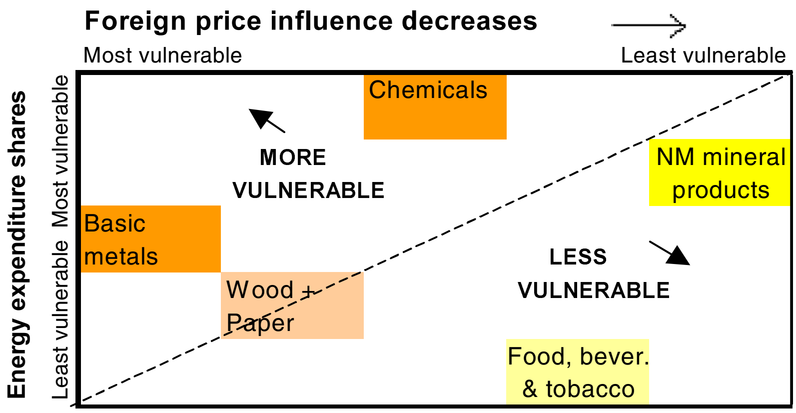
Further insights into vulnerability

We said at the beginning that there are several ways in which vulnerability is measured. We are now in a position to combine them in useful ways.

To give an example¸ Chart 2.1 below illustrates the situation when unit energy costs and price-power are taken together for the combined ETR countries. The vertical axis shows increasing energy expenditure share of output, and the horizontal axis shows increasing market power, that is, decreasing foreign price influence in price-setting. Vulnerability is highest in the top left-hand corner where the energy share is highest and price-setting ability is lowest. Vulnerability is lowest in the bottom right-hand corner.

The most vulnerable sectors are basic metals and chemicals in the top left-hand of the chart. The chemical sector has the highest energy expenditure share and basic metals is the most exposed to the world price - it is the least able to pass on cost increases.

Chart 2.1 Vulnerability with respect to pricing power, ETR countries



In the bottom right-hand corner of the chart are the less vulnerable sectors, food, beverages and tobacco and then non-metallic minerals products. Ranked in the middle in terms of vulnerability is wood and Paper.

The implications are that the introduction of ETR would require most attention to be paid to its effects on the competitiveness of basic metals and chemicals compared to non-metallic mineral products and food, beverages and tobacco. These rankings of vulnerability apply jointly to the countries that implemented ETR.

Another important qualification of a sector's vulnerability is its scope for introducing economically worthwhile energy efficiency investments. Encouragement to efficient energy-saving improvements is a major objective and a useful feature of carbon/energy taxes. Potential technology adjustments available to energy intensive sectors in the UK had been estimated by Entec as part of the process of Climate Change Agreements, and these can be used for illustrative purposes. Here again the sectors can be ranked, by scope for adjustment measured in percentage energy saving potential at positive NPV, starting with those that have least scope (i.e. the most vulnerable again), as shown in Table 2.5.

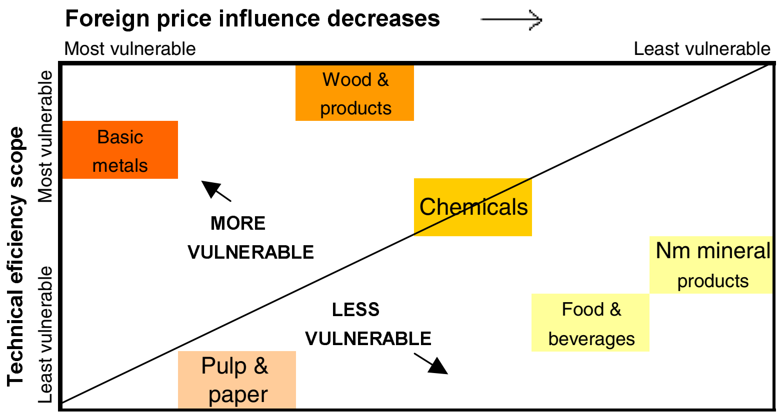
Table 2.5 Ranking of sectors with respect to scope for technological adjustment, UK 1995

Wood and wood products	(least scope, most vulnerable)
Basic metals	
Chemicals	
Non-metallic mineral products	
Food and beverages	
Pulp, paper and paper products	(most scope, least vulnerable)

Source: Entec/Cambridge Econometrics, 2003

The sectors now ranked according to their technological potential for energy efficiency adjustments can be similarly incorporated in a chart. Chart 2.2 relates to the UK and along with ranked vulnerability to price competition, it shows ranked vulnerability with respect to absence of scope for technological adjustment.

Chart 2.2 Vulnerability with respect to scope for technology and price-setting, UK



At the extremes, it can be seen that in the UK basic metals is again clearly in a relatively vulnerable position in the chart, now joined by wood and wood products. food, beverages and tobacco and the non-metallic mineral products sectors are least vulnerable - they have modest potential for adapting technology and have scope for price setting. Chemicals and pulp and paper fall in between.

To sum up on the implications, the most vulnerable among the selected sectors in terms of energy intensity and constraints on pricing and technological scope is likely to be the basic metals sector. By contrast, non-metallic mineral products and food beverages and tobacco are the least vulnerable. The importance of these results is that they indicate where to prioritise mitigation in the event of environmental tax reform.

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COMETR WP3

An assessment of the impacts of ETR on the competitiveness of selected industrial sectors

by

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As discussed in WP2 seven EU countries (Denmark, Finland, Germany, Netherlands, Slovenia, Sweden and the UK) have already implemented modest ETRs, and the purpose of this work package was to assess whether there is any evidence that different industrial sectors had experienced damage to their competitiveness as a result, or whether, conversely, there was evidence consistent with 'the Porter hypothesis', that government regulation (including the imposition of environmental taxes) could improve firm and sectoral competitiveness by stimulating innovation and the take-up of cost-saving technologies that had before been overlooked. To this end, four separate, but complementary, analyses were undertaken.

Impact of the ETRs on energy costs

The sectors chosen for the analysis were as set out in Table 3.1, and comprised sectors of medium to high energy intensity, and of low to high exposure to international trade.

Table 3.1 Sectors chosen for ex-post analysis of effects of ETR

Sector (NACE 3-digit):	
15.1	Meat and meat products
21.2	Paper products
24.1	Basic chemicals
24.4	Pharmaceuticals
26.1	Glass and glass products
26.5	Cement, lime and plaster
27.1-3	Basic ferrous metals
27.4	Basic Non-ferrous metals

The work required the construction of a detailed data set for each of the sectors in each of the ETR countries over the 1990s and early 2000s, that included output (Y), energy use (GJ) and energy prices (EP), and expenditures on energy taxes (ET). The change in energy costs in a time period ($C_{2/1}$) due to the implementation of energy taxes is $GJ_2*(ET_2 – ET_1)$. The savings in energy costs in the same period ($S_{2/1}$) due to reductions in energy intensity stimulated by the increased energy taxes is $[(GJ_1/Y_1 – GJ_2/Y_2)*Y_2]*EP_2$. Then a negative effect on competitiveness could occur if $C_{2/1}>S_{2/1}$, while evidence consistent with the Porter hypothesis would be if $C_{2/1}<S_{2/1}$.

The generation of the required dataset was far from straightforward, given that data at the required sectoral detail is not generally available from a single consistent source, so that it had to be constructed from a range of sources, and some problems with the dataset remain. This should be borne in mind when interpreting the results.

Four countries were selected for the analysis: Denmark and Finland, which implemented ETRs in the early 1990s, and Germany and UK, which did so in the late 1990s/early 2000s. For each country, two tables were constructed, showing the development of the energy intensity and the effective energy tax rate (defined as the sectoral energy tax expenditures divided by the sectoral energy use) over the period in question. It should be noted that, because of widespread special tax treatment of the different sectors (which of course also varied between countries), the effective tax rate for the different sectors within and between countries was very different.

In fact the energy intensities of the sectors exhibited a wide variety of trends, although most sectors in most countries exhibited a generally downward trend. Table 3.2 describes these trends and also gives the range of the effective tax rates for the different sectors. It may be seen that these rates differ by one to two orders of magnitude for the different sectors, but the ranges are quite comparable across the different countries, with Denmark exhibiting the lowest, and Sweden the highest, tax rates. As is seen in more detail below, in general the lowest tax rates were applied to the sectors with the highest energy intensity, so that in many cases the tax rate applied to these sectors was very low indeed.

Table 3.2 Energy Intensities and Tax Rates in Different ETR Countries

Country	ETR year	Energy intensity (GJ/k€)	Tax rate (€/GJ)
Denmark	1993/1996/1998	Sectors 24.4, 26.1, 26.5 show notable change in trend after ETR	Ranges from -0.004 to 1.75
Finland	1990/1994/1997	Downward trend in almost all sectors (not 15.1, 26.5)	Ranges from 0.02 to 1.6
Germany	1999-2003	Downward trend in most sectors (stable 26.5, 27.1-3)	Ranges from 0.07 to 1.2 (below average 26.5, 27.1-3)
UK	2001	Mixed trend	Ranges from 0.01 to 1.1

Consistency with the Porter hypothesis would imply that imposition of the tax would reduce the energy intensity of the sectors, and a simple graph of energy intensity over time soon showed whether this was the case. However, this relation is only likely to be strongly evident where both the energy tax rate and the energy intensity were high and therefore the tax would give a significant stimulus to energy saving.

For those sectors where simple inspection of the graph revealed seeming inconsistency with the Porter hypothesis a further table for $C_{2/1}$ and $S_{2/1}$ was constructed to search for a possible explanation. Such an explanation could be that either the energy intensity or the energy tax rate (or both) for the particular sector was too low for the imposition of the tax to have any stimulating effect.

Table 3.3 gives the summary results of the exercise for the four countries which had data for all the sectors. The descriptors Low, Medium, High refer to the relative positions of the variables (energy intensity/energy tax rate) of the sectors within the same countries. These variables vary dramatically across the countries, especially the tax rates and their evolution. The comparison is only between the listed sectors (i.e. a Low energy intensity is low relative to the eight sectors, not necessarily in respect of other sectors in the country concerned). It may be noted that within each country, in the discussions about energy taxation, sectors will argue, for example, that they have High energy intensity in respect of other sectors in the country, and therefore deserve favourable tax treatment, rather than comparing themselves with the same sector in other countries.

The table shows fairly clear consistency in respect of the energy intensities of the same sectors in different countries. Only in respect of 27.1-3 and 27.4 does the UK have a higher relative energy intensity ranking than other countries, but inspection of the figures reveals that these intensities are not high in absolute terms compared with the other countries. Inspection also reveals, though with exceptions, that sectors with Low energy intensities tend to have High or Medium tax rates, while sectors with High energy intensities have Low or Medium tax rates. Finland (sectors 21.2 and 26.5) is the only country with exceptions to this trend.

The results show that there is some evidence of consistency with the Porter hypothesis, but it is patchy. However, there is only one case where the absence of such consistency cannot be explained on the grounds that either or both of energy intensity or the tax rate were too low to stimulate reduced energy intensity. In Finland, high energy intensities and tax rates in sector 26.5 failed to improve energy intensity as expected.

The same sectors in different countries exhibit different results, with only 26.1 (glass) showing consistency with the Porter hypothesis in all countries, and 24.1 (basic chemicals) in all but one. In all other sectors, two countries show consistency and two do not.

A major difference between the countries was when they implemented their ETRs (see Table 3.2). In Denmark and Finland, implementation was in the early 1990s, and the tax rates were generally maintained or continued to increase throughout the period (the Danish sector 26.5 is an exception, with tax rates falling from 1998). In German and UK implementation was much later.

Table 3.3 Evidence Consistent or Otherwise with the Porter Hypothesis

	Denmark	Finland	Germany	UK
15.1 Meat				
Consistent with PH?	No	No	Yes	Yes
Energy intensity	Low	Low	Low	Low
Energy tax rate	High	Medium	High	High
21.2 Paper & card				
Consistent with PH?	No	Yes	No	Yes
Energy intensity	Low	Low	Low	Low
Energy tax rate	Medium	Low	High	High
24.1 Basic chemicals				
Consistent with PH	Yes	Yes	Yes	No
Energy intensity	Medium	Medium	Medium	Medium
Energy tax rate	Medium	Medium	Medium	Low
24.4 Pharmaceuticals				
Consistent with PH?	Yes	No	Yes	No
Energy intensity	Low	Low	Low	Low
Energy tax rate	High	Low	High	Medium
26.1 Glass				
Consistent with PH?	Yes	Yes	Yes	Yes
Energy intensity	Medium	Medium	Medium	Medium
Energy tax rate	Medium	Low	Low	Medium
26.5 Cement, lime & plaster				
Consistent with PH?	No	No	Yes	Yes
Energy intensity	High	High	High	High
Energy tax rate	Low	High	Low	Medium
27.1-27.3 Basic ferrous metals				
Consistent with PH?	Yes	Yes	No	No
Energy intensity	Medium	Medium	Medium	High
Energy tax rate	Medium	High	Low	Low
27.4 Basic non-ferrous metals				
Consistent with PH?	No	Yes	Yes	No
Energy intensity	Low	Low	Low	Medium
Energy tax rate	High	Medium	High	Medium

The patterns of energy taxation of the late implementers of ETR, Germany and the UK, over the 1990s and early 2000s were very different. Despite ETR in Germany which increased tax rates for all sectors over 1998-2000, tax rates fell significantly in all sectors over 1995-1998, and in some cases by 30-50% over 2000/01, before increasing significantly again in 2002. Although many of the energy intensities were falling over 1995-2003, and all sectors ended the period with lower energy intensities than they had at the beginning of it (which is not true for all four countries being analysed), the signal coming from the tax rate was variable to say the least.

In the UK the tax rate fell significantly in all sectors (sometimes by a factor of 10) between 1990 and 2000, before rising again (but remaining below the level in the 1990s) in the ETR of 2001. Consistent with this, the energy intensity of four of the sectors changed little through the 1990s, while after 2000 energy intensity in three of the sectors increases.

Statistical Estimation of Competitiveness Impacts

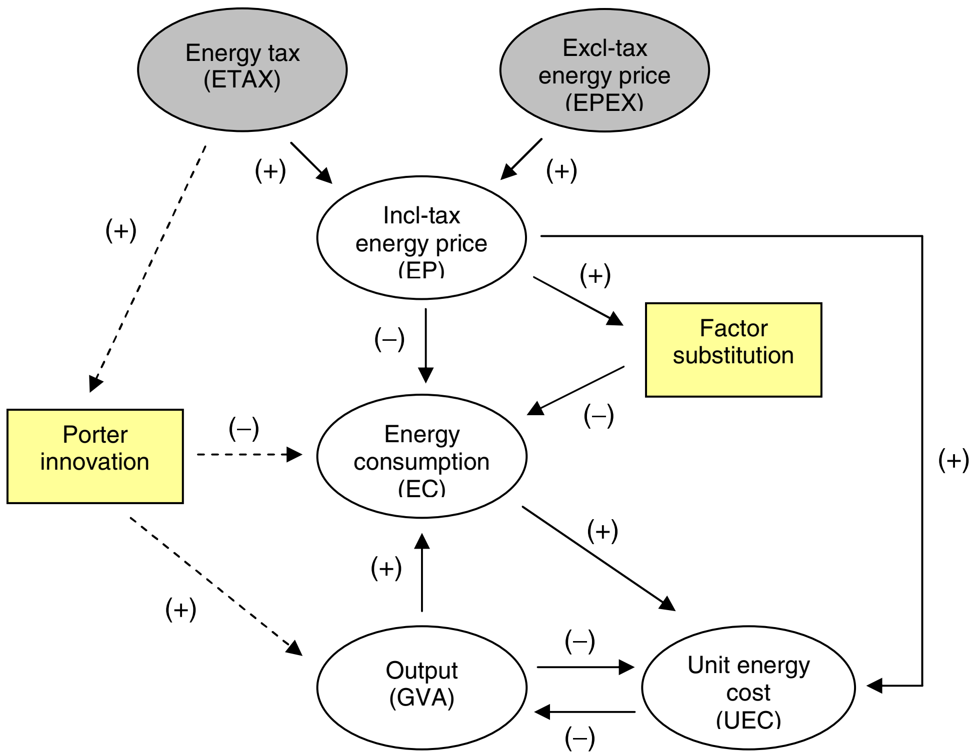
Another way of approaching the COMETR sectoral dataset would be to subject it to statistical analysis and estimation. To this end, a detailed econometric analysis of the dataset was undertaken to estimate how changes in real energy taxes and real energy prices affect, on the one hand, competitiveness measured in terms unit energy costs and unit wage costs and, on the other hand, economic performance in terms of output (gross value added). In addition, the analysis assessed whether the experience in the case-study countries provides any support for the Porter hypothesis in relation to environmental taxes.

The model underlying the analysis is shown schematically in Chart 3.1. The arrows show the directions of influence between the various system variables; while the signs indicate whether an increase in the "start variable" is expected to cause the "end variable" to increase or decrease. For example, an increase in unit energy costs is expected to cause a reduction in output (all else being equal). For simplicity, labour and other input factors have been omitted from the diagram, although they are included in the analysis.

In addition to having a direct positive impact on unit energy costs, increases in energy prices (due either to increases in market prices or taxes) have an indirect negative impact via the resultant reduction in energy consumption and factor substitution. An increase in unit energy cost leads to a reduction in output reflecting a loss of competitiveness (as does an increase in unit labour cost). However, there is are two feedback effects; with reductions in output having a direct positive impact on unit costs (due to its inclusion as the denominator) and an indirect negative impact via the resultant reduction in energy consumption.

The Porter hypothesis proposes that environmental regulation can lead to improvements in competitiveness by inducing innovation that would not have occurred otherwise. In this analysis, the regulation takes the form of increases in energy taxation and the potential innovation pathways are shows by the dashed arrows in Chart 3.1. The model allows for two forms of innovation. The first yields improvements in production energy efficiency, which in turn reduces energy consumption and hence unit energy costs. The second yields improvements in non-price competitiveness (e.g. through new product development or enhanced environmental credibility with consumers), leading to increases in demand and hence output.

Chart 3.1 Underlying model for the analysis



It is clear from Chart 3.1 that the relationship between energy prices, energy taxes, unit costs and output is complex. In particular, unit costs and output are both determined endogenously within the system. Consequently, the equations for unit energy cost, unit labour cost and output were estimated simultaneously in a three-equation, fixed effect panel-data model. For the purposes of the analysis, all of the variables were logged so that the estimated values of the coefficients in the three equations can be interpreted directly as percentage elasticities. The estimated elasticities for the three equations are shown in Table 3.4, along with their respective t-statistics and p-values.

An increase in market energy prices (EPEX) leads to an increase in unit energy costs (UEC); with a long run elasticity of 0.77 (i.e. a 1% increase in the real excl-tax price of energy causes a 0.77% increase in unit energy costs).[3] The impact of energy taxes (ETAX) is also positive, with a long run elasticity of 0.03. The ratio of the two elasticities (at 26:1) is greater than the ratio of EPEX to ETAX (which averages 17:1), which is consistent with a Porter process innovation impact for ETAX. However, the difference between the two ratios is not statistically significant. The implied own-price elasticity of energy consumption is in the range -0.2 to -0.5 (depending on whether the EPEX or ETAX elasticity is used as the basis for the calculation), which is in line with the values found in previous studies. Factor substitution between labour and energy is not very strong. While the cross-elasticities of ULC and UEC are both positive as one would expect, neither is statistically significant. Increases in output

[3] The long-run elasticity is equal to 0.546 / (1 – 0.289).

have a negative impact on both unit energy and labour costs (and hence unit production cost), implying that the industries are not perfectly competitive.[4]

Table 3.4 Estimated elasticities

Equation	Variable	Elasticity	t-stat	p-value
GVA	ETAX	0.023	4.24	0.00
	UNIT COST	–0.241	–20.05	0.00
	GVA(t–1)	0.206	7.44	0.00
UEC	EPEX	0.546	11.04	0.00
	ETAX	0.021	2.66	0.01
	ULC	0.066	0.95	0.34
	GVA	−0.534	−9.11	0.00
	TREND	0.009	3.74	0.01
	UEC(t–1)	0.289	9.12	0.00
ULC	WAGE	0.372	9.55	0.00
	UEC	0.050	1.60	0.11
	URC	0.164	6.67	0.00
	GVA	−0.265	−6.61	0.00
	TREND	–0.006	–3.54	0.02
	ULC(t–1)	0.362	11.51	0.00

Increases in unit production cost lead to a reduction in output (GVA) as expected, with a long run elasticity of –0.3. However, there is a positive relationship between energy tax (ETAX) and output, which is highly statistically significant. While this does not constitute definitive proof, it is consistent with the existence of Porter demand-related innovation.

The estimated elasticities allow the impacts of increases in energy taxes to be evaluated. Table 3.5 shows the long-run impacts of a doubling of energy taxes (i.e. a 100% increase).[5] The first column shows the first-order impacts; while the second column shows the second-order impacts arising from the first-order changes in output.[6] The energy tax increase causes overall unit costs to increase by only 0.4%, with a resultant reduction in output of 0.1%. This is swamped by the innovation impact of the tax increase, with the result that output increases by almost 3%. The resultant reductions in unit costs offset around two-thirds of the first-order increases and lead to slight further increase in output.

[4] That is, sectors are operating on the downward portion of their average cost curves.
[5] This is consistent with the actual increases in energy taxes imposed under the ETRs in the case-study countries.
[6] Third (and higher) order effects are insignificant.

Table 3.5 Long-run impact of a 100% increase in energy tax

	First order impact	Second order impact	Final impact
Unit energy cost	+3.00%	–2.16%	+0.84%
Unit labour cost	+0.23%	–0.12%	+0.11%
Unit cost (1)	+0.42%	–0.28%	+0.14%
Output			
- without innovation	–0.12%	-	-
- innovation	+3.00%	-	-
- with innovation	+2.88%	+0.08%	+2.96%

(1) Assuming that energy and labour account for 10% and 50% of total costs respectively

This econometric analysis suggests that the energy tax increases imposed under the ETRs during the 1990s had only a very small impact on unit production costs. Furthermore, it would appear that the increases stimulated demand-related innovation which more than offset the negative impact of the cost increases on output. However, caution should be exercised in placing too strong emphasis on the results of the analysis in isolation. Due to the limitations of the datasets, the analysis does not allow for sector heterogeneity. And to the extent that government regulation, support programmes and subsidies to stimulate energy savings, competitors' costs, etc. are correlated with the included variables (particularly ETAX), the elasticities estimated in the analysis may represent a broader policy variable rather than a pure tax effect.

Assessment of Competitiveness Impacts through Indicators

Although, as noted above, competitiveness is a complex concept that is open to a range of interpretations, at the most basic level it may be considered that a firm (or economic sector) loses competitiveness if its cost of production rises faster, or falls more slowly, than that of its competitors. In theory therefore, changes in sectoral competitiveness can be measured directly by comparing the changes in production costs of firms in all competing countries. Unfortunately, for many sectors there may be no meaningful unit of measurement for aggregate output (even at the firm level), making the definition of unit production cost problematic. Even for sectors where there is a meaningful unit of measurement for output, the necessary data may not be available. For this reason, alternative indicators of competitiveness need to be found.

Intuitively possible alternative indicators are the share of global production, import intensity and export intensity (if a sector's competitiveness improves one might expect its share of global production and export intensity to increase, and its import penetration to fall, with the opposite being the case if it deteriorates). The validity of these indicators (for export intensity contingent on certain conditions) was confirmed by a formal theoretical model. Data on these indicators was generated and inspected for each of the eight sectors and for each of the seven countries (Denmark, Finland, Germany, Netherlands, Slovenia, Sweden and UK) under investigation. Table 3.4 lists the results for the 56 combinations of eight sectors and seven countries.

Each country/ sector case is grouped according to the percentage change in unit cost and the changes in competitiveness observed in the data. Overall the data quality and the high degree of volatility in the data make it difficult to speak of clear trends. Losses in competitiveness occur only in countries/sectors where the impact of the ETRs on unit costs has been smaller than (or equal to) one percent. There is no case of a decrease (or increase) in competitiveness where the impact of the ETRs was above 1%. In Slovenia (26.5) and Finland (26.5) where the impact of the ETR was above 5% no change in competitiveness was registered in the data.

Table 3.6 Sectoral Competitiveness Analysis in ETR Countries

% change in unit costs	Change in competitiveness			Total
	Gain	No change	Loss	
Less than 1%	2	39	9	**50**
1% - 5%	0	5	0	**5**
More than 5%	0	1	0	**1**
Total	**2**	**45**	**9**	**56**

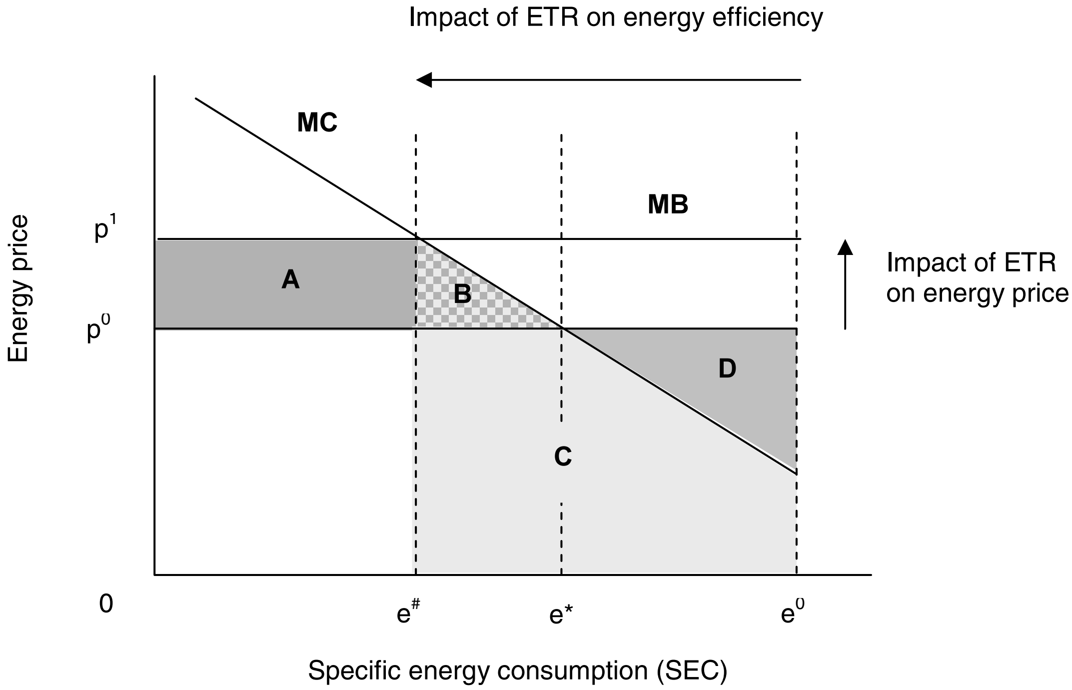
Out of 56 cases the data show no support for a change in competitiveness in 45 cases. Only in nine cases do indicator movements point to a loss in competitiveness. These occur in the UK (sectors 15.1, 21.1, 27.1-3, 27.4), Germany (21.2, 24.4, 26.1), Finland (24.4) and the Netherlands (27.4). An increase in competitiveness is found in the Danish pharmaceuticals industry and the Dutch meat processing sector.

In summary, the ETRs have not been significant in terms of their impact on unit production costs (below 1% in 50 cases). While there is some evidence for a decline in competitiveness in selected countries/sectors, there is no consistent pattern and it is not possible to conclude that the reform was a significant contributing factor.

Potential for cost improvements in energy efficiency

It is often claimed that there are significant opportunities for industry to improve energy efficiency at negative, net cost. If this is the case, then the potential negative impacts on competitiveness of environmental tax reforms (ETRs) that increase industrial energy costs may be partly – or even wholly – offset by improvements in energy efficiency. This is illustrated by the hypothetical example in Chart 3.2. Prior to the introduction of the ETR, specific energy consumption (e^0) is greater than the cost-efficient value (e^*). Since the marginal cost of improving energy efficiency per unit output is less than the marginal benefit – which is equal to the price of energy (p^0), there is scope for reducing net unit production costs (given by the shaded area D).

Chart 3.2 Impact of energy tax increase on unit energy cost



If specific energy consumption falls to the cost-efficient value ($e^{\#}$) as a result of the introduction of the ETR, then the change in unit energy cost is given by A – (C + D); which may be positive or negative, depending on the relative magnitudes of the percentage changes in the energy price and specific energy consumption. The cost per unit output of achieving the improvement in energy efficiency is given by B + C and hence the overall impact on unit production cost is given by A + B – D. Consequently, if there is no pre-ETR cost-inefficiency (i.e. D=0), then the ETR necessarily increases overall the overall unit production cost. However, if the pre-ETR cost-inefficiency is sufficiently large, it is possible that the unit production cost may fall.

In order to determine the likelihood of this possibility, the potential for cost-efficient improvements in energy efficiency in the United Kingdom prior to the introduction of the ETR in 2001 was assessed using three complementary analyses.

- A "bottom-up", technology-based simulation model (ENUSIM) was used to assess the potential for cost-efficient reductions in specific energy consumption (SEC) based on information about the costs and impacts of identified technologies, plus assumptions about economic parameters (such as energy prices, discount rate, etc.) and behavioural responses.
- Actual performance data reported under the Climate Change Agreements (CCAs) was compared with "business-as-usual" counterfactuals (generated by ENUSIM) to assess the scale of the improvements in SEC that have been achieved over recent years and to estimate plausible payback periods for energy-related investments.
- A theoretical model was used to explore how a cost-minimizing firm might be expected to behave and to determine what information can be gleaned about the cost-efficiency of actual and target energy efficiency improvements from

observed SEC performance data and the firm's use of the flexibility mechanisms allowed under the CCAs (i.e. the banking of over-performance for use in future periods and the trading of performance credits through the UKETS).

The simulations generated by the ENUSIM model suggest that in 1995 there was a significant potential for cost-efficient improvements in energy efficiency in all of the COMETR sectors, ranging from around 10% (for Steel, Meat Processing and Cement, Lime and Plaster) to over 20% (for Non-ferrous Metals, Chemicals and Paper). However, the shape of the cost curves generated by the model also suggests that for the majority of this potential, the financial savings were only marginal and hence the potential scale of offsetting reductions in unit costs due to efficiency improvements was not that great.

Turning to the performance under the CCAs; with the exception of the Meat Processing sector, there have been significant reductions in SEC versus the sectors' respective base years. In particular, the Paper, Chemicals and Ferrous Metals sectors all achieved improvements in the order of 15%-20% over a 6-7 year period; although, in the last case this appears to have been driven by major structural changes in the sector. Compared to a business-as-usual (BAU) counterfactual, the improvements in SEC are reduced somewhat, but still significant; ranging from 4% to 17%. These reductions are reflected in the sectors' performance against their interim CCA targets; with all of the sectors (except Meat Processing) beating their respective targets by a considerable margin – up to six years ahead of schedule in some cases.

With the exception of the Ferrous Metals and Paper sectors (for which there are plausible explanations), there is a close correlation between the actual improvement in energy efficiency reported under the CCAs and the potential improvement calculated by the ENUSIM model. That is, those sectors with the greatest modelled potential for cost efficient improvements have achieved the greatest actual improvements. This lends considerable credence to the estimates of the cost-efficient improvement potentials produced by the model.

The improvements in SEC generated significant financial benefits; with reductions in annual energy expenditures versus BAU ranging up to £235 million (see Table 3.6). There is no evidence to suggest that the sectors have undertaken any incremental capital expenditure to achieve these reductions. Consequently, any investments that were made specifically to improve energy efficiency must have displaced other investment expenditures. The extent of any such displacement is not known. However, as can be seen from the final column of Table 3.6, it would have to have been significant for the investments in energy efficiency improvements to have failed reasonable pay-back requirements. The only exception is the Meat Processing sector, for which the payback period would be more than six years if energy efficiency investments accounted for only 2% of the total capital expenditure.

Table 3.7 Estimated annual reductions in energy use and expenditure

Sector	Annual saving vs. BAU		Total CAPEX (£ million)	Displ'ment for 3-year payback [1]
	Energy Use (TJ)	Energy Exp (£ million)		
Meat processing	< 100	< 1	371	<1%
Paper	9,600	50	471	27%
Chemicals	56,000	235	2,199	27%
Glass	3,500	15	160	23%
Cement, lime and plaster	5,100	15	55	68%
Ferrous metals	57,000	215	333	>100%
Aluminium	10,500	55	50	>100%

(1) Assuming a 20% discount rate.

Based on the insights provided by the theoretical model, it is possible to draw some inferences about the marginal costs of the achieved improvements in energy efficiency from the use of the two flexibility mechanisms allowed under the CCAs (i.e. banking and trading). While the over-performance against the interim CCA targets has been banked, trading has only been used retrospectively by a relatively small number of firms to meet shortfalls against their targets; with little evidence that firms have used the market-mechanism as a proactive "energy management option". Given the large number of banked permits and the early achievement of future targets, it seems unlikely that the number will fall to zero by the end of the agreements in 2010. The theoretical analysis suggests that this would imply that the improvements in energy efficiency were achieved at zero, or negative, cost.

Taken together, the insights provided by the three analyses suggest that there was significant potential for cost-efficient improvements in energy efficiency in all but one of the sectors. However, the scale of the resultant reductions in unit production costs is less clear. While the modelled cost curves imply that the reductions may not be that great, the analysis of the CCA performance suggests that they may have been more significant. The one exception to this general conclusion is the Meat Processing sector. For this sector, the high attrition rate of participants from the CCA; the under-performance versus the CCA target; the minimal reductions in SEC and energy costs; and relatively long estimated payback period; all suggest that that improvements in energy efficiency have been costly for this sector.

COMETR WP4

The effects of ETR on competitiveness: modelling with E3ME

by

Paul Ekins, PSI

The economic impacts of ETR

The economic effects of ETR are felt in a number of ways at a number of different levels. Most obviously the increases in energy or environmental taxes will increase the prices of the affected fuels or activities. Producers will be able to pass on a greater or lesser proportion of those price increases depending on whether they are in less or more competitive markets.

The revenue recycling mechanism will also affect prices, perhaps directly by reducing the cost of other inputs into production, when this might reduce the prices of goods and services, therefore wholly or partly offsetting the inflationary effect of the tax increase. Another possibility, where the revenue recycling is through a reduction in employers' social security contributions, is that this will increase the demand for labour. In a situation of full or near full employment, this may act to increase wages, which would then add to the inflationary effect of the tax increase, with further knock-on effects throughout the economy.

Another possible economic impact of the tax increase is that firms will seek to reduce their energy use by purchasing energy efficient intermediate or investment goods from appropriate companies. This could have multiple economic effects. First, it will reduce the energy use of the company making the investment, and this will serve to offset wholly or partly the increased tax expenditures (so that company energy expenditure may actually be *lower* than before the tax increase). Second, it will add to the output of the energy efficiency companies, serving to offset wholly or partly any reduction in output from the increased taxes on energy. Thirdly, the investment will stimulate technical change more generally, especially over the longer term. More energy-efficient equipment is often more productive in other ways as well.

All these effects act in different ways on different companies (depending on how their managements respond to the tax increase), different sectors (depending, among other things, on their energy intensities and openness to international trade) and different countries (depending on their overall economic structure). Moreover, there is continuous interaction and feedback at all levels between these effects and all the other influences on economic activity. The effects of ETR on international competitiveness are, therefore, multi-faceted and complex. The only way that insights can be generated into such effects in a complex system like a national economy is through economic modelling.

Previous Modelling Results of the Economic Impacts of ETR

Effects on the competitiveness of one country, or on economic sectors within a country, due to measures such as ETR, and subsequent impacts on environmental emissions, are sometimes called 'spillover effects'. Where the measures are intended to reduce carbon emissions, then any rise in carbon emissions in other countries due to their increased relative competitiveness is called 'carbon leakage'. In the literature, there has been a particular emphasis on the spillover effects of carbon mitigation polices taken by Annex I countries on the rest of the world. The effects may be divided into price effects (on international competitiveness and overall CO_2 emissions – carbon leakage) and non-price effects, sometimes called technological spillovers.

While much of the literature recognises the existence of spillovers, different models produce different conclusions with varying level of uncertainties, with an added complication that the effects may be displaced over time. The measurement of the effects is made more difficult because they are often indirect and secondary, although they can also accumulate to make local or regional mitigation action either ineffective or the source of global transformation. It is important to emphasize the uncertainties in estimating spillover effects. In the modelling of spillovers through international trade, researchers rely on approaches (eg bottom-up or top-down), assumptions of perfectly homogeneous versus differentiated products, and estimates (eg of substitution parameters) whose signs and magnitudes are disputed. Many of these models focus on substitution effects in estimating costs and do not consider the induced development and diffusion of technologies, as well as information, policy and political changes brought about by the originating mitigation actions. For example, Grubb et al. (2002) argue that spillovers from Annex I action, via induced technological change, could have substantial effects on sustainable development, with emissions intensities of developing countries at a fraction of what they would be otherwise. 'However, no global models yet exist that could credibly quantify directly the process of global diffusion of induced technological change.' (Grubb et al. 2002, p. 302).

There is general agreement in the literature that the international competitiveness of economies and sectors may be affected by mitigation actions (see surveys by Boltho (1996), Adams (1997) and Barker and Köhler (1998)), such as ETR. In the long run, exchange rates change to compensate for persistent loss of national competitiveness, but this is a general effect and particular sectors can lose or gain competitiveness. In the short run, higher costs of fossil fuels may lead to a loss in sectoral price competitiveness especially in energy-intensive industries. This may lead to the re-location of industry, in relation to which Sijm et al. (2004) conclude that 'existing studies cannot provide a clear picture about the effect of environmental policy on the relocation of energy intensive industries; but they do indicate that - if a relation between environmental policy and relocation should exist - it is statistically weak.' (p. 165). This is in line with the conclusions of the IPCC's *Third Assessment Report* (TAR, IPCC 2001), namely that 'reported effects on international competitiveness are very small and that at the firm and sector level, given well-designed policies, there will not be a significant loss of competitiveness from tax-based policies to achieve targets similar to those of the Kyoto Protocol.' (p. 589). The TAR also found that international permit trading substantially reduces leakage.

Recent years have seen a number of new empirical studies of carbon leakage, some at least of which suggest that carbon leakage is potentially a serious threat to the effectiveness of mitigation policies. However, such results are not found in the empirical studies of carbon leakage as a general response to mitigation under the Kyoto Protocol. Sijm *et al.*, (2004) summarise these modelling results. 'Models provide a useful, but abstract tool for climate policy analysis; they are faced by several problems and limitations with regard to practical policy decision- making, including problems such as model pre-selection, parameter specification, statistical testing or empirical validation.' (p. 14). Moreover, the potential beneficial effect of technology transfer to developing countries arising from technological development brought about by Annex I action is substantial for energy-intensive industries, but has so far not been quantified in a reliable manner. 'Even in a world of pricing CO_2 emissions, there is a good chance that net spillover effects are positive given the unexploited no-regret potentials and the technology and know-how transfer by foreign trade and educational impulses from Annex I countries to Non-Annex I countries.' (Sijm *et al.* 2004, p.179). In any case, they conclude that, in practice, carbon leakage is unlikely to be substantial because transport costs, local market conditions, product variety and incomplete information all favour local production, and the cost effects of environmental regulation are found to be small.

Modelling ETR with E3ME: Methodology and Approach

Economic models are constructed using both theoretical insights about the relationships between different economic variables (for example, it is normally assumed that the quantity of a good demanded is reduced if its price is increased, and vice versa), and through statistical estimation of the parameters of these relationships. There are different kinds of economic models which make different theoretical assumptions and therefore have different structures. That is one reason why different models can give different outcomes in their modelling of economic interventions such as ETR. This is not the place to go into a detailed comparison of different models. For the COMETR project the model used was a macro-econometric European model (including the 25 countries which were members of the EU in 2006, plus Norway and Switzerland) called E3ME, which is described in some detail in the relevant COMETR working paper (CE 2006).

As discussed earlier, the notion of 'environmental tax reform' (ETR) typically involves the modification of the national tax system to move the burden of taxes from conventional taxes, for example those imposed on labour and capital, to environmentally-related activities, such as taxes levied on resource use, especially energy use, or environmental pollution. To counterbalance the possible adverse effects of an increase in green taxes, other taxes are reduced using the revenues generated by the ETR implementation (called 'revenue-recycling'). The implementation of a revenue-neutrality policy is designed to ensure that the tax burden falls more on 'bads' than on 'goods' by ensuring that price signals, as a result of the introduction of ETR, give an incentive to households and industries to alter behaviour.

The 'revenue recycling' may take effect through reductions in:

- Direct taxes (income tax, corporation tax);
- Social security contributions
    - paid by employers;
    - paid by employees;

- Other measures
    - Support schemes for investment expenditure (and depreciation); and
    - Benefits or other compensatory measures.

An ETR can, in principle, provide complete tax exemptions for economic sectors or reduced tax rates for different energy fuels and economic sectors in combination with some form of negotiated agreements with targets to improve energy efficiency or carbon emissions. Tax ceilings may also be established to limit the total tax burden faced by individual companies. However, such special measures may reduce the economic efficiency of the ETR overall.

In order to model the effects of ETR, a number of scenarios were generated by E3ME over the period 1994 to 2012 (the projection period therefore includes Phase 2 of the EU ETS), the main two of which are reported here:

- the Reference Case (R) which is a counterfactual projection without the ETR, but including current and expected developments in the EU economy, e.g. the EU ETS
- the Baseline Case (B) which is an endogenous solution of E3ME over the period 1994-2012. This scenario includes the ETR in each Member State covered by the project, exemptions or special treatment for the industries most affected and the compensating reduction in another tax. This scenario is calibrated closely to the observed outcome through using historical data which include the effects of ETR implementation.

Modelling ETR with E3ME: Results

This section discusses the simulation results from the COMETR scenarios, by looking at the Baseline solution, and taking an overview of the results from the countries that pursued ETR in the 1990s, and then discussing the competitiveness effects on individual energy intensive sectors.

The Baseline solution for COMETR is an endogenous model solution of E3ME that fully covers the period 1994-2012 annually. The Baseline solution is calibrated to be consistent with a combination of historical data and forecast. This section compares the results for the Baseline case against the Reference case. In summary, this illustrates the difference between what did happen and what would have happened had there been no ETR (with both cases projected to 2012). The exception to this is that revenue neutrality is assumed in each case through the revenue recycling mechanisms. Exemptions, non-payments and negotiated agreements are included as accurately as possible as they happened, subject to the total revenues matching the published figures in each case.

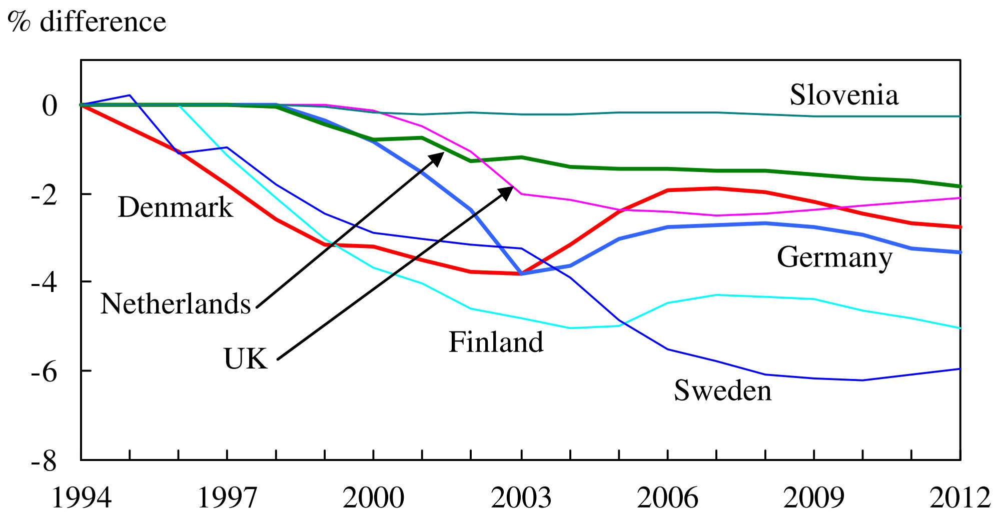
As the taxes included in the analysis increased fuel prices, we would expect the primary effect to be a reduction in the demand for energy. The scale of the reduction will depend on the tax rates, on how they are applied to the various fuels and fuel user groups, on how easy it is for fuel users to substitute between the different fuel types and non-fuel inputs, and on the scale of the secondary effects from resulting changes in economic activity.

The western European countries that have implemented an ETR show a reduction in fuel demand from the ETR (see Chart 1; For Slovenia, the CO_2 tax,
although not strictly part of an ETR, has been included in the Baseline scenario to

give an example of environmental taxation in the New Member States[7]). In most cases the reduction in fuel demand was in the region of 4%, although it was slightly larger in Finland than the other regions.

A key feature of the results is the recovery in fuel demand in several of the examined countries over 2004-05 in the Baseline case relative to the Reference case, due to higher world energy prices, included in both the Baseline and Reference cases. In most of the ETRs, the environmental taxes were not raised in line with fuel prices (and in some cases may have been reduced), implying a reduction in the relative change in fuel prices. In most of the ETRs the environmental taxes were not increased in line with fuel prices (and may have been reduced in some cases), so the relative change in fuel prices becomes less in 2004-05.

CHART 1: THE EFFECT OF ETR ON TOTAL FUEL DEMAND

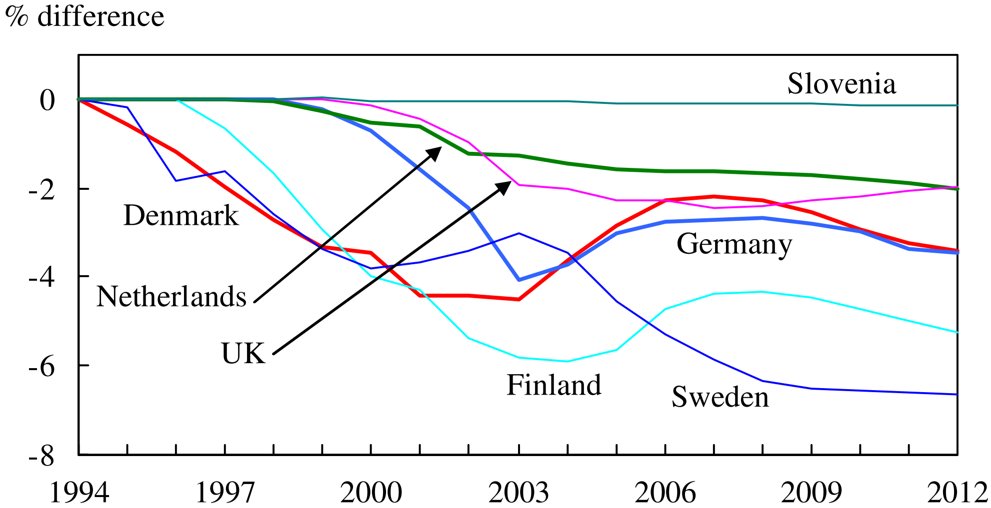


Note(s) : % difference is the difference between the base case and the counterfactual reference case.
Source(s) : CE.

We would expect to see a reduction in atmospheric emissions from lower consumption, but total emissions will also depend on the relative consumption levels of each fuel type. For example, a tax system that encourages the use of coal is likely to produce higher emissions than one which encourages the use of natural gas or bio-fuels. E3ME includes explicit equations for fuel shares of hard coal, heavy oil, natural gas and electricity. Assumptions are made about the other fuel types linking them to the closest modelled alternative (e.g. other coal is linked to hard coal, crude oil to heavy oil). For middle distillates (petrol, diesel, etc) demand is linked to total fuel demand by that sector. The reason for this is that demand for these fuels is dominated by the transport sectors. These sectors do not generally use any other fuels, so fuel share equations are not required.

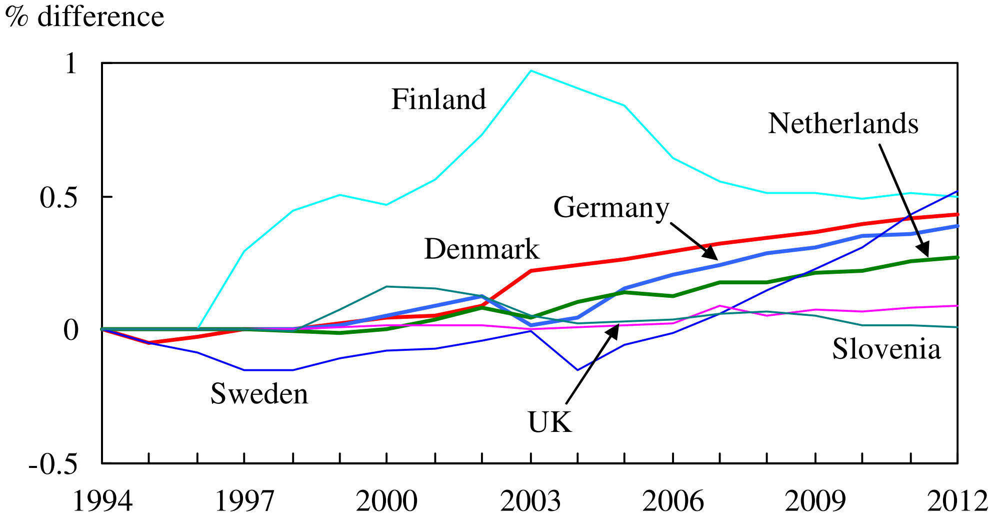
[7] According to Slovenia's 2002 report to UNFCC its carbon-energy taxation is part of a broader green tax reform, but Slovenia mainly restructured its energy taxation to include a carbon component.

CHART 2: THE EFFECT OF ETR ON GHG EMISSIONS



Note(s) : % difference is the difference between the base case and the counterfactual reference case.
Source(s) : CE.

CHART 3: THE EFFECT OF ETR ON GDP



Note(s) : % difference is the difference between the base case and the counterfactual reference case.
Source(s) : CE.

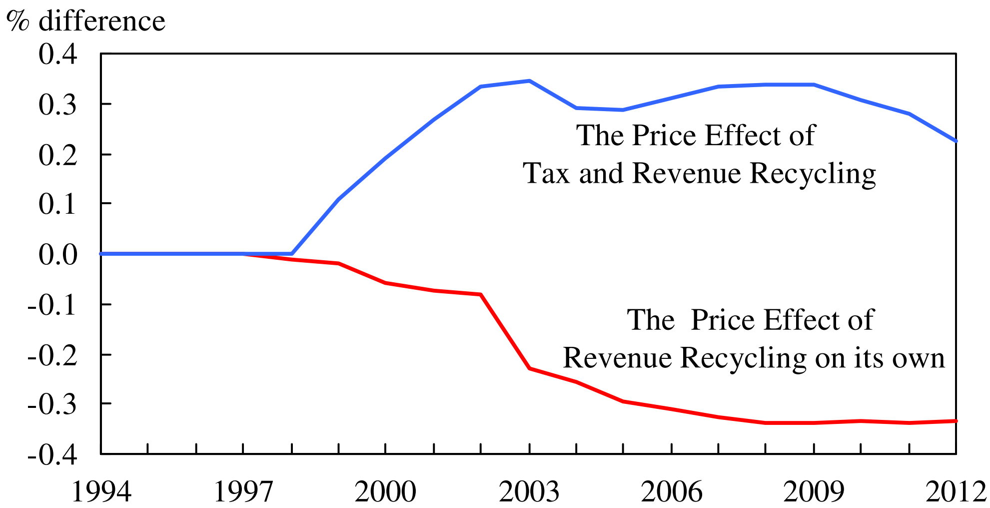
The scenario results show that there are reductions in GHGs in six of the countries (see Chart 2). The effects closely follow the results for total fuel consumption, with the largest reductions occurring in regions with the highest tax rates. The largest reduction in emissions occurs in Finland and Sweden. It should be noted that in most cases the fall in emissions is relatively larger than the fall in fuel demand, indicating that the tax policies are efficient at reducing emissions.

As a general rule, the effects of the ETR will be positive on economic activity, depending on how the revenues from the environmental taxes are recycled.

However, it is likely that there will be transition costs, so the gains may not be immediate. Five of the ETR countries have an increase in GDP as a result of the ETR (see Chart 3). In Sweden, the effects take slightly longer to come through, as the very large increase in household electricity taxes depresses real incomes in the short run. Finland has a short-term boost to GDP from the effects of the taxes on fuel demand, because a reduction in the demand for imported fuel improves the country's trade balance.

As the ETRs result in higher fuel prices it is considered likely that there will be an increase in the overall price level. The degree of this is likely to be dependent on the scale of the increase in fuel costs, how easy it is for industry and consumers to switch between fuels to cheaper alternatives (and non-energy inputs) and how much of the cost is passed on by industry to consumers (this is dependent on the level of competition in the industry, which is estimated econometrically for each region and sector). It should also be noted that the revenue recycling may have a deflationary effect when the revenues are recycled through reductions in employers' social security contributions (ie labour costs). This is demonstrated for Germany (where just under half the revenues were used for reducing employers' contributions) in Chart 4 below. In Denmark and the UK, there were no significant increases in the overall price index. In the UK this is because the tax is relatively small and was compensated with slightly cheaper labour costs. In Denmark the tax was larger, but was again compensated with lower labour costs (see Chart 5).

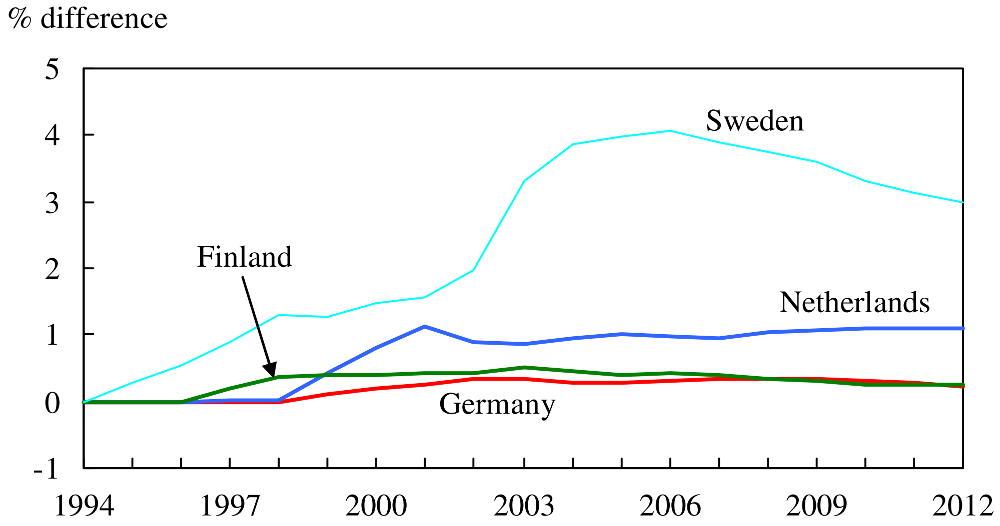
CHART 4: PRICE EFFECTS IN GERMANY



Note(s) : % difference is the difference between base case and the counterfactual reference case for Tax and Revenue Recycling and is the difference between the no revenue recycling case and the base case for revenue recycling.

Source(s) : CE.

CHART 5: CONSUMER PRICE INDEX



Note(s) : % difference is the difference between the base case and the counterfactual reference case.

Source(s) : CE.

The measure of inflation, the consumer price index, will record a larger increase in cases where the taxes are levied on households rather than industry. The reason for this is that the consumer price index is a weighted average of the price of consumer products, including energy. In the cases where the tax is levied on households the whole tax is reflected in the consumer price index, rather than just the share that is passed on by industry. Therefore it is not unexpected that the largest increases are in the Netherlands and, in particular, in Sweden (see Chart 5).

Table 4.1 Definition of COMETR sectors

E3ME Sector	NACE Definition
5 – Food, Drink and Tobacco	15, 16
7 – Wood and Paper	20, 21
10 – Pharmaceuticals	24.4
11 – Chemicals nes	24 (ex 24.4)
13 – Non-Metallic Mineral Products	26
14 – Basic Metals	27

The Porter hypothesis suggests that environmental regulation can induce efficiency and innovation and improve competitiveness as efficiency gains partially, or more than fully, offset the costs of complying with the regulation. In the COMETR context, environmental regulation has been more narrowly defined, however, as energy taxation implemented to encourage households and industries to behave in an environmentally-sustainable manner. On this definition, our results show, in contrast, that in the absence of revenue recycling mechanisms, ETR leads to a net loss of output in all examined countries (except Finland). However, when there is revenue recycling, ETR, as modelled within E3ME, produces a small 'double dividend' effect in every country, with GDP increasing by up to 0.5% compared to the Reference case.

In addition to investigating the effects of ETR at the country level, the COMETR project also focused on four of the most energy-intensive E3ME sectors, plus food and pharmaceuticals to provide a comparison. These are defined in Table 4.1.

Table 4.2 gives a good indication of the importance of energy as an input to each sector and region, with the figures being expressed as a percentage of turnover[8]. Table 4.2 shows that even in the most energy-intensive industries, energy does not represent a large share of inputs. Only in one case, Other Chemicals in the Netherlands, does the share of energy inputs in turnover exceed 10%. In most cases the figure is around 5%, with non-metallic minerals and basic metals apparently having slightly larger shares.

If energy represents around 5% of an industry's input costs (turnover – profit), then even a 50% increase in energy costs is going to lead to only a 2.5% increase in total input costs – even assuming that the industry is unable to reduce its fuel consumption or substitute between different fuel inputs. This may or may not be absorbed by firms within the industry (if there were perfect competition within the industry it would be completely absorbed, if there were no competition it would be completely passed on). The effect of any price increases will depend on the relevant price elasticities (domestic and export) for the industry's products. Typically these would be less than one, so a 2.5% increase in prices would not lead to a 2.5% decrease in product demand. Consequently, even in the energy-intensive sectors we would not expect to see large falls in output.

Table 4.3 shows the results for price increases from ETR for 2004. This year was chosen because it is the final data-point in the input series; by 2004 the ETRs are in place, but there is no blurring of results by the assumption that tax rates remain constant in real terms after 2004.

Table 4.2 Energy as a share of turnover (%)

	DK	DE	NL	FI	SE	UK	SI
Food, Drink & Tobacco	1.5	2.0	1.5	1.4	1.0	1.5	1.9
Wood & Paper	1.9	3.3	2.9	5.1	3.7	3.0	6.5
Pharmaceuticals	0.4	7.2	0.0	6.5	0.3	0.9	0.0
Other Chems	4.2	6.5	17.5	8.9	8.4	3.9	4.3
Non-Metallic Minerals	5.4	5.8	4.2	3.5	4.4	4.4	8.9
Basic Metals	3.0	8.7	5.8	6.6	4.5	4.7	9.4

Source(s) : CE, E3ME database

As expected, the largest increases in prices are in the non-metallic mineral products and basic metals sectors. Prices fall in the wood and paper sector (which operates in an EU market rather than national markets). This is mainly due to a reduction in labour costs in the sector (which form a much larger share of input costs than energy does), and this reduction is mainly a result of reductions in social security payments in Germany and the UK.

[8] Figures for the Pharmaceuticals and Other Chemicals sectors are estimates (except for the UK) as these sectors are not explicitly defined at the NACE 2-digit level. These estimates are derived by summing across the rows and columns of the input-output table and taking relative gross output shares. For Germany and Finland the allocation of fuel use to Pharmaceuticals seems unreasonably high and it is likely that most of this demand should in fact have been allocated to Other Chemicals

Only two of the sectors show price rises above 1%. These are both in Sweden, where the effects are actually an indirect result of higher consumer prices, particularly in electricity (from the ETR) which in turns leads to an increase in wages. In most other cases (excluding wood and paper) the differences are in the range of 0.2-0.4%.
In most cases the price increases also include a factor for an increase in investment. This mainly represents firms' decisions to purchase new machinery in response to higher energy prices. While this may have a negative short-term effect in price competitiveness, it will improve long-term non-price competitiveness through the production of higher-quality output (which may again command higher prices).The effects of the ETRs on industry output are less easy to interpret because they include a number of different factors:

- price effects outlined above
- non-price effects from additional investment
- consumer demand
- activity in export markets
- production in competing import markets

Table 4.4 shows the percentage increase or decrease in gross output at factor cost (which excludes tax payments) for each of the examined industries, again in 2004. The results show that, in many, cases the over-riding effect is higher domestic demand from consumers. In most cases, gross output in the affected industries increases slightly. This is not entirely unexpected given the modest nature of the price increases recorded. The scale of the increases varies across sectors much more than across countries. The smallest differences are in the UK where the ETR was smallest. This suggests that domestic demand is a key determinant in industry output.

Table 4.3 Increase in industry prices, 2004 (% baseline V reference)

	DK	DE	NL	FI	SE	UK	SI
Food, Drink & Tobacco	0.01	0.05	0.00	0.46	1.69	0.00	0.04
Wood & Paper	-0.57	-0.40	-0.34	-0.26	-0.33	-0.48	-0.32
Pharmaceuticals	0.01	-0.09	-0.01	0.87	0.05	0.09	-0.02
Other Chems	0.32	0.72	0.11	0.36	0.28	0.36	0.08
Non-Metallic Minerals	0.33	0.46	0.26	0.77	1.06	0.29	0.16
Basic Metals	0.51	0.43	0.50	0.53	0.48	0.62	0.46

Food & drink in Sweden is a special case in the results: prices do rise in Sweden in the food and drink industry (see Table 4.3). However, this is not by as much as the overall consumer price index, which rises primarily due to electricity costs. Consequently, food & drink becomes comparatively cheaper and receives a larger share of consumer spending, in turn consumer spending is boosted overall by reductions in income tax. Consumer demand accounts for half of gross output in the food & drink industry.

Table 4.4 Increase in industry gross output, 2004. (% base V reference)

	DK	DE	NL	FI	SE	UK	SI
Food, Drink & Tobacco	0.65	0.56	0.13	0.64	4.24	0.02	0.28
Wood & Paper	0.29	0.17	-0.27	0.06	0.19	0.04	0.04
Pharmaceuticals	0.08	-0.02	-0.06	0.14	-0.05	0.00	-0.04
Other Chems	0.03	0.00	0.00	0.31	0.46	-0.07	-0.07
Non-Metallic Minerals	0.08	-0.28	0.05	0.54	0.31	-0.03	0.02
Basic Metals	0.08	-0.15	0.63	0.08	0.08	-0.16	0.00

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COMETR WP 5

Carbon Leakage

by

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Introduction

The motivation for work package 5 (WP 5) has been to assess the environmental effects of environmental tax reforms (ETR) and in particular the extent of the occurrence of carbon leakage, i.e. the potential dislocation of industrial production and related carbon emissions to other geographical areas. The assessment of environmental effects has been carried out with primary focus on carbon-energy taxation.

Whereas WP 4 analyses the competitiveness issue as a consequence of the introduction of an ETR in detail, WP5 addresses the related issue of leakage, but with a main focus on environmental effects. The analysis is complicated by the circumstance, that leakage can take place globally and externally to the EU, so that the modelling requirements are very comprehensive and also data intensive.

The data used for the analysis in WP5 has been compiled under previous work packages (WP 3 and WP 4) by and large.

The work package has three different components which can be distinguished between different economic (macro-economic, sectoral) levels. The analysis of carbon leakage is carried out by means of using the macro-economic E3ME-model, two sectoral approaches and more qualitative case studies:

- First of all the E3ME-model and the data extensions foreseen allow for the analysis of leakage at an overall level, taking into account changes in trade patterns and import/export ratios, which may reflect dislocation of certain activities from ETR-countries to non-ETR countries. As mentioned above, a comprehensive carbon leakage analysis requires an approach build on a world model. However the E3ME-model is rather a European model meaning that carbon leakage and the potential dislocation of industries can only be analysed at the European / EU level.
- Secondly, the development trends of the different sub-sectors analysed throughout the COMETR project (WP 2, WP 3 and WP4) have been studied from two different approaches: a decoupling analysis and a net-export analysis.

  The former approach assesses the linkage between the development of environmental and economic variables over time, i.e. whether a change in an economic variable, for example GDP, is reflected in a comparable change of an environmental variable, such as energy consumption, or whether there is no recognizable correlation between the two variables.

The latter approach addresses the possibility whether stringent environmental policies which can either be expressed in strict environmental regulation or via the increased application of market-based instruments, such as taxes and trading schemes, will lead to the relocation of domestic industries, in particular when such policies are implemented unilateral. This subject matter is also known under the topic pollution haven hypothesis (PHH) in the economic literature. Assessing the existence of the PHH is a difficult and complex undertaking, in particular if the focus is directed to answering the question what are the exact causes for the relocation of domestic industries, i.e. in our case whether relocation took place as a consequence of the introduction of an ETR. Therefore the analysis used in this part of work package is not able to verify or reject the PHH but it can provide some interesting insights in the evolution of the competitiveness of the sectors. The basic idea behind the approach applied, i.e. the net export analysis, is to calculate an indicator measuring a country's net export with the world (or other countries depending on data availability) as a proportion of the country's consumption from the selected economic sector. The definition of the net export ratio in terms of the country's shares of global production and global consumption suggests that it might provide a good competitiveness indicator, with movements in the ratio giving an indication of changes in competitiveness – i.e. a declining ratio indicating deterioration in competitiveness, an increasing ratio indicating an improvement.

- Third WP5 consists of qualitative case studies of structural developments in the eight sub-sectors. These case studies synthesize existing literature and other evidence on structural trends in profiles of the studied sectors, so as to provide more insight into the internal dynamics of the sectors and possible responses to carbon-energy taxation in the past and in the future. In addition to literature search interviews have been conducted with key informants and specialists within the individual sub-sectors. The case studies focus on the economic and technological developments of the sub-sectors as well as the evolution of international trade. Furthermore, the issue of leakage, i.e. the relocation of domestic industries as a possible response to carbon-energy taxation, has been addressed throughout the case studies, e.g. on basis of interviews with industry managers from the sub-sectors.

Hence the project output of work package 5 combines the results from a European macro-economic model with the findings of sectoral case studies.

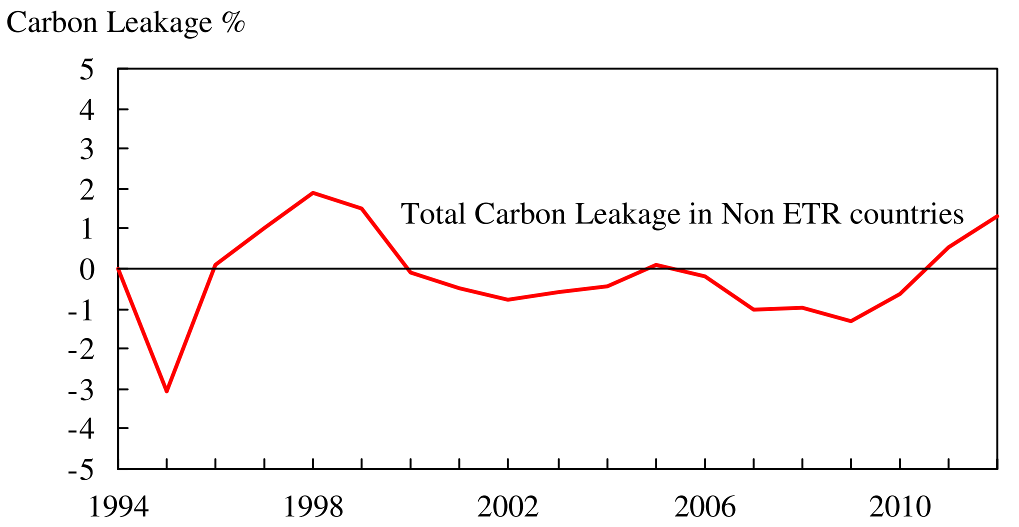
Leakage in terms of an increase in CO_2 emission in regions outside of the EU occurred. The causes of these increases are manifold and the results of our analysis reveal that there is no carbon leakage at the EU level as a result of the introduction of ETR's in some EU member states, mainly due to technological spill-over effects. One of the reasons for the increase in CO_2 emissions is the globalisation process. Data clearly show that the global production share of energy-intensive products is decreasing in developed countries and increasing in developing countries, in particular as some of the case studies show.

Environmental effects with specific reference to carbon leakage

Environmental effects including the possibility of carbon leakage as an outcome of ETR implementation are placed high on the political agenda. Economic and environmental effects are studied in other parts of the COMETR project, whereas the focus of this component is to address the effects in a wider and more global context.

The phenomenon of carbon leakage as a consequence of an increase in CO_2 emissions outside the countries taking unilateral domestic policy measures has attracted attention in the IPCC's *Second Assessment Report* (1995) as well as in its *Third Assessment Report* (2001). In addition, numerous studies have been published on this subject during recent years. Results vary widely although it seems that there is a consensus that global leakage for Kyoto-style action is around 10%. However, the estimates of leakage rates are very sensitive, and are critical in relation to the models adopted and the underlying assumptions.

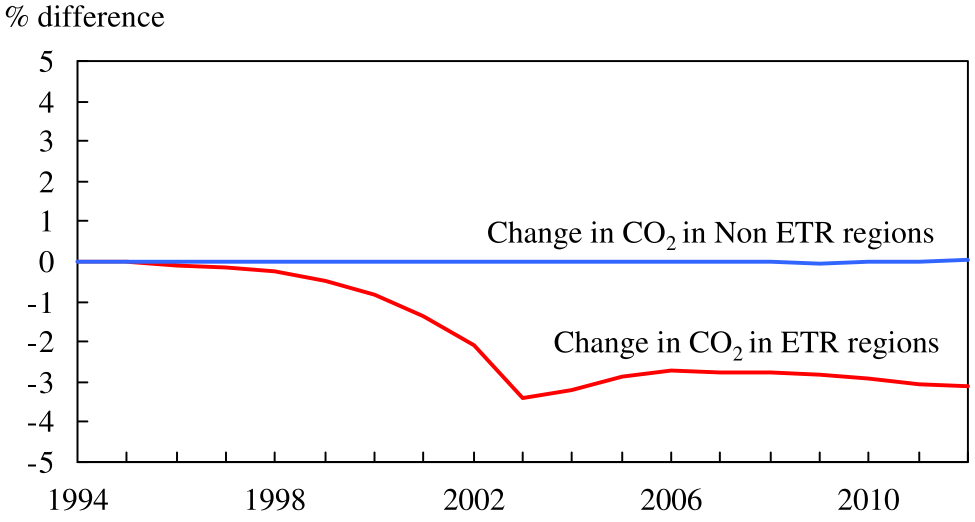
CHART 1: TOTAL CARBON LEAKAGE IN NON ETR COUNTRIES AS A RESULT OF ETR



Note(s) : Carbon Leakage is the change in carbon emissions in countries without ETR divided by the change in carbon emissions in ETR countries and expressed as a percentage.

Source(s) : CE.

CHART 2: CHANGES IN CO_2 EMISSIONS IN ETR AND NON ETR REGIONS



Note(s) : % difference represents the difference between the baseline case and the reference case.
Source(s) : CE.

The modelling of carbon leakage with E3ME as a consequence of the implementation of ETRs in several EU member states shows that in some years 'negative' carbon leakage was recorded, due to technological spillover effects, measured through increases in carbon-saving investment in some non-ETR member states, suggesting that there was a reduction in aggregated carbon emissions in both ETR and non-ETR countries (see the chart 1).

Chart 2 shows that CO_2 emissions fall in the ETR countries collectively over the period by 3-4% in 2012 as a result of the ETR. In contrast the ETRs have almost no effect on the level of CO_2 emissions in non ETR countries. This suggests that there was no carbon leakage from ETR regions collectively to non ETR regions. However, an important caveat exists as E3ME is not a world model, meaning that the above-mentioned result is limited to EU member states.

The main findings of this deliverable are summarised as follows:

- Carbon leakage is measured as the increase in CO_2 emissions outside the countries taking domestic mitigation action and then dividing by the reduction in the emissions of these countries. In the context of this study and the use of E3ME, the change in emissions in both Environmental Tax Reform (ETR) countries[9] and non-

[9] Countries who have undertaken Environmental Tax Reform (ETR) are Denmark, Germany, Finland, the Netherlands, Sweden, and the UK. Slovenia was included as an example of a new member state, as it implemented a carbon-energy tax, but not a full ETR.

ETR countries[10] has been taken as the difference between the Baseline case, which includes revenue recycling, and the counterfactual Reference case.

- Studies of the effects of the Kyoto Protocol have shown carbon leakage (from tax and permit schemes that do not include ETR) in the range of 5-20% using static computable general equilibrium models (CGE). However, Sijm *et al* (2004) conclude that, in practice, carbon leakage from the implementation of the EU ETS is unlikely to be substantial because transport costs, local market conditions, product variety and incomplete information all tend to favour local production.
- In the period investigated in this study, 1994-2012, our results for ETRs in Europe show that carbon leakage is very small and in some cases negative[11]. The six Member States who implemented ETRs all recorded a reduction in CO_2 emissions when comparing the Baseline case to the Reference case. However, countries who did not implement ETRs did not record substantial increases in CO_2 emissions; in fact the increases were very small, furthermore in some cases negative carbon leakage was recorded, for example, whereby CO_2 emissions fell in both ETR and non ETR countries.
- As an indirect proxy measure for carbon leakage, it is instructive to examine the effects on exports and imports in both ETR and non ETR countries, particularly in energy-intensive industries, given the nature of the reform. If exports in ETR countries fell, or imports rose, this would provide evidence for possible carbon leakage. However, in support of the simple carbon leakage indicator, exports and imports in Germany and the UK remained largely unchanged.
- Both indirect and direct analysis of carbon leakage suggests that carbon leakage will not take place as a result of unilateral action to reduce carbon emissions through environmental tax reform. The main reason for this conclusion is that ETR has very little effect on non-ETR regions. In certain cases, due to technological spillover effects, as measured through increases in investment in some non-ETR Member States negative carbon leakage occurs, albeit to a small degree.
- The ETRs do not strongly affect industry prices, because the tax rates are small and because even in energy intensive industries, energy costs are a small proportion of total costs. As industry prices do not increase greatly, firms are able to absorb the additional cost or pass the cost on to the consumer. Only in competitive, export-driven markets does the small industry price increase, lead to a decrease in output in the UK and German Basic Metals industries. However, the decline in industry output is small and does not provide strong evidence for carbon leakage.

The issue of carbon leakage is definitely not a new topic in assessing environmental policy measures in an international context. Consequences of international trade on the environment are studied by many scholars and often circle around the pollution haven hypothesis (PHH); that, under free trade, multinational firms may close plants in countries with stringent environmental standards and establish new ones in

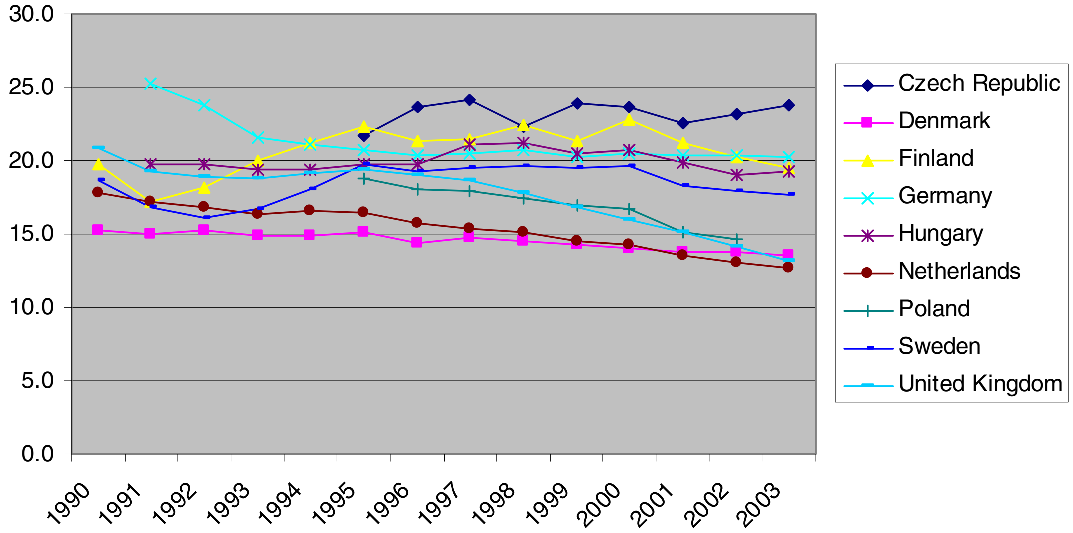
[10] Non-ETR countries are defined as the remaining EU 25 countries who did not undertake Environmental Tax Reform.

[11] Negative carbon leakage can occur when, following unilateral environmental action on one country, a second country's carbon emissions fall. This is most likely to take place as a result of technological spillover.

countries with laxer standards, in particular in developing countries. There is an ever-increasing body of academic and empirical literature attempting either to verify or to reject the PHH. However, a definitive answer does not exist due to methodological problems with regard to analysing the PHH and also of lack of appropriate data. It seems that a consensus has been found as the 'prevailing conclusion of the pollution haven literature is that environmental requirements have a small negligible effect on relocation' (Oikonomou et al., 2006, p.3663, see also Smarzynska and Wei, 2006).

However, adoption of a wider view is necessary when assessing whether the introduction of an ETR may have caused the relocation of industries to foreign countries. Empirical evidence shows that the significance of the manufacturing industry has diminished in the majority of EU member states over recent years when measured as value added generated compared with development in GDP.

Chart 5.3 Evolution of value added of manufacturing industry as % of GDP in selected EU member states



Source: OECD STAN database, Eurostat and author's own calculations

The development paths shown in the figure are not consistent but the overall trend is, as the importance of manufacturing industries in 2003 declined in relation to 1990, and since has declined further. The decline can be seen in the UK over the period as a whole in contrast to the situation in Finland and Sweden where the significance of the manufacturing industry increased in the mid to late 1990s but dropped thereafter. It should be mentioned in this context that during the 1990s these two countries implemented ETRs and increased the carbon energy tax rates levied on energy consumed by manufacturing industries.

A rather intriguing aspect and closely related to the reduced importance of the manufacturing industry in developed countries is the loss of global market share for a whole range of different products, many of which must be described as energy-intensive products (see Figure 5.1).

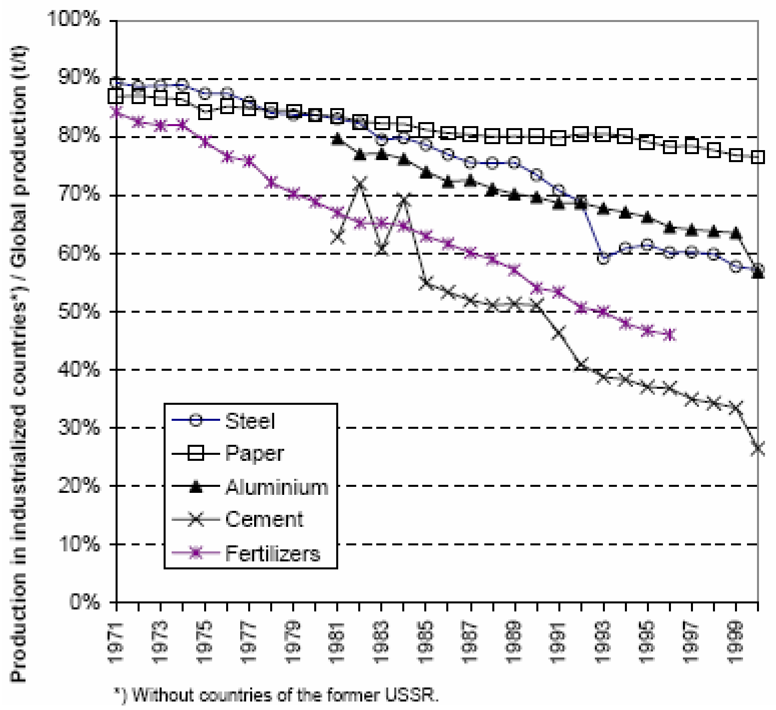


Figure 5.1 Global production shares of energy-intensive products in industrialised countries (source: Sijm et al., 2004, p. 152)

This loss of global market share started already in the 1970s, parallel with an increase in foreign direct investment (FDI) to developing countries, in particular in Asia, which has accelerated even further during the 1990s. It is hard to imagine that stricter environmental policies in industrialised countries were the mechanism initiating the process of investment in developing countries, thereby triggering relocation of industry. However, the majority of direct foreign direct investment is still between industrialised countries (UNCTAD, 2003). The trend in losing global market share in energy-intensive industries of developed countries as illustrated in Figure II.2 is a part of the globalisation process. The loss of global market share is not necessarily the result of a decrease in output but rather the consequence that large production capacities have been built up developing countries, in particular in China, as shown for crude steel production in Table II.1. For example, the production of crude steel in Germany increased between 1995 and 2004 while the global share dropped from 5.6 percent to 4.4 percent during this period. The drop in global share was still bigger in the UK which is not surprising as total production decreased by more then 20 percent. The opposite is true in China where total production increased by around 186 percent and putting China on the first rank regarding crude steel production with a global share of almost 26 percent.

It may therefore be useful to link the analysis of the pollution haven hypothesis with the flow of foreign direct investment (FDI) as the source for establishing new production capacities in foreign countries, in particular when thinking of relocation of industries to developing countries. Studies analysing the PHH generally do not take into account the underlying reasons and determinants for FDI, although the trade literature offers some plausible arguments for FDI and distinguishes between the main types of FDI (see for example Christie, 2003 and Demeskas et al., 2005):

- Horizontal FDI (market-seeking investment): FDI is undertaken with the aim of satisfying demand in the market in which investment is made (i.e. foreign market from the perspective of the investor).
- Vertical FDI (cost-minimising investment or efficiency-seeking investment): a multinational company invests in a foreign country as the costs are lower and production costs are minimised.

It may be argued that investments according to the horizontal FDI type are of limited significance with regard to the PHH as the main motivation is to produce for the domestic markets and not for export. This contrasts with vertical FDI by multinational companies as this type of investment aims to produce at lowest cost and to sell globally.

Decoupling: The economic, environmental and technological performance of specific sub-sectors in ETR countries

Decoupling analysis is progressively being used by international organisations, such as the OECD, Eurostat and the Nordic Council of Ministers, to assess the economic and environmental performance of economies as well as economic sectors. The concept of decoupling is rather simple, as it shows the change in environmental pressure, such as energy consumption, against the evolution of the driving force, i.e. an economic variable such as the GDP, over a predetermined period. Decoupling analysis is useful as it indicates the growth rate of an environmental pressure relative to an economically relevant variable to which it is causally linked.

Table 5.1 Decoupling factor[12] between energy consumption and output of economic sectors in EU member states during the period 1995-2002 (output measured in 1995 prices[13])

	Meat & meat products (15.1)	Paper & paper products (21.2)	Basic chemical s(24.1)	Pharma-ceuticals (24.4)	Glass & glass products (26.1)	Cement, lime & plaster (26.5)	Ferrous metals (27.1-3)	Non-ferrous metals (27.4)
UK	0.31	0.11	-0.07	0.04	0.23	0.48	-0.07	-0.20
DE	0.38	0.14	0.11	0.16	0.02	-0.04	-0.11	0.12
DK	0.00	-0.16	0.06	0.27	-0.61	0.15	-0.39	0.19
NL	-0.29	-0.22	-0.05	0.44	-0.04	0.12	0.01	-0.16
FI	-0.16	0.07	0.12	0.32	0.22	n.a.	-0.22	-0.12
SE	0.24	-0.47	-0.35	0.29	0.30	-0.19	-0.24	-0.08
SI	-0.45	-0.28	-0.32	-0.56	0.12	-0.34	-0.23	-0.15

Note: DK - time period is 1995-2001 for all sectors; FI – time period is 1995-2000 for sectors 21.2, 24.4, 26.1, 27.1-3 and 27.4; NL – time period is 1995-2000 for sectors 26.5, 27.1-3 and 27.4

Source: author's own calculation based on COMETR database

The decoupling factors for energy consumption relative to production are given in Table 5.1.The results do not show consistent developments between sectors and countries. Nevertheless the overall picture shows that decoupling between energy consumption and output occurred in the majority of the countries. No decoupling can be found in at least two economic sectors in each of the countries analysed. An exception is the situation in Slovenia where it can be stated that no decoupling is the rule, i.e. only in a single sector decoupling is revealed.

The data used in this study indicate that decoupling between output and energy consumption occurred most frequently in Germany, i.e. in six of the eight sectors. The UK data are showing that in five of the eight sectors a decoupling trend, followed by Denmark and Finland where decoupling can be reported from four of the eight (seven) sectors analysed. The Netherlands and Sweden are ranked last as the data show that only in three out of the eight (seven) sectors decoupling took place.

There are two sectors which are in particular of interest: Decoupling occurred in sector 24.4 ('pharmaceuticals') in all six old EU member states as compared to the situation in sector 27.1-4 ('ferrous metals') as here the data indicate that only in the Netherlands decoupling occurred during the period analysed.

[12] Decoupling factors are positive in the presence of decoupling with a maximum of 1 in cases when environmental pressures reaches zero. A decoupling factor of zero or negative states that no decoupling occurred during the past analysed.

[13] All monetary figures were adjusted to 1995 prices by using national GDP deflators.

Case studies on leakage and energy intensive sectors

Detailed case studies of the eight sub-sectors written as part of this work package show some interesting features with regard to improvements in energy efficiency measures, sometimes also connected to negative costs. These case studies are furthermore attractive in the sense that they describe the most current developments in technologies applied in the sub-sectors as well as indicating the international trade in the products of these sectors. For example, international trade of cement is relatively unprofitable where it is transported over land due to its very low value/mass ratio; and this fact is reflected in trade statistics with a considerable share of exports generally being sold to the closest geographical neighbours of the producing country.

The findings of the different case studies are presented in a separate annex to this summary report.

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COMETR WP 6

Stabilisation, Mitigation and Compensation

by

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Introduction

It has been suggested that carbon-energy taxes would need to be increased to a level of 20-30 Euro/tonne CO_2 in 2020 in order to achieve a stabilisation target for greenhouse gas concentrations. While increases in carbon-energy taxation inevitably raise questions concerning the negative impacts on economic growth and competitiveness, the European experience shows that governments, as part of already agreed environmental tax reforms (ETR), in fact have implicit carbon-energy taxes in place with a nominal level that in many cases exceeds this level. Still, European governments have introduced exemptions, especially for energy-intensive industries, and as such to some extent, for the biggest polluters, the incentives to improve energy efficiency and shift towards low-carbon fuels have been weaker than the nominal rates would suggest. In view of the need to increase the real level of carbon-energy taxation, while retaining the competitiveness of the European economy, WP6 has addressed the member state approaches for mitigation and compensation applied to energy-intensive industries in the ETR countries. In line with OECD WP6 distinguishes between mitigation measures which are ex-ante and compensation measures which are ex-post; while ex-ante mitigation measures provide for reductions in tax rates or modification of tax bases, ex-post compensation is outside the realm of the taxes as such and include revenue recycling, subsidies and border tax adjustments.

Theoretical motives for mitigation and compensation

In the public finance literature it has been pointed out, e.g. by Bovenberg and de Mooij (1994), that revenue-neutrality of environmental tax reform is desirable, but that it might not be sufficient if one wants to avoid negative effects. This is due to concerns about a *tax interaction effect*, which may arise if energy prices lead to increases in consumer prices that lower the value of after-tax income.

The tax interaction effect neutralises the positive effects of environmental tax reform and may in fact turn negative in the case where the relief on income taxation is too small to offset the price increases. In the case of negative results, the energy taxes may instead have inflationary effects, as employees demand compensating wage increases. An important exception to this concern occurs, however, when revenue-recycling takes place via a lowering of employers' social security contributions (SSC). This is because it is the employer who is relieved for the costs and hence directly benefits from the offset of the carbon-energy tax burden.

Some economists question whether the tax interaction effect should really be a concern. First of all, the assumptions of the theoretical argument of tax interaction effects are very strict; it is assumed that the pre-existing income taxation system *a priori* minimises the excess tax burden. It also hinges on the assumption that ETR is introduced on top of a set of regulations that effectively internalises the externalities (Weinbrenner, 1996). Some authors also question the elasticities and, especially for the Nordic countries, there is evidence that for dual-earner families higher prices actually increase rather than lower labour supply. The orthodoxy on the tax interaction effect would seem to deserve closer scrutiny.

In WP6 we have focused on the competitiveness issue in relation to the recommended and 'conventional' revenue recycling approach. Even if the fiscal orthodoxy is adhered to, and employer's social security contributions are lowered to offset the company burden of energy taxation, a fundamental asymmetry prevails among energy-intensive and less energy-intensive industries, which has been stipulated to cause further distortions to competitiveness. The most energy-intensive sectors account for a disproportionate share of energy consumption in relation to their labour force, and hence a revenue-recycling which compensates for carbon-energy taxes by lowering labour-costs will suffer from a certain asymmetry. The most energy-intensive companies will experience a net burden even if the revenue is recycled on a per employee basis. Less energy-intensive sectors, on the other hand, which are more intensive in labour use, may actually benefit positively from ETR. It can be argued that this mechanism is exactly what ETR is about, and that it is desirable with such a shift in competitiveness among energy-intensive and less energy-intensive industries. Still, in the design of ETR a desire to lower the burden for the most energy-intensive industries via numerous mitigation and compensation measures is clearly visible – sometimes as a result of last-minute lobbying efforts. These circumstances call for a closer inspection of the costs of ETR at the sectoral level, which has been carried out in WP6.

Ex-ante mitigation measures

The special mitigation arrangements that have developed within the unilaterally introduced ETRs have, unfortunately, replaced the transparency and intended economic signals with what materialises when the heat of vested interests meets with the mists of tax legislation – a rather thick fog of exemptions.

We abstain from an attempt to accurately summarise the mosaic of exemptions here; the interested reader is referred to WP6 as well as WP1 for the relevant details. Some visible patterns do stand out, however;

- In all member states carbon-energy tax rates are normally lower for industrial sectors than for households and transport use (see Annex 3 in WP1)
- In some member states exemptions and reductions are to some extent contingent upon 'voluntary agreements' involving compliance with binding targets for energy efficiency. Hence, Denmark and the UK provide for greatly reduced tax rates to a range of sectors and industrial processes on the basis of such arrangements. While the UK provides reduced rates for coal, gas and electricity, Denmark allows for reductions for all fuels.
- In some member states a tax rate 'threshold' for large consumers, above which one or more reduced tax rates apply for a range of fuels, has been created.

The thresholds themselves vary significantly and in the Finnish case only about 12 companies find themselves above the threshold, whereas many more Dutch companies are believed to benefit. While in the Dutch case the threshold is based on physical energy use, Finland and Sweden have established a threshold for tax expenditures as a share of economic output,

- In Germany the reduced tax rates for industry are closely tied with the tax shift principle of ETR; companies that suffer from a higher net tax burden as a result of ETR can benefit from an additional "peak-adjustment" which caps the additional tax burden exceeding 20 per cent. About 1,600 companies benefit from this 'spitzen-ausgleich' (Bach, 2005:17).
- the EU's Energy Taxation Directive prescribes specific exemption mechanisms for selected industrial sectors, notably metallurgical and mineralogical industries, but the member states do not always make direct use of these.

It appears that member states to some extent make selective use of exemptions to protect their domestic industrial structure and interests, but are careful not to violate formal EU requirements, cf. below. Germany, for instance, has introduced domestic energy taxes above EU minimum levels for all fuels except coal, a circumstance which seems to convey a relative advantage to the iron and steel industry.

Ex-post compensation measures

With respect to ex-post compensation measures it is in view of the theoretical debate especially the approaches adopted for revenue recycling that are of interest;

- Sweden and Finland have mainly recycled revenue by lowering income taxes. For Sweden it has for many years been a tax policy aim to lower the pressure of income taxation on labour income. The tax reforms in these two countries have aimed at lowering direct income taxes, and the carbon-energy taxes have contributed to securing alternative revenues for some, but not all, of the income tax reductions. This observation applies for Sweden's early environmental tax reform (1990) as well as the most recent phase (after 2001). It also applies to Finland for the more comprehensive tax shifts introduced since 1997.

- Denmark and UK, on the other hand, have more closely followed the recommendations from the fiscal conventionalists, e.g. revenues have been aimed predominantly at a lowering of employers' social security contributions, so as to avoid inflationary effects. However, because of the imbalance between energy consumption on the one hand and numbers of employees on the other, the lowering of social security contributions, at the company level, does not necessarily lead to full compensation for the individual company. The imbalance has then, in Denmark as well as in the UK, been compensated and mitigated via the various mechanisms for energy-intensive industries such as agreements and reduced rates for heavy industries. The real purpose of the exemptions seems to have been to avoid the tax interaction effects (See WP1). Finally, both countries have earmarked some revenues (5-20%) for direct energy efficiency subsidies, e.g. via the Carbon Trust, perhaps out of concerns than incentives would otherwise be too weak.

- Netherlands and Germany have followed 'mixed' approaches. The Dutch reduced income taxation in the initial phase, and a particular issue here was social concerns, which led to the increase of the basic tax free allowance for income as well as to complicated formulae for exempting basic consumption of electricity and gas (Vermeend and van der Vaart, 1998:11). In the second phase the Dutch adhered more to the side of fiscal conventionalists and reduced the employers' wage component, but they also reduced corporate taxes. In Germany the ecological tax reform split the revenue recycling equally between a reduction of employers' and employees' social security contributions, hence establishing a programme of revenue recycling less concerned with fiscal orthodoxy and more with political appeal, taking into account that the eco-tax reform aimed equally at gasoline prices and fuels as such.

- Slovenia introduced an "implicit" ETR; it restructured its existing energy taxes into fuel taxes with a carbon-energy tax base and increased their raising of revenue; with this approach the introduction of other taxes were avoided, but as it is difficult to know which taxes that would otherwise have been relied on the approach can also be regarded as pragmatic.
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Hence we can summarise the observations on the revenue recycling approaches by dividing the member states in question into three different groups; the fiscal conventionalists (UK and Denmark), the fiscal pragmatists (Sweden and Finland) and finally the political pragmatists (Netherlands, Germany and Slovenia). The pragmatists are labelled so, because reforms were designed so as to accommodate the pressing concerns with the tax systems and the electorate, rather than with fiscal theory.

EU law and state aid issues relating to carbon-energy taxation

The different mitigation and compensation approaches reflect somewhat different strategies for dealing with competitiveness concerns. In recent years member states have increasingly been constrained by the EU's regulations on state aid in the environmental sector and the 2003 Energy Taxation Directive. Under these regulations the *exemptions* from environmental taxes are regarded, functionally, as a potential form of state aid and have become subject to a range of restrictions and procedures. Although there are significant differences in member state approaches to ETR and ETR-mitigation, under EU-law a common legal framework has gradually emerged. This legal framework constrains the options of member states when considering mitigation and compensation approaches. WP6 reviews in some detail the relevant EU legislation and decisions pertaining to member states' carbon-energy taxes.

The state aid guidelines offer certain opportunities for reducing the tax rates of energy-intensive industries, especially if these are higher than the EU's minimum tax rates. These opportunities are to some extent modelled on the basis of the 1995 decision regarding the Danish CO_2-taxation scheme, which was the first member state to obtain explicit Commission approval of its carbon-energy taxation system. As agreements between energy-intensive industries and the relevant authorities played a certain role in obtaining tax rate reductions in the Danish scheme, it was not surprising that the Commission's state aid guidelines reflected the role of agreements vis-à-vis selective tax reductions as accepted in the Danish case.

Hence the Danish scheme, and the subsequent state aid guidelines, provided a menu of acceptable solutions to mitigation efforts that surfaced in the decisions on the German and UK schemes. It is therefore not surprising that self-commitments and agreements as an instrument play a key role in both the German and British cases. Conversely agreements as a policy instrument are absent in the Swedish, Finnish and Slovenian schemes which were devised prior to the EU membership of these countries. And although the Dutch have a notorious practice of long-term agreements for energy efficiency, these agreements are not directly linked with the derogations from energy taxes, as the Dutch established their tax system as a response to the relative failure of the agreements to deliver the desired CO_2 reductions (Enevoldsen, 2005).

The costs and benefits of ETR at the sectoral level

In WP6 we have explored the premises of the exemptions by focusing on the sectoral perspective; what are the costs of ETR to industries and to which extent have these costs been compensated by revenue recycling through a lowering of the employers' social security contributions (SSC)? We take advantage of the COMETR database to explore the net tax burden and the associated distributional implications of ETR for the various industry sectors.

From the company perspective the increased level of carbon-energy taxation is offset by two factors: 1) revenue recycling by reducing SSC, and 2) improved energy efficiency, which leads to lower energy costs per unit of output (cf. Enevoldsen et al., 2007). A third factor is also at play, the so-called Porter effect, i.e. the increase in output as a result of the pressure to innovate and become more competitive.

Table 6.1 provides an overview of the share of ETR net expenditures at the sectoral level as a share of the gross operating surplus[14] (GOS) for three countries for which the revenue recycling data could be disaggregated to the sectoral level. While the existence of Porter effects were identified by the WP3 analysis, we have not included the estimates in Table 6.1.

Table 6.1 The net costs of ETR in per cent of gross operating surplus, taking into account revenue recycling to employers only, as well as the share of improved energy efficiency related to the increase in carbon-energy taxes.

	Meat	Paper	Chem.	Pharm.	Glass	Cement	Ferrous	Non-ferrous
DK_{96-02}	-0.8		-0.1	-0.1	-0.3	1.4	-2.3	-0.9
DE_{99-02}		1.2		1.1	0.2	-0.4	-1.6	-2.1
SE_{96-02}	0.0	0.0	-0.5	0.0	-1.5	-3.7	-2.9	-0.3

The decomposition of the ETR costs at the sectoral level shown in Table 6.1 for Denmark, Germany and Sweden show that ETR, with exemption mechanisms in place, only in exceptional cases induces a gain for energy-intensive industries. The general pattern is one of a burden for the most energy-intensive industries. Conversely, the less energy-intensive industries (meat, pharmaceuticals, paper products) have managed to offset the costs of ETR, though substantial gains are not apparent either.

[14] Gross operating surplus denotes the surplus of activities before consumption of fixed capital.

From the sectoral perspective the burden for cement and glass is less than 1 per cent of the gross operating surplus where there is some revenue recycling of employers' SSC, while for ferrous and non-ferrous metals it appears to have reached in some cases 2 per cent of gross operating surplus. In the Swedish case, with no SSC-revenue recycling, the costs are estimated to be higher and up to 4 per cent of gross operating surplus for cement and steel. Company managers in energy-intensive industries may not have appreciated the tax-induced improvements in energy efficiency and may have focused more on the gross burden of ETR, which, unadjusted for the gains, has reached up to 5 per cent of the gross operating surplus for some energy-intensive industries in all three countries.

When interpreting the results of Table 6.1 it needs to be borne in mind that Sweden did not recycle revenue via a lowering of SSC, but via lowering of income taxes. The impacts of revenue recycling via lowering of income taxes on salary levels cannot be accounted for here (readers interested in the broader macro-economic view are referred to the E3ME-results for Sweden in WP4).

In the case of Germany about 50 per cent of the revenue was recycled via lowering of employers SSC. The burden mainly accrues to the most energy-intensive industries, in particular ferrous and non-ferrous metals. However, the figures do not incorporate the 'spitzen-ausgleich' exemption mechanism, e.g. the thresholds for peak tax burdens, and so Table 6.1 actually overestimates the net costs of ETR for energy-intensive industries in Germany (the same caveat is valid for Figure 6.2). The German ex-post compensation scheme is rather complex, and more detailed national studies (Bach, 2005) have made attempts to account for the 'spitzen-ausgleich'.

In the case of Denmark the complex tax exemption mechanisms, combined with the unusually high tax rate for heating, have evened out the tax burdens among sectors, but ferrous industries appear to have experienced some inroads in their gross operating surplus. Cement, surprisingly, has accomplished a positive net benefit from ETR, this is due to the substantial fuel shifts carried out (in particular substitution to the use of waste as fuel) and the energy efficiency improvements attained.

Bearing in mind that above only the *accelerated* energy savings that could be attributed directly to the annual tax rate increases were included, we show below in figures 6.1-6.3 the value of the gross energy savings accomplished by the various sectors. The additional energy efficiency savings attained in most sectors are far higher than can be attributed statistically to the tax rate increases. As energy prices were relatively stable over the period analysed here, changes in underlying fuel prices contribute only marginally to the savings. The gross energy savings are the costs foregone per GJ of output at the current energy prices.

With respect to the Porter hypothesis (Porter, 1991), it states that environmental regulation which is flexible and based on market-based instruments, such as carbon-energy taxes, may actually improve competitiveness. This effect arises not only out of the improvements in energy efficiency induced by the regulations, but also as a more dynamic impact as a result of the pressure on industries to innovate with respect to their processes and products, which may be helpful in becoming more competitive and win market shares.

In the COMETR project both the E3ME modelling of the macro-economic impacts (WP4) and the panel regression analysis of the impact of energy taxes in 56 industrial sectors pointed (WP3) to the existence of such dynamic Porter demand effects.

Figures 6.1, 6.2 and 6.3 provide an overview of the costs of the ETR burden relative to the gross energy efficiency savings. In addition the three figures provide an estimate for the Porter demand effect on the basis of the relationships derived in the panel regression analysis, which identified a statistically significant relationship.[15]

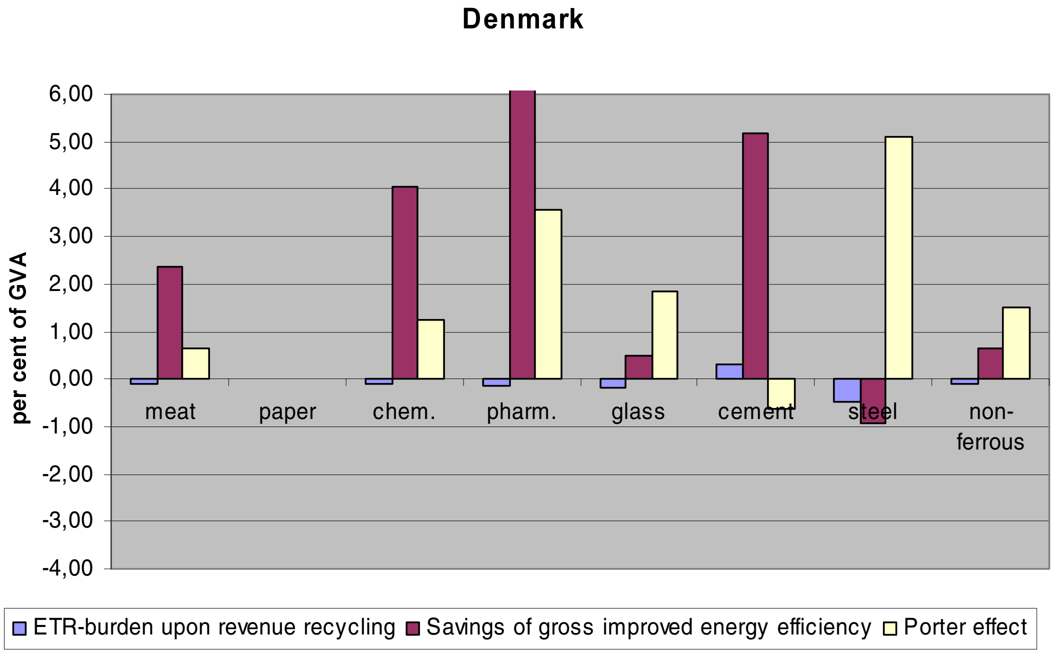

Figure 6.1 Net tax burden of ETR in Denmark in comparison to savings from improved energy efficiency and the Porter demand effect – as a share of gross value added (GVA).

[15] As a minor degree of multi-collinearity in the panel regression could not be ruled out, the demand effects must remain a best guess and requires further efforts with improved econometric techniques.

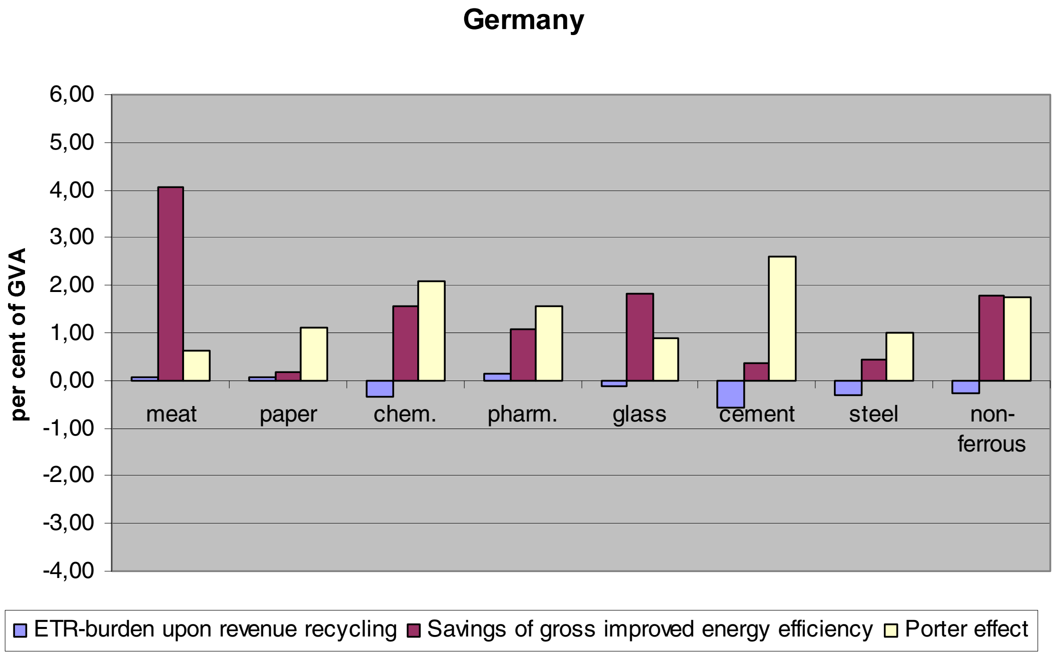

Figure 6.2 Net tax burden of ETR in Germany in comparison to savings from improved energy efficiency and the Porter demand effect – as a share of gross value added (GVA).

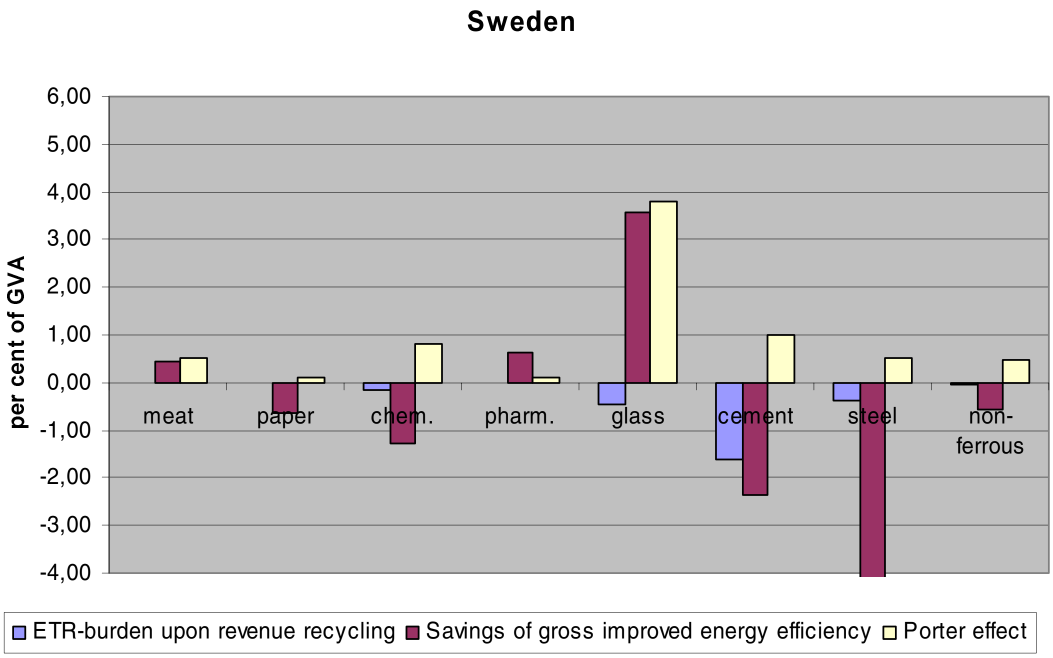

Figure 6.3 Net tax burden of ETR in Sweden in comparison to savings from improved energy efficiency and the Porter demand effect – as a share of gross value added (GVA).

First of all, the net burden of ETR – as a share of gross value added (GVA) – is in practically all sectors an order of magnitude lower than the gross energy efficiency savings attained, as well as the estimated Porter effects. Important exceptions to this general trend can be noticed for cement and steel industries. Here the gross energy savings are not impressive in relation to the ETR burden, apart from the case of Danish cement.

As noted above the ETR costs for Germany are overestimated, as the value of the *Spitzen-ausgleich* has not been included. As the ETR costs as a share of GVA are nevertheless very modest this observation is without implications for the following inspection of the differences between Denmark, Germany and Sweden, which to some extent are striking and deserve attention.

For chemicals, pharmaceuticals and cement the gross energy savings are far more significant in Denmark than in either of the other two countries. Conversely Germany has the lead for ferrous and non-ferrous metals and meat. Sweden excels in its glass industry only, while several other sectors saw their energy efficiency deteriorate.

For Germany, ETR was initiated as late as 1999 and has been under implementation for a shorter period of time than ETR in Denmark and Sweden, which we analyse here for the period from 1996 (and for all three countries up to 2002). Previous research has shown that the time span required for adaptation to increased energy taxation is about 4 years (Enevoldsen, 2005), so the time span should be sufficient to capture the full effects in Germany. In Germany, 50% of the revenue has been recycled to lower employers' social security contributions, and this helps to create a positive balance for ETR for three sectors, even without considering improved energy efficiency savings and Porter effects.

Cement and steel technology issues

The concern with competitiveness appears to be justified mainly with respect to the cement and steel sectors, which seem to have had some difficulties absorbing the ETR burden; although Danish cement stands out as a notable exception to this pattern with its considerable energy efficiency savings. The Danish savings were achieved by lowering energy intensity from approx. 67 GJ/1000 euro output to a level of 50 GJ/1000 euro output in just seven years, e.g. by 25 per cent. Still, Sweden's energy intensity for cement is at about the same level as Denmark's and Germany's is even lower (40 GJ/1000 euro output), so the pattern for Danish cement may reflect that a backlog of improvements was drawn upon.

In Sweden and Germany, cement has been subject to higher tax burdens than Danish cement (0.35 euro/GJ and 0.21 euro/GJ, respectively, versus 0.05 euro/GJ in Denmark (Ryelund, 2007)); nevertheless, cement's energy efficiency has not improved markedly in the two former countries either. It seems that Swedish cement was able to absorb the tax through a lowering of its energy costs by switching fuels, hence keeping overall energy costs roughly constant. In Denmark both fuel switching and energy savings were involved. The findings lead to the suggestion that more substantial tax rates would be required to induce further energy savings, and that the industry might be facing a technology threshold that would require additional effort to transcend.

A recent IEA report (2007) states that by switching to dry process rotary kilns the energy efficiency of cement industries could be improved by up to 50 per cent compared with traditional wet process technologies.

As cement accounts for about 10 per cent of total final industrial energy use, the potential contribution to energy savings from the use of best available technology is by no means trivial, but the investments required for cement plants are significant and amount to approximately three years of turnover (Jilkova, Pisa and Christie, 2006). Cement is not a profound price-taker, as the value-to-weight ratio of cement does not allow for long-distance land transport, but direct access to port facilities can extend the range of trade activities. After the food processing sector, the non-metallic minerals products sector, the parent sector of cement, is the least trade intensive, cf. the WP2 market structure analysis (Scott, Keeney and 2006). Non-metallic minerals are also ranked as the least sensitive in terms of price-setting power. These circumstances suggest a certain robustness of the cement sector and may support innovations and diffusion of cleaner technology. As dry-process rotary kilns is the dominating technology in the countries considered here, there would be a need to introduce more innovative and energy-efficient technologies in Europe in order to reconcile the competitiveness of the industry with strict policies to limit carbon emissions.

With respect to steel it is second to cement in energy intensity, with levels varying from 19 GJ/1000 Euro output in Germany over 13 GJ/1000 Euro output in Sweden and only 5 GJ/1000 Euro output in Denmark, where plants rely mainly on the technology of electric arc furnaces. The differences are believed also to reflect differences in average plant size and product characteristics as well (including wider use of scrap steel in Denmark). In terms of economic output the sector is not declining and is not as such a 'sunset' industry. For steel we identify the highest effective tax burden in Denmark (0.77 Euro/GJ), as opposed to approximately 0.27 Euro/GJ in Sweden and Germany. Energy efficiency deteriorated in Sweden's steel industry; and the same trend, although less pronounced, has been identified for Denmark, whereas for Germany a very modest increase can be identified for the steel sector. The effective tax burden per GJ for the steel sector is at the same level as tax burdens in other sectors, including the energy-intensive chemicals sector. A closer inspection of the energy costs suggests that the modest tax burdens have been absorbed by fuel shifts that entailed a lowering of energy expenses. As the lowering just about offsets the increased tax burden no net improvement in energy efficiency and productivity is evident.

A recent IEA report which reviews technology options in the steel industry shows that a broad menu of technological processes are employed in the sector (IEA, 2007:108). The traditional basic oxygen furnace (BOF) method is one of the most energy- and carbon-intensive, and the options for improvement in energy efficiency are relatively limited. A switch to use of electric arc furnaces based on gas would entail more significant savings in relation to carbon emissions. Furthermore, by switching from pig iron to use of scrap iron in traditional electric arc furnaces, CO_2 emissions per tonne of steel can be reduced to 20 per cent of the level with the traditional BOF method. The main issue here is that the method is subject to the constraint of the limited availability of scrap iron of suitable quality. Conventional BOF methods continue to account for 2/3 of production capacity in Europe, while, for example, electric arc furnaces account for only about 30 per cent of steel production in Germany and 20 per cent in the UK. As electric arc furnaces rely on electricity rather than coal, the production method can be based on hydropower or gas, as is the case in Slovenia and Denmark, rather than coal, as predominantly used in the sector in Germany and Sweden (Christie, Hanzl and Scott, 2006: 31). As the iron and steel industry is clearly a price-taker, limited opportunities exist for passing on the costs of carbon, if factored into the cost structure via ETR. However, a more phased introduction of ETR, with some revenue recycling for an investment programme to renew production technologies, would allow for an implicit fuel shift in favour of electric arc furnaces. Improved levels of steel recycling would furthermore increase the capacity of scrap-based steel processing and, as the sector's location decisions are tied more with availability of iron than with energy requirements, this might support the sector in continuing its production activities within the EU.

Conclusions

In WP6 we have explored the effective sectoral burdens of ETR for energy-intensive industries. Without taking either revenue-recycling or energy efficiency into account, the burden of ETR for energy-intensive sectors, net of the value of exemptions and reductions, has not exceeded 5 per cent of gross operating surplus in any sector in the countries for which data is available. For Denmark and Germany the net burden, taking into account the value of the revenue recycling of employers' social security contributions and the tax-induced energy efficiency measures, has not exceeded 2 per cent of gross operating surplus for the most negatively affected sectors, ferrous and non-ferrous metals. For other energy-intensive industries, glass and cement, the burden has been in the region of 1 per cent. These figures do not include the German peak-tax -adjustment and so represent a conservative estimate of the costs for Germany.

Overall, the net costs of ETR are, in most sectors, exceeded by the value of the gains in energy efficiency which has been obtained over the same period of time. The exceptions to this pattern are Danish steel, the German steel and cement sectors as well as some Swedish energy-intensive sectors, where energy efficiency improvements have not been sufficient to offset the burden imposed by ETR. The troubled history of ETR in Sweden is believed to have produced a backlash, as energy-intensive industries increased energy consumption in response to the marked reduction in CO_2 taxation in relation to the initial 1991-level that was introduced in 1993. In Denmark and Germany, on the other hand, the costs of ETR are offset by gains in energy efficiency, while a potential Porter effect (of improved competitiveness) as detected in other work packages, most likely adds to these gains.

From a sectoral perspective, the burden of ETR for specific energy-intensive industries hence remains modest. Company managers in energy-intensive industries may have failed to appreciate the benefits of improvements in energy efficiency as well as the positive impacts of revenue recycling. Where revenue recycling via reductions in employers' social security contributions has been employed to compensate for competitiveness effects, as recommended in the fiscal literature, the burden has been significantly lower; for the sectors of cement and glass it amounts to less than 1 per cent of the gross operating surplus, while for ferrous and non-ferrous metals in some cases it appears to have reached 2 per cent of gross operating surplus.

As technologies are available which allow for significant reductions in the consumption of fuel and carbon emissions in the most energy-intensive sectors, the cement and steel sectors, a gradual reduction of exemptions seems feasible and would not necessarily endanger the economic activities of these sectors if combined with targeted technology investment programmes.

A revenue-neutral shift of taxation from labour to carbon-energy primarily benefits labour-intensive industries, but if the transport sector is included in the tax-base shift, as was the case in Germany, the additional revenue which accrues from this source allows for higher levels of compensation for the energy-intensive industries.

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Annex:
Summary of case studies on energy intensive sectors.

Sector 15.1: Meat and meat sector[16]

Economic development of the sector

During the 1980s and the 1990s the meat sector in Europe underwent significant structural changes. Despite national differences a general trend towards fewer meat processing facilities with a bigger average throughput can be observed. As a consequence of this centralisation the meat industry is now controlled by a few very large companies in each country.

Differences in terms of the economic significance of the meat sector are observable. In the Netherlands and Denmark the meat sector constitutes 4 and 7 percent of the total output in the total manufacturing industry, respectively. The meat sector constitutes 2.7 percent of the total manufacturing industry in the UK and less than 2 percent in the remaining COMETR countries as compared to 2.7 percent at the EU 15 level (see Table A.1). Denmark and the Netherlands are also the two COMETR countries with the largest export percentage in the meat sector.

Table A.1 Total output of the meat industry as share of total output of manufacturing industry (year 2000)

Country	Meat industry as % of total manufacturing industry
EU15	2.5
Denmark	7.7
Finland	1.9
Germany	1.6
Netherlands	4.1
Sweden	1.7
UK	2.7

Source: COMETR WP3 database

The Danish meat industry underwent extensive structural changes during the 1990s. In 1990 the company Danish Crown was established after a merger between 3 meat companies, and during the following years several slaughter companies and meat processing companies have been merged into Danish Crown. Today Danish Crown process 20 million pigs (in thirteen slaughterhouses) and almost 400 thousand cattle (in 4 slaughterhouses) each year and is the largest pig slaughter company in Europe and the third largest meat processing company in the world. Danish Crown exports around 90 percent of their products, but despite the size of the company Danish Crown only supplies around 10 percent of the market for pig meat in Europe and around 2-3 percent globally. Despite mergers and a meat sector with fewer and larger companies, the meat market can still be seen as a market exposed to intense competition. Meat products are traded globally in competition with a large range of global players where no one company can set the price. However, the companies do

16 The summary is based on the case study by Anders Ryelund (NERI).

not only compete on price. Quality and veterinarian standards are also important competitive factors.

Changes in consumption patterns can be seen as one of the major factors behind the structural changes observed in the meat sector. The causes for the changes in public behaviour are manifold. For example, during the 1990s production of beef decreased in particular in the UK – due mainly to the outbreak of BSE – with a concomitant rise in the production of poultry.

Energy consumption of the sector

The result of the case study reveals differences in energy consumption between different meat products. For example, poultry products are the most energy intensive in terms of the electricity needed to freeze the product. According to Danish estimates it only takes approx. 80 kWh to freeze a tonne of beef while the freezing of poultry requires at least twice the amount of electricity.

Table A.2 Electricity consumption related to freezing of meat products

Meat product	kWh per tonne of meat
Poultry products	120-260*
Pig meat	115
Cattle	80

*Note: *Depending on the type of packaging*

Source: Pontoppidan et al. 2000

The change in consumption patterns in Europe is not the only element behind structural change in the meat industry. A range of EU regulations and political initiatives have also contributed to structural change, leading to fewer but larger meat processing facilities. Over the last 30 years the EU Common Agricultural Policy has significantly influenced production of various agricultural products. Various types of subsidy schemes have given farmers economic incentives to increase production of specific products. Furthermore, EU regulations defining hygiene and quality standards in the meat sector are other examples of EU regulation with structural impact. Hygiene regulations, such as EC Directive 91/497, pose serious economic challenges for meat companies.

New veterinary and environmental standards force the meat companies to make changes in the production process and to undertake large investments in new equipment in order to comply with the requirements imposed. In general the demand for better hygiene and food products of higher quality has caused a higher energy consumption that counters the general trend toward a more energy efficient production. One example of changes in hygiene standards with consequences for energy consumption is the use of hot water. In the 1980s and the beginning of the 1990s it was standard to use water at 60 degrees Celsius for cleaning and sterilising. The standard temperature increased to 82 degrees in 2001 to ensure better hygiene. A second example is the chilling of recollected blood. In the beginning of the 1990s slaughterhouses did not chill recollected blood; however, to ensure hygiene and avoid odour problems recollected blood is now chilled to 5 degrees Celsius (Ramirez et al. 2006).

In general the meat sector is not an energy-intensive sector and hence energy taxation does not have a great influence on the composition of input expenditure in the meat sector. The level of total energy taxation in the sector is displayed in Table A.3.

Table A.3 Energy taxation in the meat industry (2002 figures)

Country	Energy tax share of GVA (percentage)	Energy tax (fixed 2000 million euro)
Denmark	0.87	9.97
Finland	0.55	2.77
Germany	0.42	16.54
Netherlands	0.42	8.15
Sweden	0.10	0.88
UK (2001)	0.31	1.52

Source: COMETR WP3 database

Energy taxation and other policy instruments applied to the meat sector may have affected the competitiveness of this sector. Complying with policy instruments costs the meat sector a significant amount of money. Environmental policy instruments such as energy taxes and regulatory instruments may contribute to consideration of outsourcing in countries where the meat sector is facing large economic burdens induced mainly by these instruments as well as by high labour costs. However, the possibilities of moving production to a country with lower costs (labour, energy, taxation, etc.) are rather limited. Due to considerations concerning animal ethics and the cost of transport of live animals, slaughterhouses need to be located at relatively short distances from the farms producing the animals. There are few examples of live animals being transported several thousands kilometres for slaughter. In other words it is difficult to relocate the slaughterhouses despite unfavourable policy instruments. The further processing of meat products, on the other hand, does not have to take long-distance transport of live animals into consideration. The location of this sub-sector is therefore vulnerable in relation to high-cost policy instruments as well as high labour costs.

Sector 21.2: Paper and paper products[17]

Economic development of the sector

The paper industry in Europe can be characterised as an important manufacturing sector within the EU. The paper and pulp industry directly employs about 275,000 people and indirectly provides employment for around 3 million people (CEPI 2004). The European paper industry provides consumers with a large variety of different paper products. Paper products can be divided into three main categories: printing/writing paper, tissue paper and packaging paper. Each of these three main categories can be further divided into a number of sub-categories.

The production of paper products in the countries analysed in this study displays a similar distribution according to the various grades of paper. In most of the countries graphic paper products (printing and writing paper) constitute around 50 percent of total paper production while packaging paper products constitute between 35 and 50 percent. The rest of the production is split between sanitary/household products and the category other paper products. Denmark and Finland differ a little from the other

[17] The summary is based on the case study by Anders Ryelund (NERI).

countries. In Denmark the production of graphic paper is lower than the average while the production of packaging paper is higher. The opposite is the case in Finland. In Finland the graphic paper production share is higher than the average while packaging share is lower. Table A.4 below displays the distribution of the various paper categories by country.

Table A.4 Total production of paper products and percentage production by grade (2000)

Country	Total production	Graphic	Sanitary & household	Packaging	Others
	1000 tonnes	Percentage of total production			
Denmark	400	30.0	0	67.5	2.5
Finland	13,509	72.6	1.3	23.1	3.0
Germany	18,184	51.3	5.6	36.2	6.9
Netherlands	3,364	40.0	4.4	55.6	0
Sweden	10,786	49.9	2.9	46.1	1.2
UK	6,604	43.1	11.0	38.7	7.3

Source: CEPI 2004

Despite the fact that several varieties of paper products exist, paper is a fairly homogeneous product from a production point of view. All commercial paper products, regardless of whether the product is printing paper, tissue paper or packaging paper/board, are produced using the same basic production method, although some of the elements or chemicals used in the production process may differ. Despite this, however, the overall production technology or structure of the paper machine remains the same regardless of the type of paper being produced.

Basic production technology has not changed significantly over the past 15 years and there is no prospect of imminent changes in the basic technology due to new technological innovations. However, researchers are experimenting with various new techniques to improve energy efficiency in the dryer section of the paper machine.

Throughout the 1990s the paper industry in Europe was a fast developing and lucrative industry. Consumption and production of paper products increased significantly. Despite capacity increases the industry had problems meeting the paper demand, leading to favourable product prices for the paper producers. Within CEPI (Confederation of European Paper Industries) countries (17 European countries), paper production increased from around 65 million tonnes of paper products in 1991 to around 93 million tonnes in 2000, an increase of more than 30 percent over less than a decade. Turnover increased even more during the same time period. The turnover from paper production in the CEPI countries almost doubled in the time period from in the region of 40 billion Euros in 1991 to 79 billion Euros in 2000.

The turn of the century marked a change in the capacity development and economic situation of the paper industry. During the period 2000 to 2005 the production level only increased from 93 million tonnes to 99 million tonnes, a small increase in comparison to the development between 1991 and 2000.

The figures indicate an almost stagnant demand for paper. However, demand for paper products is slightly more complicated than the figures imply. Consumers have continually increased their demand for paper products. The demand for paper products has been met partially by the increase in the total volume output described above and partially by improved technology in the paper-making process. Technological developments have made it possible to increase the quality and strength of paper and thereby have made it possible to use thinner paper for various purposes. Basically a sheet of paper weighs less today than it did ten years ago. This development has led to a drop in the demand for paper as the same amount of paper (when measured in tonnes) can satisfy an increased demand for paper products (sheets of writing paper, cardboard boxes, etc.). In effect, unit consumption of paper products has increased more than the actual production level, as the actual production level is defined in tonnes of paper.

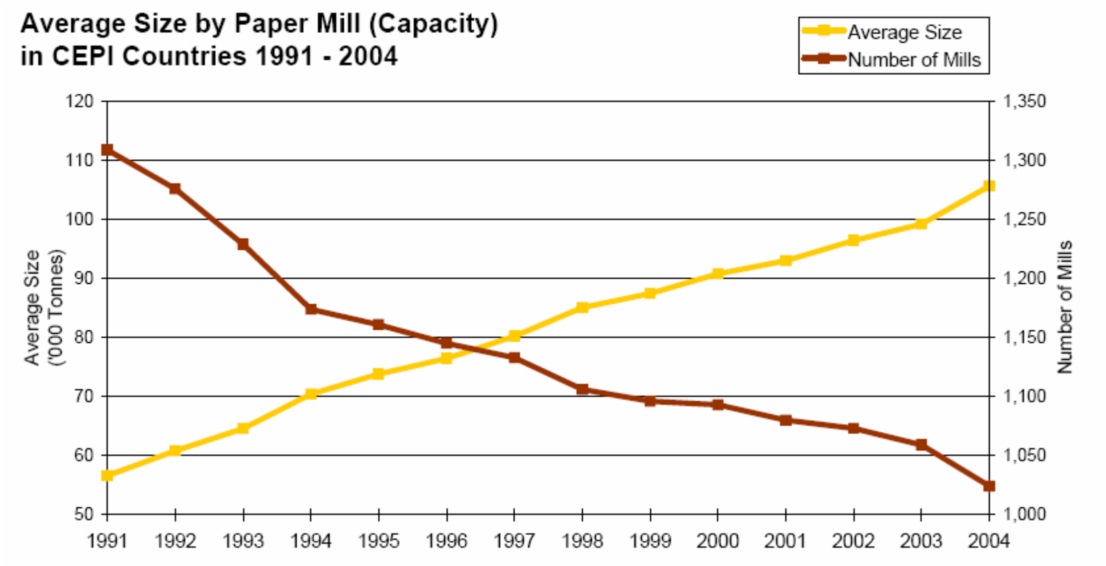
While the increase in paper production has slowed, development in turnover has been declining since 2000. Turnover in the CEPI countries dropped from around 79 billion Euros in 2000 to around 74 billion Euros in 2005. This fall in turnover can be explained partly by the payment structure in the paper industry as well as capacity. Paper is generally priced according to the weight and not according to the number of units delivered. This price setting method favours the consumers when technological improvements allow for thinner and lighter paper with the same quality and strength. The consumer receives more units of paper product for the same amount (weight) of paper. On the other hand, this means that paper producers are faced with decreasing turnover in the case where production in tonnes is stable. An increase in turnover would require an increase in demand for paper products (in units) that exceeds the increase in unit production per tonne of paper.

Changes in paper production

Changes in capacity and in production facilities for individual companies develop slowly in the paper industry. The paper industry is capital intensive with a long depreciation period for capital investments. Typically paper companies invest an average of 6-10 percent of turnover annually. The high capital intensity makes it difficult for paper companies to adapt to new market situations rapidly. Given the fact that the paper industry lacks short and medium term investment flexibility, future market trends and the trends in technology and environmental regulation need to be carefully examined before policy and investment decisions. Decisions on capital investments concerning capacity, production processes, energy, etc. determine the actual production for many years. The life expectancy for paper machines is 25-30 years.

Despite the inability to make rapid changes, the paper industry has undergone significant structural development over the past 15 years. Overall capacity has increased and at the same time number and size of paper mills have also changed significantly. Figure A.1 below shows the development in capacity of paper mills against number of paper mills in the CEPI countries. The number of paper mills has dropped significantly, by almost 30 percent, in the period 1991-2004, but at the same time the average size or capacity of the paper mills has almost doubled.

Figure A.1 Average Size by Paper Mill in CEPI Countries



Source: CEPI 2004

The paper industry in Europe today is dominated by two major companies. Today the Smurfit Kappa Group and SCA control almost 50 percent of the total European paper market. The general trend towards larger production facilities has to some extent been curbed by increased use of recycled fibres. Pulp and paper mills that have specialised in using recycled paper as the primary fibre source have a different input-output structure compared with production facilities relying on virgin fibres. Recycled paper production facilities rely on input of wastepaper from densely populated areas, and the same populated areas are expected to receive the output from the production. A large number of relatively small operations based on recycled paper can therefore be found located in close proximity to population centres (Ruth 1998).

International Trade

The capacity increase caused overcapacity in Europe, which clearly affected the turnover and the profits of the companies in the paper industry. One solution to the problem of overcapacity in Europe could be to export to countries outside Europe. Table A.5 below shows that export from CEPI countries to countries outside Europe has increased by more than 30 percent between 1999 and 2005. During the same period the import level remained fairly constant and even decreased slightly. In 1999 around 9 percent of total paper production in the CEPI countries was exported to countries outside Europe while around 11 percent was exported in 2005.

Table A.5 Importance of export and import in the European (CEPI) paper industry (1000 tonnes)

	1999	2000	2001	2002	2003	2004	2005
Production of paper products	85,757	90,542	90,075	93,015	94,722	99,060	99,334
Export (non-European countries)	7,541	7,699	8,007	9,460	10,485	11,627	10,668
Import (non-European countries)	3,208	3,133	2,678	2,828	3,090	2,864	2,977

Source: CEPI 2001, 2004 & 2006

Despite that export to non-European countries only constitutes a small share of output this does not mean that European countries rarely export paper products. Except for the UK the countries analysed export more than 15 percent of output from the paper industry to other EU countries. Denmark, Finland, Germany and the Netherlands all export between 20 and 40 percent of total output. Sweden exports between 40 and 50 percent of the total output while the UK only exports around 10 percent. The high export to EU countries indicates that export is possible and profitable when the transport length is not too long and transport costs not too large.

Energy related issues

The sector 'paper and paperboard products' belongs to the pulp and paper industry (NACE classification 21) which is considered to be an energy-intensive industry. It is interesting to note the difference between the energy intensity of the pulp and paper industry (sector 21) on one hand and the paper and paperboard products industry (sub-sector 21.2) on the other. The former is characterised as a sector with high energy consumption whereas the paper products industry (sub-sector 21.2) can be categorised as a industry with low energy intensity. Even though energy and energy costs are of less importance than other input variables in the paper and paper products industry, energy expenditure still constitutes a significant expenditure for the paper industry. Table A.6 below shows that the energy tax in the paper industries constitutes between 0.13 and 0.67 percent of the sector's GVA in the various countries.

Table A.6: Energy taxation in the paper and paper products industry (2002 figures)

Country	Energy tax share of GVA (percentage)	Total energy tax (million Euro)
Denmark[01]	0.40	1.39
Finland	0.23	0.67
Germany	0.50	26.68
Netherlands	0.67	7.84
Sweden	0.13	0.98
UK	0.13	5.97

Source: COMETR WP3 database

The table reveals that the energy tax share as % of gross value added for the sector is comparable to the meat sector (sector 15.1) as discussed above.

Sector 24.1: Basic chemicals[18]

Introduction

The basic chemicals industry (NACE 24.1) is a complex and heterogeneous industry in terms of the various commodities that constitute its output. In the larger context of its parent industry, the chemicals and pharmaceuticals industry (NACE 24), it can be seen as the main sub-industry dealing with primary processing, i.e. with the manufacture of the basic commodities which are further processed in the other sub-industries of NACE 24, namely pesticides, herbicides and other agro-chemical products (24.2), paints and varnishes (24.3), pharmaceuticals (24.4), glycerol, soaps and detergents (24.5), explosives (24.6) and synthetic fibres (24.7).

[18] The summary is based on the case study by Edward Christie (wiiw) and Sue Scott (ESRI).

The output of the basic chemicals industry is made up of the following 7 main sub-groups of commodities defined at the 4-digit level (24.11 to 24.17):

- Industrial gases (e.g. hydrogen, argon, nitrogen, CO_2);
- Dyes and pigments (e.g. oxides, peroxides, tannins);
- Other basic inorganic chemicals (e.g. inorganic acids, chlorates, sulphates, nitrates, salts);
- Other basic organic chemicals (e.g. hydrocarbons, alcohols, ethers);
- Fertilizers and nitrogen compounds;
- Plastics in primary form;
- Synthetic rubber.

Taking a broader view and looking at the chemicals (24) and rubber and plastics (25) industries together as if it were one industry we find that it is dominated by three main sub-industries: basic chemicals (24.1), plastic products (25.2) and pharmaceuticals (24.4), which together account for around 71%-73% of activity depending on which measure one chooses

Selected Global Economic Indicators

Global production data that would cover an industry as heterogeneous as basic chemicals do not exist in any simple, easily available form. Therefore we limit ourselves to presenting a small selection of global indicators that are available in the public domain. We also limit coverage to petrochemicals, plastics in primary form and fertilizer production.

The main types of petrochemical products are produced essentially in three world regions, unsurprisingly Asia, Western Europe and North America. South America is much further behind. North America is the largest region in the world in terms of ethylene and propylene production. For benzene Asia is the leading region, followed by Western Europe. Generally speaking Western Europe accounts for around one third of world production of basic petrochemicals. The most recent trends in the development of new capacities in the industry indicate strong growth in two world regions: the Middle East and China.

In geographic terms production and consumption of plastics is currently dominated by three regions: Western Europe, North America (NAFTA) and Asia (not counting Japan). The importance of Asia is forecast by everyone to grow very strongly over the next 10 years due especially to the rise of China and to a lesser extent to strong growth in India and in certain Southeast Asian countries. According to BASF (2004) the three main regions mentioned above were close to parity in 2003 in terms of production volumes, each reaching between 41 and 49 million tonnes. BASF (2004) forecasts that in 2015 Western Europe will reach 58 million tonnes (+41%), NAFTA 68 million tonnes (+51%), and Asia without Japan 115 million tonnes (+135%). As for the demand side, the forecasts are that Western Europe will be in a balanced position, while NAFTA and Asia without Japan will be net importers (5 and 8 million tonnes respectively) as consumption growth slightly outstrips production growth in both regions. The global picture for ammonia is presented in Table A. 7 for the main world regions.

Table A.7 Ammonia production by region, ths tonnes of Nitrogen equivalent

Region	2000	2001	2002	2003	2004
Western Europe	10,815	9,891	9,729	9,750	9,961
Central Europe	4,664	4,232	3,599	4,430	4,809
E. Europe & C. Asia	14,644	14,517	14,517	15,401	16,201
North America	15,919	12,557	14,038	12,267	13,267
Latin America	4,981	5,858	6,466	6,516	7,332
Africa	1,076	1,033	1,116	1,128	1,050
West Asia (M. East)	7,340	7,930	8,525	8,037	8,044
Asia	46,804	46,885	48,880	50,569	54,682
Oceania	681	879	796	914	914
World Total	106,923	103,780	107,665	109,011	116,260

Source: IFA – Production and International Trade – February 2006

Obviously Asia is by very far the largest producer. This region includes around 3.5 billion people (54% of world population). Still, it is remarkable to see the huge per capita production level of Eastern Europe and Central Asia, which with a much smaller population than Western Europe or North America produces a larger total than either of them. The other issue to note is that the bulk of world growth is due to Asia.

In the case of urea production it can be concluded that - as with ammonia - Asia is of course by far the largest producer. However the relative positions are quite different. Western Europe is not a particularly large producer. Central Europe has a production level which is high in per capita terms, and North America, West Asia and Eastern Europe and Central Asia are all quite large producers. The latter two regions are large net exporters as well, and their implied consumption levels are in fact quite low compared to their production levels. Looking only at 2004 data, implied consumption in the case of West Asia is only 52% of production, and for Eastern Europe and Central Asia consumption is only 25% of production.

Overview of the European Basic Chemicals Industry

A snapshot of the basic chemicals industry in the European Union can be constructed using Eurostat's Annual Detailed Enterprise Statistics. This is shown in Table A.8.

Table A.8 Turnover by sub-industry and country in 2003, EUR millions

Country	Industrial Gases	Dyes and Pigments	Other Inorganic	Other Organic	Fertilizers	Primary Plastics	Synthetic Rubber	TOTAL 24.1
Germany	*834*	4,591	3,469	23,994	2,382	29,864	*834*	65,968
France	2,088	1,210	2,765	15,413	2,391	5,187	951	30,005
UK	*2,040*	*2,040*	2,370	11,622	1,410	5,724	1,104	26,310
Netherlands	*272*	758	1,356	12,820	1,192	7,725	*272*	24,395
Ireland	*56*	*56*	46	21,242	302	221	0	21,923
Italy	1,228	905	1,841	2,725	944	12,124	204	19,971
Belgium	622	650	2,042	8,549	401	3,676	665	16,604
Spain	976	798	1,444	2,801	905	7,425	262	14,609
Finland	192	281	939	626	366	1,073	297	3,774
Poland	251	*26*	294	793	1,098	838	*26*	3,326
Austria	216	*41*	266	489	360	1,270	*41*	2,683
Hungary	156	34	94	142	113	1,105	1	1,644
Portugal	182	53	118	332	222	669	0	1,576
Slovenia	51	107	76	57	0	44	0	334
TOTAL	9,165	11,550	17,120	101,604	12,085	76,944	4,655	233,121

Note: Figures in smaller italic script are interpolated estimates
Source: Eurostat SBS and own calculations

The data presented in Table A.9, covering the 14 countries selected, represents a total of 233,121 million Euros, thus a coverage of 98%[19]. The countries are ranked according to total turnover for the industry as a whole.

Table A.10 presents the relative importance of each country for each sub-industry in turn, giving the shares that each country has out of the total turnover for the 14 countries as a group.

Table A.10 Country share by sub-industry and country in 2003, % of sub-industry turnover

Country	Industrial Gases	Dyes and Pigments	Other Inorganic	Other Organic	Fertilizers	Primary Plastics	Synthetic Rubber	TOTAL 24.1
Germany	*9%*	40%	20%	24%	20%	39%	*18%*	28%
France	23%	10%	16%	15%	20%	7%	20%	13%
UK	*22%*	*18%*	14%	11%	12%	7%	24%	11%
Netherlands	*3%*	7%	8%	13%	10%	10%	*6%*	10%
Ireland	*1%*	*0%*	0%	21%	2%	0%	0%	9%
Italy	13%	8%	11%	3%	8%	16%	4%	9%
Belgium	7%	6%	12%	8%	3%	5%	14%	7%
Spain	11%	7%	8%	3%	7%	10%	6%	6%
Finland	2%	2%	5%	1%	3%	1%	6%	2%
Poland	3%	*0%*	2%	1%	9%	1%	*1%*	1%
Austria	2%	*0%*	2%	0%	3%	2%	*1%*	1%
Hungary	2%	0%	1%	0%	1%	1%	0%	1%
Portugal	2%	0%	1%	0%	2%	1%	0%	1%
Slovenia	1%	1%	0%	0%	0%	0%	0%	0%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%

Source: Eurostat SBS and own calculations

As we can see from tables A.9 and A.10 basic chemicals production in the European Union is dominated by eight countries (94% of the total of the 14 countries, 92% of the total of the 20 countries mentioned earlier), with Germany clearly in the lead. The

[19] The total turnover for the industry adds up to 237,121 million EUR.

other large Western European economies are also among the top 8, alongside the Netherlands, Ireland and Belgium. This geographical pattern matches to some degree the geographical distribution of European GDP, with a bias in favour of North-West Europe. The largest producer from among the New Member States is Poland. The second largest is the Czech Republic, not shown in the tables due to missing data for all sub-industries. Total turnover for the industry (2,217 million Euros) places it ahead of Hungary but behind Austria. All in all the share of the New Member States in total EU turnover is quite modest.

Table A.11 indicates the (estimated) relative importance of each sub-industry at the national and EU levels. Thus as we can see the basic chemicals industry in the European Union is strongly dominated by two sub-industries: *Other basic organic chemicals* and *Plastics in primary form*, accounting for a total of 77% of total industry turnover in 2003 (44% and 33% respectively). Concentrating just on these two sub-industries we are drawn back to Table A.10, from which we can see that the most important EU countries for other basic organic chemicals are Germany, Ireland, France and the Netherlands, while the most important EU countries for plastics in primary form are Germany, Italy, the Netherlands and Spain.

Table A.11 Sub-industry share by country in 2003, % of national turnover

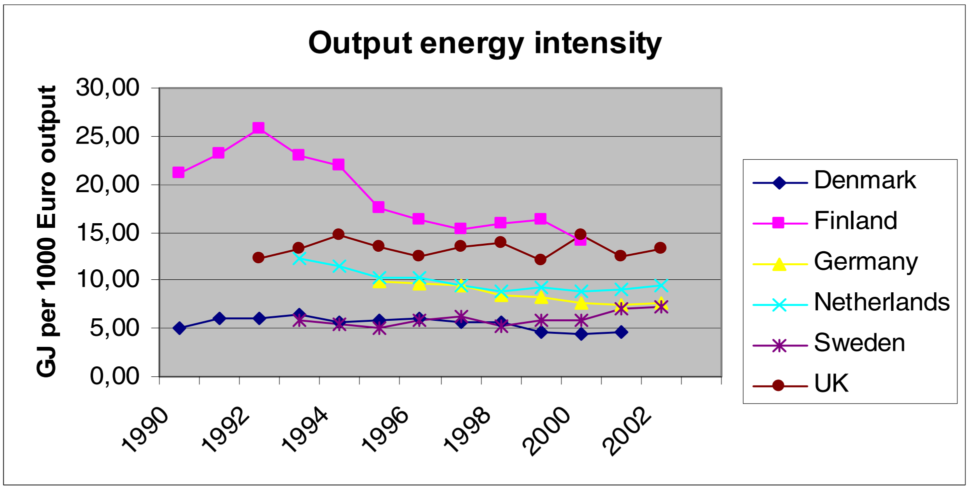
Country	Industrial Gases	Dyes and Pigments	Other Inorganic	Other Organic	Fertilizers	Primary Plastics	Synthetic Rubber	TOTAL 24.1
Germany	1%	7%	5%	36%	4%	45%	1%	100%
France	7%	4%	9%	51%	8%	17%	3%	100%
UK	8%	8%	9%	44%	5%	22%	4%	100%
Netherlands	1%	3%	6%	53%	5%	32%	1%	100%
Ireland	0%	0%	0%	97%	1%	1%	0%	100%
Italy	6%	5%	9%	14%	5%	61%	1%	100%
Belgium	4%	4%	12%	51%	2%	22%	4%	100%
Spain	7%	5%	10%	19%	6%	51%	2%	100%
Finland	5%	7%	25%	17%	10%	28%	8%	100%
Poland	8%	1%	9%	24%	33%	25%	1%	100%
Austria	8%	2%	10%	18%	13%	47%	2%	100%
Hungary	9%	2%	6%	9%	7%	67%	0%	100%
Portugal	12%	3%	7%	21%	14%	42%	0%	100%
Slovenia	15%	32%	23%	17%	0%	13%	0%	100%
TOTAL	4%	5%	7%	44%	5%	33%	2%	100%

Source: Eurostat SBS and own calculations

Energy use by the chemicals sector

The energy intensity of the chemical industry in ETR countries in the nineties is shown here in Figure A.2 (from COMETR WP3). The intensity is expressed in GJ per €1000 of output of the industry (expressed in constant 2000 prices). As such, the figure effectively charts Specific Energy Consumption (SEC).

Figure A.2 Energy intensity in the basic chemicals industry, GJ per thousand EUR output (constant 2000 prices)



Source: COMETR WP3 database

As can be seen the energy intensive chemical industries are in Finland and the UK. Least energy intensive are those in Denmark and Sweden, with those in the Netherlands and Germany in the middle. The high intensity for Finland may represent the fact that it was a small player in chemicals, engaged in ethylene production in a relatively minor way where its intensity was above the EU average in 1995. By contrast the UK's high intensity may be due to the high share of petrochemicals in the UK's chemical industry.

A feature is the extent to which the intensities of four ETR countries, excluding Finland and the UK, are coming closer together. Even Finland looks as though its intensity is on track to reach that of the others. The UK's ETR was one of the last to be implemented, in 2001, so that the lack of improvement is consistent though of course it may not be directly related to that fact. Germany was also one of the last to introduce ETR. It is by far the largest producer of chemicals in the group and its strong improvement since the start of data in 1995 is perhaps consistent with the way in which more attention is sometimes paid to high-profile sectors.

One of the central questions relates to the findings on energy saving potential. If, as seen, the potential reduction in specific energy consumption in the chemical industry between 1990 and 2010 lies in a range up to 20 per cent (an approximate amount), can the movement in SEC shown in Figure A.2 tell us to what extent these potentials have been exploited? The following figures in Table A.12 are the changes in energy intensity since the introduction of ETR and since 1990 to the present (or since the earliest year for which figures are available).

Table A.12 Changes in energy intensity, %.

	Change in energy intensity, %	
	Since ETR (year)	Since 1990 (or earliest year)
Sweden	+24 (1993)*	+24.0 (1993)
Denmark	-19 (1995)	-6.7
Netherlands	-6.4 (1996)	-22.5 (1993)
Finland	-7.6 (1997)	-33.3
Germany	-5.8 (1999)	-21.5 (1995)
UK	+9.6 (1999)	+7.7 (1992)

Note: Sweden's ETR occurred in 1991 but the earliest figure relates to 1993

Source: COMETR WP 3 database and own calculations

The table indicates primarily a high level of variation and country specific influences. That said, it appears that Finland, the Netherlands, Germany and Denmark have made considerable progress on energy efficiency. Sweden, a relatively small player in the chemicals sector, has not while the UK has seen the relatively energy intensive petrochemicals component of the sector increase its share. On the issue of carbon leakage it is suggested that broad technological movements occur and respond to relative price changes. Given that technological possibilities are developing all the time, this provides comfort for the sector's ability to cushion itself in the face of ETR and maybe reap benefits from the process.

Company interviews

Last but not least the findings of interview with chemical companies located in the EU which were undertaken as part of the COMETR project complements the analysis offered in the previous section and should enable the reader to get a more concrete feeling for the constraints and opportunities faced by specific companies, as well as the actual impact of current environmental policies in the EU, given general economic conditions. Some of the most interesting and intriguing points made during the interviews with the CEO of a company located in the EU are[20]:

- Demand is influenced by GNP and expenditure on pharmaceuticals and foods, and appears to be on track for continued growth.
- The location's costs, especially labour costs are a cause for concern in the US parent company.
- Energy forms a sizable share, at 17%, of their variable costs such that, say, a 10% rise due to carbon taxes could dent profits.
- Energy has not commanded much attention during the last five years.
- Following from the above, energy efficiency opportunities are now likely to exist that could be worthwhile.
- In addition the price of energy has risen and management say that more opportunities are probably available and the criteria for investment are more likely to be met.
- Furthermore they are open to advice and would be willing to consider options that an agency for sustainable energy might present.

[20] The company interviewed is a subsidiary of the parent corporation that has its headquarters in the US. The subsidiary makes cellulose, which forms the major part of medicines in tablet form. Other uses include the coating of tablets. The major customer is the pharmaceutical industry with the food industry also being an important outlet.

These points indicate that ETR is unlikely to be detrimental to the company, especially if payroll costs were reduced in the reform and technical information were forthcoming from an agency for sustainable energy.

Sector 24.4: Pharmaceuticals[21]

The pharmaceuticals industry can be seen as being made up of two main sub-industries, in line with the NACE 4-digit codes Basic pharmaceutical products (24.41) and Pharmaceutical preparations (24.42).

Basic pharmaceutical products (NACE 24.41) can also be referred to as primary processing or primary manufacturing of pharmaceutical products. It covers the production of the active ingredients or drugs which will be then used in the manufacturing of pharmaceutical preparations (NACE 24.42), which can also be referred to as secondary processing or manufacturing. Here the active ingredients or drugs are converted into products suitable for administration to humans or animals, i.e. in the form of tablets, capsules, liquids, creams or aerosols.

The pharmaceutical industry

Generally speaking the pharmaceuticals industry is not particularly energy intensive when compared with certain other branches of manufacturing, e.g. basic chemicals in certain cases, metal smelting or paper pulp production.

On the other hand the pharmaceuticals industry is skill-intensive and includes a very important R&D component. This is particularly true in OECD countries, where most of the world's pharmaceuticals companies are based, including not only corporate headquarters and R&D but also significant parts of the manufacturing processes themselves, so that OECD countries are the major producers in the world as well as the major exporters to the rest of the world, and of course the main consumers. A specific aspect of the pharmaceutical industry that should be borne in mind is that world demand has been until now located essentially in OECD countries if one chooses monetary measures. This is due to a combination of factors, especially their much higher purchasing power as compared to other parts of the world. Furthermore the significant ageing of the OECD population, in particular thanks to gains in life expectancy, is a structural feature which further increases demand for a number of pharmaceutical products. This pattern is also verified when looking at trade flows, as will be seen later.

Supply and demand data, world and Europe

As mentioned above the pharmaceuticals market is dominated by OECD countries. This can be seen in Table A.13, where it can be seen that in 2005 the largest market (measured by sales) was North America, followed by Europe[22] and Japan. The rest of the world accounts for only 8.4%. The world's retail pharmaceuticals market amounts to some US$ 550 million.

[21] The summary is based on the case study written by Edward Christie (wiiw) and Sue Scott (ESRI).
[22] The European Union plus Norway and Switzerland.

Table A.13 Global market share by region, 2005

Region	Market Share
USA & Canada	48.2%
Europe	30.7%
Japan	8.4%
Latin America	4.3%
Rest of the World	8.4%

Source: EFPIA 2006

As for production, the European Federation of Pharmaceutical Industries and Associations provides a rough guide, based on ex-factory prices valuation. This is reproduced in Table A.14. The United States is thus clearly dominant in both supply and demand. However what the data indirectly suggest (it is unfortunate that the market share of Canada is not separately available) is that Europe may have excess supply and thus be a net exporter while the reverse should be true, but less strongly, for the United States.

Table A.14 Global production share by region, 2004

Region	Production
USA	39.3%
Europe	35.8%
Japan	10.8%
Rest of the World	14.1%

Source: EFPIA 2006

What are the current trends and what do they indicate for the short- to medium-run? EFPIA explains with some measure of concern that there has been a relative shift in R&D and innovation capacity in favour of the United States. Total spending in pharmaceutical R&D was higher in Europe than it was in the USA in the early 1990s but this changed towards the end of that decade and the USA has now become the dominant player. This is reflected in sales statistics if one focuses on newly developed medicines: measuring global sales over 2001-2005 of medicines introduced for the first time during that period, EFPIA finds that the US market accounted for an impressive 66% of global sales, while Europe accounted for only 24% of global sales. There is therefore some anxiety about the relative loss of competitiveness of the European pharmaceuticals industry. At the same time these results clearly indicate the relative unimportance of other parts of the world, at least in terms of the high value added segment of the industry

Analysis of international trade flows

The international market for active ingredients (NACE 24.41) is dominated by the European Union, the United States and Switzerland. They are trailed not very closely for the moment by China. Japan, Canada and the others are relatively small exporters. The trade volumes are particularly large among the three major exporters.

In the case of final products of the sector (NACE 24.42) the domination of the OECD countries is very clear, as China's ranking is considerably lower. Also it is interesting to note that the EU is by very far the world's largest exporter, far ahead of the United States. It is also striking that Switzerland is a larger exporter than the USA.

Table A.15 Final Products Export Trade Matrix, USD million, 2005

→	EU	CH	US	CA	AU	JP	MX	CN	BR	RU	TR	RoW	WLD
EU	-	5,753	17,752	2,797	2,439	2,941	749	573	446	2,440	1,259	15,376	52,524
CH	9,266	-	1,992	565	349	761	142	166	222	251	357	2,396	16,465
US	7,787	1,075	-	2,130	446	684	438	127	350	16	79	1,473	14,607
CA	242	235	2,129	-	19	19	9	4	11	7	5	155	2,836
AU	582	4	176	48	-	34	2	55	11	0	8	1,310	2,229
JP	517	130	1,104	3	23	-	2	94	1	1	2	275	2,152
MX	17	1	269	42	43	0	-	0	155	0	0	555	1,081
CN	33	18	15	2	32	55	1	-	4	4	7	325	497
BR	51	2	1	6	1	0	41	0	-	0	0	210	311
RU	4	1	0	0	0	0	0	0	0	-	0	139	145
TR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	-	NR	NR
Sum	18,499	7,218	23,439	5,592	3,352	4,495	1,383	1,020	1,199	2,720	1,718	22,214	92,848

Notes: NR = Not Reported, presumed nil; A zero in a cell means the export flow is less than 0.5 million USD; Intra-EU trade was netted out

Source: UN COMTRADE and own calculations

As for the general distribution of final products it is even more concentrated than the distribution of exports of active ingredients. The distributions for the EU, the USA and Switzerland are similar to those found earlier, with the EU having a more diversified pattern while Switzerland and the USA have patterns that are in effect centred on the EU. It is also interesting to note that the bilateral trade balance between the EU and the USA (+10 bn USD) is reversed when compared with that of active ingredients (-1.8 bn USD), so that the EU ends up with a large positive overall balance with respect to the USA.

Leading companies

Table A.16 shows the 12 largest companies in 2005, by revenue, using self-reported data from the company web-sites. As can be seen all of these companies are based either in Western Europe or in the United States.

Table A.16 The top 12 pharmaceuticals companies by revenue, EUR millions, 2005

Name	Country	Output (2005)
Pfizer	USA	41,235
Johnson & Johnson	USA	40,592
GlaxoSmithKline	UK	31,734
Bayer (*)	Germany	27,383
Sanofi-Aventis	France	27,000
Novartis	Switzerland	25,892
Roche	Switzerland	22,935
AstraZeneca	UK/Sweden	19,291
Abbott	USA	17,925
Merck & Co.	USA	17,683
Bristol Myers Squibb	USA	15,433
Wyeth	USA	15,076

Note: (*) includes important revenues from chemicals

Source: EFPIA 2006 and corporate web-sites

It should be said that these leading companies are especially active in the upper segment of the industry, i.e. the production and sale of final products, although they are all to some degree vertically integrated and also produce some of the active ingredients themselves.

The industry is relatively fragmented. The top dozen or so companies account for half of the world's US$ 550 billion retail pharmaceuticals market, with the largest not holding 10% of the market (Economist 2005). More mergers among Europe's pharmaceutical companies are expected. Mergers of firms that are searching for synergies in production and markets also help to increase size. The benefits of large size are unclear. Large size can mean better laboratories that can attract talented researchers unless, that is, the smaller units succeed in being more focused.

Energy intensity of the pharmaceutical sector

As was mentioned earlier the pharmaceuticals industry is not particularly energy-intensive. However it can be of interest to differentiate between the two main segments, as the manufacturing of active ingredients is roughly 3.5 times more energy intensive than secondary manufacturing.

From the data available there appears to be some definite flexibility in fuel use. What these reactions suggest is that the sector is able to respond and adapt to changes in relative price and absolute prices and that they can achieve this over quite a short period of five years. This is presumably achieved through adjustments to technology and product changes. But before looking at technological potential – based on the findings of an interview with pharmaceutical company - it is worth viewing the scale of energy taxation in the pharmaceutical industry since the introduction of ETR. Table A.17 shows energy/carbon taxation as a share of gross value added and the total energy/carbon tax expenditure of the sector in the six countries covered in the study.

Table A.17 Energy taxation in the pharmaceutical industry, 2002

	Energy tax € million	Energy tax share of GVA %
Denmark	4.85	0.29
Finland	0.42	0.15
Germany	13.31	0.14
Netherlands	15.22	0.60
Sweden	0.68	0.03
UK	5.05	0.05

Source: COMETR WP3 database

Energy/carbon tax forms the lowest share of GVA in Sweden and the UK The fact of the matter however is that the tax is modest in all countries, ranging up to 0.60% of GVA at most. It is rather unlikely that energy/carbon taxes have a serious financial effect, except in those companies that are inflexible or more energy intensive than the norm for the sector.

The findings of an interview with the chief executive of a subsidiary of a multi-national company

In the course of investigations the chief executive of a subsidiary of a multi-national company was interviewed and asked about technology adaptations that had been undertaken in view of approaching carbon taxes, as shown in Box A.1. This subsidiary manufactures active ingredients solely for export. The company engaged pro-actively in negotiated agreements with the energy agency.

Box A.1 Case study of adaptation by a multi-national subsidiary in face of approaching carbon/energy taxes[23]

Background – The plant and a sister plant employ over 350 people and have turnover of over €300 million. The plant produces active pharmaceutical ingredients for medicines used in treating conditions associated with middle to old age. Production at the site began some two decades ago.

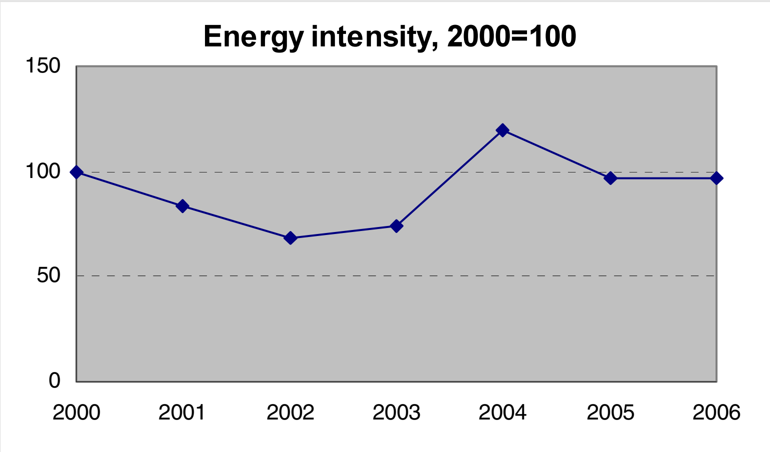
The parent company with headquarters in the Far East is a major company there. It has net sales worldwide of over 7000 million US dollars, alongside R&D expenses of more than 1000 million US dollars. All of the products manufactured in the subsidiary are the result of original research at headquarters. The company works in products that they have developed and so they are divesting of any newly-merged establishments that make products that they have not discovered themselves. The company describes itself as a leader in its fields.

The products from the subsidiary are distributed in bulk powder form to licensees of the company and to the parent's own operations for formulation into final dosage form. Products are exported to Europe, the US and the Far East.

They describe themselves as R&D driven and their aim is to launch a steady stream of innovative new products. Net sales of the company last year rose 2% over the previous year, but in-licensing activities, and R&D and sales promotion expenses meant that operating income rose by less than 1%. However they see R&D expenses as investments that will yield growth in the medium-to-long term by expanding the product line-up.

Technology - ***The site uses natural gas, for which the company arranged a deal with the supplier when originally setting up. With combustion being below 19 MW they are not participants in the EU ETS. They do belong to a negotiated energy agreement run by the energy management agency. This was a voluntary move after the announcement of a carbon tax.***

Participants in the agreement commit to provide information for the agency's annual reports on their company's performance, in the form of an index of energy intensity. The index is calculated in relation to the company's start-year in the network, which is set at 100. It is therefore not a benchmark in the sense that one could use it for comparisons with those of other companies or countries. It only shows progress with respect to time. This maintains confidentiality. In calculating the index, aggregate product is measured in a format developed by the company. The following graph charts this company's progress since 2000.



Much of the variation in intensity is due to outages, construction work, and additional installations, showing how easily random events can swamp quantity targets. Only by 2005 do the investments start to kick in: a more energy efficient chiller fitted with a variable-speed-drive screw compressor, which delivers greater process temperature control. Another factor was boiler house efficiencies achieved following installation of an auto-flame system on the

[23] This example is taken from a non-ETR country, which in 2000 had announced that it proposed to introduce ETR and in 2004 cancelled the proposed introduction of ETR.

steam boilers. This delivers increased combustion control. Future plans include reducing steam operating pressure to the minimum acceptable level following a detailed thermal system review, and a reduction in lighting costs following a site-wide audit.

A new programme of Energy Agreements has been developed for high energy users structured on a new Energy Management Standard. Notably it requires top management support and a real commitment to a structured approach to energy management. There are indications that there will be proper feedback afterwards in terms of investment, savings and payback.

The company is engaging in this programme too and they are currently assembling the necessary data which they will then analyse. The company routinely records in their reports their energy use and their emissions of CO_2 and engage in energy-conscious routines - for example, when replacing equipment they investigate the energy usage of the replacement. When analysing investments they are not constrained to use prescribed criteria, though in fact they would generally stick to accepting projects with a 3-year payback. A 4-year payback by contrast would tend to be rejected but as energy prices are high at present there would be enough projects that are worth undertaking now.

It is parent company policy to reduce energy use and emissions and the parent is committed to increasing energy efficiency. The company as a whole has an overall CO_2 emission target for 2010 of a 20% decrease on their 2004 level and progress so far has been satisfactory.

When assessing the possibility of carbon leakage it is instructive to find out what drew pharmaceutical companies to their current locations in the first place. The issues in location choice are neatly covered in discussions with the same company that was interviewed for Box A.1. Financial advantages, personnel and physical aspects are important, as can be seen from Box A.2.

Box A.2 Case study of location choice

The European subsidiary company was the parent company's first plant to be situated oversees. The parent company situated in the Far East wanted a European establishment in order to be able to sell easily to the US and Europe. Other factors also came into play, such as ability to use English as the language, the good infrastructure, the speed with which plans could get off the ground and go through the design and building stages. Low tax, such as corporation and income tax, was an important factor as was, in particular, the high level of general education.

With the requirements of testing for quality control the staff had to be well educated. While it would be possible to build establishments more cheaply in developing countries, the question is whether they would get the same quality of staff.

The parent has plans for large expansion based on their new products. They take all locations into consideration, and quality of life is important for management. This would be the case despite the fact that the tax regime could be more favourable in some other regions. They have a regional headquarters in Europe and a number of European sales affiliates. They have pharmaceutical markets and manufacturing sites in a number of EU countries and are also engaged in clinical development in Europe.

Conclusion

The pharmaceutical sector was found to be dominated by the large OECD economies, in particular by the US and the European Union. Energy costs are considered important but they are not a major concern. The patterns of trade in recent times do not suggest that there is an adverse effect on the export import ratio, except in the case of Germany. There has however been a consistent decline in the UK's export-import ratio, though this started well before Environmental Tax Reform. Trends in energy intensity have seen improvements in recent times including over the years of ETR. A feature of note is that there appears to be flexibility as to fuels used and responsiveness to relative price changes is not contradicted.

It is remarked from the case studies in the pharmaceutical sector (and other sectors) that the recent rise in energy prices has meant that energy efficiency technologies are now considered in a more positive light. Because the rises are the result of worldwide movements, they generally affect all establishments. Unless a company is more energy intensive than the norm in the manufacture of the product it would not see the price rise as a major threat (except that customers have less spare cash). This appears to be an explanation for the absence of complaints about energy prices encountered in the course of the interviews, though there were also no complaints registered concerning any energy/carbon taxes.

There are technological opportunities out there to be taken, with savings of 5 to 10% in the short-term and higher savings in the long-term. There seems to be a positive attitude towards energy agencies, who appear as helpful advisors. Their ability to engender the use of more realistic payback requirements on investments on foot of audits in energy agreements is crucial. It would be unfortunate if the momentum of the current energy efficiency drive were lost when/if world prices decline.

In the event of ETR being introduced by Europe unilaterally, the company's trade outside Europe could be at a disadvantage. But given the opportunities for energy saving continuing focused energy advice and revenue recycling are pursued, the disadvantages may be imperceptible in this sector.

Sector 26.1: Glass and glass products[24]

The full case study provides an overview of the glass and glass products industry (defined as corresponding to NACE 26.1) in Europe in terms of its main economic, technological and energy-use features.

The glass sector

The main types of glass products are: flat glass (e.g. for windows in construction, in cars), container glass (e.g. bottles and jars), fibreglass (e.g. glass wool for insulation), tableware glass and special glass. From an economic point of view one of the most striking features is the fact that trade intensity varies substantially between the five main types of glass. This is shown in Table A.18, which shows glass production in the European Union by type in tonnes together with the level of imports from outside the European Union and the implied import penetration ratios.

[24] The summary is based on the case study written by Edward Christie (wiiw).

Table A.18 Production, imports and import penetration by type of glass, EU, 2005

Glass types	Container	Flat	Tableware	Fibre	Other	Total
Production	20,000,000	9,200,000	1,450,000	726,730	1,230,000	32,606,730
Extra EU imports	262,192	545,573	415,671	318,619	436,244	1,978,299
Import Penetration	1.3%	5.9%	28.7%	43.8%	35.5%	6.1%

Source: CPIV web-site

The production of, especially, flat glass, fibreglass and special glass (i.e. 'other' in Table A.18) is highly globalised and dominated by a small number of large multinational corporations with international production and distribution networks. Significant volumes of international trade in these products take place in the cases of fibreglass and special glass. Trade in flat glass is more limited, though not negligible, and has the potential to increase in future.

Tableware glass on the other hand is mostly produced within small- and medium-sized enterprises both inside and outside the European Union. Because its output is quite heterogeneous in terms of exact sizes, shapes and other aspects, i.e. much less standardised than flat or container glass, and because of sometimes quite high value-weight ratios, there is also a significant share of international trade in such products.

Container glass is rather different from the other types of glass. It is by far the least trade-intensive type, primarily due to the low value-weight ratio of empty glass containers. The scope for truly global competition is therefore very limited, as opposed to what is the case with flat glass, fibreglass or special glass. Container glass is also different from the other types in that recycling plays a very major role in its production cycle. In some cases up to 80% of the quantity of melted container glass (just prior to forming) comes from recycled glass. Recycling plays a much smaller role for the production of other types of glass, although the proportion of recycled glass is typically around 20%-25% in the case of flat glass (EEA 2005).

Production patterns for flat glass

The world market for flat glass (float, sheet and rolled) is approximately 41 million tonnes, representing a value of around USD 19 billion at the primary manufacturing level and of around USD 56 billion at the secondary processing level. Geographically, global demand is dominated by China (35%), Europe (24%) and North America (15%), together accounting for 74%. As with many 10 commodities, the growth of demand in China has been particularly impressive as China's share in global demand for flat glass was only around 20% in the early 1990s. In terms of market segments demand is dominated by building products. Pilkington gives the following estimates of the market segment shares in terms of tonnage: 70% for windows in buildings (whether new or replacement), 10% for automotive glass and 20% for furniture and other interior applications.

Table A.19 shows the production volumes of the five different types at the EU level revealing an increase in the total production volume as well as in all types with the exception of special glass.

Table A.19 Glass production volumes in the EU and EU-15, thousand tonnes

	Flat	Container	Tableware	Fibre	Other	Total
EU-15						
1999	7,464	17,464	1,104	529	1,530	28,091
2000	7,640	17,690	1,177	550	1,284	28,341
2001	7,554	17,917	1,268	546	1,336	28,621
2002	7,929	18,333	1,307	648	1,292	29,509
2003	7,710	18,414	1,285	649	1,174	29,232
2004	7,871	18,415	1,291	693	1,027	29,297
2005	7,845	18,441	1,267	727	867	29,147
European Union						
2004	9,200	19,900	1,570	693	1,210	32,573
2005	9,200	20,000	1,450	727	1,230	32,607
2005 shares	*28.2%*	*61.3%*	*4.4%*	*2.2%*	*3.8%*	*100.0%*

Source: CPIV and own calculations

Production patterns for container glass

In terms of volume it is container glass that is by far the most important, as shown in Table A.19 having a production share of more than 60% at the EU level in 2005. This part of the industry is different from flat glass production in several respects. Recycling plays a much more important role than in the other sub-industries. This is due primarily to technical reasons, as the quality threshold for used glass (called *cullet*) to serve as material input in the melting process is much lower when producing container glass than when producing other types of glass. This has made it possible to reach recycling rates of close to 80% in certain EU countries.

An important underlying issue which helps explain the importance of recycling has affected the container glass industry in the last decades, particularly in certain Northern European countries. This was the taxation and regulation of glass bottles (in particular with respect to "one-way bottles"). This had a twin effect: a partial shift away from glass in the packaging of certain beverages (i.e. in favour of cardboard, plastic or aluminium) as well as an incentive to promote recycling. Thus some degree of consolidation of production facilities had already taken place in the industry before the first ETR packages were introduced anywhere in the European Union. Because of the relatively low value-weight ratio of glass containers, production tends to be relatively local or national, with the larger production volumes taking place in the larger EU member states, each of which typically has several production sites spread across its territory. Because of this economic geography feature the container glass industry used to be more fragmented and more structured along national lines than the flat glass industry, though this has partly changed in terms of ownership patterns. At the European level there has been significant consolidation in terms of ownership over the last 15 years.

Energy costs and the EU glass industry in the broader context

In 2003 the cost of purchased energy products reported by EU glass producers accounted for around 5.3% of the turnover value for the industry as a whole in the European Union. However, rather large differences between the different glass types are observable ranging from 1.9% to 8.3%. Therefore it cannot be excluded that carbon/energy taxes can influence the decisions of the glass industry as energy costs may be significant in terms of total production costs.

Energy costs in the production of flat glass

The general setting for the flat glass industry was described by the respondent as one of steadily rising global competition, chiefly due to the rise of China, in spite of the inherent limitations to trade due to transportation costs. Raw (unprocessed) flat glass does indeed have a low value-weight ratio, however even some basic additional processing will raise the value-weight ratio so as to make significant intercontinental trade commercially viable. Indeed, in spite of the still relatively low import penetration into the EU mentioned above (5.9%) Chinese investment, production and especially export growth have been impressive over the last decade. Furthermore the respondent stressed that it is no longer the case that China is only active in the low value-added segments of the industry. Though unprocessed and low-quality float is still produced in large volumes in China it is also the case that an increasing number of processing steps (coating, silvering and the like) can and are being conducted in China (for example mirrors, which can then be exported to Europe). Also, the gap in technological and managerial skills with respect to OECD countries is closing, as new investments often use the newest technologies, while the younger cohorts of local (Chinese) staff are increasingly well qualified, e.g. the growing availability of Chinese engineering graduates with MBAs from American or European universities. Expatriate managers and engineers from OECD countries are still part of the picture, but the point at this stage is that the local staff is able to absorb Western know-how effectively. This comes on top of the more standard phenomenon known in the context of endogenous growth theory as "learning-by-doing", whereby local staff will experience an increase in their human capital over time as their experience of working in a modern flat glass production site goes up. This issue was addressed by the respondent, and taken even further. As he put it, once the production lines (set up by the multinationals) are there, it does not take much time for local staff to make sense of how they operate, and indeed of how to reproduce their design elsewhere in the country. In other words technological and know-how transfer (and indeed plain copying) is progressing at a fast pace.

The implications of these general economic developments should be that China (and possibly other non-OECD countries, though to a lesser degree) will continue to gain global market share, in particular in segments representing highly standardised goods, that European production of certain flat glass products will decrease, and that therefore import penetration into Europe should increase. Current investment trends seem to be that a substantial share of the investment in completely new production lines is going to emerging economies, while capital investments in Europe are more often about refurbishing existing installations so as to extend their lifetime.

Although things do not look too disastrous for European production in the future, significant shifts in global patterns are taking place and are expected to continue to take place, mainly due to developments in China. As for the impact of environmental policies, the respondent of the interview carried out as part of the case study clearly felt that it was an unwelcome additional burden on conducting business in the European Union. In spite of the still rather low import penetration rate it is clear that developments in China do represent a significant challenge, though not a life-or-death struggle, for the future of European flat glass production. As things stand, the pressure on European producers would evidently be lower in the presence of less ambitious environmental policies. On the other hand it is interesting to note the positive impact on the industry of new regulations on the energy performance of buildings. All in all it seems that Europe has good chances of maintaining its competitive edge thanks to its head-start in segments such as low emissivity glass, while China, not surprisingly, is steadily moving up the production chain. Provocatively, one could therefore wonder whether it is at all a good idea to increase the production costs for goods that are internationally traded given the problem of carbon leakage, although flat glass, thanks to its relatively high value-weight ratio, is not perhaps quite a knife-edge case. On the other hand, focusing environmental policies on the non-tradable sector, e.g. buildings, seems to offer an alternative form of double dividend, i.e. reducing GHG emissions while creating demand for new technologies and products in which European producers can become world leaders.

Looking to the future, the respondent expressed the hope that environmental taxes would be reduced. It was implicit to our conversation that the likelihood of environmental tax harmonisation across the EU was seen by the respondent as being low, but obviously this would constitute an equally valid policy option, notwithstanding potential competition from the EU's immediate neighbours.

Conclusions

The European glass industry has felt the impact of ETR and is currently under some pressure due to the EU ETS as well as due to other environmental policies. The glass industry however remains a very heterogeneous industry, with significant differences in vulnerability and economic geography patterns among its sub-industries. Focusing only on the two most important sub-industries in volume terms it is possible to formulate, for the flat glass industry and for the container glass industry separately, a number of key conclusions.

The flat glass industry in the European Union may soon arrive at a crossroad. A share of the volume of primary manufacturing could potentially move outside of the European Union as non-Annex I producers reach the threshold of producing flat glass products of a sufficient value-added content to enable significant trade over larger distances. China in particular is a major topic of discussion in the industry, while environmental policies inside the EU are seen as an unwelcome additional burden, giving even more reason perhaps to invest in new production facilities in China with a possibility of subsequently exporting back to Europe.

The container glass industry is rather different due to its inherently lower trade-intensity and the correspondingly higher degree of heterogeneity across the EU. It is in part an old story. Due to taxation and regulation on glass bottles the industry shrank and consolidated in certain North European countries already before ETR took place, while recycling rates reached high levels and some substitution in favour of other materials took place within the broader packaging industry.

Still, the main issue now would logically be to prevent distortions within the single market to make sure that there is a somewhat level playing field for producers in different member states. Beyond this it seems to make good environmental sense to tax and cap emissions for an industry that produces goods with a low trade intensity. If any more general conclusion is possible, one could simply say that trade intensity remains a decisive variable when assessing the impact of environmental policies. The positive impact of EU and member state legislation on the energy performance of buildings, as well as the successful restructuring of parts of the container glass industry seem to support a quite simple idea: if it can't move, tax it. If it can move, there are risks to taxing it. Current policies are what they are for a number of institutional and historical reasons. In general, EU industry is bearing a significant (some would say disproportionate) share of the effort towards fulfilling the goal of reducing greenhouse gas emissions. The expected positive effects of encouraging industry to become more energy efficient are perhaps less than one may hope in industries where competition is strong, as energy-intensive industries have had reason enough to try to reduce energy consumption prior to ETR and to the EU ETS. On the other hand it is clear that more will need to be done in future in order to reduce the carbon intensity of the two other key sectors in terms of greenhouse gas emissions, namely transport and buildings, and that such efforts could generate demand for new products, for innovation and for investments in which EU companies could become global leaders. This could be thought of as an alternative type of double dividend.

Sector 26.5: Cement, lime and plaster[25]

The industry is subdivided into the three sub-sectors: NACE 26.51: Manufacture of cement, NACE 26.52: Manufacture of lime and NACE 26.53: Manufacture of plaster. The main focus is directed to the first sub-sector, i.e. the production of cement.

Cement production

Cement is typically made from a blend of limestone and clay or sand (in order to have both calcium and silicon in the final product) which is heated to around 1450°C in a kiln, which is a large, inclined, rotating cylinder. This yields a material called clinker. The production of clinker generates CO_2 emissions due to the main desired chemical of the process, which is called *calcination* and which removes CO_2 from the initial ingredients that were fed in. Furthermore there are substantial CO_2 emissions from the combustion of the fuels used to generate the high temperature required for the process to take place. As for CO_2 emissions it has been estimated that around 50% of total emissions are due to the calcination itself, a further 40% are due to the combustion of fuels to generate the working temperatures, and the remaining 10% are due to the use of electricity and transport means. In total the World Business Council on Sustainable Development (WBCSD) (2005) cites a figure of around 5% of global anthropogenic CO_2 emissions due to the production of cement *alone*. Due to the heating process in the kiln the cement manufacturing process is very energy intensive but it is as well capital intensive. In contrast to the high energy and capital intensity labour costs are less critical to the cement industry as they are to certain other industries.

[25] The summary is based on the case study written by Jirina Jilkova and Vitezslav Pisa (IEEP) and Edward Christie (wiiw)

The cement industry

Table A.20 shows total production levels, measured in thousands of tonnes, of hydraulic cement for the world's 15 largest producing countries, ranked using the 2004 levels, where the EU15 and the NMS9[26] are treated as if they were countries. The volumes shown in the table sums up to 84% of total world production based on 2004 levels.

Table A.20 Largest producers of hydraulic cement (physical volumes)

Production of cement, ths of tonnes	2000	2001	2002	2003	2004
China	597,000	661,040	725,000	862,080	933,690
EU-15	194,965	194,062	193,475	196,004	198,554
India	95,000	105,000	115,000	123,000	125,000
United States	89,510	90,450	91,266	94,329	99,015
Japan	81,097	76,550	71,828	68,766	67,369
South Korea	51,255	52,046	55,514	59,194	53,900
Russia	32,400	35,300	37,700	41,000	43,000
Turkey	35,825	30,125	32,577	35,077	38,019
Brazil	39,208	38,927	38,027	34,010	38,000
Indonesia	27,789	31,300	34,640	35,000	36,000
Thailand	25,499	27,913	31,679	32,530	35,626
Mexico	33,228	32,110	33,372	33,593	34,992
Iran	23,880	26,640	28,600	30,000	30,000
Egypt	24,143	24,700	28,155	26,639	28,000
NMS-9 (NMS-10 minus Malta)	29,367	25,906	24,836	26,173	27,925
World Total	1,660,000	1,750,000	1,850,000	2,020,000	2,130,000

Source: United States Geological Survey (USGS) and own calculations

What is immediately striking is the gigantic share of world production held by China. An incredible 43.8% of the world's cement is produced there. This is almost five times more than what is produced in the EU15, the world's second largest producer, which accounts for 9.3% of world production in 2004. Other large producers are the USA, India, Japan, South Korea and Russia. The EU's New Member States, NMS-9 in the tables, are at the 15th place, just behind Egypt, in other words not a particularly high volume.

All in all there is a pretty clear relationship between population, GDP growth and cement production. China is producing such gargantuan amounts because of the enormous surge in domestic construction that it is experiencing, itself fuelled by the country's long-standing double-digit GDP growth and the huge investments that are associated with it.

At the EU level production is especially high in the large EU countries as well as in the Mediterranean EU countries. The shares for the eight largest countries are shown in Table A.21. These shares have not fluctuated much in the last few years.

[26] The new member states of the EU

Table A.21 Largest cement producers in the EU (share of 2004 total)

Country	2004
Spain	20.7%
Italy	16.8%
Germany	14.1%
France	9.3%
Greece	6.6%
Poland	5.7%
United Kingdom	5.0%
Portugal	4.4%
Sub-total	82.5%

Source: United States Geological Survey (USGS) and own calculations

Spain is the leading producer, with double the level of France and four times the level of the UK in spite of its smaller economy. Greece and Portugal are also quite important producers in spite of their small populations (each around 10 million) and small total GDP levels. To some extent this Mediterranean dimension may be explained by the tourism- and retirement-fuelled construction industry.

The cement industry's output is relatively homogeneous. Because the level of quality is very similar among classes of cement, and moreover because types of cement can be easily substituted with one another, price is the key factor.

International trade of cement

Cement has a very low value/mass ratio, making trade across large distances unprofitable in the case of land transport. Sea and inland waterway transport on the other hand can keep transport unit costs relatively low, so that trade could potentially take place across the seas and over rivers and canals, but not across large land distances. Instead production and distribution form regional clusters within geographically large areas, while locations close to sea or waterway terminals may have the option of importing as well, although the costs of loading and unloading operations for sea transport dampen the attractiveness of such transactions.

Looking at trade statistics, one finds indeed that in most cases a very large share of exports are taken up by a country's immediate geographical neighbours. As for intercontinental trade, one finds that China is the largest non-EU exporter of cement into the EU. However this flow is an exception. The other non-regional (non European) exporters into the EU export only rather modest amounts. Adding together the exports from regional partners (non-EU Europe) one finds a larger total than when adding up the exports from all other partners.

Table A.22 Main import flows of cement within the wider Europe region

Importer	Origin	Value (mill USD)	Cumulative value (mill USD)	Cumulative share	Land border
France	Belgium	69.8	69.8	6.8%	yes
Belgium	Germany	57.3	127.1	12.3%	yes
Germany	France	54.3	181.4	17.6%	yes
France	Germany	45.2	226.6	22.0%	yes
Italy	France	45.1	271.8	26.4%	yes
Italy	Croatia	33.7	305.5	29.6%	no
Austria	Germany	33.2	338.7	32.9%	yes
Belgium	Netherlands	32.5	371.2	36.0%	yes
Hungary	Ukraine	29.7	400.9	38.9%	yes
UK	Ireland	28.1	429.0	41.6%	yes
France	Spain	23.4	452.4	43.9%	yes
Hungary	Slovakia	22.8	475.2	46.1%	yes
Italy	Greece	22.5	497.7	48.3%	no
Austria	Slovakia	22.0	519.7	50.4%	yes
Switzerland	Germany	19.2	538.9	52.3%	yes
France	Greece	18.4	557.3	54.1%	no
Ireland	UK	16.9	574.2	55.7%	yes
Malta	Italy	16.9	591.1	57.3%	no
Belgium	France	14.8	605.9	58.8%	yes
Germany	Czech R.	14.2	620.1	60.2%	yes
Germany	Belgium	14.2	634.3	61.5%	yes
Sweden	Germany	13.4	647.7	62.8%	no
Germany	Luxembourg	11.9	659.6	64.0%	yes
Switzerland	Italy	11.9	671.5	65.1%	yes
France	Italy	11.3	682.8	66.2%	yes
UK	France	11.2	694.0	67.3%	no
Germany	Netherlands	10.3	704.2	68.3%	yes
Slovenia	Italy	10.0	714.3	69.3%	yes
Italy	Poland	9.5	723.7	70.2%	no
Croatia	Hungary	9.3	733.1	71.1%	yes
ALL	ALL	1,030.8			

Source: UN COMTRADE and own calculations

As it can be seen these 30 flows (out of 311 reported in UN COMTRADE statistics) account for just above 70% of all imports in the wider region. Almost all of them are between adjacent countries, and most of the exceptions concern countries that only have a short sea and/or land and/or tunnel distance between them, e.g. UK and France, Italy and Croatia, Germany and Sweden. This data is a strong confirmation of the highly regionalised nature of trade in cement. Countries that might have rather strong cost advantages both in terms of labour and in terms of energy such as Ukraine are only exporting significant amounts to direct neighbours such as Hungary, although in that particular case one should factor in the effect of trade barriers.

Where do these results leave us in terms of a possible pollution haven hypothesis? As mentioned earlier, cement production is quite highly energy intensive while having a low wholesale price, implying a high share of energy costs in the wholesale price. So given the economic geography of cement trade it stands to reason that there is a *limited potential* for a pollution haven effect within the wider Europe region. The likeliest possibilities would involve neighbouring countries with substantial differences in energy prices, provided trade barriers are not a problem. For example one could imagine such a scenario between the easternmost EU member states and the westernmost CIS countries, but trade barriers may cancel out the energy cost advantage.

Sector 27.1-3: Ferrous metals[27]

This summary provides a global overview of the iron and steel industry including a discussion on the technical potential in energy efficiency in the EU. For the purposes of this study the Iron and Steel industry is defined according to NACE rev. 1 as including codes 27.1, 27.2 and 27.3.

Iron and steel are manufactured respectively from iron ore and/or scrap iron or scrap steel in a number of different possible processes. The complete chain of production may be seen as follows:

1. extraction and treatment of raw materials (iron ore and, typically, coke)
2. production of iron
3. production of steel
4. casting of steel
5. rolling and finishing of steel, leading to semi-finished or finished steel products such as sheets, tubes, wires, etc.

The production of iron is the most energy-intensive step and traditionally takes place in a blast furnace. In the industrial age, steel has traditionally been produced in open hearth furnaces (OHF). In the 1950s, the Linz-Donawitz Procedure, or Basic Oxygen Furnace (BOF) procedure, was developed in Austria. One of the key differences is that the Basic Oxygen Furnace (BOF) procedure requires some share of scrap (10%-35%) to be inputted together with the pig iron. Scrap is either directly reduced iron (DRI), or scrap steel (bits of steel that are being recycled).

The other main type of procedure for steel production is the electric arc furnace (EAF). In the EAF process, the metal is melted using electric arcs. The major raw materials are scrap (again scrap steel and/or DRI), not pig iron. Electricity is the main source of energy of this procedure. Indirectly, due to the necessary production of electricity, the EAF process as a whole also contributes to CO_2 emissions. The levels depend on how the electricity was produced in the first place.

For the purposes of environmental assessments it is useful to distinguish between EAF which uses mainly scrap steel and EAF which uses mainly DRI due to the different levels of CO_2 emissions that each entails in the aggregate: the production of DRI involves higher emissions of CO_2, while EAF is less carbon-intensive than BOF because it uses electricity. All in all the results of carbon dioxide emissions per tonne

[27] The summary is based on the case study written by Edward Christie and Doris Hanzl (wiiw) and Sue Scott (ESRI).

of produced steel (in 1995) are shown in Table A.23 revealing large difference in the CO_2 intensities of the different technologies..

Table A.23 CO_2 emissions per tonne of steel by main process – 1995

Emissions of CO_2 in the Steel Industry, 1995 (M tonnes)		
Process	Total	T CO_2/t steel
BOF	1292	2.5
Standard EAF	120	0.6
DRI based EAF	50	1.2
Total	1462	1.9

Source: OECD 2003

Basic global economic data

In 2003, major crude steel production areas in the world were the following: the EU-15 produced about 17% of world crude steel in 2003, the new Member States (NMS) about 2%, the CIS around 11%, the USA had a share of 10%, Japan of 11%, China about 23% and the rest of the world (RoW) some 26%. In the last ten years, China recorded the largest increase in world steel production, gaining about 10 percentage points in world steel production. Table A.24 below shows the dramatic increase in steel production as the output almost tripled between 1995 and 2004. On the other hand the table is also of interest as it reveals different evolution between Germany and the UK as steel production increased slightly in the former country but dropped dramatically in the later. Only one other of the major steel producing country, i.e. Poland, faced also a decrease in steel production

In 2004, the five major steel-producing countries in the world were China, Japan, the United States, Russia and South Korea, accounting for almost 57% of total world crude steel production.

Table A.24 Major steel producing countries, 2004, millions of tonnes of crude steel

	Country	mmt	In % of total	In % of 1995	mmt 1995
1	China	272.5	25.8	285.8	95.4
2	Japan	112.7	10.7	110.9	101.6
3	United States	98.9	9.4	103.9	95.2
4	Russia	65.6	6.2	127.2	51.6
5	South Korea	47.5	4.5	129.2	36.8
6	FR Germany	46.4	4.4	110.3	42.1
7	Ukraine	38.7	3.7	173.5	22.3
8	Brazil	32.9	3.1	131.2	25.1
9	India	32.6	3.1	148.2	22.0
10	Italy	28.4	2,7	102.3	27.8
11	France	20.8	2.0	114.9	18.1
12	Turkey	20.5	1.9	155.5	13.2
13	Taiwan, China	19.5	1.8	168.0	11.6
14	Spain	17.7	1.7	128.2	13.8
15	Mexico	16.7	1.6	137.5	12.1
16	Canada	16.3	1.5	113.1	14.4
17	United Kingdom	13.8	1.3	78.4	17.6
18	Belgium	11.7	1.1	100.8	11.6
19	Poland	10.6	1.0	89.2	11.9
20	South Africa	9.5	0.9	108.7	8.7
	Total World	**1056.7**	**100.0**	**140.5**	**752.3**

Source: International Iron and Steel Institute (IISI)

International Trade in Iron and Steel

In 2003, the largest steel exporters of semi-finished and finished steel products were the following: The EU-15 exported some 33% of total world steel products3, 29% the RoW, 19% the CIS, 10% Japan, 4% the NMS, 3% China and 2% the USA. In the last years, the EU-15 lost some 3 percentage points in world trade, while the RoW, the CIS and Japan gained small shares. In absolute figures, all regions of the world expanded their exports between 1995 and 2003, with the only exception of China, which saw a small reduction. Major importers of semi-finished and finished steel products are the RoW (41%), the EU-15 (33%) and China (13%), the latter one saw a large jump since 1999.

Global outlook

According to the International Iron and Steel Institute's (IISI) latest Short Range Outlook (dated: 2 October 2006), the prospects are good for continued real growth in the demand for steel worldwide. Apparent steel use is forecast to grow to 1,179 million tonnes in 2007 from a total of 1,029 million tonnes in 2005. This represents an average annual growth of 7% over the two year period. The strongest growth continues to occur in China which saw a 14% increase in apparent steel use in 2006 with a further 10% growth expected in 2007. India also saw strong growth in 2006 at 10% owing to increasing expenditure on infrastructure. Within Europe strong recovery in Germany has contributed to growth approaching 8% in apparent steel use in the EU15, which may include some addition to inventories. In the rest of the world South America, the Middle East, Africa and non-EU Europe also saw strong growth in 2006, bringing world growth overall to 8.9%.

The expected adverse impact of the recent further sharp rises in the price of oil and energy has not materialised, at least not to the extent of stifling fast demand growth. The forecasts confirm the trend of recent years of an increase in steel use in-line with general economic growth and of fastest growth occurring in the countries with the highest GDP growth such as India and China.

Production processes and technologies

As explained above, there are three main production processes for crude steel: the classical (now quite rare) open hearth process, the electric arc furnace process, and the basic oxygen furnace process (there are of course sub-variants of these).

The main production process in use in the world today is the basic oxygen furnace (BOF) process, accounting for almost two thirds of global production. The driver for the increase in the share of world production by BOF is China, where production by this process has increased more than four-fold over the period. Electric arc furnaces (EAF) are used for around a third of world production. The rest is produced by open hearth production, which is being phased out across the world and survives only in certain former eastern block (CIS) and certain low income countries, though it has been on the decrease also in those countries. China had stopped using this technology altogether by 2003.

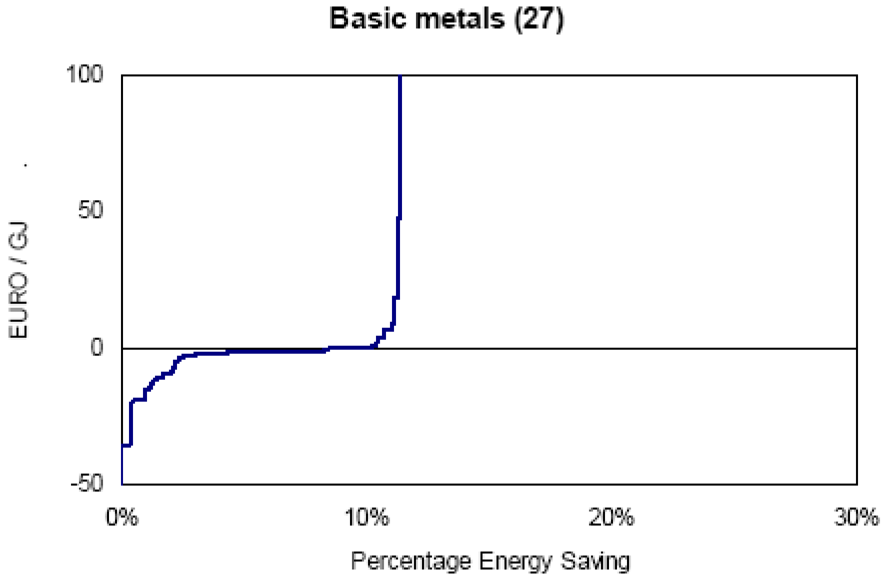
The EAF process has gained importance in the EU-15 and in the USA (the two regions where it is the most used in relative terms) but lost relative (not necessarily absolute) importance in China and Japan, and has stayed roughly stable in the CIS. What do these figures imply in terms of CO_2 emissions? The EAF process has much lower emissions than BOF, roughly four times less per tonne of produced crude steel. However the two technologies are not entirely substitutable, and it is not clear whether the share in production of the electric arc furnace process can rise much above the share it has reached in the EU-15.

EAF and BOF do not require the same mix of inputs: EAF requires a much higher share of purer forms of iron or steel, i.e. more scrap steel and/or more DRI, whereas BOF can process much higher shares of pig iron. This matters, as the required levels of (sufficiently high quality) scrap and/or DRI may not be available at reasonable prices. As can be seen in the table below, EAF, and in particular standard EAF (using mainly scrap, not DRI), is much less CO_2 intensive. However, as seen above, EAF accounts for a much smaller share of world production than does BOF. In fact, the share of BOF has increased over the 1995-2003 period due to its massive expansion in China.

Technical potential in the EU

If there were good potential technical improvements in energy efficiency in the EU this could restrain, if not stem, the tendency to relocate. We saw in Work Package 2 that there was potential, as presented in the context of negotiations for the UK's Climate Change Agreements for energy reductions at positive net present value, but only up to a certain extent - some 3 or 4 per cent perhaps. Illustration of the potential is reproduced here as Figure A.3 (Entec/Cambridge Econometrics, 2003) and it refers to technologies that were not yet implemented as of 1995, making the information somewhat dated.

Figure A.3 Energy saving supply curve, UK 1995.



Source: Entec & Cambridge Econometrics 2003

Another comprehensive study for the US produced a similar energy conservation supply curve based on measures with paybacks of generally less two years (Worell et al. 1999). Achievable energy savings of 17%, with associated carbon savings of 18% were identified for the iron and steel industry in the US in 1994. It is not known how this would translate to present prices and advances in technology. Such potential in 1994 is surprising given that energy intensive sectors, such as the iron and steel sector, are more assiduous in exploiting energy saving technologies, and suggests that potential may still be unexploited for the same reasons. On the other hand, more recent judgement on future abatement potential in the UK concludes that at the majority of UK sites, for example, there may be few further operational opportunities in the line of operational management for achieving significant additional CO_2 emission reductions.

Management of 'arising gases' had potential but the recent and future predicted gas prices mean that this is now already being addressed (which is a case in point). Where modifications to plant or equipment are concerned, few if any opportunities for measures remain. Apparently, high energy costs and the impact of Phase I and Climate Change Levy/Agreements have already provided incentives to optimise energy efficiency in the UK.

Up to date information on actual energy intensities for companies in this sector is not to hand, and ongoing negotiations on Phase II of the EU ETS national allocation plans make such information more commercially sensitive than ever. The evolution of environmental policy in the alternative locations, however, will also be factors in the location decision of companies in the iron and steel industry. In sum the location decision of companies in the iron and steel sector is influenced by many factors and ETR would be but one small element. Environmental policies in potential new locations relative to those pertaining to European sites could play a moderately important role and potential for technological improvements may be thin in some countries, like the UK, though there may be a threshold level of steel production that Europe could sustain nevertheless.

Sector 27.4: Non-ferrous metals[28]

The sector non-ferrous metals (NACE classification 27.4) is a constituent of the basic metals sector which, as shown in Work Package 2, operates in a very competitive market. The sector consists of five sub-sectors: precious metals production (gold, silver, platinum – classification 27.41), aluminium production (classification 27.42), lead, zinc and tin production (classification 27.43), copper production (classification 27.44) and other non-ferrous metal production (essentially nickel - classification 27.45)[29].

The production process

The basic element for the production of aluminium is aluminium ore, most commonly bauxite, which is plentiful and occurs mainly in tropical and sub-tropical areas: Africa, the West Indies, South America and Australia, though there are also some small deposits in Europe.

Bauxite is mined and then refined into aluminium oxide trihydrate (Al_2O_3) (alumina), typically following a three-stage process called the Bayer Process. Alumina is then electrolytically reduced into metallic aluminium following a process called the Hall-Héroult Process. This process is also called *aluminium smelting*. This is a very energy-intensive process as it requires extremely high electric current. Currently a modern aluminium smelting plant would consume around 14 kWh to produce one kilogramme of aluminium. Aluminium smelting is also by far the production step that generates the most greenhouse gas emissions per tonne of output in the production chain of aluminium products. These considerations are an important part of the context for the location decisions of alumina and aluminium enterprises.

Primary aluminium (called 'primary' to distinguish it from secondary or aluminium recycled from scrap) production facilities are located all over the world, often in areas where there are abundant supplies of inexpensive electrical energy, typically next to a hydro-electric plant or next to a nuclear- or thermal-powered electricity production plant. This is done in order to ensure a stable and reliable supply of electricity. Also, because such arrangements influence the location of production facilities, special contracts are negotiated between the aluminium smelting facility and the power plant, typically long-term contracts (several years) with preferential and stable prices.

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[28] The summary is based on the case study written by Edward Christie (wiiw) and Sue Scott (ESRI).

[29] The main focus is directed to the discussion of the aluminium production – see for information related to the other sub-sectors the attached case study.

Worldwide and European aluminium production

The production of aluminium itself, shown in Tables A.25 and A.26, we find a country distribution which is much more closely related to the world distribution of real GDP, though two main groups of countries are over-represented for specific reasons: countries with a large supply of hydro-electricity such as Canada and Norway on the one hand, and countries that are also large producers of bauxite and that have developed to a high degree the complete vertical chain of production such as Brazil and Australia. Beyond this we find, as with many basic manufactured goods, that China is by far the largest producer in the world, and that it has experienced spectacular growth in the last few years, with its produced volume of primary aluminium more than doubling in just 5 years, reaching a world share of 22.4% in 2004. Over the same period production also rose in the other major countries, though at much more modest rates. The only exception is the United States, where production slumped from a high in 2000 and has stagnated since then. One should note that production growth in China shows no sign of slowing down. According to data from the China Nonferrous Metals Industry Association (CNIA) available at the web-site of the International Aluminium Institute (IAI), China produced 6.689 million tonnes in 2004, and already 7.743 million tonnes in 2005, a growth of over 15%, bringing its share of the world total to around 25%. Preliminary figures for the first half of 2006 moreover show yet more growth as compared to the first half of 2005.

Table A.25 Largest producers of primary aluminium (ths tonnes)

Country	2000	2001	2002	2003	2004
China	2,800	3,250	4,300	5,450	6,670
Russia	3,245	3,300	3,347	3,478	3,593
EU-25 (12 countries)	2,816	2,868	2,900	2,927	3,021
Canada	2,373	2,583	2,709	2,792	2,592
United States	3,668	2,637	2,707	2,703	2,516
Australia	1,769	1,797	1,836	1,857	1,900
Brazil	1,277	1,140	1,318	1,381	1,457
Norway	1,026	1,068	1,096	1,192	1,322
South Africa	673	662	707	738	863
India	644	624	671	799	862
United Arab Emirates, Dubai	470	500	536	560	683
Venezuela	571	571	605	601	624
World Total	24,300	24,300	26,100	27,900	29,800

Source: USGS and own calculations

Table A.26 Largest producers of primary aluminium (% of world total)

Country	2000	2001	2002	2003	2004
China	11.5%	13.4%	16.5%	19.5%	22.4%
Russia	13.4%	13.6%	12.8%	12.5%	12.1%
EU-25 (12 countries)	11.6%	11.8%	11.1%	10.5%	10.1%
Canada	9.8%	10.6%	10.4%	10.0%	8.7%
United States	15.1%	10.9%	10.4%	9.7%	8.4%
Australia	7.3%	7.4%	7.0%	6.7%	6.4%
Brazil	5.3%	4.7%	5.0%	4.9%	4.9%
Norway	4.2%	4.4%	4.2%	4.3%	4.4%
South Africa	2.8%	2.7%	2.7%	2.6%	2.9%
India	2.6%	2.6%	2.6%	2.9%	2.9%
United Arab Emirates, Dubai	1.9%	2.1%	2.1%	2.0%	2.3%
Venezuela	2.3%	2.3%	2.3%	2.2%	2.1%
World Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: USGS and own calculations

Looking more specifically now at the European situation, as shown in Table A.27, we find that Norway is the largest producer, thanks to the abundance of hydro-electricity, followed by the major EU economies.

Table A.27 Aluminium production in Europe[30], by country (ths tonnes)

Country	2000	2001	2002	2003	2004
Norway	1,026	1,068	1,096	1,192	1,322
Germany	644	652	653	661	675
France	441	462	463	443	450
Spain	366	376	380	389	398
United Kingdom	305	341	344	343	360
Netherlands	302	294	284	278	326
Iceland	224	243	264	266	271
Italy	189	187	190	191	190
Romania	179	182	187	190	190
Greece	168	166	165	165	165
Slovakia	137	134	147	165	160
Bosnia and Herzegovina	95	96	103	111	115
Serbia and Montenegro	88	100	112	112	115
Slovenia	84	77	88	110	110
Sweden	101	102	101	101	101
Poland	47	45	49	45	51
Switzerland	36	36	40	44	45
Hungary	34	34	35	35	35
Croatia	15	16	16	16	16

Source: USGS and own calculations

Table A.27 also reveals that the production of aluminium in the countries analysed in the COMETR project, i.e. those which introduced ETRs during the 1990s and early 2000, have remained constant or increased during the first five year of the 21st

30 Excludes CIS and Turkey.

century. It could be argued that the evolution of the aluminium industry has not been affected by the introduction of energy/carbon taxes. However this is not too surprising as energy used in the production of aluminium is generally tax exempt which goes back to the regulation laid down in Article 2 (4) of the 2003/96/EC – Energy Taxation Directive – states some form of energy consumption (i.e. used for other purposes than as motor fuel or for heating purposes) is not covered in the Directive, i.e. tax exempt such as electricity used principally for chemical reduction and in electrolytic processes, such as aluminium production.

The introduction of the EU Emission Trading Scheme (EU ETS) affected the industry although during the first phase of the EU Emissions Trading Scheme (ETS) the aluminium industry is exempt from participation. However, the industry has been caught by the high price increases for electricity on foot of the EU ETS.

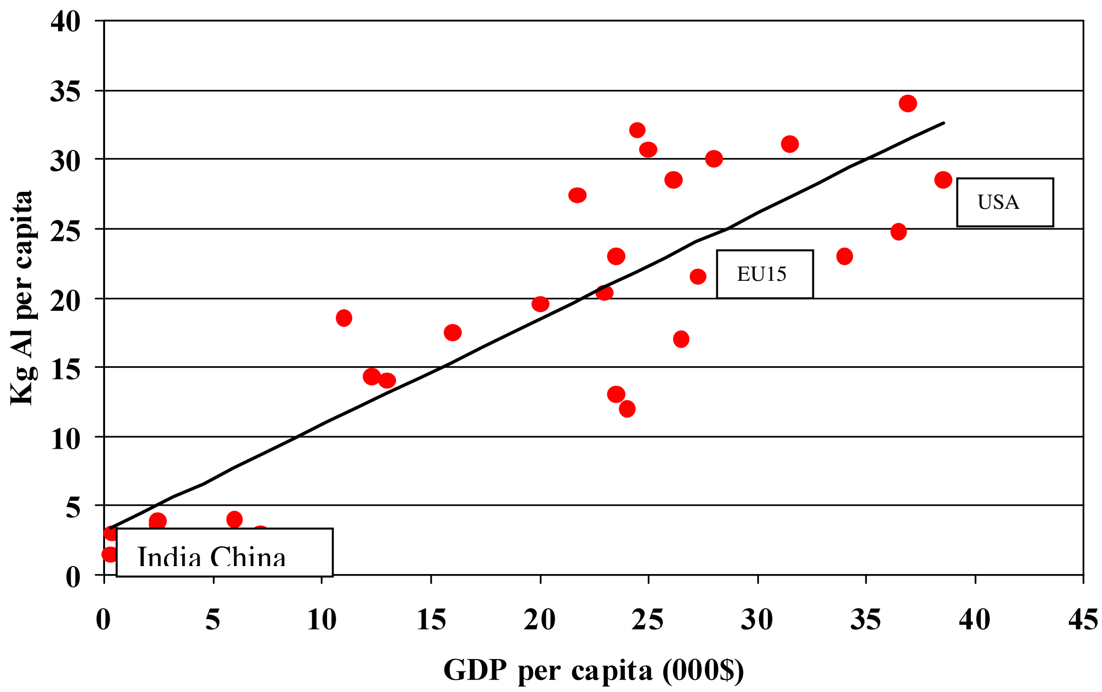
Determinants of demand for aluminium and demand outlook

There is a huge number of uses for aluminium. It has many applications in the fields of aeronautics, road and rail transport, building and construction, power distribution and food preservation. End-markets in Western Europe are transportation (36%), building (25%), packaging (17%), engineering (14%) and other uses constitute 8%. Aluminium has special appeal due to its unique properties. Its light weight, its strength, corrosion resistance, conductivity, its barrier function and of course its 100% 'recyclability' make it unusual, and such features become more valuable as energy prices rise. The substitution of aluminium for other materials, such as steel or glass, lowers energy needs for transport, which is a growing consideration and would, of course, be more so if ETR were applied in a consistent manner to transport fuels. Examples of recent applications are the Airbus A-380, the TGV duplex (the French high-speed train with enlarged capacity). Owing to its ease of recycling, nearly three quarters of all aluminium ever made remains in use today (IAI 2006).

The reductions in fuel consumption and emissions through replacement of iron and steel in transport vehicles, for example, has been estimated. Replacing 100 kg in vehicles results in lifetime saving in CO_2 of between 1.4 tonnes and 4.5 tonnes in the case of buses, or 3.8 to 10.5 tonnes in the case of trains. Lifetime emissions from aluminium intensive cars can be 20% lower.

Turning to the macro side, demand for aluminium is related to economic activity as seen in Figure A.4

Figure A.4 Consumption of aluminium with respect to GDP, kg per head/GDP per head (000$).



Source: European Aluminium Association

The demand outlook for aluminium, barring a world economic downturn, is therefore strong with the fast growing regions of the world leading the way by far. The burgeoning automotive market in developing countries presents large opportunities. Growth in European demand is also firm but obviously not as fast as in the emerging regions. For the longer term, estimates have been made of required increases in world capacity. One long-term perspective out to 2020 put forward by a major company projects demand growth of 3.8% per year. This indicates a requirement for a 14.2 million tonne increase in world capacity between 2011 and 2020.

Market type, developments, technology potential

Work Package 2 of the COMETR project showed how the basic metals sector, which includes non-ferrous metals of which aluminium is an important part, operates in a very competitive environment. Of the energy intensive sectors investigated, the basic metals sector was among the sectors least likely to be able to set the price and most likely to have to sell its products at the world price.

Aluminium is a relatively homogeneous product which adds to the likelihood that it is subject to competition. In addition it has a very high value to weight ratio making it cheap to transport. At a present price of US$ 2,600 per tonne of aluminium, for example, transport costs are a very small part of the industry’s costs. This applies to sea transport in particular. Overland transport is obviously more costly but it is still quite cheap. Transportability means that the sector can generally locate where production conditions are good value.

The industry has seen a number of mergers recently. These have consolidated operations, increased vertical integration and the size of units. Turning to the EU-25, nearly three quarters of the 3 million tonnes of primary aluminium was produced by 4 largely integrated groups. These four also control more than three quarters of the rolling industry and over a third of the extrusion industry in the EU-25. While more concentrated power could in fact reduce competitive pressure, it may be unlikely given the present intention of many corporations gain competitiveness.

R&D plays a major role in the non-ferrous metals sector, in particular European R&D in aluminium. About 80% of new smelters built worldwide over the last 15 years are based on European technology. The European aluminium industry is the leader in smelting technology. A spin-off from the strong position of European companies in electrolysis technology is that most supporting equipment also comes from Europe (computer control, handling systems, et cetera), and European equipment manufacturers have reached a leading position in the downstream rolling, foil and extrusion technology supply. Adaptation to energy price increases, through retro-fitting, efficiency improvements, expansions and restructuring, has been facilitated by this R&D.

Recycling

Relatively modest potential energy efficiency improvements in the non-ferrous metals sector exists and can only be made through investment in technical upgrades. However, attention now turns to the potential for improved recycling and by contrast with primary production, recycling has seen rapid growth. Recycling 1 kg of aluminium saves 8 kg of bauxite, 4 kg of chemicals and 14 kWh of electricity. It also saves on cooling and processing water, bauxite residues, SO_2 emissions and landfill space. Aluminium is the only packaging material that more than covers the cost of its own collection and processing at recycling centres. A property of aluminium is that it does not become downgraded in re-use. It can be recycled indefinitely. There is no loss of quality - it can be re-used for identical new parts.

Aluminium is the most valuable recyclable in the waste stream but its rate of recycling varies widely. The quality of data on recycling rates is somewhat mixed. Recycling rates for building and transport applications range from 60% to 90% in various countries. Globally it is estimated that just over a half of end-of-life aluminium is recovered and re-used, while the rest ‘escapes the loop’. Expressed in tonnes, there are globally 7.4 million tonnes re-used annually and 6.7 million tonnes ‘escaping the loop’ (in turn broken down as 3.4 to landfill and 3.3 ‘under investigation’). For cans the recycling rate is usually the worst, and the data most variable. Table A.28 shows European recycling in the case of aluminium cans, for which the European average is estimated at 52%. Large differences between European countries are found in terms of recycling efforts by the citizens.

Table A.28 Aluminium can recycling rates in Europe

Country	Aluminium can recycling rate in % (2000)
Switzerland	91
Finland	91
Sweden	86
Norway	85
Iceland	85
Germany	80
Benelux	70
Austria	50
Turkey	50
UK	42
Italy	42
Greece	36
France	23
Spain	22
Portugal	21

Source: European Aluminium Association

Compared to the production of primary aluminium, recycling aluminium requires only 5% of the energy; hence only around 5% of the CO_2 is released. It is in fact even smaller when the complete process of mining and transport and the landscape interference of mining are considered.

Assessing the question of relevance of carbon leakage with regard to the aluminium industry it can be summed up that the indications of leakage potential is possible as demand for non-ferrous metals in the EU and especially in developing countries is continuing to increase and that investment in new capacity in the EU is not strong. However considerable investment has gone into upgrades and energy efficiency improvements. There may be concern that EU primary aluminium production does not have the capacity to cover growth of EU demand. On the other hand EU secondary production from scrap has some potential that could be exploited. This would be especially the case if external costs or benefits were counted in the calculations of economic feasibility. Meanwhile, trends in imports of non-ferrous metals as a share of demand in ETR countries do not show that import penetration is clearly increasing, except in the case of Sweden, though its export/import ratio has also been rising of late.

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