Competitiveness Effects of Environmental Tax Reforms

COMETR

Annex to Final Report
to the European Commission, DG Research and DG Taxation and Customs Union

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2007

EC Sixth Framework Programme for Research
Activity Area: Scientific Support to Policies

Contract no.: SCS8-CT-2004-501993
Instrument: Specific Targeted Research or Innovation Project
Thematic Priority: 8 - Underpinning European integration, sustainable development, competitiveness and trade policies (including improved means to assess economic development and cohesion)
Period covered: Entire project duration (month 1 – 30)
Date of preparation: 31 August 2007
Start date of project: 1 December 2004
Duration: 2.5 years
Project coordinator: Professor Mikael Skou Andersen
Project coordinator (organisation): National Environmental Research Institute, University of Aarhus (NERI), Grenåvej 14, DK-8410 Rønde; http://www.dmu.dk/COMETR
Front page photo: Offshore windmills (DK), Samsø Energy Academy.
Revision: 1.0

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Data sheet

Title: Competitiveness Effects of Environmental Tax Reforms (COMETR)
Subtitle: Annex to Final report to the European Commission, DG Research and DG TAXUD

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Publisher: National Environmental Research Institute ©
University of Aarhus - Denmark
URL: http://www.neri.dk

Year of publication: December 2007
Editing completed: November 2007

Referees: Work package deliverables have been reviewed by members of the project consortium.

Financial support: European Commission, Sixth Framework Programme for Research, Activity Area "Scientific Support to Policies", Contract no. SCS8-CT-2004-501993.

Please cite as: Andersen, M.S., Barker, T., Christie, E., Ekins, P., Gerald, J.F., Jilkova, J., Junankar, S., Landesmann, M., Pollitt, H., Salmons, R., Scott, S. and Speck, S. (eds.), 2007: Competitiveness Effects of Environmental Tax Reforms (COMETR). Annex to Final report to the European Commission, DG Research and DG TAXUD. National Environmental Research Institute, University of Aarhus. 485 pp. - http://www.dmu.dk/Pub/COMETR_Annex_Report.pdf

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.

Keywords: Competitiveness; tax; CO_2; socio-economic; macro-economic; energy-intensive; trade; Porter hypothesis; environmental tax reform; double dividend; energy taxation; climate

Layout: Ann-Katrine Holme Christoffersen

Number of pages: 485

Internet version: The report is available in electronic format (pdf) at NERI's website http://www.dmu.dk/Pub/ COMETR_Annex_Report.pdf

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The final report and the summary report are available at http://www.dmu.dk/COMETR

National Environmental research Institute, Denmark
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Case Study on the Meat and Meat Products Industry (NACE. 15.1)

Project EU COMETR – Work Package 5.3

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1 Meat products and production method

This section of WP5.3 focuses on the meat industry selected for the COMETR research. In the initial phase of COMETR 8 NACE rev. Rev 1.1 3-digit sectors were selected for detailed analysis. Sector 15.1 or 'Production, processing and preserving of meat and meat products' (NACE Rev. 1.1) was one of the sectors selected for the COMETR study. This sector includes the sub-sectors 15.11 *Production and preserving of meat*, 15.12 *Production and preserving of poultry meat*, and 15.13 *Production of meat and poultry meat products*. The following pages will give a description of some of the production and economic characteristics of the meat industry in the COMETR countries as well as some of the basic challenges the sector faces in relation to energy consumption.

1.1 Production process in the meat sector

The production process in the various types of slaughterhouses can be divided into five different elements. This division can be applied to the slaughter of pigs and cattle as well as poultry (sector 15.11 and 15.12). The description of the work process in each of the five production sub-processes can be found in Box 1 below.

Box 1 The five elements of the production process in slaughterhouses

1. Stunning and slaughtering

   The slaughter process is initiated with the stunning of the animal. The animals are stunned by means of carbon dioxide, electric shock, or a bolt gun. Thereafter the throat of the animal is cut in order for it to bleed out.

2. Hide removal/scalding/de-feathering and eviscerating

   After the kill, the hide is removed on bovine animals, pigs are scalded and poultry is de-feathered in order to clean away parts of the animal not suited for human consumption. In addition to the external preparation the entrails of the animal are also removed and the insides of the carcasses are cleaned.

3. Chilling

   After the carcasses have been cleaned the meat is chilled from the live body temperature to about 5 degrees C to avoid bacteria growth and ease the further processing

4. Cutting and boning

   The fourth element of the slaughter process involves removal of unnecessary bones and the cutting of the carcases into pieces that can be sold for consumers or for further processing.

5. Cold storage

   The fifth element of the slaughter process is the freezing of the carcasses. The meat, except for meat sold as fresh meat, is deep frozen in order to ensure longer shelf life.

Source: Pontoppidan, 2001: p. 8-10, 16-18
European Commission, 2003: p. 29-46

In addition to the slaughter process for cattle, sheep, pig and poultry meat, 15.1 also includes the further processing of meat products. Sub-sector 15.13 (production of meat and poultry meat products) includes the further processing of meat into a large variety of different meat products. The production methods vary significantly across the different products in this sub-sector. Such different products as sausages, smoked meat products, grilled products, semi-prepared and ready-made meals are all produced within sub-sector 15.13. Despite the heterogeneity in the products within 15.13 and hence substantial differences in production methods within the sub-sector there is still a common feature within 15.13 that differentiates this sub-sector from the others in 15.1. Production within 15.13 is considered to be significantly more energy intensive than production both in 15.11 and 15.12. Production of meat and poultry products (15.13) constitutes between 15 and 40 percent of the total production within sector 15.1 in Germany, the Netherlands and UK (Eurostat, 2006b, see also Table 2 and 3 in section 2.1), whereas the sub-sector consumes between 40 and 60 percent of the total energy consumption in 15.1; thereby, 15.13 can be described as more energy intensive than sub-sector 15.11 and 15.12 (Ramirez, 2006: p.1716).

Within sub-sector 15.13 energy is mainly used for heating purposes in the cooking processes of the meat products. In 15.11 and 15.12, on the other hand, energy is mainly used for refrigeration and to heat water for hygiene purposes. Recent European studies have estimated that the refrigeration plant in slaughter houses consumes between 45 and 90 percent of the electricity consumption during the working hours in the day time and almost 100 percent of the electricity consumption during no-production periods (European Commission, 2003: p. ii and Ramirez, 2006: p. 1716). Approximately the same figures are the result of an older US study of the energy consumption in the meat sector. The result of this study is presented in Table 1 below. In this study energy use for refrigeration is estimated to constitute 59 percent of the total energy consumption within the meat sector. Production of hot water is the second largest energy consumer within the meat sector using 10 percent of total energy consumption. The rest of the production elements within the meat sector each consume less than 10 percent of total energy consumption.

Table 1 Energy consumption in the meat sector.

Meat processing activity	Percentage of energy usage
Refrigeration	59 percentage
Boiler room	10 percentage
Rendering	9 percentage
Slaughter	6 percentage
Compressed air	5 percentage
Boning room	3 percentage
Others	8 percentage

Source: Waste Reduction Resource Center (WRRC), 2006

2 Structural development in the meat sector

During the 1980s and the 1990s the meat sector in Europe underwent a significant structural change. Despite national differences a general trend towards fewer meat processing facilities with a greater 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. In Germany the number of slaughterhouses reduced from 556 to 535 in the period from 1990 to 1997. In the UK the number of slaughterhouses reduced from 1,538 to 703 in the period 1987-1997, and in the Netherlands the number of slaughterhouses reduced from 477 to 344 in the period 1985-1996 (Fritzson, 2006b: p. 793, European Commission, 2003: p. 2-8 and Ramirez, 2006: p. 1715).

Also in Denmark the meat industry has undergone extensive structural changes during the 1990s. In 1990 the company Danish Crown was established as a merger between 3 meat companies. Up through the 1990s and until 2001, 4 other Danish slaughter companies and meat processing companies were merged into Danish Crown. Today, Danish Crown processes 20 million pigs (in thirteen slaughterhouses) and almost 400 thousand cattle (in 4 slaughterhouses) each year. Danish Crown 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 European market for pig meat and around 2-3 percent of the world market. 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 not only compete on prices. Quality and hygiene standards are also important competitive factors. In some of the high-price markets like Japan and USA it is simply not possible to sell meat products if the products do not live up to high quality standards (Danish Crown, 2006, Danish Meat Association, 2006: p. 9 and Interview with Charlotte Thy from Danish Crown).

The structural change with mergers and the appearance of very large companies within the meat sector can to a large extent be ascribed to the general marked development in the past 30 years. Increased international trade and higher quality demand have given large and effective companies a competitive advantage fuelling the trend of increasing company size. However, the structural changes in the meat sector can also, to some extend, be explained by sector specific factors within the meat sector. The following subsections will describe how sector specific characteristics have affected the structural change within the meat sector.

2.1 Changes in consumption patterns

Changes in consumption patterns can be seen as one of the major factors behind the structural changes observed in the meat sector. Consumption patterns or the demand for specific product groups or types of products can have a significant effect on the composition of the meat sector and thereby also the environmental impact stemming from the meat sector.

Outbreak of diseases like foot-and-mouth disease, swine pest, BSE and most recently bird flu can have a significant impact on the demand for the type of meat in question. The effect on demand is not necessarily limited to the area subject to an outbreak of a disease. Consumers over a much larger area can react to an outbreak and can avoid specific products altogether. The outbreak of BSE is an illustrative example. Demand for beef products was significantly reduced as a result of the BSE scandal. The outbreak of BSE was mainly restricted to the UK and to some extent the Netherlands and France, but the change in consumption of and demand for beef did not only affect the UK. Reduction in demand limits production and the number of cattle going through the slaughterhouses. When the total number of animals going through the slaughterhouses decreases, as a result of the decreased demand, the remaining animals are most likely to go through the most effective and large slaughterhouses. The result of a smaller number of animals is therefore fewer but larger meat processing facilities (Ramirez, 2006: p.1713-1714).

The distribution of production between the 3 sub-sectors within 15.1 displayed in Table 2 and 3 illustrates the changes caused by the outbreak of BSE. Sector 15.11 includes both the production of bovine and pig meat. In Denmark, Germany and the Netherlands pig meat constitutes more than 70 percent of the meat production (15.11) and, because bovine meat only constitutes a small percentage, the decrease in demand caused by BSE cannot be observed. In the UK, on the other hand, bovine meat constitutes more than 50 percent of the total production and the change in the demand for beef is apparent (Eurostat, 2006b). Table 2 and 3 below display how the share comprised by 15.11 reduced from 40 percent to 29 percent between 1995 and 2000 in the UK resulting from the decline in demand for bovine meat.

Table 2 Production share of the 3 sub-sectors in sector 15.1 (year 1995)

	15.11	15.12	15.13	Total 15.1
Denmark	69.0	7.5	23.5	100 pct.
Finland	59.3	1.4	39.3	100 pct.
Germany	38.5	30.3	31.2	100 pct.
Netherlands	60.9	24.4	14.8	100 pct.
Sweden	62.8	8.0	29.2	100 pct.
UK	40.4	19.3	40.3	100 pct.

Source: calculation based on Eurostat, 2006b data

Table 3 Production share of the 3 sub-sectors in sector 15.1 (year 2000)

	15.11	15.12	15.13	Total 15.1
Denmark	73.2	9.1	17.7	100 pct.
Finland	39.2	9.1	51.6	100 pct.
Germany	42.7	29.2	28.1	100 pct.
Netherlands	59.7	23.2	17.2	100 pct.
Sweden	60.1	9.3	30.6	100 pct.
UK	29.2	30.3	40.4	100 pct.

Source: calculation based on Eurostat, 2006b data

At the same time as the production of beef decreased in the UK, the production of poultry increased. Table 2 and 3 above show the developments. Between 1995 and 2000 the share of poultry increased from 19 percent of the total meat production to 30 percent. Such changes are interesting from a structural point of view, but the change also affects the environmental pressure exerted by the meat sector as the various sub-sectors consume different amounts of water and energy. One example of these differences is displayed in Table 4 below. Danish studies have revealed the electricity consumption associated with freezing the various kinds of meat products. The results of the study displayed in the table show that poultry products are the most energy intensive in terms of the electricity needed to freeze the product. According to the Danish estimate it only takes around 80 kWh to freeze a tonne of beef, while freezing poultry easily requires twice that amount.

Table 4 Electricity consumption associated with the freezing of meat products

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

*Depending on the type of packaging

Source: Pontoppidan, 2000: p.11 and Pontoppidan, 2001: p.15 and 20.

The general trend with a decrease in the demand of beef and pig meat and an increase in the demand of poultry is not the only change in consumption patterns that can be observed. A new trend in consumer behaviour has emerged. Demand for and consumption of industrially processed meals, such as semi-prepared and ready-made meals, has increased significantly in the recent past. Consumers are demanding more convenient products that only require a minimum of time to prepare before serving. This change in consumption behaviour is also expected to cause significant structural changes also impacting the environmental impact of the meat industry. The importance of 15.13 within the overall meat sector can be expected to increase and as industrially processed meals replace home-made meals, a large proportion of the energy used for food preparation will be consumed in meat and food processing plants rather than in private households (Fritzson, 2006a: p. 594, Fritzson. 2006b: p. 792).

2.2 Structural changes induced by EU regulation

Change in consumption patterns is not the only element behind structural changes in the meat industry. Different types of EU regulation and political initiatives have also contributed to the structural change comprising fewer but larger meat processing facilities.

During the past 30 years the EC/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. In addition to the subsidy scheme on dairy products, the EU system has also introduced a quota system regulating the production of dairy products to avoid overproduction. Beef production can to a large extent be characterized as a side product of dairy production. Limits imposed on dairy production via the quota scheme along with more efficient dairy cows have therefore limited the availability of cattle for slaughter. The reduced number of cattle caused by dairy regulation and the food scandals will cause structural changes as the fewer cattle will be processed at larger and more economically efficient slaughterhouses with a larger throughput. Smaller slaughterhouses have not and will not be able to compete for the reduced number of cattle and are forced to close down production (Ramirez, 2006: p.1713-1714).

EU regulation defining hygiene and quality standards in the meat sector is another example of EU regulation with structural impact. Hygiene regulations, such as EC Directive 91/497, pose serious economic challenges to meat companies. New quality 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 regulation. OECD studies have shown that this type of regulation-induced cost imposes a larger economic burden on small companies compared with larger companies. First of all it is more difficult for small meat processing facilities to cope with the economic burden of hygiene regulations. There are considerable economies of scale associated with the cost of updating production facilities according to the regulation standards and in general it is difficult for small companies to generate sufficient turnover to absorb the expenditures associated with complying with the regulation. In addition to this, small plants often supply domestic markets and it is difficult for these companies to offset the costs of the hygiene-related investments through exports to high-priced foreign markets with a willingness to pay for the improved standards of hygiene. Based on the economic consequences of hygiene- and quality-related regulation it can be argued that this type of regulation fuels the structural development towards larger companies with a large throughput (OECD, 1997:p.38 and Ramirez, 2006: p.1715-1716).

3 Energy and technology in the meat industry

The structural development towards larger slaughterhouses with a higher throughput should, in theory, be expected to result in more efficient production with lower energy consumption per produced unit. Economies of scale can be expected, all other things being equal, gradually to improve the energy efficiency and thereby decrease the energy input needed per produced unit of goods. However, case studies of the differences between large and small slaughterhouses and meat plants in Sweden and Denmark have rejected this theory. It is argued that improved hygiene standards and the requirement for higher sanitary standards in large meat facilities undermine the energy savings from economies of scale (European Commission, 2003, p. 8). In general the demand for better hygiene and food products of higher quality has caused higher energy consumption that counters a general trend towards more energy efficient production. Outbreaks of foot-and-mouth disease, BSE and bird flue, etc, plus the awareness of bacteria such as salmonella have increased consumer demand for hygiene in the meat sector. Hygiene- and quality-related changes in the production process require energy as hygiene is closely related to hot water and quality is closely related to fast cooling and cold storage. One example of hygiene changes 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 60 degrees C water for cleaning and sterilisation. The standard temperature has been increased to 82 degrees C 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 but to ensure hygiene and avoid odour problems recollected blood is now chilled to 5 degrees C (Ramirez, 2006: p. 1722-1724 and WRRC, 2006).

3.1 Comparative analysis of the energy characteristics in the meat industry

The meat sector is the least energy-intensive sector of the eight 3-digit NACE sectors included in the COMETR research. Compared with most of the other sectors, both energy consumption per unit of output and the energy share of the total input rank very low in the meat processing industry. The meat processing industry consumes around 1 GJ per 1,000 euro output (see Figure 1 below), whereas sectors like the cement industry and metal industry consume up to between 40 and 60 GJ per 1,000 euro output. Compared with the situation in other industries, energy cannot be regarded as a central input factor. Taking into consideration that the energy intensity is at a very low level, a difference of 50 percent between the highest and the lowest energy intensity across the meat sectors in the COMETR countries cannot be described a significant difference. Compared with other sectors, the meat sector can be described as homogeneous and a difference of 0.5 to 1 GJ can easily be caused by small differences in the product combination (beef, pig meat, poultry or semi-prepared meals).

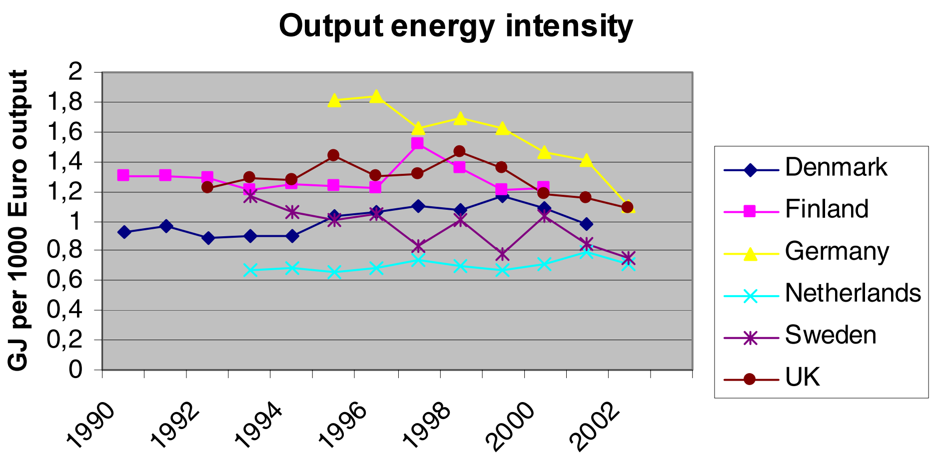

Figure 1 Energy intensity in the meat industry
Source: Calculations based on COMETR WP3 database
Note: The calculation has been made in constant (2000) euro prices.

Figure 1 displays the differences in the meat industry energy intensity between the COMETR countries during the observed time period. It is important to notice that the Netherlands and Denmark, the two countries with the largest and most developed meat sector, both can be characterized as low energy intensity countries. In the Netherlands and Denmark the meat sector constitutes respectively 4 and 7 percent of the total output in the total manufacturing industry. 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 (see Table 5 below).

Table 5 Meat industry share of total manufacturing industry (year 2000)

EU15	2.5
Denmark	7.7
Finland	1.9
Germany	1.6
Netherlands	4.1
Sweden	1.7
UK	2.7

Source: Calculation based on Eurostat, 2006a data.

Denmark and the Netherlands are also the two COMETR countries with the largest export percentages in the meat sector. These figures indicate that the meat industry in the Netherlands and Denmark is of great importance and requires a highly developed technological level to maintain this leading position. The leading market position can only be secured by a constant focus on improving the production process including a focus on energy consumption (figures based on COMETR WP3 database).

Despite these differences the meat sector can still be described as a homogeneous sector in terms of energy consumption. Figure 2 below shows the energy cost per output.

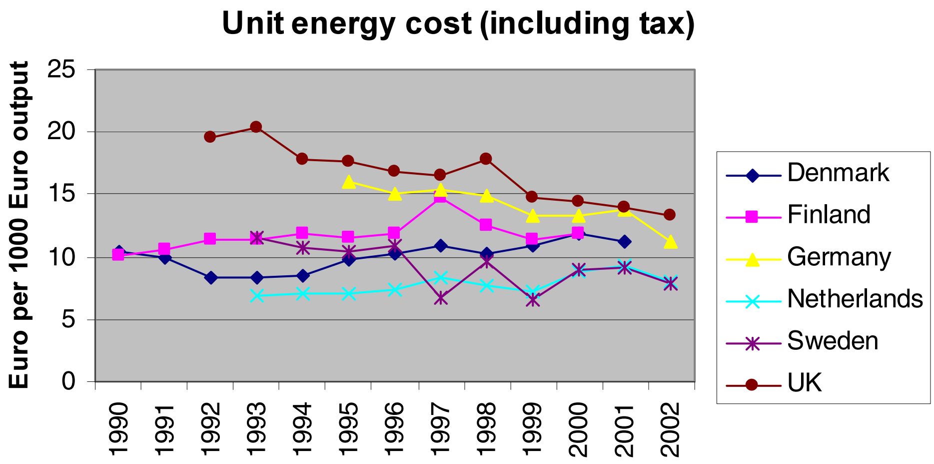

Figure 2 Energy cost per unit of output in the meat industry
Source: Calculations based on COMETR WP3 database
Note: The calculations are made in constant (2000) Euro prices.

3.2 Variations in energy mixture

The energy mixture or combination of the different energy carriers is a result of various national, historical and industry-specific features. Figure 3 below shows how electricity and natural gas can be described as the most important energy products consumed in the meat and meat product industry. Despite the dominant position of natural gas and electricity, attention can be drawn to several differences in energy mixture across the six countries. End-product characteristics, energy infrastructure and relative energy costs are three explanatory factors that can be described as the main drivers with regard to the energy mix applied and the differences observed in Figure 3.

First of all, end-product characteristics affect the need for energy and thereby the composition of energy products used in the meat sector. Energy demand for slaughtering, cleaning, parting and cooling differs depending on whether the products are chicken, pork or beef. Energy demand also differs depending on the preservation technique of the product. Meat products can be sold as fresh goods or deep frozen. Meat products can also be smoked and cured via additives and the energy consumption differs depending on which method is used. For example deep-frozen products require more energy in the production process than fresh goods. In addition to these differences the energy consumption in the meat sector also depends on the extent of further preparation of the meat products in the form of e.g. sausages, formed meats and meat-based ready meals. Demand and consumption of industrially processed food products such as ready-made and semi-prepared meals are increasing. Advanced industrially processed food products require more energy than non-cooked products and thereby this tendency can influence the energy demand and energy mix in the meat sector (Fritzon, 2006a: p.594, Fritzon, 2006b: p.792).

Secondly, the energy infrastructure as well as the national characteristics of the energy distribution system represents a major explanatory factor behind the differences in energy mix across the COMETR countries. The energy infrastructure, i.e. level of self-sufficiency and distribution net (pipelines, power grid or road/rail transport), is not equally developed for all energy products in all countries. This method is especially appropriate to analyse large overall differences in the energy mixture between countries. For example there are significant differences across the COMETR countries with regard to self-sufficiency and the proportion and extension of pipelines for natural gas. These differences are a significant explanatory factor for the variation in consumption of natural gas across the COMETR countries. Figure 3 below shows that natural gas constitutes a fairly large percentage of the total energy consumption in Denmark, Germany, the Netherlands and UK. In Sweden and Finland, on the other hand, natural gas consumption only constitutes a small share of total energy consumption. Energy infrastructure can explain these differences. UK, the Netherlands and Denmark are virtually self-sufficient in natural gas while Finland and Sweden are forced to import their entire consumption of natural gas (Hierl, 2000: p.32). The very existence of natural gas as a natural resource in a country causes a more extensive distribution net and naturally also a much higher consumption of natural gas. The availability of natural gas as a natural resource in a country can be read directly from consumption pattern of energy in the meat industry. Sweden and Finland, the only two COMETR countries with no domestic production of natural gas, are also the two COMETR countries with the lowest share of natural gas consumption. Figure 3 below shows the combination of energy products consumed in the COMETR countries. The figures show how natural gas consumption constitutes less than 10 percent of the total energy consumption in Finland and Sweden, whereas natural gas consumption constitutes between 20 and 60 percent of the total energy consumption in UK, the Netherlands and Denmark.

The energy situation in the Netherlands is especially noteworthy. Figure 3 below shows how the Dutch meat sector almost exclusively relies on natural gas and electricity. High consumption of natural gas and electricity is a common feature for many Dutch sectors and can be explained by a high self-sufficiency of natural gas in the Netherlands combined with government support of this energy carrier. Out of the 12.48 million tonnes of oil-equivalent total energy consumption used in 2001 for energy purposes in the entire Dutch industry, natural gas and electricity constituted respectively 42.9 and 28.0 percent of total energy consumption. Coal and oil products only constituted 17 percent of the total industrial energy consumption, and were primarily consumed in the iron and steel industry and in the chemical industry. The iron and steel industry consumed 81 percent of the total industrial coal consumption while the chemical industry consumed 83 percent of the total industrial oil consumption (IEA, 2004: p. II 110).

The situation in Germany differs slightly from that in the other countries. Germany only has a small domestic production of natural gas and imports approximately 80 percent of its total natural gas consumption (Hierl, 2000: p.32). Despite the dependency on import of foreign natural gas Germany can still be categorized as a large consumer of natural gas. Whereas Finland and Sweden have easy access to large amounts of hydropower and biofuels, Germany does not have domestic access to large amounts of fossils fuels or other energy sources, except for coal; Germany is therefore dependent on the import of various energy sources. Figure 3 below shows how natural gas constitutes approximately 40 percent of the total energy consumption in the German meat industry. Several other sectors in Germany also consume large quantities of natural gas and the status of Germany as a natural gas consuming country can be explained by easy access for Germany to the European natural gas distribution network. The European natural gas transmission grid shows how Germany is linked both to the large natural gas fields of Norway, UK and Denmark in the North Sea as well as the large natural gas pipelines from Russia (Hierl, 2000: p.36). The combination of the lack of domestic energy production and easy access to a European natural gas supply network can therefore be characterized as a major explanatory factor for the large consumption of natural gas in Germany despite low domestic extraction of natural gas.

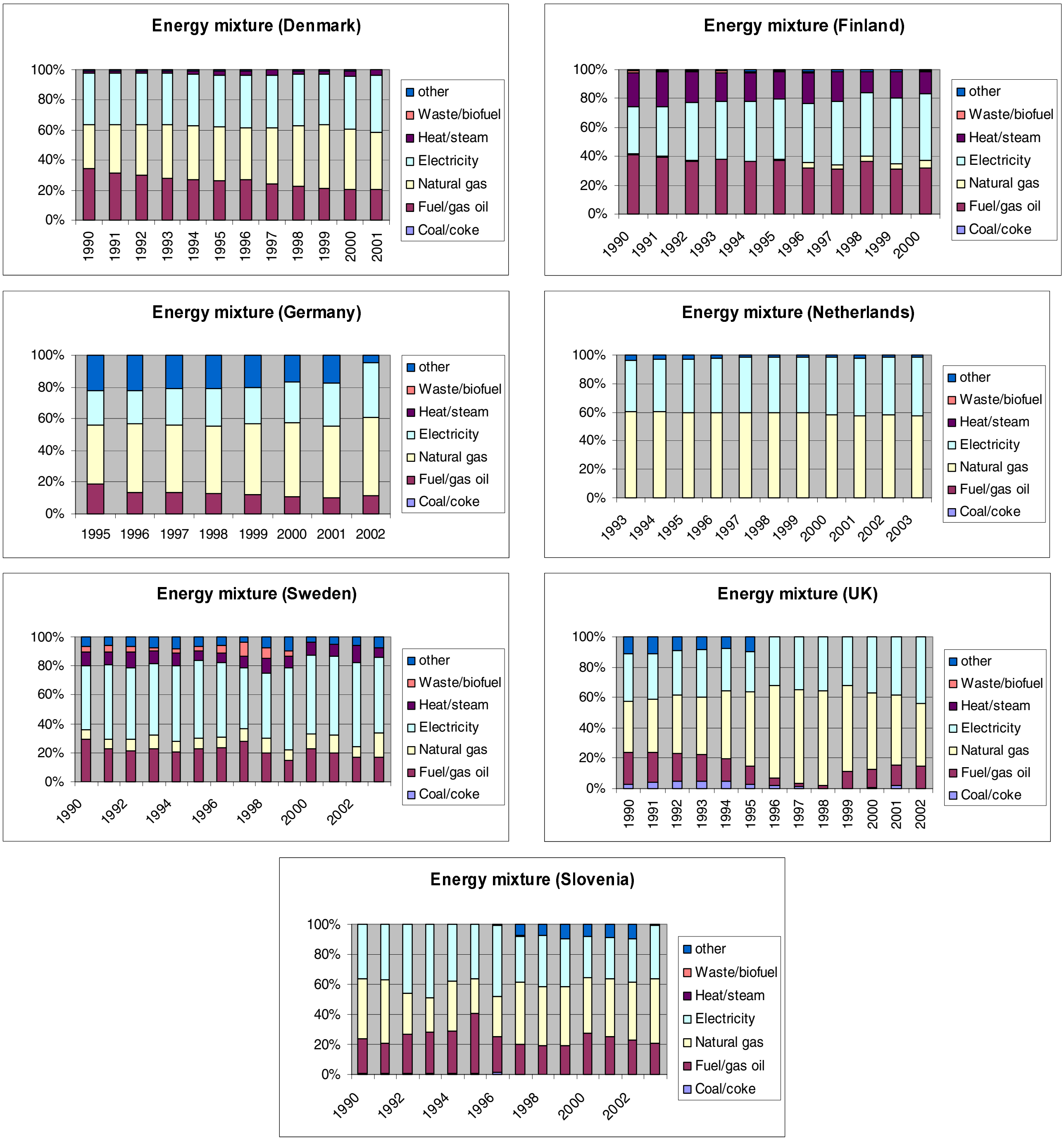

Figure 3 Energy composition in the COMETR countries

Source: Calculations based on COMETR WP3 database

Note: The energy consumption data delivered by the Dutch statistical bureau only differentiates between three kinds of energy carriers: natural gas, electricity and 'other'. In some sectors this lack of detail in the differentiation of the energy carriers can make it difficult to observe the real changes in energy consumption. In the meat sector however, the 'other' energy category is of limited importance and does not affect the evaluation of the overall development in the energy mixture.

The third feature of energy infrastructure that has the ability to affect the combination or mix of energy products is the relative price of the various energy products. Relative changes in energy prices can lead to changes in the profitability of the consumption of the various energy products. Both actual prices and relative prices are constantly changing, as Table 6 below shows. The price changes can be caused both by market price changes and government issued energy taxation. Regardless of the origin of the price changes, the company executives can be expected to adapt to relative price changes and shift energy consumption to other energy products if a switch is economically profitable. Incremental developments in energy mix indicate gradual changes caused by some explanatory factor which is also undergoing gradual changes. The Danish case with a gradual increase in natural gas consumption versus a gradual decrease in fuel/gas oil (see Figure 3 above), as well as the Finnish case with incrementally increasing electricity consumption and incrementally decreasing fuel/gas oil consumption, and the German case with incrementally increasing natural gas consumption and incrementally decreasing fuel/gas oil consumption are all examples of incrementally changing consumption that is well suited to show the price effect on the consumption of energy.

Table 6 Percentage total price change between 1995 and 2000 in the meat sector (measured in constant prices)

	Fuel oil	Gas /diesel oil	Natural gas	Electricity
Denmark	189.8	49.3	-22.2	9.7
Finland	57.9	68.7		-12.7
Germany	68.2	89.7	30.4	-41.7
Netherlands			28.9	5.0
Sweden	53.4	44.0	68.3	-35.1
UK	31.4	28.3	-24.2	-23.7

Source: Calculations based on COMETR WP3 database

Table 6 above shows that both the fuel oil and the gas oil price increased significantly in Denmark between 1995 and 2000. In the same time period the price for natural gas decreased while the electricity price only increased marginally. As expected these relative price changes have led to a change in the energy mix applied in the Danish meat sector. The consumption of fuel and gas oil, the energy products that have incurred substantial price increases, has decreased significantly during the period from 1995 to 2000. During the same period, Table 7 below shows a 43 percent decrease in gas oil consumption and a 12 percent decrease in fuel oil consumption in the Danish meat sector. On the other hand, consumption of both natural gas and electricity, which did not experience large price increases, increased during the same period.

In the Finnish case, Table 6 above shows how both fuel oil and gas oil experienced price increases during the period from 1995 to 2000. During the same time period the electricity price decreased. The relative price changes led to a significant decrease in gas oil consumption and a significant increase in electricity consumption. The Finnish consumption of fuel oil increased marginally, which is contrary to the expectation based on the relative price assumption. However, the total energy consumption increased more (in percentage) than the consumption of fuel oil causing the relative importance of fuel oil to decrease in accordance with the relative price assumption.

The German case also exemplifies how price changes can be characterized as the explanatory factor for incremental changes in consumption of specific energy products. During the time period from 1995 to 2000 the Germany fuel oil and gas oil price increased by more than 60 percent while the electricity price decreased and the natural gas price only increased 30 percent. The development towards a relative price advantage for electricity and natural gas coincides with an increase in consumption both of natural gas and electricity, while the consumption of fuel and gas oil decreased significantly during the same time period.

Table 7 Percentage consumption change between 1995 and 2000

	Total	Fuel oil	Gas /diesel oil	Natural gas	Electricity
Denmark	0.9	-12.1	-43.5	12.9	4.0
Finland	11.8	5.7	-22.7		23.1
Germany	-5.5	-75.6	-40.1	17.6	13.1
Netherlands	14.1			11.0	22.7
Sweden	1.1	-19.6	7.4	44.2	2.8
UK	-12.8	-76.8	79.5	-10.5	23.6

Source: Calculation based on COMETR WP3 database

3.3 Carbon-energy taxation in the meat industry

In general the meat sector is not an energy-intensive sector and hence carbon-energy taxation does not have a great influence on the composition of input expenditure in the meat sector. However, energy taxation still constitutes a noticeable economic burden for the meat sector. The level of the total energy taxation in the sector is displayed in Table 8 below. Eighteen million Euro of carbon-energy taxation in Germany represents a significant sum of money. The tax burden becomes especially visible in countries where few, very large companies dominate the sector. For example, in Denmark the meat sector is dominated by one company (Danish Crown). This company can display a very high carbon-energy tax payment simply because the throughput is very large. The absolute sum is high and company executives can present a persuasive argument to the politicians when the numbers are presented. Despite the fact that energy, and thereby carbon-energy taxes, only constitutes a small share of the total input in the meat sector, the energy tax actually constitutes a noticeable percentage of the gross value added in the sector. Table 8 below shows the data for the seven COMETR countries for the year 2000. Except for the UK, the energy taxes constitute a somewhat high proportion of total GVA.

Table 8 Energy taxation in the meat industry (2000 figures)

	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	0.31	1.52
Slovenia		0.88

Source: calculations based on COMETR WP3 database

*Note 1: It should be noted that almost the entire Danish meat sector run as cooperative slaughterhouses. This business structure can affect the GVA values in Denmark. The surplus or company profit in the Danish cooperative slaughterhouses is paid back to the members of the cooperative as an extra payment for the animals delivered to the slaughterhouses. Effectively this means that input costs are increased, while GVA appears lower than it really is. Even though taxation on energy consumption in the Danish meat sector is significant because the meat sector is defined as a light process and therefore pays the standard tax rate, the tax share of GVA in the Danish meat sector might be elevated significantly in relation to the other countries because of this special company structure in Denmark.

Carbon-energy taxation and other policy instruments applied to the meat sector may have affected the competitiveness situation. Together with labour costs and other economic burdens, environmental instruments contribute to consideration of outsourcing in countries where the meat sector is facing high costs. However, the possibilities of moving production to a country with lower costs (labour, taxation, etc) are rather limited. Because of considerations concerning animal ethics and the costs 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 (sub-sectors 15.11 and 15.12). The further processing of meat products (sub-sector 15.13), 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 to high-cost policy instruments as well as high labour costs. According to Charlotte Thy, environmental manager at Danish Crown, Danish Crown has moved a very large proportion of the further processing of meat products to Germany and Poland in order to reduce costs. For example, Danish Crown no longer produces Danish bacon in Denmark. The meat is transported to Germany and Poland where it is further processed and packaged (interview with Charlotte Thy).

3.4 Energy-related technological development

Improvements in energy efficiency are always welcomed by company leaders. However, in sectors with low energy intensity such as the meat sector, consideration of energy efficiency and initiatives to improve energy efficiency might not always be a high priority because energy efficiency improvements often require capital investments. Improvements in energy efficiency also often require careful planning and monitoring and this type of effort costs money. Structural developments in the meat sector with increasing plant size increase the potential for energy-saving initiatives. The economic cost, in the form of capital investments and monitoring, of initiatives related to energy efficiency decreases relative to the economic benefit of the energy improvements as plant size increases, because there is a energy consumption is much higher in large plants (Fritzson,2006b: p.793).

Danish Crown is a good example of a company where it makes economic sense to focus on consumption of energy. Danish Crown consumes 250 million kWh electricity each year and a change in energy consumption of a few percent can amount to significant economic savings. The potential savings have brought about intense focus on energy consumption in Danish Crown. Every week employees monitor and report the energy consumption relating to the various production lines. The energy consumption is benchmarked against the energy consumption in other Danish Crown slaughterhouses in order to identify problems and the potential for saving energy. The considerable focus on energy consumption has paid off and Danish Crown has been able to improve their energy efficiency significantly over the past 15 years. Figure 4 below shows the development in energy consumption in Danish Crown over the past 15 years and the chart shows that Danish Crown has been able to reduce total energy consumption per pig by about 25 percent.

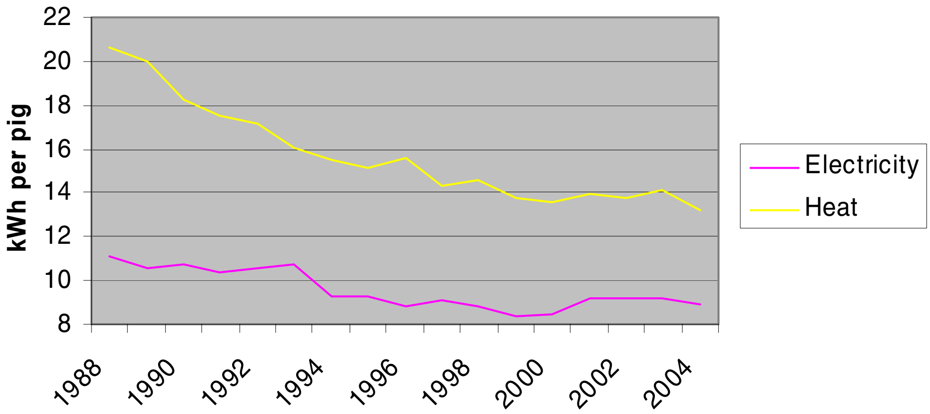

Figure 4 Energy consumption in Danish Crown
Source: Danish Crown, 2005: p. 6-7.

A 'snake in the grass', however, appears when it comes to the possibilities for further energy improvements in future. Figure 4 above shows how the decrease has stagnated in the last part of the observed period and according to the environmental manager in Danish Crown, Charlotte Thy, it has become more and more difficult to find areas for energy improvements. One of the factors causing setbacks in the work with improving energy efficiency is constantly developing quality standards. Improving standards of hygiene takes energy and when initiatives relating to hygiene and quality standards are introduced the energy consumption per pig increases. High quality and hygiene standards are a necessity when the company wants to supply consumers with high demand for food-safety and the energy engineers simply have to submit to these requirements (interview with environmental manager Charlotte Thy, Danish Crown). Figure 5 and 6 displayed below demonstrate the situation. The yellow lines in both figures show energy consumption as it would have been without any new initiatives on quality and hygiene standards. It is apparent that Danish Crown has been able to gradually reduce the energy consumption per pig during the observed period. However, since the beginning of the 1990 various hygiene and quality standards have countered this development. The negative effect of new quality and hygiene standards on energy efficiency is especially apparent when new standards are introduced. Introduction of new standards is represented in the figures by the sharp increase in the red lines depicting the actual energy consumption.

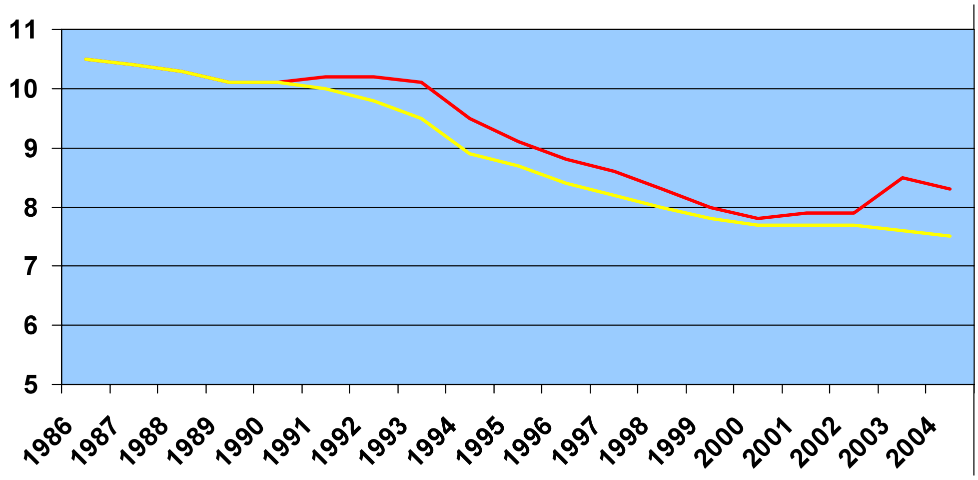

Figure 5 Electricity consumption taking new standards into account (kWh per pig)

Source: Information on the situation in Danish Crown delivered by Charlotte Thy, environmental manager in Danish Crown

Red line: Actual electricity consumption.

Yellow line: Electricity consumption without new quality, hygiene and work environment standards

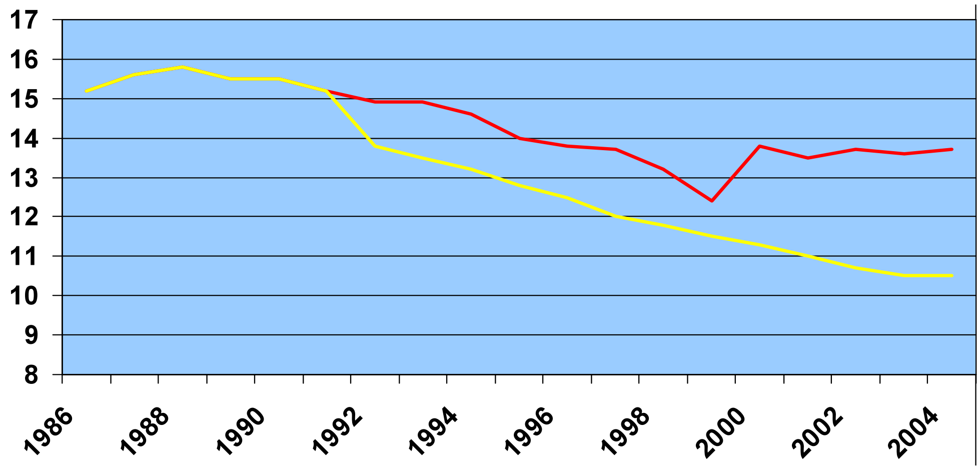

Figure 6 Heat consumption taking new standards into account (kWh per pig)

Source: Information on the situation in Danish Crown delivered by Charlotte Thy, environmental manager in Danish Crown

Red line: Actual heat consumption.

Yellow line: Heat consumption without new quality, hygiene and work environment standards

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Case Study on the Paper and Paper-board Products (NACE 21.1)

Product: EU COMETR – Work Package 5.3

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Contents

1 The paper industry, products and production method

In the initial phase of COMETR, 8 NACE Rev. 1.1 3-digit sectors were selected for detailed analysis. Sector 21.2 or 'Manufacture of articles of paper and paperboard' (NACE Rev. 1.1) was one of the sectors selected for the COMETR study. This sector includes manufacture of corrugated paper, paperboard and containers of paper. Sector 21.2 also includes manufacture of household and sanitary goods and toilet requisites. Also included is manufacture of paper stationery, manufacture of wallpaper plus manufacture of other articles of paper and paperboard. The following pages will give a description of some of the production and economic characteristics of the paper industry in the COMETR countries as well as some of the basic challenges the sector faces in relation to energy consumption. It should be noted that the following sections start with a wider description of paper production that is not strictly narrowed to sector 21.2. Paper and paper products production is often evaluated as a joint process, and in order to understand the dynamics of sector 21.2 it is important to get an overall understanding of the entire paper production industry.

1.1 Paper products

The paper industry in Europe is 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, p.10).

The European paper industry provides consumers with a large variety of different paper products. In total Western European paper companies produced 79 million tonnes of paper in 1997 (99 million tonnes in 2005). 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 divided into several sub-categories. Figure 1 below shows the different categories of paper products and the production share of each type of paper products compared to the total production of paper.

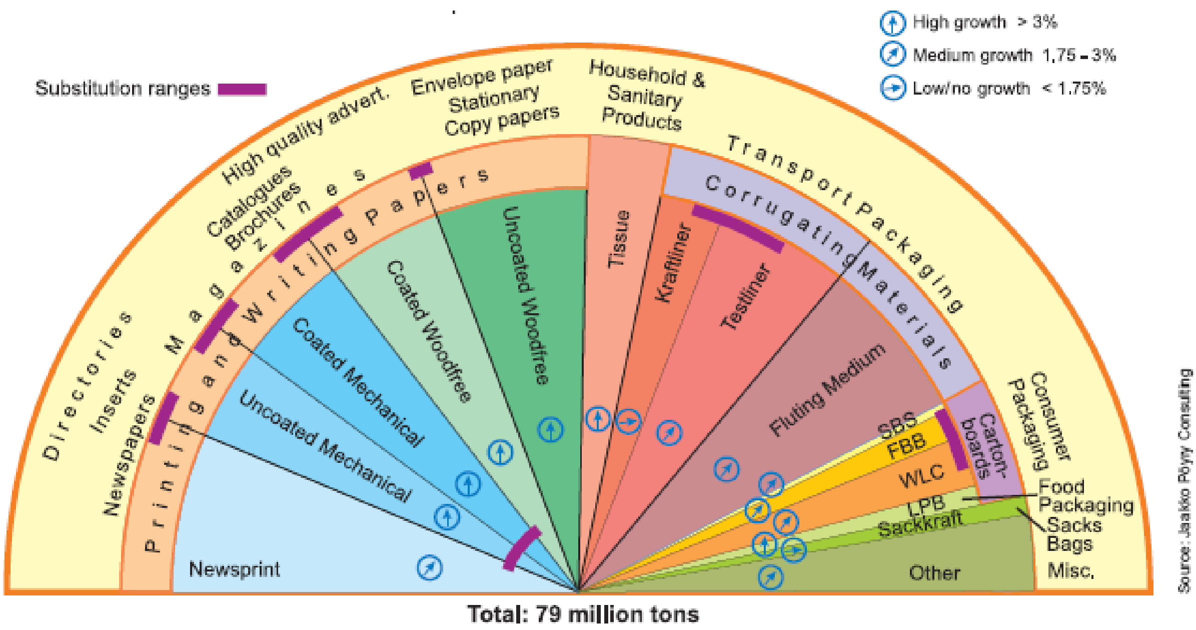

Figure 1 Paper and paperboard production in Western Europe (1997)
Source: CEPI,1999: p.6

The production of paper products has a similar distribution between grades in the COMETR countries. In most of the countries graphic (printing and writing) paper products constitute around 50 percent of the total production of paper while packaging paper products constitute 35-55 percent. The rest of the production is split between sanitary/household products and the category of 'other' paper products. Denmark and Finland differ slightly from the other COMETR 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; the graphic paper production share is higher than the average while the packaging share is lower. Table 1 below displays the entire distribution of the different paper categories.

Table 1 Total production of paper products and percentage production by grade (2000)

	1000 tonnes	Percentage of total production			
	Total production	Graphic	Sanitary & household	Packaging	Others
Denmark	400	30.0	0	67.5	2.5
Finland	13509	72.6	1.3	23.1	3.0
Germany	18184	51.3	5.6	36.2	6.9
Netherlands	3364	40.0	4.4	55.6	0
Sweden	10786	49.9	2.9	46.1	1.2
UK	6604	43.1	11.0	38.7	7.3

Source: CEPI, 2001: p.48-49

1.2 Producing paper, a simplified description of the paper production process

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 whether it is printing paper, tissue paper or packaging paper/board, are produced using the same basic production method. The various different paper categories require variation in the chemicals used and variation in some of the elements in the production process. Despite the variation in some of the elements of paper production, the overall production technology or structure of the paper machine remains the same regardless of the type of paper being produced.

Paper machines consist of five basic elements; headbox, wire section, press section, drying section and reeling. The five components of a paper machine are illustrated in Figure 2 below, and in the following sections the processes in the paper machine will be described further.

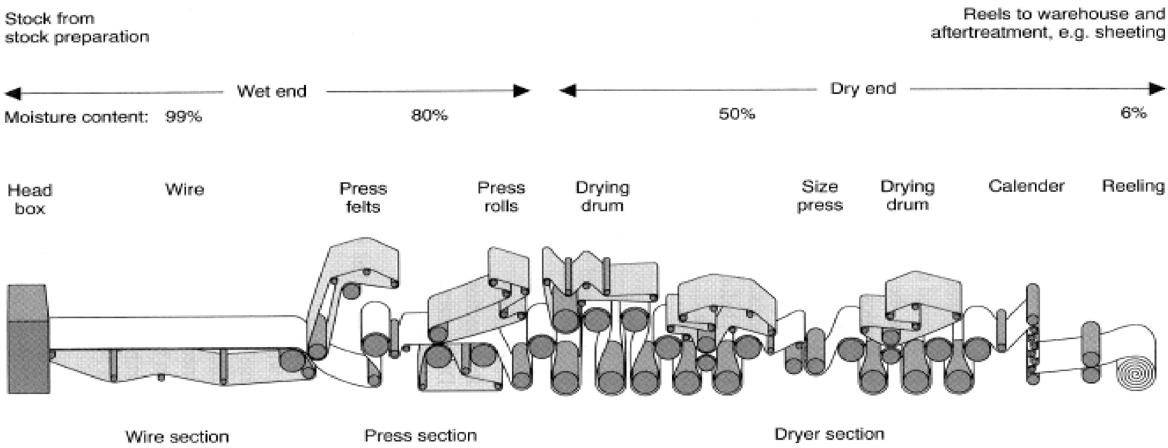

Figure 2 Schematic of a paper machine
Source: Åsblad et al., 2001, p.25.

Clean pulp or 'stock' is fed into the headbox where the stock is mixed with water. The mix consists of approximately 99 percent water and 1 percent stock. The suspension of stock and water is then introduced to the wire section in a thin layer, depending of the quality and thickness of the final paper product. In the wire section most of the water is drained away from the paper mass. The draining is accelerated in the press section by rolls, foils and vacuum boxes. When the paper mass reaches a solid content around 20 percent the paper web becomes self-supporting, but the paper web is further pressed until it reaches a solid content of about 50 percent. The paper then enters the drying section of the paper machines. In the drying section the paper passes over 40-50 steam-heated cylinders until the paper reaches a solid content of about 95 percent. Finally the paper is reeled on to large rolls of paper that can be shipped off to be converted into sheet paper, carton boxes, tissues etc (Åsblad ed. al, 2001, p.24-27 & International Papers, 2006 & Ruth,1998: p.149 & de Beer, 1998: p.26).

This basic production technology has not changed significantly during 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 the energy efficiency in the dryer section of the paper machine. These new techniques will be discussed further in the energy consumption and technology section. The use of chemicals has changed during the past couple of decades and is expected to change further due to environmental regulation and the availability of new and better chemicals. Also the technology to control the fibres in the headbox has improved during the last 15 years. Better control of the fibres means stronger and thinner paper, while at the same time reduces the demand for pulp and reduces the energy input needed to dry the paper. On top of this, the size of the paper machines has increased significantly during the past 15 years. Ten years ago a 2.5 metre wide paper machine was considered normal but today this is considered small. Paper machines today are up to 10 metres wide and the width is constantly developing (Interview with Ole Lund, SCA packaging). Despite these changes the basic technology has remained unchanged during the time period examined in COMETR.

2 Structural trends in the paper industry

2.1 Production level and capacity of the paper industry

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 experienced problems meeting the demand for paper from consumers which led to favourable product prices for the paper producers (interview with Ove Lund, SCA packaging). Within the 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 in the same period; turnover from paper production in the CEPI countries almost doubled from about 40 billion Euro in1991 to about 79 billion Euro in 2000 (CEPI, 2004: p.18).

The turn of the century marked a change in capacity development and the economic situation of the paper industry. In the period from 2000 to 2005 the production level only increased from 93 million tonnes to 99 million tonnes (approx. 6 percent), a significant slowing in the production increase in relation to the period from 1991-2000 (CEPI,2004: p.18 and CEPI,2005: p.1).The figures indicate almost stagnant demand for paper. However, the demand for paper products is slightly more complicated than the figures imply. Consumer demand for paper products has continually increased. 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. The technological developments have made it possible to increase the quality and the strength of paper, making 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 decreased demand for paper as the same amount of paper (in tonnes) can satisfy an increased demand for paper products (e.g. numbers of sheets of writing paper, cardboard boxes, etc.). In effect the consumption of units of paper products has increased more than the actual paper production level because the production level is defined in tonnes of paper (interview with Ove Lund, SCA packaging).

While the increase in paper production has slowed, turnover has been decreasing since 2000. Turnover in the CEPI countries dropped from about 79 billion Euro in 2000 to about 74 billion euro in 2005 (CEPI,2004: p.18). This fall in turnover can be explained partly by the payment structure in the paper industry. Paper is generally priced according to the weight of the paper 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 products for the same amount (weight) of paper. On the other hand, this means that the paper producers face decreasing turnover in the case of a stable production (tonnes) level. An increase in turnover requires an increase in demand for paper products (units) that exceeds the increase in unit production per tonne of paper stemming from technological improvements in the paper production. The fall in turnover can also be explained by capacity developments. The capacity increase of the 1990s resulted in an overcapacity with regard to paper production facilities. This overcapacity has been affecting the paper market since around 2000 pushing the price of paper down and thereby affecting turnover.

2.2 Capacity adaptation

Capacity changes and changes in the production facilities of the individual companies are progressing slowly in the paper industry. The paper industry is capital intensive with capital investments written off over long periods. Typically paper companies annually invest an average of 6-10 percent of turnover. The high capital intensity makes it difficult for paper companies to adapt to new market situations stemming from rapid changes in consumer expectations and regulatory initiatives. 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 examined carefully before policy and investment decisions are made. Decisions on capital investments concerning capacity, production processes, energy, etc determine the actual production for many years. The life expectancy of a paper machine is 25-30 years. These machines need to be kept running 24 hours a day 365 days a year to create a reasonable economic return and company executives therefore only have limited possibilities to make major and instant changes in the production facilities, in order to react to ongoing market changes (CEPI, 1005: p.4, 13, Ruth,1998: p.148).

Despite the limited potential 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 the number and size of paper mills have also changed significantly. Figure 3 below shows the development in capacity structure of the paper mills in the CEPI countries. The number of paper mills has gone down by one third during the observed time period and at the same time the average size or capacity of the paper mills has almost doubled.

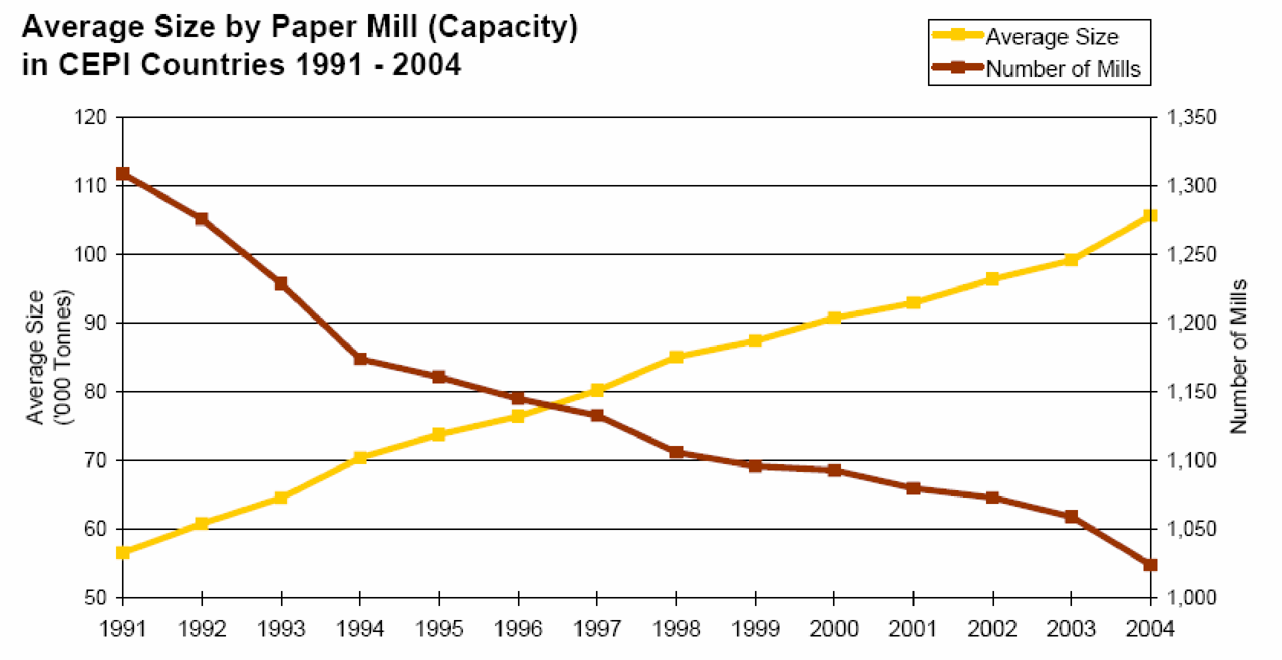

Figure 3 Average size by paper mill (capacity) in CEPI Countries 1991-2004
Source: CEPI 2004: p. 14

Basically paper production has been centralized to fewer and bigger production facilities. The increase in the average size of the paper companies can be explained by the technological development in the paper industry. Paper machines are getting wider. Ten-fifteen years ago a width of 2.5 meters was the norm for paper machines but today it is not unusual to see 10 meters wide paper machines. Also the capital intensity of the paper industry and the associated economics of scale have contributed to the closing down of smaller and less efficient paper mills (Nilsson,1995, p.1). The increase in the size of the paper machines increases the production capacity. Simultaneously with the increase in the average size of paper mills, the paper industry has also faced a number of company mergers and takeovers. The paper industry in Europe today is dominated by two major companies. Today the Smurfit Kappa Group and SCA controls almost 50 percent of the total European paper market (interview with Ove Lund, SCA packaging). This general trend toward larger production facilities is to some extent counteracted by the increased use of recycled fibres. Pulp and paper mills that have specialized 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 waste paper from densely populated areas at the same time as these 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: p.150).

2.3 Capacity adaptation and foreign trade

As described above, the development in consumption of paper products in the 1990s resulted in an increase in the paper production capacity. The capacity increase has caused an overcapacity which during the past five years has affected the turnover and the surplus of companies in the paper industry. Furthermore the paper industry is described as capital intensive, a characteristic which makes immediate change in production facilities difficult. Effectively it is therefore impossible to make any rapid changes in the production capacity of the paper industry.

One solution to the overcapacity problem in Europe could be to export the production overcapacity to countries outside Europe. Table 2 below shows that the export from CEPI countries to countries outside Europe has increased by more than 30 percent from 1999 to 2005. In the same time period the import level remained fairly constant and even decreased a little. When comparing the 30 percent increase in export to the development in the production level it becomes apparent that even though export constitutes an increased share of the total production, export to countries outside Europe only constitutes a limited share of the total production. In 1999 around 9 percent of the total paper production in the CEPI countries was exported to countries outside Europe while around 11 percent of the total production was exported in 2005.

Table 2 Importance of export and import in the European (CEPI) paper industry (1,000 tonnes)

	1999	2000	2001	2002	2003	2004	2005
Production of paper products	85757	90542	90075	93015	94722	99060	99334
Export (non-European countries)	7541	7699	8007	9460	10485	11627	10668
Import (non-European countries)	3208	3133	2678	2828	3090	2864	2977

Source: CEPI, 2006, p.1, 13 and CEPI, 2004a, p.8, 16 and CEPI, 2001, p.6

If we look at the overall export level from EU countries to both European and non-European countries the level increases. In 2005 EU countries exported paper products worth a total of 4,400 million dollars or 23.8 percent of the total world export (UN COMTRADE).

The CEPI and UN data is furthermore supported by the data collected for WP3 in the COMETR project. Figure 4 below shows the export situation for paper and paper products from 6 of the 7 COMETR countries. First of all the charts show that most countries export less than 10 percent of the production to countries outside Europe. Only Sweden has a significantly higher export share. The paper industry in Sweden exports between 15 and 20 percent of the total output. However, this high export figure should be seen in the light of the general status of Swedish pulp and paper industry. Sweden is one of the major producers of paper in Europe because of easy access to low-priced input in the form of wood. The Swedish paper industry can therefore produce paper at a very competitive price; therefore, it is natural that Sweden is an important exporter of paper products. The charts in Figure 4 furthermore show that the export level to countries outside Europe stayed fairly constant during the period observed. Similarly to the CEPI data, the COMETR data indicate that the European paper industry has not been able to export the production overcapacity.

Even though export to non-European countries only constitutes a small share of the output this does not mean that the COMETR countries rarely export paper products. Except for the UK the COMETR countries export more than 15 percent of the output from the paper industry to other EU countries. Denmark, Finland, Germany and the Netherlands all export between 20 and 40 percent of the total output. Sweden exports between 40 and 50 percent of 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 and thereby the associated transport costs are not too high.

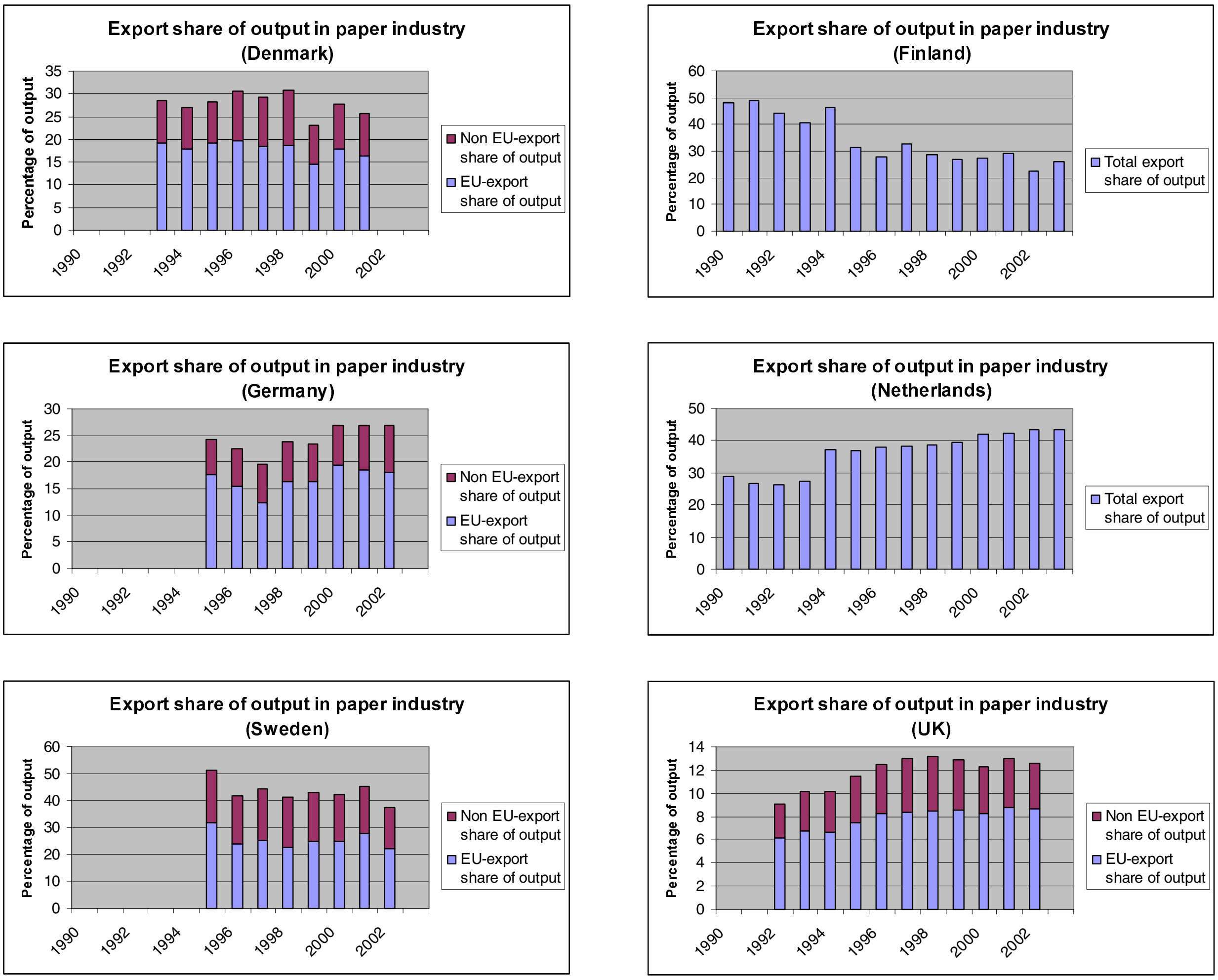

Figure 4 Trade analysis of sector 21.2 in the 6 COMETR countries

Note: For Finland and the Netherlands only total export data is available. For both Finland and the Netherlands the trade data is drawn up on the basis of two different data sources. It has been necessary to use two data sources because no one data source includes data for the entire time series. The use of two data sources causes a shift in the export level. In the Finnish case it could be argued that the export level from 1990-1995 represents the true export level while the 1996-2003 export level is underestimated due to the change in data collection methods of the data source (see COMETR data collection process paper for further explanations).

Source: Calculations based on the COMETR WP3 database

The CEPI export statistics and the WP3 data showing relatively low export levels to countries outside Europe also correspond with information given by Ove Lund, Finance Manager in the SCA group. Products from the paper industry are characterized by having a low price to weight ratio. A tonne of paper costs around 300 Euro. Reels of paper are a relatively homogeneous product with comparable prices regardless of the end purpose (newsprint, sanitary, packaging, etc.) of the paper. Transport costs are primarily determined by the weight of the product and because of the low price to weight ratio of paper the transport costs are relatively high compared with the value of paper. Ove Lund describes that it would cost around 30 Euro (or 10 percent of the value of the paper) to transport a tonne of paper from Denmark to the Netherlands. Transport from Denmark to southern Europe would cost around 60 Euro or 20 percent of the value of the paper. The high transport costs effectively reduce transport, especially long-distance transport, simply because it is rarely economically profitable to transport paper over long distances. Paper is therefore mainly transported over fairly short distances for domestic use or to neighbouring countries (interview with Ove Lund, SCA packaging). Export has therefore not been a viable solution to the overcapacity problem in Europe.

The only real possible solution for the European paper industry to avoid the overcapacity problem has therefore been to close production facilities down. One example of such a closure is the SCA paper mill in Grenå, Denmark. The SCA group decided to close down some of their production facilities in order to support a more profitable European paper capacity level. The Grenå paper mill was closed in the beginning of 2006. One of the problems with the closure of paper mills is the potential capital loss. The paper industry is very capital intensive and paper machines have a life expectancy of 25-30 years. The paper machines at the Grenå paper mill were not worn down and in order to minimize the capital loss these paper machines were sold to paper producers in Turkey and South Africa for approximately 125 million Euro. 125 million Euro for some used paper machines with the capacity to produce around 210,000 tonnes paper annually indicates the high capital intensity of the sector. One of the main reasons for the SCA group to close down production facilities was to improve the capacity situation in Europe. The fact that one of the Grenå paper machines was sold to Turkey indicates that paper products are seldom exported over long distances. Moving a paper machine from Denmark to Turkey effectively means that the production capacity has been moved far enough away from Europe to reduce the overcapacity in Europe. It is simply not expected that any real export to Europe will ensue from paper production in Turkey (interview with Ove Lund, SCA packaging and Lund, 2005, p.4).

2.4 Foreign trade and recycled paper

Differences in the trade characteristics between the six COMETR countries can be further illuminated by the utilisation of recovered paper. Recovered paper is an important input to paper production in many paper production facilities, but the use of recovered paper also has a tendency to affect the entire structure of paper production. While traditional pulp and paper companies are often located in the vicinity of forests or with easy transport ways to forest areas, because these companies rely on virgin fibres from wood, pulp and paper, mills that have specialized in using recycled paper as the primary fibre source are increasingly located in close proximity to population centres with dense populations that consume both large amounts of paper and produce large amounts of wastepaper for recycling. This structural difference effectively means that paper production based on recycled fibres is to some extent anchored more locally, both in terms of input and output, than paper production based on virgin fibres (Ruth, 1998: p.150). It is therefore interesting to look at the use of recovered paper when analysing the trade differences between the COMETR countries. Utilisation of recovered paper has increased significantly since the mid 1980s. Figure 5 below, showing the recycling rate and the total amount of recovered paper in the CEPI countries, shows how the amount of recovered paper almost doubled (from 25 million tonnes to about 47 million tonnes) between 1991 and 2001.

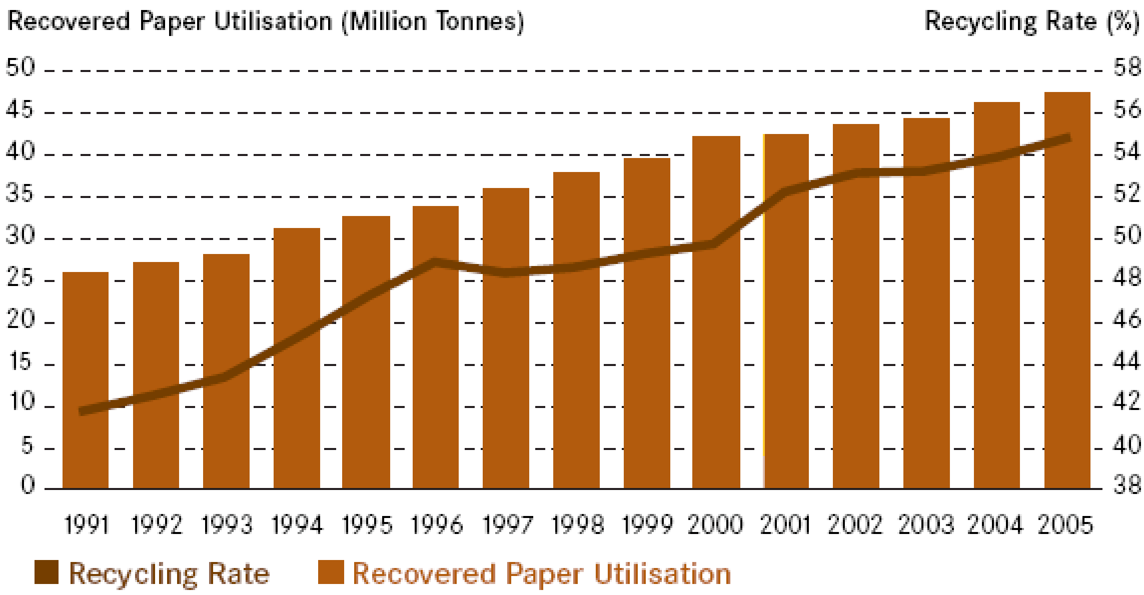

Figure 5 Development in the use of recovered paper and the recycling rate in CEPI countries
Recycling rate: Percentage of recovered paper utilisation compared to total paper consumption
Utilisation rate: Percentage of recovered paper utilisation compared to total paper production
Source: CEPI, 2006, p. 18

The increase in the overall use of recycled paper in the CEPI countries reflects some large differences between the individual countries. Table 3 below presents the utilisation rate or the percentage of recovered paper utilisation as a percentage of the total paper consumption in each of the COMETR countries. Finland and Sweden both have low utilisation rates while Denmark has a very high utilisation rate. In Denmark the input of recycled paper in the paper production constitutes more than 100 percent of total paper production. The percentage can exceed 100 percent because some of the paper fibres are lost when paper is being produced using recycled paper as the basis for the input of paper fibres. At the other end of the scale Finland and Sweden both have utilisation rates below 20 percent. This means that the amount of recycled paper constitutes less than 20 percent of the total production of paper products. Effectively this means that paper production in Finland and Sweden is based on primarily virgin fibres. Paper production in Denmark is based on fibres from recycled paper, while paper production in the remaining countries is based on a mixture of virgin fibres and recovered fibres. These differences seems obvious from a natural resources point of view. Finland and Sweden are the two COMETR countries with the easiest and cheapest access to wood due to vast areas of forest and therefore it would appear natural that paper production in Finland and Sweden is based on virgin fibres.

Table 3 The utilisation level of recycled paper in the COMETR countries in 2002

	Utilisation rate
Denmark	102.7
Finland	5.5
Germany	65.0
Netherlands	71.1
Sweden	17.4
United Kingdom	74.2

Note: Utilisation rate: Percentage of recovered paper utilisation compared to total paper production.

Source, CEPI, 2003: p.12

Ruth (1998) argues that the production of paper from recycled paper is anchored more locally both in terms of input and output (see above). This effectively means that export of paper products can be expected to be more extensive from countries with a paper production based on virgin fibres compared with paper production based on recycled fibres. Virgin fibres simply constitute a large input base that makes large-scale production with improved export potential possible. The trade data in the COMETR dataset to some extent support this theory. Denmark, Germany and UK all have low export rates for paper products, while Sweden and Finland display a high export ratio. The low values in the second half of the period in Finland are expected to be caused by changes in the Finnish data collection method. The Finnish export ratio is assumed to be high, also in the second half of the research period, and this assumption of a high export ratio in Finland is confirmed in data published by CEPI. Table 4 below presents the CEPI data on export share of total production in 2002. The data confirm that the Finnish paper industry has a very high export ratio. The CEPI data are measured in tonnes, whereas the COMETR data is measured in monetary values. The two datasets are therefore not completely comparable in absolute terms. Based on general economic theory[1] it can be expected that export products are sold at a lower price than domestic products, causing the export share of total production in monetary terms to be lower than the export share of total production in physical (tonnes) terms. This difference can explain the approximately 50 percent differences between the export share of total production in physical terms and export share of total production in monetary terms. Despite these differences it is apparent that the CEPI data reflect the same situation as the COMETR data in Figure 4 above. In both the CEPI and the COMETR data Sweden and Finland display the largest export share while the UK by far has the lowest export share of the six countries. Denmark and Germany are placed in between the two extremes, while the Netherlands also has a high export share.

[1] According to economic theory companies are forced to lower prices on the international marked because of more intense competition and higher transport cost.

Table 4 CEPI data on trade characteristics in 2002

	Total production (tonnes)	Domestic deliveries (tonnes)	Export (tonnes)	Export share of total production
Denmark	404	153	251	62.1
Finland	12 267	1 090	11 177	91.1
Germany	16 410	8 695	7 715	47.0
Netherlands	3 889	9 58	2 931	75.4
Sweden	10 498	1 493	9 005	85.8
UK	6 190	4 944	1 246	20.1

Source: CEPI, 2003: p.20

3 Energy consumption and technology in the paper industry

3.1 Energy characteristics in the paper industry

Paper products and paper production have earlier in this paper been described as fairly homogeneous. Despite the fact that paper products are used for various purposes, paper production methods are fairly standardized as described in section 1.2. These similarities are reflected in the overall energy characteristics of the sector. Figure 6 below shows similar energy intensity in all the COMETR countries.

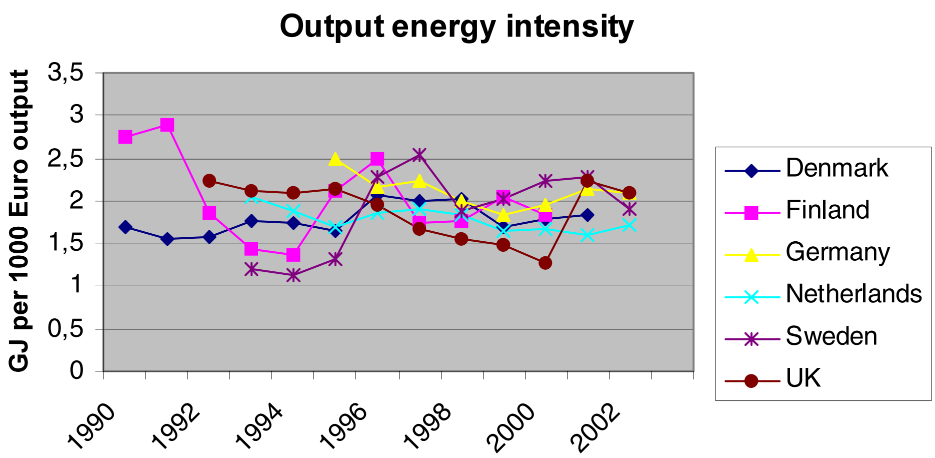

Figure 6 Energy intensity in sector 21.2 (2000 prices)
Source: Calculations based on COMETR WP3 database

The differences in energy intensity can partly be explained by differences in the energy price across the COMETR countries. The most prominent differences in energy price can be found in the natural gas prices. Table 5 below shows how the natural gas price at the end of the observed time period in the UK is less than half of the price in any other country. It can be argued that low energy prices lead to limited incentives to focus on energy savings which in turn affects the overall energy intensity. The Finnish paper industry was also charged low natural gas prices, but unlike in the UK natural gas only constitutes a small percentage of the total energy consumption and therefore did not affect the Finnish energy intensity in the same way. Natural gas constitutes less than 15 percent of the total energy consumption in Finland, except for 1990 and 1991, whereas natural gas constitutes more than 40 percent, except in 2001 and 2002, of the total energy consumption in the UK paper industry (see Figure 8 below on the mix of energy products in the COMETR countries).

Table 5 Natural gas prices (including tax) in the paper industry (EURO/GJ)

	Denmark	Finland	Germany	Netherlands	Sweden	UK
1990	5.0	2.7	5.0		8.9	2.8
1991	4.7	2.8	5.3		9.1	2.9
1992	2.7	2.7	4.7		8.7	2.8
1993	5.0	2.8	4.5	4.1	7.0	2.6
1994	5.2	3.2	4.3	4.0	6.0	2.4
1995	4.3	3.4	4.2	4.3	5.8	2.1
1996	3.8	3.6	4.2	4.4	7.2	1.7
1997	4.1	3.9	4.5	4.7	9.1	1.6
1998	3.9	3.8	4.3	4.7	8.7	1.6
1999	3.7	3.9	4.0	4.2	8.3	1.5
2000	4.5	4.3	5.4	5.3	7.7	1.6
2001	5.1	4.8	5.3	5.8	9.9	2.0
2002	4.2	4.1	5.3	5.1	7.3	2.0

Source: Calculations based on COMETR WP3 database

The notion that company managers focus on the relative cost of energy instead of actual energy consumption is supported by a comparison of the unit energy costs across the COMETR countries. Figure 7 below on the energy cost per output in the paper industry shows how the UK unit energy cost aligns with the unit energy cost of the other COMETR countries during the second half of the observed time period. Effectively the paper industries in the various countries have very similar energy costs per unit of output. In 2000 the unit energy cost varies between 13.7 euro and 17.2 euro per 1,000 euro output across the six COMETR countries. The 3.5 euro variation between the lowest and the highest unit energy cost only constitutes a deviation of 25 percent compared with the lowest unit energy cost. Taking into consideration that the production method (use of virgin versus recycled fibres) and the product grades (i.e. newspaper print, hygiene products, packaging paper) varies between the six countries, causing some differences in both energy required and value of output, the 25 percent variation in unit energy costs can be categorized as a very small variation.

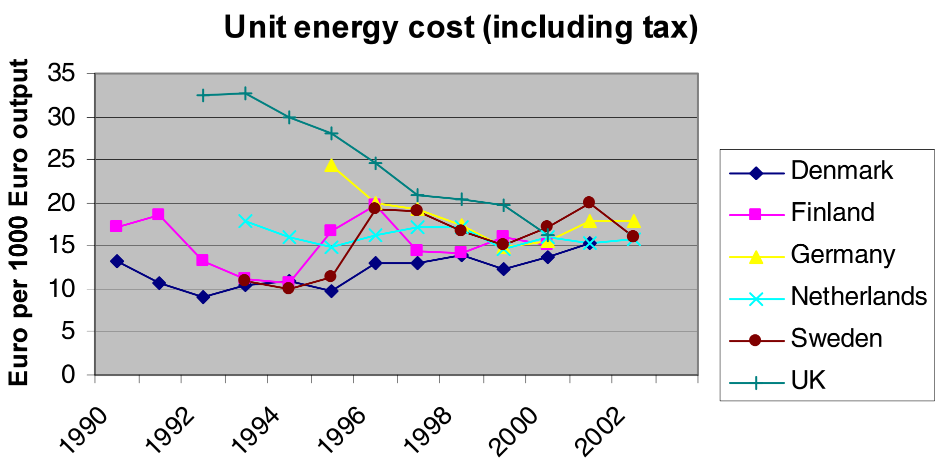

Figure 7 Energy cost per output in sector 21.2 (2000 prices)
Source: COMETR WP3 database

3.2 Variation in energy mix

Despite the general similarities in energy intensity and unit energy costs, there are still some rather prominent differences in the energy consumption patterns across the COMETR countries studied here. This section will look into the variations in energy mixture across the COMETR countries. Paper industries in the COMETR countries consume a large variety of different energy products. Variation in the energy product mix can partly be explained by at least three factors.

First of all the production of paper articles can be divided into different grades or types of paper products, such as packaging, sanitary, graphic/stationary, etc. In section 1.1 the table on 'total production of paper products and percentage production by grade' showed how the COMETR countries produce different amounts of the various paper grades. Different products require different production methods in the production process and these differences can be one of the explanations behind the variation in the mix of energy products used in the six COMETR countries.

Secondly, the energy mix used in the COMETR countries can be influenced by the energy infrastructure or the national characteristics of energy distribution system. The infrastructure of energy supply both in the form of the level of self-sufficiency and distribution net (pipelines, power grid or road/rail transport) is not equally developed for all energy products in all countries. For example significant differences are apparent across the COMETR countries in self-sufficiency and the extent of pipelines for natural gas. The UK, the Netherlands and Denmark are virtually self-sufficient in natural gas, while Finland and Sweden are forced to import their entire consumption of natural gas (Hierl, 2000: p.32). The very existence of natural gas as a natural resource in a country causes a more extensive distribution network to be built up and naturally also a much higher consumption of natural gas. The availability of natural gas as a natural resource in a country can be read directly from consumption pattern of energy in the paper industry. Sweden and Finland, the only two COMETR countries with no domestic production of natural gas, are also the two COMETR countries with the lowest share of natural gas consumption. Figure 8 below shows the combination of energy products consumed in the COMETR countries. The figures show how natural gas consumption in Sweden and Finland constitutes less than 10 percent (except for Finland between 1990 and 1992) of total energy consumption, whereas in the UK, the Netherlands and Denmark natural gas consumption constitutes between 20 and 70 percent of total energy consumption. The situation in Germany differs slightly from that in the other countries. Germany imports approximately 80 percent of its total natural gas consumption (Hierl, 2000: p.32), but can still be categorized as a large consumer of natural gas. Whereas Finland and Sweden have easy access to large amounts of hydropower and biofuels, Germany does not have domestic access to large amounts of fossils fuels or other energy sources, except for coal, and Germany is therefore dependent on the import of various energy products. Figure 8 below shows how natural gas constitutes more than 50 percent of the total energy consumption in the German paper industry. Several other sectors in Germany consume large quantities of natural gas and the status of Germany as a natural gas consuming country can be explained by easy access for Germany to the natural gas distribution network. The European natural gas transmission grid shows how Germany is linked both to the large natural gas fields of Norway, UK and Denmark in the North Sea as well as the large natural gas pipelines from Russia (Hierl, 2000: p.36). The combination of the lack of domestic energy production and easy access to a European natural gas supply network to a great extent explains the large consumption of natural gas in Germany despite low domestic extraction of natural gas.

Thirdly, the different energy mix between countries can be caused by differences in carbon-energy taxation and hence the relative costs of the various energy carriers. A textbook example of the importance of the relative prices of energy carriers can be found in the Danish case. Until 1996 the Danish paper industry had a high consumption of fuel and gas oil. From 1997 and onwards the consumption of fuel and gas oil in the Danish paper industry has only constituted around 10-15 percent of the total energy consumption. The decline in the consumption of fuel and gas oil coincides with a significant increase in carbon-energy taxation on fuel and gas oil in 1996. During the second half of the period observed, the ex-tax price of fuel and gas oil also increased significantly. In the time period from 1996-2001 the total price of fuel oil increased by 200 percent while the price of gas oil increased by just over 70 percent. The total price of natural gas and electricity only increased 34 and 17 percent in the same time period. These differences in price development seriously affected the price balance between fuel oil and gas oil on the one side and natural gas and heat on the other. The change in the consumption levels of the energy carriers coincides with the movements in the price balance. The Danish case can therefore be concluded to represent a natural example of how relative price changes can shift the consumption levels of energy carriers.

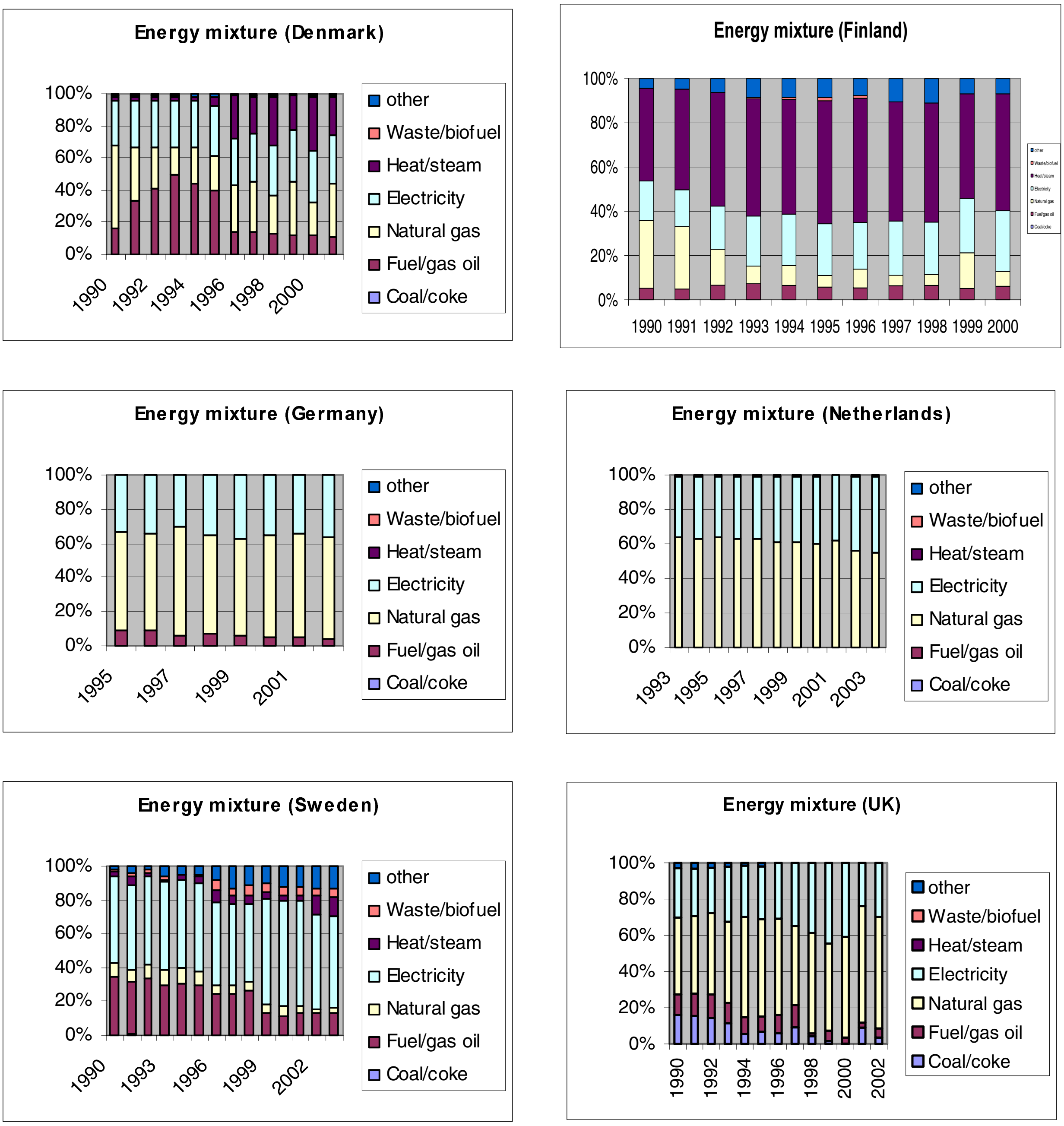

Figure 8 Energy composition in the COMETR countries

Source: Calculations based on COMETR WP3 database

Note: The energy consumption data delivered by the Dutch statistical bureau only differentiate between three kinds of energy carriers: natural gas, electricity and 'other'. In some sectors this lack of detail in the differentiation of the energy carriers can make it difficult to observe the real changes in energy consumption. In the paper sector, however, the 'other' energy category is of limited importance and does not effect the evaluation of the overall development in the energy mix.

3.3 Carbon-energy taxation and the paper industry

The entire pulp and paper industry (main sector 21) is considered to be an energy-intensive industry because of the high energy consumption in pulp production and basic paper production, whereas the paper products industry (sub-sector 21.2) can be categorised as less energy intensive (see COMETR deliverable 3.4 for further description of 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, however, still constitutes a significant expenditure for the paper industry. Improvements in energy consumption effectiveness are of great importance and the next section will look more closely into technology and technological developments related to the consumption of energy in the paper industry. When trying to minimize the cost of inputs, such as energy, consumption effectiveness or energy intensity is important. However, from a company executive point of view the cost structure of the energy input is equally important as the energy effectiveness. For this reason company executives and industry organisations, also from the paper and paper products industry, have been active in debate concerning carbon-energy taxation and other regulatory induced increases in energy prices. Table 6 below shows that the carbon-energy taxation in the paper industries in the COMETR countries constitutes between 0.13 and 0.67 percent of the GVA in the various countries. A tax burden constituting less than a half percent of the total value added appears on the surface to be of insignificant economic importance to the companies. However, when this tax share is translated into actual monetary payments, it becomes apparent that more substantial sums are at stake. The second column of Table 6 below shows that in Germany alone the government collected more than 25 million Euro in carbon-energy taxation from the paper and paper product sector.

Table 6 Energy taxation in the paper and paper products industry (2000 figures)

	Energy tax share of GVA (percentage)	Total energy tax (million euro)
Denmark	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: Calculations based on COMETR WP3 database

As in any other private sector, costs arising from taxation and regulation on the paper industry often raise concern from company executives and industry organisations, as these costs often can constitute significant sums of money. One recent example of regulatory induced increases in energy costs in the European paper industry is the EU emission trading scheme (ETS). The pulp and paper industry have supported the basic principle of the ETS of emission reduction in a cost-efficient manner. Despite this support of the ETS scheme the paper industry have criticised some of the economic costs related to the ETS. The paper industry has a fairly high consumption of electricity and heat, which means that changes in prices on these energy carriers will affect the paper industry significantly. The high consumption of electricity and heat is the background for the criticism launched by the paper industry of the effect of the ETS on electricity prices. The pulp and paper industry, as well as many other large electricity consumers, is not content with the fact that electricity producers pass on the opportunity costs of emission allowances that have been grandfathered to the electricity producers. The design of the ETS makes it possible for the electricity producers to pass on the opportunity cost instead of the actual cost caused by the ETS, thereby increasing the electricity price to an unnaturally high, non-competitive level. Ultimately the high electricity price harms the competitiveness situation of the large electricity consumers (Hyvärinen, 2005).

3.4 Energy efficiency and technological improvements

The focus on energy and energy costs, mainly driven by changing demand and more stringent environmental regulation, has led to extensive research on energy technology and caused a significant change in the technological methods applied in the pulp and paper industry (Nilsson, 1995).

The most energy-intensive process when producing paper is the drying. The drying process reduces the water content of the paper after the paper has come from the paper machine press. In conventional paper machines the paper is heated in order to reduce the water content. The paper passes a series of cylinders heated by steam (see section 1.2 above). About 90 percent of the steam (the steam is either obtained from the public grid or produced directly at the paper mills) required in paper production is used in the drying section of the paper machine. The electricity demand on the other hand is more evenly distributed across the different elements of the paper production process. Simply because the drying element is the most energy-intensive, it is natural that technological development related to energy has been focused here (de Beer, 1998: p. 26-29; Nilsson, 1995). The energy savings potential is significant. In a study from 1998 it has been estimated that a 30 percent reduction in the consumption of both heat and electricity would be technically possible within a decade (de Beer, 1998: p.25).

Several different options for technological development are available. The various technological changes of the drying section can focus on the basic problems in the drying section and include increasing the solid content from the press section (a lower-water percentage takes less energy in the drying section), reducing overall heat losses, using less air, or increasing the heat extraction from each unit of steam used in the drying section (Nilsson, 1995). Several alternative technological solutions that approach these basic problems have been developed with various degrees of success.

These technologies include a *press drying system*. The press drying system usually has a heated press roll in between the press section and the drying section. Data indicates that the drying rate in a press-drying section is between 2 and 10 times faster than in the conventional drying cylinders, making it possible to reduce the number of drying cylinders significantly compared with a conventional paper machine as described in section 1.2 above. When using the press drying system there is simply no need for the extra drying cylinders and thereby the heat requirement is reduced. The second technological option for reducing energy consumption is the *condensing belt drying system*. In the condensing belt drying system the paper is dried in an airless drying chamber. Paper is heated by contact with a hot steel band, heated by steam or hot gas, and the evaporated water from the paper passes through two layers of wire gauze before it is condensed on a cold steel band and removed by pressure and suction. In a condensing belt drying system the heated area is much larger than in a traditional paper machine. A steel band simply has a larger surface area than the conventional drying cylinders. The drying rate can be 5-15 times higher than with a convention drying cylinder system. It has furthermore been estimated that the condensing belt drying system can reduce the steam requirement by approximately 10-20 percent compared with conventional drying systems. The third example of a new and innovative drying system is labelled the *air impingement drying system*. With the air impingement drying system air heated to 300 degrees C is blown at high velocity against the wet paper causing the water in the paper to evaporate. The impingement drying system is used in combination with a reduced number of conventional drying cylinders. It has been estimated that the air impingement drying system can reduce the heat consumption by approximately 10-40 percent. The fourth and final new technology described here is labelled the *airless drying system*. The airless drying system uses conventional drying cylinders, but as an addition to the conventional system the entire drying section is sealed within an airtight and insulated hood. The sealing makes it possible to reuse the latent heat of the evaporated moisture from the paper. Evaporated moisture is compressed from atmospheric pressure to 4 bar in order to increase the heat, and thereafter this superheated steam is redirected to the drying cylinders. It has been estimated that the reuse of the latent energy in the evaporated water can reduce the heat consumption in the drying section by as mush as 70 to 90 percent (de Beer, 1998: p.31-37). The examples of technological innovation described above show a large potential for energy reductions. Unfortunately some of these technological innovations are difficult to implement and require extensive capital investment. Therefore the new technologies cannot, especially in the short run, be expected to be implemented in the paper industry despite the potential for energy efficiency (de Beer, 1998: p.37-40).

Also within EU framework research on energy consumption and consumption of natural resources in the paper industry technology has attracted some attention. Technologies to improve the environmental impact of the paper industry are constantly being developed and improved. A recent example of ongoing research and development in the paper industry is the ECOTARGET research project. ECOTARGET is an integrated research project financed by the EU Commission within the EU Sixth Framework Programme. The ECOTARGET project was initiated in 2004 and is scheduled to end in 2008. The project has been labelled the largest research project ever in the European pulp and paper industry and has a total budget of 17.9 million euro. The purpose of the project is to design new and innovative processes for radical changes within the pulp and paper industry. The project not only includes energy-related issues but includes a broad span of resource consumption issues related to production of pulp and paper. Basically the aim is to design new production methods that can produce more output per input (wood raw material, energy, water) and methods that can reduce the level of waste and emissions. In relation to energy the goal of the ECOTARGET project is to design new production methods that can reduce energy consumption per unit of output by 30 percent (ECOTARGET, 2006).

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Competitiveness Effects of Environmental Tax Reforms (COMETR)

The Basic Chemicals Industry

WORK PACKAGE 5 – Industry Studies

Authors: Edward Christie (wiiw) and Sue Scott (ESRI)

31 December 2006

Abstract
This study starts off with a basic global overview of the basic chemicals industry in terms of production volumes and main production locations. European production patterns are then shown separately, and additional elements such as trade flows and leading companies are also briefly discussed. Energy use and emissions of the industry are then discussed at the European level, together with results from interviews of selected European manufacturers.

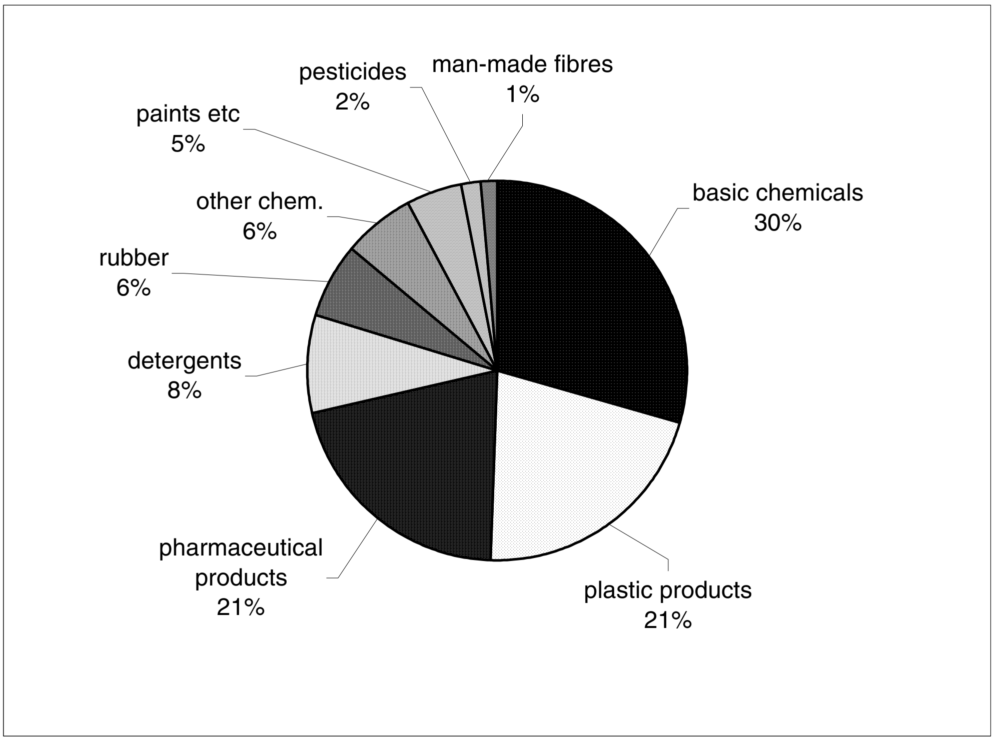
Table of contents

Section 1 – Introduction

The basic chemicals industry 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).

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[1]. Graph 1.1 shows the (estimated) shares in the total turnover of NACE 24 plus NACE 25 of each NACE 3-digit sub-industry within that grouping. The shares are based on estimated turnover totals for 2003. Basic chemicals is the largest 3-digit level industry within the NACE 24 and 25 grouping with 30%.

Graph 1.1 – The basic chemicals industry in the context of NACE 24 + 25



Source: Eurostat SBS and own calculations and estimations

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.

[1] Eurostat (2005) finds a total of 73.3% for gross value added based on SBS data for 2002. Using SBS data for 2003 we find a share of around 71% for total turnover.

A more detailed description (down to the 6 digit level) of what is included in CPA 24.1 can be found in Appendix A. One should note here that the sub-industry often referred to as *petrochemicals* is a part of Other basic organic chemicals (24.14).

At the European level the two most important sub-industries are *Other basic organic chemicals* and *Plastics in primary form*. Using 2003 SBS data we arrive at estimates of total turnover shares within the basic chemicals industry of 44% and 33% respectively (more detailed estimates are presented in section 3). Given the importance of the (secondary) plastic products industry (NACE 25.2) we conclude that a substantial part of total activity within the NACE 24 and 25 grouping is devoted to plastic products, whether in primary or in secondary form (roughly 30% judging from the figures given above).

For these reasons this study will present certain general results concerning the plastics industry in general in those cases where differentiation between primary and secondary production isn't available (e.g. corporate data). This study will also focus rather more on the two main sub-industries mentioned in those cases where data on the less important sub-industries are not easily available. In the case of other basic organic chemicals this will include looking especially at the petrochemicals industry.

These choices have an important scientific and technological justification as well, and it is relevant here to give a very brief description of the (main) production chain of organic chemicals. The starting point is the oil refinery. Refining of products such as crude oil is part of the fuel manufacturing industry (NACE 23). Much of the output is used for transportation (e.g. petrol for land vehicles and kerosene for aircraft). Heavy outputs such as tar are used for road construction purposes. A much smaller part of the output (around 4% of total output in Europe) comes in the form of naphta, which constitutes the main material input for the petrochemical industry in Europe. The main alternative is gas. Naphta is a heterogeneous liquid similar to, but on average slightly heavier than, petrol. It is fed into plants called steam crackers. These installations break (crack) the carbon- and hydrogen-based molecules (i.e. organic compounds) in the naphta into shorter molecules which are important basic components that will find uses in many parts of the chemicals industry. The most important outputs are ethylene, propylene and benzene. Two generic terms for such compounds are *alkenes* (used mostly in scientific circles) and *olefins* (used mostly in industry circles). The key characteristic of these compounds is that they include at least one carbon-to-carbon double-bond. Ethylene, also called ethene[2], is the key input for the production of polyethylene, which is the most common type of plastic. It is a polymer of ethylene, i.e. a long molecule that is the result of the bonding of a large number of molecules of ethylene. Polyethylene is a traditional name. The modern scientific name is polyethene (as ethene is to ethylene). A third synonym, used mainly in the UK, is polythene. A detailed description of the chemistry of polyethylene can be found in Piel (2005). Propylene (propene) can likewise be polymerised to produce polypropylene (polypropene), also a widely-used plastic. As for benzene it is a so-called aromatic hydrocarbon (includes a carbon ring of six carbon atoms) and is used as an input in the production of plastics, detergents, dyes, pesticides and pharmaceutical ingredients.

This brief discussion brings us to the manufacture of plastics. Plastics are materials composed of long organic molecules, in most cases synthetic polymers. Thus the key manufacturing process that leads to plastics in primary form is polymerisation, which consists in bonding a large number of copies of an identical base molecule (the monomer) to one another into a long chain. The resulting polymers are plastics in primary form. Secondary processing of the polymers leads mainly to the manufacturing of plastic products (NACE 25.2), or to the manufacturing of synthetic fibres (NACE 24.7), e.g. nylon or acrylic filament or yarn.

[2] Ethene (C_2H_4) should not be confused with ethane (C_2H_6). Ethene has a double bond between the two carbon atoms, ethane hasn't, hence the difference in the number of hydrogen atoms. In terms of classification ethene is an *alkene*, whereas ethane is an *alkane*.

There are many different types of primary plastics and several possible classification systems. The main classification which seem useful to us is the chemical view which differentiates plastics according to their composition (polymers of ethylene, of styrene, of vinyl chloride etc.)

Section 2 – 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. In this section we will 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.

Petrochemicals

Table 2.1 – World production of selected petrochemical products by region, 2005

Product / region	Asia	Western Europe	North America	South America	Total
Volumes (ths tonnes)					
Ethylene	15,824	21,600	28,688	3,853	69,965
Propylene	11,258	15,406	16,608	1,908	45,180
Benzene	8,726	8,425	7,647	1,118	25,916
Shares					
Ethylene	23%	31%	41%	6%	100%
Propylene	25%	34%	37%	4%	100%
Benzene	34%	33%	30%	4%	100%

Source : International Petrochemical Information Forum – from www.petrochemistry.net

As we can see from table 2.1, 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 share for the European Union is slightly higher (production in the New Member States is larger than in the non-EU Western European states, see table 3.4 in the next section). 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.

Plastics in primary form

Global production of plastics is dominated by six main polymer groups, and in particular by the three main types, which are polyethylene, polypropylene and PVC. Together the top three accounted for 68.7% of global production in 2004, while the top 6 types accounted for 88.6% of global production in 2004. The production volumes and shares are presented in table 2.6. The data presented are estimates re-calculated from secondary sources.

Table 2.2 – World production of plastics by type, ths tonnes, 2004

Type	Volume	Share
Polyethylene (PE)	71,323	31.8%
Polypropylene (PP)	44,577	19.9%
Polyvinyl Chloride (PVC)	37,891	16.9%
Polystyrene (PS) and Expanded PS (EPS)	17,831	8.0%
Polyethylene Terephthalate (PET)	14,488	6.5%
Polyurethane (PUR)	12,259	5.5%
Engineering plastics and blends	11,144	5.0%
Others	14,487	6.5%
TOTAL	224,000	100.0%

Source: Piel (2005), PlasticsEurope Deutschland e.V. and own calculations

In the industry it is common practice to distinguish between two or three main types of polyethylene. It is also (as in table 2.2) common and convenient to use acronyms for plastic types. The three main sub-types for polyethylene are low density polyethylene (PE-LD, or LDPE), linear low density polyethylene (PE-LLD, or LLDPE) and high density polyethylene (PE-HD, or HDPE). The former two are grouped together in certain reports and publications.

What are the expected medium-run trends that are expected? According to forecasts (made in 2004) available from PlasticsEurope Deutschland, production and consumption of the main types of plastics should all rise in the next years. Absolute growth in volume should be strongest for polypropylene (PP). In relative (%) terms the strongest growth is expected for PET, which is well-known in Europe notably for its use in the production of recyclable plastic bottles for non-alcoholic beverages. In terms of downstream industrial demand one interesting source of growth expressed in BASF (2004) is the increase in relative demand for plastic products by the passenger vehicle industry. In total vehicle weight terms plastics accounted for only 6% of the total in 1975. This proportion had reached 13% in 2002, and BASF(2004) forecasts that this share should reach 18% in 2007.

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.

Fertilizers

The main data source on global fertilizer production in the public domain is the International Fertilizer Association (IFA). As this sub-industry is only a very small part of the chemicals industry we restrict our coverage to just two important commodities: ammonia and urea. Data on other commodities is available from the IFA web-site[3]. The global picture for ammonia is presented in tables 2.3 and 2.4 which show production and net trading position (exports to the world minus imports from the world) for each main region.

[3] www.fertilizer.org

Table 2.3 – 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.

Table 2.4 – Ammonia net trade position by region, ths tonnes of Nitrogen equivalent

Region	2000	2001	2002	2003	2004
Western Europe	-1,923	-1,811	-1,684	-1,853	-1,838
Central Europe	204	76	-56	137	193
E. Europe & C. Asia	3,810	3,799	3,246	3,872	3,971
North America	-2,680	-3,430	-3,389	-4,299	-4,429
Latin America	2,280	2,770	3,138	3,119	3,638
Africa	-373	-377	-380	-345	-278
West Asia (M. East)	513	744	699	648	664
Asia	-1,673	-1,623	-1,510	-1,252	-1,876
Oceania	-157	-95	-39	7	-40

Source : IFA – Production and International Trade – February 2006 and own calculations

In terms of net trade it is Eastern Europe and Central Asia which is the largest net exporter, followed by Latin America. At the opposite end North America is the largest net importer, followed by Asia and Western Europe at roughly equal net positions in 2004.

Production and net trade by region for urea are presented in tables 2.5 and 2.6. As with ammonia Asia is of course by far the largest producer. However here 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.

Table 2.5 – Urea production by region, ths tonnes of Nitrogen equivalent

Region	2000	2001	2002	2003	2004
Western Europe	1,917	2,235	2,081	2,068	2,049
Central Europe	1,496	1,303	1,184	1,398	1,418
E. Europe & C. Asia	4,198	4,024	4,303	4,456	4,891
North America	5,283	4,438	5,080	4,511	4,976
Latin America	1,171	1,593	1,922	1,941	2,126
Africa	34	0	0	0	0
West Asia (M. East)	4,945	5,420	5,870	5,608	5,618
Asia	30,331	30,168	31,667	32,579	35,422
Oceania	204	226	200	223	227
World Total	49,578	49,408	52,306	52,783	56,727

Source : IFA – Production and International Trade – February 2006

The position of Asia is close to being balanced in proportional terms. However Oceania and Africa are, respectively, highly dependent and totally dependent on imports. Latin America, North America and Western Europe are relatively large net importers relative to their domestic production levels.

Table 2.6 – Urea net trade position by region, ths tonnes of Nitrogen equivalent

Region	2000	2001	2002	2003	2004
Western Europe	-1,177	-918	-863	-1,216	-954
Central Europe	592	286	228	512	160
E. Europe & C. Asia	3,491	3,199	3,446	3,415	3,671
North America	-844	-1,203	-645	-1,550	-1,246
Latin America	-2,124	-1,562	-1,565	-1,865	-1,755
Africa	-573	-634	-730	-657	-814
West Asia (M. East)	2,417	2,901	3,009	3,007	2,708
Asia	-956	-1,276	-2,075	-765	-938
Oceania	-710	-689	-665	-719	-800

Source : IFA – Production and International Trade – February 2006 and own calculations

Section 3 – 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 (also referred to as the Structural Business Statistics, SBS). This is shown in table 3.1.

Table 3.1 – Total Turnover by Sub-Industry and by 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*	4591	3469	23994	2382	29864	*834*	65968
France	2088	1210	2765	15413	2391	5187	951	30005
UK	*2040*	*2040*	2370	11622	1410	5724	1104	26310
Netherlands	*272*	758	1356	12820	1192	7725	*272*	24395
Ireland	*56*	*56*	46	21242	302	221	0	21923
Italy	1228	905	1841	2725	944	12124	204	19971
Belgium	622	650	2042	8549	401	3676	665	16604
Spain	976	798	1444	2801	905	7425	262	14609
Finland	192	281	939	626	366	1073	297	3774
Poland	251	*26*	294	793	1098	838	*26*	3326
Austria	216	*41*	266	489	360	1270	*41*	2683
Hungary	156	34	94	142	113	1105	1	1644
Portugal	182	53	118	332	222	669	0	1576
Slovenia	51	107	76	57	0	44	0	334
TOTAL	9165	11550	17120	101604	12085	76944	4655	233121

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

For reasons of confidentiality, but also in some cases because data is not reported, there are some missing values for certain countries at the NACE 4-digit level. The methodological choice we have made is to stick to turnover data for 2003[4]. Unfortunately no data at all was available for Sweden, Greece, Malta and Cyprus. Luxembourg was also excluded as it has zero activity in all sub-industries except synthetic rubber, the turnover of which is confidential thus requiring a confidential total for the whole industry as well. Adding up total turnover for the industry for the remaining 20 EU member states we found a total turnover of 237'317 million Euros. We then excluded those countries for which more than 2 sub-industries were not reported, and ended up with a subset of 14 countries. The data we present in table 3.1, covering the 14 countries selected, represents a total of 233'121 million Euros, thus a coverage of 98%. The countries are ranked according to total turnover for the industry as a whole. We preferred to stick to this sub-set of incomplete data, rather than present the data only for those countries which had no confidential or missing values at all, as this would have excluded a further 6 countries, including important producers such as Germany and the UK.

In order to use the data to compute estimates of the share of each sub-industry by country and of the share of each country by sub-industry we made estimates of the confidential values based on direct interpolation. This was done by taking the industry total, subtracting the sum of the turnover of those sub-industries for which data is available, and allocating half of the difference to each of the sub-industries for which data isn't available. In the absence of any additional information at the national level we felt that this was the simplest solution. The interpolated data points are marked in each of the tables we present in this section in smaller, italic script. Obviously this attempt at "filling the gaps" is problematic and should certainly not be used as if it were actual data. Nevertheless we felt it was useful to produce such interpolations in the context of this general overview of the industry at the EU level.

Table 3.2 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 3.3 presents the relative shares of each sub-industry for each country in turn, as well as for the 14 countries as a group.

[4] The data for 2003 was much more complete at the time of extraction (3 October 2006) than the data for 2004. As for the choice of the variable this is because turnover has less missing values in the database than has for example gross value added.

Table 3.2 – Country shares by sub-industry 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
Note: Figures in smaller italic script are interpolated estimates

As we can see from tables 3.1 and 3.2 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 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 (2217 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 3.3 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 3.2, 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 3.3 – Sub-industry shares 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
Note: Figures in smaller italic script are interpolated estimates

Selected indicators of the petrochemicals industry in Europe

Tables 3.4 and 3.5 give some basic indicators concerning cracker capacities in Europe, respectively by country and by corporate operator. All the data was taken from the petrochemistry.net web-site and reflects the situation at the end of 2005.

Table 3.4 – European steam cracker capacities, ths tonnes ethylene per year, 2005

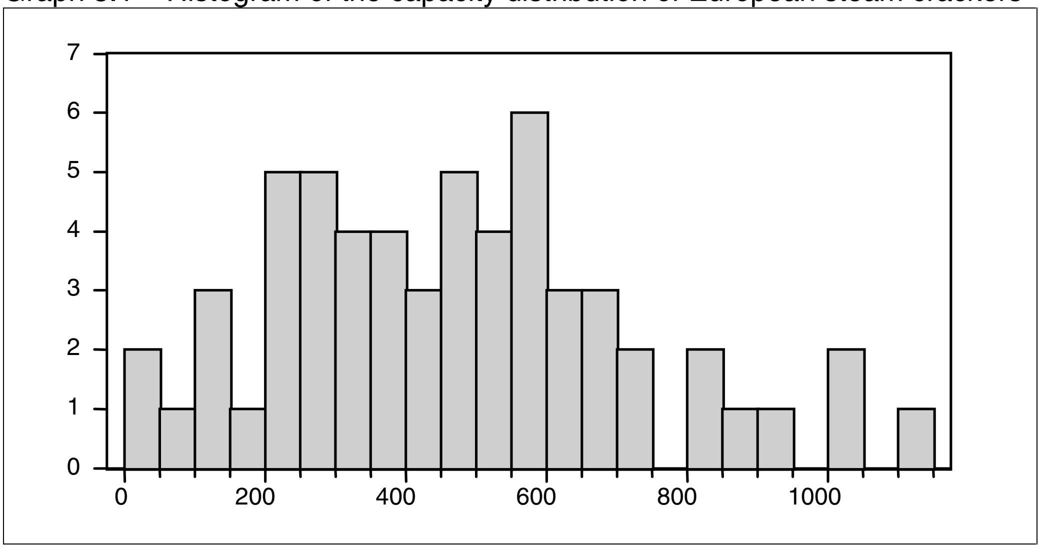
Country	Capacity	Country	Capacity
European Union		***Other Europe***	
Germany	5588	**Norway**	460
Netherlands	3970	**Bulgaria**	450
France	3435	**Romania**	200
United Kingdom	2841	**Serbia**	200
Belgium	2210	**Croatia**	135
Italy	2170	**Switzerland**	25
Spain	1500		
Sweden	620		
Hungary	610		
Austria	500		
Czech Republic	485		
Portugal	370		
Poland	360		
Finland	330		
Slovakia	200		
Greece	20		
EU Total	*25209*		
Europe Total	26679		

Source: petrochemistry.net and own calculations

It should be said that there is a slight mismatch between the totals also published online and the implied totals found when adding up national capacities (26679 instead of 26354). Beyond this detail one sees that the geographical distribution of cracker capacity in Europe is in keeping with the patterns found earlier in this section, i.e. that more-or-less matches European GDP distribution, though with a bias in favour of North-West Europe, although here Ireland does not appear. However the Netherlands and Belgium are important locations. This is connected in part to shipping routes, as two major locations for crackers in those countries are located in or near major ports (Antwerp in Belgium and Terneuzen in the Netherlands). However such facilities are also often located quite far inland, with a view to delivering to local markets and industries, so that proximity to other industrial sites and to population centres also explain the pattern (e.g. crackers in the Ruhr region, the Schwechat complex next to Vienna's international airport).

The main European locations for steam cracking match traditional national and/or regional networks. As can be guessed from table 3.4 there are essentially 6 traditional networks: Germany, the Benelux, France, the UK, Italy and Spain, which together account for 86% of total EU capacity. One of the major challenges for the European petrochemical industry is the lack of interconnectedness between these 6 traditional networks. Because of this situation there is a lack of competition at the national / regional level within the European Union, with many downstream users (e.g. producers of plastics) facing a very limited choice of suppliers for their material inputs. The atomised structure of cracker capacity also reduces the scope for economies of scale. According to petrochemistry.net[5] most European steam crackers are small by current standards, with the bulk of installations between 200 and 700 thousand tonnes of ethylene per year and with only three installations in excess of 1 million tonnes per year. This can be seen from graph 3.1.

Graph 3.1 – Histogram of the capacity distribution of European steam crackers



Source: petrochemistry.net and own calculations
Note: vertical axis: number of installations; horizontal axis: capacity of installations

On the other hand steam crackers recently set up in other world regions, especially in the Middle East and in China, typically exceed the 1 million tonnes per year mark.

Notwithstanding the issue of average capacity per installation one major improvement that industry analysts would like to see would be a much improved transport and distribution network, most notably in the shape of a network of olefin pipelines (pipelines dedicated specifically to the transportation of olefins) so as to interconnect the 6 main networks (and possibly others) to one another and to major chemical industry sites.

We now turn briefly to corporate issues. Table 3.5 shows the distribution of European cracker capacity by operator[6]. We find a mix of major oil companies and chemicals companies. BP, Total, Eni, Shell

5 We are particularly grateful for the detailed comments and suggestions made by Mr. Jacques Autin of CEFIC / Petrochemistry.net.

6 In many cases the operator is simultaneously the owner, but there are also cases of owners selling partial capacity rights to other corporations, e.g. ExxonMobil to Shell in the case of the Mossmorran cracker (UK). In

and ExxonMobil are all in the top 12. Important chemical industry corporations are also in evidence, notably Dow, BASF and Huntsman. Thus the degree of vertical integration with respect to the oil industry is quite strong. This is due in part to historical reasons, as traditionally industry was organised along national lines in the larger European countries, with governments encouraging some degree of vertical integration on the part of the national oil companies.

Table 3.5 – Cracker capacities by operator, ths tonnes ethylene per year, 2005

Operator	Capacity	Share	Origin
BP	3465	13.0%	UK
Dow	2985	11.2%	USA
TOTAL (ATOFINA)	2600	9.7%	France
Eni (EniChem)	2550	9.6%	Italy
BASF	2177	8.2%	Germany
Shell	2072	7.8%	UK / NL
ExxonMobil	1460	5.5%	USA
Sabic Europe	1250	4.7%	Saudi Arabia
ÖMV	1233	4.6%	Austria
Repsol	900	3.4%	Spain
Huntsman	865	3.2%	USA
Statoil	775	2.9%	Norway
Sub-total	***22330***	***83.7%***	

Source: petrochemistry.net and own calculations

On the other hand there has been some pulling back on the part of certain oil companies in recent years, notably Shell. The return on investment of steam cracking when the oil price is high is relatively low, whereas core activities of oil companies such as production and sale of crude and possibly refining and sale of refined fuels become much more profitable.

Chemicals companies view the situation quite differently. Their main concern is to make sure they will have timely, sufficient and reasonably cheap supplies of their feedstock, hence a motivation to participate in joint ventures or outright ownership of such installations.

Selected indicators of the plastics industry in Europe

Some production and demand data is compiled at the European level by PlasticEurope, though unfortunately not always with the same country coverage. The data is presented in table 3.6. Western Europe has a small deficit (excess demand) in terms of PE, but quite comfortable surpluses in the other two main types of plastics, PP and PVC.

Table 3.6 Production and demand of main types of plastics in ths of tonnes, 2005

Type	Production	Demand	Surplus	Country coverage
Polyethylene (PE)	12230	12560	-330	EU-15, CH, NO, MT, CY
Polypropylene (PP)	9050	7930	1120	EU-15, CH, NO
Polyvinyl Chloride (PVC)	6850	6200	650	European Union

Source : PlasticEurope

Section 4 – General Outlook for the European Chemicals Industry

The Basic Chemicals sector processes raw materials and supplies its product to intermediates, and to other manufacturing industries. Being trade-intensive, the state of the international economy is a major determinant of the sector's prospects and important features of that international environment are the cheap labour and fast demand growth in emerging economies.

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all cases capacities were allocated to the operator(s) in proportion to official participation / ownership structures. Capacities reported for subsidiaries were re-allocated to the parent companies.

Basic Chemicals consists of a heterogeneous group of products, with varied weight- and bulk-to-value ratios and hence transport costs. Production of those components with low ratios can be expected to gravitate to low-cost factories in developing countries, unless there are other location-specific features that come into play. The question for the EU industry is how it will respond.

The current outlook

The general pattern of recent and expected growth in Chemical production in the EU is described by CEFIC (The European Chemical Industry Council). Table 4.1 gives the overall growth situation of chemicals and the breakdown into main components. Note that CEFIC combines the components slightly differently and includes a few components that are outside the Basic Chemicals sector, NACE 24.1, that is analysed in COMETR. Notably consumer and fine chemicals are included in the CEFIC analysis. This does not materially alter the general pattern of activity. Their measure of Chemicals excludes Pharmaceuticals.

Table 4.1: Change in production by the Chemical industry, % per year

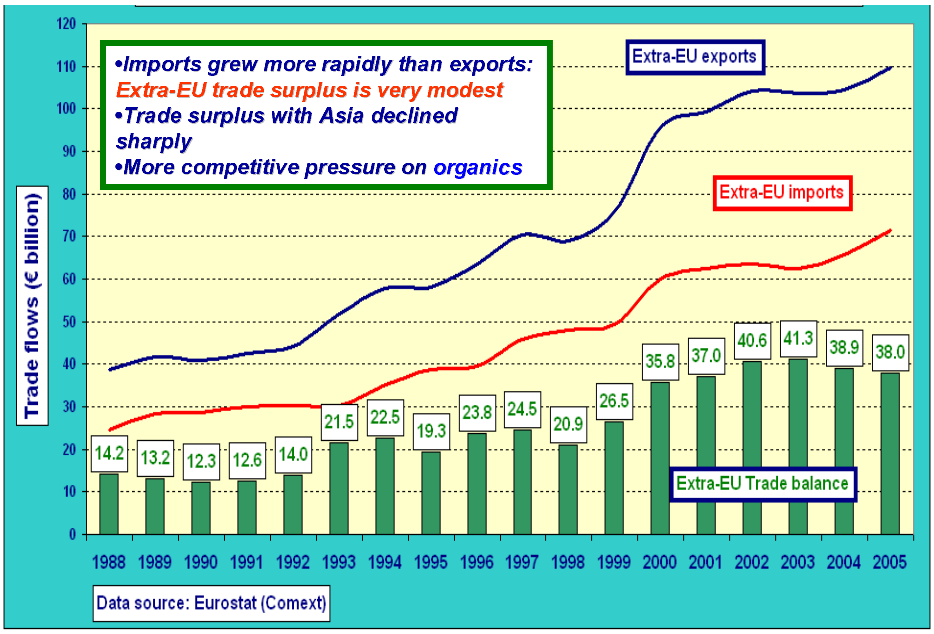
	2004	2005	2006	2007
Petrochemicals NACE 24.14	4.1	2.3	3.1	2.1
Basic inorganics NACE 24.11 24.13 24.15	1.8	8.0	2.0	1.7
Polymers NACE 24.16 24.17 24.7	2.7	2.9	3.0	2.8
Specialty and fine chemicals NACE 24.12 24.2 24.3 24.6	3.8	-1.0	2.5	2.0
Consumer Chemicals NACE 24.5	1.6	4.2	2.0	2.0
CHEMICALS (Total of the above)	3.0	2.4	2.6	2.2

Source CEFIC, 2006.

As far as the recent past is concerned, petrochemicals and polymers have seen steady progress, with the basic inorganics (e.g. gases, chlorine, fertilisers) enjoying a surge, at 8%, in 2005. What makes the growth somewhat remarkable is the fact that the price of a major input, oil, soared. This affects the chemical industry globally, but it is noted that the sector as a whole did not suffer from the higher price. The modest but generally benign growth path is expected to continue though somewhat more restrained, so that the EU chemical sector as a whole is forecast to grow by 2.2 % in 2007. This good EU performance has been driven by strong domestic demand and growth in trade with EU partners. The outturn for domestic sales in 2006 is predicted to be up by 4.6%. According to CEFIC most chemical sub-sectors have benefited from improved business conditions. Since the above forecasts were made, sound continued growth in Europe has led CEFIC to be slightly more optimistic for 2007.

Europe has had an external trade surplus in Chemicals which has risen considerably since 1999. However the pattern of late has seen this surplus stabilise in 2002 and 2003 followed by declines in 2003 and 2004. Figure 4.1 shows this pattern with the extra-EU exports and extra-EU imports, and the resulting trade balance.

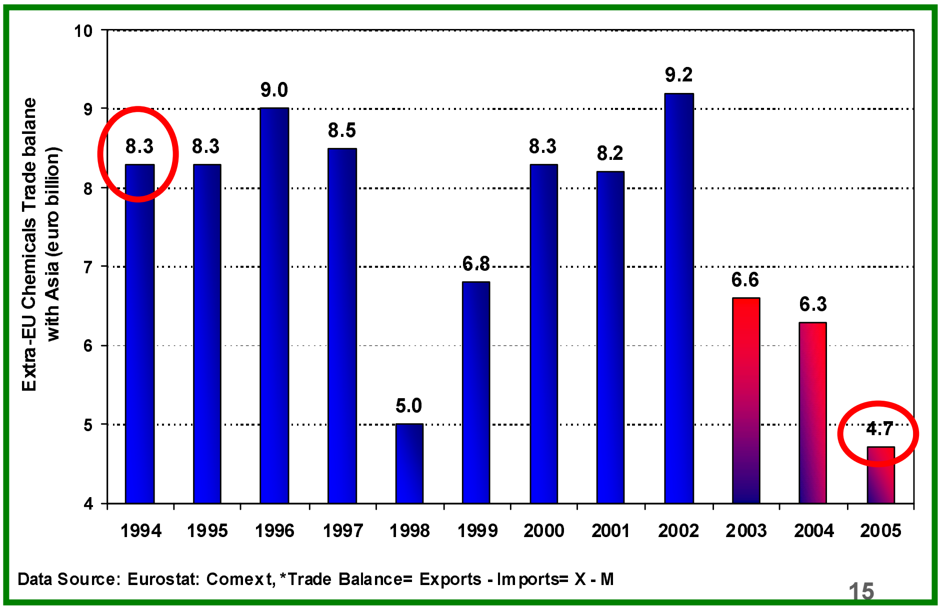
Figure 4.1: Extra-EU25 exports and imports and trade surplus in Chemicals, € billion 1988-2005



Source: CEFIC, 2006

This decline in trade surplus is driven in particular by trade with Asia, as illustrated in Figure 4.2. A marked recent growth in imports from Asia has brought the trade surplus with this region to its unusually low level in 2005.

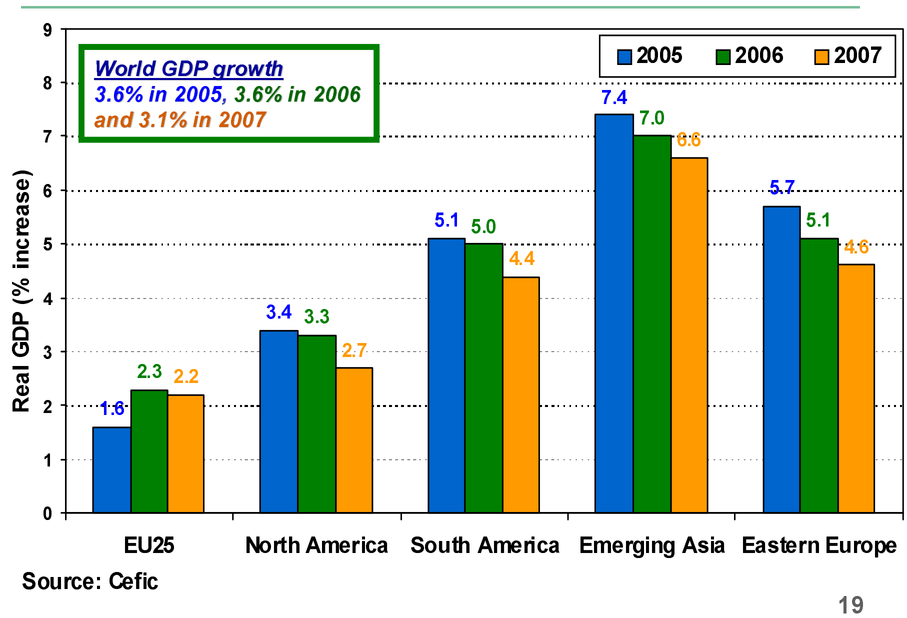
Figure 4.2: EU Chemicals trade balance with Asia, € billion 1994-2005.



Source: CEFIC, 2006

Producers' plans for the future in East Asia and especially in the Middle East are apparently for major increases in ethylene capacity. The oil states are moving into Propylene too (Economist, 2006). Populous countries, India and, more so, China are growing richer, as Figure 4.3 demonstrates, and capacity expansion is underway on a large scale.

Figure 4.3: World economic outlook, % GDP growth by region 2005-7.



It appears however that despite high capacity growth in China, growth in demand there is so high that it will be many years before China becomes a net exporter of chemicals.

Regulations and REACH

The sector is subject to many regulations, through licensing requirements, and the new Directive, REACH, which has been the subject of lengthy negotiation, is in prospect. In brief, REACH aims for establishment of procedures whereby industry would make available information on the hazards, risks, and risk reduction measures for chemicals currently in use, and would create greater confidence that dangerous substances were being used safely. Safety policy on chemicals needs harmonisation not only out of consideration for the Single Market but because of the nature of chemicals themselves.

A difficulty with agreeing the Directive is that there is frequently not enough information on which to clarify the epidemiology, though it is intended that the operation of REACH itself will facilitate recording and study of properties of chemicals.[7] In particular the risk reduction issue revolves around such debates as the need for a balance between the requirement to substitute substances and the right of industry to sell them. The European Parliament's Environment Committee emphasises substitution and its desire for manufacturers to show that the benefits of use of certain such substances outweigh their risks, that there are no suitable alternatives and the risks can be controlled, and that authorisation be subject to a five-year expiry date (ENDS, 2006).

Negotiations between MEPs, member states and the European Commission over the proposed REACH rules are ongoing (November 2006). The European Parliament votes on the legislation in December, but a disagreement over plans to oblige companies to substitute hazardous chemicals for safer ones may not be resolved by then. In the absence of agreement following Parliament's vote, the three institutions try to hammer out a compromise under the "conciliation" process.

Such regulatory safeguards come initially at a price. Developing countries that do not have safeguards in place could indeed steel a march on regulated countries except that, with higher living standards, their populations too are likely to demand higher standards of environmental protection.

[7] There is for example disagreement between the Chlor-alkali industry and environmental interests on the recording of mercury balances (Euro-Chlor and EEB).

RESPONSE by Europe:

Strategy on production, integration, and R&D

Production: There are likely to be significant changes within the industry over the next five years. For example, production in the UK of relatively simple chemicals are likely to be candidates for transfer to the developing world while the high-tech, high value-added end of the market should continue to expand (Keynote, 2006). East Asia (India and China) and especially the Middle East are moving into ethylene production and propylene and into downstream products too (Economist, 2005). In response to increased import penetration by products from emerging economies, there is a European tendency to move away from producing commodity products into producing low-volume high value added products.

Integration: Another potential response is industrial restructuring which can be aided by acquisitions and mergers. An interesting phenomenon is the successful exploitation of the advantages of the 'cluster'. BASF the world's biggest chemical site situated in Germany is benefiting from its programme of integration. With enviable profit performance between 2002 and 2005, the efficiencies of this cluster show how a traditional business can remain competitive, even when it operates in Germany: an expensive place relative to some emerging economies. The BASF complex at Ludwigshafen comprises upto 250 individual chemical factories with 8000 different products. Production from every aspect is exploited such that the numerous by-products are used locally. Consequent savings in transport, handling and transactions according to BASF could amount to €300 million in logistics, €150 million in energy and €50 million in infrastructure (Economist, 2006).

R & D: Another response is to intensify R&D in order to gain 'knowledge-driven' advantage. For example, the German chemicals industry spends a higher proportion of its revenue on research and development than that of any other country. (Germany also supplies more than 12 per cent of world exports of chemicals, the biggest single share.) The European chemicals sector is moving ahead with a multi-million innovation plan aimed at taking it 'closer to environmental sustainability'. Industry participants in SusChem (European Platform for Sustainable Chemistry) produced a Strategic Research Agenda in November 2005 to focus European R&D spending on the most promising areas with respect to future sustainability and profits. These areas are:

- bio-based economy
- energy
- health care
- information and communication technologies
- nanotechnology
- sustainable quality of life
- sustainable product and process design, and
- transport.

An Implementation Action Plan explains how the research priorities can be implemented, focusing on activities and actions (SusChem, 2006).
Estimates of funding in the order of €1.4 billion annually in the coming years are envisaged - around half of which is expected to come from public sources,

Meanwhile R&D efforts in emerging economies are also strengthening, suggestive perhaps of the higher environmental standards that will be demanded in emerging economies. The National Natural Science Foundation of China (NSFC) has been a pioneer and key player in fostering green chemistry and technology in China, in particular basic research, and its budget for green chemistry and technology projects for the period 2006 – 2010 has been doubled. The Chinese plans are impressive with projected total Chinese R&D at 112 billion US$ by 2020 (equivalent to 2.5% of predicted GDP).

Section 5 – Technologies, energy intensity and carbon emissions

When carbon taxes are introduced, other things equal, a company is likely to think of more 'amenable' locations, that is, jurisdictions with no carbon taxes or with relatively lax environmental regimes, especially if its technology cannot adapt. Such relocation means that the emissions would simply occur elsewhere, an effect dubbed 'carbon leakage'. If on the other hand the company faces technological possibilities for emissions reductions, these could enable it to cope with the environmental regime. It would not feel the need to relocate on this score.

This section on technology looks at (A) the potential for reduction of CO_2 emissions and where possible it assesses future possibilities for technical adaptation. In (B) the actual energy use of the sector since the introduction of ETR is described with a view to assessing if energy intensiveness did in fact decrease.

(A) Potential for reduction of emissions

An important source of information on technical potential for reducing carbon dioxide emissions within the EU15 is the study by de Beer *et al* (2001) which covered the chemicals sector. Their report is a bottom-up analysis, commissioned by DG Environment of the European Commission as part of a large study by Ecofys and others, and it benefited from comments from a panel of experts and a workshop. Though one should take into account the assumptions made and the caveats, it forms a reliable source of independent information.

The study's base year was 1990 and in their list of options for reducing emissions, the authors only included those options that had a probability of being commercially available before 2010, and in fact of having a 'high probability' of so being. The crux is the issue of 'commercial' availability, since there are invariably options that are possible but that would penalise the firm's profitability. A real interest rate of 4 per cent was used in the calculations over the lifetime of the equipment or investment. Where new capacity was concerned, options were defined based on technology with an efficiency level equal to the best practice value of 1995. Importantly, 'best practice' means the best that has been realised, rather than 'best available' which may not in fact have been realised. The study did not consider shifts to other potential product *mixes.* Transactions costs are not taken into account.

The emission reduction potential for 2010 was first calculated using a reference level based on assumed industrial growth rates taken from the PRIMES (1999) study and on 'frozen technology', which assumes no energy efficiency improvement and no reduction in specific energy consumption. Table 5.1 summarises the reference level for the chemicals industry as a whole. The 'indirect emissions' are related to consumption of electricity and steam. As shown in the table, a 65% growth in emissions of CO2 is foreseen in the reference case for 2010, based on the assumption of technology being frozen at 1990 levels.

For the purposes of their study de Beer et al consider the chemical sector in three parts. The first part is fertilisers or agrichemicals of which the most energy-intensive process is the production of ammonia (NH3), which is a raw material for fertilisers.

Table 5.1: Energy use and emissions in 1990 and in 2010*

Fuel use EJ	**CO_2 emissions Mt**			
1990	**Direct**	**1990 Indirect**	**Total**	**2010 Reference level Total (frozen technology)**
2.0	38	217	254	420 (+ 65%)

**Based on growth rates given by Primes (1999) and assuming fixed 1990 technology*
*** Excluding shifts between fuels and subsectors.*
Source: de Beer et al, 2001. This table also includes pharmaceuticals.

The second is petrochemicals of which the cracking of naphtha to produce ethylene and propylene are important building blocks in the petrochemical industry and used in the manufacture of plastics. The third part is inorganic chemicals which include the production of chlorine/alkali.[8] Key parameters and the options to improve energy efficiency are now considered for each of these three parts in turn.

Fertiliser industry – key parameters

Some 50 ammonia plants were in operation in 1994 producing about 11 million tonnes, located in 11 countries, the main operations being in the Netherlands, Germany, France and Italy. In technical terms, the three types of production process for ammonia production in use in Europe at the time of the report were:

Steam reforming of natural gas or other light hydrocarbon;
Partial oxidation of heavy fuel oil or vacuum residue;
Production based on H_2 and N_2-rich streams from other processes.

The first process was predominant. There were only 4 plants (2 in Germany, and I each in Greece and Portugal) using the second and 3 plants using the third process (France, Spain and the UK). The 'best achieved' specific energy consumption (energy used per unit of output) and the average values are the parameters of interest. These are summarised in Table 5.2. The best achieved level represents an improvement on the average of 20 to 30 per cent in process 1 and 5 to 15.5 per cent in process 2.

Table 5.2: Ammonia production – Specific Energy Consumption, GJ per tonne of NH_3

Process	Specific Energy Consumption in GJ per tonne NH_3	
	Best achieved	**Average**
1. Steam reforming	28	35 to 40
2. Partial oxidation	38	40 to 45

Note: Values include the use of energy carriers as feedstock (21 GJ per tonne of NH_3). Source: EC, 1997.

Specific Energy Consumption levels for individual EU Member States in 1995 are given in Table 5.3.

Table 5.3: Specific Energy Consumption, 1995, GJ per tonne of NH_3

Specific Energy Consumption, GJ per tonne NH_3														
AUT	BEL	DEU*	DNK	ESP	FIN	FRA	GBR	GRC	IRL	ITA	LUX	NLD	PRT	SWE
34.1	37.8	34.1	-	28.1	-	37.8	38.7	44.5	31.0	37.8	-	34.0	44.0	-

** Federal Republic of Germany only. Source: PSI, 1998.*

In sum, the key parameters show that there is scope for reducing energy use per unit of output. If one compares the best performances of the steam reforming process with the partial oxidation process, the latter gives energy unit saving of 26 per cent. Within process 1, improvements of over 20 per cent are possible if a company moves from average to best achieved technology. While there were fewer plants using the other processes, improvements were still possible, and particularly if they were in a position to move to process 1.

Options for improving energy efficiency in ammonia production

The authors proceed to describe the options for improving energy efficiency and this information is summarised in Table 5.4.

[8] A fourth part, 'Other chemicals' consists of pharmaceuticals and fibres and is dealt with in COMETR under the heading of Pharmaceuticals.

Table 5.4: Options for improving Specific Energy Consumption in NH_3 production

Option	Description	Improved SEC GJ per tonne NH_3	Implementation cost per GJ saved
Process integration	Better integration of heat exchangers, cogeneration of heat and power as well as other adaptations to the process. Analysis of the process by 'pinch analysis' is also useful tool.	3 to 4	€ 10
Advanced reformer	Reduce large losses on steam reforming by: (a) reducing the duty of the primary reformer and (b) efficient use of heat generated.	3 to 5	€ 65
Efficient CO_2 removal	Use advanced solvents, pressure swing absorption or membranes for scrubbing,	In the order of 1	€ 15
Low pressure ammonia synthesis	Reduces the need for compression power but also reduces yield.	Varies from 0 to 0.5	€ 25 plus €1 increased costs in O+M per GJ
New capacity	Best practice is 28 GJ per tonne.		

SEC: Specific Energy Consumption. Sources: de Beer, 2001, from de Beer et al, 1994, 1998, EC, 1997.

Petrochemicals – key parameters

About 50 steam crackers were in operation in 1998 in 12 of the EU15 countries and the capacity of ethylene was about 20.5 million tonnes, according to CEFIC (1999). Major ethylene producing countries were Germany, France, the Netherlands, UK and Italy. Three of these are ETR countries. Of the other three ETR countries, Sweden and Finland were minor producers with one cracker each and Denmark had no ethylene production capacity. Specific Energy Consumption for liquid crackers in 1995 is shown in Table 5.5, in the top row. For comparison, de Beer et al also show the Specific Energy Consumption per tonne of 'high value chemicals' in the bottom row. As takes more account of the differences in product mix between countries it is a better indicator of energy efficiency.

Table 5.5: Specific Energy Consumption in the petrochemical industry in 1995, GJ per tonne of ethylene and per tonne of high value chemicals.

	Specific Energy Consumption, GJ per tonne												
	AUT	**BEL**	**DEU**	**ESP**	**FIN**	**FRA**	**GBR**	**GRC**	**ITA**	**NLD**	**PRT**	**SWE**	**EU**
Ethylene	33.8	34.9	32.3	32.4	33.8	33.7	33.8	33.3*	32.4	33.6	32.4	33.8	33.3
Ethylene best practice	22.3	22.3	23.1	23.1	20.8	22.3	20.8	23.1	23.1	22.4	23.1	20.8	
High value chemicals	18.2	18.9	16.4	16.6	18.2	17.3	18.2	17.0	16.6	16.5	16.6	18.2	17.0

** EU average. The countries Denmark, Ireland and Luxembourg are omitted as there are no entries for them. Source: de Beer et al, 2001.*

Of the ETR countries, Germany performs well on both ethylene and high value chemicals, having lower Specific Energy Consumption than the EU average, though its 'best practice' ethylene process is less efficient. This contrasts with Finland, Great Britain and Sweden which only excel in their 'best practice' processes. Heterogeneity, length of plant life and the advance of technology at the moment of investment are likely to be factors here.

Options for improving energy efficiency in the petrochemical industry

Table 5.6 summarises some options.

Table 5.6: Improving Specific Energy Consumption in the petrochemical industry.

Option	Description	Improved SEC GJ/t ethylene	Implementation cost per GJ saved
Miscellaneous simple measures	Monitoring, controlling, insulation energy accounting etc..	2.8 or 7 to 10 %	€ 10 or under 2-year payback
Process integration	Optimise design e.g. by pinch analysis	1.5 or 5 %	€ 20
Gas turbine integration	For naphtha cracking	2.9	Not generally economical
Debottle-necking	Performed during regular maintenance activities	1 to 1.5	€ 10
Cracking furnace yield	Selective radiant coils, conductive ceramics, or high-pressure combustion, insulation etc..	1.3 or 4 %	€ 40
Fractionation	Distillation controls, replacing ethylene refrigerant by a multi-component one, optimising distillation sequence, advanced recovery systems, using heat pumps.	1.5	€25
New capacity	Best practice Specific Energy Consumption	9 to 13 See Table 5	

SEC: Specific Energy Consumption. Source: de Beer et al, 2001. The authors point out that one or more experts stated that the potential savings were unrealistic.

Inorganic chemicals: chlorine/alkali – key parameters

Chlorine and alkali are produced by electrolysis of brine using one of three different types of electrolysis process: using a mercury flow, a diaphragm or an ion-selective membrane.

The mercury cell is the most common in the EU. Electricity consumption for mercury cells is approximately 11 GJ per tonne of chlorine, whereas for the other cell types it is between 9.5 and 10 GJ per tonne (Phylipsen *et al.,* 1998).

Improving Specific Energy Consumption in chlorine production

Given the above difference in energy need, an option is to replace mercury by membrane cells, as shown in Table 5.7.

Table 5.7: Option for improving Specific Energy Consumption in Chlorine production

Option	Description	Improved SEC GJ per tonne chlorine	Implementation cost per GJ saved
Replace mercury	By membrane cells	0.05 to 1.55	€ 0*

** Zero cost for the 40% of mercury processes that are due for replacement in any event and zero additional investment costs are assumed. Source: de Beer et al., 2001.*

On the basis of a fifty-year life for a chlorine plant, 40 per cent of the plants based on mercury flow would be replaced during 1990 to 2010. Companies undertaking such replacement could therefore benefit from the improved Specific Energy Consumption, which amounts to a saving in energy of 0.5 to 14 %.

Summary of potential CO2 reduction in EU Chemicals industry

The report by de Beer *et al* summarises the technical potential for reducing CO_2 emitted by the chemical industry. We saw in Table 5.1 the 1990 emissions at 254 Mt and the 65% increase in emissions to 420 Mt in 2010 in the reference case based on frozen technology. Gathering together the potential savings outlined above, the reduction in emissions compared to the reference case amounts to 85 Mt. Details are given in Table 5.8.

Table 5.8: Technical potential for reducing CO_2 emissions by the chemicals industry

1990	2010				
Emissions Mt	Frozen technology reference level Mt	Reduction on reference level Mt	Emissions Mt	Change on 1990 level %	Change on 2010 reference level %
254	420	85	335	+32	-20

Source: de Beer et al.,2001. There is additional potential, not included here, from implementing CHP.

The reduction of 85 Mt of CO_2 represents an increase of 32% on 1990 levels (instead of a 65% increase when frozen technology prevails) and a 20% decrease on the 2010 level with frozen technology level. As such the -20% is the emissions equivalent of the potential Specific Energy Consumption change. Further detail of CO_2 reduction potential is shown in Table 5.9, which breaks down the 85 Mt potentials into cost brackets.

Table 5.9: Breakdown of reductions potential in EU Chemicals industry into four cost brackets, euro per tonne CO_2 avoided.

€ per tonne CO_2 avoided	Emission reduction (Mt CO_2)
< 0 euro	78
0 – 20 euro	7
20 – 50 euro	0
> 50 euro	0
Total	85

Source: de Beer et al., 2001.

According to the table, the vast bulk of the reductions are achieved at zero or negative cost, though transactions costs, including management time, are not accounted for.

To summarise, potential technologies are central to the issue of leakage as they can reduce energy intensity (Specific Energy Consumption) and thereby soften, remove or indeed reverse the negative impact of ETR. They can reduce the attraction of alternative locations and, most importantly, the adoption of such technologies is a *raison d'être* for introducing ETR. The chemical industry has the possibility of a 20% reduction in CO_2 emissions, compared with 'frozen' 1990 technology, mostly at low or negative cost as illustrated in Tables 5.8 and 5.9. It follows that the chemical industry could on average withstand a sizable rise in energy costs. The industry may not withstand a 20% rise because CO_2 reduction does not translate to the same percentage change in energy costs *per se* and, furthermore, some representations dissented from the potentials outlined here, but the 20% gives an order of magnitude.

(B) Energy use by the chemicals sector

Ideally it would be possible to compare the potential for reducing Specific Energy Consumption during the period 1990 to 2010, outlined above, with the actual pattern of Specific Energy Consumption. While data limitations do not yet allow such comparisons, it is possible to look at characteristics of the chemical industry's energy consumption to see whether there are indications of directions of change.[9] In the meantime it has to be noted that background changes constantly underway and may mask effects due to ETR. It is useful to start by reminding ourselves of the key dates of the introduction of ETR in the relevant EU countries, which are as follows:

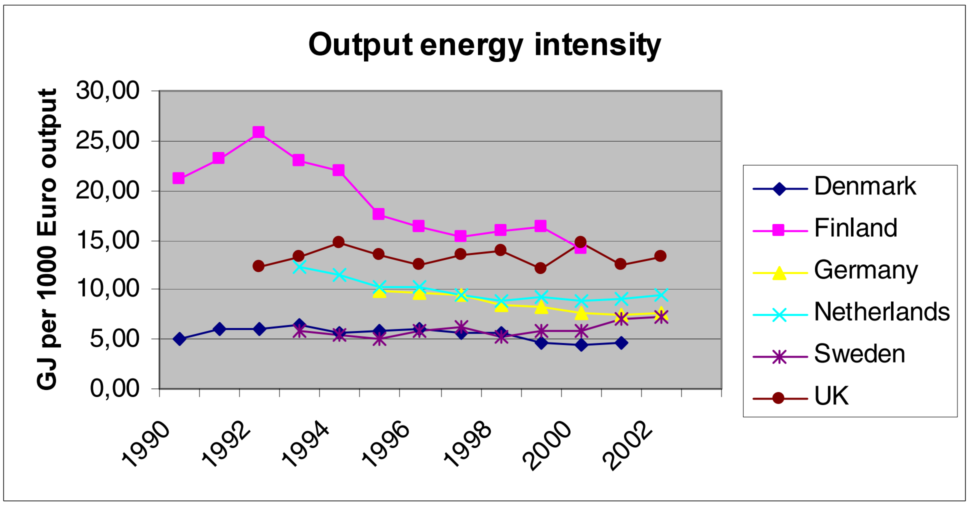
Sweden *1991*
Denmark *1995*

[9] Ecofys will be updating and developing the analysis by de Beer *et al.*.

Netherlands	*1996*
Finland	*1997*
Germany	*1999*
UK	*1999*

The energy intensity of the chemical industry in ETR countries in the nineties is shown here in Figure 5.1 (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.

Figure 5.1: Energy Intensity in the chemicals industry, GJ per €1000 (constant price) output.



Source: Databank of COMETR WP3.

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, as seen above, a small player in chemicals, engaged in ethylene production in a relatively minor way where its intensity was above the EU average in 1995 (Table 5.5 above). 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 1999, 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.

Energy unit costs in which energy taxes are included are shown in Figure 2. The convergence of these unit energy costs can be compared with the figures for energy tax as a percentage of Gross Value Added, shown in Table 5.10. Here indeed we see that Finland has the highest tax, which is consistent with Finland having the highest unit energy costs and then having the steepest decline in energy intensity. Such a pattern does not carry through to the other countries. However Table 5.10 serves to indicate the high amount of revenue from energy taxation in Germany and the Netherlands.[10]

[10] Fuel used as input for the production process is exempt from taxation, and in the chemical industry constitutes about 50 per cent of total fuel use. It has not been possible to separate it out here.

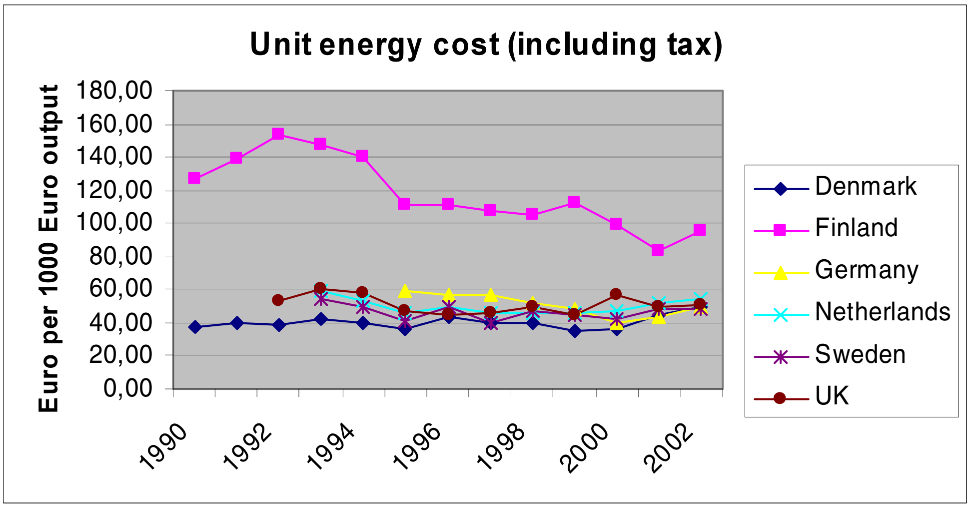
Table 5.10: Energy taxation in the basic chemical industry (2002 figures)

	Energy tax € million*	Energy tax % of GVA
Denmark	3.11	1.00
Finland	27.36	3.44
Germany	299.69	1.51
Netherlands	96.14	2.24
Sweden	6.53	0.53
UK	43.91	0.59

** Expressed in constant 2000 prices. Source: Databank of COMETR WP3.*

Turning to the graph of unit energy costs in Figure 5.2, it has to be said that the graph shows no visible sign of the effect on expenditure of the carbon tax aspect of the ETR, though many things could explain this. The two high intensity countries, Finland and the UK, seem relatively higher than in Figure 5.1, but the data here only go up to 2000. The unit energy costs of the other countries are converging strongly, into the range 40 to 60 Euro per €1000 output.

Figure 5.2: Energy expenditure including tax (euro) per €1000 output of the Chemicals industry at constant 2000 prices



Source: Databank of COMETR WP3

Having looked at energy tax rates expressed as a share of Gross Value Added, it is worth looking at price changes of energy *per se* between 1995 to 2000 of prices charged to the Chemicals Industry. These price changes are given in Table 5.11 and are tax inclusive.

Table 5.11: Change in energy price (tax inclusive) between 1995 and 2003 in the Basic Chemicals sector, %

	Fuel oil	Gas/diesel oil	Natural gas	Electricity
Denmark	77.5	55.1	-8.2	0.14
Finland	31.0	43.8	39.3	0.17
Germany_2002	59.2	58.1	26.7	-33.6
Netherlands_02	-	-	18.5	-2.3
Sweden	61.4	51.2	58.7	-9.1
UK	28.4	22.0	1.5	-34.3

Source: Databank of COMETR WP3.

The range in price changes within countries and the difference between countries is marked. A pattern does emerge nevertheless. The price of electricity has generally fallen in the 1995 to 2003 period. Compared to the price of fuel oil and gas oil, the price of natural gas has generally risen less steeply, or fallen or stabilised in the cases of Denmark and the UK.

Considering these individual energy price changes in the context of the changes in consumption of individual fuels, shown here in Table 5.12, can any patterns be identified?

Table 5.12: Change in energy consumption by the Basic Chemicals sector between 1995 and 2003, %.

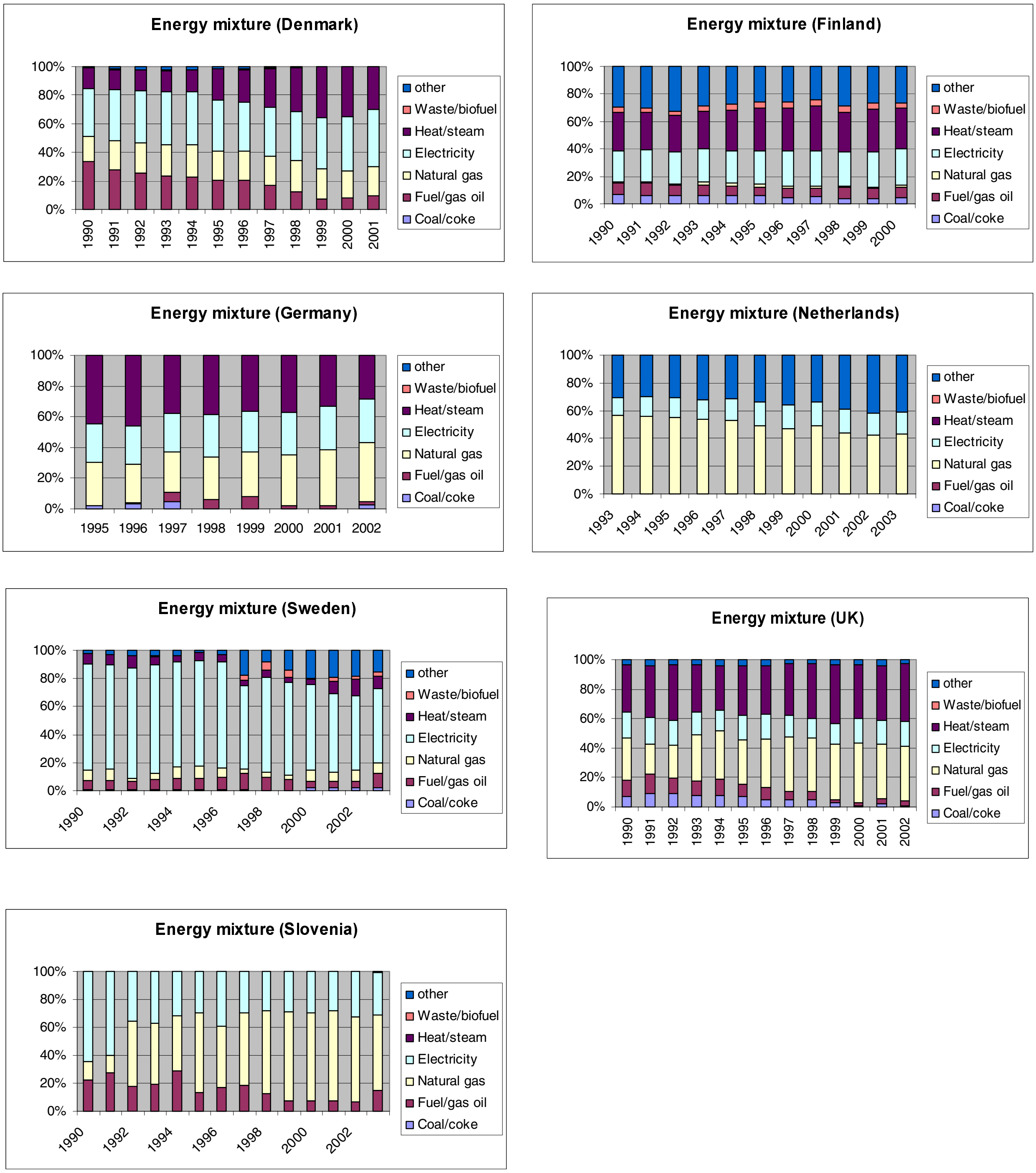
	Fuel oil	Gas /diesel oil	Natural gas	Electricity	Total
Denmark	-68.8	-47.6	-17.4	-12.6	-19.1
Finland	-1.0	2.5	-47.3	31.0	-4.9
Germany_02	-	-	27.0	0.7	-5.4
Netherlands			-16.6	18.0	7.8
Sweden	70.1	30.1	40.1	24.2	76.6
UK	-61.8	35.6	51.9	21.7	23.0

Source: Databank of COMETR WP3.

By comparing Tables 5.11 and 5.12 a few possible patterns are discerned, taking each country in turn. Denmark's fuel oil has the highest price rise and it has the largest consumption decline, alongside a switch to increased gas oil. Finland's electricity price decline is reflected in a rise in electricity consumption. In Germany, price movements would lead one to expect movements into more natural gas and electricity, which indeed saw rises, though the data are lacking in the cases of the other fuels. In the Netherlands the rise in the price of natural gas relative to that of electricity saw negative and positive responses in natural gas and electricity consumption, respectively. In Sweden a relative price rise in fuel oil and natural gas saw demand for both increase. Finally, in the UK, price falls for natural gas and electricity saw their consumption rise at the expense of fuel oil, the price of which had risen. These changes suggest a pattern of logical response to relative price changes.

Further detail on the changing fuel mix in each ETR country can be observed in Figure 5.3.

Figure 5.3: The composition of Energy consumption in ETR countries.



Source: Databank of COMETR WP3.

Denmark's switch out of fuel oil is a long-term trend which sits aside a long-term trend of increasing heat/steam. Finland's pattern is fairly stable though the rise in electricity's share seems firmly established. Germany saw a rise in the share of natural gas at the expense of fuel/gas oil. The share of natural gas in the Netherlands declined while that of 'Other' fuels grew. In Sweden the long-term trend sees a decline in electricity and a rise in' Other' fuels. Lastly, the UK sees a rise in share of natural gas and decline in fuel/gas oil. Although these patterns are based on scant data, the responses to relative price changes are consistent and plausible.

This pattern revealed in this detailed information concurs with that of the previous tabular information for 1995 and 2000. Such responses indicate that companies in the Basic Chemicals sector are able to alter technology to switch fuels to respond to changing conditions. They also suggest that in the event of the introduction of carbon taxes companies are likely to be able to pursue adaptations and energy efficiency options, rather than necessarily need to relocate.

Finally, the central question relates to the findings on energy saving potential described in part A above. 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 5.1 tell us to what extent these potentials have been exploited? The following figures in Table 5.13 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 5.13: 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)

Source: Databank of COMETR WP3. Sweden's ETR occurred in 1991 but the earliest figure relates to 1993.

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.

Section 6 – Company interviews

This section contains the results of interviews of suitably knowledgeable employees of two chemicals companies with activities in the European Union. This additional information 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.

Company A – a major multinational corporation

Interviewed person: head of energy

Introduction

The company is one of the world's major chemical companies, with an extensive presence in Europe and the Middle East followed by the Asia Pacific region. The company offers a range of products and services for markets that include agriculture, medicine, communications, construction, transportation and apparel.

Output

Looking at the market in agriculture the company produces fertiliser (not ammonia) and crop protection materials. Produce for the industrial and consumer market includes plastics where output includes ethylene copolymers with special properties - products with sustainable performance advantages such as faster processing, extra toughness, better cold-temperature flexibility, extra clarity, softer touch, better heat and oil resistance, better sound deadening or more reliable sealing and adhesion. These would have end-uses ranging from solar panels to road, from roofing to golf balls. There are many more products, with different ways of classifying them.[11]

The company's products are generally low in labour inputs and intensive in energy. They are divesting of some sites such as those making some of their older trademarked products which are now no longer profitable and do not form part of their core output. These products can be made more cheaply elsewhere such as in Turkey. Much of the company's output is sold as inputs to other companies and if they move then production could possibly move too, depending on the economics.

Most of the European sites have been in their present locations for many years. The trend at present is to move production upmarket. Examples would be the manufacture of fibres with special properties, made under patent. The company undertakes its own R&D, which is spread around the world but with most located in the US. The main European R&D concentration is in Switzerland where there are tax advantages.

Some of the company's new products are biotechnology-based, using soya, for example. Such products are less energy intensive. A joint venture is underway to make an alternative product that can be used by cars without modification, because it is similar to gasoline. The company is moving away from petrochemicals and veering towards bio-based products. It has become harder to compete in the field of heavy chemicals, especially as proprietary knowledge has become public, once the patents have run out.

Location

Chemical products are so diverse and have such a wide range of uses that in trying to find a main overall determinant of demand it has to be GDP. At present strong GDP growth and hence demand for the company's products arises mainly in the Far East. In tandem with GDP, innovation is also a major factor - a new product creates its own demand. While the main expansion is in emerging countries, some European expansion and acquisitions are also taking place.

Some of the company's products though not all are heavy, which has a bearing on transport and location decisions. Another consideration is that some products with chemical inputs might require temperature to be controlled during transport, raising transport costs in that manner. Clusters of plants can have advantages and some clusters still exist, but few are single company sites. For example their site at X consisted of one company once and now has twenty, which probably means that integration is not optimal.

Market-seeking and efficiency-seeking both apply in the company's choice of location. It might be desirable to have a site 'two days away' from its market. Other considerations also have to be taken into account. For example, China places a tariff on imports. Saudi Arabia and Russia are the main locations with cheap energy. Russia subsidies energy, but the company does not have production facilities in Russia.

Technology

Given the variety of products it is not feasible to describe the 'main' production process, but the company requires heat and electricity, and steam for just about everything. The company used to use coal for steam and electricity. Now the only European plant using coal is one subsidiary. The subsidiary has a convenient jetty nearby for importing the coal. The company's shift in fuel has been to gas rather than to oil and there is now little flexibility, an exception being the subsidiary where there is the possibility of using biomass.

Generally fuel oil and coal are priced similarly. An exception would be South Africa where coal is cheap, owing partly to a shortage of export facilities there. Hence making electricity in South Africa is cheap. The price of gas is highly variable, and is influenced by development of pipelines. Gas prices tend to be high in the US, though they could fall with pipeline development. There is pipeline

[11] The company does not manufacture chlor-alkali.

development underway in Europe but the price of gas, and of electricity, in Europe are expected to remain high.

There are usually a few measures and new technologies that can help energy efficiency. One could make some improvement in insulation, for example. There are new technologies especially in the important area of controls. Lighting and motors are also areas where new technology comes into play. Despite these shifts, the company would still be using a very large amount of energy.

Impacts of environmental regulations, taxes etc.

Environmental constraints are in the minds of company personnel. In relation to plant location, however, the company has not built many new plants. Undoubtedly if there were potentially similar plants in two countries, advantages with respect to energy costs and regulations would tip the balance.

An issue is the problem of uncertainty. The fact that regulations/taxes change or enforcement varies makes it difficult to plan and hard to make investment decisions. In fact environmental standards *per se* do not vary hugely, but sometimes aspects can catch one out. Sometimes they would be very specific and prescriptive.

An example of this can be given with respect to the **Waste Incineration Directive.** The instrumentation required is costly. Some petrochemical by-products are safe to burn under certain conditions and can save on fuel costs. One site discovered that the directive made it difficult to burn the product. Not only do they now have to pay for the by-product to be removed and incinerated, they also have to buy replacement fuel. The Waste Incineration Directive is an example of a regulation that makes Europe an expensive place in which to operate.

ETR in Europe has had different effects, depending on how it was applied. In Germany, for example, the specifics of ETR were not quite right. A rebate comes with the eco-tax in return for good environmental performance. However the German eco-tax rebate was not properly conditional. In the end the marginal tax rate is what matters, applied to the last bit of energy, and the German incentive was effectively not good enough by ignoring that fact.

The Dutch and Flemish ETRs with their covenant system is quite good. Companies have an incentive to reduce emissions. However the system requires bench-marks that could be difficult to obtain. Sometimes there are only a few companies involved or even few companies in other countries outside the scheme from which to derive sensible benchmarks. There is often a reluctance to reveal their benchmarks and site specific issues can also create difficulties.

The UK ETR is the most effective. The Climate Change Levy (CCL) put up the price of energy though the reductions in social insurance were not very beneficial and not enduring. However the Negotiated Agreements (NA) were good and the rebate gave companies a real incentive to reach their targets. Two levels of advice were involved. The first was the basic energy audit and the second, importantly, provided specialised advice. The Carbon Trust is providing this and their information is helpful. Another good measure is the Combined Heat and Power Quality Assurance Scheme (CHP QA). Tax breaks are awarded for operating CHP to certain standards. Seminars, preferably half-day or one-day, are helpful. (This specific method for imparting information has often been found to be favoured in removing barriers to energy efficiency, as in Sorrell *et al.*, 2004).

The effects of **ETS** are somewhat similar to those of a carbon tax. The price of electricity has risen, because the permits are a cost to companies if used rather than sold. The company has been allocated its own carbon permits, but it is the rise in the marginal cost of electricity that has more of an incentive effect than the limits imposed by their own permits. Because the permit price is so variable this introduces huge uncertainty when the company wishes to consider investment decisions. How the next allocation is made will affect them, especially in countries like Luxembourg where the company is one of but ten companies, making it hard to plan ahead. Basically a system of carbon taxes like the Climate Change Levy, with negotiated agreements, would be easier.

On the question of whether **Border Tax Adjustments** could be introduced to overcome the penalty imposed by carbon taxes when trading with non-ETR countries, this was felt to be a possibility. If however all of a company's output was exported, the border tax adjustment would counter-balance the carbon tax, and the result might not show much change in the company's carbon emissions. There is also the problem of determining the amount of tax adjustment for the carbon dioxide emitted. This would be difficult in the case of fibres, for example. There are difficulties either way.

The problem with ETS is that it is so unequal. The allocations determine the price, but the strictness of the allocations varies. Germany's allocation was not strict, France omitted chemicals altogether, the UK allocation was quite tight. So one can see that treatment of chemicals manufacturing by the ETS within the EU was unequal.

Follow-up interview with Operations Manager of a site making Plastics
located in a non-ETR country but in EU15.

For this enterprise the possibility of relocating in a cheaper country to produce plastics (Engineering Polymers) is indeed an option. This would be for reasons of labour costs as well as for energy costs. The company is energy intensive, but it is the labour bill that is a prominent issue. Their energy cost is no higher than in the neighbouring country which is in ETR and subject to carbon taxes, as far as the respondent was aware. Their labour input is not especially highly qualified. The jobs consist of machine operators and the like so that relocation would not present difficulties on that score.

The site's processes involve melting polymers and putting them through an extruder. An extruder is a high volume manufacturing processer in which raw plastic material is melted and pushed through a die to be formed into a continuous profile. At the end of the process the product is cooled or frozen, using water. The company's energy input consists of oil and electricity and apparently extruders come with few alternatives with respect to energy input. Energy is also required for the freezing stage. Without a major change in equipment the company could not alter its energy use.

If the company were to relocate, Eastern Europe would be considered as a destination. Markets are growing in the EU's recent Accession States and production costs would be lower. Competition from the East is not an issue.

Owing to lack of versatility in the extrusion process, there is little scope for improvements in energy efficiency. There would however be a possibility of retrieving the heat from the cooling water, for use in their process.

Company B – A producer of cellulose

Interviewed person: CEO

Background
Company B is located in a member state of the European Union (country Y), and 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.

More specifically, the product is called microcrystalline cellulose (MCC). According to the annual report, the use of cellulose in the food sector is to add and enhance texture, stabilize emulsion, suspend solids, add opacity, be a stabiliser under high temperature processing and to increase dietary fibre. With respect to pharmaceuticals (tablets or granules), the cellulose accelerates disintegration and dispersion, is a binder and stabiliser, and has consistent and reproducible flow rate, and good water uptake.

The parent company has three categories of products: industrial chemicals, agricultural products, and specialty chemicals. The specialty chemicals category includes microcrystalline cellulose production which, along with carrageenan and alginates form biopolymers, is the largest component of sales of specialty chemicals. Most of the growth in specialty chemicals in fact lay in a strong performance by Lithium, which is not produced at the corporation's (interviewed) subsidiary. Lithium, used for energy storage in hand-held electronic devices, forms 31% of sales from the specialty chemicals category. Sales in Biopolymer were essentially level. Despite 'stiff headwinds' of higher costs of raw material, energy and transportation, the parent company announced that both revenue and operating profits in specialty chemicals grew in 2005. With a view to further growth the corporation explores options for product acquisitions, in-licensing, technical collaboration and equity ventures, as the best way to broaden their market.

The company sells microcrystalline cellulose to pharmaceutical and food ingredients companies in the USA and in Europe. They are developing novel oral dose delivery systems and other biopolymers for pharmaceutical and biomedical applications. They are also working with food companies. The annual report looks forward to higher sales, continued productivity improvements and lower interest expenses. The year 2006 is expected to show low to mid-single digit revenue growth in specialty chemicals. The main input in the production of microcrystalline cellulose is specialty paper pulps. These are mainly purchased from several North American producers. Other important inputs are labour and energy purchases are in the region of one sixth of variable costs.

Demand

GNP tends to be the ultimate driver of growth of demand. The company is seeing significant sales growth in emerging markets in Asia. The food ingredients business of B Biopolymers experienced strong growth in the Chinese beverage market where the microcrystalline cellulose-based products are used for beverage stability and shelf-life extension. The company entered the Chinese market in the 1990s.

R&D produces new products and these in themselves are drivers of demand, providing a portfolio of initiatives. The expansion of franchises is also expected to provide growth over the next three to five years. One of the risk factors listed by the company would be a failure to continue to make process improvements to reduce costs. Meanwhile the present single-digit growth should continue for some twelve years in any event, and demand is more or less consistent throughout the world. The new film-coated release product is expected to do well. The corporation is optimistic about the prospects for specialty chemicals over the next couple of years to continue growth in the mid single-digit range with earnings growth slightly above this trend. They say that they enjoy a solid customer base in non-cyclical end markets.

Specific trends driving growth include increasing consumer interest in healthier foods, greater convenience and growth in per capita consumption of processed foods in emerging markets. Growth moderation in recent years has been put down to increased price pressures. The customer base in the food market includes large and small food processors though these have been merging in recent years, and the aim is to ally with the market leaders.

Part of B's response to the pressure from low-cost producers is that B can supply the most reliable and broadest range of products and services.

Location

The siting of the subsidiary was due to the presence of an educated work force, a state grant, and an attractive rate of corporation tax. The original design was to use fuel oil and butane. But gas came on stream and customers were eagerly sought and the gas price is likely to have been low. Berthing facilities were also good.

Specialty chemicals are produced in several plants on four continents. The annual report describes how this allows the needs of local customers to be met while at the same time providing global scale in manufacturing and supply chain logistics. Customers of the Corporation as a whole are located worldwide, with almost 80% of revenue being generated in North America, Europe, the Middle East and Africa. Long-lived assets are located mainly in North America and Europe. Revenue by region from specialty chemicals shows nearly equal shares for North America and for Europe, the Middle East and Africa. The Asia Pacific region is in third place, followed by Latin America.

To maximise earnings growth B Corporation state that they engage in reducing costs and prudently managing their asset base. High cost production capacity in other categories has been shut down or out-sourced to third parties in Mexico, China and India. Their intention is to divest any business that cannot sustain a return above its cost of capital.

The company is currently actively looking at the possibility of locating in the Far East and it would appear not inconceivable that development in such locations could replace the B subsidiary. The US parent is concerned about rising costs in country Y (where the B subsidiary is located), including environmental costs. However by not being licensed with respect to the EU's IPPC they are spared the associated managerial costs. If the company were to expand or move they would be looking to India perhaps, where the cost per kilo of product would be considerably lower.

The company uses a lot of water and now have to pay to discharge their residual effluent as well as for water use. The price is simply volume-based, and does not cover pollution content. The effluent is what comes out of their own waste water treatment plant.

Their main R&D facility is in the US, but their research and applications organization is situated in many parts of the globe.

Technology

Turning to the subsidiary's energy use, their combustion plant is less than 19 MW. They are therefore not participants in emissions trading. The annual energy bill amounts to about a sixth of variable costs. They are now looking at various money-saving technologies because of the big rise in energy costs and in waste water charges.

They are investigating energy recovery from the sprayer driers and are talking to manufacturers of potentially appropriate plant equipment. They are also in the throes of looking at water cleaning processes, as members of country Y's programme for cleaner production plants. The project is still ongoing - it may result in a proposal for improving their technology. The company is accredited to the ISO 9000 quality standard and the ISO 14001 environmental standard.

The company has met with country Y's agency for sustainable energy and receive their communications. They are not part of the network of large energy users that has been organised by the agency. However they do intend to go to the relevant workshops, especially now that fuel costs are higher - energy efficiency investments "now make economic sense".

The criteria that they use for appraising investment proposals includes a required Internal Rate of Return of at least 20% and a 2 to 3 year payback. There were engaged in small upgrades five years ago to the tune of 5 or 6 million euro. Capacity expansion had also been considered but they 'de-bottlenecked' instead.

Expansion is in the offing as both the B subsidiary and one of the plants in the US are too small. But country Y is becoming a more expensive location, especially in terms of salaries. Changes in the regulatory environment, particularly in the US and the European Union are considered to have the potential to impact adversely on their ability to continue selling certain products, according to the annual report. They also feel that they may not be able to offset the impact of higher prices for raw materials and energy.

Concluding points concerning company B

On the issue of carbon leakage, important points to note are:

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 country Y's agency for sustainable energy might present.

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 country Y's agency for sustainable energy.

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Appendix A – Breakdown of CPA 24.1 at the 6-digit level

24.11	**Industrial gases**
24.11.11	Hydrogen, argon, rare gases, nitrogen and oxygen
24.11.12	Carbon dioxide and other inorganic oxygen compounds of non-metals
24.11.13	Liquid and compressed air
24.12	**Dyes and pigments**
24.12.1	Oxides, peroxides and hydroxides
24.12.2	Tanning or dyeing extracts; tannins and their derivatives; colouring matter n.e.c.
24.13	**Other basic inorganic chemicals**
24.13.1	Chemical elements n.e.c.; inorganic acids and compounds
24.13.2	Metallic halogenates; hypochlorites, chlorates and perchlorates
24.13.3	Sulphides, sulphates; nitrates, phosphates and carbonates
24.13.4	Salts of other metals
24.13.5	Other basic inorganic chemicals n.e.c.
24.14	**Other basic organic chemicals**
24.14.1	Hydrocarbons and their derivatives
24.14.2	Alcohols, phenols, and their halogenated, sulphonated, nitrated or nitrosated derivatives; industrial fatty alcohols

24.14.3	Industrial monocarboxylic fatty acids; carboxylic acids and their derivatives
24.14.4	Organic compounds with nitrogen functions
24.14.5	Organo-sulphur compounds and other organo-inorganic compounds; heterocyclic compounds n.e.c.
24.14.6	Ethers, organic peroxides, epoxides, acetals and hemiacetals; other organic compounds
24.14.7	Miscellaneous basic organic chemical products
24.14.8	Residual lyes from the manufacture of wood pulp, excluding tall oil
24.15	**Fertilizers and nitrogen compounds**
24.15.10	Nitric acid; sulphonitric acids; ammonia
24.15.20	Ammonium chloride; nitrites; nitrate of potassium; ammonium carbonates
24.15.30	Nitrogenous fertilizers, mineral or chemical
24.15.40	Phosphatic fertilizers, mineral or chemical
24.15.50	Potassic fertilizers, mineral or chemical
24.15.60	Animal or vegetable fertilizers n.e.c.
24.15.70	Sodium nitrate
24.15.80	Fertilizers n.e.c.
24.16	**Plastics in primary forms**
24.16.1	Polymers of ethylene, in primary forms
24.16.2	Polymers of styrene, in primary forms
24.16.3	Polymers of vinyl chloride or of other halogenated olefins, in primary forms
24.16.4	Polyethers and polyesters; polycarbonates, alkyd and epoxide resins
24.16.5	Other plastics in primary forms; ion exchangers
24.16.6	Waste, parings and scrap, of plastics
24.17	**Synthetic rubber**
24.17.10.5	Synthetic latex
24.17.10.9	Other synthetic rubbers

Case Studies with a view to assessing likely carbon leakage due to ETR

Pharmaceuticals industry – NACE 24.4

EU COMETR – Work Package 5.3

Authors: E. Christie (wiiw) and S. Scott (ESRI)

Abstract

This document provides a short global overview of the pharmaceuticals industry followed by assessment of leakage potential under various headings.

After a brief introduction, basic data on global market and production shares are given. Trade flows are then analysed, differentiating between primary and secondary processing. The pharmaceuticals industry is, in value terms, very clearly dominated by the large OECD economies, in particular by the United States and the European Union. It is also essentially a knowledge-driven industry, in which innovation and R&D play very important roles. In general energy costs are not a particularly important concern for pharmaceutical firms, although it is useful to differentiate between primary manufacturing (the production of the active ingredients) and secondary manufacturing (the production of the medicaments), the former being substantially more energy intensive than the latter.

There follow sections looking at potential for abatement through technological adaptations, finding only modest potential in the short-term owing to authorisation procedures, but medium to high potential in the longer run. The effect of ETR was and would be quite minor, given the option of negotiated agreements. (Companies in negotiated agreements in the UK, for example, would enjoy an 80 per cent rebate on the Climate Change Levy in return for undertaking agreed efficiency upgrades.) In general it appears that relocation does not arise as a serious issue in relation to ETR. The industry is heavily engaged in R&D in order to improve efficiency and develop new medicines. The outlook is positive on the economic side. The populations of Europe are ageing and becoming richer, and opportunities in the developing world are opening up, though the problem of protecting patents persists.

Introduction

The pharmaceuticals industry can be seen as being made up of two main sub-industries, in line with the NACE 4-digit codes:

24.41 Basic pharmaceutical products
24.42 Pharmaceutical preparations

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.

To facilitate the analysis one may define major product groups. One such list can be found in World Bank et al. (1999). It lists the following:

- Antibiotics (e.g. penicillin, streptomycin)
- Other synthetic drugs, e.g. sulfa drugs, anti-TB drugs, analgesics, anesthetics
- Vitamins
- Synthetic hormones
- Glandular products
- Drugs of vegetable origin, e.g. quinine, strychnine, brucine, emetine
- Vaccines and sera[1]
- Surgical sutures and dressings
- Other products, e.g. calcium gluconate, ferrous salts, glycerophosphates, saccharin, antihistamines, tranquilisers, antifilarials, oral anti-diabetics

Another, simpler, classification is the legal status which is also useful:

- Proprietary ethical products or prescription-only medicines, i.e. that are usually patented products
- General ethical products or prescription-only medicines that are made to a recognised formula that may be specified in standard industry reference books, i.e. generics
- Over-the-counter products, i.e. non-prescription products

Finally there are two convenient acronyms that should be noted: POM, which stands for prescription-only medicine, and OTC, which stands for over-the-counter (non-prescription) products.

Coming now to the production chain, one may describe it as follows, again following World Bank et al. (1999).

(a) Preparation of process intermediates
(b) Introduction of functional groups
(c) Coupling and esterification
(d) Separation processes such as washing and stripping
(e) Purification of the final product
(f) Additional preparation steps such as granulation, drying, tablet pressing, printing and coating, filling and finally packaging

Each of these steps requires some use of energy and therefore entails some indirect emissions of greenhouse gases. Furthermore each step may produce waste and emissions of pollutants that are specific to the chemistry of the products that are handled. Generally speaking however 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.

Section 1 – Supply and demand data, world and Europe

[1] sera is the plural of serum

As mentioned the pharmaceuticals market is dominated by OECD countries. This can be seen in table 1.1, where we see that in 2005 the largest market (measured by sales) was North America, followed by Europe[2] and Japan. The rest of the world accounts for only 8.4%. The world's retail pharmaceuticals market amounts to some US$ 550 million.

Table 1.1 – 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)
Note: shares re-scaled to total 100%

As for production, the European Federation of Pharmaceutical Industries and Associations (EFPIA, 2006) provides a rough guide, based on ex-factory prices valuation. This is reproduced in table 1.2. 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 1.2 – Global production shares 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 (2006) 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 (2006) 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.

Section 2 – Analysis of international trade flows

Using trade data classified according to the SITC (Revision 3) one can differentiate between the ingredients from primary processing (SITC code 541)[3] and the final products from secondary processing (SITC code 542)[4]. For convenience we will from now on refer to the former as being the *active ingredients* and to the latter as being the *final products*.

A very large share of the trade in pharmaceutical products takes place just among the wealthiest countries, essentially Western Europe (among which Switzerland occupies an important place), the USA, Canada, Australia and Japan. Other important traders (mainly as importers) are Turkey, Mexico,

[2] The European Union plus Norway and Switzerland.
[3] Medicinal and pharmaceutical products, other than medicaments of group 542.
[4] Medicaments (including veterinary medicaments).

South Korea, Singapore and Russia. China has also become relatively important recently in the active ingredients sub-industry. India on the other hand is still a rather unimportant trader here.

In order to provide a snap-shot of global trade patterns we have opted for presenting bilateral trade matrices based on reported export flows drawn from the UN's COMTRADE database. After looking at the most important trading partners of the European Union we settled on the following list of countries in descending order of value of exports: the EU, the USA, Switzerland, China, Japan, Canada, Mexico, Australia, Brazil, Russia and Turkey. Table 2.1 shows the export flows from and to the selected countries and regions for 2005 for pharmaceutical ingredients (SITC 541). Table 2.2 shows the derived shares. Both tables should be read row-by-row[5].

Table 2.1 – Active Ingredients Export Trade Matrix, USD million, 2005

→	EU	US	CH	CN	JP	CA	MX	AU	BR	RU	TR	RoW	WLD
EU	-	5,861	1,453	205	800	389	302	550	433	275	401	4,330	14,998
US	7,633	-	398	80	816	871	269	207	94	21	25	926	11,340
CH	6,902	791	-	67	165	261	67	117	46	59	129	832	9,435
CN	987	726	40	-	191	53	35	33	77	20	15	1,105	3,280
JP	559	320	13	54	-	4	5	10	3	0	10	196	1,175
CA	151	386	6	4	16	-	2	11	2	0	4	66	647
MX	77	149	0	0	1	5	-	0	14	0	0	75	321
AU	59	41	10	8	13	6	1	-	2	0	0	95	235
BR	34	71	2	1	1	0	8	0	-	1	1	79	198
RU	9	0	0	0	0	0	0	0	0	-	0	46	56
TR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	-	NR	NR
Sum	16,410	8,345	1,923	419	2,003	1,589	689	926	671	376	585	7,751	41,687

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

The final row in table 2.1 is the sub-total. It is not exactly equal to the corresponding sum of imports, a familiar problem of trade statistics, and it is of course lower than total imports as there are missing countries but it provides useful orders of magnitude.

Table 2.2 – Active Ingredients Export Trade Matrix, Shares, 2005

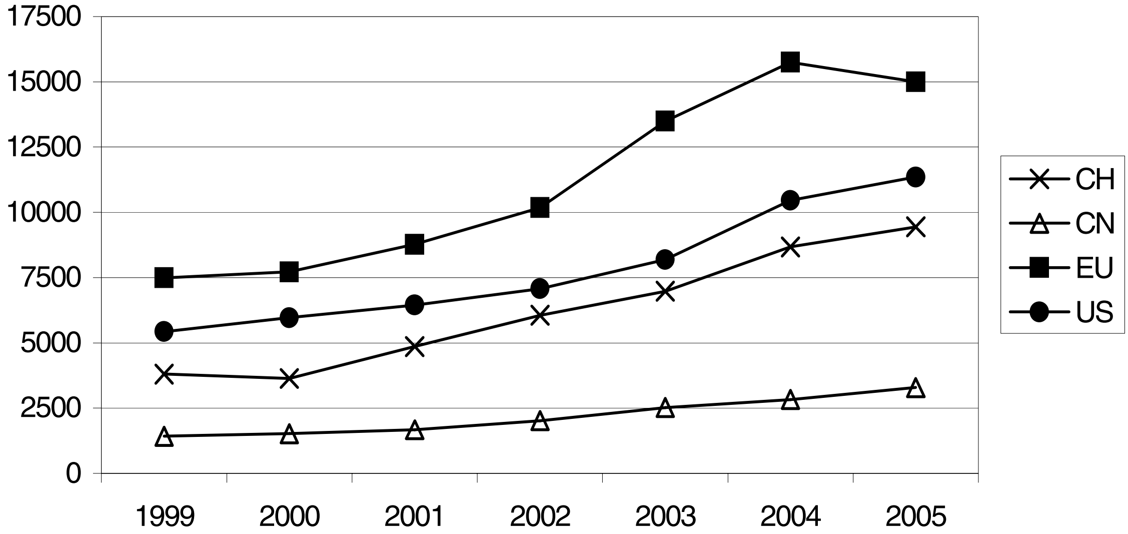
→	EU	US	CH	CN	JP	CA	MX	AU	BR	RU	TR	RoW	WLD
EU	-	39%	10%	1%	5%	3%	2%	4%	3%	2%	3%	29%	100%
US	67%	-	4%	1%	7%	8%	2%	2%	1%	0%	0%	8%	100%
CH	73%	8%	-	1%	2%	3%	1%	1%	0%	1%	1%	9%	100%
CN	30%	22%	1%	-	6%	2%	1%	1%	2%	1%	0%	34%	100%
JP	48%	27%	1%	5%	-	0%	0%	1%	0%	0%	1%	17%	100%
CA	23%	60%	1%	1%	2%	-	0%	2%	0%	0%	1%	10%	100%
MX	24%	46%	0%	0%	0%	2%	-	0%	4%	0%	0%	23%	100%
AU	25%	17%	4%	3%	6%	3%	0%	-	1%	0%	0%	41%	100%
BR	17%	36%	1%	0%	1%	0%	4%	0%	-	0%	0%	40%	100%
RU	17%	1%	0%	1%	0%	0%	0%	0%	0%	-	0%	81%	100%
TR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	-	NR	NR

Source: UN COMTRADE and own calculations

[5] The first row of table 2.1 shows that the EU exported a value of 5861 million USD to the USA, a value of 1453 million USD to Switzerland, and so on. The codes are: EU (European Union), US (United States of America), CH (Switzerland), CN (China), JP (Japan), CA (Canada), MX (Mexico), AU (Australia), BR (Brazil), RU (Russian Federation), TR (Turkey), RoW (Rest of the World), WLD (World total).

As can be seen the international market for active ingredients 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. As for the distributions, the EU has a quite diversified export pattern, whereas the US and Switzerland direct almost all their exports to the selected countries, in particular to the EU.

Graph 2.1 – Recent Evolution of Active Ingredients Exports, USD millions



Source: UN COMTRADE

Looking at recent trends (graph 2.1) we see that nominal export growth has been impressive for the three major players as well as for China. The EU in particular widened its lead up to 2004, though it narrowed again in 2005 due to a fall in EU exports. As for China it seems to have held its own over the 1999-2005 period, but its average growth rate was second to Switzerland's and only slightly higher than those of the EU and the USA. On current trends, it does not look as though China will catch up with any of the three major players. Of course this is no basis for a forecast, one would need a more detailed analysis of the likely evolution of prices and investment flows, but at least we can say that as things stand there is no clear sign that China is catching up with the major players.

The picture becomes more complete when one looks at the export matrix for final products (tables 2.3 and 2.4).

Table 2.3 – 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

Here in the case of final products 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.
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, as was flagged by the consumption and production shares at the start.

Table 2.4 – Final Products Export Trade Matrix, Shares, 2005

→	EU	CH	US	CA	AU	JP	MX	CN	BR	RU	TR	RoW	WLD
EU	-	11%	34%	5%	5%	6%	1%	1%	1%	5%	2%	29%	100%
CH	56%	-	12%	3%	2%	5%	1%	1%	1%	2%	2%	15%	100%
US	53%	7%	-	15%	3%	5%	3%	1%	2%	0%	1%	10%	100%
CA	9%	8%	75%	-	1%	1%	0%	0%	0%	0%	0%	5%	100%
AU	26%	0%	8%	2%	-	2%	0%	2%	0%	0%	0%	59%	100%
JP	24%	6%	51%	0%	1%	-	0%	4%	0%	0%	0%	13%	100%
MX	2%	0%	25%	4%	4%	0%	-	0%	14%	0%	0%	51%	100%
CN	7%	4%	3%	0%	6%	11%	0%	-	1%	1%	1%	65%	100%
BR	16%	1%	0%	2%	0%	0%	13%	0%	-	0%	0%	67%	100%
RU	3%	1%	0%	0%	0%	0%	0%	0%	0%	-	0%	96%	100%
TR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	-	NR	NR
Sum	20%	8%	25%	6%	4%	5%	1%	1%	1%	3%	2%	24%	100%

Source: UN COMTRADE and own calculations

Canada, Australia, Japan and Mexico could be referred to as medium-sized exporters of final products. As for China its export level is rather low. This is in sharp contrast to its high ranking as an exporter of active ingredients and suggests that China will first and foremost be moving into the lower value-added part of the production chain, i.e. primary processing, as it has done in a number of other industries, though this may well be only a preliminary stage of Chinese industrial development in pharmaceuticals.

As discussed earlier when looking at global production and market shares it is quite clear that the global market is dominated by North America and Europe, in that order, and that capacities are such that, at the moment at least, Europe is the world's leading exporter and a large net exporter due to high demand especially in the United States. Looking to the future EFPIA (2006) expresses some quite serious concern at recent trends in terms of innovation and R&D investments, as the United States has been much more active in this respect than has the EU. Beyond production it is also the case that American demand has been strong and is impressive in absolute terms (partly a result of a higher GDP per capita, but also societal issues perhaps).

As we have just seen with this brief discussion the over-riding concern of the industry seems to be to make enough investments in highly skilled staff and high-technology equipments and R&D in order to keep or obtain a competitive edge. The industry generates essentially so-called North-North trade flows, as well as some intra-industry trade as some of the active ingredients are sourced from other countries as we saw. Nevertheless a very large share of these flows takes place among the three large players, although China could make its presence felt more strongly over the next few years.

Section 3 – Leading companies

Table 3.1 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 3.1 – Top 12 pharmaceutical companies by revenue, EUR millions, 2005

Name	Country	Output (2005)
Pfizer	USA	41235
Johnson & Johnson	USA	40592
GlaxoSmithKline	UK	31734
Bayer (*)	Germany	27383
Sanofi-Aventis	France	27000
Novartis	Switzerland	25892
Roche	Switzerland	22935
AstraZeneca	UK/Sweden	19291
Abbott	USA	17925
Merck & Co.	USA	17683
Bristol Myers Squibb	USA	15433
Wyeth	USA	15076

Source: EFPIA(2006) and corporate web-sites
Note: (*) includes important revenues from chemicals

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 (Economist, 2006). Mergers of firms that are searching for synergies in production and markets also helps 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.

Section 4 – Energy Intensity

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. This can be seen from the estimates presented in table 4.1 which are based on Eurostat's annual detailed enterprise statistics. These estimates were calculated by taking the sum of the cost of purchased energy products divided by total turnover.

Table 4.1 – Estimated energy unit costs (turnover basis) of the EU's pharmaceuticals industry

Estimated energy intensity	1999	2003
Active ingredients (24.41)	1.9%	1.9%
Final products (24.42)	0.6%	0.5%
Ratio	3.3	3.6

Source: Eurostat and own calculations

The two sub-totals were summed over those countries for which data was available for both years, namely Belgium, Germany, Spain, France, Italy, Austria, Portugal, Finland and the United Kingdom. While some of these countries are small producers (e.g. Finland) all the major EU producers are covered in the estimates.

In light of this result the analysis of a possible impact of energy prices and carbon taxes should focus on the active ingredients sub-industry (24.41). A manufacturer of active ingredients that is a subsidiary of a multi-national was selected for interview.

Section 5 – Trends in ETR countries

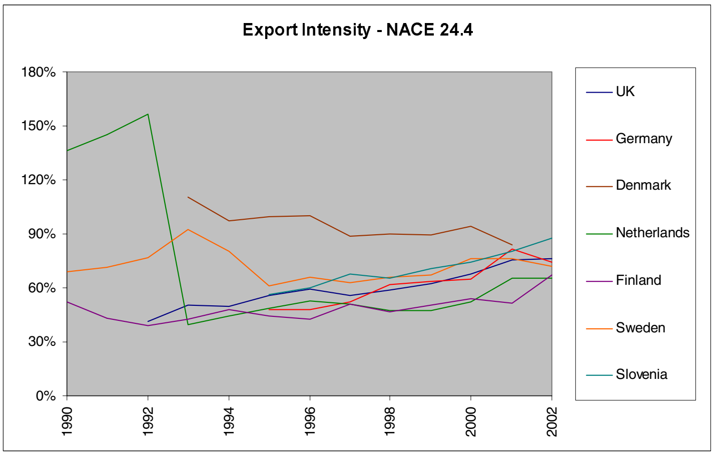
Recent trends in ETR countries are now checked[6] to see if the effects of ETR are noticeable and to see how the pharmaceutical sector has responded to various influences. The key dates for the introduction of ETR in the relevant EU countries, against which to judge effects of ETR, are as follows:

Sweden 1991
Denmark 1995
Netherlands 1996
Finland 1997
Germany 1999
UK 2001 (announced 1999).

For Slovenia, the CO2 tax, although not strictly part of an ETR, has been included to give an example of environmental taxation in the New Member States. Slovenia is discussed in the following passages, where data allow.

It is useful to see what recent trade patterns tell us about trends in the pharmaceutical sector. Figure 5.1 shows the export intensity of the sector. With the exception of Denmark, these recent trends indicate that the amount exported, expressed as a share of total output of the sector,[7] is rising. From 1995 to 2001, export intensity rose from rates in the 40% to 60% range, up to rates in the 55% to 80% range. A few setbacks are recorded, but these appear to be temporary and do not suggest a deterioration in competitiveness.

Figure 5.1: The pharmaceutical sector's total exports/output, %

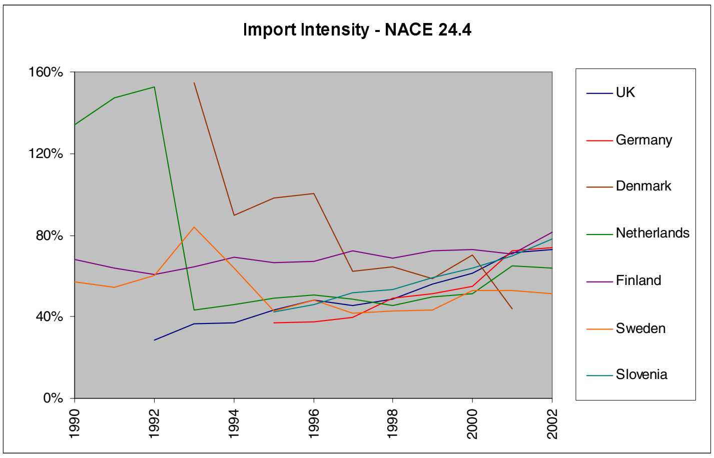


Source: COMETR, work package 3.

The corresponding pattern for import intensity of the pharmaceutical sector is shown in Figure 5.2, measured as imports as a share of domestic consumption.[8] With the exception again of Denmark, the pattern is also upwards, rising from the range of 40% to under 70% in 1995, up to the range 55% to over 70% in 2001. It is worth noting that the pattern is showing an increase in import penetration though not strong except in the case of the UK.

[6] Other work packages in COMETR undertake methodical econometric analyses of the data. In assessing the data in an informal manner this work package aims to gain further insights on the sector.
[7] Total output of the sector is measured as the sum of expenditure on intermediate consumption and energy, compensation of employees, net production taxes, plus operating surplus, all calculated in current price € .
[8] Domestic consumption is measured as output (as above) minus exports plus imports.

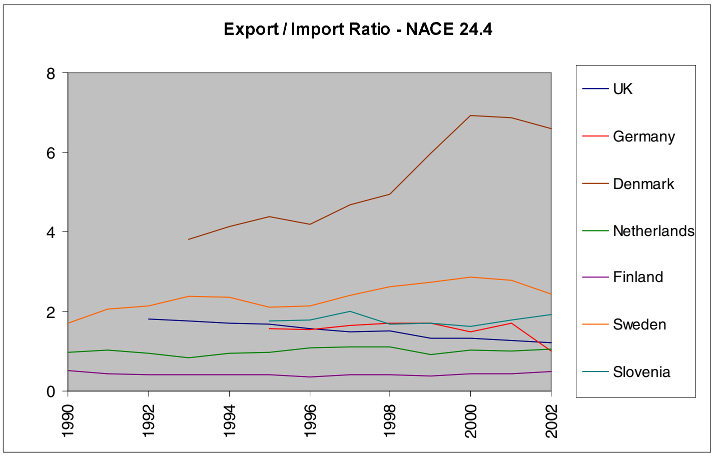
Figure 5.2: Imports of pharmaceuticals as a share of domestic consumption, %



Source: COMETR, work package 3.

Finally the export-import ratio, is shown in Figure 5.3, which has some interesting trends. A smooth decline in the export-import ratio occurs in the UK over the period, and Germany has one main drop in 2002. Finland and the Netherlands have static ratios, and Sweden's and Denmark's have risen overall though they are declining in the two last years.

Figure 5.3: The pharmaceutical sector's export-import ratio.

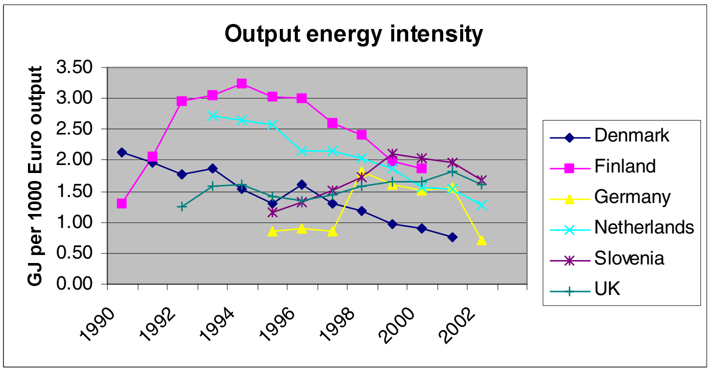


Source: COMETR, work package 3.

Movements in the case of Slovenia are in general very much in line with those of the other countries. These three figures on trade make no suggestions either way of an effect on the competitiveness of the pharmaceutical sector due to the ETRs. The sector having modest energy intensity this does not come as a surprise

The trend in energy intensity per unit of output is shown in Figure 5.4 and the first point to note is that the trends seem to be converging. Secondly all countries saw a decline in energy intensity in the most recent year or years for which data are available. Germany starts its fall in energy intensity in 1999, coinciding with its ETR. The UK's ETR occurred in 2001 and its energy intensity starts to fall after that year. These may be coincidences. For the Netherlands, Finland and Denmark it has already been falling for several years before their ETR. (Data for Sweden are not valid.).

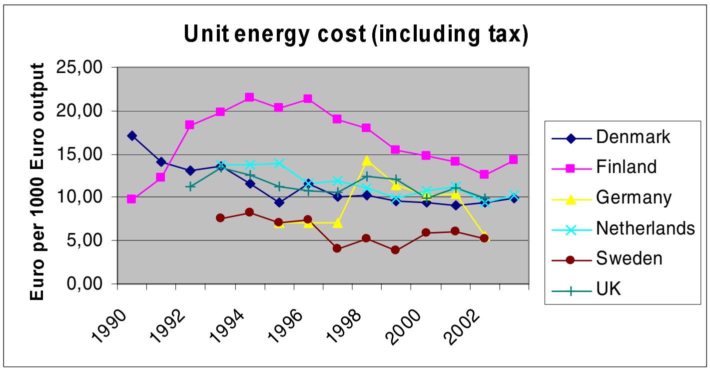
Figure 5.4 – Energy intensity per unit of output (in 2000 prices).



Source: COMETR WP3.

We can next look at Figure 5.5 showing the path of unit energy costs, which are similar to energy intensity except that energy is measured in cost terms. Movements in its path are therefore the result of price changes combined with quantity changes.

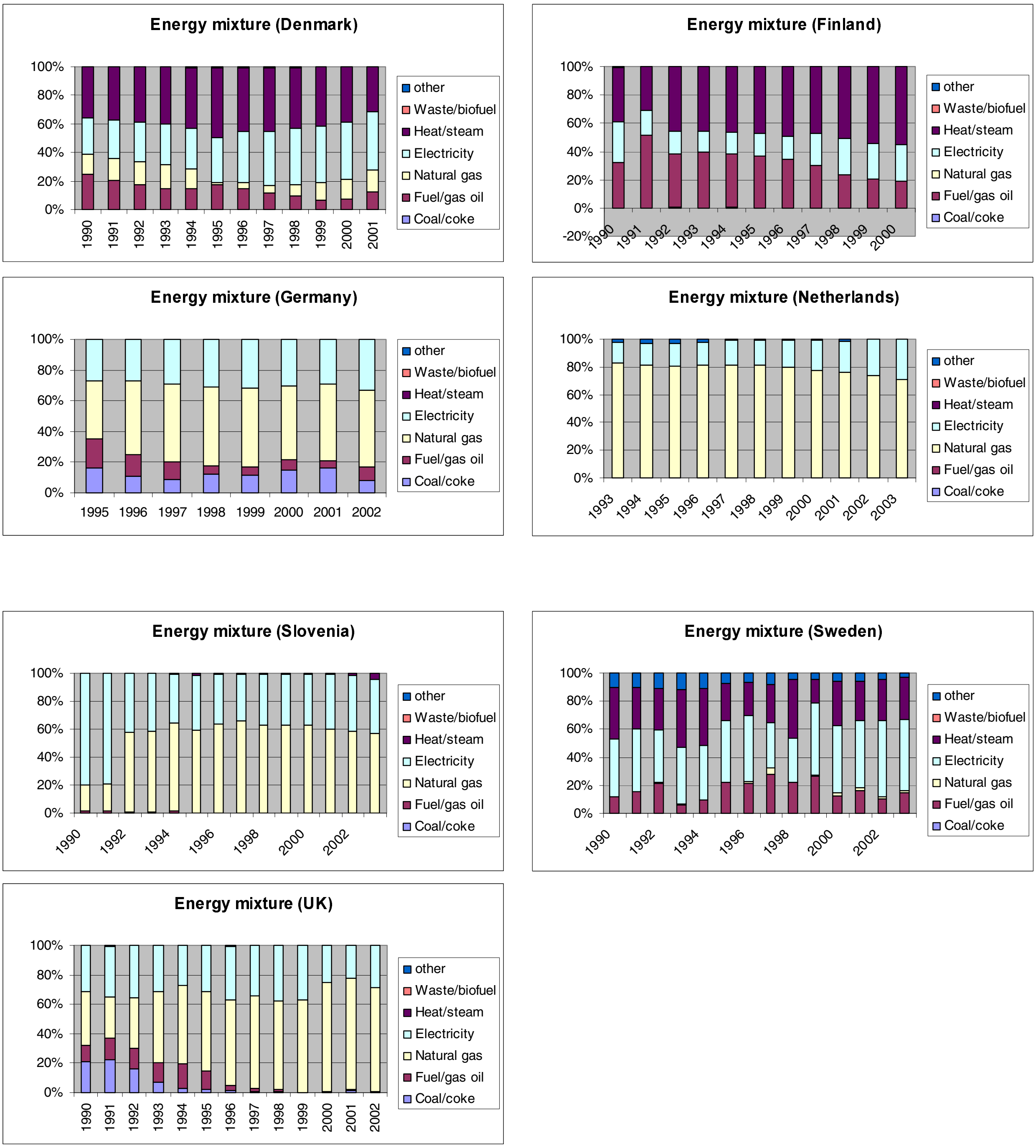
Figure 5.5 - Energy cost per unit of output



Source: COMETR WP3.

A summary of movements in fuel shares is given in Figure 5.6. Denmark, Finland the Netherlands and to some extent Sweden increased the share of electricity, and Denmark and the UK increased the share of natural gas. These movements in many instances are consistent with relative movements in fuel prices as we shall see.

Figure 5.6 – Fuel shares from 1990, %



Source: COMETR WP3.

Table 5.1 shows the changes in prices of fuels charged to the pharmaceutical industry between 1995 and 2000. The price of electricity fell during this period or else, together with natural gas, rose relatively less than other fuels. The price of natural gas actually fell in the UK, helping to explain the downward movement in unit costs.

Table 5.1 –Total price changes of fuels in the pharmaceutical sector, between 1995 and 2003, %

	Fuel oil	Gas /diesel oil	Natural gas	Electricity
Denmark	229.3	200.1	56.8	1.2
Finland	30.1	43.8	39.3	-2.6
Germany_02	59.2	58.1	26.7	-33.7
Netherlands			29.5	-10.4
Sweden	-10.5	234.8	63.0	2,9
UK_02	34,5	28.6	1.0	-37.1

Source: COMETR WP3.

Table 5.2 gives the percentage change in consumption of energy, and details for individual fuels, between 1995 and 2000. There is a striking degree of fuel switching and while this may reflect changes in processes or quantities of different products, the consistency with price changes is again noted. UK had the biggest electricity price drop and relatively low price rises for other fuels, and this tallies with UK having the biggest rise, 48.2%, in total energy consumption. Denmark's drop in fuel oil consumption is consistent with its large price rise, and the same applies to Sweden in respect of gas oil which saw a big price hike.

Table 5.2 - Percentage energy consumption change between 1995 and 2003

	Total	Fuel oil	Gas/ diesel oil	Natural gas	Electricity
Denmark	45.0	-79.6	26.9	1568.3	96.7
Finland	-14.9	-88.8	-10.0	-	41.7
Germany_02	15.2	-27.9	-55.5	52.3	41.6
Netherlands	-29.1			-37.3	23.3
Sweden	38.5	3296.4	-49.9	2259.3	59.9
UK	48.2	-93.1	-89.1	94.2	3.5

Source: COMETR, WP3.

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 it is worth viewing the scale of energy taxation in the pharmaceutical industry since the introduction of ETR. Table 5.3 shows energy taxation as a share of gross value added.

Table 5.3 - 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
Slovenia	0.61	0.19
Sweden	0.68	0.03
UK	5.05	0.05

Source: COMETR, WP3.

Energy tax forms one of the lowest shares of GVA in the UK, which incidentally has the highest energy intensity (bar Slovenia), according to Figure 5.4. The fact of the matter however is that the tax is so small, ranging up to 0.60% of GVA at most, that it is unlikely to have a serious financial effect, except in those companies that are inflexible or more energy intensive than the norm for the sector.

Section 6 - Technology potential

We already saw that energy taxes are a small part of value added in the pharmaceutical sector. In so far as technological adjustments can reduce CO_2 emissions at reasonable cost this would be a further pointer as to how companies avoid the potential effect of ETR on competitiveness and the desire to re-locate. It is of course precisely to encourage technological change, and indeed to guarantee rewards to technological discoveries, that ETR is intended.

Needs at R&D stage

Despite the flexibility in fuels and fuel intensity seen above, technology in the pharmaceutical sector could be described as quite rigid for given periods of time. In the pharmaceutical sector especially, designing out environmental impacts are best tackled at the R&D stage. Developing a new product can take more than a decade with huge associated costs. Then the product has to go through the processes of the various regulatory agencies, such as the US Food and Drug Administration and the UK's Medicines and Healthcare Products Regulatory Agency. The process specifies how a product is made and once it has been authorised change is discouraged and may need to be re-authorised, taking perhaps several years, not to mention the cost.

This is well recognised. The BREF note[9] for the pharmaceutical industry states that environmental considerations have to be incorporated into process development. A point made by Britest, a collaborative organisation set up by the pharmaceutical industry to encourage best practice, is that to comply with IPPC companies need to demonstrate that they are reducing their impacts by incorporating environmental concerns early on in the development of new products. Another motive for increased efficiency at the design stage is that retro-fit and end-of pipe treatment are likely to be more costly in the end.

To some extent the requirement of early authorisation makes it more difficult for pharmaceutical companies to adapt to price changes, such as carbon/energy taxes in ETR. This restricted technical flexibility needs to be taken into account.

Technology

Active ingredients: Basic pharmaceutical product - NACE 24.41

As described in the introduction, in production of many active ingredients in medicinal products the production process is based on chemical reactions. Ingredients are added to each other and mixed together at specified temperatures for certain lengths of time to give a product in crude form, often powder.

A + B raw materials → Solvent → Product D

The crude form of the product can then be purified by several steps of washing and drying. Electricity would be used for motor power, process cooling, compressed air, and ventilation. Gas or oil would be used to generate steam on site as a source of heating during manufacture. It would also be used for space-heating the premises and would tend to be the largest component on a kWh basis. Testing for quality control plays a central role. This is an area where qualified personnel in appropriate disciplines are required.

Final product: Pharmaceutical preparations - NACE 24.42

The crude product is then made up, by the same company or another company, into the formulations that the patient is to receive. The final marketed product is made up in tablet or capsule form, for example, and packaged for the market.

Technology improvements

A range of measures to reduce CO_2 is listed by de Beer *et al*. (2001) that can be applied in the pharmaceutical industry, which forms a part of the chemical sector that they analyse in some detail. Measures applicable to pharmaceutical companies are generic in nature. These are listed by de Beer *et al*. as:

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[9] Under the IPPC Directive, information on Best Available Technology (BAT) for individual sectors should be exchanged between member states. The Commission publishes the results as the BAT Reference documents – known as BREF notes. They are to help member states to produce their own standards. BREF notes are available from http://eippcb.jrc.es/pages/FActivities.htm

- Adjustable speed drives.
- Energy efficient motors and appliances.
- Optimising pressurised air systems by reducing leaks, splitting the systems into several pressure levels and lowering the pressure for certain applications.
- Improved lighting.
- More efficient separation processes.
- Improved reactor design.
- More efficient burners.
- Optimise heat exchanger networks.
- Application of heat pumps.

They suggest that these can be categorised into a tranche of low-cost measures and a second tranche of high-cost measures, as shown in Table 6.1.

Table 6.1 - Measures for reducing energy use and CO_2 emissions in the pharmaceutical sector

Measures	Saving per year %		Investment per t CO_2 eq saved annually	Abatement cost
	Fuel	Electricity	€ / t CO_2 eq	€ / t CO_2 eq
Low cost	5	15	200	-49
High cost	10	10	667	-11

Source: de Beer et al, 2001, Table 3 and page 28.

The rounded nature of the figures suggests that these are rough estimates. The authors use a 15-year lifetime in order to derive the (discounted) cost per tonne of CO_2 abated, which as seen in the final column is negative. To the companies these would be worthwhile measures. It is seen that savings of the order of 5 to 15 % are deemed possible, and that these would be profitable investments over a 15-year period.

With recent rises in energy prices and through the operation of negotiated agreements it is likely that some of these measures that could be retro-fitted have been adopted by now. However we saw that energy is not a very large share of value added in the sector. This means that other priorities are likely to command valuable managerial time which, along with demanding payback periods, is one of the barriers to undertaking worthwhile energy saving measures (Sorrell, *et al.,* 2005*).*

Other sources of information on technology potential include the BREF notes. The BREF for pharmaceuticals says that moving to small-scale, continuous, intensified reactor technologies could lead to a "step change" in environmental performance. There are also several process intensification techniques that can complement such reactors. Other emerging techniques include microwave-assisted organic synthesis and constant flux reactor systems - both more efficient ways of delivering heat to drive reactions.

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 1. This subsidiary manufactures active ingredients solely for export. The company engaged pro-actively in negotiated agreements with the energy agency. In return the company would receive a large rebate on its carbon taxes.

Box 1 - CASE STUDY of adaptation by a multi-national subsidiary in face of approaching carbon/energy taxes*

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.

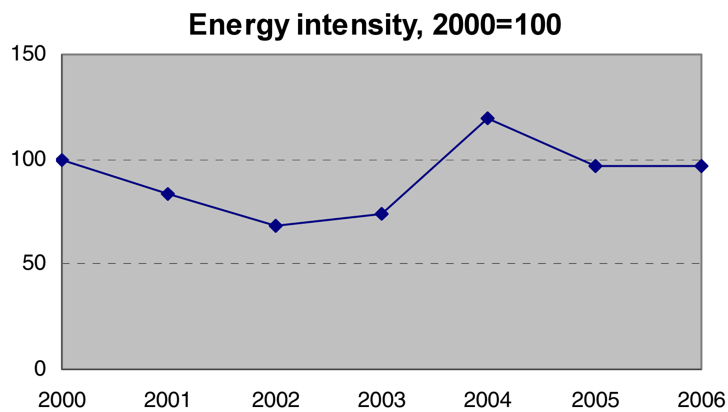
The parent company with headquarters in the Far East is a major company there. It has net sales worldwide of over 7000 million US dollars, alongside R&D expenses of more than 1000 million US dollars. All of the products manufactured in the subsidiary are the result of original research at headquarters. 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 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.

* 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.

Technology adaptations as part of negotiated agreements have proceeded at a mixed pace, as seen in the energy intensity chart in Box 1, but participation has proved to be a valuable learning experience. In the case study cited here, the energy agency provided free audit and advice, and the agency is perceived in a good light. The existence of opportunities for saving energy is recognised.

According to the agency, the tax rebate is an important element in assessing the financial attractiveness and indeed alters the economics of energy efficiency actions in a fundamental way. This of course presupposes that there is a carbon tax to start with, in the absence of which one questions whether the commitment on the part of industry would be so positive. The self-selected companies in the agreements had already taken many low-cost actions. The pilot study for the new energy agreements programme shows an average energy efficiency gain for the ten companies of over 15%. Required investment averaged less than 25% of the annual energy bill. The simple payback for each company averaged about 1.5 years and annual CO_2 savings per site averaged nearly 4000 tonnes.

Section 7 - Pharmaceutical industry self-motivation

A characteristic of the pharmaceutical industry is that it has a growing need to be seen to be environmentally responsible. This is reflected in the industry’s many initiatives in environmental upgrades and transparent operations, which in turn are a response to greater awareness on the part of the public of potential harms and attention to image.

Keeping track of one’s emissions is part of the some pharmaceutical companies’ efforts. Two major companies have developed models that allow the operator to produce an auditable trail to show how the company has considered the environmental impacts of new products. It also helps the company qualify for a more flexible multi-product protocol. However, their IPPC applications apparently say less than they might about the current use of greener chemistry or plans to develop alternative techniques.

Efforts into designing more energy efficient manufacturing processes with over 15% savings are being made. By-products include reductions in hazardous solvents and acids previously used, reducing the amount of liquid waste sent for incineration. Other research is being undertaken in to ionic liquids, microwave technology and supercritical CO_2 (ENDS, 2006). However, there may remain inertia within the industry. Despite the prospect of significant costs savings and more productive processes, companies in general find it hard to change. For example, it is acknowledged that techniques such as stirred-tank batch reactors are the mainstay of the industry because they are flexible and reliable, but they are not the most efficient.

Section 8 – Location choice

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 1 above. Financial advantages, personnel and physical aspects are important, as can be seen from Box 2.

Box 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.

Other developments are influencing location choice. As stated at the start, world demand has been located mainly in OECD, that is, richer countries. The 2003 World Trade Organisation deal to improve poor countries' access to patented medicines enabled pharmaceutical firms in the developing countries such as India to make cheap copies. While this should enable these companies to supply poor countries, it appears that these companies are also interested in chasing the lucrative markets, which again for now means the US predominantly, and also Europe (Economist, 2003). This issue reminds one that balancing the need for patents to encourage medicine invention and testing, on the one hand, with the need to make the results cheaply available for the poor, on the other hand, is not straight-forward.

These firms are seeking acquisitions in Europe and, in addition to selling generic versions of off-patent medicines, they are now in turn seeking to become R&D based. Firms in the Far East are planning to spend sizable shares of revenues on R&D, on both new drugs and on variants of existing ones. There are medicines with annual sales of $42 billion that are estimated to go off-patent before 2007. The first company to file a generic version of a drug receives exclusive rights (along with the patent holder) to manufacture the drug for 180 days. This has been achieved already by Far Eastern companies.

At the same time as difficulties in upholding patents against competition from generics, some companies have had their medicines withdrawn due to safety fears and their new drugs in the pipeline are not realising their promise.

The issue for ETR is that competition could become more intense, with corresponding increased pressure on profit margins. So, despite the moderately low energy input of pharmaceuticals, the need for potential cost-effective energy saving technologies in ETR countries, prospective or otherwise, and other location considerations are nevertheless important.

Attracting investment to a location is helped by several factors including good *procedures for set-up*, as stated by the company interviewed for the case study. A country might have higher taxes than another, but more streamlined dealings with the development authority, the local authority, environment authority and utilities count for a lot also.

Encouragement to R&D can be another factor. For example an R&D tax credit has been introduced to encourage such work in Ireland, which has a particularly successful track record in attracting pharmaceutical companies. In addition stamp duty on intellectual property has been abolished. The enticements may still be financial but they do not necessarily include keeping energy cheap. Up-skilling the workforce is the next part of Ireland's strategy - perceived competitors apparently include such far-flung locations as Puerto Rico and Singapore.

Finally, when considering location the issue of transport costs has to be addressed. It is seen that locations tend to be far apart and, though proximity to markets has advantages, transport costs are not usually cited. This is because in general the products have high value and low weight which makes them relatively easy to transport.

Section 9 - Outlook for the pharmaceutical sector

Discussions with the case study subsidiary point to some main issues that influence the pharmaceutical sector's outlook, summarised in Box 3.

Box 3 - CASE STUDY view of the future outlook

Demand for health products increases with GNP. Besides GNP other factors affecting demand include demographic conditions, currency exchange rates, and legislative and regulatory developments. Demand is also driven by demographic factors. The company's product focuses on conditions of middle-age to old-age. This older niche market is, of course, one of the characteristics which is becoming more pronounced in Europe.

Sales growth is modest at present but there are new products coming along. The intention is to create markets by means of new products. Business resources are being focused on specific global franchise areas.

The US is the largest pharmaceutical market in the world. Nevertheless it is in East and South East Asia that the company expects market growth. Earning power and sales structure are improving through focused investment. The Far East takes the majority of its sales as a whole, while Europe, the US and Asia share the rest in declining order. Factors affecting demand include economic conditions, currency exchange rates, and legislative and regulatory developments.

The supply side is also part of the outlook where pharmaceuticals are concerned. Key drivers of future growth are said to include good product mix, launch speed, sales representation, production continuity and satisfactory dealings with issues such as intellectual property.

We can elaborate on the points raised by the case study on the outlook for pharmaceuticals. Global sales of pharmaceuticals have almost doubled in the eight years 1997 to 2005. The short-term outlook for pharmaceuticals production in the EU is for 4.5% growth in 2007, from an expected out-turn of 6% growth in 2006 (CEFIC, 2006).

The clouds on the horizon are high oil prices and dollar weakening. Early 2006 saw a pick-up. In 2005 pharmaceuticals had a poor year with growth of 3.4%, owing to weakness in private consumption.

Pharmaceuticals along with fine chemicals are now expected to be the major engine of growth of the chemicals sector as a whole.

CEFIC adds that the EU pharmaceuticals industry continues to develop in a few countries at a higher pace than in the rest of Europe. Intensive implantation and investments of laboratories in some countries (France, Ireland and UK) in previous or more recent years give competitive advantages to these countries. New strategies are being devised in the pharmaceutical world to deal with the different risk factors that threaten it: inefficient research, tough public policies for health spending, competition from generics, withdrawal of some products, structural price decreases due to the generics and also to the increasing pressure of the social security systems in many countries (CEFIC, 2006).

The world economic climate is relatively healthy, with positive trends evident in Western Europe, North America and Asia. World GDP growth is expected to moderate in 2007, with EU performance continuing to lag that of the rest of the world. Movements in European consumer confidence are broadly positive. Growth rates in prescription medicines have decreased recently but a slow recovery is now expected.

Looking at the regional distribution, a shift of growth to the emerging markets in Latin America (Mexico, Brazil) Asia (Korea, China) and Eastern Europe can be observed. Patent expiries in the US and price cuts in Western Europe and Japan are a factor that is dampening growth prospects, according to one major company. CEFIC points out that high energy prices are a cost factor that has additional adverse effects on consumers' purchasing power.

A further point needs to be made on the issue of patents and market conditions in the US. Democrat party control of the US Congress is likely to see efforts to reduce healthcare costs and to allow government to negotiate directly with pharmaceutical manufacturers. This is to bring about lower prescription prices for senior citizens. Use of cheaper generic forms of medicines may also increase. American drug prices are largely set by the market and this has had the effect of attracting large companies to invest in the US. Challenges from generics will see firms trying to cut their costs, which could be another factor affecting the general outlook.

Section 10 – 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 price 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 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, and if border tax adjustments, continuing focused energy advice and revenue recycling are pursued, the disadvantages may be imperceptible in this sector.

Table 10.1 summarises the importance of various criteria affecting the pharmaceutical industry's attitude to re-location, when ETR is introduced.

Table 10.1 - Relocation Criteria Matrix: Pharmaceutical industry NACE 24.4

Criteria	Importance of criterion
1. Energy intensity	Low to modest
2. Energy price differences, ETR	Low
3. Scope for shifts in fuel mix	Medium to high
4. Costs of trade (weight to value ratio, transport costs, tariffs, NTBs)	Low costs
5. Importance of location (irrespective of costs of trade)	Medium
6. Knowledge-intensity, R&D-intensity	Very high
7. Importance of regulation	Very high
8. Fragmentation of production chain	Medium
9. Residual X-inefficiency, scope for energy efficiency gains	Medium in short-term Medium to high in long-term
10. ETR offsetting mechanisms	Medium, offsets to date via negotiated agreements, some benefit from labour tax reductions
11. Border tax adjustments	Medium potential Possibly complicated due to heterogeneity of products
12. Indirect cost effects due to ETR	Low
13. Competitiveness of the international market	Medium

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Competitiveness Effects of Environmental Tax Reforms (COMETR)

The Glass and Glass Products Industry

WORK PACKAGE 5 – Industry Studies

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31 December 2006

Abstract

This document provides an overview of the glass and glass products industry (defined as corresponding to NACE, rev. 1, code 26.1) in Europe in terms of its main economic, technological and energy-use features. It starts with an economic overview of the glass and glass products industry, discussing production volumes and locations, international trade flows and leading companies, with a particular focus on the European dimension. Production processes are also briefly reviewed. The study then addresses the concrete challenges faced by companies in the two most important sub-industries, namely flat glass and container glass, notably using the results of interviews made with European companies in each sub-industry.

Section 1 – Introduction

Glass is primarily made from silicon dioxide (silica), SiO_2, which can be found in nature in the shape of sand or quartz. In practice it is sand that is the most important raw material for glass production. Sand is a very abundant raw material; however, only certain deposits provide sand that is of sufficient purity for glass making.

Pure silica has a melting point of 1700 °C – 1900 °C, depending on its exact crystalline structure. This high melting point would imply very high production costs, so two other substances are added in most cases, in order to lower the melting point and simplify processing. The first is soda ash[1] (sodium carbonate Na_2CO_3). However soda ash makes the glass water-soluble, which is usually undesirable, so lime (calcium oxide, CaO) will be added to restore insolubility (fluxing agent). The resulting combination has a melting point[2] of around 1550 °C. Production thus takes place using purpose-built furnaces, most often using either natural gas or fuel oil to generate the required temperature. The resulting product contains about 70% of silica and is called *soda-lime glass*. Soda-lime glass accounts for about 85% of all manufactured glass in Europe, according to EEA (2005). The only types of glass that do not include silica as a major constituent are the chalcogenide glasses, used for fibre optics and specialized technical applications.

As well as soda and lime, glass may contain other ingredients added to change its properties. Boron trioxide may be added to change the thermal and electrical properties, as in Pyrex. Lead oxides may be added to improve the sonority and to increase the refractive index of the glass. Aluminium oxide may be added to improve chemical resistance and to increase viscosity at low temperatures. Also, metal ions can be added to give colour, e.g. Cu^{2+} for light blue, Cr^{3+} for green or Mn^{3+} for violet.

[1] One alternative is potash (the equivalent potassium compound).

[2] The necessary temperature for melting may be lower depending on the presence of other materials. IPPC(2001) cites a general temperature range of 1300 °C to 1550 °C.

The main types of glass products are: flat glass (e.g. for windows in construction, in cars), container glass[3] (e.g. bottles and jars), fibreglass (e.g. glass wool for insulation), tableware glass[4] and special glass[5]. 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 1.1, 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.

Table 1.1 – 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 website

The production of, especially, flat glass, fibreglass and special glass 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 takes 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).

Energy intensity in glass manufacturing

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. This is shown in table 1.2. The estimate is based on Eurostat's detailed annual database on enterprise and construction (SBS) and covers 14 EU member states, together accounting for around 90% of EU-wide turnover based on 2003 data and estimates. The table also shows the cost-based energy intensity for the sub-industries, based on a smaller number of countries due to data availability constraints.

[3] Also called hollow glass, and sometimes packaging glass.
[4] Also called domestic glass in the UK, i.e. glass objects for the household.
[5] This is a broad category. Notable products are cathode-ray tubes for television sets, light-bulbs, medical products, lenses and other optical products.

Table 1.2 – Estimates of cost-based energy intensity of the EU's glass industry

NACE Code	Industry	1999	2003	Countries[6]
26.11	Flat glass	5.5%	6.3%	BE, DE, ES, FR, PT, FI
26.12	Processing of flat glass	2.1%	1.9%	BE, DE, ES, FR, IT, LV, AT, PT, FI
26.13	Hollow glass	6.6%	8.3%	BE, DE, ES, FR, IT, NL, AT, PT, FI
26.14	Glass fibres	4.1%	6.1%	DK, DE, ES, FR, IT, NL, FI, UK
26.15	Other glass	4.2%	4.5%	DK, DE, ES, FR, IT, UK
26.1	**Total**	**4.5%**	**5.3%**	BE, DK, DE, ES, FR, IE, IT, LV, NL, AT, PT, SK, FI, UK

Source: Eurostat and own calculations

The estimates clearly show the impact of primary processing stages, in particular glass melting, which is present in all sub-industries except 26.12 which is the secondary processing industry for flat glass. Hollow glass manufacturing, which covers what is elsewhere referred to as container glass production, is the most costly in terms of energy purchases. Primary production of flat glass ranks second.

The corresponding proportions with respect to gross value added would of course be higher, not to mention the relation to profits, so that 5.3% should be interpreted as being a relatively high ratio. Also, one may note for comparative purposes that the same measure of cost-based energy intensity for manufacturing as a whole, computed for a similar selection of countries[7] for 2003, is just 1.7%.

Production processes

The core part of the glass production process is glass melting which takes place in purpose-built furnaces in which the raw materials are melted into a liquid which will subsequently be shaped into the final products. Glass production is energy-intensive especially in view of the high temperatures which must be obtained for glass melting. Glass production is also carbon-intensive, on the one hand due to the greenhouse gas emissions (in particular CO_2) that result from the combustion of fossil fuels in the furnaces (although there is some glass production that takes place using electric furnaces), but also due to the chemistry of the glass melting process. Soda ash, when heated, breaks down into sodium oxide (Na_2O), which acts as the fluxing agent that helps reduce the melting temperature of silica sand, and CO_2, which is released.

The five main types of furnaces that are used in the industry are cross-fired regenerative furnaces, end-fired regenerative furnaces, recuperative furnaces, oxy-fuel furnaces and electric furnaces.

Regenerative furnaces include a heat recovery system based on the use of the heat from the waste gases from combustion. Two regenerator chambers are built in. At any one time, one of the chambers is being heated by waste gases that go through it (the chamber walls absorb the heat from the gases), while the other chamber, which was previously heated by waste gases and retained heat in that manner, is used to pre-heat air. This process is periodically reversed. The air that was pre-heated feeds the combustion of the fuels in or over the raw materials that are being melted, and the waste gases are caught by the other chamber. The efficiency of this process, in other words the overall thermal efficiency of the furnace, can be tuned to the specific size and type of regenerative furnace. Obviously the choice of surface materials (notably for the pre-heating chambers), the periodicity of the chamber reversals and the exact angles of the burners, among numerous other technical characteristics, may be fine-tuned for better results. Computer-based modelling is commonly used by the large multinational producers in order to optimise the various parameters.

Cross-fired regenerative furnaces are the most used in large capacity installations. The term "cross-fired" refers to the fact that the pre-heating chambers are positioned on either side of the combustion

[6] The country codes are, in order of appearance: BE (Belgium), DE (Germany), ES (Spain), FR (France), PT (Portugal), FI (Finland), LV (Latvia), AT (Austria), NL (Netherlands), UK (United Kingdom), IE (Ireland), SK (Slovakia).

[7] Eurostat SBS data for Belgium, the Czech Republic, Denmark, Germany, Estonia, Spain, France, Ireland, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Netherlands, Austria, Portugal, Slovakia, Finland and the UK.

chamber, with sets of burners, as well as the ports for the pre-heated air and the waste gases, positioned on either side of the combustion chamber. In this way the flames from the burners and the pre-heated air come from one side of the combustion chamber during the first half of the cycle, and then from the other side during the second half of the cycle.

End-fired regenerative furnaces use the same principle, the main difference being that the two pre-heating chambers are on the same side, so that the flame path forms a U-shape, projecting the waste gases into the adjacent pre-heating chamber, for the first half of the cycle from left to right, and from right to left for the second. Interestingly, IPPC (2001) points out that end-fired regenerative furnaces are in fact more cost-effective than the cross-fired models with respect to the recycling of thermal energy. However the authors also explain that end-fired furnaces are less flexible in terms of adjusting the overall temperature profile, making the cross-fired system more cost-effective in the case of larger furnaces.

Recuperative furnaces, used for smaller capacities, also use a form of heat recovery. The waste gases are likewise channelled through a heat exchanger, generally made of metal, so as to pre-heat the combustion air. However recuperative furnaces cannot recycle quite as much of the thermal energy as regenerative furnaces. On the other hand recuperative furnaces are less costly in terms of capital investment and are also operationally more flexible. All in all these features make recuperative furnaces the best choice for medium-size capacities.

Oxy-fuel furnaces use oxygen instead of air to feed the combustion. Some of the advantages of this process is the reduction of nitrogen oxides as well as of particulate emissions. The oxy-fuel technology is less mature than that of regenerative and recuperative furnaces, although the number of installations is growing. According to IPPC (2001) oxy-fuel furnaces are more common in North America than in the EU, and its use is especially prevalent for the manufacture of glass fibre and of special glass, while it is only seldom used for container glass or flat glass.

Electric furnaces, finally, function by making electric current flow through the raw material, thus generating resistive heating.

According to IPPC (2001), the bulk of European melting capacity (measured in tonnes of produced glass per year) was taken up by the two main types of regenerative furnaces (44% for cross-fired, 37% for end-fired). The data reported in IPPC (2001) refers to the year 1997, however this broad type of descriptive data does not change very quickly due to the high capital costs involved. The reason for the domination of regenerative furnaces is that they are preferred to other types of furnaces in the cases of medium and large capacity installations. IPPC (2001) finds almost only cross-fired regenerative furnaces in use for installations of a capacity exceeding 500 tonnes per day (large capacity), while end-fired regenerative furnaces are often (but not always) used for medium capacity installations (100 to 500 tonnes per day). For small capacity installations (less than 100 tonnes per day) the picture is more diversified, though recuperative and electric furnaces are the two more common types. The other issue of importance for the choice of furnace is the type of glass being manufactured. As mentioned earlier, oxy-fuel furnaces are relatively common for glass fibre and special glass, but not for container or flat glass. As this report focuses on the latter two types of glass (due to their much larger share of European production in terms of tonnage), it is best to focus on the other types of furnaces, in particular on the two types of regenerative furnaces and on recuperative furnaces. IPPC (2001) reports that practically all flat glass produced in the EU is produced using cross-fired regenerative furnaces. With container glass the pattern is rather more diversified, and scale of operation will turn out to be the main variable to consider.

The second part of primary manufacturing of glass is the forming of the molten glass into the final product. Focusing just on the two main types of glass by volume, i.e. container and flat glass, one should briefly distinguish between the main sub-types.

In the case of flat glass the three main sub-types are float glass, sheet glass and rolled glass. By far the most important sub-type is float glass, accounting for 88% of global flat glass production by volume in

2005 (36 million tonnes out of a total of 41 million tonnes) according to Pilkington (2006). Sheet glass accounts for 7% (3 million tonnes) and rolled glass for 5% (2 million tonnes). Float glass is made by pouring the molten glass out of the furnace and onto a shallow bath of molten tin, on which it floats and spreads out, forming a level surface. Thickness can be adjusted to be between 0.4 mm and 25 mm. This process enables the production of clear, tinted and coated glass for buildings and clear and tinted glass for vehicles. Sheet glass results from an older production process which is gradually being replaced by float and which still survives mainly in China and in certain African, Asian and Eastern European countries. Sheet glass is made by making the molten glass go through rollers vertically after it comes out of the furnace. Sheet glass is of inferior quality compared to float glass. Rolled glass results from the molten glass being pushed through rollers horizontally and generally results in glass that is not clear (lower light transmission than float glass). Thus rolled glass is used in applications where clearness isn't aimed at. On the other hand rolled glass can be embossed with patterns, making it useful for certain specific applications.

Container glass is produced by moulding the molten glass (called gob) into the desired shape. This is done using two moulds, a first so-called blank mould, and then a second one called the finish mould. The two main methods are called blow-and-blow and press-and-blow. In the first, the gob is dropped into the first mould (which matches the external dimension of the product, e.g. a bottle, but not the internal dimension, i.e. the shape and thickness of the glass). Compressed air is then blown into the first mould, pushing the glass to the inner sides of the mould and prevents the glass from being too thick. The result is then put into the finish mould. The glass is then blown a second time in the finish mould thus acquiring its desired final shape. On the other hand press-and-blow manufacturing consist of a first phase during which the gob is pressed into the constraining shape of the blank mould. The result is then inserted into the finish mould and blown into, giving it its final shape.

Section 2 – International trade flows

We now look at international trade statistics for all types of basic glass products together except glassware (SITC Revision 3, code 664), i.e. flat glass, sheet glass, glass fibre, scrap glass and other types of glass such as for bulbs, but not container glass or tableware glass. We find that global exports are dominated by four main players: the United States, the European Union, Japan and China, in that order, together accounting for 68% of global exports in 2005. This is shown in table 2.1.

Table 2.1 – Largest exporters of glass, USD millions, 2005

Exporter	Value	Share	Cumulative share
United States	2770	20%	20%
European Union	2357	17%	36%
Japan	2351	17%	53%
China	2117	15%	68%
Mexico	777	6%	74%
Canada	657	5%	78%
South Korea	494	4%	82%
Taiwan	402	3%	85%

Source: UN COMTRADE

However most countries in the world are net importers of glass, including the United States, so that the picture looks quite different when one looks at net exporters and net importers. Table 2.2 shows, for 2005, the six largest net exporters of glass and table 2.3 shows the seven largest net importers of glass for 2005. The position of the United States is roughly balanced.

Table 2.2 – Largest net exporters of glass, USD millions, 2005

Reporter	Net Exports
Japan	1269.2
China	809.9
European Union	624.4
Indonesia	210.2
Philippines	137.0
Thailand	106.7

Source: UN COMTRADE and own calculations

Table 2.3 – Largest net importers of glass, USD millions, 2005

Reporter	Net Imports
Romania	114.0
Switzerland	173.4
Russia	196.2
Mexico	213.9
Canada	585.4
Taiwan	841.4
South Korea	882.0

Source: UN COMTRADE and own calculations

With this measure the ranking shows Japan clearly in the lead, followed by China and the European Union. Somewhat further behind one finds three large Asian middle-income countries. As for net importers one may note the positions of Romania and Switzerland which are of interest from the European perspective.

Tables 2.4 and 2.5 show total imports into the EU-15 countries by main country of origin of the two main types of glass, flat and sheet glass in table 2.4 and container glass in table 2.4. The SITC revision 3 codes selected for the data were 6643, 6644, 6645, 6647 and 6648 taken together for table 2.4, and 6651 for table 2.5. As can be seen from these tables, the value of flat and sheet glass imported into the EU-15 countries[8] from outside the EU-15 was roughly 6.5 times larger than the corresponding import flow for container glass. This is in keeping with the much lower trade-intensity of container glass that was mentioned in the introduction. It is also interesting to note the relatively larger importance of inter-continental trade in flat and sheet glass, as the top two countries of origin are the United States and China. On the other hand the EU's New Member States, in particular the Czech Republic, Poland and Hungary, are important source countries for both types of glass (though this data must be seen in the context of the low import penetrations for both types.)

Table 2.4 – Imports of flat and sheet glass into the EU-15, USD millions, 2005

Partner	Value	Share
United States	358	19%
China	252	14%
Czech Rep.	239	13%
Poland	184	10%
Hungary	137	7%
Turkey	85	5%
Taiwan	79	4%
Japan	74	4%
Total	1841	100%

Source: UN COMTRADE and own calculations

[8] This selection was made in order to simultaneously assess the importance of the EU's New Member States that joined in 2004 as compared to non-EU countries such as China and the United States.

Table 2.5 – Imports of container glass into the EU-15, USD millions, 2005

Partner	Value	Share
Switzerland	38	14%
Czech Rep.	35	13%
Poland	35	12%
China	32	12%
Bulgaria	21	8%
United States	17	6%
Hungary	14	5%
Saudi Arabia	12	4%
Total	279	100%

Source: UN COMTRADE and own calculations

Section 3 – Global and European production patterns

We start off by looking at production volumes by type of glass in the European Union (table 3.1). The CPIV data was collected so as to always cover current EU membership, so the data for the years 1999-2003 cover only the 15 countries that were members in April 2004. However the data for all 25 countries as well as for just the EU-15 is available for 2004 and 2005.

Table 3.1 – Glass production volumes in the EU and EU-15 – thousands of 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

As we can see container glass is by far the most important type of glass by volume, followed by flat glass. Growth in the EU-15 has been rather weak over the period for the two main types of glass. The two main reasons for this are that the EU-15 experienced rather weak aggregate economic growth over that period together with the fact that the glass market in the EU-15 is already a very mature market, so that total demand for glass tends to grow at most at the same pace as GDP, whereas the elasticity of demand will typically be slightly higher than 1 in less developed economies. However one should note one phenomenon not visible from the data in table 3.1, which is that there is significant growth in European demand for certain processed forms of flat glass, notably so-called low emissivity coated glass for windows in new buildings and, in some cases, for replacement windows in existing buildings.

We now turn to brief descriptions of the markets for the two most important types of glass by volume, flat glass and container glass. Unified data sources are hard to come by, so each sub-industry is approached in a slightly different way.

3.1 Production patterns for flat glass

According to Pilkington (2006) the world market for flat glass (float, sheet and rolled) was approximately 41 million tonnes (equivalent to 5.125 billion m^2 if one assumes an average ratio of 125

m^2 / tonne), 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 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 (2005) 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.

Out of the 41 million tonnes mentioned above, around 25 million tonnes (61%) were of higher-quality float glass. 3 million tonnes (7%) were sheet glass, 2 million tonnes (5%) were rolled glass, and the remaining 11 million tonnes (27%) were of lower-quality float glass, produced essentially in China. Focusing now just on higher-quality float glass, one may say that production is quite highly concentrated in terms of corporate ownership, with just four companies accounting for close to 70% of global production. The top companies are NSG/Pilkington[9] and Asahi (Japan), each with 20.5% of global production capacity, followed by Saint-Gobain (France) with 14% and Guardian (USA) with 13.5%.

At the European level (taking the enlarged European Union plus the Western Balkans and Turkey), Pilkington (2006) reports that supply capacity was around 11 million tonnes in 2005. Capacity utilisation isn't precisely known in the public domain, though Pilkington (2006) contains a graph which seems to indicate that it might have been around 83% in 2005. This would imply a production volume of 9.13 million tonnes. This estimate is however clearly a bit too low as the CPIV data indicates that production in the European Union was 9.2 million tonnes in that year, to which one should add whatever production there was in the Western Balkans and in Turkey. In the absence of further data it is not possible to disentangle this issue.

Pilkington (2006) also gives a breakdown of European flat glass production capacity by company. Capacity is held for the most part by five companies: Saint-Gobain (France), with 25%; NSG/Pilkington (Japan / UK), with 24%; Glaverbel (Japan / Belgium[10]) with 20%; Guardian (USA) with 13% and Sisecam (Turkey) with 8%. The remaining 10% is split among small producers, notably Euroglas (Germany) and Sangalli Group (Italy). Sisecam started flat glass production in Bulgaria in February 2006, its first flat glass line in the enlarged European Union of 2007. In addition some of the smaller companies such as Interpane (Germany), Scheuten (Netherlands) and Sangalli Group are quite important players in certain specific segments of secondary processing.

3.2 Production patterns for container glass

In terms of volume it is container glass that is by far the most important, as shown in table 3.1. This part of the industry is different from flat glass production in several respects. As mentioned in the introduction, 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. For a technical discussion on some of the challenges of recycling in the industry see for example Beerkens and Van Santen (2005).

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

[9] Pilkington plc, originally a UK company, was acquired by NSG UK Enterprises Limited, a subsidiary of Nippon Sheet Glass Co., in June 2006.

[10] Originally a Belgian company, Glaverbel was taken over by AGC (Asahi Glass Company) from Japan in 1981. Nevertheless this branch of AGC still uses its original name.

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, with notably US giant O-I (Owens Illinois) acquiring several leading European producers. It was also the case up to the 1990s that some production sites were owned by food and beverages manufacturers, such as Danone in France. In this particular case this changed in 1999 when O-I acquired the facility (through BSN Glasspack). O-I is now a major player on the European market, with production sites in 11 EU member states, including all the large member states and 4 of the new member states that joined in April 2004. Apart from O-I one should mention Rexam plc and the Saint-Gobain group. Rexam plc, a UK multinational specialised in the packaging industry, has glass container operations in several member states, notably Germany, the Netherlands, Sweden and Poland, and which describes itself as the second largest container glass producer in Northern Europe. French group Saint-Gobain owns a set of companies with a large number of production sites, notably Saint-Gobain Emballage, their French glass container manufacturing company, as well as Vicasa (Spain) and Oberland Glas (Germany). A smaller player one may finally mention which also has production activities in several member states is Vetropack Holding Ltd, a Swiss group that has expanded into Austria and into Central and Eastern Europe.

Section 4 – Energy costs and the EU glass industry in the broader context

This section assesses the role and impact of energy costs, including energy taxation, on the European glass industry, given the specific economic conditions it must operate under. The goal is to provide some understanding about what constraints the industry operates under, how environmental policies affect its economic decisions, and to what extent a number of classical concepts from environmental economics are helpful in describing current developments in the industry.

The contents found below are in part the result of telephone interviews that I conducted with manufacturers of glass in the European Union. In light of the quite important differences in the economic geography of container glass on the one hand, and of flat glass on the other, I carried out one interview for each of these two segments. For flat glass I interviewed an appropriately knowledgeable employee of a company that manufactures flat glass in the European Union[11]. For container glass a telephone interview was conducted with an appropriately knowledgeable employee of a container glass manufacturer in a Northern European country in which environmental tax reform (ETR) was introduced before 2003. For convenience I will refer to the flat glass company as "company A" and to the container glass company as "company B".

The goal in each case was to first get a broad-brush idea of the general conditions under which each firm operates, in particular what are its major concerns or constraints in conducting profitable business. Obviously one expects respondents to complain about taxation and regulation whenever given the chance, this is fair game in such situations, but the more interesting results perhaps concern the reactions of respondents to more specific concepts of environmental economics, as well as, of course, to their spontaneous comments about the nature of their economic and regulatory environment.

A number of questions arise in the context of EU policies designed to limit greenhouse gas emissions. The scope of the COMETR project is to assess the impact of environmental tax reform (ETR) on the competitiveness of European industry. While this may be partly a backward-looking exercise, e.g. comparing the relative situations of ETR countries with non-ETR countries within the EU over a suitable time period, the practical view of things as far as the respondents are concerned is that they are faced with both ETR and the more recently introduced emissions trading scheme (EU ETS). Both

[11] I purposely stick to very general formulations as requested by both respondents.

policy instruments are designed to encourage industry to limit emissions, and the issue is further complicated by other types of taxes on energy products. In practice it was therefore easier to ask respondents to consider the role and impact of energy costs as a whole, and then try to find out how and to what extent the taxation and EU ETS components mattered to them, given the importance of other conditions. In particular I sought answers to the following questions:

a. to what extent (if any), have ETR and/or the EU ETS helped to "focus minds" on improving fuel efficiency at a basic operational level (i.e. whether there is or was any residual X-inefficiency in the company or industry)
b. to what extent energy costs drive investment decisions in the technological sense (i.e. searching out and implementing improved technologies that use less energy and/or have lower emissions)
c. to what extent energy costs may be offset by changes in the fuel mix
d. whether revenue recycling mechanisms sound like attractive policies that could help offset the additional costs caused by ETR and/or the EU ETS
e. to what extent energy costs (the ETR and EU ETS components in particular) drive investment decisions in the locational sense (i.e. the so-called Pollution Haven Hypothesis, or whether carbon leakage is an issue in the industry)

All of these questions must of course be considered within the relevant economic context, notably trade-intensity due to value-weight ratios and transportation costs, the knowledge-intensity of the industry (importance of human capital and R&D), the fragmentation of the production chain (stages of varying value added margins) and the importance of market segmentation (on the side of demand).

4.1 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 in section 1 of this report (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 doesn't 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.

The issue of standardisation, i.e. in terms of size, thickness and basic properties of the glass, is an interesting one. Existing buildings, notably private houses, do not have a single, standardised size of window frames, making market penetration from outside Europe more difficult. Nevertheless, the construction industry and its customers have the cost of construction materials, including windows, very much on their mind. If money can be saved by using imported standard-sized windows, one may as well standardise the window frames in the first place. On the other hand the respondent was keen to point out that he remains optimistic about the future of European production. There are, after all, some advantages to geographical proximity to the final buyers, notably in terms of customer service. Again, products that are not highly standardised, as well as products with short lead times and most of the higher value added segments represent good potential for European producers, and this is indeed where the most recent investments are already being made. One particular issue worthy of mention here is the impact of legislation on the energy performance of buildings at both the EU and member state levels, notably encouraged by European Union Directive 2002/91/EC. As a result, demand for low emissivity glass, which helps to reduce heat loss through windows in winter, is booming in those EU member states that were more advanced with respect to the corresponding legislation (notably Germany) and is expected to do likewise across the rest of the European Union over the next few years.

The first finding from company A with respect to environmental economics was the respondent's reaction to question a. on X-inefficiency. The concept of X-inefficiency was immediately clear to the respondent, who said that it was essentially non-existent in company A, and had been so for some time. Put simply, given the inherent importance of energy costs, and given the high degree of competition on the flat glass market, company A has been making significant efforts to reduce energy costs for a long time, i.e. long before ETR was introduced in certain EU member states. The idea that ETR and/or the EU ETS could provide a tipping point that would push management to make improvements to energy efficiency other than those requiring outright technological change was therefore judged to be incorrect. In other words company A is doing its best to be on or close to the cutting-edge in technological terms. This finding leads to an answer to question b. For company A, energy costs are very important in determining what types and levels of investment should be made and what technological options should be chosen. Coming to the general question of whether ETR, other taxes on energy products and the EU ETS were having a general impact on the industry, the answer was a clear yes. It should also be noted that the respondent stressed the importance of the additional administrative costs related to ETR and the EU ETS, which in effect operate as an additional overhead cost for companies in the industry. Turning now more specifically to technological issues, one should bear in mind the scale of operation of company A, a scale of operation which is in fact the norm in the industry, i.e. implying production facilities with large capacities. As discussed in the introduction, this naturally leads to the use of cross-fired regenerative furnaces. There are really no alternatives at that level. What can be done, however, is to constantly try to tweak or fine-tune a number of technical elements so as to get the most out of existing installations. In this respect R&D and high quality scientific and engineering skills are very important.

Given the answers to questions a. and b., the additional cost of production that comes as a result of environmental policies is primarily seen as a not particularly welcome burden which squeezes margins and makes business less profitable. As pointed out in the introduction, businesses, when asked, will always complain about taxation. However things become more interesting when one asks about what steps can be taken by companies and/or government to offset part of these costs.

With respect to the fuel mix (question c.), the answer was essentially that, although natural gas is very convenient when easily available (pipeline) and is the most commonly used fuel for flat glass production in the European Union, it is also the case that energy prices are monitored closely by company A, while furnaces are built in such a way as to enable the use of both fuel oil and natural gas. One may also note that, as pointed out in IPPC (2001), some furnaces can even use both fuels at the same time through different burners. It is therefore possible for companies in the industry to make some improvements to cost-based energy intensity by manipulating the fuel mix. The other issue to bear in mind is the influence of long-term contracts for the sourcing of fuels. For technical reasons production lines cannot be switched on and off on a whim, and are in fact designed to operate continuously throughout an entire campaign of several years. This is a constraint for producers, but, together with the large volumes of fuel required, it also gives them leverage when negotiating fuel prices with suppliers. This particular issue would merit further investigation, though accurate data may be hard to come by.

The other offsetting mechanism which occupies a place of choice among the policy recommendations of environmental economists is revenue recycling, i.e. through a partial or total compensation of the (total economy) revenue effect of ETR thanks to a corresponding reduction of other taxes. A classical example, which ties in with general views about labour economics, would be to reduce the tax wedge for labour by reducing payroll taxes (if there are such taxes) and/or reduce social security contributions. Of course reducing VAT or any other tax on consumption or income would also respect the principle of revenue recycling, ensuring a reduction of the revenue effect of ETR while upholding the (desired) substitution effect that should encourage a lower consumption of energy. However from the point of view of a particular business such a policy will have quite different effects depending on the extent of recycling and the choice of tax. I put to the respondent the example of a reduction in social security contributions. His reaction was one of scepticism, essentially because manning has already been reduced as much as was possible, and now that the current procedures are in place the respondent couldn't imagine that a reduction in social security contributions would lead to a substitution of energy in favour of labour. The main problem is simple: energy and labour are not substitutable, so that companies in the industry solve the two cost minimising problems (energy and labour) independently from one another. Of course it is true that a reduction in labour taxation would be welcome, less tax is still less tax, but the point made by the respondent was that one shouldn't expect employment to increase as a result of such a reform. Still, the respondent was describing his industry. Economy-wide effects on employment that would result from a reduction in the tax wedge would be expected to take place under revenue recycling. Coming back to the flat glass industry, the respondent added that in any case the temptation for the major players in the industry to invest in China would not be significantly weaker with revenue recycling on social security. The problem is simple: the difference in total labour costs would remain very large between the EU and China, and it is difficult to imagine that revenue recycling measures would reduce labour costs by so much in Europe as to make investment in China no longer attractive.

I now turn to the issue of the Pollution Haven Hypothesis (PHH). This question, together with the related question of carbon leakage, is obviously crucial from the point of view of European environmental policy. Put simply, what good is ETR, or indeed the EU ETS, if the only thing that happens is that production relocates to countries with less stringent standards (non-Annex I countries) so as to export to Europe, while global energy use and global GHG emissions remain just as high? Of course, assessing carbon leakage in the glass industry would require a separate study. Nevertheless it is interesting to put the question of the PHH to companies to see how they react. Perhaps predictably, the respondent admitted that this was a possibility, but should be seen within the bigger picture of large emerging markets with low labour costs as well as low costs of compliance with respect to standards and regulations in general. The respondent gave the example of health and safety standards, which are significantly less costly to meet in China as in the European Union. More broadly speaking, the major players in the industry are multinational corporations with production facilities spread across the world. In making their investment decisions such companies simply put more in the countries where they expect the returns to be higher. So what of the PHH? Transporting goods from China to European markets isn't a costless operation so production costs must be lower than in Europe by a sufficient margin, and this is clearly the case today given current (partly export-oriented) foreign investments. As things stand, the labour cost differential clearly seems to be the main driver, but on the other hand if one assumes that there is no substitution between labour and energy then energy cost differentials will act as an additional driver for such investments, thus confirming the PHH. In spite of this the actual scale of the effect remains very difficult to estimate as it is tangled up with other cost differentials.

As a conclusion, one may note the respondent's feeling that, although things do not look 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 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, isn't 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.

4.2 Energy costs in the production of container glass

As discussed earlier, container glass is the least trade-intensive type of glass due to its low value-weight ratio. It would thus seem to constitute a stationary target for ETR as carbon leakage should be limited in scope. This is indeed the case, but it neglects one very basic point: most foodstuffs and beverages than can be packaged in glass containers can also be packaged using other materials, e.g. cardboard, plastic or aluminium. On the other hand perhaps environmentalists would argue that, if ETR provokes or increases such substitutions, then so be it, perhaps glass should be used less than it currently is for packaging purposes. Such environmental policy-induced substitutions have taken place in certain EU member states, and this also explains in part why recycling is so highly developed in the industry, though these developments essentially pre-date concerns about climate change.

Company B, which operates in a country which introduced ETR before 2003, reports that it was under strong pressure to change its production processes specifically because of ETR. That pressure went far beyond tackling X-inefficiency, which in fact doesn't seem to have been significant prior to ETR due to already significantly high energy costs. Though company B wasn't experiencing significant competition from actually imported goods it was constantly aware of the possibility of foreign producers (producing in other EU countries) entering its market. What happened instead was that company B was forced to restructure its production facilities to bring down its marginal cost of production. This required making a number of new investments as well as closing down existing facilities. Essentially company B switched to a smaller number of larger production lines. It simultaneously switched from recuperative furnaces to regenerative furnaces, a step which was consistent with production lines of a higher capacity. Furthermore the investment cost for a regenerative furnace of a given capacity is higher than for a recuperative furnace of the same capacity, but the gains in terms of reduced energy intensity are large enough, ensuring that the long-term return on investment is higher. We therefore find here a case of ETR having a decisive impact on the choice of the production technology and leading to correspondingly lower emissions per produced unit.

On the other hand the respondent expressed some frustration about the fact that conditions were (are) less stringent in certain other EU member states. This is of course a fair point, and clearly the goal of ETR isn't to distort competition and effectively favour producers in certain member states over those in other member states. Nevertheless, as seen from an outsider's point of view, one is tempted to conclude that ETR had a positive and indeed desirable effect. Since company B maintained its position on its home market (notwithstanding leakage to other sectors, e.g. plastic packaging) while reducing its emissions one may say that emissions were reduced without carbon leakage taking place.

What of the offsetting of increased energy costs? With respect to the fuel mix the possibilities of company B are basically zero for the moment due to the unavailability of a natural gas pipeline terminal within a reasonable distance of the facility. As a result, company B uses only fuel oil (electricity would anyway be out of the question for cost reasons), although the respondent pointed out that the company would certainly switch if the supply infrastructure for natural gas would improve sufficiently. As for revenue recycling, some gains could obviously be made, but the respondent was rather more focused on pointing out the double pressure from ETR and the EU ETS, as well as having to comply with other environmental norms, e.g. with respect to sulphur oxide emissions. As a result of the latter company B uses fuel oil that has a low sulphur content. This last element is an additional motivation for company B to switch to natural gas, as then both CO_2 and sulphur oxide emissions would be reduced. Finally, the respondent expressed concern that NO_X emissions might also be taxed at some stage in the future.

The question of the Pollution Haven Hypothesis was indirectly assessed. In effect, the survival of company B shows that carbon leakage didn't happen because the additional costs brought along by ETR, once the necessary restructuring had been carried out, was offset by the transportation costs potential competitors would have faced (in addition to costs inherent to market entry, e.g. marketing costs). In the end, the respondent indicated that company B didn't believe that it would have to close down once it had assessed the impact on costs of its new capital investments. On the other hand it is of course fortunate that company B had both the managerial vision and the financial strength to carry out these investments. This last issue would deserve separate analysis, as it is of course crucial for the success of environmental policies that companies are able to carry out the long-term investments that are necessary in order to lower carbon intensity.

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 crossroads. 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. Simultaneously, other environmental policies, also driven by a desire to hold down greenhouse gas emissions, are creating demand for knowledge- and R&D-intensive products, a segment in which EU producers are well positioned. On the other hand this global evolution pattern isn't unfamiliar. In many industries there is an international fragmentation of the production chain, with a number of basic components (and increasingly more sophisticated ones too) being manufactured in non-Annex I countries. In the case of flat glass however it seems rather difficult to imagine a strong degree of fragmentation for both technical and economic reasons. It is both technically easier and economically more cost-effective to retain the entire production chain (from melting through forming to coating, silvering, tinting and other such steps) in Europe when producing higher quality products, so that the penetration of non-Annex I countries into the EU market should remain limited as long as EU producers maintain a competitive edge in terms of knowledge and technologies. Beyond specific niche segments that would anyway survive in the EU it is therefore clear that EU producers need to continue to invest in R&D and human capital in order to keep the upper hand in the high value added segments. Looking to the future this should also mean a competitive edge on the global market if and when other countries adopt similar legislation.

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.

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Competitiveness Effects of Environmental Tax Reforms (COMETR)

The Cement, Lime and Plaster Industry

WORK PACKAGE 5 – Industry Studies

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31 December 2006

Abstract
This study provides an overview of the cement, lime and plaster industries from the economic point of view as well as from the point of view of energy use and CO_2 emissions, starting from the global perspective before focusing more strongly on the European level. More detailed data is also given for the specific case of the Czech Republic, thanks to investigations and interviews conducted in that country. The main focus of the study is the cement industry, with a shorter contribution on the lime industry. We do not cover the plaster industry, which is the least important of the three sub-industries both economically and from the points of view of energy consumption and carbon emissions.

Section 1 – Introduction and basic definitions
The industry is made of three parts:

NACE 26.51 - Manufacture of cement
NACE 26.52 - Manufacture of lime
NACE 26.53 - Manufacture of plaster

Cement, lime and plaster are the basic binding materials used in construction. Together they form the key ingredients for all types of cement, concrete, mortar and plaster.

The core chemical elements that play the key roles in these materials are calcium, Ca, and silicon, Si. Calcium is found in nature in the shape of calcium carbonate, $CaCO_3$, which is also called calcite, and which is the main component part of limestone, a naturally occurring type of sedimentary rock. Silicon can be found in various types of sand and clay. The most common type of sand is made up mostly of silicon dioxide, or silica, SiO_2, often in crystallised form (quartz sand).

Cement
Cement is a hard binding material which can be used for masonry or, if made into concrete, for highly resistant supporting structures in construction.

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.

The second stage of production is to grind the clinker into a fine powder. This final product is called cement. It is a powdered material which develops strong adhesive qualities when combined with water and is used to bind bricks and/or stones together in the construction industry. The more precise term for this type of material is hydraulic cement. Portland cement is the most common type of hydraulic cement. Concrete is made by blending cement and aggregate. Aggregate is a mix of particles of varying sizes, for example a blend of sand and gravel. The variance in the size of the particles gives the final product stronger mechanical properties. Concrete is used to make supporting structures such as pillars and supporting walls. It is also used to make slabs, e.g. for large outdoor structures.

Due to the heating process in the kiln the cement manufacturing process is very energy intensive. According to the Cembureau[1] web-site, the production of one tonne of cement requires the combustion of between 60 and 130 kilograms of fuel oil (or equivalent) and, *in addition*, on average 110 kWh of electricity. BGS (2005) cites an estimate for the average *total* consumption of primary energy per tonne of produced cement of 1414 kWh in the case of UK production in 2004, and a projection for an improvement down to 1303 kWh per tonne for 2006. As for CO_2 emissions it has been estimated, as cited for example in WBCSD (2005), 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 WBCSD (2005) cites a figure of around 5% of global anthropogenic CO_2 emissions due to the production of cement *alone*. BGS (2005) tentatively cites an estimate of 7%. In any case it is clearly a critical industry from an environmental point of view.

Mortar (masonry) is primarily comprised of cement, lime, and sand. Grout is comprised of cement, sand, and other additives.

Lime

Quick lime, sometimes called burnt lime, or just lime, is calcium oxide, or CaO, and is made from limestone. This is done by heating the limestone to around 900˚C so as to irreversibly remove CO_2. The chemistry of the process is essentially the same as with clinker production, i.e. calcination, though in the context of lime production it is sometimes also called lime-burning. It is likewise energy intensive due to the high temperature required, and it generates substantial CO_2 emissions for direct chemical reasons, in addition to the emissions due to the use of fuels.

Slaked lime, also called hydrated lime, is calcium hydroxide, or $Ca(OH)_2$. It may be created by exposing quick lime to water, although there are other possibilities. It has many uses notably in the chemicals, leather and food processing industries, thanks to its chemical properties (as a base it can be used to get rid of acids).

Hydraulic lime is a variant of slaked lime which contains certain impurities and which is used to make mortar.

Plaster

Plaster is a soft binding material used for finishing purposes rather than for supporting structures.

The main natural type of plaster is gypsum plaster (plaster of Paris, or just plaster), which is based on Gypsum, $CaSO_4{\cdot}2H_2O$. Gypsum plaster powder is made by dehydrating Gypsum by heating it. The powder is then mixed with water so as to rehydrate it and transform it back into Gypsum. The trick is that when one does this in practice the Gypsum does not immediately set: one has time to force it into a shape of one's choosing.

Other types of plaster include cement plaster, based on cement, plaster powder and water, earthen plaster (based on clay, sand and natural fibres) and lime plaster. Lime plaster is obtained by mixing slaked lime with sand, adding water, and then exposing it to the air. When this happens the slaked lime

[1] Cembureau is the representative organization of the cement industry in Europe.

reacts with the ambient CO_2 and turns into calcium carbonate, $CaCO_3$, in other words in turns (back) into limestone.

Section 2 – The Cement Industry (26.51)

World production data

The best source we have found is the United States Geological Survey (USGS). This data was counter-checked with data from CEMBUREAU, which is the representative association of the cement industry in Europe, and found to be essentially the same, though the USGS data was more comprehensive at the global level. Table 2.1 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 are treated as if they were countries. Table 2.2 shows the corresponding shares in total world production. The volumes and shares shown in the two tables sum up to 84% of total world production based on 2004 levels.

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.

Table 2.1: 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: USGS and own calculations

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.

Table 2.2: Largest producers of hydraulic cement (shares of world total)

Production of cement, share of world total	2000	2001	2002	2003	2004
China	36.0%	37.8%	39.2%	42.7%	43.8%
EU-15	11.7%	11.1%	10.5%	9.7%	9.3%
India	5.7%	6.0%	6.2%	6.1%	5.9%
United States	5.4%	5.2%	4.9%	4.7%	4.6%
Japan	4.9%	4.4%	3.9%	3.4%	3.2%
South Korea	3.1%	3.0%	3.0%	2.9%	2.5%
Russia	2.0%	2.0%	2.0%	2.0%	2.0%
Turkey	2.2%	1.7%	1.8%	1.7%	1.8%
Brazil	2.4%	2.2%	2.1%	1.7%	1.8%
Indonesia	1.7%	1.8%	1.9%	1.7%	1.7%
Thailand	1.5%	1.6%	1.7%	1.6%	1.7%
Mexico	2.0%	1.8%	1.8%	1.7%	1.6%
Iran	1.4%	1.5%	1.5%	1.5%	1.4%
Egypt	1.5%	1.4%	1.5%	1.3%	1.3%
NMS-9 (NMS-10 minus Malta)	1.8%	1.5%	1.3%	1.3%	1.3%

Source: USGS and own calculations

This general explanation also helps to explain the relatively high production levels seen in India, the other growing Asian giant, though of course growth in India is much slower than in China, and on a much smaller GDP base.

Cement production in the European Union

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 2.3. These shares have not fluctuated much in the last few years.

Table 2.3: 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: USGS and own calculations

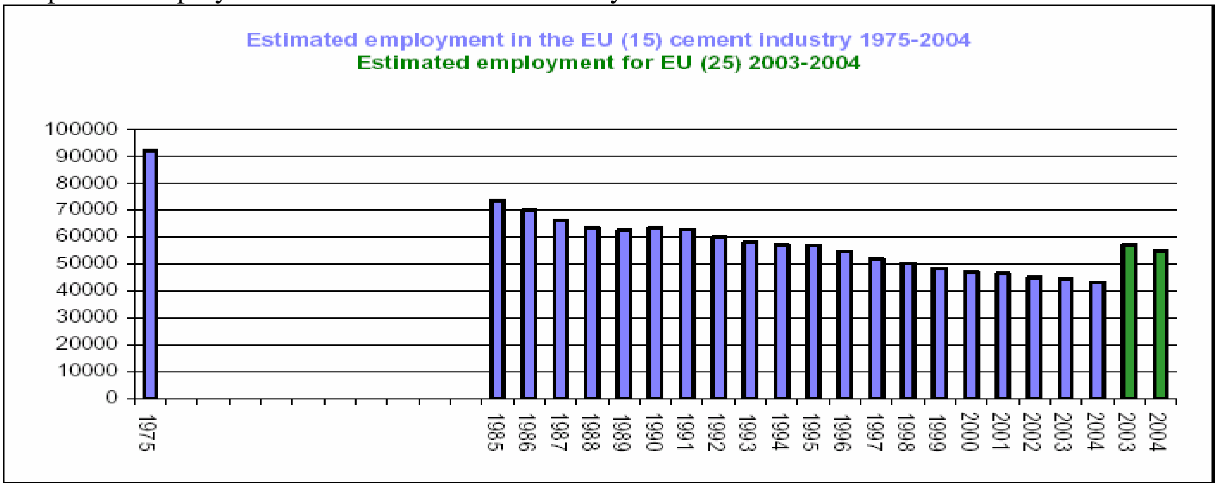
Spain is the leading producer, with double the level of France and four times the level of the UK in spite of its smaller economy. Greece and Portugal are also quite important producers in spite of their small populations (each around 10 million) and small total GDP levels. To some extent this Mediterranean dimension may be explained by the tourism- and retirement-fuelled construction industry. Economic growth has also been higher than the EU average in particular in Spain. Beyond this there are also idiosyncratic local preferences for certain construction materials over others, e.g. concrete is (relatively speaking) not in widespread use in the UK.

Investment and employment

Cement production is capital intensive. The overall set-up cost of a cement plant in the EU is about 150 million Euro per million tonne of annual production capacity. On average, the costs of a new plant may be covered by around three years of turnover. The costs of modifications or adjustments of existing plants are also relatively high but necessary for preserving the value of existing plants. Availability of financing, e.g. thanks to efficient financial markets, is therefore important for cement companies.

Labour costs are less critical to the cement industry as they are to certain other industries, as capital and energy costs are relatively more important. Moreover, the labour intensity of cement production has continuously declined over the last few decades as a result of increased automation of production. As a result, employment in Europe's cement industry has steadily declined over the last years, while labour productivity has increased. The former development can be seen from graph 2.1. Another very clear example is China, where employment per million tonne of cement produced dropped from 555 in 1980 to 272 in 2000 according to Battele (2002) though that particular development is tangled up with China's more general transition from socialism.

Graph 2.1: Employment in the EU's cement industry – 1975-2004

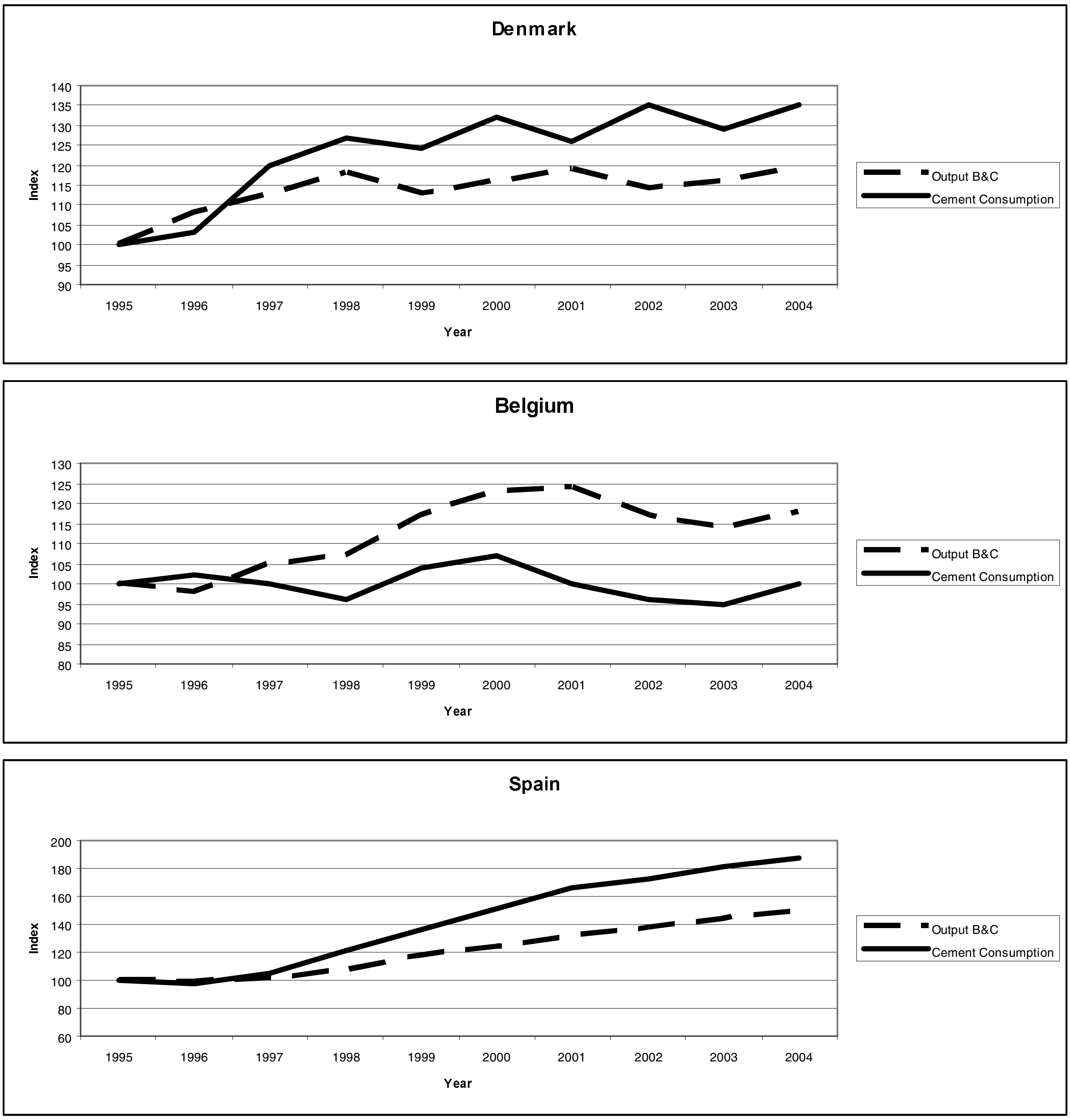


Source: EC 2005

The demand for cement in Europe

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. There is nevertheless a quality premium on prices, though it plays a relatively minor role. Contrary to lime, demand for cement stems almost exclusively from the building and construction (B&C) sectors. Historically, trends in demand and consumption of cement reflect the economic cycle as construction activity is pro-cyclical. The following graphs show dependency of cement consumption on the output of building and construction sector. To depict the situation, three countries with a relatively different shape of time series were chosen. However, such similar patterns in construction output and cement consumption are observable in most of the European countries.

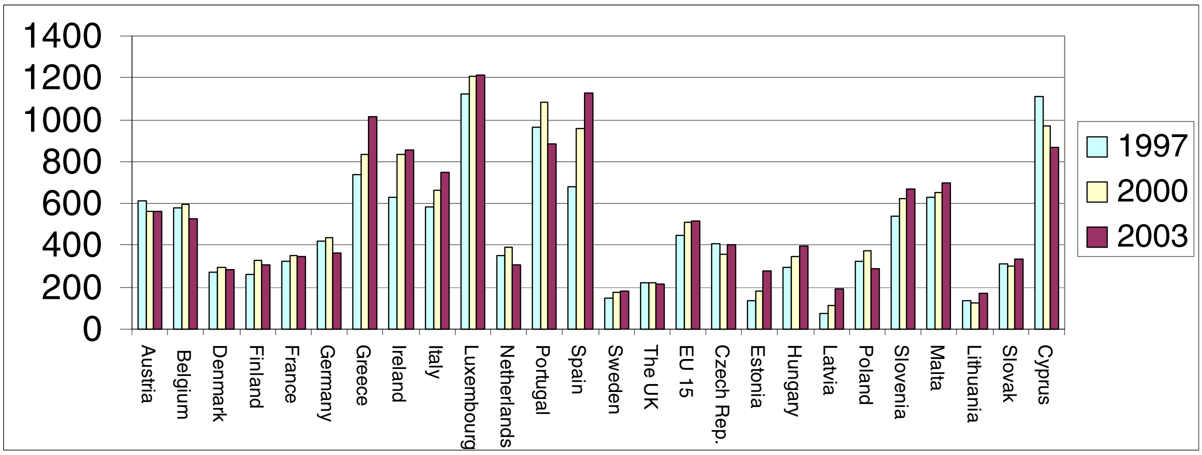
Graph 2.2: Construction output and cement consumption: Denmark, Belgium and Spain (1995-2004)



Source: Cembureau

Consumption of cement differs among countries. The differences are mostly caused by the intensity and quality of construction, types of buildings and the amount of utilization of cement in architecture. The development of cement consumption per capita in EU-25 countries is depicted in graph 2.3. The highest consumption of cement per capita is recorded in Luxembourg, followed by Spain, Greece and Portugal in 2003. High jumps in the case of Greece are caused by preparations for the Summer Olympic Games of 2004. On the other hand, Nordic countries and the United Kingdom are characterized by relatively low consumption of cement per capita. Among the new member states only Cyprus, Malta and Slovenia are above the average of EU-15 countries in 2003. This reflects their higher GDP per capita as well as the effect of the tourism industry.

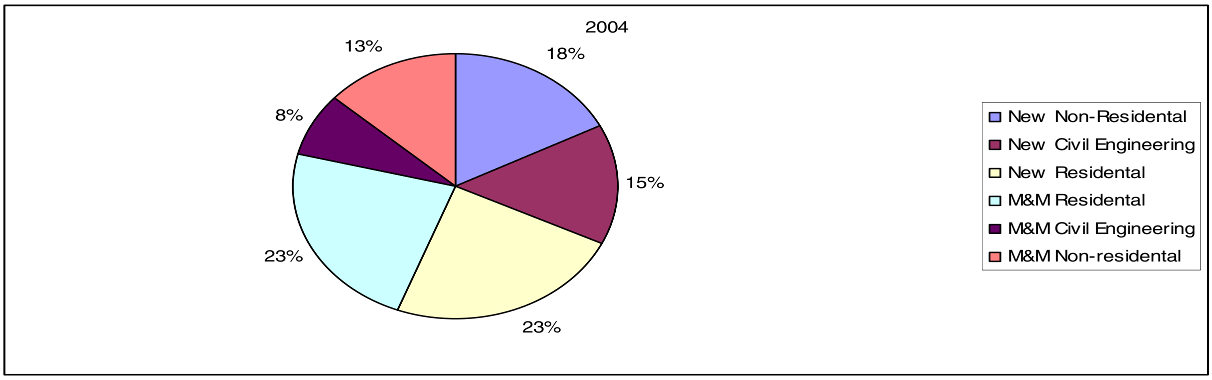
Graph 2.3: Consumption of cement per capita: EU 25 (1997, 2000 and 2003)



Source: World Statistical Review, 2004

Demand for cement may be broken down according to the nature of the construction activity, namely whether new or existing installations, and whether the construction activity is in the residential, non-residential (e.g. office buildings) or civil engineering (e.g. bridges, tunnels) segments. The breakdown for Cembureau countries for 2004 is shown in graph 2.4. The distribution in the year 2000 was almost identical.

Graph 2.4: Structure of the demand for cement – Cembureau Countries (2004)



Source: Cembureau 2005
Note: M&M = Maintenance and modernisation

Taking new construction together with maintenance and modernisation works, one sees that the largest segment is the residential one, accounting for around 46% of total activity. As for the new versus maintenance and modernisation split, one notes that the former is slightly larger than the latter (roughly 56% versus 44%).

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 (SITC Revision 3 code 6612), 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 2.4: Main export flows of cement into the EU, 2005

Exporter	**Value**
Non-Regional Origin	
China	84.4
Thailand	9.9
Japan	1.9
South Korea	1.0
United States	0.7
Canada	0.5
Argentina	0.2
Indonesia	0.2
Brazil	0.1
Sub-Total	**98.8**
Regional Origin	
Croatia	50.7
Russia	31.3
Ukraine	30.8
Belarus	20.4
Switzerland	7.0
Bulgaria	1.0
Romania	0.1
Sub-Total	**141.3**

Source: UN COMTRADE, own calculations
Flow units: USD millions; Cut-off point of 0.1 on rounded export flow

Also most of these flows are not particularly large when compared to intra-EU flows. So basically the only analysis of trade that is relevant is one that focuses on the European Union itself and its immediate neighbourhood, with China as the only exception. This is shown in table 2.5, which is a selection of the 30 largest intra-regional import flows. The table was constructed from UN COMTRADE data on cement imports reported by each selected country from each selected country. The country selection was: all current European Union members (25 countries), plus Croatia, Russia, Ukraine, Belarus, Switzerland and China. The flows were then sorted in descending order.

Table 2.5: Main import flows of cement within the wider Europe region

Importer	Origin	Value	Cumulative value	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**	**1030.8**			

Source: UN COMTRADE, own calculations
Flow units: USD millions

In the event none of the flows concerning China was among the top 30, so we took the liberty of naming the table as referring to a "wider Europe region". The table indicates the value of the import flow in USD millions, the cumulative value of all flows greater or equal, the cumulative share of total intra-regional import flows, and finally we indicated which flows are between countries that share a common land border.

As we can see these 30 flows (out of 311 reported in UN COMTRADE) 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. Spain is a small exporter in total and its only significant flow is with France, again for geographical reasons. As mentioned before, none of the flows with China are really important, so by implication the rest of the world can be completely ignored. Finally Russia and

Belarus do not appear within the ranking either, though again in these cases trade barriers should be taken into consideration as part of the explanation.

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. A more detailed analysis should therefore be undertaken, taking into consideration the effects of trade barriers, transport costs and trade facilitation measures in order to forecast what might happen to, e.g., Russian cement exports to the Baltic States, Belarusian cement exports to the Baltic States and to Poland, or Ukrainian cement exports to Poland, Slovakia and Hungary. The other region to consider would be Southeast Europe, with Slovenia, Italy, Hungary and Greece as potential destination markets and Romania, Bulgaria and the Western Balkans countries as potential countries of origin. Small scale effects should also be expected among current EU member states in cases where adjacent countries present substantial differences in energy prices, though these differences would only be partly due to differences in energy and/or CO_2 related taxation.

Map 2.1 shows the potential cement export capacities in the EU's neighbourhood according to a Cembureau position paper that was released in early 2004. It is not clear from Cembureau (2004b) where the data comes from exactly and what year it refers to. In any case, taking the data as given, we see that the largest capacities are found in Russia, Ukraine and Turkey with more than 10 million tonnes. Relatively high capacities are also found in Belarus and Romania. The general pattern is not surprising, as larger countries are more likely to have larger supply capacity surpluses. It would be interesting to monitor the trade flows between neighbouring countries either side of the EU's external borders in order to see whether the export potentials described are being exploited.

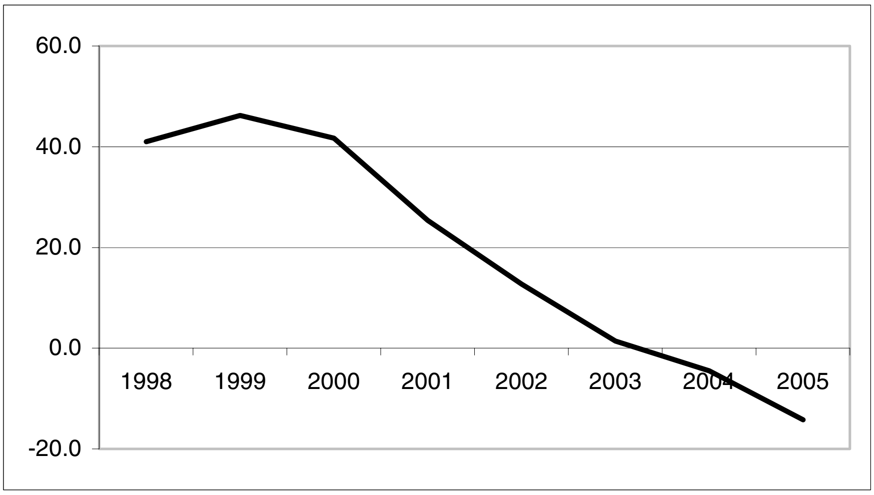
Map 2.1: Cement export capacities in Europe's neighbourhood

Source: Cembureau (2004b)

The scenarios touched upon above assumed implicitly the existence of competitive markets, with energy prices acting as the only possible distortion. In practice, regional and national industry concentration and market power play an important role. Furthermore, there have been cases of anti-competitive behaviour from firms, i.e. cartel-type arrangements, for instance in Germany. In April

2003 three leading German cement companies were found guilty of conspiring to keep cement prices artificially high and were heavily fined by the German Anti-Trust Office. The effect of the German anti-trust action can be seen for example with respect to the trade position of the Czech Republic, which used to be a net exporter of cement to Germany but is now a net importer. This is shown in graph 2.5.

Graph 2.5: Net exports of cement from the Czech Rep. to Germany – USD millions



Source: UN COMTRADE, own calculations

The particular case of German cement exports to the Czech Republic demonstrates that price differentials between EU member states can still be to a large extent due to factors other than energy price and labour cost differentials. Indeed it seems hard to understand how Germany could be a net exporter of such a commodity to a country like the Czech Republic without taking into account market structures in both countries. A full assessment of the European cement market would therefore require such an analysis on a country-by-country basis.

Leading companies

As shown above the cement industry cannot be global in terms of production facilities. However there are multinational corporations that specialise in cement production and operate in many different countries by owning and operating a set of local production facilities that are each used to supply their local market. It is thus the case that foreign direct investment (FDI) is overwhelmingly of the market-seeking type. The other remarkable feature about cement industry companies is how narrowly specialised they are on cement, concrete and aggregate. There is very little horizontal diversification. Table 2.6 gives basic data for 7 leading companies. The data refers to 2005. Sales are expressed in millions of Euros and reflect global sales.

Table 2.6: Leading Cement Companies (2005)

Company	Country of headquarters	Cement and clinker (ths tonnes)	Sales	Countries of operation
Lafarge (*)	France	120,900	16,000	Global
Holcim	Switzerland	110,600	11,928	Global
CEMEX	Mexico	81,000	12,315	Americas, Europe, Asia, Middle East
HeidelbergCement	Germany	68,400	7,803	Europe, Asia, Africa
Italcementi	Italy	56,300	5,000	Europe, N. America, Asia, N. Africa
Buzzi Unicem	Italy	32,245	2,951	Europe, N. America, CIS
Cimpor	Portugal	19,806	1,535	SW Europe, Africa, former colonies

Source: Corporate annual reports and other corporate publications
Note: (*) Cement and clinker volume estimated using 2005H1 and 2006H1 volume data

The leading cement companies in the world are Lafarge (France), Holcim (Switzerland), CEMEX (Mexico), HeidelbergCement (Germany), Italcementi (Italy) and Buzzi Unicem (Italy). With an eye on the European perspective we have also added Cimpor (Portugal), given its strong presence in Portugal and Spain.

The last column in table 2.6 indicates the countries of operation of the companies. Lafarge and Holcim both have operations in many countries on every single continent, hence the label "global". The companies shown above also make important revenues from the production and sale of ready-mix concrete and aggregate. These three products together account for very substantial shares of total sales, though Lafarge is also a leading producer of gypsum.

Production processes, energy use and emissions

The production of cement can be fragmented only once (if at all) after clinker originates in the kiln. It can then be transported for milling elsewhere (up to 300 km). Table 2.6 shows the number of cement plants with and without kilns for each EU member state in 1995 and in 2004. As we can see, fragmentation of production has increased over the period.

Table 2.7: Comparison of number of plants and mills: EU 25 (1995 and 2004)

	Plants with kilns - 1995	Plants with kilns - 2004	Plants wo kilns – 1995	Plants wo kilns - 2004	% wo kilns 1995	% wo kilns 2004
Austria	11	9	1	3	9	33
Belgium	5	5	3	3	60	60
Cyprus	n	2	N	0	n	0
Czech Rep	n	6	N	1	n	16.7
Denmark	1	1	0	0	0	0
Estonia	n	1	N	0	n	0
Finland	2	2	0	0	0	0
France	38	33	5	6	13	18
Germany	50	38	20	19	40	50
Greece	8	8	0	0	0	0
Hungary	n	4	N	0	n	0
Ireland	2	4	0	0	0	0
Italy	64	58	29	35	45	60
Latvia	n	1	n	0	n	0
Lithuania	n	1	n	0	n	0
Luxembourg	1	1	1	1	100	100
Netherlands	1	1	2	2	200	200
Poland	n	12	n	1	n	8
Portugal	6	6	1	2	16	33
Slovak Rep.	n	6	n	0	n	0
Slovenia	n	2	n	0	n	0
Spain	37	37	5	13	13	35
Sweden	3	3	0	0	0	0
United Kingdom	23	15	1	1	4	6

Source: EC 2001, EC 2005

For the production of 1 tonne of clinker, one needs on average 1.57 tonnes of raw material. Most of those 0.57 tonnes are lost as CO_2 emissions. These emissions are the result of the calcination process and cannot be significantly reduced by changes in technologies. The total approximate values of these CO_2 emissions can be seen in National Inventory Reports under category 2A1[2]. Table 2.8 shows examples of these emissions for selected EU countries.

[2] Emissions from fuel combustion on the other hand are found under category 1A2 in National Inventory Reports.

Table 2.8: Activity Data on CO2 emissions from cement production: selected EU countries (1993-2001) - Gg CO2

	1993	1994	1995	1996	1997	1998	1999	2000	2001
Austria	2032	2102	1631	1634	1761	1599	1607	1712	1720
Czech Rep.	2693	2644	2642	2479	2498	2430	2114	2040	1790
Denmark	1206	1192	1204	1282	1441	1452	1365	1406	1432
Finland	727	731	760	767	906	902	964	1017	1015
Germany	29180	29222	29072	27668	28535	29038	29462	28494	25227
Netherlands	500	500	400	300	400	400	500	500	500
Sweden	1056	1073	1263	1184	1075	1105	1111	1251	1297

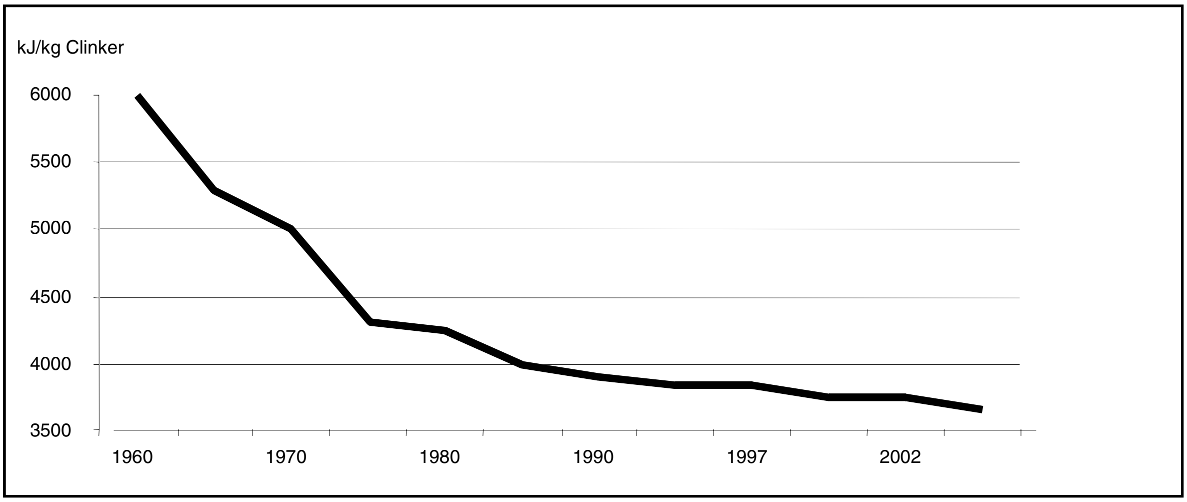
Source: National Inventory Reports

Cement Kiln Technologies

The production of cement is very energy intensive. Energy costs represent 30-40 % of total production costs, i.e. excluding capital costs (EC, 2001). These are embodied either in the fuels used for burning process in kilns or transport vehicles, or by electricity, which is needed for milling or grinding processes and/or for transportation. The needs for electricity are estimated to 90-130 kWh/t of cement (EC, 2001) or 105 kWh/t of cement (Cembureau website)

Most of the fuels used are combusted in the kilns in order to produce clinker. Graph 2.6 shows the average energy consumption needed for producing 1kg of clinker in Cembureau countries for the period 1960-2003. As can be seen, huge progress in energy efficiency has been achieved. However improvements in energy efficiency slowed down in the 1990s. The overall trend is the consequence of changes and improvements in technologies, in this case mainly of a transition from wet, semi-wet and semi-dry process kilns to dry process kilns. Dry process kilns are today's best available technology.

Graph 2.6: Fuel Energy Consumption: Cembureau Countries (1960 – 2003)[3]



Source: Cembureau

Generally, energy consumption in dry process kilns is approximately 3300 kJ/kg, while wet process kilns are up to twice more energy-intensive (approx. 5000-7000 kJ/kg). This is mainly due to the fact

[3] Currently, Cembureau countries are: Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxemburg, Netherlands, Norway, Poland, Portugal, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and associate members Latvia and Romania. The Slovak Republic and Iceland left Cembureau in 2003.

that, with the wet process, water has to be vaporised, thus requiring additional energy. The semi-dry and semi-wet processes are in the middle range of energy intensities.

Table 2.9: Energy intensity according to kiln type

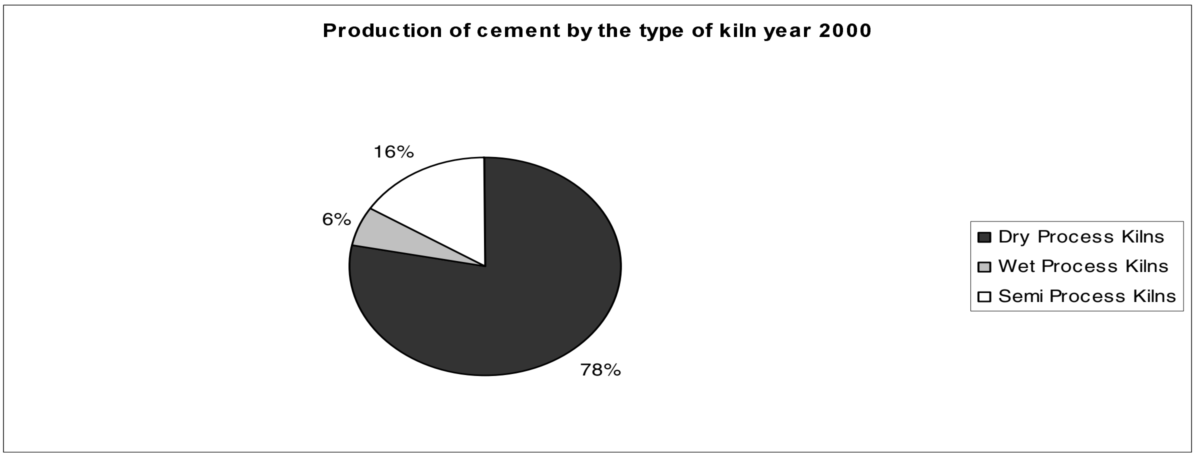
Type of kiln	Actual Fuel Energy Use (MJ/t clinker)
Dry proces, multi-stage cyclone preheater, and precalciner kilns	Approx. 3000
Dry process rotary kilns equipped with cyclone preheaters	3100 - 4200
Lepol type kiln = semi-wet/semi-dry processes	3300 - 4500
Dry process long kilns	up to 5000
Wet process long kilns	5000 - 6000
Shaft kilns	3100 - 4200

Source: EC 2001

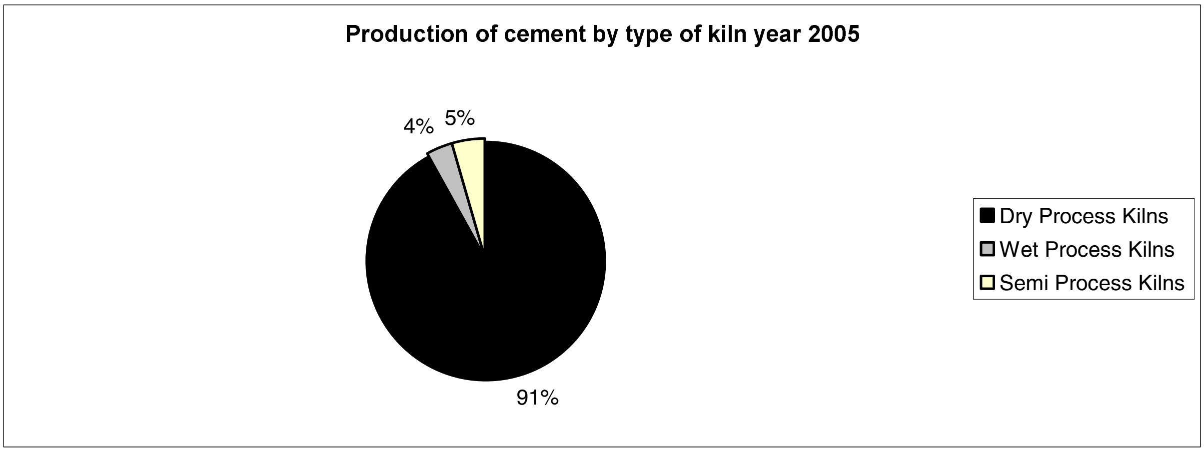
As can be seen from table 2.9, the switch from the wet process kiln to the dry process kiln could lead to energy savings up to 3000 kJ/kg of clinker. Currently, there exist several types of kilns for dry process and one additional special type of kiln, shaft kilns, which are efficient only for small production capacities.[4]

In contrast to what was prevalent in the 1960s, clinker production in the years 2000 and 2005 took part mostly in dry process kilns, as can be seen from graph 2.7. The share of production following semi-dry or semi-wet processes declined sharply between 2000 and 2005 as a result of conversions to dry process kilns. The rest of European production came from wet process kilns. Dry process kilns, which are the best available technique, now account for 91% of EU-15 production, up from 78% as recently as the year 2000.

Graph 2.7: Production of cement by type of kiln: EU 15 countries (2000 and 2005)



[4] Generally, kilns have a capacity around 3,000 t of clinker per day. For rotary kilns this can go up to 15,000 t/day. For shaft kilns on the other hand a typical capacity would be just 300t/day



Source: EC 2001, 2005

How does Europe compare to other world regions? Table 2.10 shows the global picture, albeit for the year 1995. One can see the outstanding position of Japan which already in 1995 had 100% of dry process kilns while Western Europe only had 58% of dry process kilns.

At the opposite end of the distribution the former Soviet Union and Australia and New Zealand had over 70% of dry process kilns, in other words a huge potential for improvements in energy efficiency.

While in Eastern Europe the situation dramatically improved between 1990 and 2000 (energy efficiency went from 5740 kJ/kg to 5200 kJ/kg of clinker), the situation in the former Soviet Union didn't change up to the year 2000, remaining on the same level of 5520 kJ/kg of clinker.

Table 2.10: Ratio of types of kiln: World regions (1995)

Region	**Type of kilns (%)**			
	DRY	**SEMI-DRY/WET**	**WET**	**SHAFT**
USA	65	2	33	0
Canada	71	6	23	0
Western Europe	58	23	13	6
Japan	100	0	0	0
Australia & New Zealand	24	4	72	0
China	5	0	2	93
South East Asia	80	9	10	1
Republic of Korea	93	0	7	0
India	50	9	25	16
Foreign Soviet Union	12	3	78	7
Other East Europe	54	7	39	0
South and Latin America	67	9	23	1
Africa	66	9	24	0
Middle East	82	3	15	0

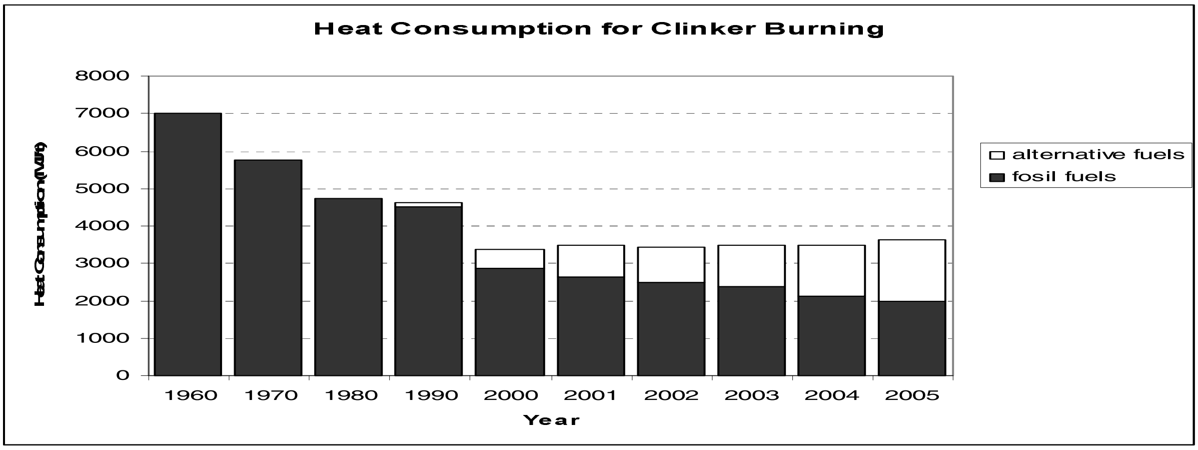
Source: Humpreys, K. & Mahasenan, M. 2002 calculations from World Cement Directory 1996

What happens once the shift in favour of dry process kilns is complete, as is the case in Japan (and almost so in Western Europe)? Essentially one can say that, given current technologies, the large easy gains are over and only minor improvements are still possible. Cembureau for example is of the opinion that the remaining margin for improvement through technical investment is only about 2%. The fact that the industry is approaching its technological frontier is supported by the slowdown in energy efficiency improvements. Also, as Eastern European countries continue along their catching-up path, the gap in technologies between Western European and Eastern European countries should narrow.

All in all one may say that the largest gains in energy efficiency for the European Union as a whole have mostly already been reached, at least in terms of the broad technological options. Beyond the choice of the main process, firms on the technology frontier may nevertheless still be able to make a number of improvements by focusing on the fuel mix.

Cement firms in the European Union thus monitor fuel prices closely, as well as paying close attention to all regulations that may affect their choice of fuel. The potential gains from improvements to the fuel mix are sufficient for that type of information to be considered sensitive by producers, as part of what contributes to having a competitive advantage. On the other hand aggregate data by country can be found, as shown in graphs 2.8 and 2.9 for the case of the Czech Republic. Generally speaking one promising solution from the point of view of costs has been to increase the share of waste (incl. urban and agricultural) as alternative fuels.[5] On the other hand, because of their lower calorific values, usage of alternative fuels acts contrary to reducing energy intensity of the industry. This development can be seen from graph 2.8, which depicts the heat consumption for clinker burning in the Czech Republic. The interesting development is that, while total energy intensity has in fact slightly risen from 2000 to 2005, both energy costs and carbon emissions have come down, given the lower carbon-intensity of alternative fuels, which in turn reduces costs inherent to carbon emissions.

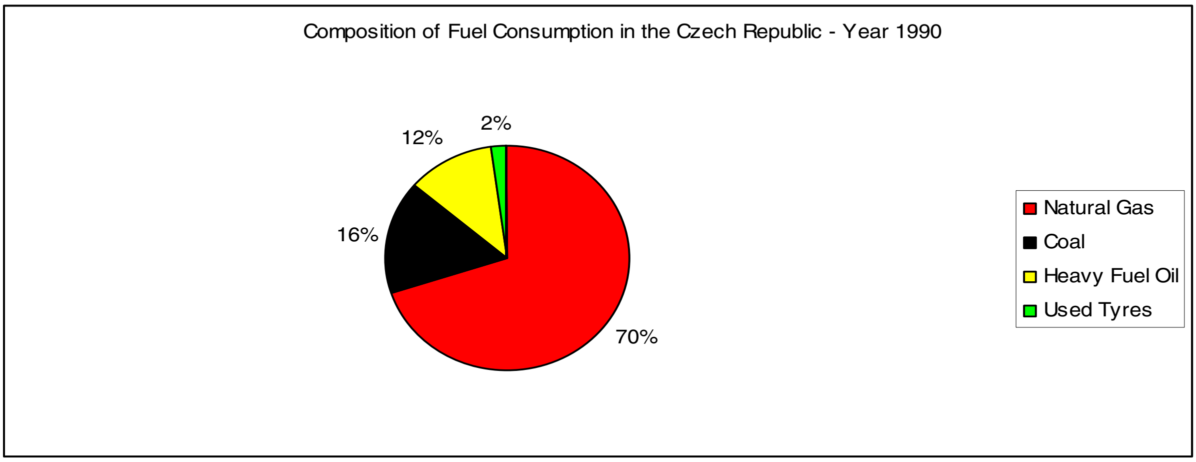
Graph 2.8: Heat Consumption for Clinker Burning: Czech Republic (1960 – 2005)

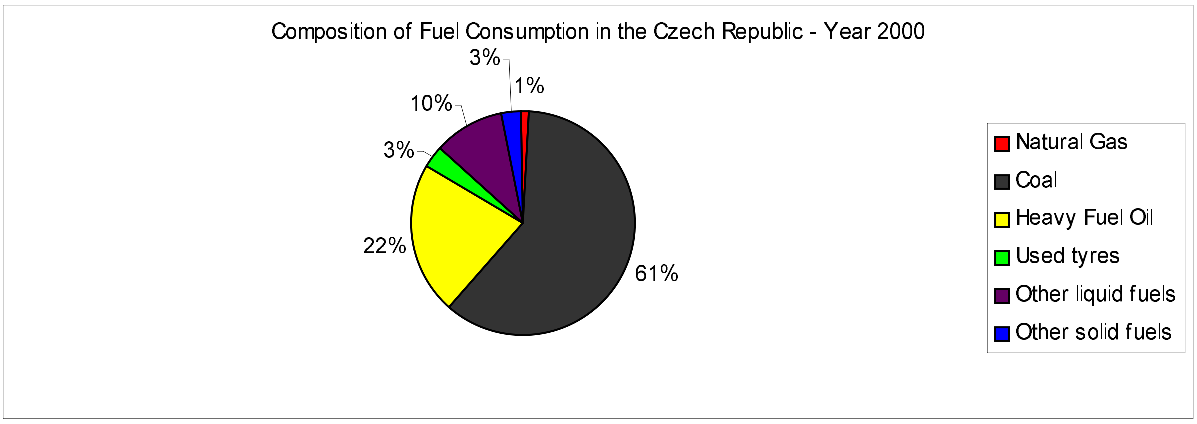


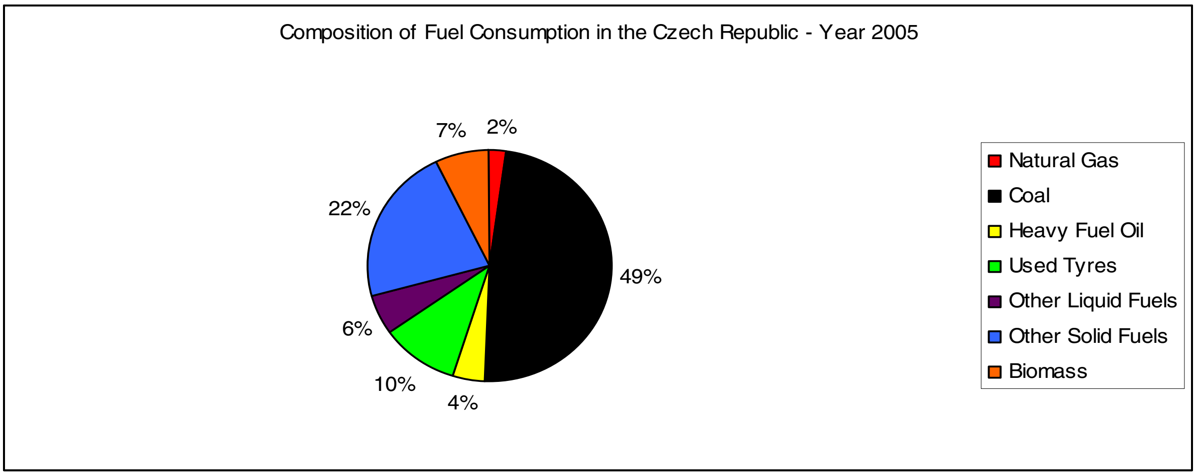
Source: Czech Cement Association

[5] The most cited examples are waste tires, biomass, used solvents, sewage sludge, municipal solid waste, and petroleum coke.

Graph 2.9: Fuels used in cement production in the Czech Republic (1990, 2000 and 2005)







Source: Czech Cement Association

Graphs 2.8 and 2.9 characterize fuel combustion in the Czech Republic according to fuel type. They reveal a trend of a growing ratio of combusted waste and alternative fuels. For example, the share of used tyres grew from 2 to 10 percent over the 1990-2005 period. Similar trends have been observed across developed countries, including EU countries. Except the growing trend in combustion of alternative fuels, in the case of the Czech Republic, the share for coal has also increased in the period 1990-2005 and has maintained strong position between the years 2000 and 2005, as the result of substitution of liquid fuels. This is because the prices for liquid fuels are highly dependent on the price of crude oil, while the latter has risen very strongly in the last couple of years. Furthermore one can also see that there has been a switch away from natural gas. This trend is a little bit unwelcome from an environmental point of view since natural gas represents one of the cleanest fuels with respect to other pollutants (e.g. sulphur oxides). This particular development is also due to the evolution of relative prices.

In Europe as a whole, the use of alternative fuels has increased sharply, going from 3% in 1990 to 15% currently. In Cembureau countries, 6 million tonnes of waste were utilized in cement kilns in 2004. This is the equivalent of 4 tonnes of coal (Cembureau, 2006) and this shift presents several advantages. Beyond the reduction in costs, alternative fuels do not pose issues with respect to the security of energy supply, while also helping to reduce emissions of GHGs[6] and reducing pressure on natural resources. Technology plays an important role here. There are specific characteristics of cement kilns that are needed in order to make it possible to use wastes or alternative raw materials[7] alongside other fuels. These characteristics include: high combustion temperatures, long residence time, an alkaline environment, ash retention in the clinker, an oxidizing atmosphere, and continuous fuel supply.

CO_2 emissions and improvements in cement manufacturing processes

Generally, about 40% of GHGs emissions from cement production come from fossil fuel combustion at cement manufacturing operations, 5% from transport activities, 5% from fuel combustion used for production of electricity, and the rest (approx. 50%) come from the process-related emissions of CO_2, i.e. calcination.

Process emissions cannot be reduced efficiently if we consider only the production of clinker. However it is possible to reduce aggregate CO_2 emissions by using less clinker in the first place. One such example is the manufacturing of blended cements.[8] Blended cements using pozzolanic materials[9] thus leads to an overall reduction in CO_2 emissions per tonne of cement. Among the pozzolanic materials, fly ash is the most available over the world. A shift in favour of composite and pozzolanic cements has already started in the EU-15 countries, as can be seen from graph 2.10. This represents a positive trend towards reducing CO_2 emissions from cement production in Europe.

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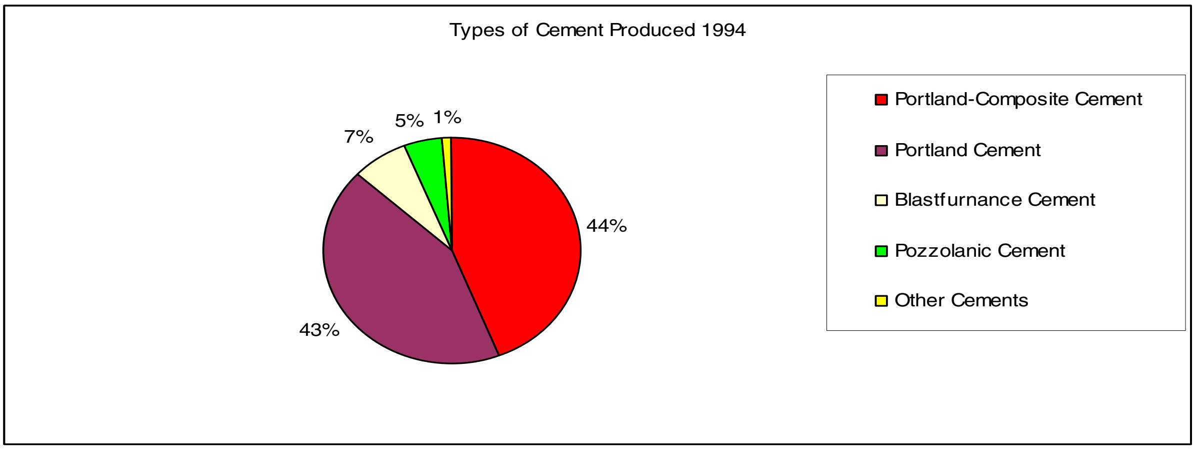
[6] This is because the waste is co-incinerated in cement kilns with other fuels instead of burning unproductively. Although these emissions are the same as it would have been burned in incinerator, the usage of those fuels reduces the need to burn traditional fuels during the cement production.

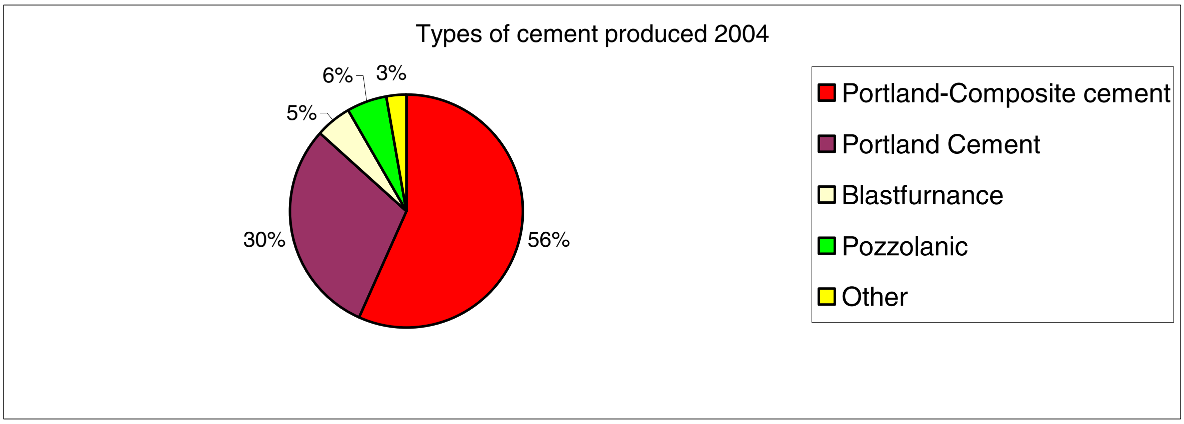
[7] Examples of wastes incinerated here are used tyres, animal meal, sewage sludge, RDF, packaging waste, waste treatment sludge, solvents, and/or used lubricants. As raw material we know for example fly ash, bottom ash, pyrites ores, ferrous waste or artificial gypsum.

[8] According to definition, blended cement is cement with fixed percentage of pozzolans replacing the Portland Cement Clinker portion in the mix

[9] These are for example blast furnace slag, fly ash produced by the steel and electric power industries or natural pozzolans

Graph 2.10: Types of cement produced: EU-15 (1994 and 2004)





Source: EC 2001, EC 2005

Further methods indirectly leading to reductions of CO_2 emissions are procedures aimed at increasing the efficiency of grinding clinker. These methods result in lowering the amount of clinker needed to produce one tonne of cement. The overall possibilities for the reduction of CO_2 emissions using such methods were estimated by Humpreys and Mahasenan (2002) to be 7%.

Larger possibilities in CO_2 emissions reduction lie in changes in fuel use. In general, the emissions from fuel combustion are directly proportional to the specific energy of each fuel and the ratio of carbon content to calorific value of each fuel. Therefore, this is equivalent to say that fuel related emissions are a function of the energy efficiency of the equipment and of the fuel mix. Possible strategies for an increase in energy efficiency and thus a lowering of CO_2 emissions are retrofitting of existing plants or complete phasing out of existing plants with the consequent transition to better processes, as with the shift in favour of dry process kilns discussed earlier. The possibilities for such changes differ among regions. A very large potential was seen for example in the CIS or the USA in 1996. Regarding fuels, there is a possibility to reduce CO_2 globally in the way described previously by substituting traditional fuels with alternative fuels and by switching from high-carbon fuels to low-carbon fuels. Humpreys and Mahasenan (2002) estimate that such changes could reduce fuel-related emissions globally (per tonne of cement produced) by up to 14%. On the other hand they estimate that the possibilities of reducing emissions from improvements to transport and in power generation are each below 1%.

Table 2.11 summarises the possibilities of reductions in CO2 emissions in the cement industry, under the assumption that the industry is technologically almost on the frontier. As we can see, the largest potential gains lie in the use of alternative fuels.

Table 2.11: Possibilities of CO2 reductions – Overview

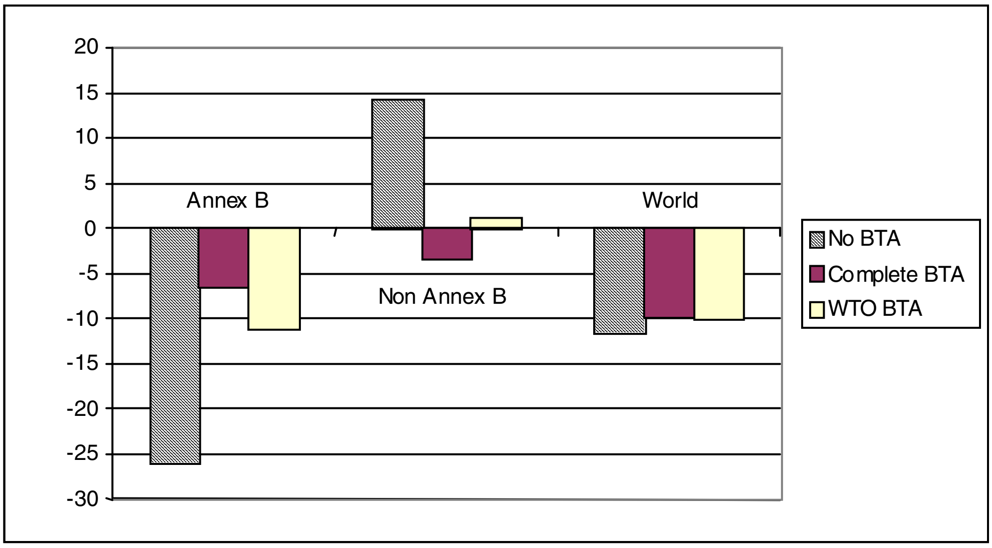
Reduction measure	Type of effect	Potential
1. Apply less CO2 intensive resources	direct	+
2. Improve thermal energy efficiency	direct	+
3. Use CO2-neutral biomass fuel	direct	++
4. Substitute clinker in cement	direct	+
5. Substitute cement in concrete	direct	+
6. Use alternative fuels	indirect	+++
7. Improve electrical efficiency	indirect	+
8. Improve distribution logistics	indirect	+
9. Improve energy efficiency of buildings	indirect	+

Source: Loo & der Meer

Carbon leakage

Possible carbon leakage in the cement industry has been estimated in OECD (2005). The study focuses on the impacts of environmental policies of Annex B countries on Annex B countries and non-annex B countries[10]. This exercise was carried out using the GEO-CEMSIM model. This assumes imperfect competition on the cement market, cement a perfectly substitutable product, road and shipping transport costs, seven different kiln technologies, and endogenous fuel switching.

Graph 2.11: Production (mill tonnes), comparison with BAU case in 2010



Source: OECD (2005)

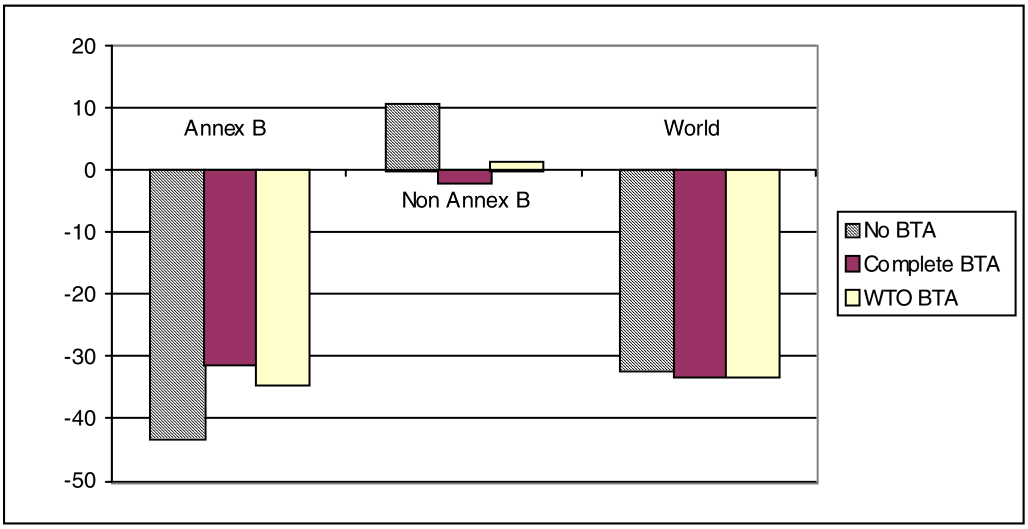
In the study four possible scenarios are examined. The "business as usual" scenario assumes all circumstances as they are; the "no-BTA" scenario where European countries, Russia, Japan and Canada implement a CO_2 tax without border tax adjustments (BTA)[11]; the "complete BTA" scenario where the BTA amounts to a full adjustment according to CO_2 content; and finally the "BTA-WTO" scenario, where the BTA is set at the level of the most efficient technology.

From graph 2.11, we can see that in the absence of a border tax adjustment one would obtain the greatest reduction in global production of cement, albeit with a shift of production from Annex B countries to non-Annex B countries.

[10] The annex B countries in the study are EU-15, Bulgaria, Czech Republic, Estonia, Latvia, Liechtenstein, Lithuania, Monaco, Romania, Slovakia, Slovenia, Switzerland, Canada, Hungary, Japan, Poland, Croatia, New Zealand, Russia, Ukraine, Norway, Iceland.

[11] A border tax adjustment in this context would be a rebate on the carbon tax for cement exported to non-Annex B countries and the imposition of the carbon tax on cement imported from non-Annex B countries.

Graph 2.12: Emissions (mill tonnes CO2), comparison with BAU case in 2010



Source: OECD (2005)

From graph 2.12 we can see what is projected to happen to emissions. There, predictably, the reduction in emissions is the smallest in the absence of any border tax adjustment. However it is interesting to note that the "complete BTA" and "WTO BTA" scenarios are almost identical in their global outcomes, though not in how the global effect is split between Annex B and non-Annex B countries. Carbon leakage would in fact only be averted in the "complete BTA" scenario. However it is rather striking to note that the difference between the "no BTA" and the other two scenarios in terms of global emissions is relatively small, while the economic impact (favourable to producers in non-Annex B countries, unfavourable to producers in Annex B countries) would not be negligible (OECD, 2005 also calculates the impact on profit margins for Annex B producers).

Section 3 – The Lime Industry (26.52)

World production data

At the PRODCOM (8-digit) level the lime manufacturing industry breaks down into the manufacturing of three commodities: quick lime (26.52.10.33), slaked lime (26.52.10.35) and hydraulic lime (26.52.10.50).

The data on lime available at USGS is less comprehensive than the data on cement. However there is data for the largest producing countries (e.g. China, USA, France, Germany, Italy, UK, India, Brazil, Mexico, Turkey). USGS states that it is aware of production (but has no reliable data) for Pakistan, Iraq and Syria. Given the size of those countries probably only Pakistan might have relatively large volumes. The data also covers only the two main commodities, quick lime and slaked lime, not hydraulic lime. Beyond these limitations it seems the USGS data should give us a reasonably accurate idea of world patterns.

Table 3.1 gives the production volumes in thousands of tonnes of quicklime and hydrated lime for each of the top 12 producing countries, ranked according to 2004 levels. Table 3.1 gives the corresponding shares in world production. The EU-25 is treated as one country. Due to missing data for smaller European countries we decided to give an estimate just for the enlarged EU of 25 member states rather than for the EU-15 and for the NMS-10 separately. The approximation for the EU-25 is based on the available data, which covers 11 countries[12] and which should in our opinion account for an overwhelming share of total EU production.

[12] Austria, Belgium, Czech Republic, France, Germany, Italy, Poland, Slovakia, Slovenia, Spain, United Kingdom.

Table 3.1 – Largest producers of quicklime and hydrated lime (physical volumes)

Production of lime, ths of tonnes	**2000**	**2001**	**2002**	**2003**	**2004**
European Union	26,428	26,929	26,048	26,002	26,100
China	21,500	22,000	22,500	23,000	23,500
United States	19,500	18,900	17,900	19,200	20,000
Russia	8,000	8,000	8,000	8,000	8,000
Japan (quicklime only)	8,106	7,586	7,420	7,953	7,950
Brazil	6,273	6,300	6,500	6,500	6,500
Mexico	5,300	4,800	5,100	5,700	5,700
Turkey	3,300	3,200	3,300	3,300	3,400
Bulgaria	1,388	2,025	1,136	2,902	2,900
Canada	2,525	2,213	2,248	2,216	2,200
Iran	2,200	2,000	2,200	2,200	2,200
Romania	1,480	1,790	1,829	2,025	2,000
Estimated World Total	121,000	121,000	119,000	124,000	126,000

Source: USGS and own calculations

As we can see from tables 3.1 and 3.2 the general production pattern is much less lopsided than with cement. China is of course a major producer, but in 2004 still only the world's second largest, though closely behind the European Union, the world's largest producer, and slightly ahead of the USA, though its share of world production has risen over the last five years, while the share in world production of the EU and of the USA have slightly fallen. Other major producers are Russia, Japan, Brazil and Mexico.

Table 3.2 – Largest producers of quicklime and hydrated lime (shares of world total)

Production of lime, share of estimated world total	**2000**	**2001**	**2002**	**2003**	**2004**
European Union	21.8%	22.3%	21.9%	21.0%	20.7%
China	17.8%	18.2%	18.9%	18.5%	18.7%
United States	16.1%	15.6%	15.0%	15.5%	15.9%
Russia	6.6%	6.6%	6.7%	6.5%	6.3%
Japan (quicklime only)	6.7%	6.3%	6.2%	6.4%	6.3%
Brazil	5.2%	5.2%	5.5%	5.2%	5.2%
Mexico	4.4%	4.0%	4.3%	4.6%	4.5%
Turkey	2.7%	2.6%	2.8%	2.7%	2.7%
Bulgaria	1.1%	1.7%	1.0%	2.3%	2.3%
Canada	2.1%	1.8%	1.9%	1.8%	1.7%
Iran	1.8%	1.7%	1.8%	1.8%	1.7%
Romania	1.2%	1.5%	1.5%	1.6%	1.6%

Source: USGS and own calculations

The country breakdown of EU production is given in table 3.3. Germany is the largest producer by some margin, followed by France and Italy.

Table 3.3 – Largest quick- and hydrated lime producers in the European Union, 2004

Lime production in 2004	Ths tonnes	Share of EU total
Germany	6,700	25.7%
France	3,000	11.5%
Italy	3,000	11.5%
Austria	2,000	7.7%
Belgium	2,000	7.7%
United Kingdom	2,000	7.7%
Poland	1,950	7.5%
Spain	1,800	6.9%
Slovenia	1,500	5.7%
Czech Republic	1,300	5.0%
Slovakia	850	3.3%

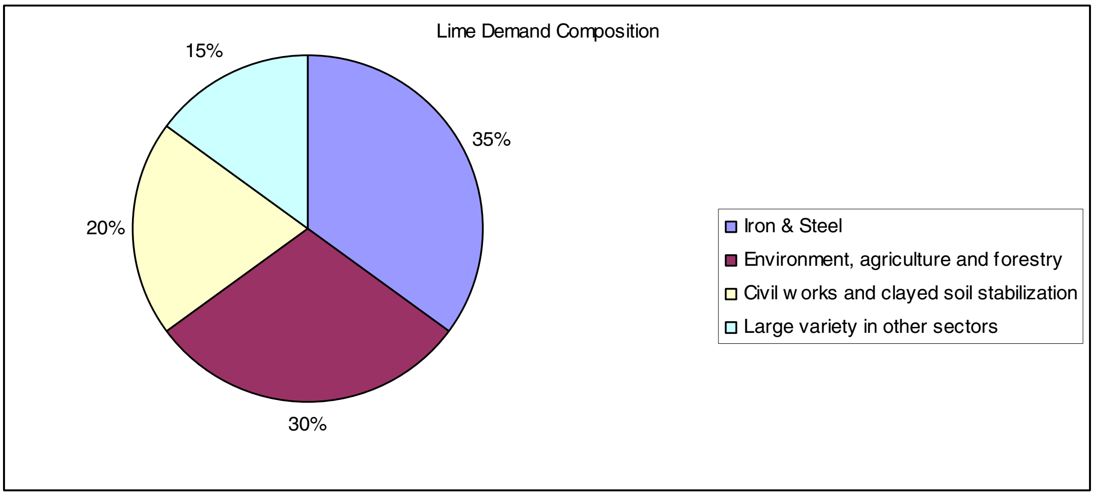
Source: USGS and own calculations

Demand for lime

The lime industry is also characterized by a relatively homogeneous product. The quality of lime also varies little, except with respect to granulometry. Quality premia do exist, but are of minor importance, so that one may make the simplifying assumption of a homogeneous good where competition rests only on price.

Regarding demand, the situation is completely different from the case of cement. One can say that up to 65% of produced lime serves for environmental purposes and the utilization differs according to the type of lime. Graph 3.1 shows the composition of lime demand in 2002 in EULA countries[13]. Comparing it to the year 1995, the ratio of the iron & steel industry preserved a relatively constant ratio between 30% and 40%. The environmental uses together with agriculture grew from 20% to 30%.

Graph 3.1: Composition of demand for lime: EULA countries (2003)



Source: EULA, 2004

Determining the demand for lime is therefore much more complicated than in the case of cement. Major demand comes from the sector iron & steel, which is consequently dependent on sectors like engineering. Environmental demand is mostly determined by current environmental policy, the critical issues associated with lime are desulphurization, water modification and sewage as well as fly ash stabilization and waste disposal. As for agriculture the main driver is a shift back to is lime-based fertilizers.

[13] The European Lime Association (EuLA) membership covers almost all EU member states plus non-members such as Turkey, Norway and Switzerland.

The same main attribute as with cement, i.e. high transportation costs due to a low value-weight ratio, also applies to lime. To be economically profitable, lime has to be transported in large amounts over small distances. Still, countries such as Ukraine, Bulgaria and Romania could in principle compete with domestic production of lime in Eastern parts of the (2004 membership) European Union. However this hasn't happened to any significant degree as EU producers are more price-competitive.

Production processes and energy use

The production of 1 tonne of slaked lime consumes between 1.4 and 2.2 tonnes of raw material depending on its quality.

The production of lime is less energy intensive than cement production. The requirements in electricity are significantly lower than in the case of cement production as they reach only 50 kWh/t of lime (EULA, 2004) in comparison with 90-130 kWh/t for cement. This is mainly because cement production consists of 2 milling/grinding procedures while production of lump lime does not. In addition, production of hydrated lime is composed of one milling.

Contrary to cement production the choice of the type of kiln is crucially dependent on which exact type of lime is in demand, which differs by reactivity and granulometry. That is why the type of kiln rather reflects trends in demand. The kilns are of three main types: rotary kilns, rotary hearth kilns and shaft kilns.

Although the calcination reaction needs less heat in lime kilns, i.e. around 1000 °C, in comparison with 1450 °C in cement kilns, heat can be better utilized in cement production because precalciners in cement industry employ hot gases coming up from kilns. The amount of energy needed for calcium limestone dissociation is 3200 MJ/t. Energy consumption in shaft kilns ranges between 3600 (Parallel-flow regenerative kiln – Maerz) and 5000 MJ/t of quicklime. Rotary kilns, which produce white reactive lime, have an energy consumption ranging between 4600 and 7500 MJ/t of quicklime.

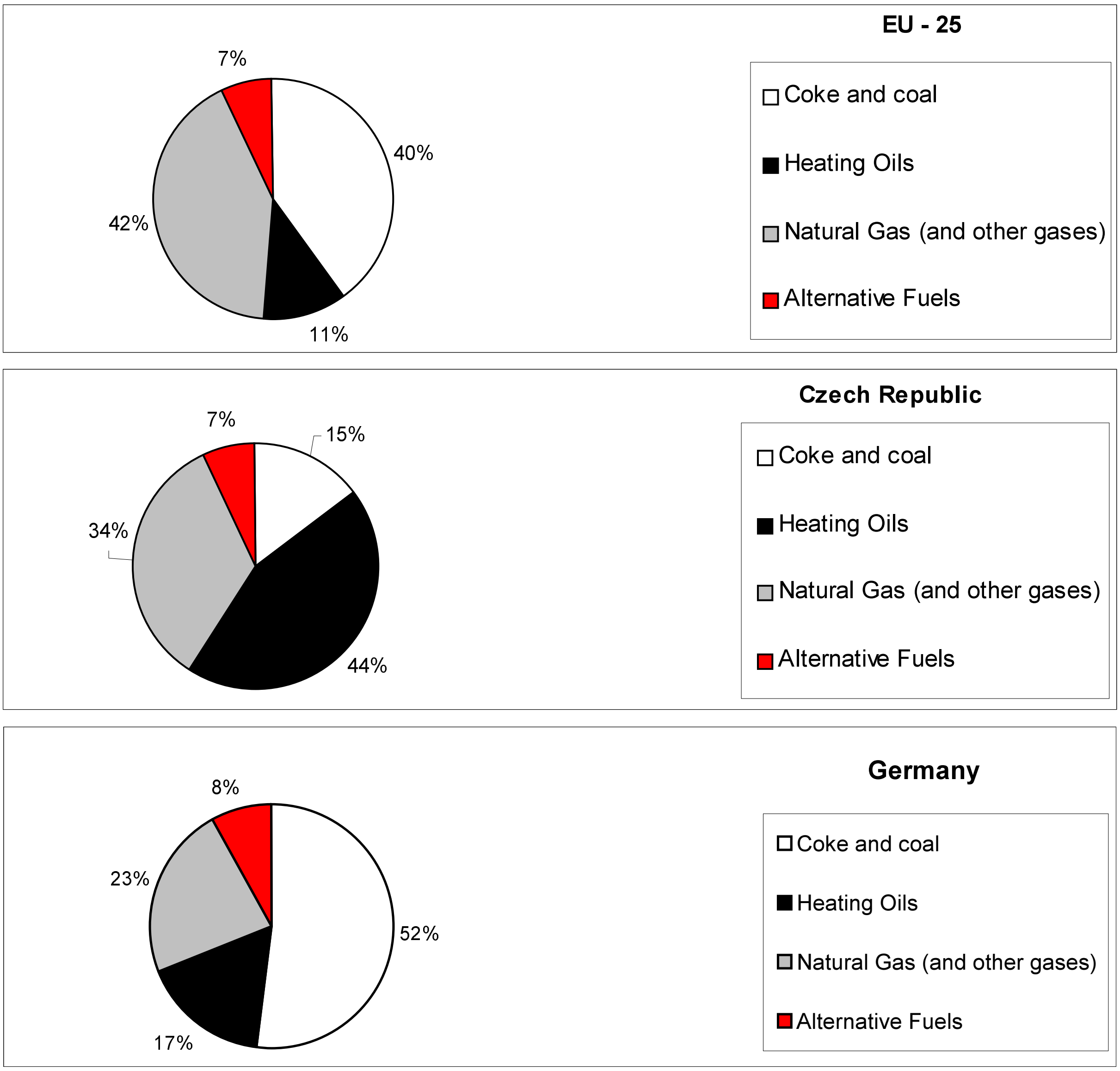
The current trend helping with improvement of energy efficiency is to completely replace old kilns by new ones, or to carry out some modification or innovation on existing equipment. These can be embodied, for example, by the installation of heat exchangers in order to recover the surplus heat from the kiln gases. (EC, 2001). According to the Czech Lime Association, lime production, like cement production, is approaching a technological frontier. The large majority of firms in the EU already use the best available technology and only minor improvements to energy efficiency are still possible at the current stage.

Because of the water content in slaked lime and because it is easy to obtain slaked lime from burnt lime, only burnt lime is transported. The transportation costs of burned lime are nevertheless roughly as high as those for cement and it is likewise not commercially viable to transport lime over long distances.

Similarly to the case of the cement industry, lime production is extremely capital intensive but not particularly labour intensive due to high degree of automation of the production process. However, because the kilns need not operate at such high temperatures and also have longer life cycles, they are also less exacting on materials and therefore cheaper. The life cycle of lime kilns is about 35 years and can be lengthened by modernization or reconstruction.

Regarding CO2 emissions and associated environmental costs, a very important aspect is the composition of fuels. In contrast to cement production, lime producers in several cases try to avoid the use of waste as alternative fuels. This is because of the final utilization of lime, for instance in the food industry or in water treatment plants. However there are other cases in which regulations enable the use of waste as part of the fuel mix, e.g. lime for the building & construction sectors. In those cases the same advantages as in cement manufacturing also prevail. Graph 3.2 shows the composition of fuels used in the lime industry in the European Union as a whole and in Germany and the Czech Republic in particular.

Graph 3.2: Fuels combusted for lime production: Selected EU countries (2005)

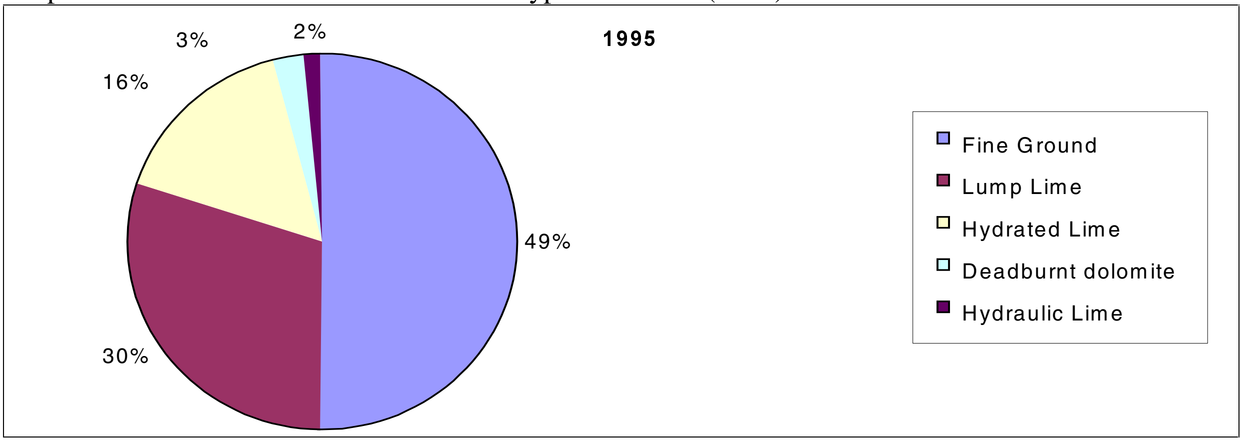


Source: Czech Lime Association, EULA

Graph 3.2 shows that there are quite significant differences in the fuel mix between countries, with Czech production making much more use of heating oils. On the other hand the shares for alternative fuels are very similar between the countries shown and the European Union as a whole. These results imply that there are limits to the extent to which alternative fuels can be used. This is partly for the reasons discussed earlier (regulations with respect to the final consumers of lime). The other main reason why alternative fuels cannot be used more extensively in the present is that the alternative fuels market is still relatively small and is subject to strong seasonal fluctuations.

We now turn to the structure of produced lime by type. This is shown in graph 3.3. The highest shares in output are taken up by fine ground lime followed by lump lime. These two types are types of quicklime and account for almost 80% of total production. Slaked lime (hydrated lime) represents a further 16% percent of output. The rest is taken up by two relatively rare types: deadburnt dolomite and hydraulic lime. These last two types are occasionally used in the building and construction sectors. Furthermore one may note that the demand for hydrated lime is growing as consumers are willing to buy it as a final product rather than hydrating lime themselves.

Graph 3.3: Estimated ratio of different lime types in EU-15 (1995)



Source: EC 2001

Future prospects for the lime industry

Lime production is dependent on the developments in those sectors that have a demand for lime. The iron and steel industry was characterized by over-production in the EU in 2004 and 2005 and therefore the demand for lime slowed down. However, an increase in demand from this sector is projected for 2006. Building and construction is expected to grow by about 1.5%-2% a year. The forecasts for the other sectors requiring lime are also positive. The overall increase in demand for lime is thus expected to be around 10% over the next ten years according to the Czech Lime Association, in other words an average growth rate of 1%-1.1% per annum.

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Competitiveness Effects of Environmental Tax Reforms (COMETR)

The Iron and Steel Industry

WORK PACKAGE 5 – Industry Studies

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31 December 2006

Abstract

This study provides a global overview of the iron and steel industry[1], with some elements about possible future developments both in economic and technological terms. The European dimension is then more thoroughly explored with respect to energy- and carbon-intensity, notably in light of the EU's environmental policies. The impact of the latter is also assessed thanks to the results of an interview with a European steel manufacturer.

Section 1 – Introduction

Iron and steel are manufactured respectively from iron ore and/or scrap iron or scrap steel in a number of different possible processes[2]. 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, wire and so on

The production of iron is the most energy-intensive step and traditionally takes place in a blast furnace. The principle is based on a carbothermic reaction: the iron ore (compounds of iron and oxygen atoms such as Fe_2O_3 and Fe_3O_4) is made to chemically react with carbon monoxide, itself produced by making carbon atoms (introduced in the form of coke) bond with oxygen atoms, in order to break up the iron ore into (in theory) pure iron on the one hand and carbon dioxide (CO_2) on the other. This process is energy-intensive because it can only give satisfactory results if conducted at high temperatures (around 2000 C). The process also automatically generates high levels of CO_2, as that is the (other) produce of the main chemical reaction involved. Besides these process-related emissions there are of course carbon emissions due to the combustion of fossil fuels, if used.

The produce of step 2 is called pig iron, and is not useful in itself because of its poor mechanical properties. Pig iron is basically an alloy of iron with varying levels of other elements such as silicon,

[1] 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.
[2] In this section we rely heavily on the introduction found in OECD (2003).

and with around 5% of carbon. Another way of producing a relatively pure form of iron is direct reduction. This is a purely chemical process which does not require the high temperatures of a blast furnace. There are many different industrial processes to do this. The main one uses natural gas as the main agent. The volumes of natural gas that are necessary are large. The produce of this procedure is called Directly Reduced Iron (DRI). The expression "sponge iron" is also used.

Pig iron is the traditional desirable input for the production of desirable forms of iron such as cast iron (carbon content of 2%-3.5%) and for the production of steel (under 2% of carbon) in step 3. In the classical production process, this is done basically by melting the iron ore and driving air (in order to bring oxygen) through it in order to absorb the impurities (notably the excess carbon). This of course also generates carbon dioxide, and is energy-intensive because the process can only happen at high temperatures.

In the industrial age, steel has traditionally been produced in open hearth furnaces. In the 1950s, the Linz-Donawitz Procedure, or Basic Oxygen Furnace procedure, was developed in Austria: the main difference is that it blows virtually pure oxygen onto the molten iron, rather than just air, and is thus more efficient. The other difference 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 resulting emissions per tonne of produced steel (in 1995) was as shown in Table 1.1.

Table 1.1 – CO_2 emissions per tonne of steel by main process – 1995

Emissions of CO_2 in the Steel Industry, 1995 (mill 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)

As we shall see in the next section, production in Europe is somewhat static with only Spain showing sizable growth of 28 % over the nine years to 2004. Blast furnaces (for iron production) in Europe are declining in number. Replacement is unlikely to occur, France being an example of a country that will not be replacing its furnaces. The UK's Department for Trade and Industry, DTI, has investigated the outlook for the sector and growth in the UK as part of the work on energy and emissions projections for Phase 2 of the EU ETS. The baseline growth rate for the UK for the iron and steel sector (including castings) was -0.8% for the period 2000 to 2005 and -0.2% for 2005 to 2010.

Drivers of demand for iron and steel generally include the level of construction activity, especially infrastructure, and purchases of automobiles, machinery and appliances. Chinese growth is the dominant feature in the world steel industry at present. In 1996 China became the world's largest steel producer, passing Japan and the US.

Chinese development is in a very intensive construction phase and economic growth would appear to be abnormally construction intensive. Construction makes huge demands on the supply of steel but, in addition, one industry expert we talked to felt that steel is being used relatively more widely than would be expected. An observer could be struck by the high amounts of steel in structures in China. New bus shelters, for example, are made of steel by contrast with the more familiar plastic shelters. The likeliest explanation would be the current relative cheapness of steel.

Location choices

Blast furnaces will tend to situate where the minerals are. They will not necessarily locate where the energy is cheap because they can import their own coal. However, where there is a positive price charged for carbon emissions this has to be factored in.

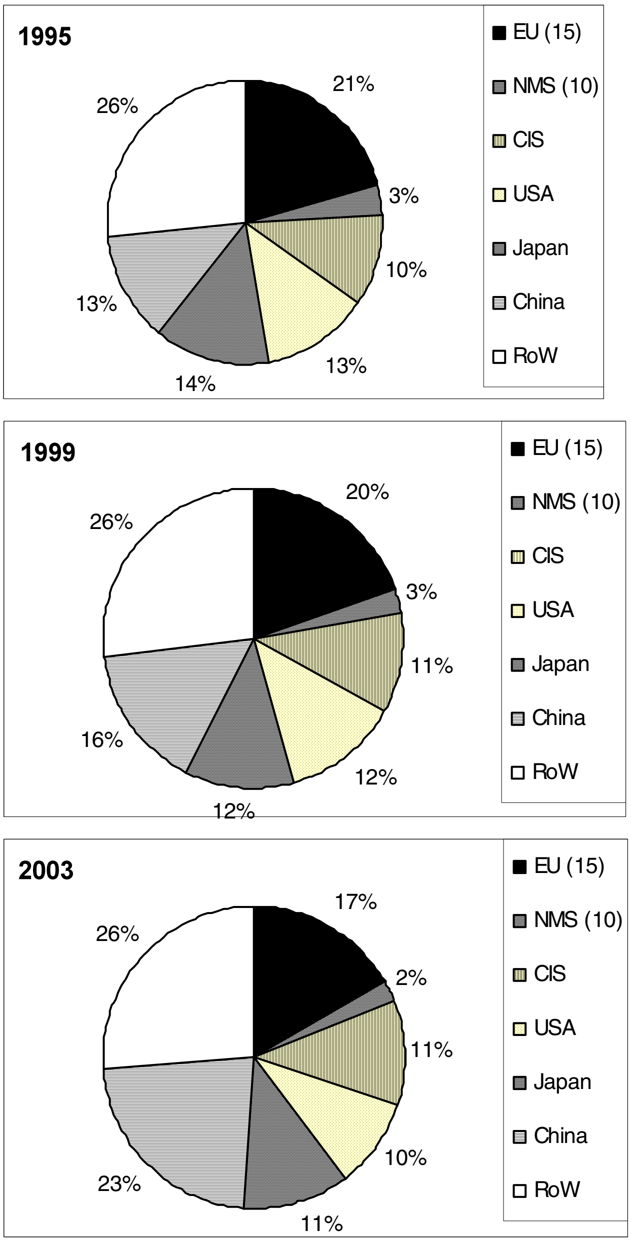
As described in Work Package 2, there are two issues to be considered where energy-intensive companies and vulnerability under ETR is concerned. One is the extent of possible technical abatement that can still be applied at reasonable cost, and the second is the pricing power of the firm. Firms that are price-setters are more likely to be in a position to weather a carbon tax. But as was seen in Work Package 2, the Iron and Steel sector is the least likely of the energy intensive sectors to be in such a position. The evidence on this confirmed that the sector operates in a highly competitive environment which suggests that, other things equal, the company would consider relocating to where carbon prices and/or environmental stringency are lower.

An aspect that may not be 'equal' is a company's scope for altering its technology to reduce its energy bill. Relocation as a result of ETR therefore hinges largely on the possibilities for adjustments to their technology

Section 2 – Basic global economic data

Major producers. In 2003, major crude steel production areas in the world were the following (see Figure 2.1): 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%.

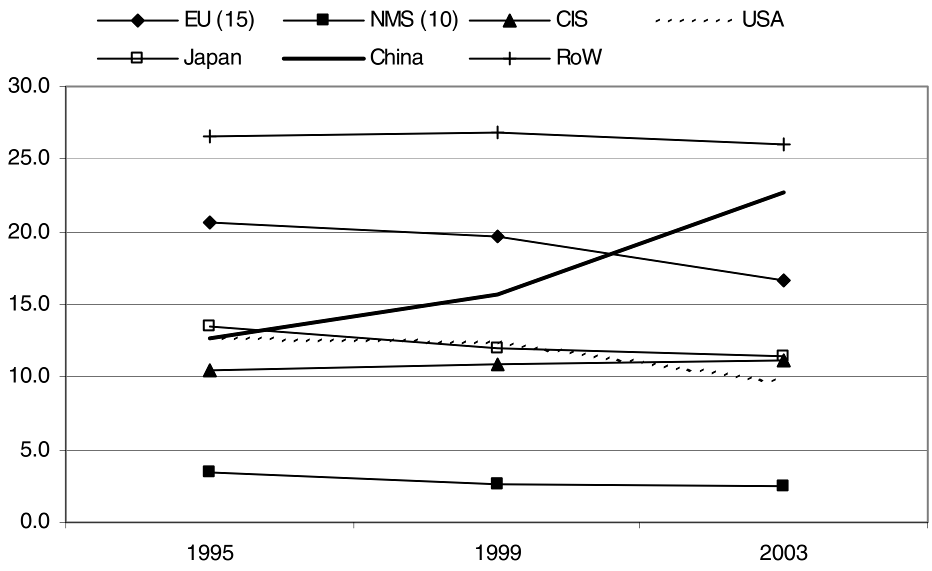
Figure 2.1 – Crude Steel Production, in %, 1995, 1999, 2003



Source: IISI

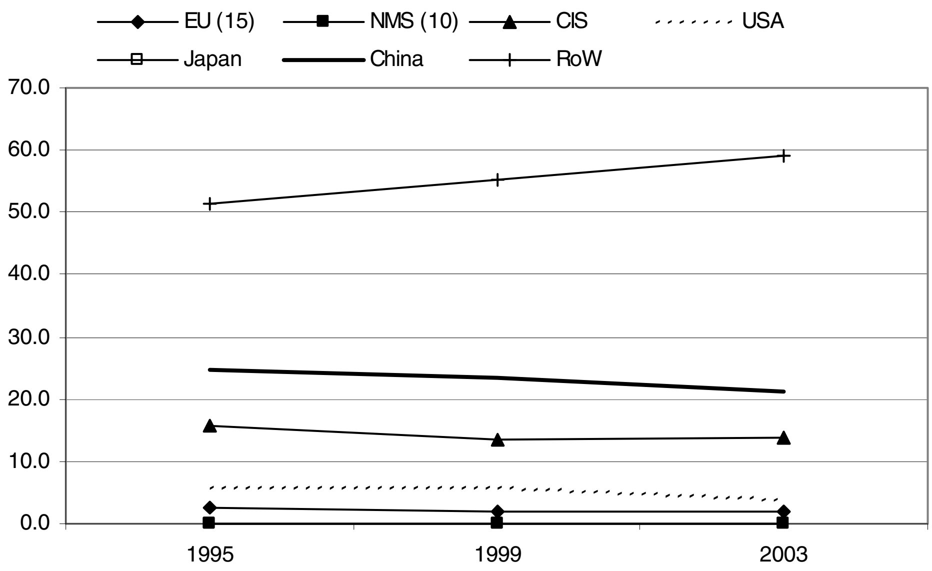
In the last ten years, China recorded the largest increase in world steel production, gaining about 10 percentage points in world steel production. The CIS also saw a slight increase, while all other world regions lost in shares (see Figure 2.2). In absolute figures, China more than doubled its crude steel production between 1995 and 2003. The other regions slightly increased their absolute crude steel production, interestingly only the NMS (transition and restructuring period) and the USA reduced their production volume during this time period in absolute figures.

Figure 2.2 – Crude Steel Production, in %



Source: IISI

Figure 2.3 – Production of Iron Ore, in %



Source: IISI

Iron ore, a major input for steel production, is produced in the following areas: About 2% of world iron ore is produced in the EU-15, 14% in the CIS, 4% in the USA, 21% in China, and the largest part is produced in the rest of the world (59%), among which Brazil (20%) and Australia (17%) are the two largest producers. The new Member States (except very small volumes from Slovakia) and Japan do not produce iron ore (see Figure 2.3). During the last ten years, the rest of the world increased its share by almost 8 percentage points, while all other regions lost.

Major steel-producing countries and companies. 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. In more detail, China held a share of 26%, Japan of about 11%, the United States of 9%, Russia some 6% and South Korea about 4%. Hence the shares of other countries following were already rather small (see Table 2.1). Major producers in the European Union were Germany, Italy, France, Spain, the UK and Belgium. Major producers in the NMS were Poland, the Czech Republic and Slovakia. The top five steel-producing companies in 2004 were Arcelor, Mittal Steel, Nippon Steel, JFE and POSCO, accounting for 17.5% of total world crude steel production (see Table 2.2). This structure has now become more concentrated, due to the merger of Arcelor and Mittal.

Table 2.1 – 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: IISI

Table 2.2 – Top steel-producing companies, 2004, millions of tonnes of crude steel

	Company	mmt	in % of total	Headquarters
1	Arcelor	46.9	4.4	Luxembourg
2	Mittal Steel	42.8	4.1	Netherlands
3	Nippon Steel	32.4	3.1	Japan
4	JFE	31.6	3.0	Japan
5	POSCO	30.2	2.9	South Korea
6	Shanghai Baosteel	21.4	2.0	China
7	US Steel	20.8	2.0	US
8	Corus Group	19.0	1.8	UK/Netherlands
9	Nucor	17.9	1.7	US
10	Thyssen Krupp	17.6	1.7	Germany
	Total World	**1056.7**	**100.0**	

Source: IISI

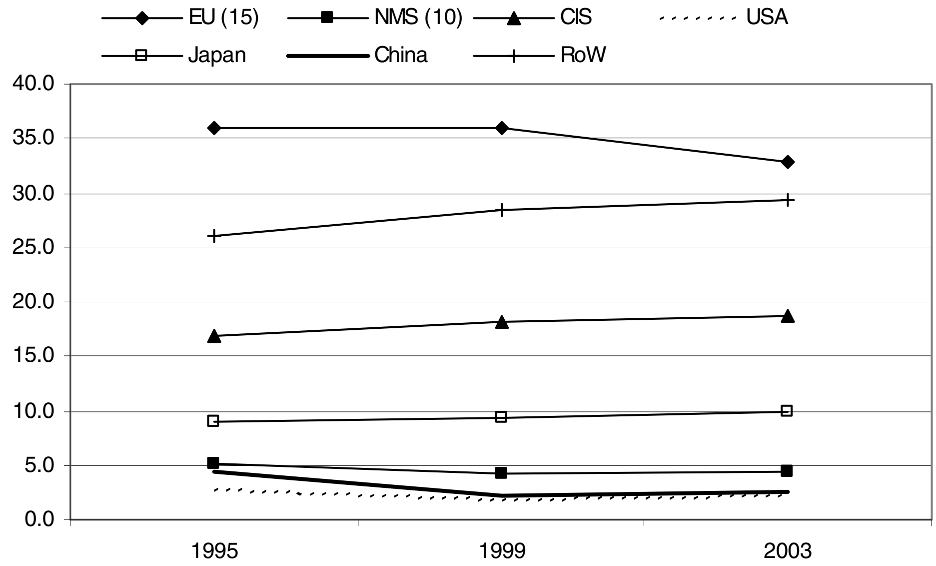
International Trade in Iron and Steel

Major exporters and importers. 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 products[3], 29% the RoW, 19% the CIS, 10% Japan, 4% the NMS, 3% China and 2% the USA. In the last

3 About 70% of total exports were intra-regional exports.

years, the EU-15 lost some 3 percentage points in world trade, while the RoW, the CIS and Japan gained small shares (see Figure 2.4). 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 (see Figure 2.5)

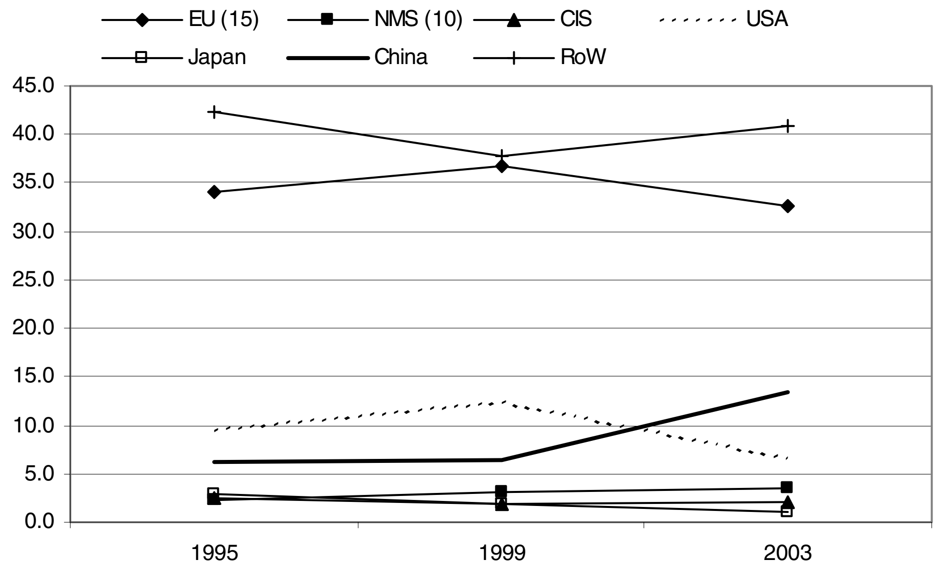
Figure 2.4 – Exports of Semi-finished and Finished Steel Products, in %



Source: IISI

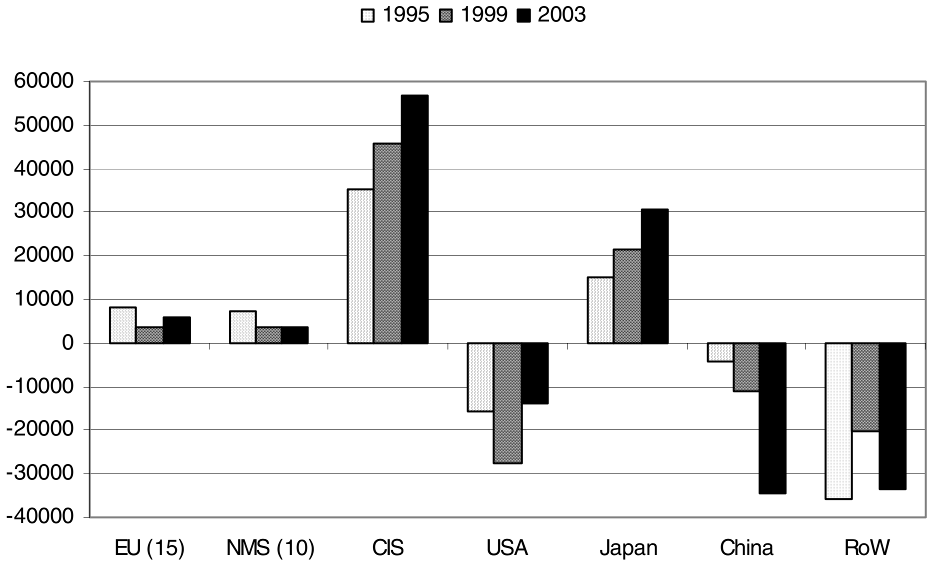
Trade balance. In 2003, the CIS were the largest net-exporters of semi-finished and finished steel products in the world, followed by Japan, the EU-15 and the NMS. On the other hand, the largest net importers were China, the RoW as well as the US (see Figure 2.6). Especially the CIS-countries increased their trade surplus in the last ten year, as did Japan. China saw a large jump of its trade deficit in 2003.

Figure 2.5 – Imports of Semi-finished and Finished Steel Products, in %



Source: IISI

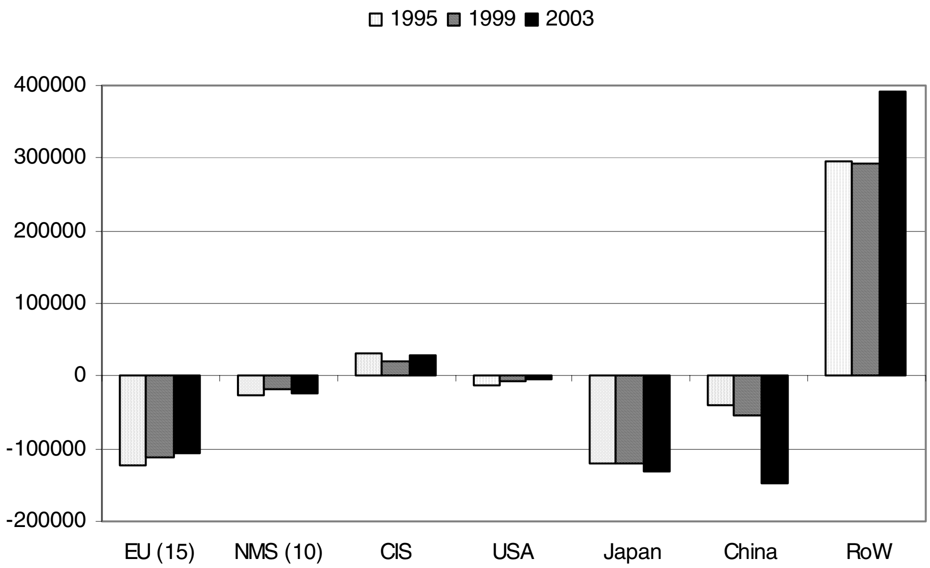
Figure 2.6 – Net Trade Balance of Semi-finished and Finished Steel Products, ths tonnes



Source: IISI

Iron ore trade. In 2003, exports of iron ore mainly came from the RoW (88%), with Brazil and Australia accounting for 63% of total world iron ore exports. The CIS exported some 8% of world iron ore, the EU-15 only 3%, while exports from the NMS, the USA, Japan and China were negligible. These shares remained rather stable between 1995 and 2003. On the other hand, major importers of iron ore in 2003 were China (25%), Japan (23%), the EU-15 (22%) and the RoW (21%). Since 1999, China recorded a large jump of iron ore imports, rising nearly threefold, and increasing its share in world iron imports by 13% percentage points. For comparison: between 1995 and 1999 the share in world imports increased only by 3 percentage points. Hence overall, only the RoW and the CIS recorded net trade balances, while the other regions were net importers of iron ore (see Figure 2.7).

Figure 2.7 – Net Trade Balance of Iron Ore



Source: IISI

Global outlook

According to the IISI's latest Short Range Outlook (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 1179 million tonnes in 2007 from a total of 1029 million tonnes in 2005.[4] 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%.

Turning to 2007, China is expected to be the region with strongest growth though stricter credit control and administrative measures introduced by the Chinese authorities are expected to have a moderating influence. For the whole world, IISI are predicting growth in apparent steel use of 5.2% in 2007, as shown in Table 2.3.

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.

Table 2.3 – Apparent Steel Use 2005-2007

	Finished steel Million tonnes			Annual change			
				2005-2006		2006-2007	
	2005	2006e	2007f	M tonnes	%	M tonnes	%
World	**1029**	**1121**	**1179**	**92**	**8.9**	**59**	**5.2**
China	327	374	413	47	14.4	39	10.4
Rest of world (excl China)	702	747	766	45	6.4	20	2.6

Source: IISI. e = estimate. f = forecast.

In the period up to 2010 world steel demand is forecast by IISI to rise by 4.9% per year. Steel demand in India and China is forecast to rise by 7 % and 8.4%, respectively, with the figure for the rest of the world put at 4% per year.

Looking out to the period 2010 to 2015 (Table 2.4), world steel demand is projected to grow at 4.2% per year on average. Annual growth for India is forecast to be 7.7% surpassing the 6.2% annual growth expected for China over that period.

[4] 'Apparent steel use' reflects deliveries to the market from producers and importers. Figures may differ from actual steel use owing to changes in inventories.

Table 2.4 – Real Steel Demand 2010 – 2015

	Trend to 2010 % per year	2010 f M tonnes	Trend 2010-2015 % per year
EU (15)	2.0	157	1.3
EU (25)	2.5	183	1.7
CIS	5.0	57	4.0
NAFTA	1.9	160	2.4
South America	3.9	40	3.7
Japan	0.4	83	-0.1
India	7.0	54	7.7
China	8.4	489	6.2
S. Korea and Taiwan	3.1	78	1.9
Rest of the world	4.0	177	4.0
World	**4.9**	**1319**	**4.2**
World excl China	3.0	831	2.9

Source IISI. f = forecast.

China has decided to decommission all outdated steel firms as part of a new round of restructuring of the steel industry to curb the glut in the world's largest iron and steel market. Under this plan, the National Development and Reform Commission (NDRC), the country's main planning body, has asked local governments to release list of outdated steel firms so that they could be demolished. Under the NDRC's restructuring plan, China will scale back iron production by about 100 million tonnes in the next five years to eliminate redundant production. The steel production will be reduced by 55 million tonnes before 2007. China's steel industry faces danger of over-production. The national steel production capacity reached 470 million tonnes at the end of 2005 and another 150 million tonnes are still in construction. But steel consumption in the year only stood at 350 million tonnes, far less than the supply. Major movements in this sector are the growth in demand in emerging economies and price rises for energy and other inputs. In such circumstances, gaining access to emerging markets is an obvious quest that beckons. The industry's production features many inter-related modules, or potentially inter-related, remembering that many steel companies had been established in the past as national 'statements'. These links warrant investigation for the scope they offer for synergies, as inputs and hence wastes such as residual heat become more valuable and technology more focused.

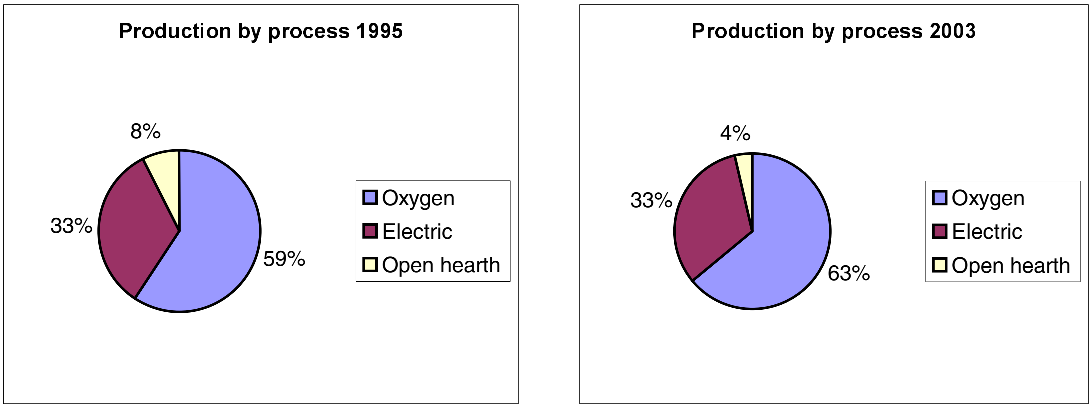
Experts are saying that rising input costs are forcing steel producers to become more integrated, and this can be the expected result. Producers re-examine processes to see where previously worthless waste can be eradicated. It would also be the result expected of ETR. If the industry could add the cost increases on to the price of steel, the rise in the price of steel will cause consumers to find substitutes and reduce consumption, if not in absolute terms, then in terms relative to what demand would have been. A more likely outcome in areas characterised by a competitive environment is that profits are squeezed

The industry's fragmentation in global terms has meant that competition has been intense and the industry had little in the way of price-setting powers. More recently the steel industry has been subject to high-profile mergers, with power presumably becoming somewhat less dissipated. One recent report suggests that European steel prices could be intentionally influenced by, for example, temporary shut-down of units in Europe (Hindustan Times 2006). Is one likely to see a rise in market power in the hands of steel producers as their number reduces? If so, what are the implications for competitiveness in the face of ETR? The answer then is that competitiveness issues hinge more on the issue of transport costs.

Section 3 – Production processes and technologies

As explained in the introduction, 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).

Figure 3.1 – Steel production by main process, 1995 and 2003



Source: IISI (2004)

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 (figure 3.1). The driver for the increase in the share of world production by BOF is China (Table 3.1), 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.

Table 3.1 – BOF process, share of total production, by world region, 1995, 1999 and 2003

Region	**1995**	**1999**	**2003**
EU15	65%	62%	59%
NMS10	78%	78%	81%
CIS	45%	57%	57%
USA	60%	54%	49%
China	60%	79%	86%
Japan	68%	69%	74%
World	59%	61%	64%

Source: IISI (2004)

Looking at the shares within regional / national production of the BOF process (Table 3.1), we see that it has gained in importance in the CIS, China and Japan, but has lost importance in the EU-15 and in the USA.

Table 3.2 – EAF process, share of total production, by world region, 1995, 1999 and 2003

Region	1995	1999	2003
EU15	35%	38%	41%
NMS10	15%	19%	17%
CIS	12%	12%	13%
USA	40%	46%	51%
China	23%	20%	14%
Japan	32%	31%	26%
World	33%	35%	33%

Source: IISI (2004)

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 (Table 3.2).

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. As explained in the introduction, 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.

So although the USA and the EU-15 may be on the right track (the picture is less clear concerning the ten New Member States, though their share in total EU-25 production is quite small), the global picture for a cleaner steel industry is not immediately encouraging. On the other hand the phasing out of the open hearth method is a welcome development.

It is useful if one can determine the benchmarks for production. Benchmarks have not in the past been widely applied in steel-making owing to the variation in a number of factors. In secondary steel-making for example (making finished products of bars, plates, sections, strips, coils and long products), the tonnage of steel made is not necessarily proportional to the amount of energy needed to make it. This may be due to a number of factors including variation in the ratio of ore to scrap and to different grades of steel. Certain types of high grade steel for the aerospace industry, for instance, may require significantly more energy than normal grade steel for the engineering industry.

There is also the perennial issue as to what should be referred to as the benchmark. For instance should one refer to the sector average, the top decile value, the level at the best actual site, or at the theoretical 'best achievable' level? Best practice can be differentiated between the two steel making routes, (1) blast furnace-Basic Oxygen Steel (BOS) making (sometimes called 'integrated process') and (2) Electric Arc Furnace (EAF). There can be significant differences in the products: EAFs tend to make more of the specialist steel products, e.g. special steel alloys and stainless steel. The two routes are used to different extents in different countries, depending on such factors as availability of scrap steel, the availability of coal and the type of downstream industry, making it difficult to determine the best or appropriate benchmark. In addition, economies of scale play a role in improving benchmarks.

A study by Entec (2006) for the UK Department of Trade and Industry (DTI) on new entrants under the EU ETS, Phase II, discusses these issues and leads up to figures expressed in tonnes of CO_2 per year at the UK's three integrated sites, Port Talbot, Scunthorpe and Teesside. But the version of the report that is in the public domain does not reveal the benchmarks, being confidential. However other data obtained from the literature on specific energy consumption and some emission factors for various plants are available and are summarised by Entec. This is reproduced below as Table 3.3.

Table 3.3: Data from the literature on energy consumption per tonne and emission factors

Reports / contacts / information sources	Plant Details	Country	Technology type(s)	Year	Energy Consumption Values
Industrial Energy Efficiency in the Climate Change Debate[13]	Theoretical plant	Global	Pig iron production in blast furnace	1995-1996	14.89 GJ / tonne iron
			Slab production by Basic Oxygen Furnace route (called BOS in UK)	1995-1996	-0.57 GJ / tonne crude steel
			Production of shaped steel by hot rolling	1995-1996	1.53 GJ / tonne shaped steel
			Production of shaped steel by cold rolling	1995-1996	1.10 GJ / tonne shaped steel
	National Average	Brazil	Production of crude steel	1995	23.3 GJ_P / tonne crude steel
		China	Production of crude steel	1995	31.4 GJ_P / tonne crude steel
		India	Production of crude steel	1995	30.4 GJ_P / tonne crude steel
		Mexico	Production of crude steel	1995	23.2 GJ_P / tonne crude steel
		South Korea	Production of crude steel	1995	19.3 GJ_P / tonne crude steel
		USA	Production of crude steel	1995	24.5 GJ_P / tonne crude steel
Future Technologies for Energy – Efficient Iron and Steel Making[14]	Average	Worldwide	Production of primary steel	1990	24 GJ_P / tonne crude steel
			Production of coke	1990	11.8 GJ_P / tonne coke
			Production of sinter	1990	2.5 GJ_P / tonne sinter
			Pig iron production in blast furnace	1990	11.6 GJ_P / tonne iron
			Production of crude steel by Basic Oxygen Furnace (called BOS in UK)	1990	0.3 GJ_P / tonne iron
Sector Guidance Note	Benchmark	EU MS (selected plants)	Production of sinter	1996	0.190 – 0.220 t CO_2 / t sinter
			Production of coke	1996	0.520 t CO_2 / t coke
			Pig iron production in blast furnace	1996	0.298 – 0.53200 t CO_2 / t iron
			Production of crude steel by Basic Oxygen Furnace (called BOS in UK)	1996	0.011 – 0.140 t CO_2 / t liquid steel

Notes: 13 Phylipson et al, 2002. 14 De Beer et al 1998.
Source: Entec, 2006, Table 9.8.

A point to note is the variation in technologies, outputs and processes. This means that in addition to the inevitable issues of restricted access to information it is difficult to compare like with like. It is also noted from Table 1 that China followed by India are the countries with the most energy intensive national averages of energy consumption per tonne of crude steel.

Entec also reproduce the benchmark emission factors from the spreadsheets for Phase I of the EU ETS. These refer to new entrants' blast furnaces. The benchmark emission factor is 1.67 tonnes of CO_2 per tonne of liquid steel produced. This factor covers the whole steel making process including the blast furnace, BOS furnace, sinter plant, and associated boilers and power plant (excluding coke ovens which are covered in a separate section under energy activities).

For coke ovens the benchmark emission factors are 0.148 tonnes of CO_2 per tonne of standard coke. The factor for those coke ovens that are equipped with heat recovery and power generation (Sun coke) is 1.08 tonnes CO_2 per tonne of coke.

A helpful calculation is given of the total impact of the EU ETS on the cost of steel production. As this would be in the same league as a carbon tax it is useful to look at this calculation here. The total impact of the EU ETS is estimated at about £25 to £30 per tonne of steel. It is equivalent to 10 % of the steel price and in the same order of magnitude as the profit per tonne of steel.

Entec assume 1.67 tonnes CO_2 per tonne of steel and a CO_2 price of GBP 17. If charged for, this gives a carbon cost of GBP 28 per tonne of steel. Assuming a price range for steel of USD 300 to USD 500 and a profit margin of 10%, the profit would lie in the range of approximately GBP 18 to GBP 30 per tonne, which compares closely with the carbon cost to be paid per tonne. A EUR 25 carbon allowance price and a 5 to 10 % shortfall of free allowances compared to an installation's needs would dent profit margins by some 1 to 2 %. This could be a factor influencing the decision with respect to location, not to mention the transactions costs of participating in the scheme.

With respect to the EU ETS, questions regularly arise as to the different technical approaches to benchmarking when it is used for allocating permits. Variations in use of benchmarks between member states will influence investment. One distinction is between the 'direct' approach and the 'integrated' approach to benchmarking, now described in turn.

The direct approach to benchmarking derives emission factors per unit of product from each stage of the production of steel at an integrated site and this approach may become more widespread. In the UK it is the proposed approach for Phase II, in place of the integrated approach of Phase I allocations.

The integrated approach to benchmarking would be an allocation based on the whole site. Under a direct approach, new entrant allocations are only given to extensions in capacity and not to increases in utilisation of existing capacity, though this is thought to be a significant element of the expansion plans of new entrants. Entec calculate the new approach would give a blast furnace but 19 % of the previous approach's allocation, and but 5 % for a new BOS furnace compared to the previous approach's allocation.

Definitions of 'new entrant' can also have profoundly different effects on the amounts allocated to existing sites. These and many other issues go to show that there are also transactions costs by dint of time spent on bureaucracy and the like.

Technologies in key developing countries

Technology in key developing countries is of interest as they are the potential destinations of companies that decide to relocate. Technologies have been analysed by Price et al, 2001. The countries investigated comprise Brazil, China, India, Mexico and South Africa, where outdated inefficient technologies are still used to produce iron and steel. The report presents further international comparisons of energy use and carbon dioxide emissions among these countries and provides an assessment of the technical potential to reduce the emissions based on best practice benchmarking.

Using a best practice benchmark, they find significant savings in the range of 33% to 49% of total primary energy used to produce steel are technically possible in these countries. Similarly they find that the technical potential for reducing intensities of carbon dioxide emissions ranges between 26% and 49% of total carbon dioxide emission from steel production. These findings refer to 1995 and the details are shown in Table 2.

Table 3.4 – Actual, best practice benchmarks and technical potential savings, primary energy and carbon dioxide per tonne of steel in 1995.

Country			
Primary energy	**Actual GJ / tonne**	**Best practice GJ / tonne**	**Potential savings GJ / tonne**
Brazil	23.1	18.6	4.5
China	36.7	20.2	16.5
India	37.3	20.5	16.8
Mexico	22.6	13.5	9.1
South Africa	44.4	n. av.	n. av.
Carbon dioxide emissions	**Actual t CO_2/tonne**	**Best practice t CO_2 / tonne**	**Potential savings t CO_2 / tonne**
Brazil	0.36	0.27	0.09
China	0.87	0.48	0.39
India	0.98	0.53	0.45
Mexico	0.42	0.24	0.18
South Africa	1.11	n. av.	n. av.

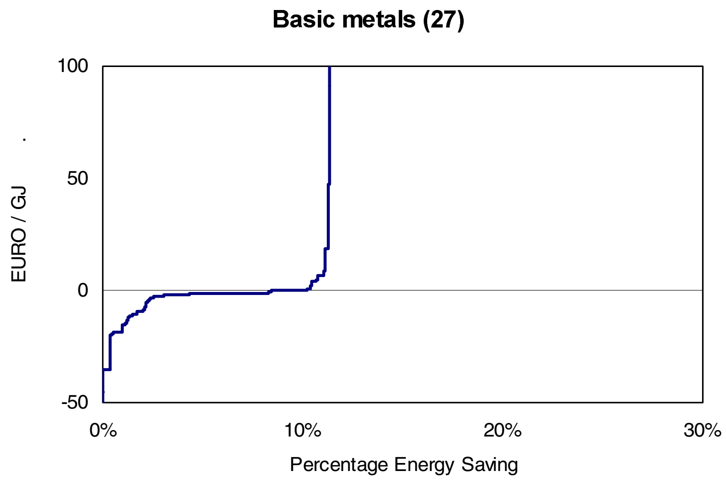
Source: Price et al, 2001.

The figures in the table are an indication of the emission reduction potential by efficiency improvements only. Additional emissions reductions can be accomplished through fuel switching. Even without fuel switching, large potentials exist. Setting the best practice benchmark at 100, India's index was 185, China's was 181, Mexico's was 175 and Brazil's was 133. From the point of view of the location question, prevalence of low standards in developing countries could encourage firms to relocate there. They could be less hassled by environmental constraints and they would be cheaper which would give them a competitive edge.

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 3.1 (Entec/Cambridge Econometrics, 2003) and it refers to technologies that were not yet implemented as of 1995, making the information somewhat dated.

Figure 3.1 – Energy saving supply curve, UK 1995.



Another comprehensive study for the US produced a similar energy conservation supply curve based on measures with paybacks of generally less two years (Worrell 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 (Entec, 2006). 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. The BREF note on the iron and steel industry is currently being reviewed and a report of the meeting will be available at end 2006 (Joint Research Centre, 2006). 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.

Section 4 – Reducing CO_2 emissions and the impact of ETR

This section looks (A) at the potential for reduction of CO_2 in the production of iron and steel. In (B) the actual energy use of the sector since the introduction of ETR is described with a view to assessing the path of energy intensiveness in relation to the potential.

(A) Potential reduction of CO_2

An independent study of the technical potential for reducing carbon dioxide emissions within the EU15 was undertaken by de Beer et al (2001). Commissioned by DG Environment of the European Commission the study covered the iron and steel sector in a bottom-up analysis. It forms part of a large study by Ecofys with others, and it benefited from comments from a panel of experts and a workshop.

The study's base year was 1990 and, in their list of options for reducing emissions, the authors only included those options that had a 'high probability' of being commercially available before 2010, meaning that they would not penalise the firm's profitability. A real interest rate of 4 per cent was used in the calculations applied to the lifetime of the equipment or investment. Where new capacity was concerned options were defined based on technology with an efficiency level equal to the best practice value of 1995, where 'best practice' means the best that has been realised, rather than 'best available', which may not in fact have been realised. The study did not consider shifts to other potential product mixes. Energy-efficiency improvement is defined as a decrease in consumption of non-renewable final energy carriers without affecting the level or nature of the activity for which the energy is used. Counteracting this bias towards conservative estimated potentials, the transactions costs are not taken into account.

The emission reduction potential for 2010 was first calculated using a reference level based on assumed industrial growth rates taken from the PRIMES (1999) study and 'frozen technology', which assumes no energy improvement and no reduction in specific energy consumption. Table 4.1 summarises the reference level for the iron and steel industry. The indirect emissions are related to consumption of steam and electricity.

Table 4.1 – Energy use and emissions of CO_2 by the Iron and Steel sector in 1990 and in 2010* assuming technology frozen at 1990 level.

	CO_2 emissions Mt			
1990 Fuel use EJ	**Direct**	**1990 Indirect**	**Total**	**2010 Reference level Total (frozen technology)****
2.3	198	48	246	266 (+ 8.1%)

** Projections to 2010 are based on growth rates given by Primes (1999).*
*** Excluding shifts between fuels and subsectors.*
Source: de Beer et al, 2001.

As shown in the table, an 8% growth in emissions of CO_2 is foreseen in the reference case for 2010, based on the assumption of technology being frozen at 1990 levels.
The authors describe in some detail the task of calculating Specific Energy Consumption levels for steel production, as between BOF and EAF, and the assumptions made, using the raw energy data from IISI. In practice the breakdown between in-house generated and purchased electricity varies considerably from plant to plant, but for the calculations it was assumed that all electricity consumed in integrated steel plants (BOF) is produced in-house so that only fuel is bought. It is also assumed that in EAF plants all electricity is bought.

In 1990 all the then EU countries had steel production facilities. As already seen integrated steel plants (based on blast furnaces and basic oxygen furnaces (BOF) accounted for 70% of the crude steel production, the balance being produced in electric arc furnaces (EAF).[5]

Table 4.1 shows estimated Specific Fuel Consumption for the production of crude steel in Basic Oxygen Furnaces and Specific Electricity Consumption for steel made in Electric Arc Furnaces in

[5] Except some steel was made in the obsolete Open Hearth Furnace in the former GDR.

1990. The authors recommend that the data be updated and point out that the product mix also affects the SEC.

Table 4.2 – Specific fuel consumption for the production of crude steel in BOF and specific electricity consumption for steel made in EAF, GJ per tonne in 1990.

	DEU	DNK	FIN	GBR	NLD	SWE	AUT	BEL	ESP	FRA	GRC	IRL	LUX	PRT
BOF	30.6	-	25.7	27.9	20.9	29.2	23.9	32.1	30.8	29.4	30.8	27.9	23.6	30.8
EAF	6.3	5.6	4.7	4.7	6.3	5.6	5.5	4.6	3.7	4.0	3.7	4.7	-	3.7

Source: de Beer, 2001. See source document for assumptions.

It is noted that Luxembourg had no EAF capacity in 1990, but since August 1997 it is based entirely on EAF. The first six countries in Table 4.2 are the countries that introduced ETR and a weighted average of their specific energy consumption levels in BOF processes is 28.73 compared to 29.60 for non-ETR countries. For EAF, the ETR countries have higher specific electricity consumption than non-ETR countries, 5.63 compared to 3.80 for non-ETR countries. While the authors might caution against placing weight on the estimates, given the assumptions they had to make, this is nevertheless consistent with yet-to-become ETR countries having more scope for improvement in EAF, which is where the investment would be predicted to take place.

Options to improve energy efficiency

It is to be noted that energy reduction that would result from changing production from blast furnaces to electric arc furnaces was not taken into account in the study by de Beer et al., As a consequence of this their estimates of potential savings are conservative. The authors caution that applications are highly case specific and that potential penetration rates are based on assumptions. The study lists ten options, as follows.

1. Injection of pulverised coal and plastics waste in blast furnaces.

Injection of fuel, particularly pulverised coal but also oil, is already common in many countries in order to replace part of the coke and save energy at the coke making stage. Coal injection of 30% can result in energy savings of 0.5 GJ per tonne of crude steel. Plastic waste is used in Bremen, collected from the waste packaging recycling system, called DSD, in Germany.[6]

2. Heat recovery from the sinter cooler[7].

The recovered heat can be used to preheat raw material, combustion air or to produce steam. The amount of sinter used varies and it determines the savings potential. As there is unlikely to be space to install a heat recovery system in some sites, the potential of this option is currently considered to be negligible.

3. Recovery of energy in process gas from blast furnace and BOF.

Various options are available to recover energy in process gases. The amount of energy that can be recovered would be 0.9 to 1.4 GJ per tonne of liquid steel.

4. Application of continuous casting.

Penetration of continuous casting was in the high 90 per cent range by 1998, with only Sweden, 88%, and the UK, 94%, and so there is assumed to be little further possible exploitation.

[6] It is noted that a conflict with the Waste Incineration Directive was encountered in the case study of the Basic Chemicals sector.

[7] Sintering melts powder material.

5. Other options for efficient recovery of low-temperature heat.
These include coke dry quenching, heat recovery from hot stove waste gas, from blast furnace slag, or using recuperative burners to furnaces that have no heat recovery. Savings are estimated 0.5 to 1 GJ per tonne of crude steel at a cost of €93 per GJ saved. Implementation, as so often, is very site specific and maximum application of 50% is assumed.

6. Scrap pre-heating in electric arc furnaces.
Saving of about 80 kWh per tonne of liquid steel can be achieved (IISI 1998). Space limitations can preclude this option for existing furnaces so that 10% application is assumed. Investment costs (€50 per GJ saved) less cost savings (€19 per GJ) give a net cost of €31 per GJ saved.

7. Oxygen and fuel injection in the electric arc furnace.
Overall a saving of 80 kWh per tonne of liquid steel is assumed if maximum penetration of 80% is applied. Investment costs are €70 per GJ saved and operation and maintenance costs are reduced by €5 per GJ saved, giving net cost of €65 per GJ saved.

8. Improved process control in mini mills.
Artificial intelligence techniques can be applied. Capital costs are estimated at €9 per GJ saved.

9. Thin slab casting.
Thinner slabs means that less energy is then required to reheat the slabs before casting. Savings are estimated at 1.5 GJ of fuel per tonne of steel and 0.15 GJ of electricity per tonne of steel. Investment costs (€48 per GJ saved) less reductions in operations and maintenance costs (€0.5 per GJ) gives a net cost of €47.5 per GJ saved.

10. Miscellaneous measures
A large number of other miscellaneous measures can be taken. Measures costing less than €25 per GJ saved are assembled in a 'low-cost' group of measures, and those above €25 per GJ saved in a 'high-cost' group of measures. The low-cost measures would save 1 GJ of fuel per tonne of steel and 0.1 GJ of electricity per tonne of steel at an average cost of €15 per GJ saved. In the high-cost group, 1 GJ of fuel and 0.05 GJ of electricity is saved per tonne of steel.

Finally de Beer et al. discuss new capacity for integrated mills and electric arc furnaces. The baseline scenario did not expect new capacity for integrated mills, except in the case of Finland. The best practice SEC that can be applied in the event of new capacity is put at 18 GJ per tonne of crude steel. Owing to growth the baseline scenario saw steel production by electric arc furnace partially replacing steel made in integrated mills, though ferrous scrap availability was uncertain. Best practice SEC is put at 0.94 GJ of fuel per tonne of crude steel and 1.1 GJ of electricity per GJ of crude steel.

Overall CO_2 Reduction Potential 1990 to 2010

Combining and summarising the above results of the potential savings in CO_2 in the production of iron and steel in EU15, the authors distinguish four abatement cost brackets. These are options where the cost is (1) less than €0 per tonne of CO_2 reduced, (2) between €0 and €20, (3) between €20 and €50, and (4) over €50 per tonne of CO_2 reduced. Table 4.3 assembles these potential reductions.

Table 4.3 – Reductions in CO_2 emissions and specific abatement costs in the iron and steel industry in the EU 15 during 1990 to 2010.

Abatement measure	**Reductions in CO_2 Mt per year**	**Cost € per t CO_2 reduced**
Application of continuous casting in integrated iron and steel plant	1	-230
Improved process control in minimills	2	-76
Pulverised coal injection up to 30% in the blast furnace (primary steel) in integrated iron and steel plant	1	-30
1. Subtotal of measures in cost range <€0 per t CO_2	**4**	
Integrated mills – new capacity, in integrated iron and steel plant	2	0
Scrap pre-heating in electric arc furnaces (secondary steel) in minimills	0.3	0
Oxygen and fuel injection in electric arc furnaces (secondary steel) in minimills	1	0
Minimills – new capacity	15	0
Miscellaneous low cost measures, in iron and steel	12	2
2. Subtotal of measures in cost range €0 to €20 per t CO_2	**30.3**	
Thin slab casting techniques, in iron and steel	1	33
Recovery of process gas from coke ovens blast furnaces and basic oxygen furnaces (primary steel), in integrated iron and steel plant	1	36
Miscellaneous high cost measures, in iron and steel	11	47
3. Subtotal of measures in cost range €20 to €50 per t CO_2	**13**	
Efficient production of low-temperature heat(heat recovery from high-temperature processes), in integrated iron and steel plant	2	135
4. Subtotal of measures in cost range > €50 per t CO_2	**2**	
All cost ranges of measures in iron and steel sector	**49.3**	

Source: de Beer et al., 2001. Note : A 15-year lifetime was assumed for all the investments.

The potential savings in all cost ranges is 49.3 Mt CO_2 per year in the Iron and Steel sector. In the currently more acceptable cost range of under €20 per t CO_2, the reduction potential is put at 34.3 Mt CO_2 saved annually. This would be a reasonable cost range in so far as those enterprises that are subject to emissions trading or carbon taxes in ETR could expect the cost per tonne of CO_2 to lie in the €0 to €20 range. According to the table, the most expensive measure in the range in fact costs but €2 per tonne of CO_2 saved.

In relation to the frozen technology reference level set at 266 Mt of CO_2 emissions in 2010, shown in Table 4.1, these reduction potentials represent 18.5% or 12.9% of emissions, respectively. We are reminded that these estimates of potential savings, though excluding transactions costs, are likely to be conservative because they do not include savings from such things as change in product mix.

(B) Recent performance

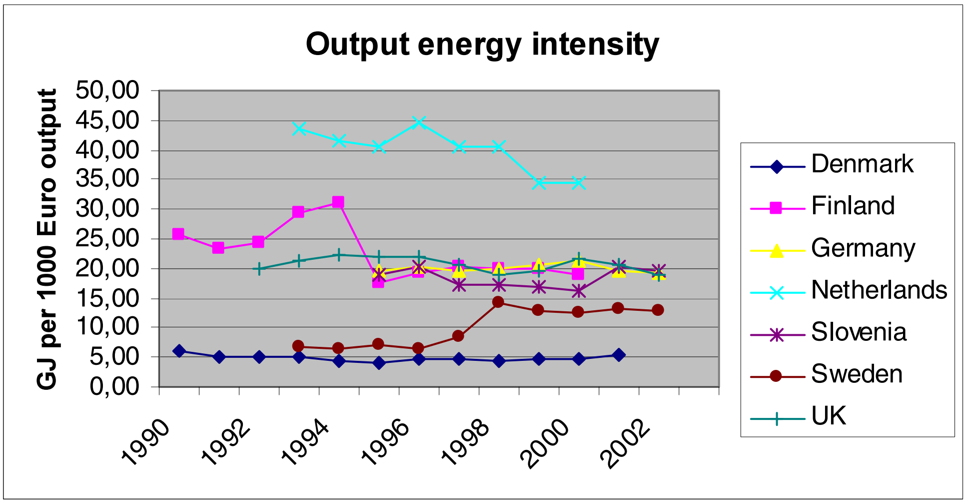
It is useful to investigate in a direct way whether there has been an attempt on the part of the ETR countries to implement energy efficiency measures during the period from 1990 to the present. Work Package 3 of COMETR has yielded some information that may throw light on this question. It is useful to start by reminding ourselves of the key dates of the introduction of ETR in the relevant EU countries, which are as follows:

Sweden 1991
Denmark 1995

Netherlands	1996
Finland	1997
Germany	1999
UK	1999

The energy intensity of the iron and steel industry in ETR countries in the nineties is shown here in Figure 4.1. The intensity is expressed in GJ per €1000 of output of the industry (expressed in constant 2000 prices). As such, the figure effectively charts each country's Specific Energy Consumption.

Figure 4.1 – Energy intensity of the iron and steel industry, GJ per €1000 (constant price) output.



Source: COMETR Work Package 3.

High energy intensity for the Netherlands, in Figure 1, is consistent with that country's high share of steel that was made in Basic Oxygen Furnaces in 1996 (de Beer et al., not reproduced here). The Netherlands and Finland show a marked improvement in energy intensity over the period. For the Netherlands the improvement came after their ETR, and for Finland it came before. Where the other ETR countries are concerned, a situation of no improvement is seen to prevail in the UK (a major European player), Slovenia and Denmark. Denmark was a very small player that only made steel in electric arc furnaces which explains its favourable position in energy intensity terms. Germany, the major European player, saw minor improvement after the introduction of ETR in 1999. Sweden introduced ETR in 1991 and has the second lowest energy intensity of the ETR countries, but has seen a significant increase in its energy intensity centring on a sharp rise in 1998. Specialty steels, in the form of alloy and high-carbon steels, form a large share of Sweden's output and stainless steel production has high prominence. A change of output mix may have been at the root of the rise.

Energy taxation and energy taxes as a percentage of gross value added are shown in Table 4 for 2000.

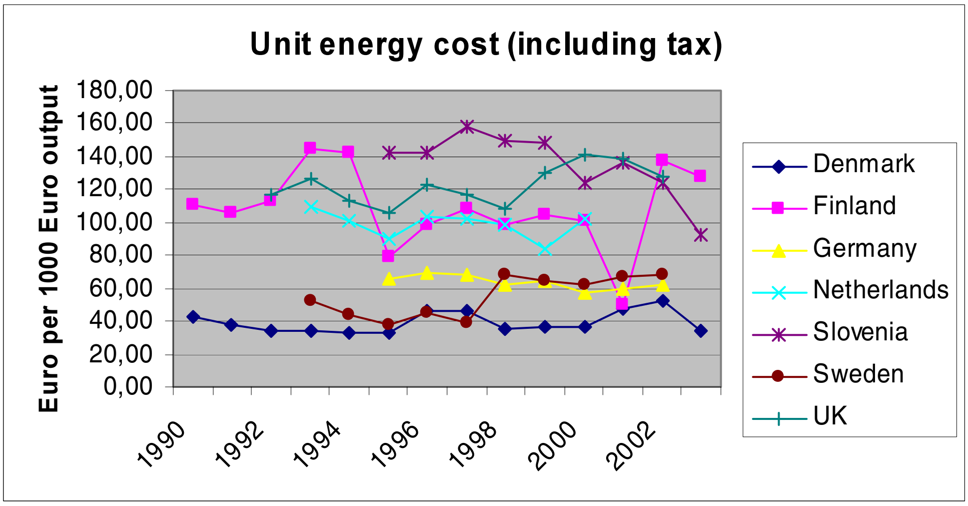
Table 4.4 – Energy taxation in the basic metal industry (2000 figures)

	Energy tax € million*	Energy tax % of GVA
Denmark	2.56	0.98
Finland	101.50	11.56
Germany	142.42	1.63
Netherlands	48.95	4.32
Slovenia	3.09	3.50
Sweden	88.27	4.80
UK	22.48	0.73

** Expressed in constant 2000 prices. Source: Databank of COMETR WP3.*

The remarkably high tax as a percentage of gross value added in Finland is consistent with its declining energy intensity in Figure 4.1. The path of unit energy costs is given in Figure 4.2. A striking point in Figure 4.2 is how the early adopters of ETR, Sweden, Denmark and the Netherlands, are the countries with relatively low unit energy costs to start with. This could suggest a complication, perhaps. It was possibly those countries where a rise in energy costs would have least impact that embarked on ETR first. This highlights the difficulty of identifying the direction of causality and the importance of empirical econometric investigation, as incorporated in Work Package 4.

Figure 4.2 – Unit energy costs including tax per €1000 output of the Basic Metals industry, at constant 2000 prices



Source: COMETR Work Package 3.

The countries with noticeable declines in energy unit costs are Germany and the UK, which both introduced ETR in 1999 but the declines were already underway by then. There is of course the issue of derogations from tax and negotiated agreements that came into play. Sectors engaging in negotiated agreements might find their unit energy costs and taxes declining quite fast after ETR.

Energy price change and fuel shifts

Having looked at energy tax rates expressed as a share of Gross Value Added, it is worth looking at price changes of individual fuels per se. Changes between 1995 and 2000 in prices that were charged to the Basic Metals industry are shown in Table 5.

Table 4.5 – Change in energy price (tax inclusive) between 1995 and 2003 charged to the Basic Metals sector, %

	Fuel oil	Gas oil /diesel oil	Natural gas	Electricity
Denmark	138,0	158,2	-45,8	36,9
Finland	30,8	43,8	39,3	17,4
Germany_02	59,2	58,1	26,7	-33,7
Netherlands_02	-	-	22,3	-17,1
Sweden	64,0	91,7	26,4	-6,4
UK	36,0	23,0	1,8	-29,1

Source: COMETR Work Package 3.

These price changes can be seen in the context of consumption changes over the same period, shown in Table 6, with a view to seeing what flexibility in fuel mix there might be and the responses by the sector in each country to the price changes. As seen in Table 6, Denmark, where prices of gas oil rose sharply, saw steep declines in consumption of these fuels by the sector. Sweden substituted mainly in to more natural gas, the price of which had risen only modestly. In Finland the industry moved to use more electricity, but also more fuel oil despite its price rise.

The price of fuel oil rose steeply in Denmark where its consumption declined quite strongly. The price of electricity fell and consumption rose in two countries, namely Germany and the Netherlands. The pattern in the UK has less consistency though a switch to natural gas from fuel oil is a logical response given the price fall.

Table 4.6 – Change in energy consumption by the Basic Metals sector between 1995 and 2003, %.

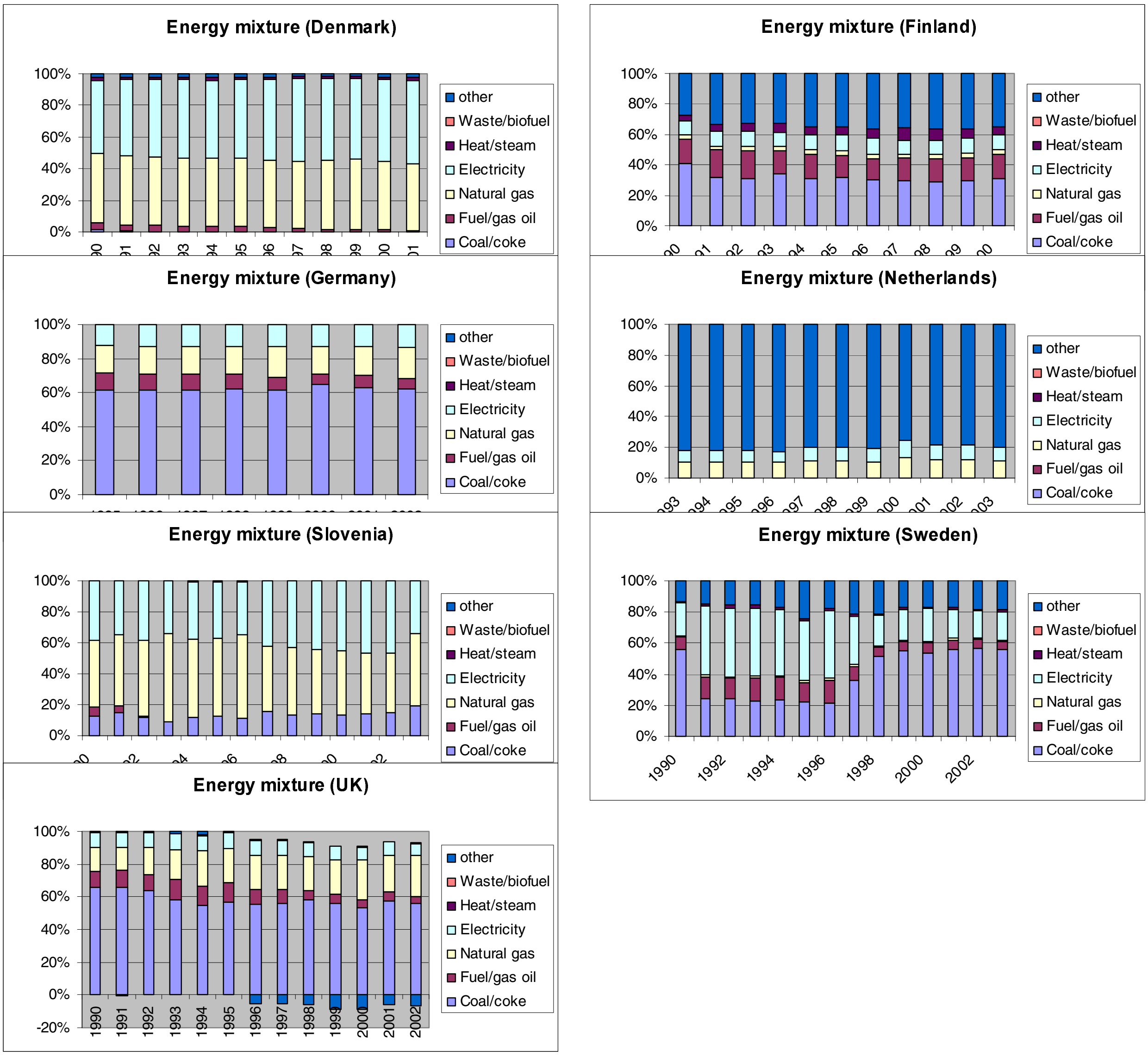
	Total	Fuel oil	Gas oil /diesel oil	Natural gas	Electricity
Denmark	-48,8	-78,4	-59,7	-19,6	-79,8
Finland	64,1	73,5	-41,9	24,0	35,9
Germany	-2,4	-42,0	-28,9	12,5	5,5
Netherlands	5,6	-	-	9,8	31,9
Sweden	107,0	5,2	-54,6	21,9	-2,8
UK	-28,8	-65,8	-98,6	-2,7	-34,0

Source: COMETR Work Package 3.

From the evidence presented there are movements that can be rationalised to an extent. The patterns are less clearly explicable compared to those of the Basic Chemicals sector (see Basic Chemical case study). This may reflect the fact that flexibility is lower in the iron and steel industry that lead times are longer and the historical nature of existing facilities reduces responsiveness.

Further detail is available for inspection in Figure 3. This shows the annual breakdown of energy consumption by fuel from 1990 to the most recent year for which data are to hand. It is seen that the Basic Metals sector in Denmark has become marginally more electricity intensive and uses less fuel oil/gas oil. In Finland the share of coal/coke has fallen while that of the category Other fuels has risen. Germanys' shares (data only available for 1995 and after) and the shares in the Netherlands and Slovenia have shown very little change. The UK saw a move away from coal/coke towards more natural gas.

Figure 4.3 – The composition of energy consumption in ETR countries, %



Finally, the central question on technology relates to the findings on energy saving potential described at the end of part A above. If, as seen, the potential reduction in specific energy consumption in Basic Metals between 1990 and 2010 is some 12.9 per cent, can the movement in energy intensity (or SEC) shown in Figure 4.1 indicate to what extent these potentials have been exploited? The reduction of 12.9 per cent was said to be achievable by the EU(15) without resorting to such actions as change of product mix.

The following figures in Table 4.7 are the changes in energy intensity since the introduction of ETR, in column 1. Column 2 shows the changes in energy intensity since 1990 up to the present, or since the earliest year for which figures are available.

Table 4.7 – Changes in energy intensity in the Basic Metals sector, %.

	Change in energy intensity, %	
	Since ETR (year)	Since 1990 (or earliest year of data)
Sweden	+89 (1993)*	+89 (1993)
Denmark	+30 (1995)	-10
Netherlands	-22 (1996)	-21 (1993)
Finland	-7 (1997)	-27
Germany	-8 (1999)	-2 (1995)
UK	-4 (1999)	-5 (1992)

*Source: Databank of COMETR WP3. * Sweden's ETR occurred in 1991 but the earliest figure relates to 1993.*

The table indicates that country specific influences are paramount. That said, there is a pattern of intensity decline in the basic metals sector for all ETR countries except in the case of Sweden, and in Denmark in more recent times. It appears that the Netherlands, a medium-sized producer among the ETR countries, has made considerable progress on energy efficiency. Contrast that with Sweden, another medium-sized producer among ETR countries, which has nearly doubled its energy intensity but from a very low base in any event. Germany the largest player in the sector, has seen moderate improvement and, next in size, the UK also. Finland is a small player, with evident improvement. Denmark has a very small presence in the sector.

Being the dominant producer, Germany's improvement is the key to the sector's performance. Its 8 per cent improvement in energy intensity since ETR falls short of the average potential improvement of 12. 9 per cent indicated by de Beer et al.. Though the average is unlikely to apply to specific countries it at least indicates that movement in the right direction is possible and has occurred. On the issue of carbon leakage therefore one would be lead to suspect that, while some leakage is probable in the context of the sector's restructuring, there may still exist technological possibilities that can cushion the sector in the face of ETR and enable parts of it to remain in Europe.

Strategy

The sector's strategy can be gleaned from statements of its executives. Components of the strategy are listed as follows:

Structure: Exploiting synergies and potential linkages; forming partnerships in low-cost, high growth countries.

Market: Securing cheaper raw materials such as iron ore; reduce exposure to price fluctuations by closer relations with customers; more bespoke production; closer attention to customer needs – e.g. reduced weight of steel for car production, higher safety.

Efficiency: Through such product alterations as longer rail length.

Climate change policy: With respect to Kyoto the industry (Eurofer) considers that major improvements in integrated steelmaking (blast furnaces) cannot be expected. A significant part of CO_2 emissions are process related, and not combustion emissions. Energy prices in Europe are higher than in the vast majority of competing countries. In the absence of world wide carbon pricing, the industry says that it will relocate out of countries that put a price on carbon. Only 39 % of world steel production is involved in the Kyoto protocol. Production in the EU25 is 19% of world production. The absence of transport and heating from the EU ETS is seen as a major distortion as does the treatment of production growth under the NAPs. Caps on process related emissions effectively limits production of steel. On cutting capacity, operators should be allowed to keep the allowances and transfer them across Europe when relocating.

New technologies need to be developed looking at Ultra Low CO 2 strategy (ULCOS). The industry has set up the ULCOS study group, which submitted a proposal for research funding to the European Commission, which accepted it.

Otherwise the industry has to invest in dwindling scope for energy efficiency technologies, buy allowances, reduce production, relocate.

Section 5 – An interview with a European steel producer

Introduction

Company A is a multinational enterprise, providing steel and aluminium products and services to customers worldwide. The company is comprised of four Divisions, Strip Products, Long Products, Distribution & Building Systems and Aluminium, and has a global network of sales offices and service centres.

Under "strategic direction", Company A state that they continue to focus on carbon steels, with a growing focus on value-added, differentiated products. They aim to build a sustainable business in Europe, while looking to secure access to steelmaking in lower cost, higher growth regions.

1. The impact of ETR and of the EU ETS.

Company A is active in certain countries that are subject to ETR, and it states that ETR does have some effect on its behaviour. In the early days of ETR most of the effort centred on setting up the necessary administrative elements. ETR wasn't revenue neutral, and there was a mechanism of revenue recycling, though the overall effect wasn't particularly strong either, as the cut in social security contributions was small and decreased over time. Company A negotiated a special agreement which resulted in a rebate. In their agreement, which started in 2002, they were able to choose between an absolute reduction or a relative reduction and they opted for the former. This puts an absolute cap on their emissions per 12-month period. There is a link to the ETS and it is quite complex. Overall, company A stated that to some extent the introduction of ETR had helped to "focus minds" further on the issue of energy efficiency. However there is not a lot that one can do to make the process more efficient. They have nearly hit the barrier. There are a few extra per cent, though mostly not worth the cost. They are in the process of re-using the combustible parts of the gas and improving procedures for recording operations. Their Agreement seems to be the main issue where efficiency is concerned. The Agreement lasts until 2010 with a Review in 2008, the first measurement being in 2002, and their performance is measured every two years. Their emissions are lower than they were in 2002 though production is rising. In a relation:

$$\text{Energy} = mX + c$$

where c is a fixed amount, and X is output, the value of m is decreasing by about 0.3 per cent per year.

Company A is in the national ETS and the EU ETS as well as being subject to ETR. This combination sometimes makes things a bit complicated: if they over-achieve on the EU scheme and have permits to sell, their national target gets tightened, as the idea is that they should not benefit from both schemes. In other words the combination of a national and EU Emissions Trading scheme seems to result in a non-linear incentives structure, or at the very least, Company A is under the impression that this is the case. This issue should perhaps be looked at in more detail by policy-makers.

The other general effect of environmental regulation (as we also found in other industry studies in this project) is that it is felt as a not insignificant burden in administrative terms. We asked rhetorically whether more time must be spent "checking the rules rather than checking out possibilities for saving energy". This was not disputed.

2. The scope for shifts in energy mix

The possibilities of company A in this respect are very limited.

3. The scope for investments in improved (i.e. more energy efficiency) technologies in view of ETS and of currently high fuel prices.

Only around 5% of Company A's steel production is from Electric Arc Furnace production (globally 30% of production is by EAF), which can only use certain types of scrap that has to be carefully selected. The integrated blast furnaces on the other hand can take up to 25% scrap.

In 1950, producing 1 tonne of iron resulted in 1 tonne of carbon emitted. Now, according to Company A, emissions are down to 0.44 tonnes of carbon per tonne of produced iron, while the "theoretical minimum" with current technologies was stated to be 0.414 tonnes of carbon per tonne of produced iron. In other words Company A is saying that it is very close to the carbon efficiency frontier. However Company A is making significant R&D investments and believes that it should be possible to achieve a 50% reduction in CO_2 emissions by 2050. They add that if carbon capture and storage became a reality one could in theory reduce CO_2 emissions down to zero.

One important change in the past was the switch from the ingot production route to continuous casting. But continuous casting has already been achieved in 90% of production so there is not much more scope. Integrating with the rolling mill is something that is subject to experimentation in the Netherlands. Physically, coke is needed so there is not much substitution possible there.

Possible actions at the margin include hydrogen injection, oil injection and plastics injection.

4. Evolution of the industry (demand, integration, specialisation etc.)

Concerning the industry's structure, global demand is about 1.2 billion tonnes of steel. Arcelor-Mittal, the new large joint company (Europe-India), produces some 100 million tonnes. The next 5 or 6 companies only add another 10 % of production. So the industry consists of many companies and competition is strong.

Looking at the raw materials side, one notes that there are only 3 companies mining iron ore and coal (BHP, Rio Tinto and CVRD). Looking on the side of final demand, the automotive sector is a major component. Furthermore, concentration in that sector is high, with the top five automotive companies accounting for 80% of demand for steel from the sector. Positioned as it is in between these two powerful markets, it is understandable that the iron and steel industry should be seeking to consolidate in order gain market power in both directions. In particular, the consolidation now underway is driven mostly by the desire to secure raw materials.

There had been excess capacity in the mid to late nineties until 2002. Recently there is a rapid build-up of capacity, with an extra 250 million tonne capacity in China. So there is now an iron ore shortage.

Arcelor-Mittal has self-sufficiency in iron ore and coal, while Brazil and India are abundant in raw materials. TaTa Steel in India and CSN in Brazil are looking at Company A. In the short-term this would mean access to raw material. In the long-term, structuring options include continuing to make iron in the EU, or relocating operations to cheaper areas and just keep the semi-finishing in Europe.

So the iron-making and the steel-making could go abroad but the rolling operation could remain in Europe. (It requires re-heating anyway and there would be no extra loss of heat.)

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Case studies with a view to assessing likely carbon leakage due to ETR

Non-ferrous metals - NACE 27.4

COMETR Work Package 5.3 - Carbon leakage

Authors: E. Christie (wiiw) and S. Scott (ESRI)

Introduction
Non-ferrous metals is a constituent of the Basic Metals sector which, as shown in Work Package 2, operates in a very competitive market. This case study of the non-ferrous metals sector is in several sections. A basic global overview of the non-ferrous metals industry is given in sections 1 to 5 in terms of production volumes and locations of the main constituent commodities. Each commodity is discussed in turn with a brief introduction on technologies, showing the main locations for primary production, European production patterns, trade flows and the leading companies. Section 6 focuses on the aluminium industry, a major constituent of the non-ferrous metals industry. Section 7 homes in on those aspects that could influence the sector's choice of location under a regime of Environmental Tax Reform including technological potential and what might encourage relocation and consequent carbon leakage. Conclusions follow in Section 8.

Introduction to the non-ferrous metals sector
We start with basic definitions. The industry is made of five parts:

DJ.27.41 - Precious metals production (gold, silver, platinum)
DJ.27.42 - Aluminium production
DJ.27.43 - Lead, zinc and tin production
DJ.27.44 - Copper production
DJ.27.45 - Other non-ferrous metal production (essentially nickel)

For the purposes of sections 1 to 5 the European Union (EU) is taken as being the union of the 25 member states unless stated otherwise, so the ten countries that joined in May 2004 are included, even if the data presented refer to periods prior to that date.

1. Precious metals production (gold, silver, platinum) DJ.27.41
Generally speaking precious metals are metals that are not very prevalent in the Earth's crust, that have a high value-mass ratio, that are highly stable chemically (e.g. against corrosion, oxidation) and that are used in part for purposes of value storage (especially gold) as well as for coinage (especially silver and gold) and jewellery (all three). Furthermore in more recent years all three metals have been used in industry in view of their excellent technical properties. Silver has the highest electrical conductivity and the highest thermal conductivity of all metals and is used for example in printed electronic circuits. Gold also has high conductivity and is highly durable, and is thus also used in the electronics industry, in particular in computer manufacturing. Platinum, thanks to its stable properties at high temperatures, is used in the chemicals industry as a catalyst for oxidation reactions, notably for the industrial production of nitric acid. One major use of platinum is in the production of catalytic converters for vehicles (notably automobiles) in order to reduce the emission of particulate pollutants. Another notable use is in the production of hard disks for computers.

Platinum production
In the extraction and production industry platinum is generally not referred to on a stand-alone basis. Instead it is part of a group called "platinum group metals" (PGMs) which includes platinum, palladium, iridium, rhodium, ruthenium and osmium. They are grouped together because they occur together in nature alongside nickel and copper in the ores that are mined. The production process for platinum and palladium (the other four metals are much less interesting) is quite complex and involves many steps to separate out all the unwanted elements.

By far the most significant economically recoverable PGM reserves are located in just five countries: South Africa, Russia, Zimbabwe, Canada and the United States with South Africa the clear leader with over 70%, followed by Russia. Zimbabwe has the potential of becoming a major producer in the future if a number of investments are carried out. This general picture is shown in table 1.1. The reserve figures are based on late 2002 estimates of what was then extractable. The reserve base estimates are based on what would be extractable by 2010 assuming certain new mining industry investments were made.

Table 1.1 – PMG Reserves and Reserve Bases, tonnes, 2002 estimates

Country	Reserve	Reserve Base	Reserve Base (%)
Canada	400	910	2%
Russia	NA	6,100	13%
South Africa	12,000	34,000	71%
United States	780	900	2%
Zimbabwe	530	5,300	11%
Rest of the world	NA	380	1%
World Total	13,710	47,590	100%

Source: Wilburn and Bleiwas (2004)

As was mentioned earlier there is some platinum production in other countries, including EU countries, but this is on a relatively small scale and is in any case quite high up in the production chain. USGS data for instance does not report any data for EU countries except for Finland and Poland. Still, the total only accounts for 0.2% of world production based on 2004 data, so basically it's not worth considering. As for palladium the overall picture is quite similar to that of platinum, except that there the 2004 production levels of Russia and South Africa are almost equal rather than having South Africa as a clear leader. Still, both countries accounted together for 81% of world production of palladium, while the EU accounted for less than 0.1%.

Gold
The production of gold is much less concentrated than that of platinum. It is a naturally more abundant metal and there are exploitable deposits in scores of countries. There is rather more gold production in the European Union than there is platinum production (mainly in Finland), but even here the total is less than 1% of total world production.

Table 1.2 – Largest Gold Producers, countries, tonnes

Country	2000	2001	2002	2003	2004	2004 (%)
South Africa	431	395	395	376	342	14.0%
Australia	296	285	273	282	259	10.7%
United States	353	335	298	277	258	10.6%
China	180	185	192	205	215	8.8%
Peru	133	138	157	172	173	7.1%
Russia	143	153	168	170	169	7.0%
Canada	156	159	152	141	129	5.3%
Uzbekistan	85	87	90	90	93	3.8%
Indonesia	125	166	142	141	93	3.8%
Papua New Guinea	75	67	65	64	73	3.0%
Ghana	72	68	69	70	60	2.5%
Tanzania	15	30	43	48	50	2.1%
World Total	2,567	2,564	2,549	2,549	2,431	100.0%

Source: USGS

Table 1.2 shows the world's 12 largest producers of gold, ranked according to 2004 data. These 12 countries accounted for 78.7% of total world production in 2004.

Silver

Silver is more prevalent and is much cheaper than gold or platinum. It is produced in a large number of countries, however its production (in terms of countries) is more concentrated than that of gold. Table 1.3 shows just the top 10 producers who, in 2004, together accounted for just under 92% of world production.

Table 1.3 – Largest silver producers, countries, tonnes

Country	2000	2001	2002	2003	2004	2004 (%)
Peru	2,438	2,571	2,870	2,921	3,060	15.5%
Mexico	2,620	2,760	2,747	2,569	2,700	13.7%
China	1,600	1,910	2,200	2,400	2,450	12.4%
Australia	2,060	2,100	2,077	1,872	2,237	11.4%
European Union	1,656	1,692	1,658	1,705	1,705	8.7%
Chile	1,242	1,349	1,210	1,313	1,360	6.9%
Canada	1,212	1,320	1,408	1,310	1,336	6.8%
Russia	370	380	400	700	1,277	6.5%
United States	1,980	1,740	1,350	1,240	1,250	6.3%
Kazakhstan	927	982	893	827	733	3.7%
World Total	18,100	18,900	18,500	18,400	19,700	100.0%

Source: USGS

The European Union is the world's fifth largest producer. Production volumes of silver have been quite stable on the global level in the last years, and so has the EU's share. American production levels have fallen substantially over the period, while Russian levels have experienced a strong rise. There has also been substantial growth in China, but not as much as with other commodities.

When looking at intra-EU data (table 1.4) one notices that silver is produced essentially in the lower-wage countries, with the exception of Sweden and Finland. The bulk of the EU's production takes place in Poland. Production in Spain seems to be on the verge of disappearing, and it is perhaps surprising that none of the large EU countries (except Poland) produce significant quantities of the metal.

Table 1.4 – Silver production in the European Union, by country, tonnes

Country	2000	2000 (%)	2004	2004 (%)
Poland	1,148	69.3%	1,250	73.3%
Sweden	329	19.8%	293	17.2%
Greece	37	2.2%	79	4.6%
Finland	25	1.5%	33	1.9%
Portugal	21	1.3%	24	1.4%
Ireland	25	1.5%	20	1.2%
Italy	4	0.2%	3	0.2%
Spain	66	4.0%	2	0.1%
France	1	0.0%	1	0.0%
European Union Total	1,656	100.0%	1,705	100.0%

Source: USGS

Largest companies

Judging by the data from table 1.5 it seems that silver production is perhaps not as globalised as, for example, the aluminium industry, although the largest company is one we have met before, BHP Billiton, which is a leading producer of alumina and of aluminium as well. At the European level we find KGHM Polska Miedz which has the monopoly of silver production in Poland. KGHM Polska Miedz is also one of the world's leading producers of copper, as the ores it mines contain both metals. The company is vertically integrated, conducting mining and excavating as well as smelting and casting of metals.

Table 1.5 – Largest silver producers, companies, tonnes, 2005

Ranking	Name	Country	Output
1	BHP Billiton	Australia / UK	1673
2	Industrias Peñoles	Mexico	1474
3	KGHM Polska Miedz	Poland	1244
4	Kazakhmys	Kazakhstan	638
5	Polymetal	Russia	588
6	Grupo Mexico	Mexico	575
7	Cia. de Minas Buenaventura	Peru	476
8	Rio Tinto	UK	463

Source: The Silver Institute

The case of Rio Tinto is more typical. It is a large, highly diversified multinational corporation, essentially focused on mining and primary production of metals and other basic minerals, with headquarters in London but with significant production facilities in many parts of the world, most notably Australia, North America and South America.

Prices of precious metals

Prices of gold, platinum and silver have all been on the rise in the last couple of years, with the gold price going from around 450 USD/oz in October 2005 to a peak of over 700 USD/oz in early May 2006. In September 2006 the price had dipped back down to slightly less than 600 USD/oz. Thus the price of gold is quite volatile and the amplitude of intra-year swings are large. The price of platinum also peaked at around the same date in May 2006, having started in September 2005 with a price slightly above 900 USD/oz, peaking above 1300 USD/oz, and back down to around 1200 USD/oz in September 2006. As for silver, over the same period, the price went from around 7 USD/oz in September 2005, peaked at just under 15 USD/oz, and was back down to around 11 USD/oz in September 2006.

2. Aluminium production DJ.27.42

Aluminium ore, most commonly bauxite, 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 not a single chemical compound. It is a type of rock which contains varying concentrations of several compounds that contain aluminium as well as other minerals. The three key minerals that contain aluminium are Gibbsite, Boehmite and Diaspore.

Bauxite is mined and then refined into aluminium oxide trihydrate (Al_2O_3) (alumina[1]), 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[2]. Aluminium smelting is also by far the production step that generates the most greenhouse gas emissions per tonne of output in the production chain[3] 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.

First stage: alumina production

The first main stage in the production chain is thus the mining of bauxite. It is then either processed into alumina on the spot and then exported, or exported right away, so that the world distribution of alumina production is rather more diversified than that of bauxite production. Table 2.1 shows the world’s largest producers of bauxite. The top 15 countries accounted for 99% of world production in 2004.

Australia is by far the largest producer, followed by Brazil, Guinea, China, Jamaica and India. The EU as a whole is a small producer of bauxite with only two member states being recorded by USGS data, according to which Greece accounts for around 80% of the EU’s bauxite production while Hungary accounts for all the rest. In non-EU Europe there is some additional bauxite production, though not very large amounts, in Serbia and Montenegro and in Bosnia and Herzegovina.

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[1] The production of alumina is a part of industry 27.42, the NACE/CPA code is 27.42.12.
[2] Source: http://www.world-aluminium.org
[3] The production chain here being the full cycle from bauxite mining to ingot casting. More information can be found in IAI (2003).

Table 2.1 - Largest producers of bauxite (ths tonnes)

Country	2000	2001	2002	2003	2004
Australia	53,802	53,799	54,135	55,602	56,593
Brazil	13,866	13,388	13,148	18,457	18,500
Guinea	15,700	15,100	15,700	16,000	16,000
China	9,000	9,800	12,000	13,000	15,000
Jamaica	11,127	12,370	13,120	13,444	13,296
India	7,562	7,864	9,647	10,414	11,285
Russia	4,200	4,000	4,500	5,500	6,000
Venezuela	4,361	4,585	5,191	5,446	5,500
Kazakhstan	3,730	3,685	4,377	4,737	4,706
Suriname	3,610	4,394	4,002	4,215	4,052
EU-25 (2 countries)	3,037	3,052	3,212	3,084	3,091
Guyana	2,471	1,950	1,690	1,716	1,500
Indonesia	1,151	1,237	1,283	1,263	1,331
Serbia and Mont.	630	610	612	590	600
Iran	400	405	420	500	500
Ghana	504	678	684	495	498
Turkey	459	242	287	364	366
Bosnia and Herz.	75	75	113	115	115
World TOTAL	135,816	137,308	144,169	154,960	158,946

Source: USGS and own calculations

As for alumina production the world leader is again by far Australia, as can be seen from table 2.2. Here however the rest of the ranking is quite different due to the fact that production of alumina from domestically sourced bauxite as well as from imported bauxite are both widespread. The cumulative share of world production of alumina for the 15 largest producers adds up to just under 98% for 2004.

Table 2.2 - Largest producers of alumina (ths tonnes)

Country	2000	2001	2002	2003	2004
Australia	15,680	16,313	16,382	16,529	16,700
China	4,330	4,650	5,450	6,110	7,000
United States	4,790	4,340	4,340	4,860	5,350
Brazil	3,743	3,445	3,962	5,111	5,100
EU-25 (9 countries)[4]	5,406	4,573	4,756	4,892	4,810
Jamaica	3,600	3,542	3,631	3,844	4,023
Russia	2,850	3,046	3,131	3,230	3,269
India	2,280	2,400	2,800	2,500	2,600
Suriname	1,800	1,900	1,900	2,000	2,000
Venezuela	1,755	1,833	1,901	1,840	1,900
Ukraine	1,360	1,343	1,351	1,434	1,563
Kazakhstan	1,217	1,231	1,386	1,419	1,468
Canada	1,023	1,036	1,125	1,109	1,170
World TOTAL	51,615	51,468	54,111	57,090	59,353

Source: USGS and own calculations

Certain countries import significant amounts of bauxite directly to transform it into alumina themselves, notably the United States and the European Union. This can be seen if one bears in mind that one needs *around 2 tonnes of bauxite to produce 1 tonne of alumina*[5]. Based on

4. The breakdown of European production is given below
[5] Source: www.world-aluminium.org

this approximation one sees that the European Union would have had to import around 6.5 million tonnes of bauxite in 2004 (around 70% of its total consumption of bauxite for its production of alumina) while the USA would have had to import around 10.5 million tonnes in 2004 (100% of its total consumption[6] of bauxite). The world's two largest economies are thus both highly dependent on imports to meet their demand. China on the other hand has so far managed to extract enough bauxite for its alumina production and is very close to the 2-1 ratio. At the other end of the spectrum we find notably Australia, Guinea, Brazil, India and Jamaica, all of which have large quantities of bauxite not used domestically for alumina production that are available for exporting. This is summarised in table 2.3, which shows the result of this simple estimate based on the 2-1 ratio. A negative sign means the country may potentially export the indicated amount of bauxite without prejudice to its domestic alumina production. It is of course only a rough guide, but it gives a snapshot of the main exporters and the main importers, plus a few selected key countries such as China and Russia which are both close to a balanced position.

Table 2.3 – Apparent bauxite need, selected countries (ths tonnes, 2004)

Country	**Apparent bauxite need**
Australia	-23,193
Guinea	-14,520
Brazil	-8,300
India	-6,085
Jamaica	-5,250
China	-1,000
Russia	538
Romania	700
Canada	2,340
Ukraine	3,126
EU-25	6,529
United States	10,700

Source: Own calculations

At the European level the main producers of Alumina are Ireland, Spain, Germany and Greece, as can be seen from table 2.4.

[6] USGS does not report any data for bauxite production for the United States but USGS data implies that there is virtually none produced, notably as imports of bauxite for 2004 were indeed around 10 million tonnes.

Table 2.4 – Alumina production in Europe[7], by country (ths tonnes)

Country	2000	2001	2002	2003	2004
Ireland	1,200	1,100	1,100	1,100	1,100
Spain	1,200	1,100	1,100	1,100	1,100
Germany	652	600	720	830	800
Greece	667	679	750	750	750
Italy	950	500	500	500	500
Romania	417	319	361	333	350
Hungary	357	300	294	300	300
Serbia and Montenegro	186	201	237	225	250
Slovakia	110	110	112	132	130
France	200	150	150	150	100
Bosnia and Herzegovina	50	50	50	50	50
Slovenia	70	34	30	30	30

Source : USGS and own calculations

Aluminium production

Turning now to the production of aluminium itself, shown in tables 2.5 and 2.6, we find a completely different country distribution, one 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.

[7] Excludes CIS countries.

Table 2.5 - 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 2.6 - 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 2.7, we find that Norway is the largest producer, thanks to the abundance of hydro-electricity, followed by the major EU economies. The table shows all countries for which data is available at USGS.

Table 2.7 - Aluminium production in Europe[8], 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

[8] Excludes CIS and Turkey.

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 Herz.	95	96	103	111	115
Serbia and Mont.	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

As with bauxite and alumina there is also a relatively simple rule-of-thumb between alumina and (primary) aluminium, and it is likewise a 2-1 ratio, i.e. roughly 2 tonnes of alumina are required to produce 1 tonne of primary aluminium. We can therefore conduct the same basic assessment as in table 2.3 and compute the apparent alumina need for each country. This is shown in table 2.8. The most spectacular case is China which has by far the highest apparent need for alumina in the world. The reason for this is very simple: China's alumina production, although itself growing at massive rates, simply can't keep up with demand, which is itself driven by a massive expansion of aluminium production, which is itself driven by very strong domestic demand for a whole range of goods that require aluminium as a material input. Canada is a big player in aluminium, though having no bauxite and involved in alumina is a small way.

Table 2.8 – Apparent Alumina need, selected countries (ths tonnes, 2004)

Country	Alumina	Aluminium	Apparent Alumina Need
Australia	16,700	1,900	-12900
Jamaica	4,023	0	-4023
Brazil	5,100	1,457	-2185
Suriname	2,000	0	-2000
Japan	340	6	-327
United States	5,350	2,516	-318
EU-25	4,810	3,021	1231
South Africa	0	863	1726
Norway	0	1,322	2643
Russia	3,269	3,593	3917
Canada	1,170	2,592	4014
China	7,000	6,670	6340

Source: USGS and own calculations

Finally, looking at trade flows concerning the European Union we find, as shown in table 2.9, that the EU imports "aluminium ore" (SITC 28731)[9] mainly from Guinea and Australia. As for alumina (table 2.10) the Lion's share comes from Jamaica.

[9] There is unfortunately not an exact one-to-one correspondence between the minerals defined by the USGS and the commodity classifications used in international trade databases.

Table 2.9 – Main sources of imports of aluminium ore into the EU (2005)

Origin	Value (mill USD)
Guinea	221
Australia	130
China	74
TOTAL	509

Source: UN COMTRADE

Table 2.10 – Main sources of imports of alumina into the EU (2005)

Origin	Value (mill USD)
Jamaica	279.7
Suriname	60.5
United States	59.9
World Total	438.3

Source: UN COMTRADE

Largest companies

Aluminium production in the world is quite concentrated in terms of the companies that are involved in it. The industry is also quite strongly vertically integrated in terms of ownership, with many of the major aluminium producers owning very significant production assets in alumina production. Table 2.11 shows the top 6 producers.

Table 2.11 – Largest aluminium companies – ths tonnes, 2005

Company	Production	Country
ALCOA	3550	USA
ALCAN	3400	Canada
RUSAL	2714	Russia
Norsk Hydro	1800	Norway
BHP Billiton	1300	Australia / UK
SUAL	1000	Russia

Source: Company web-sites, media reports

Recent news reports (August 2006) indicate that consolidation is on the way. In particular, the two major Russian producing companies RUSAL and SUAL have announced plans for a merger which would make the resulting company the largest producer in the world, just ahead of US giant ALCOA. The merger also involves the Swiss trading company Glencore which owns large assets in alumina and bauxite mining across the world. This is to give the new Russian company security of supply over its inputs.

Recent aluminium prices

In the last years the spot price of aluminium has been going up, as can be seen from Figure 2.1 which shows that the price of aluminium was fluctuating in a reasonably stable manner between around 1100 and 1800 USD / tonne between 1998 and 2004, with the average price steadily rising over 2004-2005. From early 2006 the price has been fluctuating around (roughly) 2500 USD / tonne, with a strong peak up to almost 3300 USD/tonne and a subsequent strong correction in May 2006.

Figure 2.1 – Price of aluminium USD/tonne, Sept. 2000 – Sept. 2006

Source: London Metal Exchange (LME) – quoted cash buyer price

3. Lead, zinc and tin production DJ.27.43

Lead is a soft, heavy and toxic metal which has been used in a number of goods in the past, but which has been phased out of the composition of a number of products due to its toxicity, e.g. as an additive to petrol. On the other hand lead is extensively used in the manufacturing of lead-acid batteries, e.g. car batteries. Other current uses of lead include radiation shielding equipment (e.g. for use with x-ray machines), ammunition, solder material for electronic circuit-boards and roofing (in sheet form).

Lead ores typically contain other metals, notably copper, zinc or silver. Mechanical processes are used to extract a concentrate (for example using froth flotation). The concentrate is then treated at high temperatures, combining smelting and sintering, in order to steadily rid the concentrate of other elements.

Zinc is a highly prevalent metal in the Earth's crust. Its main uses are in combination with other metals, either in alloys or to galvanise or parkerise steel. Zinc is also used in coinage, in the manufacturing of batteries and in household construction in the shape of wall-tiles and kitchen fittings. In compound forms zinc also has applications in the chemicals industry and in the pharmaceuticals industry. Contrary to lead zinc is a necessary component of the human diet.

Ores containing zinc, most often sphalerite which is made up mostly of zinc sulphide (ZnS) but also some iron, are mined and then processed mechanically, e.g. using froth flotation. The concentrate is then usually treated using high temperatures, notably by roasting to cause oxidisation. An alternative to roasting is flash smelting. The result, zinc oxide, is then progressively leached using sulphuric acid. The final stage is electrolysis, as with aluminium.

Tin is a malleable and ductile metal and one of its main uses is in the production of solder. Other applications include coating or plating of lead, zinc or steel to prevent corrosion and use in alloys with other metals, notably copper (e.g. bronze).

Ores containing tin are mined and then processed at high temperatures in a furnace, most typically a reverberatory furnace. With some metals the process is less complex.
Due to the use of high temperatures the production of all three metals in their primary form are energy-intensive processes.

Production of lead

Production of primary lead is conducted as described above. Furthermore it is important to mention production of secondary lead (from recycling, for example of used car batteries) as it accounts for an important part of lead production in many countries, 100% in certain cases. At the global level secondary lead production accounts for about half of total lead production. Primary lead production by country is shown in table 3.1. China is by far the largest producer, experiencing robust growth (+50%) between 2000 and 2004. The second largest producer is the European Union, although production levels have fallen substantially (-44%) over the period. Production also fell significantly in the United States and in Japan, but somewhat less in Canada, while remaining roughly stable in South Korea, Mexico and Peru. Taken together this looks like indirect evidence of a relocation pattern in favour of low wage countries, while global supply has slightly dipped over the period.

Table 3.1 – Largest producers of primary lead, tonnes

Country	2000	2001	2002	2003	2004	2000 (%)	2004 (%)
China	998,000	984,000	1,100,000	1,290,000	1,500,000	27.8	44.1
European Union	715,942	687,065	625,084	454,617	403,000	19.9	11.9
Australia	223,366	270,000	181,000	310,000	233,000	6.2	6.9
South Korea	170,704	161,000	178,722	167,575	168,994	4.8	5.0
Kazakhstan **	185,800	158,700	161,800	133,200	157,000	5.2	4.6
United States	341,000	290,000	262,000	245,000	148,000	9.5	4.4
Mexico	143,223	143,523	128,241	137,482	137,000	4.0	4.0
Canada	159,192	127,007	133,815	118,506	131,015	4.4	3.9
Peru	116,412	121,181	119,588	112,289	118,570	3.2	3.5
Japan	129,469	127,358	107,744	105,462	91,200	3.6	2.7
WORLD	3,593,671	3,493,790	3,401,221	3,474,203	3,399,979	100.0	100.0

Source: USGS and own calculations

** data includes secondary lead production

Looking at the European data in table 3.2 it is striking to see that production has decreased in every single European country for which USGS reports data, and has even been phased out completely in three countries over this short five-year period of 2000-2004. Most impressive is the apparent complete shut-down of production in France, which in 2000 still accounted for 100,000 tonnes. The second largest fall in levels is Germany, roughly 75,000 tonnes less in 2004 than in 2000. It is interesting to note that low-wage European countries have not fared better than the average, as can be seen from the data from Southeast European countries.

Table 3.2 – Primary lead production in Europe[10], tonnes

Country	2000	2001	2002	2003	2004
EU countries					
Belgium	98,000	76,000	68,000	45,000	43,000
France	100,000	96,000	76,000	14,000	0
Germany	210,515	153,743	141,084	133,417	134,000
Italy	75,000	82,000	75,000	48,000	45,000
Poland	35,412	45,000	30,000	28,000	30,000
Sweden	30,604	31,322	30,000	24,200	28,000
United Kingdom	166,411	203,000	205,000	162,000	123,000
European Union Total	**715,942**	**687,065**	**625,084**	**454,617**	**403,000**
Non-EU countries					
Bulgaria	74,100	75,000	57,000	60,000	54,000
Macedonia	19,000	19,000	19,000	6,000	0
Romania	25,000	24,000	26,000	23,100	25,000
Serbia and Mont.	1,242	0	170	0	0
Europe Total	**835,284**	**805,065**	**727,254**	**543,717**	**482,000**

Source: USGS and own calculations

The picture is very different if one looks at secondary lead. Here it's the United States, followed quite closely by the European Union, that are the world's largest producers. China is a distant third, although growth has been very impressive with a trebling of production in just five years. For the USA and the EU however volumes have been quite stable, though declining slightly over the period. Generally speaking the country distribution of secondary lead production is much more concentrated than that of primary lead, and high-income countries are much more active in this thanks in part to more thorough recycling policies.

Table 3.3 – Largest producers of secondary lead, tonnes

Country	2000	2001	2002	2003	2004	2000 (%)	2004 (%)
United States	1,130,000	1,100,000	1,120,000	1,140,000	1,110,000	36.9%	33.3%
European Union	992,295	922,696	960,200	917,229	959,000	32.4%	28.7%
China	102,000	211,000	230,000	290,000	300,000	3.3%	9.0%
Japan	182,209	175,088	178,016	189,831	185,500	6.0%	5.6%
Canada	125,641	103,921	117,449	104,527	110,382	4.1%	3.3%
Mexico	110,000	110,000	110,000	110,000	110,000	3.6%	3.3%
South Africa	46,000	55,000	61,000	64,900	61,500	1.5%	1.8%
South Korea	10,000	10,000	63,900	60,000	60,000	0.3%	1.8%
WORLD	3,059,230	3,076,965	3,236,165	3,331,788	3,336,483	100.0%	100.0%

Source: USGS and own calculations

To sum up we can take a look at the overall picture given by adding up primary and secondary lead production, as shown in table 3.4. China is the world's largest producer by some margin, followed by the EU and the USA. Other countries follow a long way behind. In spite of the inclusion of secondary production the overall pattern is clear: production falling quite substantially in the EU, the USA and Japan but surging massively ahead in China.

[10] Excludes CIS and Turkey.

Table 3.4 – Largest producers of lead, total, tonnes

Country	2000	2001	2002	2003	2004	2000 (%)	2004 (%)
China	1,100,000	1,195,000	1,330,000	1,580,000	1,800,000	16.5%	26.7%
European Union	1,708,237	1,609,761	1,585,284	1,371,846	1,362,000	25.7%	20.2%
United States	1,471,000	1,390,000	1,382,000	1,385,000	1,258,000	22.1%	18.7%
Japan	311,678	302,446	285,760	295,293	276,700	4.7%	4.1%
Australia	251,796	303,000	211,000	350,000	273,000	3.8%	4.1%
Mexico	253,223	253,523	238,241	247,482	247,000	3.8%	3.7%
Canada	284,833	230,928	251,264	223,033	241,397	4.3%	3.6%
South Korea	180,704	171,000	242,622	227,575	228,994	2.7%	3.4%
WORLD	6,652,901	6,570,755	6,637,386	6,805,991	6,736,462	100.0%	100.0%

Source: USGS and own calculations

Production of zinc

Zinc production data must be treated slightly differently from lead data. This is because, on the one hand, secondary production is much less common at the global level than with lead, but also because many countries report undifferentiated totals. We will therefore consider only the totals, noting that at the global level, according to USGS data for 2004, zinc reported as primary accounted for 46% of total production but zinc reported as secondary for only 3%, with the remaining 51% undifferentiated. Furthermore for those countries where the differentiation is available it is the case with low- and middle-income countries that secondary zinc constitutes a much lower share of the total (less than 8%) than primary zinc. The share is higher in India (9% in 2004) as well as in Japan (20% in 2004) and in the United States (38% in 2004). For most European countries the breakdown isn't available, though the Netherlands, Norway and Finland report only primary production, while a few other countries report only secondary production, but of very small amounts. Further research would be needed to assess the importance of recycling of zinc at the European level.

Coming now to the production data by country (table 3.5), we find once again China in the first place, with the European Union not too far behind. In fact China and the EU have essentially swapped places in the ranking and in terms of their share of the world total between 2000 and 2004. Growth in Chinese production was around +26% over the period, while EU production fell by 1%. The EU and China are trailed by several medium-sized producers, in particular Canada, South Korea and Japan. The United States is among the top 10, but is not a major producer. Global zinc production increased over the 2000-2004 period by around 1 million tonne (+11%). Half of that growth was due to China alone. Besides China substantial growth took place in South Korea (+42%), Mexico (+36%), Brazil (+34%), India (+31%) and Kazakhstan (+21%). One additional case to mention is that of Namibia which started producing zinc in 2002, reaching a level of 119,200 tonnes in 2004.

Table 3.5 – Largest producers of zinc, total, tonnes

Country	2000	2001	2002	2003	2004	2000 (%)	2004 (%)
China	1,980,000	2,040,000	2,100,000	2,320,000	2,500,000	21.9%	24.9%
European Union	2,179,231	2,281,929	2,352,560	2,174,076	2,157,750	24.1%	21.5%
Canada	779,892	661,172	793,475	761,199	805,077	8.6%	8.0%
South Korea	473,897	508,000	600,027	647,500	671,000	5.3%	6.7%
Japan	698,751	684,054	673,906	686,115	667,247	7.7%	6.6%
Australia	494,500	558,500	571,500	557,500	477,500	5.5%	4.8%
Mexico	235,073	303,810	302,122	320,364	320,000	2.6%	3.2%
Kazakhstan	262,200	277,100	286,300	279,000	316,500	2.9%	3.2%
United States	371,000	311,000	294,000	303,000	305,000	4.1%	3.0%
Brazil	198,777	200,061	256,434	258,000	266,000	2.2%	2.6%
India	201,000	232,000	255,400	277,900	262,400	2.2%	2.6%
Russia	230,000	237,000	244,000	253,000	240,000	2.5%	2.4%
World Total	9,024,919	9,273,575	9,689,458	9,863,228	10,041,466	100.0%	100.0%

Source: USGS and own calculations

As was mentioned, Europe, the EU in particular, remains a major producer of zinc at the global level and overall production levels have remained roughly stable. However production was completely shut down in two countries, the UK and Macedonia, and seems to have almost ceased in Serbia and Montenegro. In the case of the UK all the production was from one smelting plant (so producing primary zinc), Britannia Zinc, which shut down[11] in February 2003. The plant also produced lead, helping to explain the dip in production visible in table 3.2. On the other hand production grew significantly in Spain (+36%). The bulk of Spanish production is from the San Juan de Nieva smelter which benefited from significant investment in recent years, and is in fact "the largest single zinc smelter in the world" according to the web-site of its owners, Xstrata Plc.

[11] http://news.bbc.co.uk/2/hi/uk_news/england/2775051.stm

Table 3.6 –Zinc production in Europe, total, tonnes

Country	2000	2001	2002	2003	2004
EU countries					
Belgium	251,700	259,300	260,000	244,000	263,000
Czech Republic	150	250	200	250	250
Finland	222,881	247,179	235,300	265,900	235,000
France	350,000	347,000	350,000	253,000	260,000
Germany	327,500	358,300	378,560	388,112	364,000
Italy	170,300	177,800	176,000	123,000	130,000
Netherlands	216,800	204,800	203,000	223,000	225,000
Poland	173,000	174,700	158,900	153,300	153,000
Portugal	3,600	3,600	3,600	3,500	1,500
Slovakia	1,000	1,000	1,000	1,000	1,000
Spain	386,300	418,000	488,000	519,000	525,000
United Kingdom	76,000	90,000	98,000	14	0
European Union	**2,179,231**	**2,281,929**	**2,352,560**	**2,174,076**	**2,157,750**
Non-EU countries					
Bulgaria	84,200	88,600	83,000	86,800	87,000
Macedonia	69,800	52,000	56,000	28,000	0
Norway	125,800	145,000	145,000	142,000	140,000
Romania	51,900	47,200	51,600	52,000	50,000
Serbia and Mont.	8,291	13,467	1,478	62	100
Europe Total	**2,519,222**	**2,628,196**	**2,689,638**	**2,482,938**	**2,434,850**

Source : USGS and own calculations

Production of tin

Tin production patterns are very different from both those of lead and zinc. Tin production is geographically very concentrated, with just three countries accounting for 83% of global production in 2004. Almost all global production is of primary tin (around 96% in 2004), although recycling is possible. The main producer of secondary tin is the United States (around 50% of world production[12] in 2004), thanks to a number of recycling programmes, e.g. "steel cans", which are made from tinplate.

Table 3.7 – Largest producers of tin, mined, tonnes

Country	2000	2001	2002	2003	2004	2000 (%)	2004 (%)
China	99,400	95,000	62,000	102,000	110,000	35.8%	42.0%
Indonesia	51,629	61,862	88,142	71,694	65,772	18.6%	25.1%
Peru	70,901	69,696	38,815	40,202	41,613	25.5%	15.9%
Bolivia	12,464	12,352	15,242	16,755	16,800	4.5%	6.4%
Brazil	14,200	13,016	12,063	12,217	12,200	5.1%	4.7%
World Total	278,000	249,000	238,000	263,000	262,000	100.0%	100.0%

Source: USGS and own calculations

As can be seen from table 3.7 China has strengthened its lead and produced 42% of the world's tin in 2004, after a growth of 10.7% over 2000-2004. Absolute growth was largest in Indonesia. Global production of tin went down however, especially due to falls in Peru and Australia. As for the European situation production levels are very low, just 0.2% of global production in 2004. Over 99% of this production takes place in Portugal, the rest being

[12] Source: USGS

anecdotal amounts from Spain. The Portuguese sites are the Neves-Corvo mine, which is also a copper mine, and the Aljustrel mine, both owned by EuroZinc.

4. Copper production DJ.27.44

Copper is a malleable and ductile metal which is a good heat conductor and an excellent electricity conductor. It is used extensively in the manufacturing of electrical and electronic equipments. Other uses include household products, coinage and glass manufacturing.

Copper ores, most often chalcopyrite (copper iron sulphide), are mined. They are then crushed, ground and concentrated. There are then two alternative processes, either leaching (e.g. with sulphuric acid) followed by electrowinning; or smelting (in stages) followed by electrolytic refining. The desired final product is called "copper cathode", which is 99.99% copper, which can be delivered and traded. Copper cathode can then be cast into wire rod, billets, cakes or ingots for further use[13]. Of course a country which produces more copper than its copper mines permit can import ores and carry out the whole process, or import the concentrate, or import blister (an intermediate stage where the concentration is 98%), or simple copper cathode, or the worked produce such as ingots.

When looking at the statistics one usually distinguishes between mined copper and refined copper. Mined copper (in tonnes) is an estimate of the copper content of the output of the mining complexes. Refined copper is the purer form, copper cathode, regardless of whether it was produced by leaching and electrowinning or by smelting and electrolytic refining. In addition refined copper production data also includes secondary production (recycling), though in certain cases such data is also available separately.

Due to reporting practices and data constraints the USGS data includes electrowon copper in both the mined copper data sets and in the refined copper data sets.

Table 4.1 – Largest producers of copper, mined, tonnes

Country	2000	2001	2002	2003	2004	2000 (%)	2004 (%)
Chile	4,602,400	4,739,000	4,581,000	4,904,200	5,412,500	34.7%	37.2%
United States	1,440,000	1,340,000	1,140,000	1,120,000	1,160,000	10.9%	8.0%
Peru	553,924	722,035	843,213	831,223	1,035,574	4.2%	7.1%
Australia	829,000	871,000	883,000	830,000	854,100	6.3%	5.9%
Indonesia	1,012,054	1,081,040	1,171,726	1,005,831	840,318	7.6%	5.8%
European Union	650,928	659,760	669,995	673,552	729,240	4.9%	5.0%
Russia	570,000	600,000	695,000	675,000	675,000	4.3%	4.6%
China	613,000	605,000	593,000	620,000	620,000	4.6%	4.3%
World Total	13,254,560	13,737,346	13,662,673	13,707,893	14,567,062	100.0%	100.0%

Source: USGS and own calculations
Note: data includes electrowon copper

Looking at the data for mined copper (table 4.1) we notice that Chile is by far the world's largest producer. Much further behind we find a quite smooth distribution with many "medium-sized" producers, notably the United States (2nd largest) and the European Union (6th largest). Global production of mined copper has grown over 2000-2004 (+10%). This growth was carried forward mainly by Chile and Peru, counteracting falls notably in US, Indonesian and Canadian production. Production also rose in the EU (+12%) and in Russia (+18%).

[13] Source: www.copper.org

Table 4.2 – Mined copper production in Europe[14], tonnes

Country	2000	2001	2002	2003	2004	2000 (%)	2004 (%)
EU countries							
Poland	454,100	474,000	502,800	495,000	531,000	69.8%	72.8%
Portugal	76,200	82,900	77,000	78,000	96,000	11.7%	13.2%
Sweden	77,765	74,269	72,100	83,100	85,500	11.9%	11.7%
Romania	16,079	19,185	18,962	21,317	20,000	2.5%	2.7%
Finland	14,354	13,715	14,400	14,900	15,500	2.2%	2.1%
Cyprus	5,197	5,176	3,695	2,552	1,240	0.8%	0.2%
Spain	23,312	9,700	0	0	0	3.6%	0.0%
European Union	**650,928**	**659,760**	**669,995**	**673,552**	**729,240**	**100.0%**	**100.0%**
Non-EU countries							
Bulgaria	92,000	88,000	92,800	91,700	93,000	14.1%	12.8%
Serbia and Mont.	86,100	31,000	36,900	26,400	30,000	13.2%	4.1%
Macedonia	6,000	9,000	5,600	4,000	5,000	0.9%	0.7%
Europe Total	**835,028**	**787,760**	**805,295**	**795,652**	**857,240**	**128.3%**	**117.6%**

Source: USGS and own calculations
Notes: data includes electrowon copper; percentages base: EU=100%

At the European level almost three quarters of total production is from Poland. Other noteworthy producers are Portugal, Sweden and Bulgaria. On the other hand production was shut down in Spain, and in Serbia and Montenegro, which used to be an important producer, has seen an abrupt fall in output in 2001, after which production levels didn't recover.

Table 4.3 – Largest producers of copper, refined, tonnes

Country	2000	2001	2002	2003	2004	2000 (%)	2004 (%)
Chile	2,668,300	2,882,200	2,850,100	2,901,900	2,895,100	17.9%	18.3%
European Union	2,340,800	2,379,913	2,417,715	2,308,752	2,316,140	15.7%	14.7%
China	1,370,800	1,518,000	1,650,000	1,860,000	2,130,000	9.2%	13.5%
Japan	1,441,611	1,425,691	1,401,079	1,430,365	1,380,144	9.7%	8.7%
United States	1,800,000	1,800,000	1,510,000	1,310,000	1,310,000	12.1%	8.3%
Russia	840,000	894,500	870,000	840,000	919,000	5.6%	5.8%
Canada	551,393	567,720	538,695	456,905	527,000	3.7%	3.3%
Peru	451,728	471,875	502,742	517,046	505,308	3.0%	3.2%
World Total	14,877,737	15,635,437	15,383,459	15,229,568	15,794,873	100.0%	100.0%

Source: USGS and own calculations
Note: data includes electrowon copper

Refined copper production is of course more evenly distributed across the globe than mined copper production. Chile is still the largest producer in the world, but by a much smaller margin. The EU on the other hand is a major producer, ahead of China, Japan and the United States. However growth was very strong in China over the period (+55%), while production fell slightly in the EU (-1%), rather more in Japan (-4%) and strongly in the USA (-27%). All in all China was responsible for over 80% of world supply growth over the period.

[14] Excludes CIS and Turkey.

Table 4.4 – Refined copper production in Europe[15], tonnes

Country	2000	2001	2002	2003	2004	2000 (%)	2004 (%)
EU countries							
Germany	709,400	693,800	695,800	597,500	652,700	30.3%	28.2%
Poland	517,800	528,737	527,820	530,000	530,000	22.1%	22.9%
Belgium	423,100	423,000	423,000	423,000	397,000	18.1%	17.1%
Sweden	130,000	204,000	224,000	214,000	235,000	5.6%	10.1%
Spain	316,000	290,700	309,000	294,000	228,200	13.5%	9.9%
Finland	114,000	120,000	127,000	136,000	144,000	4.9%	6.2%
Austria	79,000	69,000	65,000	75,000	88,000	3.4%	3.8%
Italy	32,800	35,500	32,400	26,700	30,000	1.4%	1.3%
Hungary	12,000	10,000	10,000	10,000	10,000	0.5%	0.4%
Cyprus	5,197	5,176	3,695	2,552	1,240	0.2%	0.1%
European Union	**2,340,800**	**2,379,913**	**2,417,715**	**2,308,752**	**2,316,140**	**100.0%**	**100.0%**
Non-EU countries							
Bulgaria	32,500	34,400	41,000	45,000	55,300	1.4%	2.4%
Norway	27,000	26,700	30,500	35,900	35,600	1.2%	1.5%
Serbia and Mont.	59,602	42,365	45,897	14,000	35,000	2.5%	1.5%
Romania	17,803	22,500	13,453	18,739	26,383	0.8%	1.1%
Europe Total	**2,477,705**	**2,505,878**	**2,548,565**	**2,422,391**	**2,468,423**	**105.8%**	**106.6%**

Source: USGS and own calculations
Notes: data includes electrowon copper; percentages base: EU=100%

The European picture for refined copper (table 4.4) shows Germany as the largest producer, followed by Poland, Belgium and Sweden. Production in the non-EU states constitutes a much lower share of the continent's total than it does with respect to mined copper, indicating that facilities in, e.g., Southeast Europe are small vertically-integrated mining and metal production facilities, whereas Germany imports the necessary inputs for transformation. Production fell substantially in Spain, Germany, Belgium and Serbia and Montenegro over the period. On the other hand there was strong growth especially in Sweden, as well as in Finland, Bulgaria and Poland.

5. Other non-ferrous metal production (essentially nickel) DJ.27.45

Although there are other non-ferrous metals that are part of this industry's commodities we will discuss only the case of nickel which is the most important.

Nickel is a hard but malleable and ductile silvery white metal. One of its main advantages is that it is resistant to corrosion. Nickel is used primarily in alloys with other metals, notably certain types of stainless steel, as well as into so-called super-alloys and for cupronickel. Super-alloys are used extensively in the aerospace industry in the manufacturing of jet engines. Other uses of nickel or its alloys include coinage, plating, rechargeable batteries and the chemicals industry (as a catalyst).

There are two main types of nickel ores: laterites and magmatic sulphide deposits. These are concentrated with appropriate methods. Traditionally the concentrates are then dried (roasted) and reduced, yielding a higher concentration intermediate (~75%), which must then be processed.

In the case of lateritic ores one may use either an electric furnace which will yield either nickel proper or ferronickel, or leaching (e.g. with sulphuric acid). With sulphidic ores the modern technologies are either electric smelting or flash smelting. The older technology was

[15] Excludes CIS and Turkey.

to use either a blast furnace or a reverberatory furnace. This older approach is less favourable from the point of view of energy efficiency and emissions.

The final step is refining, in order to obtain high purity nickel. This is done most commonly by electrowinning. Alternatives are chemical reduction (for lower purity end products) and the carbonyl process (also yielding high purity nickel).

Mined nickel production is geographically quite concentrated, with the largest production taking place in Russia, followed by Canada. Table 5.1 presents the largest producers of mined nickel in the world in terms of nickel content (the output being in some cases concentrate, in other cases ores). Russia is the leading producer and occupies a stable position at the top of the ranking. It is followed by Canada and Australia, also with stable output levels. Indonesia's output has grown quite significantly over the period, as have those of Colombia and China. Global mined nickel production has increased by just under 7.5% over the period. The European Union is a small producer[16], accounting for less than 2% of world production. The United States and Japan do not produce any mined nickel, although this could change in the case of the United States.

One should note that this production pattern could change somewhat in the future as the distribution of reserves is a bit different from current production patterns. Russia does have large reserves, but there is a sleeping giant in the shape of Cuba which, according to European Nickel Plc (2004), holds 38% of the world's reserves in nickel as against 14% for Russia and 10% for New Caledonia.

Table 5.1 – Largest producers of nickel, mined, tonnes

Country	2000	2001	2002	2003	2004	2000 (%)	2004 (%)
Russia	315,000	320,000	305,000	310,000	315,000	24.4%	22.7%
Canada	190,793	194,058	189,297	163,244	186,546	14.8%	13.5%
Australia	166,500	205,000	207,800	210,000	178,100	12.9%	12.8%
Indonesia	98,200	102,000	123,000	143,000	133,000	7.6%	9.6%
New Caledonia	126,041	117,734	99,841	112,013	118,279	9.8%	8.5%
Colombia	58,927	52,962	58,196	70,844	75,032	4.6%	5.4%
Cuba	68,064	72,585	71,342	74,018	72,421	5.3%	5.2%
China	50,300	51,500	53,700	61,000	64,000	3.9%	4.6%
World Total	1,290,953	1,344,871	1,346,843	1,390,645	1,386,712	100.0%	100.0%

Source: USGS and own calculations

We now turn to plant production data for nickel, which is further down the production chain and includes essentially refined nickel but also in some cases finished chemical solutions containing nickel, ferronickel or oxide sinter[17]. The data (table 5.2) presents total nickel content. Russia is also the largest producer of plant nickel in the world, and Canada is also a major producer. However Japan and the EU are large producers as well. On the other hand the United States does not have any production of primary nickel to speak of, although there are projects for nickel mining under consideration and there is also some secondary production. Globally primary nickel supply has risen over the 2000-2004 period by just under 13%. The largest growth took place in Colombia and in China.

[16] Data for New Caledonia is presented separately. In spite of its special status with respect to France it cannot be considered part of the European Union, contrary to France's overseas departments.
[17] The breakdown between these being available only for some cases. At the global level 55% of plant production is of nickel proper, 22% of ferronickel (an alloy of nickel and iron), 8% is oxide sinter, 1% is chemicals containing nickel, and 13% is unspecified (proportions based on USGS data for 2004).

Table 5.2 – Largest producers of plant nickel, tonnes

Country	2000	2001	2002	2003	2004	2000 (%)	2004 (%)
Russia	248,000	252,000	239,000	260,000	265,000	22.2%	21.0%
Japan	160,724	153,804	157,485	163,274	169,111	14.4%	13.4%
Canada	134,225	140,591	144,476	124,418	151,518	12.0%	12.0%
European Union	123,608	120,999	119,458	114,311	125,044	11.1%	9.9%
Australia	112,200	128,100	132,200	129,400	122,000	10.0%	9.7%
China	50,900	49,700	52,400	64,700	72,000	4.6%	5.7%
Norway	58,679	68,221	68,530	77,183	71,410	5.3%	5.7%
Colombia	27,730	38,438	43,987	47,868	49,200	2.5%	3.9%
New Caledonia	43,914	45,912	48,650	50,666	43,016	3.9%	3.4%
Cuba	39,516	40,701	38,738	42,282	40,306	3.5%	3.2%
World Total	1,117,688	1,165,148	1,184,926	1,221,206	1,260,553	100.0%	100.0%

Source: USGS and own calculations

Table 5.3 – Plant nickel production in Europe, tonnes

Country	2000	2001	2002	2003	2004	2000 (%)	2004 (%)
EU Countries							
Austria	1,700	1,600	1,500	1,500	1,500	1.4%	1.2%
Finland	53,798	54,975	52,751	56,100	53,900	43.5%	43.1%
France	12,276	13,033	11,444	11,138	12,103	9.9%	9.7%
Greece	17,126	16,870	19,229	18,000	18,115	13.9%	14.5%
Poland	732	704	744	785	820	0.6%	0.7%
United Kingdom	37,976	33,817	33,790	26,788	38,606	30.7%	30.9%
European Union	**123,608**	**120,999**	**119,458**	**114,311**	**125,044**	**100.0%**	**100.0%**
Non-EU Countries							
Macedonia	0	2,970	5,149	5,555	5,500	0.0%	4.4%
Norway	58,679	68,221	68,530	77,183	71,410	47.5%	57.1%
Europe Total	**182,287**	**192,190**	**193,137**	**197,049**	**201,954**	**147.5%**	**161.5%**

Source: USGS and own calculations
Notes: Percentages base: EU=100%

At the European level (table 5.3) we can see that the major producers are Norway and Finland, followed by the UK, Greece and France. There was not much growth in the European Union but strong growth in Norway (+21.6%) and good news for a change from Macedonia.

Largest companies

The corporate landscape of nickel production is dominated by a small number of companies and there has been a lot of action in terms of mergers and acquisitions in the last two years. The world's five largest producers are presented in table 5.4, where we find in first place Russia's MMC Norilsk Nickel, which mines the large nickel deposits of North-Western Russia, and Canadian group INCO which is not far behind in terms of production volume. In third place we find mining giant BHP Billiton which has seen strong growth in production thanks to the acquisition of Australia's WMC[18].

[18] XStrata also tried to acquire WMC but was outbid by BHP Billiton.

Table 5.4 – Leading producers of nickel, companies, thousands of tonnes

Company	Country	Production volume	Period	Source
MMC Norilsk Nickel	Russia	243.0	2005	Web-site
INCO	Canada	223.4	2005	Web-site
BHP Billiton	Australia / UK	165.1	2005Q2-2006Q1	Quarterly production reports
XStrata (Falconbridge Ltd)	Switzerland (Canada)	114.0	2005	Annual report
ERAMET	France	59.6	2005	Web-site
OM Group	USA	NA (5th largest)	NA	Web-site

Source: Corporate web-sites, annual reports, quarterly reports

In fourth place we find the Swiss group XStrata which acquired the other large Canadian producer, Falconbridge Ltd, in 2006. French group ERAMET also boasts quite high production volumes thanks to its ownership of mines in New Caledonia. Finally in fifth place one finds OM Group, a US company. Unfortunately it was not possible to find nickel production data in physical units on their web-site, but they advertise themselves as the "world's fifth largest producer of nickel".

Two additional companies should be mentioned: minerals giant Anglo American plc, which is not among the largest producers but nevertheless had an output of 27'000 tonnes of nickel in 2005, and Brazilian group Companhia Vale do Rio Doce (CVRD) which has made a number of acquisitions and is currently making a number of investments in nickel mining operations in Brazil and has announced its ambition to become a global player in nickel, notably with its attempts to acquire INCO of Canada.

Inside the European Union there are a number of production sites for nickel products that are owned by the companies mentioned above. INCO owns the Clydach Refinery in Swansea (UK) which produces battery-grade and specialty-grade nickel, nickel powder and nickel coatings, using Canadian nickel as feedstock. OM Group has two production facilities in Finland, one in Harjavalta (briquettes, electrolytic nickel, plating-grade, powder, nickel sulphate), and one in Kokkola (cobalt-based products). ERAMET has a facility in Sandouville (France) producing high purity nickel and salts of nickel and cobalt using nickel matte from its mining operations in New Caledonia. ERAMET has announced that it would like to increase production in France by sourcing additional feed from a mine it would develop in Indonesia.

6. Focus on aluminium industry and leakage

In this sixth section, the aluminium sector is considered in more detail. This makes it easier to cover those aspects that have a bearing on carbon leakage in the event of ETR. This is not an empirical analysis, such as the analysis in Work Package 4, but a qualitative account. Aspects that influence a sector's vulnerability, such as its adaptability or CO_2 reduction potential that could influence carbon leakage in the aluminium industry, will be covered and discussion of the industry proceeds in the following order:

- Production in 2005
- Determinants of demand for aluminium and outlook

6.1 Production in 2005

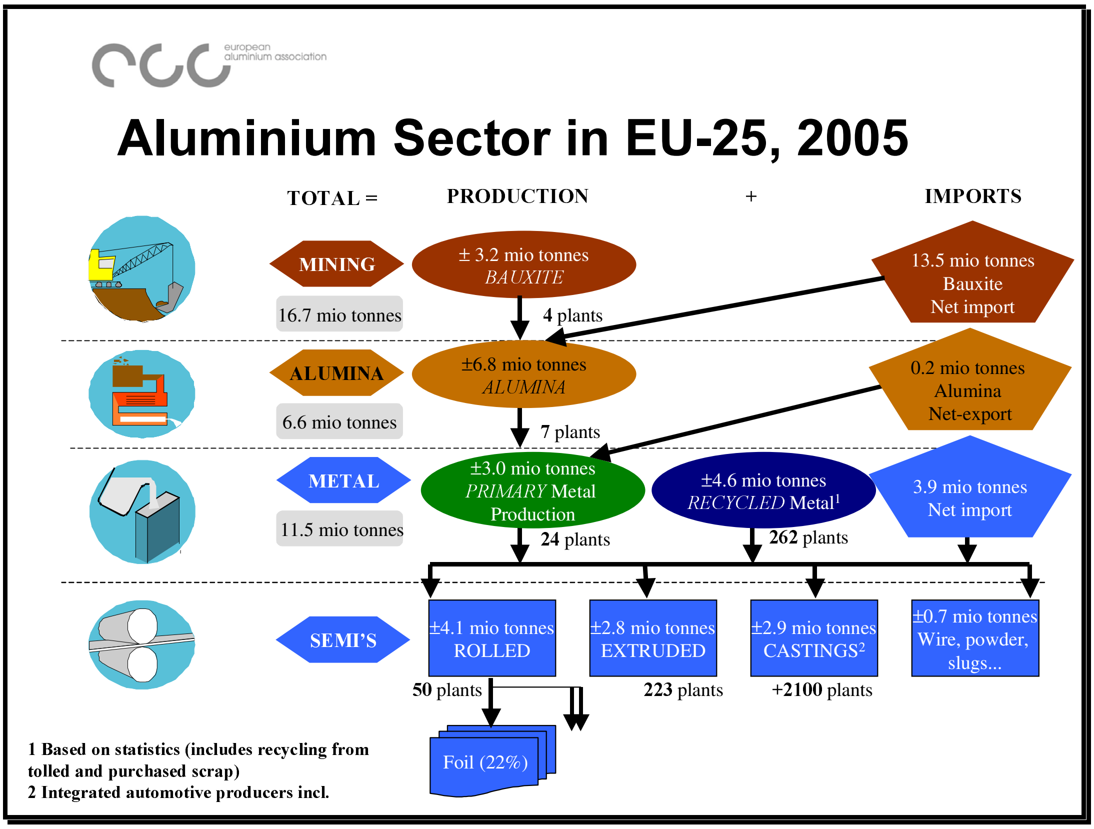
Aluminium processes and world magnitudes have already been outlined in the introduction so that only an overview of production of aluminium in 2005 is given here. Figure 6.1 summarises the sector's activities for the EU-25. The main stages of production are represented by the four rows: (1) bauxite mining, (2) alumina, (3) aluminium metal and (4) semi-fabricated product (European Aluminium Association, 2006).

The first row shows total mined bauxite used in the sector in the EU-25, 16.7 million tonnes, as the sum of EU production and imports. Bauxite is the raw material for the manufacture of 6.8 million tonnes of alumina shown in the second row. Exports of 0.2 million tonnes of alumina leaves 6.6 million tonnes used in the production of primary aluminium. In the third row, primary aluminium production amounts to 3 million tonnes as indicated. 'Primary' aluminium means aluminium that is made from scratch from bauxite using electrolysis (rather than from scrap aluminium). To this is added an even larger amount of secondary aluminium, an important addition produced by recycling scrap, to which we return later, and net imports of 3.9 million tonnes of aluminium. This gives a total supply of 11.5 million tonnes of aluminium. These two middle rows are the focus of attention here. The fourth row gives the breakdown into main aluminium semi-finished products (denoted "semi's"). In descending order of magnitude semi-finished products are: rolled (e.g. foil, sheets), extruded, castings, and other products such as wires, et cetera.

Aluminium has special characteristics. It is strong, durable, flexible, impermeable and light-weight (a third of the weight of steel), it does not rust and it is 100% recyclable, any number of times. It is a good conductor of electricity. The range of forms it can take and of surface finishes available lend themselves to a variety of products. First produced in 1888, aluminium has become the second most used metal in the world after iron.

The full process of manufacturing new stocks of aluminium is responsible for about 1% of global GHGs. The high strength-to-weight ratio of aluminium plays an important role in producing lighter goods and lighter forms of transport, which thereby reduce fuel consumption, without compromising performance and safety. Because of these characteristics demand for aluminium is wide-ranging.

Figure 6.1: Four stages of production in the aluminium sector, million tonnes (to be read row by row)



Source: European Aluminium Association, 2006

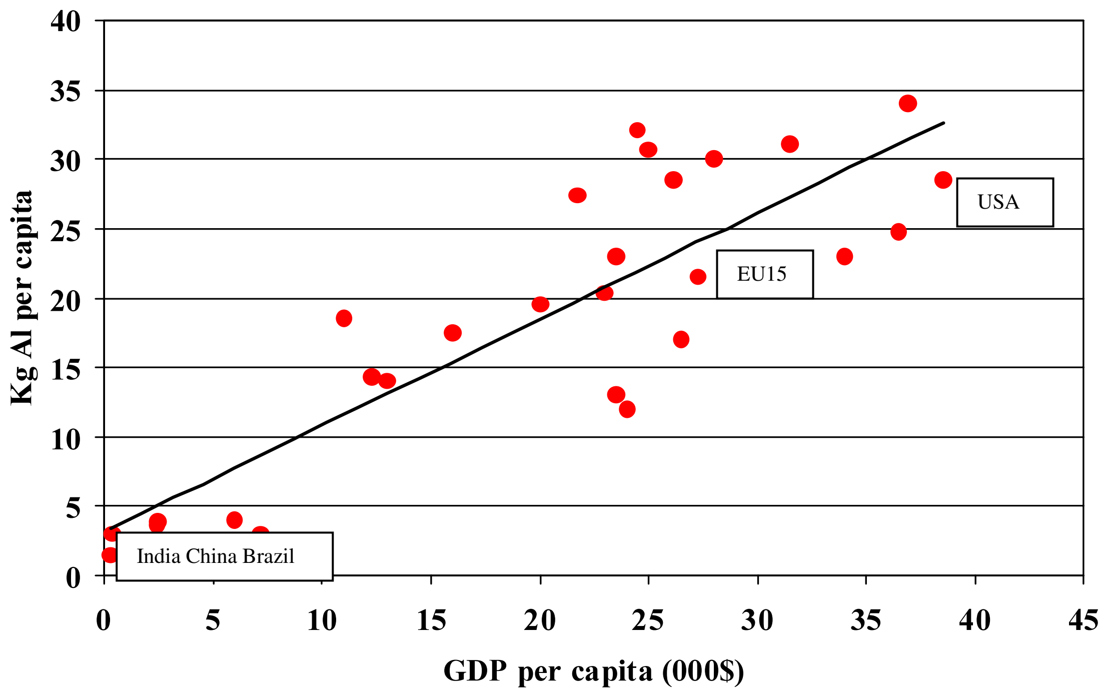
6.2 Determinants of demand for aluminium and demand outlook

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% (EAA and OEA, 2006). 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 (EAA).

Turning to the macro side, demand for aluminium is related to economic activity as seen in Figure 6.2, from the European Aluminium Association.

Figure 6.2: 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.

With many ageing plants in Europe, the field with respect to new plants is therefore open, and depends on factors that influence location choice. Table 6.1 gives a rundown of the ages of smelters and of closures that took place in the EU-15, which have occurred mainly since 1990.

Table 6.1: Size, age and closures of smelters in EU15.

Country	Location	Capacity in 2003	Start up
AUSTRIA			
Amag	Ranshofen	closed in 1992	
Salzburger aluminium	Lend	closed in 1992	
FRANCE			
Aluminium Pechiney	Auzat	closed in 2003	
	St. Jean de Maurienne	135	1979
	Lannemezan	50	1978
	Noguères	closed in 1991	
	Rioupéroux	closed in 1991	
	Venthon	closed in 1993	
Aluminium Dunkerque	Dunkerque	250	1991
GERMANY, FEDERAL REPUBLIC			
Aluminium Rheinfelden	Rheinfelden	closed in 1991	
Hydro	Norf	221	1962
	Stade	70	1973
Corus Aluminium GmbH	Voerde	89	1971
Aluminium Trimet	Essen	154	1971
Hamburger Aluminium-Werk GmbH	Hamburg	130	1975
Vaw	Lunen	closed in 1989	
	Töging	closed in 1996	
Veb	Lauta	closed in 1990	
	Bitterfeld	closed in 1990	
GREECE			
Aluminium de Grece	Distomon	163	1969
ITALY			
Alcoa Italia	Fusina 1	44	1972
	Porto Vesme	146	1972
Alumix	Fusina	closed in 1992	
Sava	Porto Marghera	closed in 1989	
Aluminia spa	Bolzano	closed in 1990	
NETHERLANDS			
Aluminium-Delfzijl	Delfzijl	110	1966
Pechiney Nederland N.V.	Vlissingen	230	1971
SPAIN			
Alcoa Inespal	Aviles	88	1959
	La Coruña	84	1961
	San Ciprian	213	1979
SWEDEN			
Kubikenborg Aluminium	Sundsvall	101	1961
UNITED KINGDOM			
British Alcan Aluminium Ltd.	Kinlochleven	closed in 2000	
	Lochaber	40	1981
	Lynemouth	164	1972
Anglesey Aluminium Ltd.	Holyhead	145	1971
HUNGARY			
Ajka	Ajka	closed in 1999	
Inota	Inota	35	1952
Hungalu	Tatabanya	closed in 1991	
POLAND			
Impexmetal	Konin	53	1966
SLOVENIA			
Talum	Kidricevo	110	1954
SLOVAKIA			
Slovalco	Ziar	130	1995

Source: European Aluminium Association

From the table it is seen that the only closure of a smelter in an ETR country since its ETR was the closure in 2000 of the smelter in Kinlochleven. This is described as one of the world's oldest and smallest aluminium smelters. It is also seen that few new smelters have been built in Europe and none recently. This is the case despite growth in demand, leading to the conclusion that, though relocation is not occurring, new capacity is locating elsewhere. However, production of secondary aluminium from scrap has grown rapidly, and along with imports is filling the gap.

7 Trends: trade, fuel use, technology potential, ETS and other policies and the Non-ferrous metals sector

Section 7 looks at trends in trade and fuel use market type, developments and technology potential for CO_2 reduction and recycling, and the EU-Emissions Trading Scheme and other environmental policies.

The key dates for the introduction of ETR in the relevant EU countries, against which to judge competitiveness effects of ETR, are as follows:

Sweden 1991
Denmark 1995
Netherlands 1996
Finland 1997
Germany 1999
UK 2001 (announced 1999).

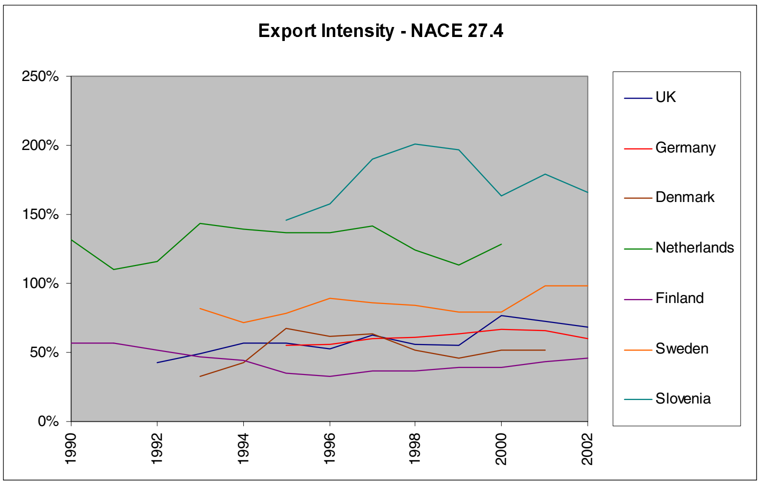
For Slovenia, the CO2 tax, although not strictly part of an ETR, has been included in the Baseline scenario to give an example of environmental taxation in the New Member States. Slovenia is discussed in the following passages, where data allow.

It is to be noted in general that the aluminium industry, making up a large share of the non-ferrous metals sector, was exempt from the carbon/energy tax element of ETR or given a rebate. There were exceptions where plants had their own power generation, for example, where they would have to pay the carbon/energy tax.

It is worth mentioning that Article 2 (4) of the 2003/96/EC – Energy Taxation Directive – states that the dual use of energy products and electricity is not covered in the Directive. Thus, energy products and electricity used in the ferrous metal and non-ferrous metal and also in the basic chemical sectors may be exempt from energy taxes.

Useful indicators of a sector's competitive health are its export and import intensities, and its export to import ratio, shown in Figures 7.1, 7.2 and 7.3 respectively, for the whole of the non-ferrous sector.

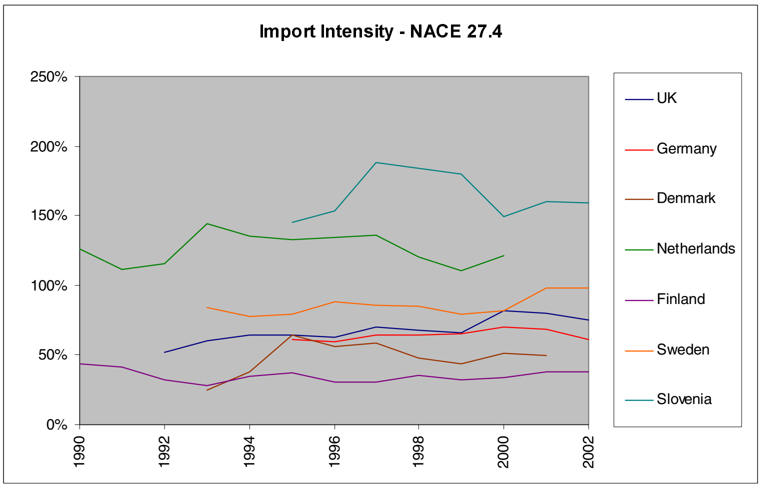
Figure 7.1: Export intensity (Total exports / Output*), %



** Output is measured as the sum of expenditure on energy, other intermediate consumption, compensation of employees plus net production taxes plus gross operating surplus. Source: COMETR WP3.*

Export intensity appears to have declined in Denmark and the Netherlands since their respective ETR introductions, though the pattern could not be said to be firmly established.

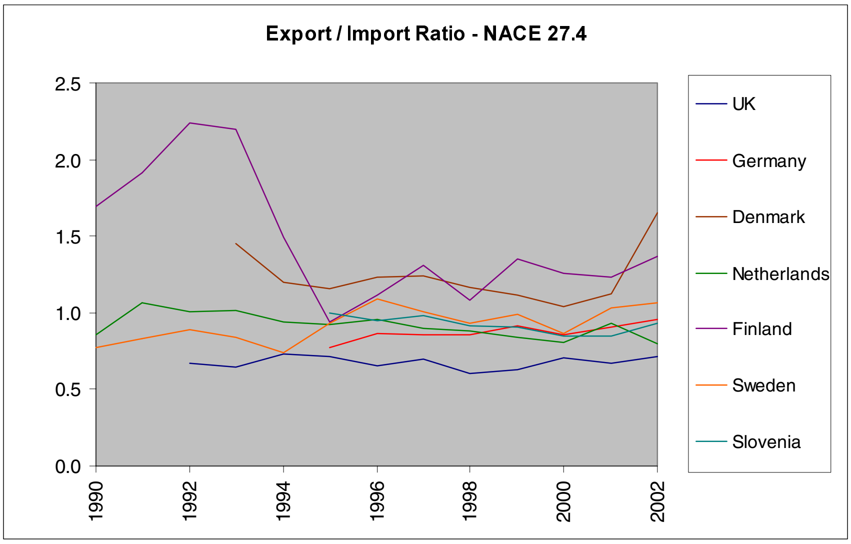
Figure 7.2: Import intensity (Total imports / Domestic consumption*), %



** Domestic consumption is measured as output (as calculated in the previous figure) minus exports plus imports. Source: COMETR WP3*

In Figure 7.2, import intensity is rising in Sweden and the UK and to a minor extent in Finland. In the case of the UK, import intensity was already rising before ETR in 2001, and Sweden's import intensity was more or less static for the first decade after its ETR in 1991, pointing to the likelihood that other influences were at work.

Figure 7.3: Export / Import ratio

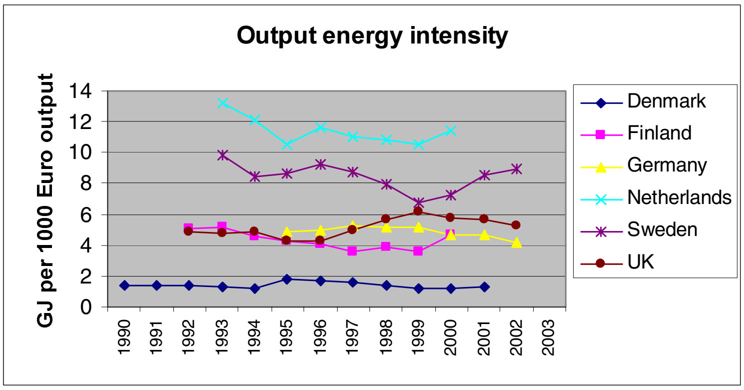


Source: COMETR WP3.

The export-import ratios for the ETR countries shown in Figure 7.3 have, if anything, risen over the periods since the respective ETRs were introduced. These three figures do not show a systematic deterioration in competitiveness. What deterioration did occur, in the Netherlands mainly, might be attributed to ETR though this is hypothetical. Given the rebates applied to the industry, though, other factors may also have been at work. In the case of Slovenia, despite the high indicated export and import intensities, the export/import ratio is more mainstream and remarkably stable, given the changes in economic conditions.

The next two figures 7.4 and 7.5 show energy intensity per unit of output and unit energy costs. Except in Finland and the Netherlands, energy intensity is following a downward path since their respective ETRs. The path is erratic in the case of Sweden. The extent to which the downward path represents compositional changes, energy efficiency drives or merely background technological progress cannot be gauged but for the most part the path is not inconsistent with improved efficiency in the UK, Germany and Denmark.

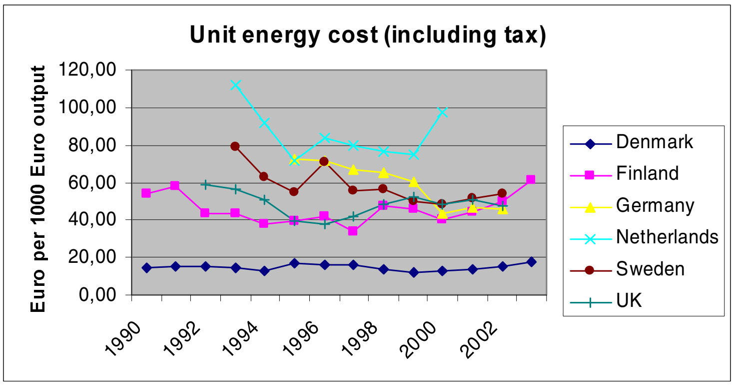
Figure 7.4: Energy intensity per unit of output (constant 2000 prices).



Source: COMETR WP3

Turning to the path of unit energy costs, this is generally downward rather than upward since the respective ETRs, except in the cases of the Netherlands and Finland.

Figure 7.5: Unit energy costs (including tax, constant 2000 prices)



Source: COMETR WP3

The downward path could reflect improvements in energy efficiency, but it is informative to check the overall movements in energy price because the net effect of the tax may have been influenced by underlying energy price trends. Table 7.1 gives the overall percentage price change (including tax) between 1995 and 2000 for four main fuels used by the non-ferrous metals industry.

Table 7.1: Percentage total price change between 1995 and 2003 in the non-ferrous metals Industry (constant 2000 prices)

	Fuel oil	**Gas /diesel oil**	**Natural gas**	**Electricity**
Denmark	69.4	-29.4	-41.5	10.6
Finland	30.9	43.8	39.3	17.4
Germany_02	59.2	58.1	26.7	-33.7
Netherlands_02			20.4	8.9
Sweden	72.2	111.2	73.2	-19.9
UK_02	28.5	19.5	0.5	-37.8

Source: COMETR WP3.

Indeed it is seen that the price of electricity, a major energy input, saw declines in four countries and only saw a serious price rise in the Netherlands. This tallies with the unit energy cost rise for the Netherlands seen above. There may also have been alterations in product mix at play. (The UK is included for interest, as its ETR in 2001 occurred outside the range shown here.)

The level of tax raised in 2000 and the energy tax share of gross value added in the non-ferrous industry is summarised in Table 7.2.

Table 7.2: Energy taxation in the non-ferrous metal industry in 2002.

	Energy tax € million	**Energy tax % of GVA**
Denmark	0.90	0.91
Finland	10.76	3.35
Germany	86.85	1.82
Netherlands_2000	4.30	0.45
Slovenia_2000	0.51	0.97
Sweden	1.11	0.19
UK	7.85	0.41

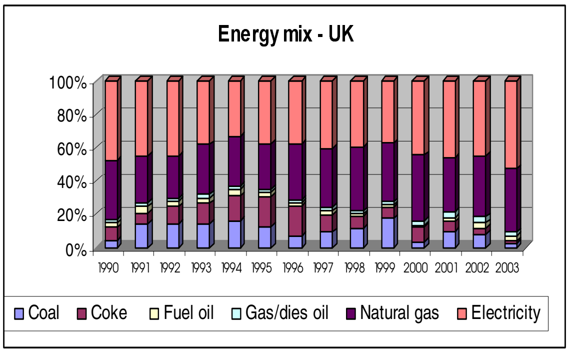
** Expressed in constant 2000 prices. Source: COMETR WP3*

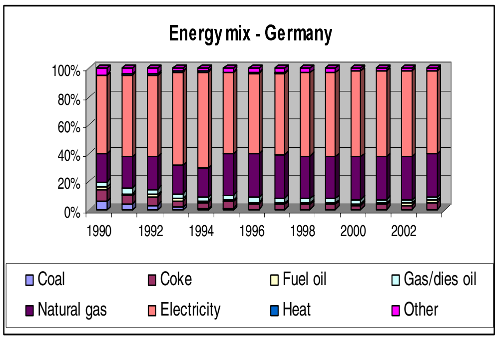
Although Finland and Germany are seen to have relatively high tax shares of gross value added in 2000, their unit energy costs were in the middle of the range for that year, as shown in Figure 7.6. This possibly indicates that, though relatively high for these countries, the tax still did not have much impact when there are so many other factors at work. Also for Germany some exemptions are not fully included (Spitzen-steuer). It is interesting to look at the price changes of Table 7.1 alongside movements in individual fuels. Figure 7.6 gives the movements in fuel shares for each ETR country, and Table 7.3 summarises the fuel consumption movements over the period 1995 to 2002.[19]

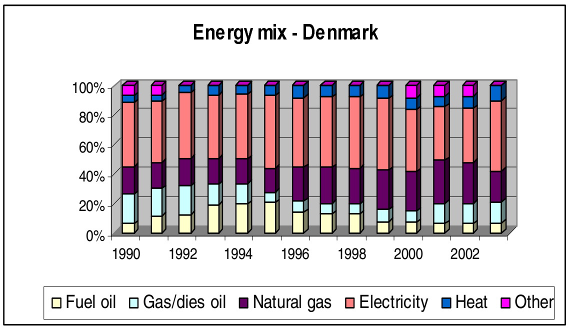
Looking first at the Netherlands, here the price of electricity rose and over roughly the same period the quantity and share rose too. This surprising trend is less strange when one notes that the price of natural gas rose by even more, such that the share and absolute amount of natural gas declined. Electricity price falls in Germany, the UK, Sweden and Finland saw, logically, electricity quantity rises for all these countries. Denmark responded predictably to price rises in fuel oil and electricity by decreasing consumption and shares of these fuels, and increasing consumption of gas oil and natural gas, the prices of which had fallen considerably. For Finland, Germany and Sweden, the prices of fuel oil and gas oil rose considerably and the quantities of these fuels consumed declined noticeably (except fuel oil in Germany). Overall the response to price looks rational. It also demonstrates that a certain amount of flexibility exists.

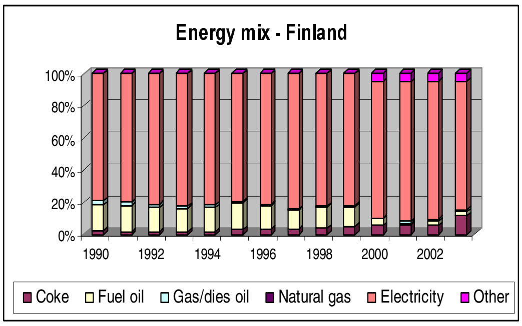
[19] The data in Figure 7.6 and Table 7.3 are derived from the IEA energy Statistics and in addition to comprising NACE 27.4, they include castings, NACE 27.53 and NACE 27.54.

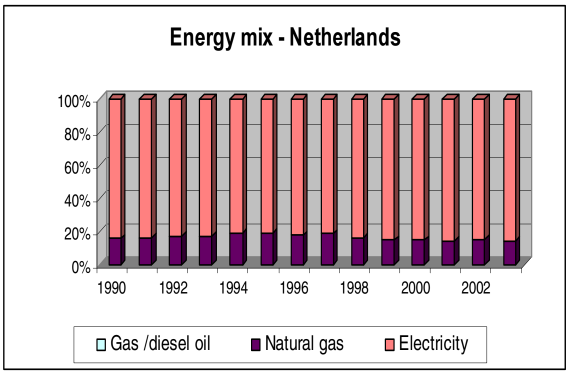
Figure 7.6: Fuel shares for each ETR country, %

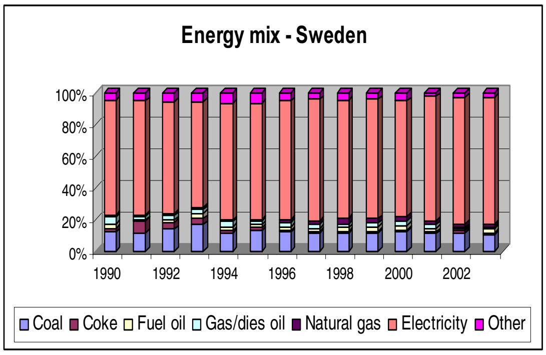












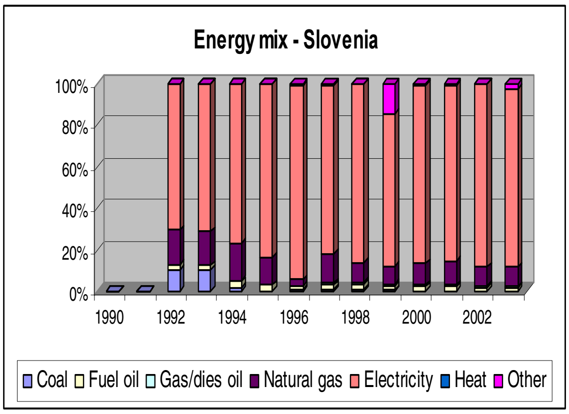


Table 7.3: Change in fuel consumption by non-ferrous metals industry between 1995 and 2002, %.

	Coal	Coke	Fuel oil	Gas/ dies oil	Natural gas	Electri-city	Heat	**Total**
Germany	-71.0	-24.6	18.8	-34.5	9.4	12.2	-44.2	5.4
Denmark			-66.7	100.0	84.6	-19.8	19.5	7.1
Finland		136.6	-81.5	0.0		29.2		18.9
Netherlands				-100	-5.9	25.4		19.1
Sweden	-5.8	-24.9	-42.9	-57.1	131.5	15.4		5.6
UK	-39.2	-82.6	0.0	78.3	31.6	11.7		-5.2
Slovenia			-25		-20.9	23.2		16.7

Source: COMETR WP3, IEA data.

Electricity

Primary aluminium production has the highest electric energy intensity of all metals. Accordingly, availability of electricity and its price are the main determinants of economic performance of existing smelters and location of new ones, according to the EAA. Access to sources of cheap energy supply is a major issue. Aluminium producers would ideally locate near a source of hydro-electricity,[20] which at present supplies over 50% of the energy used to produce aluminium supplied to the European market. Sources of electricity in European primary aluminium production are as follows (EEA):

Hydro-electricity	52%
Hard coal	20%
Nuclear electricity	15%
Brown coal	5%
Natural gas	5%
Crude oil	3%
Total	100%

A second requirement is for long-term bi-lateral contracts on energy supply. Large capital investments are understandably discouraged by the prospect of price volatility, and securing long-term price contracts is paramount. It is pointed out that the smelter's continuous pattern of demand may also offer synergies to the supplier.

Of particular relevance is the pattern of improved efficiency of electricity use at the electrolysis stage. Between 1950 and 2000 electricity consumption at electrolysis stage per tonne of aluminium has reduced by 30%. Reductions in CO_2 emissions have also been strong though not pro rata, as it depends on the source of electricity production.

Other emissions are not elaborated on here for want of space. Suffice it to say that PFCs (another greenhouse gas), fluoride emissions and polycyclic aromatic Hydrocarbon (PAHs) have also been reduced on foot of plant modifications.

Market type, developments, technology potential

Work Package 2 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

[20] As yet the cost of habitat destruction in the course of building new hydroelectric schemes does not get included.

transport. At a present price of US$ 2600 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.

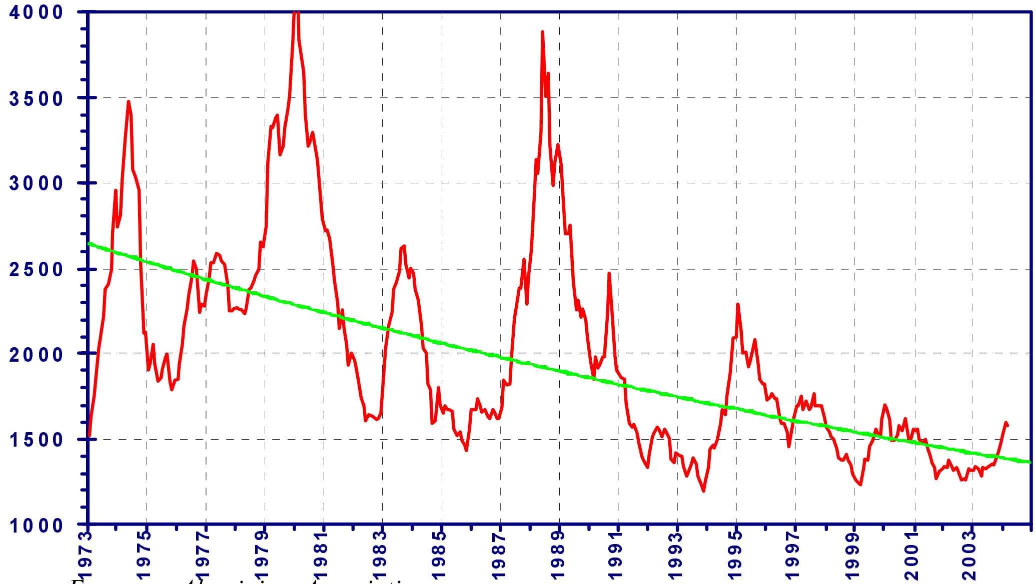
Turning to the EU-25, nearly three quarters of the 3 million tonnes of primary aluminium was produced by 4 largely integrated groups. These four also control more than three quarters of the rolling industry and over a third of the extrusion industry in the EU25. While more concentrated power could in fact reduce competitive pressure, it may be unlikely given the present intention of many corporations gain competitiveness.

R&D intensive

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 rises, through retro-fitting, efficiency improvements, expansions and restructuring, has been facilitated by this R&D. An indication of the resulting effect on the long-term pattern of aluminium price is shown in Figure 7.1, for prices on the London Metal Exchange (LME) for the period 1973 to 2004, expressed in constant US $. Though highly volatile owing to movements in exchange rates, energy prices and market conditions, the underlying long-term downward trend indicates that production methods have improved. More will be said about this under the technology heading below.

Figure 7.7: Price of aluminium on the London Metal Exchange since 1973, constant $US.



Source: European Aluminium Association.

Location requirements.
Another feature of the industry is the requirement for locations with favourable transport attributes. Many companies will choose to locate at ports or where good berthing facilities can be provided.

7.2 Technology potential for CO_2 reduction
Technology is a central issue in energy-intensive sectors in two major respects. Technology upgrades are, firstly, the objective of ETR and, secondly, the means to help companies to adapt and overcome their vulnerability to competitive disadvantage caused by ETR. Technology upgrades are both the aim of policy and means for facilitating survival under the policy.

The first question as to how technological upgrades can promote the objectives of ETR by reducing emissions was described in Work Package 3. It is the second aspect that is addressed here, that is, the sector's potential for adapting to survive ETR by investments in energy efficiency. If the ETR causes a serious dent in the sector's return to capital and there are no technological options to come to the rescue, then the company could consider locations where environmental constraints are slacker, with potential detrimental results all round. Apparently there are countries in the Middle East that are at present going for growth with little regard for environmental outcomes. In democracies however there are sometimes pressure groups that can publicise evasion and some companies prefer to have an image that conveys a sense of responsibility. In any event if a company faces technological possibilities for emissions reductions, these could enable it to cope with the introduction of carbon/energy taxes.

Potential reduction of CO_2.
An important source of information on technical potential for reducing carbon dioxide emissions within the EU15 is the study by de Beer *et al* (2001), which covered the non-ferrous metals sector. Their report is a bottom-up analysis, commissioned by DG Environment of the European Commission as part of a large study by Ecofys and others, and it benefited from comments from a panel of experts and a workshop. Though one should take into account the caveats and assumptions made, it forms a reliable source of *independent* information.

The study's base year was 1990. The emissions for 2010 were first calculated as a reference level based on assumed industrial growth rates taken from the PRIMES (1999) study and on 'frozen technology', which assumes no energy efficiency improvement and no reduction in specific energy consumption. Table 7.4 summarises the reference level for the non-ferrous metals industry. The 'indirect emissions' are related to consumption of electricity and steam.

Table 7.4: Energy use and emissions of CO_2 by the non-ferrous metals sector in the EU15 in 1990 and in 2010* assuming technology frozen at 1990 level.

Fuel use EJ	**CO_2 emissions Mt**			
1990	**1990** **Direct**	 **Indirect**	 **Total**	**2010 Reference level** **Total (% increase)** **(frozen technology**)**
0.5	16	33	50	68 (+ 36%)

**Based on growth rates given by Primes (1999).*
*** Excluding shifts between fuels and sub-sectors.*
Source: de Beer et al, 2001.

As shown in the table, a 36% growth in emissions of CO_2 is foreseen in the reference case for 2010, based on the assumption of technology being frozen at 1990 levels.

Efficiency improvements are considered only for primary production, that is, for production of aluminium from alumina. (Secondary aluminium production is production from recycled scrap aluminium.) Primary production is the most energy intensive step as mentioned in the introduction, a modern smelting plant requiring 14 MWh per tonne of aluminium or 15 MWh in the average European plant.

Primary aluminium production in 1990 and 2000 in EU15 countries is shown in Table 7.5. Non-zero entries only are given, and the ETR countries are shown first.

Table 7.5: Production of primary aluminium in EU countries in 1990 and 2000, '000 tonnes.

Thousand tonnes of primary aluminium											
DEU	**GBR**	**NLD**	**SWE**	**ETR**	**AUT**	**ESP**	**FRA**	**GRC**	**ITA**	**Non ETR**	**EU**
727	303	272	97	1399	89	353	296	150	226	1114	2416
644	305	302	101	1352	-	366	441	168	189	1164	2516

Source: Nordheim, 2000; de Beer et al., 2001. Index Mundi website. Totals are subject to rounding.

Three options for improving energy efficiency

1. Retro-fit of existing Hall-Héroult process

Several options for retro-fitting existing cells in plants are listed by de Beer *et al.*. Savings depend on the process existing at the start. By 2000 the scope for retro-fitting was estimated to be 33% of EU capacity, as most of the smelters in the EU were already operating the more efficient PFPB (Point-Fed Pre-Baked) technology (Nordheim, 2000). An average saving of 1 MWh per tonne of aluminium for 33% of EU capacity is assumed. Costs for such a retro-fit are subject to a wide range, from €50 to €335 per GJ saved.

2. Inert anodes

Field testing was underway and these were not commercially available at the time that de Beer *et al.* were reporting. Savings materialising by end-year of 2010 were not anticipated.

3. Wettable cathode

The wettable cathode had been field-tested and was undergoing further analysis. Commercial designs were barely expected in 'the next 10-20 years'. (More is said about this later.) In combination with a drained cathode this could give energy savings of 0.2 to 0.3 MWh per tonne at any given plant, representing a saving of up to 2% on today's consumption.

New capacity might bring about efficiency improvements but new capacity was not assumed in the scenario considered by de Beer *et al.*

CO_2 reduction potential in non-ferrous metals other than aluminium

While discussing technological potential it should be mentioned that de Beer *et al* also considered potential savings in the production of other non-ferrous metals in the EU, including in copper, zinc, lead, nickel, cobalt and precious metals. The production volumes are far less than those of aluminium and the authors do not deal with each separately. However measures to improve energy efficiency are known to be available and therefore, for the 1990 to 2010 period, savings of 25% in fuel demand and 25% in electricity demand are estimated, working out at a 1.1% improvement per year on average for the group as a whole.

Details of CO_2 reduction potential in all non-ferrous metal production is shown in Table 7.6, which breaks down the overall potential, 10.9 Mt, into four cost brackets.

Table 7.6: Breakdown of reductions potential in EU15 Non-ferrous metals industry into four cost brackets, euro per tonne CO_2 avoided.

Cost in € per tonne CO_2 avoided	**Sub-sector and Measure**	**Emission reduction (Mt CO_2 per year)**
< 0 euro	*Non-ferrous, other than aluminium:*	
	Miscellaneous measures	10
0 – 20 euro	None	0
20 – 50 euro	None	0
> 50 euro	*Aluminium:*	
	Retrofit existing Hall-Héroult process.	0.5
	Wettable cathode.	0.4
Total	Non-ferrous metals	10.9

Source: de Beer et al., 2001.

As seen in Table 7.6, the scope for energy efficiency at production stage lies mainly in the non-aluminium sub-sectors. Where aluminium is concerned the potential savings are small at 0.9 million tonnes of CO_2 and very costly. It makes sense to promote uptake of better options, to which end economic instruments are being applied.

This conclusion on the limited scope in primary aluminium production is endorsed by the recent review of sectors to be considered for inclusion in the third round of the EU ETS, running from 2013. The review, called LIFE-ETS (LETS, 2006) considers the potential for CO_2 abatement in the EU. Out of the total 8 million tonnes of CO_2 emitted by the aluminium sector, it estimates potential abatement to be 7.5%, but "at high cost".

In addition to carbon dioxide, aluminium production has associated PFC emissions amounting to some 4.23 million tonnes of CO_2 equivalent. Most abatement technology has been applied already, though there are some limited potential reductions.

Recycling

Having seen the relatively modest potential energy efficiency improvements in the non-ferrous metals sector through investment in technical upgrades, attention now turns to the potential for improved recycling. By contrast with primary production, recycling has seen rapid growth.

Recycling I 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.[21]

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

[21] "Indeed for most aluminium products, aluminium is not actually consumed during a lifetime, but simply used" (EEA and OEA, 2006)

3.3 'under investigation'). For cans the recycling rate is usually the worst, and the data most variable. Table 7.7 shows European recycling in the case of aluminium cans, for which the European average is estimated at 52% (EEA and IAI).

Table 7.7: Recycling rates of aluminium cans, %

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

Aluminium is not magnetic and cannot be separated by the giant magnets that are used to separate steel cans. In addition, many cans have a steel body but an aluminium top and bottom, making sorting more difficult. The EU Packaging Directive sets a target for 50 per cent joint recycling for steel and aluminium packaging, by 2008 by 12 EU states, and by 2011 in Portugal, Ireland and Greece. In addition to this end-of-life scrap there is also 'new scrap', which is 53% of all scrap, consisting of surplus material arising during production up to the point of sale to the consumer.

Many examples of 'waste' through low recycling rates are cited[22], and it is instructive to ask why recycling is not higher. Inadequate recycling is caused by the fact that prices do not reflect a raft of true environmental costs (of landfill, energy emissions, transport emissions, et cetera). Incorporating the costs of environmental damage would help by rectifying the root of the problem. There may be additional barriers to recycling in the form of ignorance, unrealistic payback criteria and set-up costs of procedures.

Compared to the production of primary aluminium, recycling aluminium requires only 5% of the energy, hence only 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.

Other metals, nickel for example, are also recyclable, and alloys have useful destinations too. EU environmental legislation on the recycling industry has demanded and resulted in the adoption of advanced technologies. The remaining potential for recycling has not been clearly spelt out and merits more investigation, but consideration of current recycling levels and the existence of uncharged external costs indicates definite scope.

In turn the secondary metal companies have invested in energy saving. In the case of beverage cans, for example, gas is collected from burning off volatile substances in the coating on cans to provide heat for the process.

[22] US airlines throw out enough cans to build 58 Boeing 747s according to the Natural Resources Defense Council.

EU ETS and environmental policy in EU and elsewhere

The first phase of the EU Emissions Trading Scheme (ETS) saw the aluminium industry exempt from participation. Nevertheless, the industry has been caught by the high price increases for electricity on foot of the EU ETS. Power suppliers are participants in the EU ETS and their permit allocation, though free, has nevertheless led to a rise in the price of electricity. The explanation for the price rise lies in the permits' value on the market. Power producers treat the use of permits as a cost like any input cost.

This indirect reflection of the price of carbon emissions in electricity prices might not raise objections in policy circles, given that pricing carbon emissions is a core requirement of greenhouse gas control. In operating ETS (a quantity-based instrument) authorities allocate *amounts of carbon permits to specific industries or processes* (in contrast to a carbon tax that simply puts a price on emitting carbon). It is quite likely that the allocations made in quantity-based policies have unforeseen indirect effects. For example, where combined heat and power generation (CHP) is concerned the EU ETS gives relatively favourable allocation (100% in the UK in the second phase is a case in point). This is likely to give the aluminium industry an incentive to install CHP and, in so far as the industry could achieve efficiencies in power use, it could sell the surplus electricity at similarly profitable prices. Free permits to generators, and to new CHP in particular, is likely to incentivise efficient production. But the favouring of a specific technology, such as CHP, may not promote the optimal path, such as the more flexible path that would be promoted by permit auctioning or carbon taxes (Fitz Gerald, 2005; Parry, 2003). Box 1 reports on discussions with an alumina producer in Europe.

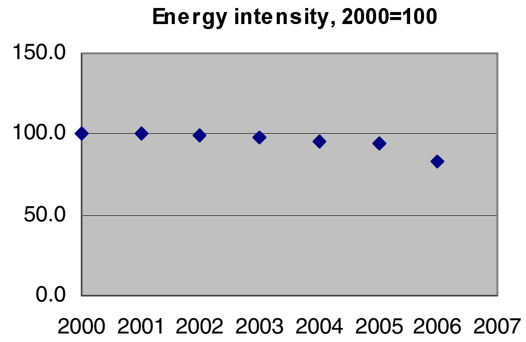
Box 1: A major European **alumina producer** interviewed said that he could accept ETS or carbon taxes, but not both.

To throw light on the likelihood of relocation it is instructive to discover what caused this alumina plant to choose the present location in the first place. That was several decades ago but underlying pressures do not change. The answer is that the location has a marine terminal for importing inputs and exporting products. The tax regime was very favourable aided by exemptions on fuel in order to attract foreign industry,[23] and at the time the power supplier was in a position to accommodate new industry on good terms in long-term contracts.

According to the director of the facility future investment in capacity is likely to concentrate on locations within Europe that are less constrained with respect to carbon permits and, indeed, on non-Kyoto countries altogether, which are likely to be cheaper in any event.

In the meantime, after the introduction of a carbon tax had been announced, the company engaged with the energy management agency in a negotiated agreement. Consisting of several actions, including setting up an energy management system, investment in CHP, and new digestion technology, actions bringing the company to Best International Practice would allow it an 80% exemption from the carbon tax.

Notably, the agreement required that identified actions with specified paybacks (longer than commercial paybacks) be implemented. The company now spends huge resources on monitoring energy use and producing real-time data, reviewed by an engineering team daily and in regular management reports. A large share of output from the CHP plant is sold to the national grid. Top management support and feedback to the energy management agency are also required. The company is now a highly efficient plant and its target is for unit energy use to reduce by almost 25% compared to that of the mid-nineties. The graph below shows the improved energy intensity. The strong commitment of the company to energy efficiency has been acknowledged by the agency to be a major driver in their improved performance.



The figure for 2006 is the target, and it represents a reduction of over 17% on the 2000 level of energy intensity.

There is uncertainty about long-term prospects due, in particular, by the lack of clarity as to the EU ETS Phase III. However with its own CHP plant, this company is spared the reported difficulty of negotiating electricity contracts with power suppliers who themselves are also subject to uncertainty.

Judging from the discussion in Box 1 it would be fair to say that policy during the period when the plant was being set up implicitly put a low price on energy.

A related issue as far as aluminium production is concerned is the difficulty of obtaining contractual agreements for a long-term supply of electricity. Electricity suppliers can enter in to long-term arrangements with customers if they themselves have assured prices for their inputs. Present uncertainty over the price of carbon in Phase II of the EU ETS, not to mention Phase III, has produced a hiatus. Such uncertainty could be a factor encouraging the aluminium industry to look at locations outside the EU and at those countries that are not Kyoto signatories and, above all, to keep their options open. Box 2 reports on discussions with primary aluminium producers in Europe.

In the UK the Aluminium Federation has a negotiated agreement set up under the UK's own Climate Change Agreement. According to evidence to the House of Lords' Science and Technology Committee the industry has reduced its emissions of CO_2 equivalent by 30% between 1990 and 2005 while at the same time increasing production of aluminium products by 30% (Stationery Office, 2005, page 209). The Federation states that improvements have been due to technical adjustments and not to structural change. Only huge investments could bring further improvements, though "where energy efficiency is the main driver, pay-back periods of 2-5 years would be expected". Long-term viability is in question when there are cheaper locations elsewhere. In addition demand for more sophisticated products may need more energy.

In the UK electricity used in primary aluminium production is exempt from the Climate Change Levy and recycling aluminium is also exempt. Nevertheless a number of complaints are registered by the Federation, relating to uneven treatment of extruders for example. Asked about the effect of carbon taxes on the sector the UK Aluminium Federation states that it would make UK companies totally uncompetitive in the world markets, affecting primary aluminium smelters first.

Box 2: A major **aluminium producer** interviewed said that their company was developing new techniques and were investing to speed up progress. It is intended to reduce energy use by 20% by 2020 and be world leaders.

A producer at another aluminium facility said that if the aluminium industry found itself subject to permits or required to bid at auction in Phase III of the EU ETS it would be a problem, because their technology is just about as good as it could get at this time. In 2002 they were using 15.2 kWh per kg aluminium, and by 2006 they were down to 14.6 kWh per kg. They stay in Europe because the demand is there but they could have to move.

If there were carbon taxes, the introduction of *border tax adjustments* to remove the competitive disadvantage would "make life easier alright".

Aluminium's light weight with consequent fuel economies from incorporating aluminium in transport vehicles is sometimes used by the industry as an argument for exemptions from carbon/energy taxes or emissions trading schemes. The life-cycle advantages of aluminium are invoked to make this case. The point is that although exemptions would make aluminium cheaper, and hence aluminium-intensive cars and travel cheaper also, the argument misses the point. Carbon taxes or carbon trading correctly targeted on the CO_2 emissions from transport are what is needed, otherwise the result of exemptions on aluminium could be increased car purchases and travel.

Meanwhile one should not overlook the fact that some developing economies, such as China, are imposing higher environmental standards too.

8 Conclusion

Summing up the indications of leakage potential, it is seen that 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, especially. 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.

Carbon leakage should be viewed broadly - as location of new capacity as well as relocation. The following Table 8.1 summarises the influences on leakage for non-ferrous metals enterprises under the main criteria. The importance of each criterion for non-ferrous metals is entered as 'high', 'medium' or 'low' and qualifications and comments are noted. The verdicts given reflect this section's main focus on the aluminium industry.

Table 8.1 Relocation Criteria Matrix: Non-ferrous metals (27.4)

Criteria	Importance of criterion
1 Energy intensity	Very high
2 Energy price differences from ETR	High (if applied without exemptions) Medium to high (is applied to secondary metals from recycled scrap)
3 Scope for shifts in fuel mix	Low to medium
4 Costs of trade (weight-value ratio, transport costs, tariffs, NTBs)	Low costs
5 Importance of location (irrespective of costs of trade)	Low Subject to supply of cheap power and convenient berthing facility
6 Knowledge-intensity, R&D-intensity	High but not necessarily tied to plant location
7 Importance of regulation	Moderate (subject to IPPC licensing etc)
8 Fragmentation of production chain	Medium (some scope for economies from physical integration)
9 Residual X-inefficiency, scope for energy efficiency gains	Medium (Some scope for recycling more scrap, which uses only 5% as much energy)
10 ETR offsetting mechanisms	High offsets to date in the form of exemptions and negotiated agreements, but small benefit from labour tax reductions
11 Border tax adjustments	High potential Easy to apply owing to homogeneous products
12 Indirect cost effects due to ETR	Low to medium (depending, increased recycling reduces landfill needs)
13 Competitiveness of the international market	High

As seen in the table the non-ferrous metals sector is highly energy intensive and operates in a very competitive market. Its transport costs are low relative to the value of its product and there are likely to be some other locations in the world with suitable berthing possibilities. The industry also has to contend with strong EU regulation on environmental standards generally. These attributes point to potential leakage.

On the other hand, ETR could be accompanied by border tax adjustments, which would not be hard to implement given the homogeneous nature of the products. The production chain is not widely fragmented or multi-staged and therefore benefits from integration elsewhere do not beckon very strongly.

This leaves the issue of fuels and technology. If there were no flexibility in production, either through fuel shifts, technology changes or product route, then on balance the forces for leakage would tip the balance. There are however a few possibilities here to mitigate these. While technology improvements in primary production do not provide much scope at present, there are possible moderate improvements at the margins. We saw an improvement in energy intensity of some 15% or more in alumina production. There is probably more potential for economies in the future judging from the research that is devoted to this area. There is not at present much scope for fuel shifting either, given that exploiting hydro-potential in Europe has reached its limits, short of high expenditure. The area of most potential appears to lie in recycling. The rates of recycling are still quite modest, with aluminium can recycling only around 50 per cent, and this area warrants further investigation.

Appendix

(1) Alumina

There are around 50 alumina plants in the world, including those in Russia and China. Most of them use some variant of the Bayer Process. Each plant is tailored to produce a tightly specified pure product (alumina) from a variable raw material (bauxite). Energy consumption is directly linked to the characteristics of the bauxite processed, and to the choice of equipment selected during the design of each plant. This will be indirectly related to fuel economics prevailing at the plant site during the design.

Aughinish in Ireland and San Ciprian in Spain are amongst the most fuel-efficient plants in the world, and there are only six plants that are comparable. These are the family of plants that use the Kaiser High Temperature digestion technology. In order of construction, these are: Gramercy, Queensland Alumina, Alpart, Eurallumina, San Ciprian and Aughinish (see table).

Of these plants, those committed to Jamaican bauxite are penalised because the bauxite cannot be slurried to high percent solids. San Ciprian and Aughinish are comparable twin plants.

Although the Alumina plant at Stade has a specific energy consumption around 10% lower than Aughinish it is not included in the comparison as it uses a tube digester design and is limited to 0.6 Mtpy. To convert Aughinish to a tube reactor would require about 110 miles of pipe in pipe. As well as not having the space for such modifications the costs would be excessively expensive and could not be justified.

Appendix Table: KAISER HIGH TEMPERATURE BAYER PLANTS

	Gramercy[24]	**Queensland Alumina**	**ALPART**	**Eurallumina**	**San Ciprian**	**Aughinish**	**Gramercy2**
Start-up Date	**1959**	**1967**	**1989**	**1973**	**1980**	**1983**	**2001**
Production (MMt / year	1.05	3.6	1.5	0.9	1.35	1.55	1.25
Location	USA	Australia	Jamaica	Sardinia	Spain	Ireland	USA
Yield (Kg/m^3)	60	65	62	65	70	70	62
Bauxite supply	Jamaica	WEIPA	Jamaica	WEIPA/CBG	CBG	CBG	Jamaica
Calcination[25]	R	R / S	S / R	Hybrid	S	S	R
Fuel type used	Oil/Gas	Coal/Gas	Oil	Oil	Oil	Oil	Oil/Gas
Power source	Steam turbine/ Combined	Purchased	Steam turbine	Purchased	Purchased	Purchased	Steam turbine/ Combined
Electricity consumed (kWh/tonne)	-	210[26]	-	250	220	220	208
Fuel consumed	20.0	12.5	18.6	11.7	10.3[27]	9.7	14.5
Total primary energy[28]	5.6	4.0	5.2	3.9	3.4	3.2	4.0

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Annex:
A review of Environmental Tax Reform and Energy Taxation in new EU Member States

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Abstract

This paper debates and summarises prospects and one ongoing realisation of environmental tax reform in the new EU Member States, particularly in Visegrad countries. We understand the environmental tax reform as a shift from taxation of activities such as labour or other human efforts towards taxation of bads such as pollution and natural resource extraction, and in this respect our main intention is to assess possibility to introduce such a concept in these countries. We review state and progress of environmentally related levies, and labour and corporate taxation in a wider context of macroeconomic conditions and consolidation of public finances. Despite many economic instruments being applied in environmental regulation in these countries, the revenues from environmentally related levies are strongly dominated by mineral oil taxation originally introduced for fiscal reasons rather then for its potential to change consumer behaviour and production patterns, and resource allocation as a consequence. Bearing also in mind the importance of energy taxation in the pursuance of environmental tax reforms in EU-15 countries, a special attention is given to the implementation of the Directive 2003/96/EC on taxation of energy products and electricity.

Keywords: environmental tax reform; energy taxation; policy analysis; CEEC

1 Introduction

This paper summarises findings on issues related to environmental tax reforms (hereinafter ETR) and environmentally related taxation in the new EU Member States. This means that not only environmentally related taxes and charges are taken into account but also overall economic and political situation, major recent and foreseen tax changes in the public finance systems particularly that ones with certain importance from the ETR perspective. This implies that we also discuss personal / corporate income taxation and VAT issues since these taxes will be presumably lowered in a possible ETR.

Hereinafter we mean by environmental tax reform a shift of taxation from labour and capital – considering them as "goods" - towards taxes on environmentally hot items such as pollution and natural resource extraction ("bads"). The main idea behind the ETR concept is to tax bads rather then goods, since pollution and resource extraction are linked to production of external costs associated with damages to human health, fixed assets, ecosystems or inter-generational externalities in the case of resource depletion. The ETR concept is often interrelated to "greening the budget" efforts that sometimes cover wider changes in tax/charge system and design not necessary leading to the shift of tax burden. A broader concept – environmental fiscal reform – is more often discussed in environmental debates. This reform has more courage and goes even further; it implies not only ETR, but also a change in support measures and removal of environmentally harmful subsidies. Despite the importance of these two lastly mentioned

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issues – greening the budgets and counterproductive subsidy removal, our paper is only dealing with the ETR concept based on tax shift.

If one assesses an existence of the ETR feature in public finance system, a definition of ETR should be clearly clarified. As suggested by Brůha and Ščasný (2004; 2006) a shift in tax burden with the ETR feature could occur in two forms. Firstly, certain tax shift from labour/profit taxation towards environmental use can explicitly state environmental concerns as motivation for the reform. We call this reform as an 'explicit' ETR. Such shift in taxation, however, need not make any reference to environmental protection and can 'invisibly' shift tax burden from goods towards bads such as energy. Direct effect of such shift is certain change in relative tax rates and consequently prices of production factors. Such effect can be also, however, reached if no change in taxation of pollution or natural resources occurs. For instance, if taxation on labour or profit is lowered while tax on pollution and natural resources remain unchanged. We can call this change as 'implicit' ETR. The main aim of our paper is to discuss prospect of 'explicit' ETR, however, bearing in mind the effect of such reform, also occurrence of 'implicit' or 'implicit' ETR will be briefly tested and discussed.

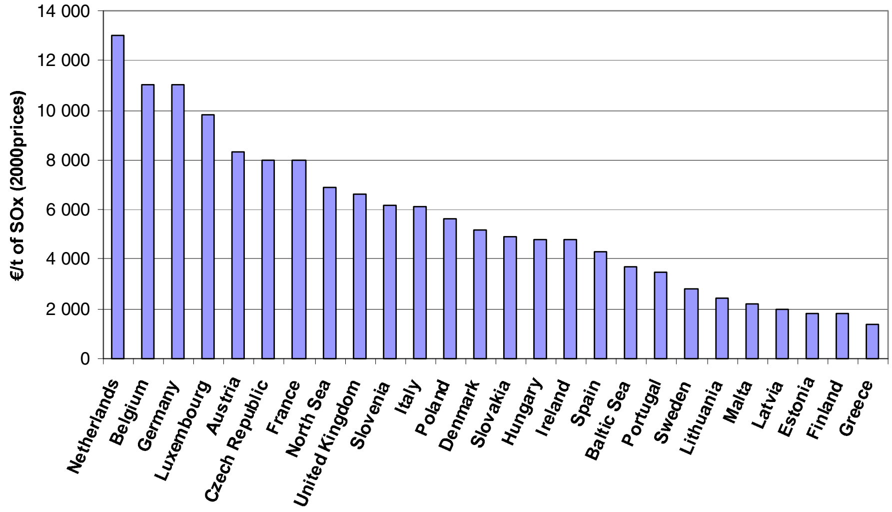
1.1 Recent situation in the field of environmental related taxes

Implementation of environmentally related taxes and charges has a long tradition in Central and Eastern European countries. Trend in their implementation has been even substantially boosted during 1990s. Following database compiled by European Environmental Agency (EEA 2000) and Regional Environmental Center (Speck et al. 2001), we can identify more then 40 tax, charge and fee bases applied in late 1990s in eleven CEE countries (see table in Annex I). This group is however heterogonous in terms of definitions, tool objectives as well as use of revenues. The only progress towards harmonisation has been occurring in the field of energy taxation (see below).

Regarding the steering aspects of environmental taxes and charges there still persists discrepancy between revenue rising and pro-environmentally oriented behaviour motivating objective. From environmental effectiveness perspective, very low tax/charge rates were not able to reach significant environmental goal; for instance rate of air emission charge were set out at about EUR 30 in CZ or EUR 80 in Poland per ton of pollutant. These rates are far away from optimal rates if we consider economic efficiency criterion; for instance Pigovian tax rate for tonne of SO_X was estimated one order higher then charges applied in CZ and Poland (see Zylicz 2002), the external costs are estimated two orders higher (see the estimates by Watkiss et al. 2005 prepared for CAFE Programme; see Figure 1[2]). Assessment of rational internalisation of external costs needs to be much more complex, i.e. all taxes and charges levied on consumption or production producing the externality should be considered together with other regulating instruments such as tradable property rights and overall taxation scheme. There is a lack of empirical examination on efficient environmental regulation considering theory and rule of optimal taxation. Moreover, according our best knowledge, there is no empirical study that would analyse regulatory effect (environmental effectiveness) of environmental charges itself. Discussing the internalisation of damage caused by classic pollutants, as we can see below, there is no other energy tax except tax on motor fuels introduced on the top of emission charges that could internalise the relevant externalities in almost any examined country.

[2] Magnitude of unit external costs per tonne of pollutant depends on receptor, especially population density around the emission source; that is the reason why the unit external costs is higher for the states located in the central Europe or in the region with high population density then in the states located close to the sea, e.g. Baltic countries.

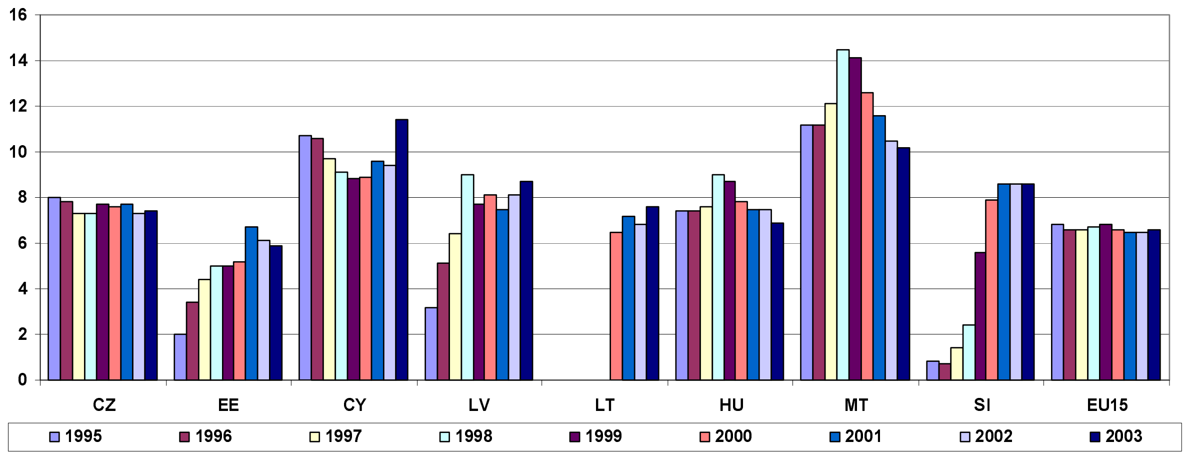
Figure 1: Marginal SO_2 damage in € per tonne of pollutant for 2010.



Source: Prepared for carrying out CBA in CAFE Programme by Watkiss et al. 2005; low end estimate.

Despite relatively low tax/charge rate, the revenues from environmentally related levies account for relatively high share in GDP, total tax or public revenues or expressed per capita. Nowadays, the share of revenues from those taxes on total tax revenues is well above an average share in old member states (EU-15) in overwhelming majority of new member states as shown in following figure. With exception of Cyprus and Malta the major part of environmental taxation falls on energy taxation.

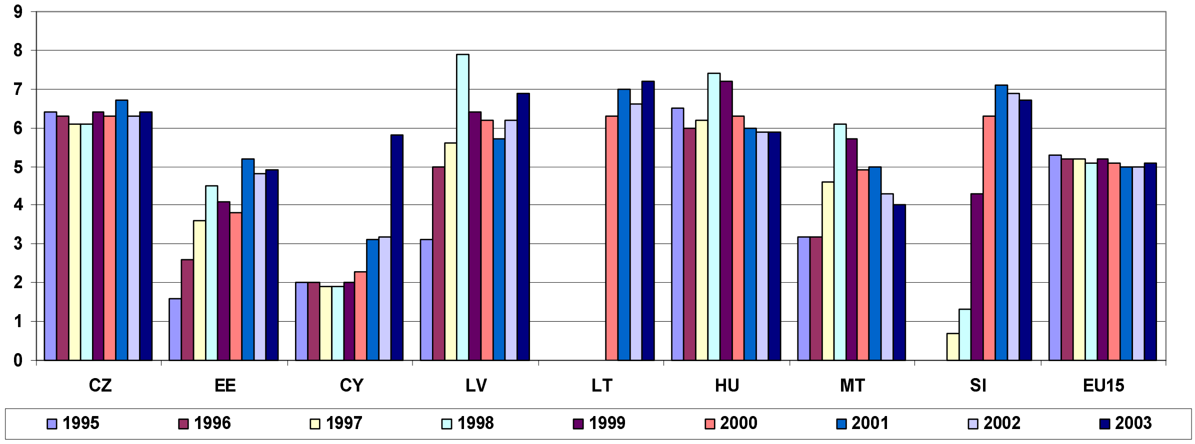
Figure 2: Environmental taxes as a share of total taxation (in %).



Note: Total taxation comprises taxes on production and imports, taxes on income and wealth, capital taxes and compulsory social contribution.
Source: EC Commission (2005a)

This, however, does not by itself imply great concern for environmental issues and use of economic instruments in NMS countries as these revenues come prevailingly from traditional excise taxes on fuels. The share of energy taxes on total tax revenues is on rise in some countries (Estonia, Cyprus, Latvia) or more or less on constant level in others (Czech Republic, Hungary). Except for Malta it currently represents major part of environmental tax revenues in all NMS. Slovenia is a specific case as energy taxation based on excise duties was not in place prior to 1999 and previously charged sales tax revenues were not accounted for in energy taxation statistics shown below.

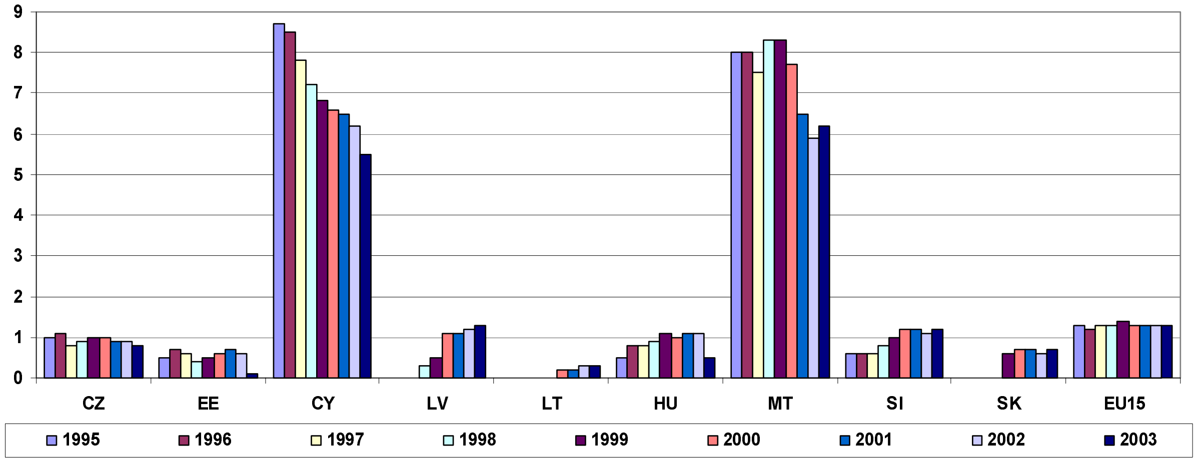
Figure 3: Energy taxes as a share of total taxation (in %)



Source: EC Commission (2005a)

All the new member states except Malta and Cyprus have lower transport taxation to total taxation rate than EU-15 average. Both Cyprus and Malta have in place relatively high vehicle taxes imposed on vehicle registration and circulation. However, the share is significantly decreasing in time in both countries and may be further reduced if a consensus is reached on directive on passenger related taxes[3] that aims at abolition of car registration taxes among others.

Figure 4: Transport taxes as a share of total taxation (in %)

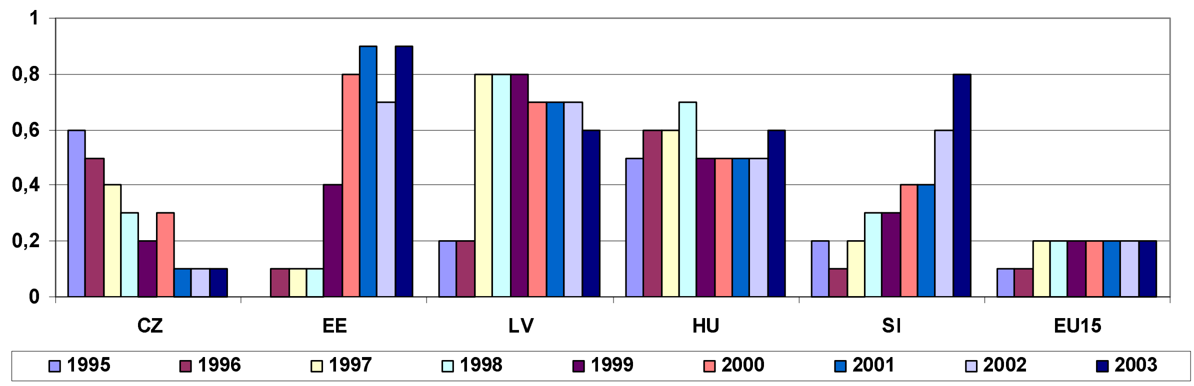


Source: EC Commission (2005a)

[3] Proposal for a Council Directive on passenger car related taxes, COM(2005) 261 final

Even though the category of pollution and resources taxation (mostly set in form of ecological charges) contains multiple taxes and fees, the revenue is rather marginal. Only in Hungary, Slovenia, Latvia, Estonia and the Czech Republic the revenue exceeds 0.1% of overall tax revenues. It should be stressed here that there is long tradition in earmarking of revenues from pollution and resource taxation to special parafiscal environmental funds. Revenue earmarking for financing environmental protection is important for the almost all Central European countries, particularly the Czech Republic, Hungary, Latvia, Poland, Slovakia and Slovenia. Obviously, the revenue neutrality will be hardly attainable if the ETR is intended to be based on increasing ecological taxes and charges levied on classical pollution and natural resources extraction earmarked for special funds.

Table 1: Pollution and resources taxation as a share of total taxation (in %)

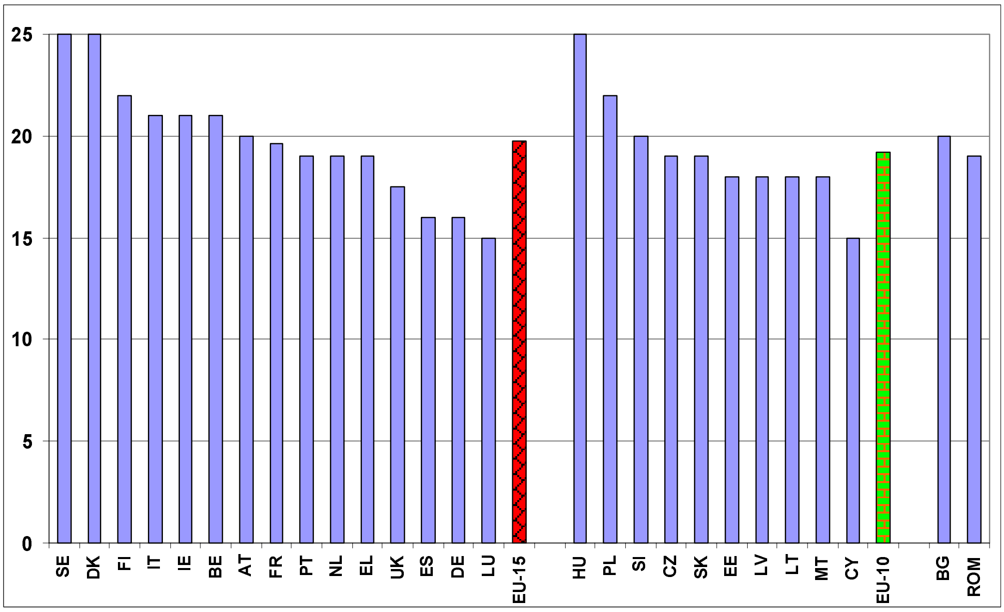


Source: EC Commission (2005a)

There is another special and important feature of CEE countries that need to be assessed, if one is evaluating a potential of the ETR based on increase of ecological charges. Improvement of poor environmental quality in CEE countries in the beginning of 1990s involved large investment expenses during entire 1990s. Moreover, the implementation of dozens directives from environmental *acquis communautaire* involved further large investments and control costs prior to and following EU accession (for instance these costs were estimated in the Czech Republic by Ministry for Environment at about 1.5% of GDP for the period 2000-2010). Obviously, the requirements of environmental regulation induce negative competitiveness effects on the economies undergoing complex restructuration. These effects enhance demand for and even pressure of affected agents on governments to introduce any support measures helping to overcome these negative impacts. Thus, if a new regulation intending to introduce new or increased rates of current ecological levies is discussed in CEE countries, a strong call for earmarking these new revenues to special (environmental) funds (so as to support environmental goals and co-finance abovementioned legislative requirements) is strongly dominating in the debate. All these tensions render a possibility for the ETR introduction based on ecological charges increase rather weak.

Considering the effect involved by taxation on change of households' behaviour, one may also pay the attention to the taxation of value added particularly on consumption of goods that have certain negative impact on the environment such as energies. New Member States and even new acceding countries do not benefit from any advantage in form of lower taxation as their rates are quite comparable with those ones in force in EU-15 Member States and above minimum standard rate required by the relevant directive (see Figure 5). Implementation of 6th VAT Directive, however, led also to an increase in VAT taxation of environmentally friendly goods that were taxed at reduced VAT rate before (around 5%) in some of new Member States.

Figure 5: Value Added Tax rates in EU25+2 (year 2005).



Source: EC (2005b).

1.2 Harmonisation of energy taxation

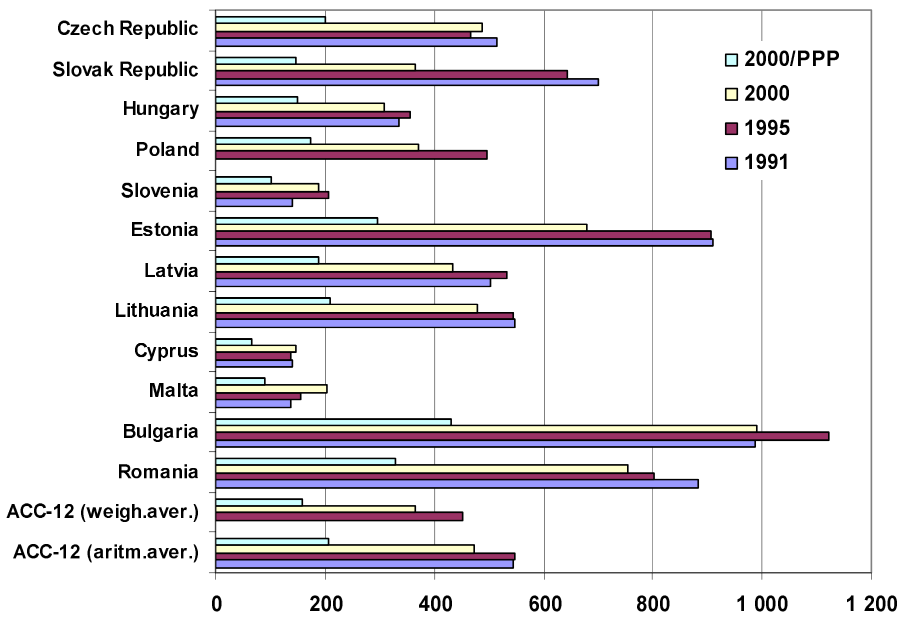
The framework for energy taxation was strengthened with the Council Directive 2003/96/EC of 27 October 2003 restructuring the Community framework for the taxation of energy products and electricity that entered into force on January 1st, 2004. Central and Eastern European states that became members of the EU in May 2004 were therefore obliged to comply with fiscal structures and the levels of taxation to be imposed on energy products and electricity set in the directive.

However, these minimum rates are liable to create serious economic and social difficulties in view of the ongoing economic transition, relatively low income level, comparatively low level of excise duties previously applied and limited ability to offset that additional tax burden by reducing other taxes. Thus the Commission suggested granting of transitional arrangements based on three principles: strict limitation in time, proportionality to the objective addressed, and where applicable with progressive alignment towards Community minimum rates. Moreover, environmental policy objectives such as environmental friendliness of heating fuels were also beard in mind.

The Council acknowledged existence of barriers to full implementation of the Directive and adopted the Council Directive 2004/74/EC of 29 April 2004 amending Directive 2003/96/EC as regards the possibility for certain Member States to apply, in respect of energy products and electricity, temporary exemptions or reductions in the levels of taxation. Since Cyprus failed to apply for transitional arrangements in due time the Council then adopted Directive 2004/75/EC of 29 April 2004 amending Directive 2003/96/EC as regards the possibility for Cyprus to apply, in respect of energy products and electricity, temporary exemptions or reductions in the level of taxation. These directives grant transitional periods to new member states in areas recognised as particularly socially and politically sensitive, including distant heating, solid fuels, electricity and gas. More detailed description is provided in country review section and summed up in a table in Annex IV.

One of the reasons for transitional period needs is that CEE countries have higher energy intensity: more than four times higher than EU average in the case of the Baltic states, Slovakia and the Czech Republic and about three times higher in the case of Poland and Hungary.

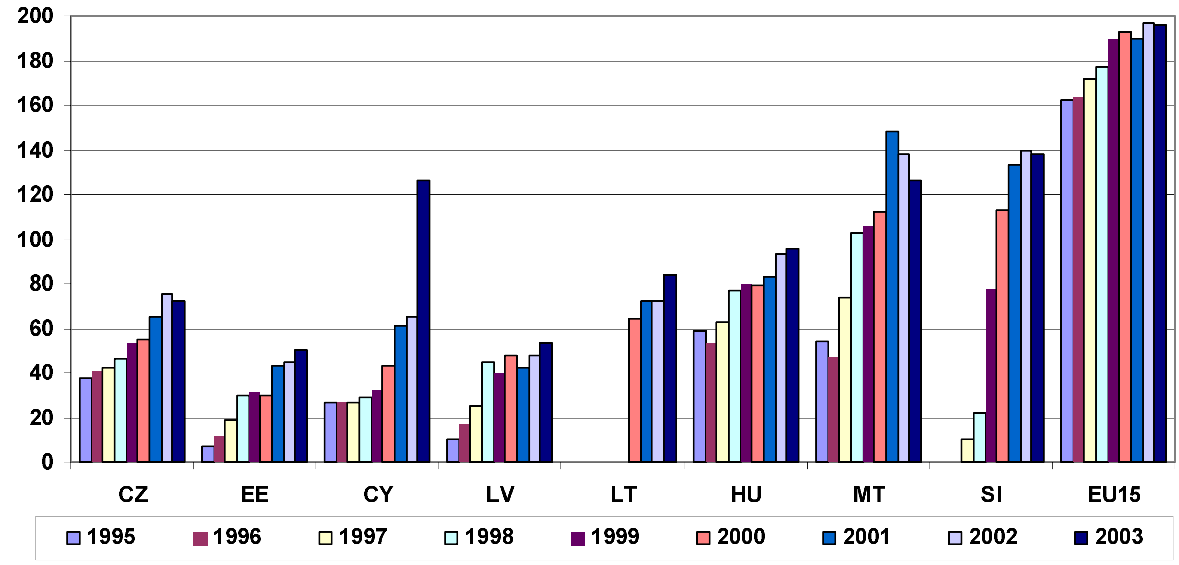
Figure 6: Energy intensity of the CEEC countries during 1990s, EU-15=100



Note: Energy intensity is expressed as a gross inland consumption of energy in unit of oil equivalent divided by GDP in constant 1995 prices.
Source: Eurostat, IEA/OECD

Therefore, a simultaneous cut in labour cost with energy-saving measure may present a desirable policy target for these countries. From the tax revenue point of view it is also worth mentioning what is the relation between energy tax revenues and final energy consumption. The following figure shows how new member states lag behind the average implicit tax rates on energy in old member states (EU 15) calculated as ratio of energy taxes per tons of oil equivalent (toe).

Figure 7: Energy tax revenues in relation to final energy consumption (ITR on energy; in EUR per toe).

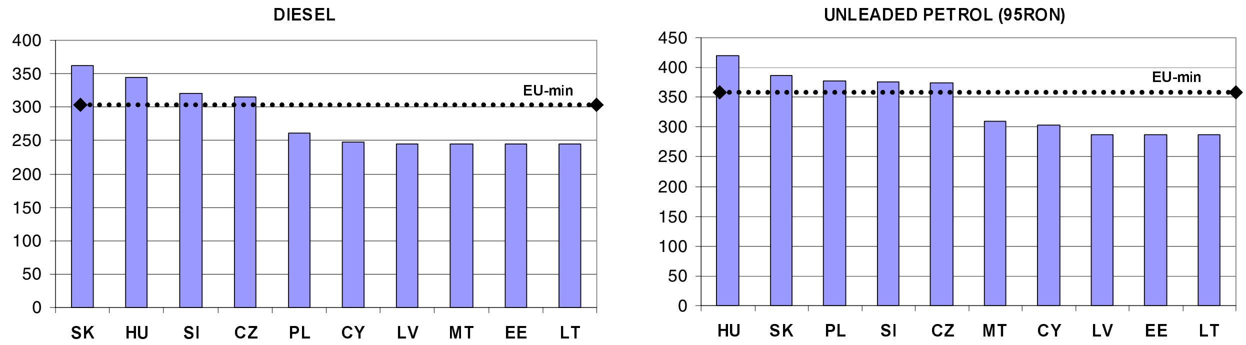


Note: ITR (implicit tax rate) on energy consumption is the ratio of energy tax revenues to final energy consumption in tons of oil equivalent.
Source: EC Commission (2005a)

However, if we consider real impact, the current rates should be compared with minimal levels prescribed by the Directive. As we can see in Figure 8, tax rates for diesel and unleaded petrol need to be increased up to the minimal rates set out by the Directive only in Baltic countries, Malta and Cyprus, and in Poland for diesel. The situation is different in taxation of electricity, gas and coal. Electricity is currently taxed in Hungary, Poland and Cyprus only; gas is taxed in Hungary, Cyprus, Malta (however gas is not used in Malta at all) and the Czech Republic (but the rate is set to zero if used for heating purposes); coal and coke is taxed in Cyprus and Slovenia.

The ETR can be enhanced only if either of new Member States decides to introduce much higher tax rates then required by the Directive. Nowadays, the minimal tax rates on electricity, gas and coal are not high enough to mobilise sufficient amount of additional revenues that may be used in the ETR. Tax rates on mineral oils are already above or very close to the minimal rates and in conjunction with high oil prices there are rather attempts to decrease taxation of diesel and petrol temporarily (e.g. in Poland and Slovenia).

Figure 8: Tax rates for diesel and unleaded petrol in new Member States (in €/1000 l)

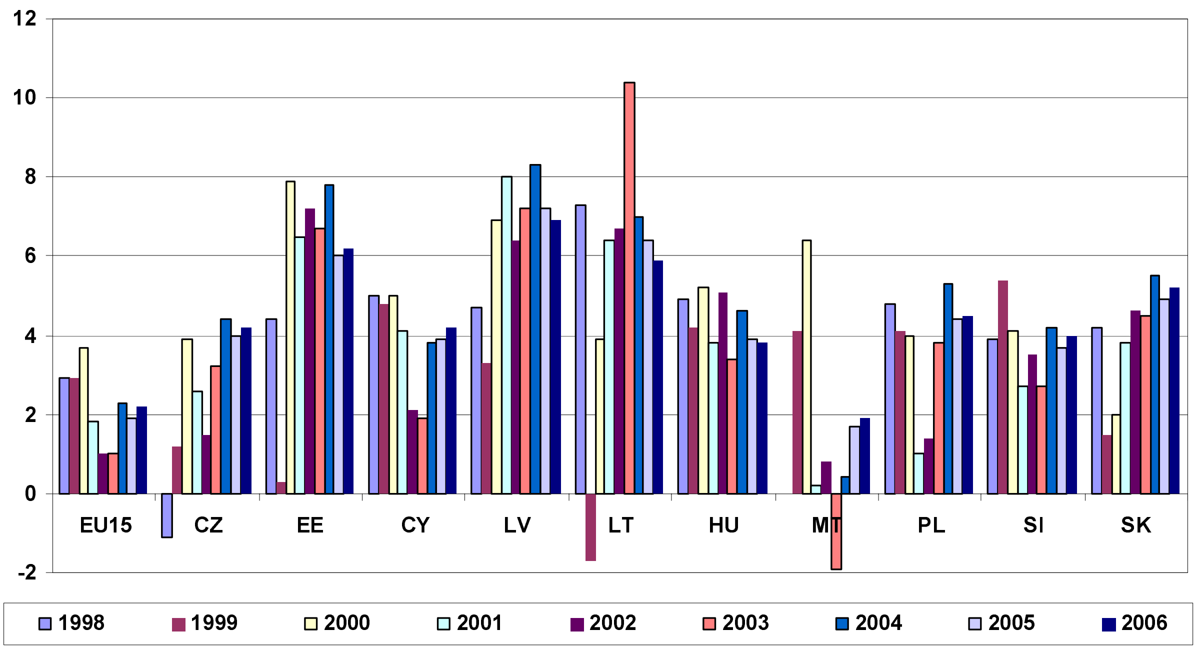


Source: EC Commission (2005b)

1.3 Public finance and macroeconomic perspective

When turning attention to overall economic climate in CEE countries handful of comments can be drawn. When starting with GDP we can see relatively high dynamics in GDP growth especially in Baltic countries and Slovakia. The only country that seems to be lacking behind average GDP growth rate in EU-15 is Malta currently recovering from economic slowdown in 2000-2003.

Figure 9: Real GDP growth rate (at constant 1995 prices as % change on previous year)



Note: data for 2005 and 2006 are forecasts
Source: Eurostat

GDP growth (since 2000 including forecast up to 2006) is in average two times higher in CEE, and even three times higher in Baltic countries compared with EU-15 average. This growth is accompanied with relatively low inflation. These conditions are of very importance if relative shares of income and profit taxation, and of environmental related levies are considered. Assuming no changes in tax regime such as change in rates or deductibles, the revenues of particular tax remain constant – meaning their share on GDP – only if its tax base is linear function of GDP. Indeed, this assumption does not hold for each base. We can assume that base for labour taxation is rather in line with nominal GDP growth, while energies are rather in line with real GDP growth. Keeping all things unchanged, if GDP grows, the relative share of labour taxation increases faster then the share of energy taxation. This divergence is even accelerated by higher inflation levels. Assuming this, higher GDP growth in CEE countries may counteract the ETR feature, if any, occurring in public finance system.

Indeed, public finance concerns are important when environmentally related levies and the ETR concept are discussed. Firstly, if environmental taxes are significantly ecologically effective, the tax base will erode, and the total public revenues decline, leaving no option for decreasing other taxes and threatening the public finance stability. This concern is, however, uncorroborated, since whenever the price elasticity of a good is between 0 and -1, then any increase of *ad valorem* tax[4] rate will not cause tax base erosion high enough to decrease the tax revenues. In the extreme case of price elasticity equal to -1, the two effects (increase in the tax rate and the tax base erosion) cancel one another out exactly. In the case of *unit* taxes, an increase in tax rate would not diminish revenues even if the price elasticity is -1. The demand has to be much more elastic to reduce the revenues after increase in a *unit* tax rate, the exact value depending on the before-tax price to tax rate ratio. Even so, empirical studies usually find energy price elasticity between -0.2 to -0.6[5].

Secondly, the *unit* taxes and *ad valorem* taxes differ substantially under the rule of constant revenues. While tax rates of *ad valorem* taxes are invariant with respect to targeting nominal or real revenues, this no longer holds for unit taxes such as excise tax. Rates of excise taxes or whatever *unit* taxes are usually not indexed on the price level. Therefore, the nominal rates of these taxes should steadily increase at the inflation rate to sustain the constant flow of real revenues. Continual increase or price indexation of excise tax rates may not be however politically or legally feasible. This is one of the reasons, why political representatives may be reluctant to use excise taxes for revenue-raising purposes. Then *ad valorem* taxes may present more desirable tool from that perspective. Indeed, revenue-raising objections to energy taxes were expressed by governments of CEE countries, namely for instance by the representatives of the Czech Ministry of Finance during preparatory work on the Czech ETR concept. Moreover, if the share of excise tax on GDP is called to stay unchanged, the excise tax rate should increase with real output, price level and technological progress. Even if we assume unitary elasticity of energy demand to output and abstract from technological progress, the excise tax rate should increase at the inflation rate. This is not obviously the case for *ad valorem* taxes such as labour and profit taxes (see more in Bruha & Scasny 2006). Note also the different impact of the technological progress: the technological progress tends to diminish direct tax rates, which sustain the desired constant real level of public revenues, while the opposite is true for excise tax rates. These considerations are crucial for assessing whether a particular tax change may or may not be called an ETR. The reason is that an increase in excise tax rates and decrease in direct tax rates may only reflect public finance stability issues, not concerns about the environment or fiscal system modernisation.

Except public finance concerns, labour market conditions are also often discussed in the ETR debate. Following double dividend hypothesis arguing that tax shift from labour taxation may boost employment and thus decrease unemployment, the ETR concept is considered as one possible tool for employment

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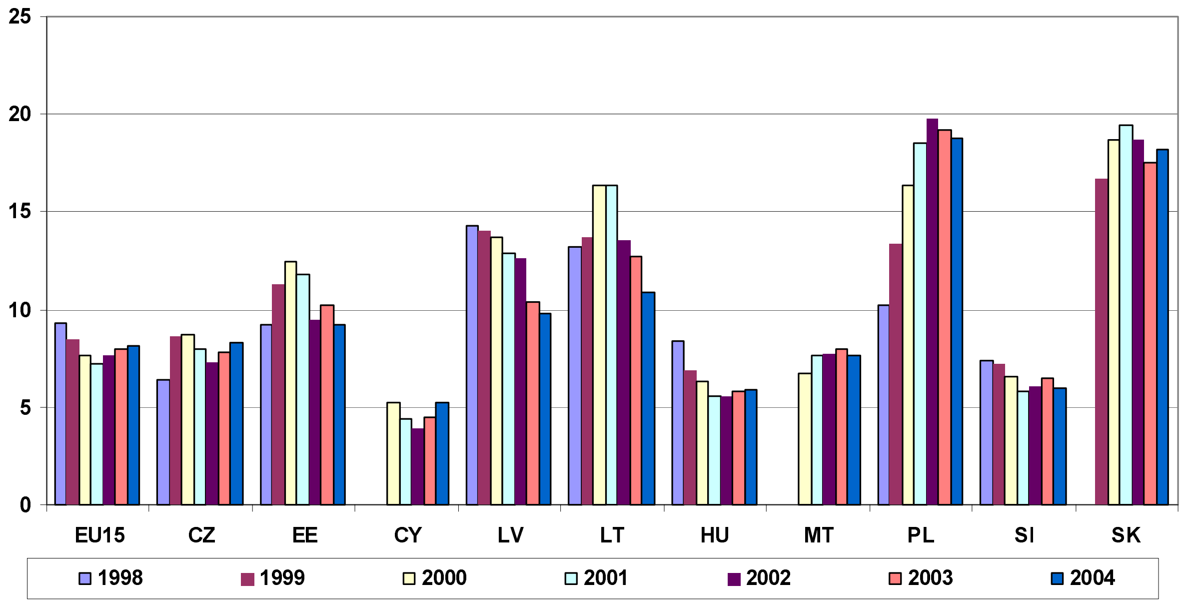
[4] *Unit tax* presents a tax that is imposed on natural unit such as litre of fuel, kilogram of coal, pieces of cigarettes or number of passenger vehicles owned. On the contrary, *ad valorem taxes* are imposed as a percentage of taxed base e.g. value added, wages and salaries or profit.

[5] For a survey on empirical estimates of price elasticities and behavioural responses see e.g. OECD 2000.

policy[6]. If this is true, a higher chance for the ETR concept introduction exists in the presence of high unemployment rate (this argument is also supported by the results of PETRAS project). Good for the ETR potential and bad for the unemployed, current rate of unemployment calms down the positive picture sketched by GDP growth rate. Only Cyprus, Hungary and Slovenia keep steadily the unemployment rate below EU-15 average, while Poland and Slovakia reach almost twice as high rate. The unemployment seems to be particular problem in Poland due to extremely big agricultural sector whose share on total employment is still surviving at almost 20% while contributing only by 3% of GDP.

Figure 10: Unemployment rate in new member states and EU-15 (in %)



Source: Eurostat

On the other hand, labour market remains relatively inflexible particularly in Visegrad countries and together with very low rate of part-time jobs (2.9% in Czech Republic and Hungary, 1.9 in Slovakia, but 12% in Poland; on the contrary 16% in EU-15 and 15% in OECD) this is perceived as a barrier for breaking gridlock of high unemployment rates.

When comparing level of labour taxation the average numbers for EU-15 and new member states do not show significant difference (36.8% vs. 34.5%) but there is a substantial difference among these states. The following figure shows that Cyprus and Malta are quite outliers from the group and that labour taxation level in Slovakia is on decline in last few years.

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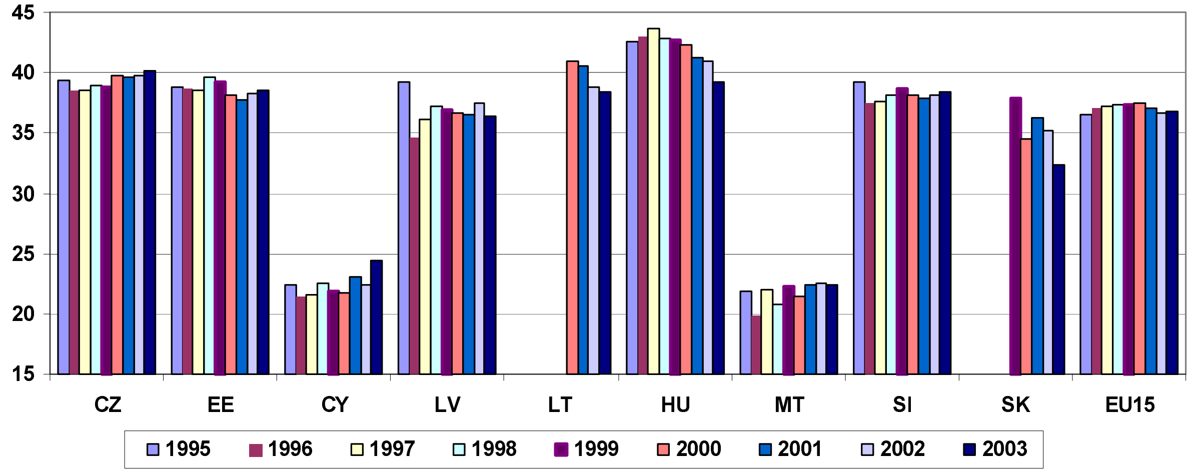
[6] We are aware of the fact that validity of double dividend hypothesis is rather complex problem and double dividend yield holds only if certain condition of labour market is fulfilled. We do not open discussion on this issue in this paper, rather refer interested reader to the relevant theoretical and empirical papers.

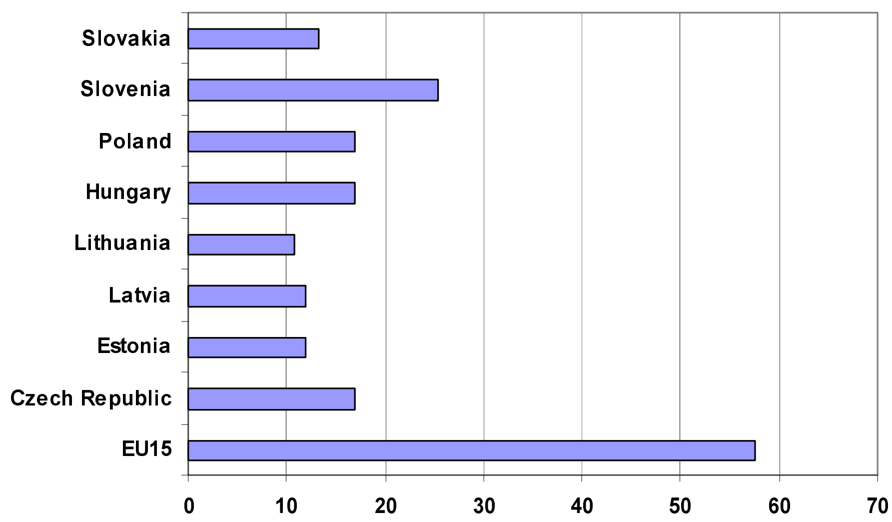
Figure 11: Implicit tax rates on labour in 1995-2003 (in %)



Note: The implicit tax rate on employed labour is defined as the sum of all direct and indirect taxes and employees' and employers' social contributions levied on employed labour income divided by the total compensation of employees working in the economic territory.
Source: EC Commission (2005a)

Moreover, CEE countries have significantly lower labour productivity compared to EU-15 (see figure below), higher labour taxes on low income earnings (except of Slovakia). To conclude, both high unemployment rate and relatively high labour taxation in new EU Member States (except Malta and Cyprus) create good conditions regarding possibility for the ETR introduction. These conditions are obviously necessary but not sufficient for possible success to introduce the ETR in CEE countries.

Figure 12: Labour productivity per person employed (2002; in thousand EUR)



Note: Labour productivity is measured as Gross Value added at current prices per person employed.
Source: Eurostat (2004)

2 Country review

This chapter describes main changes in tax system that are of relevance from the ETR perspective for all ten new EU Member States; for Visegrad countries (Hungary, Poland, Czech Republic and Slovakia) and Slovenia, Baltic countries (Estonia, Lithuania, Latvia), Malta and Cyprus. Each chapter is structured as follows: firstly overall description of environmental related levies in the country is provided, secondly special attention is paid for energy taxation, last development in ecological charges is described, then public finance changes relevant from the ETR perspective are briefly discussed, and lastly main ETR country movements and actions conclude. We apologise to provide unbalanced information for some countries, particularly in the case of Cyprus and Malta due to lack of information we were able to get.

2.1 Hungary

2.1.1 Environmental related levies in brief

Revenues from environmental related taxes and charges reached 3.668 bln EUR in 2004 representing some 12% of all taxes revenues. Excise duties made almost three quarters of environmental related taxes and charges revenues.

Table 2: Environmental related taxes and charges in Hungary (2004, in million EUR)

Tax/charge	Revenue	% of total
Environmental product charges	80	2.2%
Environmental load fees	26	0,7%
Energy tax	44	1.2%
Excise duties*	2 701	73.6%
Annual car tax	136	3.7%
Car registration tax	250	6,8%
Company car tax	100	2.7%
HGV tax	10	0.3%
Motorway tolls	76	2.1%
Land protection fee	13	0.4%
Forest maintenance fee	16	0,4%
Mining royalties	76	2.1%
Water resources charge	44	1,2%
Fee on nuclear energy	96	2.6%
TOTAL	**3 668**	**100%**
Overall tax revenues	30 200	
Percentage of all taxes	12%	

* including excise duty on alcohol and tobacco (excise duties on fuels alone brought EUR 1 602 million, representing 5.3% of total tax revenues)
Source: Lukács (2005)

2.1.2 Energy taxation

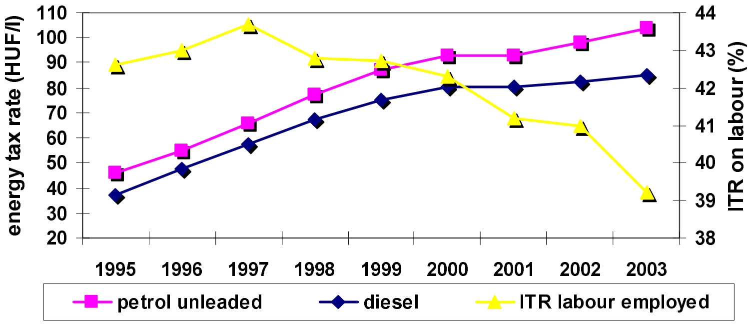
The modifications of excise regulations involved changes in tax rates as of 1 January 2004. The changes of excise tax rates were mostly driven by the law harmonisation. New energy tax was imposed on consumption of electricity and natural gas at applicable rates that are about 40% higher than the minimum requirement set by the EC Energy Directive. Revenues of HUF 11 billion (which represent about 50 thousands EUR) will be raised from this source in 2004. The tax is payable by utility suppliers, energy traders and large consumers eligible to enter the free market.

Energy taxation directive adopted shortly before EU enlargement represent an uneasy task for implementation at the time of accession for all CEE countries. Hungarian government therefore requested transitional periods for energy products and electricity used for district heating and for coal and coke. The first request was backed with argument that significant part of households (approx. 18%) occupies distant heated flats and therefore should bear the costs of energy tax paid on the inputs while the remaining household could benefit form the exemption granted in the directive to the individual heating. The Council held this request proportionate and granted a transitional period until 1.1.2010.

The second request was substantiated by excessive administrative costs. From the overall coal consumption some 96-97% lies outside the scope of the directive or is exempted (e.g. electricity production). Taxing the remaining 4600 TJ would lead to disproportionate administrative costs. Moreover the Hungarian government pledged to establish an effective system for coal taxation. The Council approved the exemption for coal and coke until 1 January 2009.

If we compare rates of excise taxes levied on motor fuels in Hungary during the 1995-2003 period with implicit tax rates on employed labour we will get ETR-like picture. Nominally these rates were increasing during the whole period while ITR on labour has decreased.

Figure 13: Trends in energy vs. income taxation



Source: IEA (2004), EC Commission (2005a)

Nevertheless, the figure in Annex III show that excise tax rates on fuels have declined in real terms (deflated using the HICP index) since 1999. Thus this means that principal tax shift did not occur and the corrective purpose of taxation has declined.

2.1.3 Other environmental taxes and charges

Environmental product charges cover charges imposed on vehicle tyres, packaging materials, refrigerators and refrigerants, motor vehicle batteries, lubricating oils, junk mail and currently introduced charge on electric and electronic products. In 2005 charge on diluents and solvents was abolished.

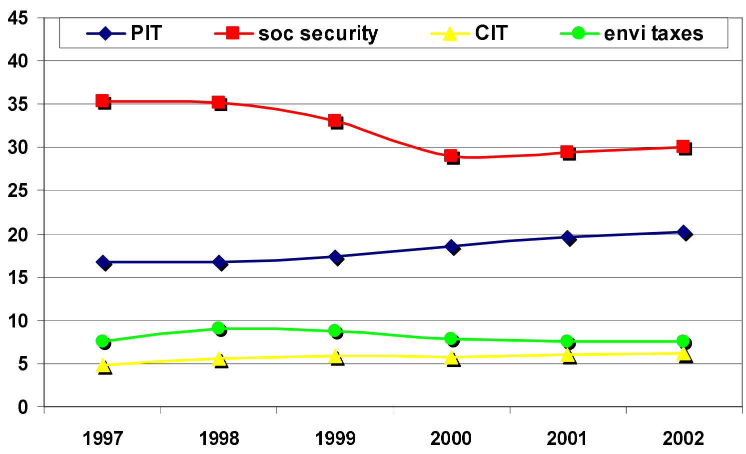
Starting from 2004 environmental load fees on air, water and soil have been introduced and it is expected to bring about revenues worth some EUR 36 million in 2005. The fee is payable by enterprises producing materials that pose a potential environmental risk to air, water, sewage or soil.

Along with these changes a registration tax on passenger cars and caravans was introduced. This registration tax replaced the existing consumption tax that aimed at making imports of used motorcars more difficult. The registration tax rates vary according to the cylinder volume, age and environmental classification. A motor vehicle tax (which is an annual tax) has been raised by more than 20% and tax on company cars has been doubled. First motorway toll was introduced in 1996 on a part of Budapest-Vienna M1 highway and M3 highway but the toll was replaced in 2000 with time-based road user charge (vignette). However, re-introducing of electronic road tolls for heavy good vehicles is planned from 2008 due to the fact that neighbouring countries has already introduced one (Austria) or plan to do so in near future (Slovakia).

2.1.4 Other changes in public finance system

The share of direct taxation on total tax receipts has seen only minor decrease by 0.5% in the 1997-2002 period. The decrease of social security revenues have been compensated by increase of revenues from personal income tax.

Figure 14: Comparison of changes in share of taxation revenues 1997-2002 (as % of total tax revenues)



Source: OECD (2005)

In 2003 personal income tax rates have been reduced, tax rates dropped from 20-30-40% to 18-26-38%. The lowest bracket increased from HUF 650 000 to HUF 800 000 (i.e. from about 2600 to 3200 EUR), and the highest one increased from HUF 1 350 000 to 1 500 000 (i.e. from about 5400 to 6000 EUR). Nevertheless actual cost of labour has increased overall since the maximum of the tax credit in personal income tax was reduced from HUF 240 0000 to HUF 120 000 (from about 960 to 480 EUR) and employees' health insurance contribution rate was raised to 4% in 2004. The changes in corporate profit tax lowered the rate from 18% to 16%.

Social security contribution payable by employers decreased from 39% in 1999 to 33% in 2000, which (calculating also with the relatively small cost increase due to higher health contribution) resulted in an overall drop in the level of wage costs by HUF 210 billion in 2000 (this corresponds to 800 million EUR). In 2001, social security contribution to be paid by employers was further cut down to 30%, and in 2002 to 29%.

VAT rates were changed too: the zero per cent tax rate was raised to 5%, the 12% tax rate went up to 15%, and the 25% standard rate did not change. The annual revenue limit for tax-exempted subjects was increased from HUF 2 million to HUF 4 million (i.e. from 8000 to 16000 EUR). Moreover standard VAT rate has been extended to electricity (taxed at the 12% rate before).

Together with preparation of the State Budget Bill for 2004 substantial changes in taxation system took place. In the personal income tax system, the middle rate of the three-tier tax schedule of 2004 (14 - 26 - 38%) will be dropped, while the minimum wage continues to be tax-free. Foreseen fiscal developments in 2006-2008 aims at a reduction of social security burden and other tax obligation of enterprises but no changes are planed with respect to excise taxes (with an exception of tobacco). However, the room for further tax reduction is substantially limited due to significant budget overruns that generate difficult conditions for fiscal policy.

2.1.5 ETR activities

For several years the lobbying for ETR is undertaken by Lévego Munkacsoport (Clean Air Action Group) an umbrella organisation of Hungarian NGOs. Each year (starting from 1999) CAAG prepares alternative state budget bill that proposes tax shifts according to ETR principles. In 2001 Environmental Committee of the Hungarian Parliament set up Green Budget Working Group that worked in close cooperation with CAAG. The working group discussed studies on ETR and prepared various proposals for gradual introduction of ETR. This cooperation achieved particular success in 2003 when the changes to tax laws and 2004 State Budget Act were in line with some key elements of CAAG proposal; however, extra revenues use was not as much in line with ETR principles.

2.2 Poland

2.2.1 Environmental related levies in brief

Environmentally related taxes and charges in Poland cover waste sector (waste charges), land, soil and forest resources, air pollution (air pollution charges), energy products (excise taxes and fuel fee), water abstraction/effluent (water abstraction/effluent charges), mining (royalties) and biodiversity and wildlife protection (entrance fees). Revenues from excise taxes on motor fuels, passenger cars and electricity amounted to EUR 4.5 bln in 2004 that is slightly less than half of all excise taxes revenues and approximately 2.3 of GDP. The revenues from fees and charges are rather marginal at the level of EUR 129 million that is less than 0.1% of GDP.

Table 3: State budget revenues (in million EUR)

	2003	% of GDP	2004	% of GDP
Total revenues	34 587,90	18,6	34 468,70	17,7
of which:				
Tax revenue	30 748,90	16,6	29 901,00	15,3
Indirect taxes	21 702,50	11,7	22 274,30	11,4
VAT	13 724,90	7,4	13 732,50	7
Excise tax	7 819,30	4,2	8 373,20	4,3
of which:				
- motor fuels	3 460,30	1,9	3 612,60	1,9
- cars	154,9	0,1	313,7	0,2
- electricity	574	0,3	583,1	0,3
- total	4 189,20	2,3	4 509,40	2,3

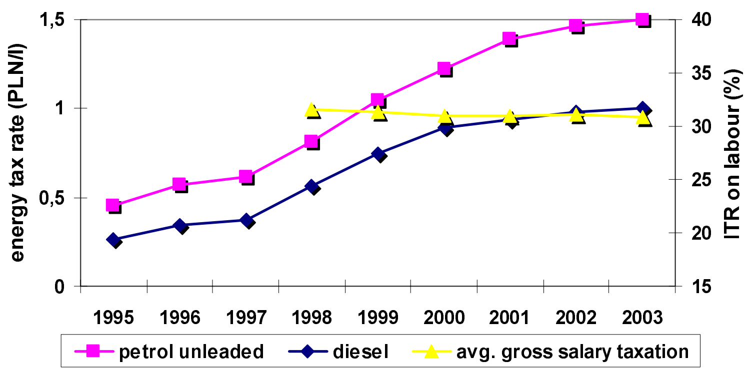
Source: Swierkula (2005)

2.2.2 Energy taxation

VAT and excise tax regulations have been finally separated according to the EU standards in 2004. With respect to the energy tax directive excise tax was broadened to include electricity and tax rates were raised for other energy products but handful of transitional periods has been negotiated - for natural gas until 2013, for gas oil until 2011, for coal until 2010 and complete exemption for coke and heavy fuel oil (see next subsection for more details on exemptions). Fuel fee on petrol was introduced in January 2004 at the rate PLN 105 per 1000 kg (EUR 23) to help finance National Road Fund.

Rates of selected excise taxes on motor fuels are displayed in Annex III. These rates are given in both nominal and real (1996 prices, deflated by the HICP index) terms. Contrary to the Hungarian case, these rates are not declining in real terms. Therefore, the corrective (and fiscal) roles of these taxes have not been falling during last years. On the other hand average taxation of gross salary remained almost stable in 1997-2003 as following figure shows.

Figure 15: Trends in energy vs. income taxation



Source: IEA (2004), EC Commission (2005a)

The Polish government facing the necessity of energy taxation directive implementation requested a great deal of transitional periods - for propellants, heavy fuel oil, gas oil used as heating oil, natural gas, coal and for electricity.

The propellants for which transitional arrangements were requested comprised leaded and unleaded petrol and gas oil. Tax increases required to achieve minimum rates of respective propellants would be 15%, 9,5% and 50%. The Council acknowledged that with respect to leaded petrol Article 18(2) allowing transitional period until 1.1.2007 in order to avoid price instability subject to insignificant distorting of competition applies. For unleaded petrol the transitional period until 1.1.2009 were granted and for gas oil until 1.1.2010 for the minimum tax level of 302 EUR and until 1.1.2012 for minimum tax level of 330, subject to effective tax rate not less than 245 EUR as from 1.5.2004 and 274 EUR as from 1.1.2008.

Transitional period for heavy fuel oil were requested due to wide utilization in heat and power co-generation, heating plants and technological processes and the lack of time for accommodating the taxation system to the possibility of applying differentiate tax rates according to uses. The Council granted the transitional period until 1.1.2008.

The request for transitional period for gas oil used as heating fuel was partly denied as the level of taxation is well above the minimum rate set by the directive. The request for total or partial exemption to gas oil used by schools and other public utilities was upheld by Council until 1.1.2008.

As natural gas is not subject to excise duty the request for transitional period was raised. However since the share of natural gas in final energy consumption only slightly exceeded 11% in 2000 Article 15(1)(g) laying down an exemption should apply.

Similarly coal was not subject to excise tax and with respect to the ongoing restructuring of coal mining industry and relative significant share of district heating on coal consumption (3%) the government applied for the transitional period. The Council approved virtually the same transitional periods for coal used for district heating and coal used for other purposes until 1.1.2012.

The request for transitional period to align current electricity taxation system with the Community framework was granted by the Council until 1.1.2006.

2.2.3 Other environmental taxes and charges

A new product fee was introduced for non-compliance with set level of recycling of specific types of products (electrical and IT equipment, batteries) and specific types of packaging. The calculation basis is the difference between required level of recycling/recovery and actual quantity recycled or recovered.

In the Third National Environmental Policy (the National Environmental Policy for 2003 - 2006 with perspectives for 2007 - 2010), the Polish government declared an intention for total elimination of existing hidden and formal subsidies for fuels and energy carriers. In the 1990s direct subsidies and debt forgiveness reached some 34 billions PLN. Restructuring programme for 2004-2010 will entail subsidies of almost 10 billions PLN (about 2.5 billions EUR).

The new National Allocation Plan allows 35% more emission than foreseen in the Climate Policy Plan. This implies that further environmental regulation is not demanded on the grounds of an external pressure.

2.2.4 Other changes in public finance system

Essential changes introduced to the tax system in the recent years were connected with approximation of EU acquis, decreasing of fiscal burden for entrepreneurs and simplification of the tax system. An important driving force for these changes was a need to recover from economic slowdown during 2001-

2002 that led to deterioration of basic macroeconomic indicators such as fall in economic growth rate, investment activity of enterprises, decrease of foreign direct investments and growth of unemployment rate (up to 20%). Agriculture remained the most problematic sector with 19% of total employment but producing only 3% per cent of GDP. Moreover there is still need for finishing of restructuring of mining and steelmaking industry.

The changes in tax system in 2002-2003 aimed at creating an environment for boosting of economic growth. These changes included accelerated depreciation of fixed assets or reduction of corporate income tax level by 1% to 27% (note that the rate was 40% in 1996). More substantial reduction occurred in 2004 when the rate was lowered to 19%. As an accomplishing measure a flat 19% personal income tax option for taxpayers running economic activity was put in place instead of previously used progressive tax rates (19%, 30%, 40%).

Until May 2008 the transitional period was granted for reduced rate of VAT (3%) for sales of products of agriculture, forestry, hunting and fishery and connected services (including fertilizers and pesticides). The other reduced rate (7%) is valid for selected services (transport, accommodation, housing construction) and products (medical, building material) and the standard rate of 22% covers majority of products and services.

At the municipal level the real estate and land tax is imposed while the tax ceiling is prescribed in the Law on Local Taxes and Fees as follows (for 2005): land used for business purposes PLN 0.66 per sq. meter (EUR 0.16) and buildings used for business purposes PLN 17.98 per sq. meter (EUR 4.32).

2.2.5 ETR activities

The ETR adoption is rather a difficult issue, especially in medium horizon - currently the theme has been frozen until the next parliamentary election in autumn 2005 and the concept itself is not specifically mentioned in any of official documents. The main argument behind this reluctant stance is the existing disarray in public finances that makes the theme unattractive. However, Ministry for Environment is making efforts such as a study on ETR potential for Poland and cooperation on German ETR know-how transmission via organising several seminars. Polish ad hoc working group on ETR was established by the Secretary of State in Ministry of the Environment of Poland. Its members consist of university and academia experts, representatives from the Polish Ministry of the Environment, the Ministry of Finance, and environmental NGO's. The main impetus for ETR comes from civil sector - Institute for Sustainable Development, an independent non-profit organisation, has organised several international conferences on ETR topic and is engaged in projects dealing with both scientific and public awareness rising aspects of ETR.

2.3 Slovenia

2.3.1 Environmental related levies in brief

Environmental taxes in place in Slovenia amounted to SIT 37 bn (EUR 154 million) in 2003. Slovenia has introduced great deal of environmental taxes – tax on use of waters, CO_2 tax, tax on lubricating oils and liquids, landfill tax and tax on old motor vehicles. Introduction of taxes on waste electrical and electronic equipment, waste batteries and tires is scheduled for 2006. Unlike CO_2 tax that was arranged as a general tax the revenues from other environmental taxes are used for financing of specific programmes.

Table 4: Revenues from environmental taxes 1999-2003

Year	1999	2000	2001	2002	2003
Revenues	SIT 22.4 bn (EUR 97 mio)	SIT 25.8 bn (EUR 111 mio)	SIT 26.4 bn (EUR 114 mio)	SIT 36.6 bn (EUR 158 mio)	SIT 37 bn (EUR 154 mio)

Source: Slovenia Business Week 7/2003 and 43/2004

2.3.2 Energy taxation

In 1999 the sales tax system was replaced with a system based on VAT and excise taxes. In 1997 a tax on CO_2 was introduced. The tax is due for gaseous, liquid and solid fuels for heating, turbines and motor vehicles according to the carbon content (as set in a ministerial decree). At the beginning the rate was 1 SIT per emission unit raised in 1998 to 3 SIT. The revenues in 2001 amounted to SIT 14 bn (EUR 61 million). In April 2005 the government exempted 96 biggest CO_2 emitters that are included in EU emission trading system from CO_2 tax. Further breaks were provided for CHP installations and other facilities that have concluded an agreement on reduction of CO_2 emissions[7].

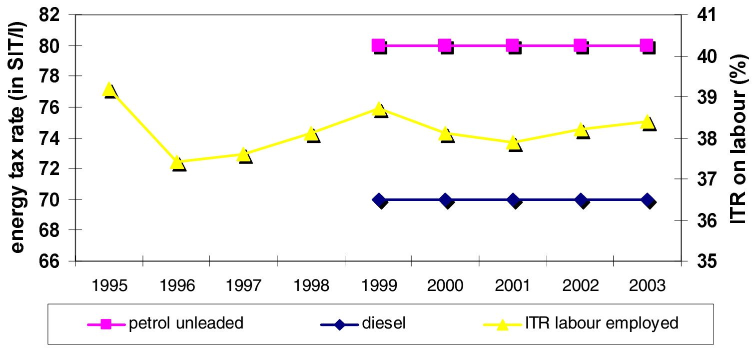
Slovenian government requested two transitional periods for implementation of minimum tax rates from Directive 2003/96/EC - for electricity and for natural gas. First one was for introducing excise duty on electricity in order to avoid jeopardising price stability and achieve a balance between the environmental and economic policies. The Council recalled that Article 18(2) allows for a transitional period until 1.1.2007 in such cases so no additional arrangements are needed.

With respect to natural gas it was argued that supplies of natural gas are subject to excise duty and to a CO_2 tax in the range from SIT 44.12 to 211.8 per GJ (EUR 0.19 to 0.93). The share of natural gas in final energy consumption was 15.1% in 2000 that is slightly above a threshold set up in Article 15(1)(g) of the Directive allowing total or partial exemption for a maximum period of 10 years. The government aims at increasing the use of natural gas to meet the increasing need for electricity and heat and to replace fossil fuels as a part of a strategy for fulfilling Kyoto commitments. The Council recognised this effort and granted the transitional period similarly to that of Article 15(1)(g).

Nominal excise tax rates on motor fuels remained constant during the 1999-2004 period and therefore their real rates declined (prices deflated by the HICP index; see the figure in Annex III). Neither the level of employed labour taxation has substantially changed as is apparent from following figure.

[7] It is estimated that to meet the Kyoto targets the share of renewable energy sources should increase to 12 percent by 2010, up from 8.8 percent in 2001 subject to improvement of energy efficiency of 10-15%.

Figure 16: Trends in energy vs. income taxation



Source: IEA (2004), EC Commission (2005a)

2.3.3 Other environmental taxes and charges

Tax on old motor vehicle was introduced in 2003 as the sixth environmental tax. The tax is paid by the producer or importer according to vehicle weight in amount of SIT 10 (EUR 0.04) per kilogram (raised to SIT 14 (EUR 0.06) in 2004). The aim of the tax is to cover expenses of a public service dealing with old motor vehicles that will be in full operation from January 2007.

2.3.4 Other changes in public finance system

The tax reform that begins to be implemented in 2005 aimed at:

- reducing the direct tax burden on labour;
- streamlining the tax reliefs in corporate income tax and spur investment in R&D as well as unburden lower income taxpayers.

Changes in the area of taxation will be accompanied by a more efficient administration of public taxes.

The new Personal Income Tax Act and Corporate Income Tax Act were adopted in 2004. However, its full implementation started with January 1st, 2005. The Personal Income Tax Act reduces primarily the burden for lower income taxpayers. In addition, the minimum threshold for payroll taxes was raised to lower the tax burden of the lowest income group. The combined effect of changes in personal income and payroll taxes is expected to enhance low income earners' employment perspectives. The new personal income tax regime aims at equalizing the tax burden on all sources of income and is based on the principle of equal tax treatment for all taxpayers with approximately equal incomes. The new Income Tax Act lays down five tax brackets, with rates ranging from 16% to 50%.

The amendment to the Payroll Tax Act raising the taxable threshold from 49% to 62% of the average salary and the taxable minimum has been raised from SIT 130,000 (EUR 542) to SIT 165,000 (EUR 688).

The Corporate Income Tax Act expands the tax base through a more precise definition of taxpayers and a stricter stipulation of detailed conditions for exemptions for those engaged in non-profit activities. Tax incentives are better targeted and geared towards fostering competitiveness. The current tax 25% tax rate is retained the effective tax rate is expected to increase from its current 12% to 17%. The expected increased revenues from this source will at least partially make up for the reduced revenues from income tax.

Social security contribution started at 19.9% for employers and 22.1% for employees were reduced for the part of employers to 16.1% of the amount of the gross wage. Over the coming years, the Government does not envisage further changes in the level of social-security contribution rates.

As expressed in updated convergence programme (January 2005) the Government is not planning significant changes in indirect taxes (primarily VAT and excise duties) in next years. So far, revisions to the VAT Act have merely harmonised Slovenia's VAT system with the one of the EU without significant fiscal consequences. The government will continue to adjust excise duties in accordance with the obligations accepted in pre-accession negotiations. Excise duties on liquid fuels will continue to be adjusted to buffer the high volatility of oil price changes and especially their secondary effects.

The combined cumulative effect of the changes in tax system on total revenue compared to the base year in 2004 will be negative of about SIT 7.5 bln. (approx. EUR 30 million) from 2007 onwards.

Recently Slovenian government released a Blueprint for Strategic Reforms as a consequence of Slovenia Development Strategy of June 2005. The proposed reforms do not deal with environmental related taxes at all as the main concern is a flat rate of income tax and VAT and gradual phase out of payroll tax.

2.3.5 ETR activities

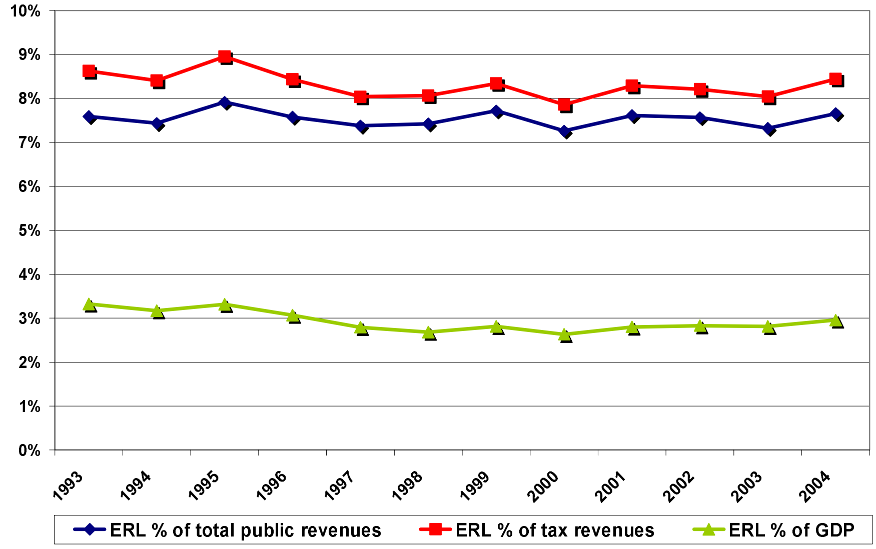
The 'Pinocchio' project attempted to lobby for ETR implementation with support from working group on environmental fiscal reform set up by EEB. NGO Fokus is publishing supporting materials as a part of its energy campaign.

2.4 Czech Republic

2.4.1 Environmental related levies in brief

Environmentally related taxes and charges account for 8% of total tax revenues in the Czech Republic (that is 3% of GDP). Excise tax on fuels makes up some 78%, road tax 7%, waste charges 5%, road user charge 3%, air pollution charges, water charges, raw material exploitation charges, ozone depleting substances charge, charges on conversion of farm/forest land and electric and electronic equipment product charges count for the rest.

Figure 17: Environmentally related levies in the Czech Republic



Source: Scasny (2005)

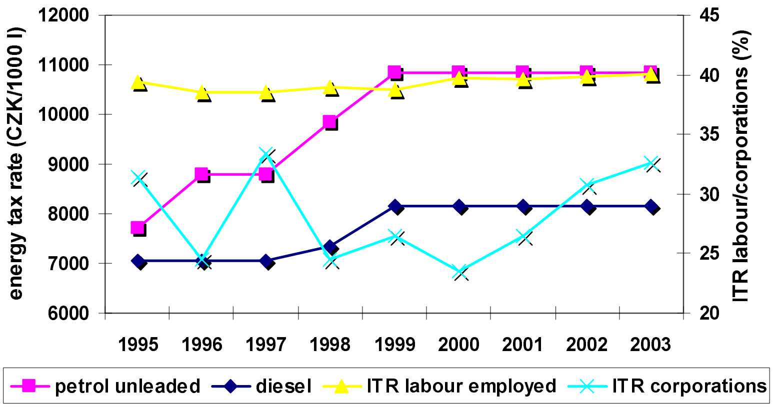
The grounding of the current tax system dates back to 1993 when the general tax reform was undergone. New excise taxes and VAT, that replaced sales taxes, were adopted together with a reform of personal and corporate income taxation. Thus the tax structure has become broadly comparable with those of the EU Member States.

Public revenues consist from taxes levied on goods and services, taxes levied on income and property, obligatory social and health insurance contributions, non-tax and capital revenues, and subsidies from abroad. The base of the tax system consists of taxes on profits and labour income, value added tax, special excise taxes (mainly on energy, tobaccos and alcohol). The system is supplemented by special taxes (such as road tax, property tax) and special fees including highway tolls. The obligatory social security and health insurance was established in parallel with the tax system. This insurance is paid to particular funds. The social and health insurance, which is de facto a linear tax on labour income, is paid by employees and employers. The social and health insurance, brings a high share of public revenues (about 40% - 45% of total public revenues), while the progressive labour income tax has a significantly smaller share: less than 15% of total public revenues). Thus public budgets obtain about 50% of revenues from labour taxation. VAT, taxation of profits and property brings about one third of total public revenues.

2.4.2 Energy taxation

Comparison of trends of taxation of motor fuels and labour shows rather insignificant changes in the level of implicit tax rates on labour and fluctuating implicit tax rate for corporations, while excise tax rates on energy carriers increased during the 90s nominally (see Figure 18).

Figure 18: Trends in energy vs. income taxation



Source: IEA (2004), EC Commission (2005a)

However, measured in the real rates (deflated by HICP) excise tax rates did actually fall (see Annex III which displays selected nominal and real rates of motor-fuel excise-tax rates).

The most important elements of energy taxation include excise taxes and VAT. Excise taxes have been applying for certain mineral oils, tobacco products and alcohols. Excise tax on mineral oils was initially levied only on their use as propellants but the scope was broadened in several steps to include heating use of certain energy products.

According to the government setting the tax rates to the minimum prescribed in the directive would lead to price increases for final consumption of around 1% for electricity, 10% for solid fuels and up to 5% for natural gas. Since electricity and solid fuels are not subject to tax (and natural gas is taxed at a zero rate) the government is willing to adjust the rates at the same time in order to avoid distortion of competition in the energy market. Moreover the liberalisation of the electricity market is underway and is due to be fully opened by the end of 2005. The main argument for transitional arrangement for solid fuels was the negative impact on employment in the coal mining regions. For these reasons the Council approved total or partial exemption or reduction of taxation of electricity, natural gas and solid fuels until January 1st, 2008.

With respect to VAT gasoline, diesel and oils were subject to the standard rate until January 1998, while other types of energy enjoyed the reduced rate. The central heating production is exempt to date as a transition period for the lower VAT rate was granted until the end of 2007.

2.4.3 Other environmental taxes and charges

In 1991, Czech Republic has introduced air pollution charges for main air pollutants. The charge payers are large and medium air pollution sources, and small stationary sources (only commercial activities). The charge rate is based on the amount of specific pollutants. 98% of revenues are derived from energy use (mainly lignite and oil).

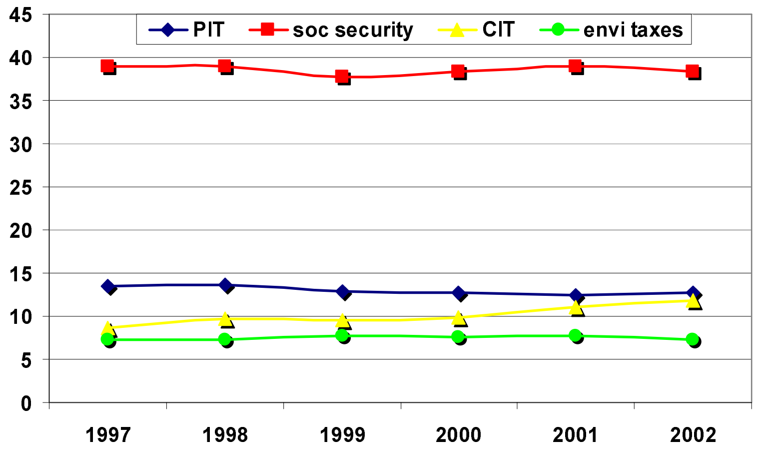
The revenues from air pollution charges go to the State Environmental Fund, the revenues from small sources to the local budget. In comparison with the excise duties on energy, this revenue have only marginal importance.

In 2005 new product charges were introduced on electric and electronic appliances aimed at financing of recycling programmes.

2.4.4 Other changes in public finance system

As it is apparent from the following figure there has not been any significant shift in taxation revenues. Share of social security contribution reaching almost 40% of total tax receipts ranks Czech Republic (together with Germany) on the top in the EU.

Figure 19: Changes in share of taxation revenues 1997-2002 (as % of total tax revenues)



Source: OECD (2005)

The VAT was introduced with 23% standard rate and 5% reduced rate. Starting from 1995 standard rate was lowered to 22% and again in May 2004 to 19%. However the latter decrease was counterbalanced with substantial reduction of items eligible for reduced rate as a consequence of total transposition of the 6th VAT Directive.

The corporation income tax was from the initial rate of 45% in 1993 continuously decreased in 7 steps to currently applied 26% which will be lowered to 24% starting from January 2006. Tax on income for individuals was based on 6 tax brackets with marginal rates ranging from 15% up to 47%. Since 2000 the number of tax brackets was reduced to 4 and the rates range from 15% to 32%. Amendment of the Act on income taxation is discussed (Autumn 2005) in order lower taxation for low-income groups by lowering first two income tax rates and by increasing the first income tax bracket.

2.4.5 ETR activities

The first concept on environmental tax reform was prepared by the Ministry of the Environment in collaboration with the Ministry of Finance during year 2000. The ETR proposal and its tax rates were mainly based on EC Energy Tax Directive proposal[8]. However further discussions were interrupted in mid 2001 as the Government intended that the concept of ETR will be incorporated in a more comprehensive reform of public finance to be prepared in mid-term horizon.

After the election in June 2002 the ETR has been declared as a one of the priorities of the new coalition government. Consequently, the Inter-ministerial Working Group on ETR was established in January 2003 containing the representatives from the main involved ministries such as finance, labour and social affairs,

[8] Proposal for a Council Directive restructuring the Community framework for the taxation of energy products, COM(97) 30 final

industry and trade, transport and environment. The aim of the Working Group was to prepare the ETR concept. The Czech Ministry of the Environment in collaboration with the Czech Ministry of Finance were obliged to prepare a concept of Environmental Tax Reform up to the end of June 2004. The deadline was then however postponed to the end of 2004 but the concept started to melt into mere transposition of the minimum rates from the Energy Directive. In this perspective Ministry of the Environment pulled out its proposals for rewriting and the new concept is awaited before the end of 2005.

In order to overcome barriers for the ETR introduction and boost discussion on the ETR, the Platform for Environmental Fiscal Reform was established in the winter 2002 in collaboration of environmental NGOs and Charles University Environment Center. Moreover, overall ten seminars on ETR were organised during 2003 to 2005 separately always with the main stakeholders such as academia, NGOs, officials, churches and foundations, trade union, industrial associations, governmental political party, and last but not least with media.

Since the ETR concept has been discussed in the Czech Republic to the greatest extent among CEE countries, we devote Annex II to a more detailed description of the evolution of the Czech ETR concept.

2.5 Slovakia

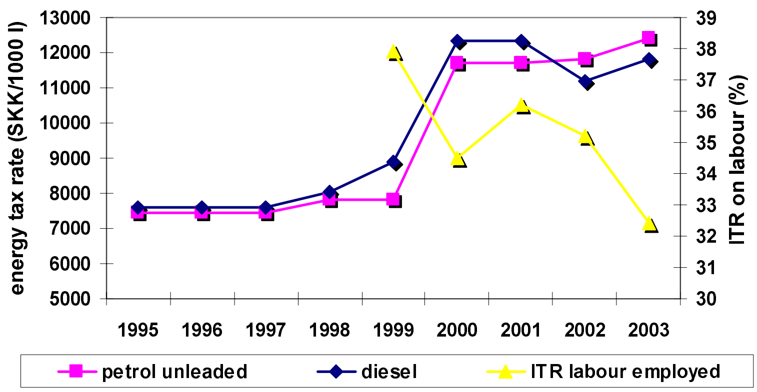
2.5.1 Environmental related levies in brief

As a former part of Czechoslovakia, Slovak Republic show high degree of similarity to environmental related taxes and charges in place in Czech Republic. The overwhelming part of revenues from these taxes is provided with excise duties on fuels – energy taxes alone counted for EUR 644 million in 2003 that is 2.15% of GDP. The remaining part is secured by bundle of fees and charges in different areas - road tax, road user charges, water and waste charges, air pollution charges, product charges for recycling and waste management, charges on conversion of farm/forest land, charge for extracted minerals and charge on disposal of nuclear energy equipment and radioactive fuel.

2.5.2 Energy taxation

In recent years substantial increase of excise tax rates on motor fuels took place while the taxation of labour seem to decrease as shown in Figure 20.

Figure 20: Trends in energy vs. income taxation



Source: IEA (2004), EC Commission (2005a)

Until now several amendments to excise tax legislation were made mainly aimed at broadening tax base and increasing tax rates. Most energy sources are now subject to excise taxes, these include motor fuels and gas oil and heavy fuel oil. Electricity, gas and solid fuels (coal) are currently not subject to excise taxation. Nominal and real rates of selected motor-fuel excise taxes are given in Annex III.

According to Slovakian government the application of minimum rates set by the Directive 2003/96/EC would lead to excessive burden on households and loss of competitiveness of domestic products thus the government raised request for transitional arrangements for natural gas, coal, coke and electricity backed by the fact that neither of these were subject to excise duties. With respect to the fact that the share of natural gas in final energy consumption is well above 15% the Council approved transitional period until 1.1.2010 for electricity and natural gas used as heating fuels and until 1.1.2009 for solid fuels both subject to effective tax rate not less than 50% of minimum rates as from 1.1.2007.

The VAT and excise tax systems were introduced in 1993 and replaced existing sales taxes, the reform was similar to the 1993 Czech Republic reform of public finance. The VAT rates were at outset at the same level as in the Czech Republic - standard rate 23% and reduced rate 5%. While reduced rate covered most of services and selected goods (coal, low sulphur fuel oil, natural gas, electricity, thermal energy) the rest was attributed to the standard rate. Even in 1993 the rates were raised to 25% and 6%. In 1996 the standard rate was put back to 23% and in 2000 the reduced rate was raised to 10%. In 2003 the rates were approximated to 20% and 14% respectively and starting from January 2004 the single rate of 19% was put in place.

2.5.3 Other changes in public finance system

Currently the main objective of fiscal policy is to reduce the deficit of public finance by 2006 below 3% of GDP (excluding the cost of implementing the second pillar of the pension system reform). The main objective in the area of employment is to bring the registered structural unemployment rate under 10% by the year 2010.

To achieve these goals, fundamental reforms focused on the consolidation of general government finance were implemented in 2003 and 2004. On 1 January 2004, a complex tax reform was launched. The VAT and both income taxes (- personal income tax and corporate income tax) were set to a single rate of 19%. The tax allowance of individuals was increased to 19.2 times the official subsistence level. The higher-than-projected collection of personal and corporate income tax is offset by lower revenues from VAT. For 2005-2007 no substantial legislative changes have been considered with respect to tax revenues. Real estate transfer tax was abolished effective January 2005. As a result, a substantial portion of the tax burden was shifted from direct to indirect taxes.

On 1 January 2004, a social system reform was launched in Slovakia, including a complex pension reform. The changes resulted in a reduction of the payroll tax by 3 percentage points for employers and in an increase of 0.6 percentage point for employees. The reduction of the tax burden was, to a certain extent, offset by an increase in the maximum assessment base, which was fixed as three times an average wage for the previous period with a majority of funds. In total, however, the share of social security contributions in the average wage declined.

2.5.4 ETR activities

Current government's policy programme does not contain clear support for incentive mechanism such as ETR. Ministry of Finance as a body responsible for tax matters seems to have no interest and obviously lacks sufficient expertise in this field. On the other hand there were voiced some critics for non-linking of new tax laws to ETR principles.

2.6 Estonia

2.6.1 Environmental related levies in brief

The system of environmental taxes in Estonia consist of excise duty on fuels, heavy vehicles and packaging, motor vehicle tax, air pollution charges (including CO_2 charge), mining charges, water charges on abstraction and effluent, and waste disposal charge. Pollution charge for CO_2 was introduced with Pollution Charge Act of 1999 for big emitters (above thermal input exceeding 50 MW) with aim to promote energy efficiency and generate revenues for environmental investments as well as reduction of socially distorting taxes. Until 2005 environmental taxes were annually increased by 20% on average. The excise tax system that was put in place in 1997 for fuels has been amended in 2003 with excise tax on heavy vehicles. In 2004 revenues from environmentally related taxes amounted to about 1.9% of GDP (2.2% including emission fees and fees for use of natural resources) and this number should grow up to 2.2% (2.5%) in 2005 that is some 3.8 bln EEK (243 mil EUR).

2.6.2 Energy taxation

CO_2 emission charge on energy production is effective from 2000 – the rate for 2005 (after relatively steep increases in 2001 and 2004) is on average 1.145 EEK/MWh (corresponding to 0.72 €/t CO_2).

Amendments to taxation laws in 2005 brought about following changes to excise duty on fuels:

- increase in the rate of excise duty on kerosene from 3,840 EEK per 1,000 litres to 4,730 EEK (+0.001% of GDP);
- increase in the rate of excise duty on diesel fuel for special purposes and light heating oil from 420 EEK per 1,000 litres to 690 EEK (+0.05% of GDP);
- increase in the rate of excise duty on heavy heating oil from 200 EEK per 1,000 kg to 235 EEK (+0.001% of GDP);
- introduction of excise duty rate on shale-derived fuel oil (235 EEK per 1,000 kg) (+0.008% of GDP);
- extension of excise duty on coal, brown coal and coke (4.7 EEK per gigajoule) (+0.002% of GDP);
- increase in the rates of excise duty on other, less important types of fuel (+0.004% of GDP).

The next intended rise of excise duty on energy products is expected to take place in 2008, with the purpose to achieve the compulsory minimum rates in liquid fuels by 2010.

In course of Energy Taxation Directive implementation Estonia raised a request for transitional periods regarding motor fuels, oil shale and shale oil, natural gas and electricity. According to the government raising rates applicable by accession to motor fuels to minimal levels prescribed by the energy taxation directive would lead to 60% tax increase in respect of unleaded petrol and 85% in respect of gas oil. For this reason the request for a transitional period for gradual adjusting of taxation level of unleaded petrol and gas oil were approved until 1.1.2010.

Since oil shale constitutes some 60% of overall primary energy balance in Estonia and neither oil shale nor shale oil was subject of excise tax one-step introduction of such tax would lead to substantial increases of energy prices (e.g. 14% for heating services) and would endanger whole industry sector. For the oil shale total exemption was granted until 1.1.2009 and the reduced rates until 1.1.2013, moreover the substantial part of oil shale utilisation - electricity production - would remain untaxed pursuant to Article 14(1)(a) of the Directive. The shale oil used for heating purposes was granted a transitional period until 1.1.2010.

Since the share of natural gas on primary energy consumption is well below the level of 15% Article 15(1)(g) could apply. The CO_2 charge is similar to an input tax and thus cannot be taken into account in respect of Article 10 of the Directive. As the case is quite similar to that of Greece (see Article 18(8)) transitional period until 1.1.2010 for switching to output taxation system was granted.

Reduced rate of VAT (5%) applies to delivery of thermal energy for non-business use (households, apartment cooperatives, churches, hospitals, public law entities etc.) until July 2007. The same reduction applies also for peat, briquettes, firewood and coal delivered to individual users.

2.6.3 Other changes in public finance system

Approximately 80% of general government revenues are contributed by three taxes: social insurance, income tax and VAT. Social security contributions contribute the largest share (about 30%) of general government revenues as these are paid by an employer on wages earned by employee and are therefore directly related to the growth of average gross wages and employment rates. The relative share of income tax was almost equivalent to social insurance contribution until 1999 and dropped later. While in 2003 income tax revenues contributed 22.6% of general government revenues, in 1999 the respective share was 27.6%. VAT collection contributed to 23-24% of general government revenues. In terms of trends even that contribution of excise duties and other indirect taxes (except VAT) to total revenues only reaches about 10% the importance of indirect taxes in tax collection is continuing to increase.

Due to relatively high taxation of labour - the effective tax rate on labour exceeds the OECD average - the income tax rate will be reduced from 26% to 20% and the amount of the monthly tax free income will rise from 1000 to 2000 crowns for the next three years (i.e. from 66 to 130 EUR).

2.6.4 ETR activities

In 2001 and again in 2004 the Government stipulated to prepare ETR strategy. Originally, the main work had to be done by Ministry of Finance but due to its reluctant attitude Ministry for Environment overtook the initiative. In 2004 a study was commissioned which had to analyse experiences with ETR in selected EU countries and recommend measures to be implemented in Estonia. During fall and winter 2004-2005 a preparation work for national ETR strategy took place with scientific support of Stockholm Environment Institute Tallinn Centre which has later prepared a complex set of environmental levies for ETR.

According to the coalition agreement, the concept of ecological tax reform was then released for public discussion as one environmental policy and strategy bundle. The overall goal was to shift taxation from labour, encourage sustainable utilisation of natural reserves and reduce pollution originating from energy production, promote renewable sources and increase energy and resource use effectiveness.

As a first phase of ETR new Act on Environmental Use Fees was drafted encompassing all the provisions from the strategy. The draft was adopted by government in September 2005 and new fees structures and rates were approved to enter into force from January 2006. The full implementation of the first phase is expected in 2006-2008. The following steps are intended:

- Personal income tax reduction by 6% (2% in 2006 and 1% each year until 2009) and increase of minimum taxable income to 24 thousand EEK per year (1534 EUR);
- Increase of CO_2 fee in three steps to EEK 11.3/15.65/31.5 per tonne and expand the tax base to all energy suppliers;
- Double air emission fees on NOx, SO_2, VOC and particles (with exception for mercaptans);
- Gradual increase of municipal waste fees from EEK 30 per tonne to EEK 156.5 per tonne;
- Double oil-shale wastes fee to EEK 15.65 per tonne;

- Introduce excise tax on electricity starting from 2009 (probably followed by exemption from CO_2 fee);
- Double resources fee;
- Levelling of water use fees for energy sector;
- Introduce car registration charge (EEK 500-1200 per year);
- Accelerate increase of excise taxes on fuels to EU minimum level and partially recycling via subsidies to public transport;
- Increase road user charges for heavy goods vehicles and extend to vehicle below 12 tonnes.

The overarching goal of the reform after finishing the second phase (2009-2013) is to abolish corporate income tax and to set flat personal income tax. Studies on impact of ETR shows that for lower income households electricity, heat and waste management costs will make together more than one-fifth of total expenditures. In average spending due to ETR will grow for this group by 0.1% in 2006 and by 1.7% in 2009. ETR share in inflation on 2006 may be up to 0.2%.

As a part of future evaluation of ETR progress and impacts it is proposed to set up list of indicators to measure successes and failures of the project.

2.7 Lithuania

2.7.1 Environmental related levies in brief

Lithuania has in place a system of environmentally related taxes and charges consisting of traditional excise duties on fuels, heavy duty vehicle tax, air pollution charges, natural resource tax (peat, etc.), water charges, waste charges and product charges on tyres, luminescent bulbs, and batteries. The crucial step towards this system was made in 1999 with the Law on Taxes for Pollution of the Environment which aims at gradual increase of environmental taxes for specific pollutants until 2007. The share of environmental taxes as a percentage of GDP increased from 2% in 2000 to 2.2% in 2003; the overwhelming majority being represented by energy taxes which are expected to bring some EUR 352 million in 2005.

2.7.2 Energy taxation

In 2004, two new pieces of legislation were passed: an amendment to the Law on Value Added Tax and a new version of the Law on Excise Duties, which will come into force on 1 May 2004, followed by a number of other legal acts on the implementation of the two laws.

From 1 May 2004, excise rates applicable in Lithuania was in general adjusted to match the minimum EU rates (on engine petrol to LTL 1318 per tonne and on gasoline to LTL 1002 per tonne), except the excises on the products for which Lithuania has been given or expects to be given a transitional period (such as petrol, gasoline, coke, lignite, electricity, orimulsion). Abolition of a reduced VAT rate on residential heating is underway.

Due continuing decommission of Ignalia nuclear power plant[9] Lithuania requested total exemption from taxation of energy sources for production electricity and heat. The Council granted exemption for coal, coke and lignite until 1.1.2007 and for natural gas and electricity until 1.1.2010. For orimulsion (mixture of bitumen and water) exemption was granted for using for other purposes than to produce electricity or heat until 1.1.2010 noting that according Article 14(1)(a) energy products used for electricity generation

[9] The phased decommissioning of the power-plant is to be accomplished by 2009.

have to and according Article 15(1)(c) energy products for combined heat and power generation can be exempt from energy taxation.

In addition, Lithuanian government requested transitional periods for motor fuels, electricity, natural gas, coal, coke and lignite and for orimulsion. At the time of the accession the rates applicable to motor fuels were in line with previous Directive 92/82/EEC but well below those prescribed by Directive 2003/96/EC. The Council granted transitional period for gradual increase of taxation of unleaded petrol, gas oil and kerosene used as propellants until 1.1.2011.

2.7.3 Other changes in public finance system

From 1 January 2003, a new Law on Personal Income Tax came into force. The new Law sets two rates of the personal income tax: 15 and 33 per cent. From 2003, individuals enjoy a higher non-taxable rate on all income received (raised from LTL 250 to 290 per month).

The expansion of the profit tax base as an outcome of tax reforms has added about 1% of GDP to general government receipts, despite the reduction of the tax rate by 9 percentage points.

Once the new tax laws are implemented, a share of the tax burden will be shifted over from labour to capital taxation.

2.7.4 ETR activities

Lithuanian Environmental Policy Centre prepared in 2003 in cooperation with partners from Latvia and Estonia an analysis on use of economic instruments named "Use of economic instruments in Baltic states".

2.8 Latvia

2.8.1 Environmental related levies in brief

Latvian tax system of environmental taxes can be broadly spitted into three categories. First one comprises excise duty on energy products that brings 1.93% of GDP being the most important in terms of revenues. Currently no tax is imposed on electricity, natural gas, coal and coke but it is expected that electricity and coal and coke will be taxed from 2007. The second category groups tax on natural resources (gravel, peat, water etc.), tax on packaging, air pollution charges on CO_2, CO, SO_2, NOx and heavy metals, water pollution charges, product charges on oils, batteries, ozone depleting substances, tyres, electronic and IT products, and charge on radioactive materials. The CO_2 tax was introduced in 2004 to cover all polluters from the beginning. The revenues from these taxes are apportioned from 60% to municipal funds while the rest goes to Environmental Protection Fund. The last category comprises tax on cars, vehicle registration fees and annual duty on cars.

2.8.2 Energy taxation

Starting from January 2005 the excise tax rates on oil products was increased. This increase has to ensure that the rates of excise tax on oil products will be harmonised with the minimum rates established by the EU. It is forecast that in 2005, as a result of the changed rates, the revenue from excise tax on oil products will grow by 16.5 million lats. In the next years, the rate will remain unchanged; nevertheless, at the same time a gradual increase in consumption is forecast.

Latvia requested several transitional periods from Energy Taxation Directive 2003/96/EC - for motor fuels, for energy products and electricity in passenger transport, for heavy fuel oil, for natural gas, electricity, coal and coke. It was emphasized that motor fuels tax alignment to minimal taxation level according to Directive would double the excise tax for gas oil and substantially increase cost of both passenger and freight transport. With respect to pre-accession low level of excise tax rates the Council granted transitional period for unleaded petrol, diesel oil and kerosene until 1.1.2011. Reduced rate or exemption from taxation in favour of electricity and energy products used in local public transport vehicles was granted until 31.12.2006.

Since excise tax on heavy fuel oil was refunded if used for production of heat or hot water it was argued that one-step increase could hardly hit low-income families. Due to this the transition period for taxation of heavy fuel oil used for district heating was granted unit 1.1.2010. It was concluded that no special arrangement in favour of enterprises is necessary bearing in mind regime under Article 17.

Since the natural gas share in final energy consumption is well below 15% threshold Latvia can profit from possibility of tax exemption or reduction granted in Article 15(1)(g). Since electricity, coal and coke were not subject to excise taxes until EU accession Latvia also requested transitional period to avoid excessive price increase (electricity price was already increased from January 2004). The Council upheld this request proportioned and granted transitional period until 31.12.2009 for electricity and until 31.12.2008 for coal and coke subject to 50% of minimum rates will be applied from 1.1.2007.

2.8.3 Other changes in public finance system

Tax policy of Latvia's government is aimed at reducing the tax burden on businesses, which would facilitate economic development and ensure competitiveness of the economy. In order to attain this objective, the following measures have been implemented:

- the rate of social security contributions has been reduced from 38% in 1996 to 33.09% in 2003;
- the rate of the corporate income tax has been reduced from 25% in 2001 to 15% in 2004;
- the rate of the real estate tax has been reduced from the maximum rate of 4% to 1.5% in 2000.

As a result of a reduction in the tax rates, tax revenue over GDP declined from 37.3% in 1995 to 31.4% in 2003. At the same time the tax base was expanded excluding exceptions of tax allowances and improving the tax revenue administration. Starting from 1 May 2004, a reduced value added tax rate in the amount of 5% is introduced.

In 2003, administratively regulated prices on several important services have changed – prices on gas (by 9.2%), water supply (12%), sewerage, heating (7.7%) and waste removal went up. Electricity tariffs picked up 15.4% in January 2004, and the tariffs for the supply of natural gas increased later that year, at the same time causing and increase in the heat production tariffs.

Medium-term macroeconomic development scenario does not envisage any significant growth of rates in the energy sector, since no development of high energy-consuming sectors can be expected. Sectoral development will be affected by reduced losses and increased efficiency as well as a gradual growth of the industry sector.

Starting from January 1, 2007, 4% instead of the current 2% of the social security contribution will be transferred to the state funded pension scheme. Starting from January 1, 2005, a 5% value added tax instead of the current 18% will be applied to domestic public transport services.

2.8.4 ETR activities

Latvia based NGO Baltic Environmental Forum organised seminar on use of economic instruments to implement principles of environmental policy in 2003 where representatives from Baltic countries discussed experiences with economic instruments.

2.9 Malta

Despite relatively high share of environmental taxes on overall tax revenues Malta has had until recently only excise tax on fuel and two transport levies. Vehicle registration tax of 50.5-75% of vehicle price is charged on first registration according to engine size. In 2002 car registration tax represented about 3.7% of total taxation (however the trend seems to be decreasing as the share was 6.0% in 1995). Annual circulation tax (so called vehicle road licence fee) is levied also according to engine capacity with rates from EUR 70 to 350 for personal cars and a special surcharge for allowance to enter Valleta. The revenues from road licence fees amounted to 5.2% of total taxation revenues in 2002.

On the eve of EU accession excise tax was extended to cover electricity and gas. Starting from September 2004 government introduced a product charge called eco-contribution that is imposed on a product which is being placed on the market. The eco-contribution is imposed on broad spectrum of products ranging from batteries, electronic and IT appliances, plastic tableware, plastic, glass or metal containers, tyres and plastic packaging.

In implementation of Energy Taxation Directive Malta requested transitional periods for electricity and all other energy products reasoning that Malta's economic activity is small and would be otherwise jeopardised. The Council accepted phased introducing of minimum tax rates and granted transitional period for electricity until 31.12.2009 with 50% of minimum rates in place from 1.1.2007. For solid fuels transitional arrangements was granted until 2008, while for natural gas for heating until 31.12.2009. For propellants – petrol, gas oil and kerosene – transitional period was granted until 31.12.2009. Moreover Malta achieved bizarre time-limited derogation for navigation of pleasure crafts and private pleasure flying until 31.12.2006.

2.10 Cyprus

Cyprus has on the one hand the fewest environmental taxes among new member states, namely fuel excise duty, electricity consumption charge, quarrying charge and registration and annual circulation tax on vehicles that bring on the other hand one of the highest share on the total tax revenues. Charge on electricity consumption (0.22 Eurocent/kWh) was introduced in 2003 in order to meet objectives of Directive on promotion of electricity from RES. The revenues are earmarked for funding energy conservation and RES promotional programmes. Substantial revenues originate from registration tax on new vehicles that is levied according to engine size ranging from 0.3 Eurocent/cc to 4.5 Eurocent/cc. A rebate of 10% is provided for CO2 efficient cars. Similar structure is applied in annual road tax.

Cyprus introduced a broad tax reform in 2003, leading to a more simplified and efficient system. In the field of direct taxation there was a significant reduction of marginal income tax rates and a narrowing of the tax base. In indirect taxation there was a harmonization of the tax base and the adoption of the minimum levels of excise and VAT rates prescribed by the acquis. The tax reform, while shifting the tax burden from direct to indirect taxation, reduced the tax burden on capital and labour contributing positively towards the creation of a more favourable business climate and on incentives to work.

With respect to energy taxation harmonisation Cyprus were granted two one-year transitional periods – the first for mineral oils used for production of cement while the second covered fuels used in local transport. Following adoption of the Directive 2003/96/EC Cyprus requested additional transitional period for propellants – gas oil, kerosene and petrol which was then granted by Council until 1.1.2010 subject to minimum levels of EUR 245 for gas oil and kerosene and EUR 287 for petrol are fulfilled.

3 **Conclusions:** ETR Policy Assessment

If practical and political feasibility of the ETR concept introduction in any transition economy is matter of an assessment, many aspects need to be discussed.

Obviously, the first look comes from the environmental field. Indeed, from the first glance, the ETR idea is particularly based on higher taxation on 'bads' such as natural resource extraction/depletion and pollution. Then, certain increase in environmental/energy taxation is implemented to fulfil some of required environmental goals. Thus, the ETR concept is to be embedded directly in an environmental discourse. Based on our brief review, there is relatively long tradition in using ecological charges and fees in environmental regulation in CEE countries. Moreover, the contribution of environmentally related taxes, charges and fees to total public or tax revenues in new EU Member States is relatively high, even higher if compared with EU-15 average.

Despite their existence, ecological charges and fees – being used as the economic instruments for environmental regulation – are not going far enough in terms of sufficient height and effective rates to reach more important and/or desired environmental goals. Moreover, the ecological charges are usually earmarked to the special environmental funds that are used for environmental purposes, as it is e.g. in the Czech Republic, Hungary, Latvia, Poland, Slovakia and Slovenia. The potential for revenue-neutral ETR can be thus diminished if the ETR is intended to be based on increasing of ecological taxes and charges levied on classical pollution and natural resources extraction and earmarked for these funds.

Looking in the past, the options for the ETR in CEE countries were also limited with chosen environmental policies during 1990s in Central Europe. In reality, despite the existence of a range of ecological charges in CEE countries as well as static and dynamic efficiency of economic instruments, normative command-and-control regulation was relatively often preferred as the main instrument in environmental protection. The reason of this choice could be found in the immediate reactions of governments on relatively bad environmental conditions in some regions inherited from the past regimes. Introduction of strict emission limits for the power sector in "Black Triangle" north western part of the Czech Republic extremely heavily polluted from combustion of coal without flue gases desulphurisation is prima-facie evidence. These regulation – adopted not only in the Czech Republic - involved large investment expenses without bringing any additional financial resources for the environmental funds or state budget in terms of using them in the ETR.

Moreover, implementation of almost one hundred of environmental directives involved further large investment and control costs. These requirements made an introduction of new or increase of current environmentally related levies more difficult. Even if additional resources from new or increased taxes and charges were obtained, there were pressures by either government or business to use these additional resources for co-financing statutory environmental requirements and/or funding new environmental protection measures. All these tensions - very relevant for all new EU Member States, weakened a possibility for the ETR introduction, particularly based on ecological charges increase. Competitiveness concerns appeared as even more powerful factor against the ETR sometimes with reference to implementation of emission trading scheme regulating greenhouse gas emissions. Despite relatively less strict requirements considering the volume of allowances allocated in the national allocation plans for the first period, an uncertainty related with emission cap and national allocation for the second phase and phase after year 2012 makes business more careful for any new regulation and very sensitive for any change.

New impetus seems to arrive with extension of energy taxation planned thanks to the implementation of Directive 2003/96/EC. In reality, the rates of excise tax on motor fuels are in the most of CEE countries already higher then or relatively close to the minimal rates required by the Directive and the rates of tax on electricity, gas and coal are not high enough to mobilise sufficiently level of additional revenues ready for use in the ETR and thus invoke the reform. How the Directive will be implemented and whether energy taxation will be introduced in a complex ETR reform in some new Member States will be seen soon after the transition periods provided by the European Council for full implementation expire.

There is also another look at the ETR coming out from public finance perspective. Albeit current excise taxes imposed on energy consumption or taxes and charges levied on transport have been dominantly introduced for revenue-raising purposes, tax base erosion argument is always underlined if ETR concept based on higher energy taxation using is discussed. One should point out that this fear is not in reality uncorroborated as the price elasticity is far away from the magnitude that would mean that *unit* tax rate increase diminishes the revenues. In spite of this fact, revenue-raising objections to energy taxes use often used when the ETR concept is discussed. On the other hand, another feature of *ad valorem taxes* such as taxes on labour or profit and *unit taxes* may play against the ETR. While rates of *ad valorem* taxes are invariant with respect to targeting nominal or real revenues, this no longer holds for unit taxes. Therefore nominal rates of unit taxes such as excises on energies should steadily increase at the inflation rate to sustain the constant flow of real revenues. Continual increase or price indexation of excise tax rates may be however politically or legally infeasible. Revenue-raising objections to energy taxation may remain thanks to the uncertainty whether the state authority will follow the rule of constant revenues. The importance of this objection is growing in the presence of not declining budget deficits and public debts what is just the case in most of CEE countries. Moreover, new Member States aim at introducing the euro currency in short term what implies to fulfil ERM II convergence criteria, particularly keep budget deficits and public debt at reasonable (required) corridors.

Considering macroeconomic conditions, there are relatively pros for the ETR. Firstly, economies of new Member states are growing rapidly and faster then the EU-15; secondly both high unemployment rate and relatively high labour taxation in new EU Member States (except Malta and Cyprus) create good conditions regarding possibility for the ETR introduction; and lastly, inflation rate is relatively low so there is no reason for fear if increase in energy prices will evoke a higher inflation in short run horizon. These conditions themselves are nevertheless not sufficient to push the ETR to the governmental agendas in these countries.

The ETR concept preparations were often pushed by environmental NGOs and supported by the Ministries of the Environment, e.g. in Hungary, Poland, Estonia and the Czech Republic. Working groups on the ETR were established at various levels including governmental and executive bodies in order to discuss or even prepare the ETR concept. Discussion platforms and variety of seminars has been organised. Dissemination and lobby action also took place in Slovenia; however, it seems that the ETR supporting activities are not so vivid like in the four above mentioned states. Baltic countries have been collaborating in several actions in order to discuss e.g. the ETR potential concept and wider use of economic instruments. The present-day implementation of ETR in Estonia can thus help to open the ETR theme at least in neighbouring countries but in case of distinctive success it may bring the new momentum even to Visegrad countries such as it has happened with flat personal income tax.

Despite the fact that solely Estonian ETR is ongoing in NMS countries, we can fortunately identify many cases of implicit environmental tax reform in recent history of CEE region. Moreover, the ETR concept is in a very advanced stage of preparation the Czech Republic, but the political support is somewhat ambiguous. One can be therefore modestly optimistic if the possibility for the ETR introduction in CEE counties is assessed. It is also commendable that the reform is not accompanied with a loud environmental rhetoric should the reform be successful.

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Annex I - Environmentally Related Levies Review

	BG	CRO	CZ	EE	HU	LT	LI	PL	ROM	SVK	SI
Motor fuel taxes/charges											
Excise tax	x	x	x	x	x	x	x	x	x	x	x
CO_2 tax				REC							x
VAT	x	x	x	x	x	x	x	x	x	x	x
Other energy products											
Excise tax	x	x	x	REC	x	x	x	x	REC	x	x
CO_2 tax				REC							x
VAT	x	x	x	x	x	x	x	x	x	x	x
Air emissions - Pollution Charges											
NOx			x	x		x	x	x		x	
SOx			x	x		x	x	x		x	
Emission non-compliance fee	x	REC	x	x	x	x	x	x	x	x	
Transport related taxation											
Vehicle tax	x	x	EEA	REC	x	REC	x	x	x	REC	
Highway toll		REC	x		x			REC		x	
Road tax		x	x				x		EEA		
Sales tax	x	REC			REC			EEA			
Import duty	x	x		REC	x		x	x	x	x	
Registration charge	x			x		REC	x	x	REC	x	REC
Company car tax	EEA							REC			
Air transport											
Noise tax/charge etc.			x		REC				REC		
Agricultural inputs											
Fertilisers/Pesticides								x			
Soil protection charge					x						
Waste related product charge											
Ozone depleting substances			x			x			REC	x	
Batteries/accumulators			REC		x	x	REC			REC	REC

	BG	**CRO**	**CZ**	**EE**	**HU**	**LT**	**LI**	**PL**	**ROM**	**SVK**	**SI**
Disposable containers/packaging				x	x	x	REC	REC			
Tires	REC		REC		x	x	REC				
Light bulbs						x					
Lubricants						x					
Refrigerators					x						
Waste											
Municipal waste user charge	x	x	x	x	x	REC	x	x	x	x	x
Waste disposal charge/tax		REC	x	x	x	x		x	REC	x	REC
Waste non-compliance fees	REC	x		x	x	x	x	x	REC	x	
Deposit refund schemes	REC	REC	x		x		x	REC	REC	x	
Levy on nuclear account	x		x		x	x			REC	EEA	
Instruments for managing water quality											
Water consumption user charge	x	x	REC	x	x	REC	x	x	x	x	x
Sewage treatment charge	x	x	x	x	x	REC	x	x	x	x	x
Water effluent charge/tax		x	x	x		x	x	x	x	x	x
Water pollution non-compliance fee	x	x		x	x	x	x	x	x	x	
Water extraction charge/tax		x	x	x	x	x	x	x	x	x	REC
Natural resource mining											
Mining charges/taxes	x	x	x	x	x	x	x	x		x	
Instruments for biodiversity and nature protection											
Charges for conversion of agricultural and forest land		REC	x							x	
Hunting charges	x	REC		x	REC		x	REC	REC		x
Fishing charges	REC	REC		REC		REC	REC	REC	REC		
Natural park entrance charges		REC						x	REC		
Nature protection non-compliance	x	REC		x	x		x	x	REC	x	
Tree cutting charges/taxes	x	REC			REC	x	x	x	REC		
TAXES/CHARGES/FEES in TOTAL	**23**	**26**	**24**	**25**	**28**	**27**	**27**	**30**	**26**	**26**	**15**

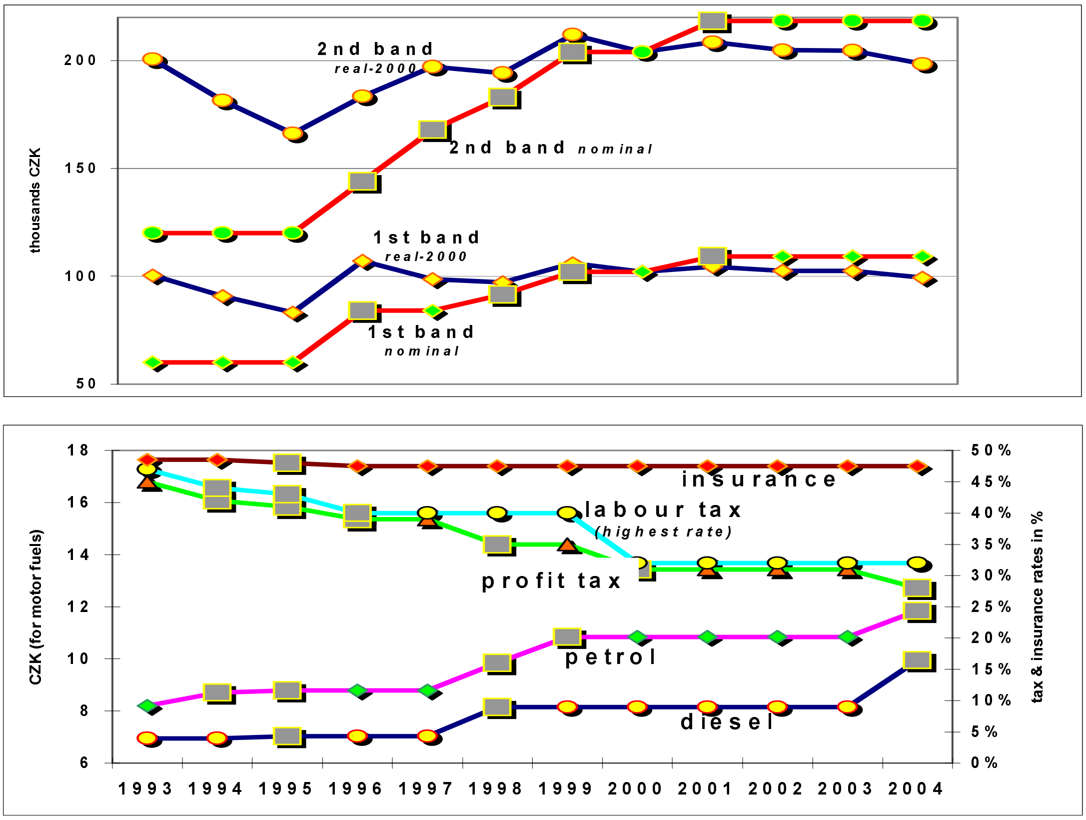
Source: Based on EEA and REC database on environmentally related levies in CEEC countries (EEA 2000 and Speck et al. 2001; review based on Ščasný 2002.

Annex II – Case study for the Czech Republic

This section discusses in more details the evolution of the ETR concept in the Czech Republic. There were several tax changes in the Czech Republic during the 1990s which have features of the ETR, i.e. the shift of the fiscal burden from labour to energies, although environmental rhetoric was not use to defend these changes. We can identify three cases of implicit ETR reform:

- ***implicit ETR 1995*** - tax rates on petrol increased by 0.9%-point, on diesel by 1.2%-point. Simultaneously, the profit and labour tax rates for the highest band decreased by 1%-point and rates of obligatory social security payments (what can be considered as indirect labor taxation) decreased by 1%-point. Although the excise tax rates on gasoline and diesel increased, they were not sufficient to offset inflation. While the share of energy taxation on the total public revenues increased by more than 1%-point, the composite tax burden on labour increased as well. These increases were balanced by decrease in profit taxation share remaining the share of VAT revenues unchanged;

Figure Appendix-1: Assessment of implicit ETR in the Czech Republic 1993-2004 (tax bands for labour taxation in upper chart, tax rates in lower one).



Note: changes in tax rates labelled by shaded squares.

- ***implicit ETR 1998*** – since January all energies except central heating have started to be taxed standard VAT rate at 22% instead of reduced one at 5%. Moreover, the excise tax rates on gasoline and diesel increased as well evene considering real terms. While the first change had obviously an impact mainly on households' behaviour and welfare, the second one had an impact on the whole economy. Even more, profit tax rate was brought down by 4%-points up to 35%. Tax shift was supported by public finance stability arguments rather then environmental one[10]: firstly by need to lower total tax burden, secondly by need to implement acquis communautaire, thirdly by need to lower tax evasion and legal obviation;

- ***implicit ETR 1999*** - excise tax rate on gasoline was increased, while labour income tax bands appreciated significantly[11]. The shares of labour income tax on total public revenues declined, while the shares of the excise tax rate slightly increased. Although this change shares some features of an 'invisible' ETR as defined above, this instance is probably the least significant of the three cases discussed here..

In the rest of the section we describe prospects of explicit ETR in the Czech Republic.

Years 2000-2001

The first concept on the environmental tax reform was prepared by the Ministry of the Environment in collaboration with the Ministry of Finance during year 2000. The ETR proposal and its tax rates were mainly based on the `Monti Proposal' (EC 1997). A more detailed design of ETR, including options for revenue recycling and potential compensations, was unclear. The proposal was introduced to the Government and further discussed in the Governmental Council on Economic and Social Strategy during the first half of 2001. Further work on the ETR, however, was interrupted by a Government Decree from June 2001. The Government intended that the concept of ETR would be incorporated within a more comprehensive reform of public finance introduced in the mid-term horizon. A more detailed vision, approaches and timetable were not clear at all.

Years 2002-2003: Government agreement and public finance reform

The Programme Agreement of the new Czech Government introduced in August 2002 marked the ETR as its one of the goals and priorities. The Government Agreement explicitly included a commitment `to start without delay to prepare a fiscal-neutral ecological tax reform', [Government of the Czech Republic 2002, chapter 4.2]. Consequently, the Inter-ministerial Working Group on ETR was established in January 2003. The aim of the Working Group has been to prepare the ETR concept. The Czech Ministry of the Environment in collaboration with the Czech Ministry of Finance were obliged to prepare The Concept of an Environmental Tax Reform by the end of June 2004; consequently a relevant act of law was to be prepared by the end of 2004.

The preparation of the ETR is going alongside the preparation of the public finance reform that started in autumn 2002. The main aim of the public finance reform is to consolidate the revenue and expenditure flows in order to decrease deficits from 6% of the GDP under 3% in 2008. The reform should lead inter alia to an increase in the excise tax rates mostly levied on motor fuels, and a significant decrease in direct taxation. We can take this shift for another instance of an implicit ETR. The additional revenues from the excise taxes on fuels are expected to amount about 8.5 bln CZK yearly, on the other hand, the revenues from the labour tax are planned to be lower by 1.8 bln CZK on average, and those from the profit tax by 5-

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[10] The changes in the excise and profit taxes were defended by the then Minister of Finance Mr. Ivan Kocarnik in the Czech Parliament in his Explanatory Report in 1997 as follows: "*...both of these acts are complementary from the fiscal point of view: one of them suggests lowering the tax load, and thus also a decrease in tax revenues, this is the act on income tax, in the order of about 9.5 bln. CZK in the year 1998. The second act suggests a certain increase in tax revenues at the amount of about 6.8 bln. CZK. That is the act on excise tax.*"

[11] Nominal adjustment of tax bands for labor income tax has a direct effect on payable taxes via changes in taxable income; e.g. nominal increase in tax bands keeping rates unchanged leads to lower taxation.

16 bln CZK yearly. Higher total revenues are predicted from obligatory insurance at the amount of about 3 bln CZK yearly.

EC Directive 2003/96/EC on taxation on energy products and electricity was already implemented by this reform of public finance, and the relevant tax rates on energies are already set above the minimum rates required by the European Commission. The taxation on electricity, solid fuels, and natural gas used for heating purposes presents an exemption. The Czech Government, as all other new EU members, has asked for a transitional period for the full implementation of the Directive until the end of 2007. This action obviously does not match the ETR idea.

Years 2003-2005: Explicit environmental tax reform

The Czech concept of the ETR is based on higher energy taxation and lower direct taxation. The first draft of the ETR concept was prepared in November 2003 and was based on tax rates included in the variant of the Czech Energy Policy prepared by the Czech Ministry of the Environment. The draft was revised in May 2004.

Meanwhile, the Czech Ministry of Finance came with its new proposal of the ETR. The proposal was mostly based on full implementation of Directive 2003/96/EC on taxation on energy products and electricity. The tax rates on solid fuels, natural gas, and electricity should comply with EU minimal rates in the year 2008. The current discussion within the Inter-ministerial WG on ETR has resulted in the third version of the ETR proposal (July 2004). This version consists of three variants, of which the one prepared by the Ministry of Finance is the most conservative.

As time has gone by, the individual ETR proposals have changed. Although the tax bases have remained the same, their rates have changed. While the first ETR proposal was oriented on the long term (30-year horizon), the following proposals covered shorter and shorter periods (from ten to four years). The shapes of the ETR proposals have also become more rounded, environmental taxation less strict, and the principle of revenue-neutrality less required and followed.

There was a requirement to allocate part of the additional revenues for social compensations, which was generally agreed and politically desirable. Representatives of the Ministry of Transport and relevant lobbies required another part of the additional revenues to be allocated to the State Fund of Transport Infrastructure. They demanded to allocate 20% of the tax revenues from the increased excise taxes on motor fuels to the Fund[12].

The political instability in June 2004 ended in resignation of the Czech Prime Minister. The concept of a fiscal-neutral environmental tax reform, however, survived as the ETR was explicitly included in the Commitment of the renewed Czech Government signed in August 2004 and even in summer of 2005 when new prime minister was chosen. An expert advisory group on the ETR has been established in the end of 2004 within the Czech Ministry of the Environment to help and enhance the ETR concept preparation and implementation. The ETR was several times discussed in the Ministry of the Environment but no agreement was reached with Ministry of Finance which is necessary step prior to submitting the concept to the Government. This gridlock seems to outlast till new elections that will take place in early June 2006.

Overall ten seminars that discussed the ETR concept from various sides and views separately with a variety of stakeholders such as academia, NGOs, state officials, churches and foundations, trade union, industry, governmental political party, and media, were held during entire period of the ETR concept

[12] A rhetoric argument relies on continuation of a current practice: since 2000, 20% revenues of excise taxes on mineral oils had been allocated to the Fund. However, this percentage was lowered to 9,1% in 2005.

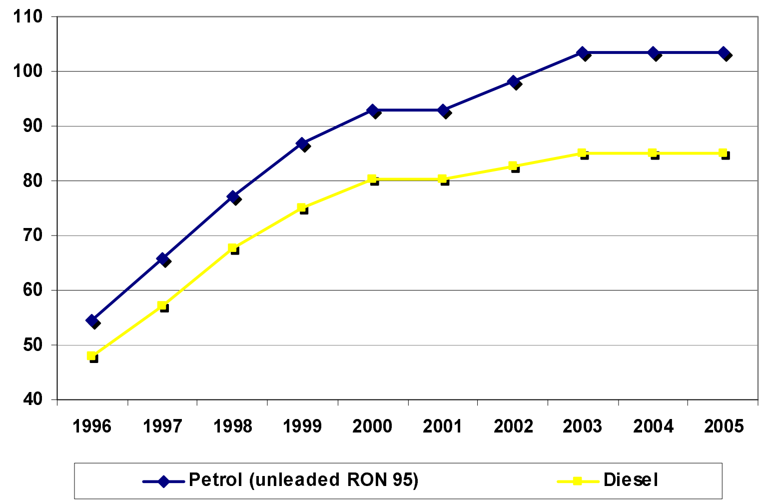
preparation (starting by February 2003 up to October 2005). These seminars significantly helped to introduce the main features of the ETR concept and encouraged discuss its complexity, understand its advantages and overcome some of the main barriers and problems related as with its implementation as enforcement with all of stakeholder groups. Useful became also collaboration with and participation of German partners in these seminars who shared their experience with the ETR introduction during the period 1999-2003 as well as discussed the latest progress and barriers for further wider ETR development.

Annex III: Nominal and real tax rates on motor fuels

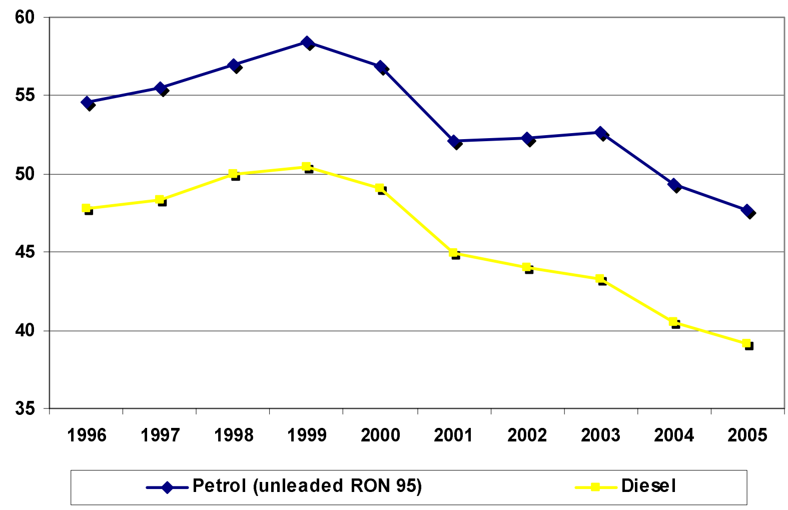
The following tables provide comparison of nominal and real tax rates on motor fuels in CEE states. Real tax rates were calculated using statistical data on harmonized indices of consumer prices (HICP) from Eurostat and expressed in 1996 prices.

Excise tax on motor fuels in Hungary.

Nominal tax rates on motor fuels (in HUF/litre)

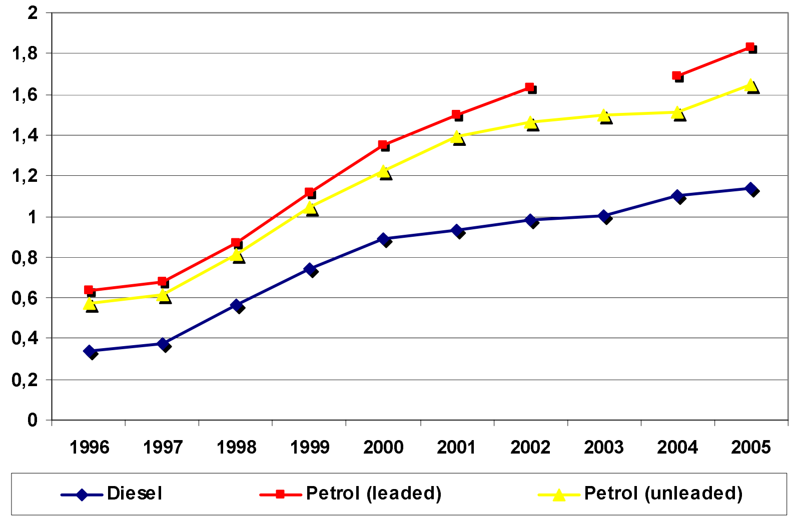


Real tax rates on motor fuels (1996 prices HUF/litre)

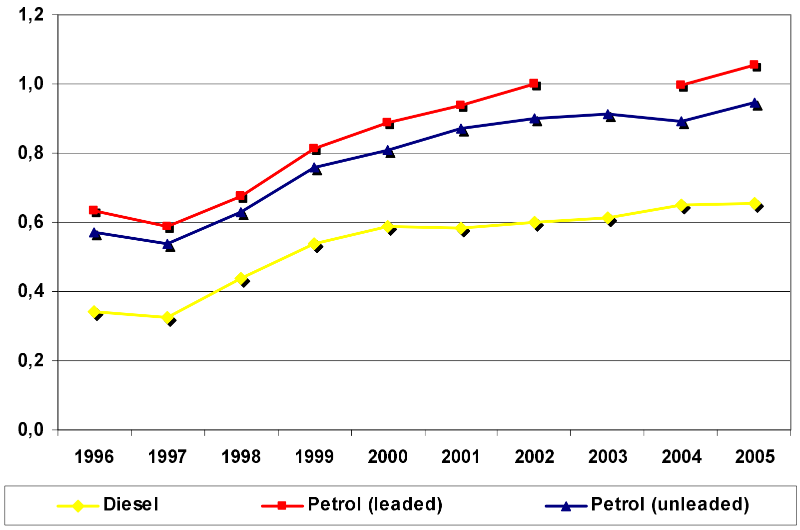


Excise tax on motor fuels in Poland.

Nominal tax rates on motor fuels (in PLN/litre)

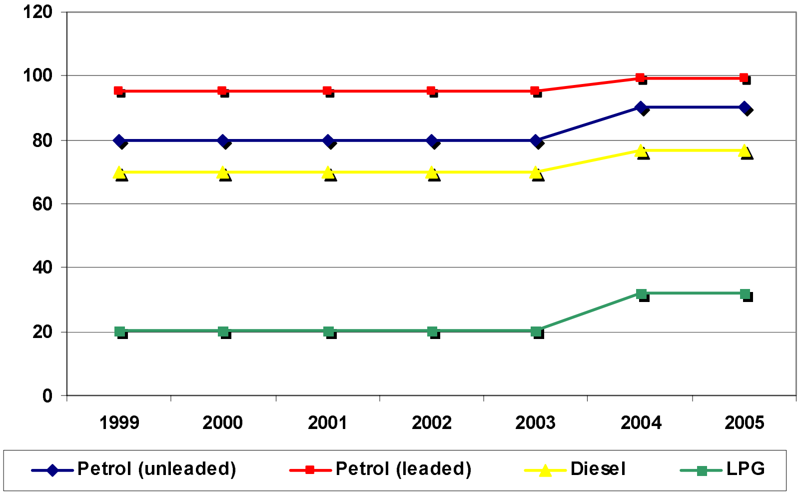


Real tax rates on motor fuels (1996 prices PLN/litre)



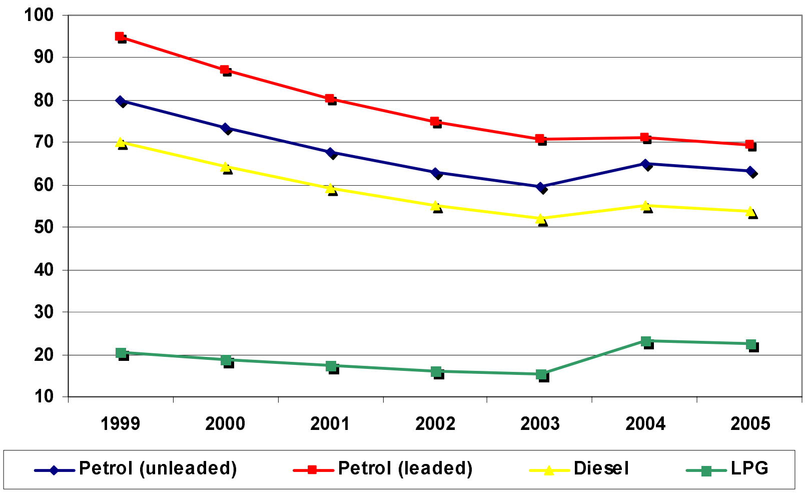
Excise tax on motor fuels in Slovenia.

Nominal tax rates on motor fuels (in SIT/litre)



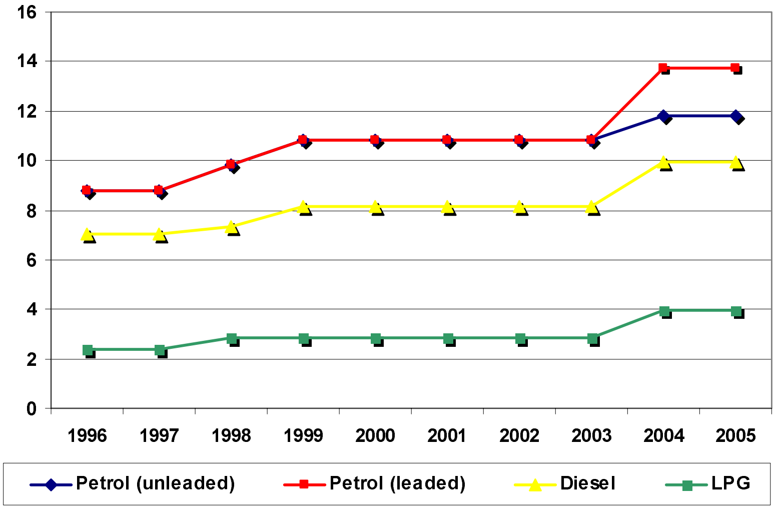
Notes: Tax rates shown for 2004 came into force in May 2004

Real tax rates on motor fuels (1996 prices SIT/litre)



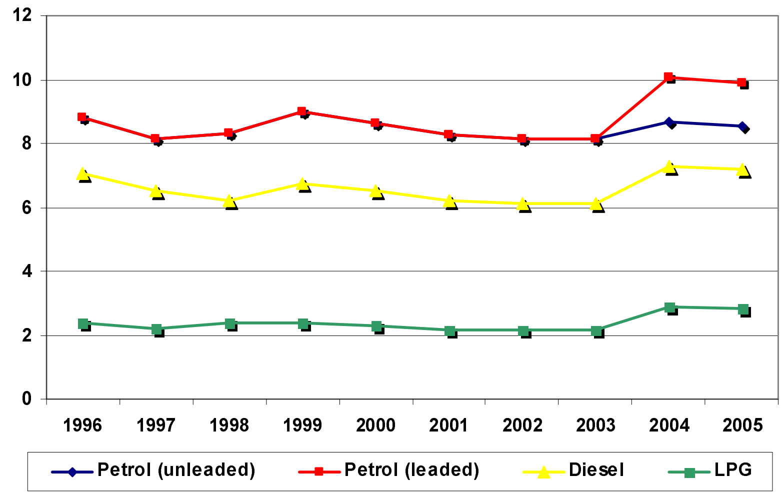
Excise tax on motor fuels in the Czech Republic.

Nominal tax rates on motor fuels (in CZK/litre; except LPG in CZK/kg)



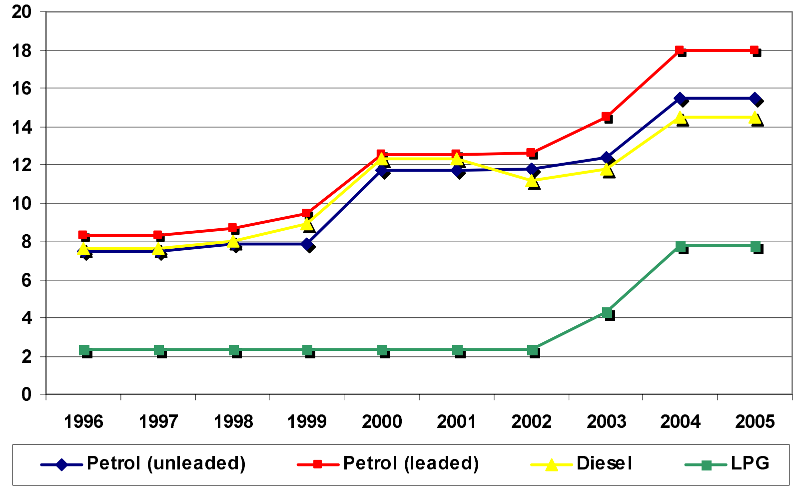
Notes: Tax rates shown for 1999 came into force in July 1999

Real tax rates on motor fuels (1996 prices CZK/litre; except LPG in CZK/kg)



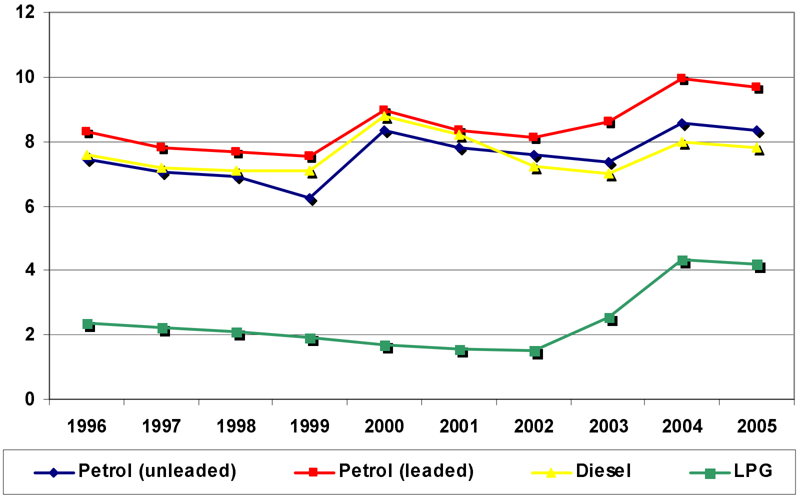
Excise tax on motor fuels in the Slovak Republic.

Nominal tax rates on motor fuels (in SKK/litre; except for LPG in SKK/kg)



Notes: Tax rates shown for 2004 came into force in March 2004

Real tax rates on motor fuels (1996 prices SKK/litre; except LPG in SKK/kg)



Annex IV: Energy taxation exemptions

Country	Sector	Energy product	Impact
Hungary	District heating	All	18% of population living in distant heated flats (often low-income families)
	Heating	Coal	Disproportionate administrative costs
Poland	Propellants	Petrol, diesel	Price stability
	CHP, energy intensive industry	Heavy fuel oil	
	Heating	Gas oil	
		Natural gas	Inflation, withdrawal from use
	District heating and other use	Coal	Undermining of coal sector restructuring, huge impact on industrial sector
Czech Republic		Electricity	Unbearable social burden for citizens
		Solid fuels	Impact on employment in coal regions
	Heating	Natural gas	Adverse impact on public budgets, rise in use of less environmentally friendly fuels
Slovenia		Electricity	Additional pressure on price and inflation
		Natural gas	Endanger replacing of other fossil fuels and meeting Kyoto targets
Slovakia	Heating		Social impact of price increase due to tax
		Natural gas	Endanger replacing of other fossil fuels
			Loss of competitiveness of domestic producers
Estonia		Motor fuels	Price increases and economic drawback
	Heating	Oil shale, shale oil	60% of primary energy balance; price increase and endangering of industry sector, increase of unemployment; 14% rise of prices of heating services
		Electricity	Price increase
Latvia		Motor fuels	Inflation rise, rapid growth of prices, sharp increase in tax fraud

	Central heating	Heavy fuel oil	Low-income families living in block-of-flats
		Electricity, coal and coke	Inflation rise, rapid growth of prices
Lithuania		Motor fuels	Impact on growth of expenses of households and businesses
		Electricity, natural gas, coal, coke and lignite, and orimulsion	Avoid adverse impacts in conjunction with Ignalia NPP decommissioning
Malta		Electricity	Jeopardy of various economic activities
		All other energy products	
	Navigation in private pleasure craft and private pleasure flying	Fuels	Job losses in bunkering industry
Cyprus		Motor fuels	Significant social impact on the expenses of households, problems of competitiveness for manufacturing sector

Annex:

Summary Tables of E3ME estimations

WORK PACKAGE 4

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Appendix A

Summary Tables of Key Parameter Sets from E3ME Estimation

Appendix A: The parameter summaries

A1.1 Glossary of parameters

TABLE A1 GLOSSARY OF PARAMETERS

APSC	Adjusted consumer price deflator
ARET	Reciprocal retentions ratio
CDEP	Child dependency ratio
ECM	Error Correction Mechanism
EX	Exchange rates
FR0	Total fuel use for energy
FRK	Investment by energy user
FRY	Output by energy user
INF	Inflation
INPT	Intercept term
LFRTD	Log R&D
LPFRC	Log price of coal use
LPFRE	Log price of electricity use
LPFRG	Log price of gas use
LPFRO	Log price of oil use
LPREN	Average price ratio
LYYN	Log(YRN/YR)
ODEP	OAP dependency ratio
PKR	Prices of investment
PQRE	Prices in non-EU markets (import sources)
PQRF	Source prices for imports
PQRMOIL	Prices of oil imports
PQRW	Prices in non-EU markets (export weights)
PQRX	Prices of export sales
PQRY	Prices of competing exports in world markets
PQRZ	Competing prices for exports to EU regions
PQWE	Avg. prices for EUR-19 of world commodities
PRCR	Price of consumption category relative to consumer price Index
PRSC	Consumer price inflation
PYH	Price of home sales by home producers
PYR	Price of industry outputs
PYRE	Price of all energy inputs
QRDI	Implicit QRD (QR+QRM-QRX)
QWXI	Rest of world activity index
RBNR	Social security benefit ratios
RLR	Interest rates
RRLR	Real long-run interest rate
RRPDP	Real gross disposable income per capita
RSER	Ratio of services to non-services value added
RSQ	Total gross output of products
RUNR	Regional unemployment rates
RWS	Regional wages and salaries
RWSR	Real retained wage rates
SVIM	Proxy for internal market program
VD	Value invested in dwellings
VYVM	GDP current prices
RLR	Interest rates

TABLE A1 GLOSSARY OF PARAMETERS (CONTINUED)

YNN	Ratio of output to normal output
YPRO	Measure of productivity by sector
YR	Industry outputs
YRKC	IST technological progress
YRKN	Non-IST technological progress
YRN	Normal output
YRULT	Unit labour costs
YRWC	Real wage costs
YRWE	External industry wage rates
YRX	Average industrial output (excluding own region)
YRY	Average industrial output (excluding own sector)
YXE	External regional wage rates
YYN	Actual/normal output
ZRDM	Europe-wide investment in machinery
ZRDT	Europe-wide investment in transport equipment

A1.2 Consumers' expenditure

TABLE A2: PARAMETER SUMMARY FOR EQUATION: CONSUMERS' EXPENDITURE

	Short term variables								Long term variables							
	INPT	RRPDP	PRCR	RRLR	PRSC	CDEP	ODEP	dY(-1)	ECM	INPT	RRPDP	PRCR	RRLR	PRSC	CDEP	ODEP
Mean	0.02	0.40	0.25	-0.42	0.04	0.96	0.96	0.14	-0.46	-2.37	0.21	0.24	-0.32	-0.07	0.75	0.73
Standard Deviation	0.34	0.77	1.29	0.77	1.37	1.15	1.17	0.33	0.37	6.18	0.55	1.05	0.76	0.94	1.03	1.08
Minimum Value	-0.94	0.00	-2.50	-2.50	-2.50	0.00	0.00	-0.25	-0.95	-29.56	0.00	-2.50	-2.50	-2.50	0.00	0.00
Maximum Value	5.40	2.50	2.50	0.00	2.50	2.50	2.50	0.95	-0.05	22.17	2.50	2.50	0.00	2.50	2.50	2.50
Percent Reg Variance	0.03	0.13	0.03	0.11	0.03	0.16	0.28	0.12	0.16	0.11	0.07	0.03	0.12	0.03	0.13	0.17
Percent Dim2 Variance	0.04	0.04	0.04	0.02	0.04	0.03	0.03	0.05	0.07	0.29	0.02	0.07	0.02	0.07	0.05	0.05
Percent Resid. Variance	0.93	0.83	0.93	0.87	0.93	0.80	0.69	0.82	0.77	0.60	0.91	0.90	0.86	0.90	0.82	0.78

A1.3 Total fuel use for energy

TABLE A3: PARAMETER SUMMARY FOR EQUATION: TOTAL FUEL USE FOR ENERGY

	Short term variables								Long term variables							
	INPT	FRY	LPREN	LFRTD	ZRDM	ZRDT	FRK	dY(-1)	ECM	INPT	FRY	LPREN	LFRTD	ZRDM	ZRDT	FRK
Mean	0.02	0.51	-0.35	-0.11	-0.04	-0.14	-0.32	0.07	-0.36	6.01	0.63	-0.33	-0.04	-0.07	-0.20	-0.13
Standard Deviation	0.16	0.55	0.47	0.25	0.13	0.32	0.74	0.28	0.26	5.43	0.45	0.23	0.11	0.18	0.27	0.34
Minimum Value	-1.89	0.00	-1.30	-1.00	-1.00	-1.00	-3.00	-0.20	-0.95	-8.59	0.00	-1.30	-1.00	-1.00	-1.00	-3.00
Maximum Value	1.82	1.20	0.40	0.00	0.00	0.00	0.00	0.60	0.00	28.86	1.20	0.00	0.00	0.00	0.00	0.13
Percent Reg Variance	0.07	0.07	0.13	0.09	0.21	0.18	0.14	0.05	0.11	0.16	0.09	0.10	0.06	0.14	0.09	0.07
Percent Dim2 Variance	0.06	0.07	0.07	0.08	0.05	0.03	0.07	0.06	0.04	0.15	0.26	0.22	0.08	0.06	0.15	0.05
Percent Resid. Variance	0.87	0.86	0.80	0.82	0.74	0.79	0.79	0.89	0.85	0.69	0.65	0.68	0.86	0.80	0.76	0.88

A1.4 Use of coal

TABLE A4: PARAMETER SUMMARY FOR EQUATION: USE OF COAL

	Short term variables								Long term variables					
	INPT	FR0	LPFRC	LFRTD	ZRDM	FRK	dY(-1)	ECM	INPT	FR0	LPFRC	LFRTD	ZRDM	FRK
Mean	0.11	0.47	-0.29	-0.23	-0.11	-0.29	0.04	-0.19	2.91	0.41	-0.33	-0.18	-0.34	-0.29
Standard Deviation	0.37	0.58	0.53	0.41	0.30	0.45	0.19	0.24	6.35	0.51	0.49	0.33	0.42	0.40
Minimum Value	-2.63	0.00	-1.30	-1.00	-1.00	-1.00	-0.20	-0.95	-18.84	0.00	-1.30	-1.00	-1.00	-1.00
Maximum Value	2.06	1.20	0.00	0.00	0.00	0.00	0.60	0.00	27.38	1.20	0.00	0.00	0.00	0.00
Percent Reg Variance	0.15	0.14	0.08	0.08	0.12	0.06	0.05	0.11	0.12	0.09	0.17	0.08	0.10	0.09
Percent Dim2 Variance	0.14	0.22	0.10	0.11	0.06	0.16	0.04	0.19	0.18	0.31	0.12	0.20	0.27	0.18
Percent Resid. Variance	0.72	0.65	0.82	0.81	0.82	0.79	0.90	0.70	0.70	0.60	0.71	0.72	0.63	0.72

A1.5 Use of electricity

TABLE A5: PARAMETER SUMMARY FOR EQUATION: USE OF ELECTRICITY

	Short term variables								Long term variables					
	INPT	FR0	LPFRE	LFRTD	ZRDM	FRK	dY(-1)	ECM	INPT	FR0	LPFRE	LFRTD	ZRDM	FRK
Mean	0.02	0.42	-0.46	-0.07	-0.04	-0.11	0.06	-0.25	1.93	0.44	-0.45	-0.04	-0.04	-0.06
Standard Deviation	0.05	0.48	0.56	0.20	0.10	0.26	0.24	0.25	3.27	0.43	0.47	0.11	0.12	0.16
Minimum Value	-0.34	0.00	-1.30	-1.00	-1.00	-1.00	-0.20	-0.95	-5.30	0.00	-1.30	-1.00	-1.00	-1.00
Maximum Value	0.51	1.20	0.00	0.00	0.00	0.00	0.60	0.00	22.52	1.20	0.00	0.00	0.00	0.00
Percent Reg Variance	0.07	0.06	0.09	0.05	0.10	0.07	0.06	0.08	0.10	0.04	0.10	0.12	0.04	0.06
Percent Dim2 Variance	0.07	0.29	0.31	0.10	0.10	0.10	0.07	0.30	0.18	0.38	0.37	0.12	0.11	0.10
Percent Resid. Variance	0.86	0.64	0.60	0.85	0.80	0.83	0.87	0.62	0.72	0.58	0.53	0.76	0.85	0.83

A1.6 Use of gas

TABLE A6: PARAMETER SUMMARY FOR EQUATION: USE OF GAS

	Short term variables								Long term variables					
	INPT	FR0	LPFRG	LFRTD	ZRDM	FRK	dY(-1)	ECM	INPT	FR0	LPFRG	LFRTD	ZRDM	FRK
Mean	0.09	0.32	-0.19	-0.15	-0.11	-0.14	0.05	-0.12	0.16	0.31	-0.21	-0.07	-0.07	-0.11
Standard Deviation	0.18	0.51	0.43	0.34	0.30	0.33	0.17	0.17	5.02	0.52	0.47	0.25	0.25	0.30
Minimum Value	-0.50	0.00	-1.30	-1.00	-1.00	-1.00	-0.20	-0.95	-19.57	0.00	-1.30	-1.00	-1.00	-1.00
Maximum Value	1.20	1.20	0.00	0.00	0.00	0.00	0.60	0.00	21.73	1.20	0.00	0.00	0.00	0.00
Percent Reg Variance	0.45	0.27	0.19	0.23	0.18	0.15	0.17	0.35	0.25	0.30	0.31	0.26	0.27	0.18
Percent Dim2 Variance	0.08	0.11	0.07	0.07	0.07	0.08	0.06	0.17	0.05	0.12	0.08	0.05	0.06	0.03
Percent Resid. Variance	0.47	0.62	0.74	0.70	0.75	0.77	0.78	0.48	0.70	0.58	0.61	0.69	0.68	0.79

A1.7 Use of oil

TABLE A7: PARAMETER SUMMARY FOR EQUATION: USE OF OIL

	Short term variables									Long term variables						
	INPT	FR0	LPFRO	LFRTD	ZRDM	ZRDT	FRK	dY(-1)	ECM	INPT	FR0	LPFRO	LFRTD	ZRDM	ZRDT	FRK
Mean	-0.02	0.62	-0.34	-0.23	-0.14	-0.27	-0.26	0.10	-0.33	7.36	0.62	-0.24	-0.20	-0.27	-0.39	-0.21
Standard Deviation	0.25	0.57	0.53	0.39	0.30	0.43	0.42	0.26	0.31	7.63	0.51	0.41	0.32	0.37	0.42	0.34
Minimum Value	-1.48	0.00	-1.30	-1.00	-1.00	-1.00	-1.00	-0.20	-0.95	-11.46	0.00	-1.30	-1.00	-1.00	-1.00	-1.00
Maximum Value	1.30	1.20	0.00	0.00	0.00	0.00	0.00	0.60	0.00	37.19	1.20	0.00	0.00	0.00	0.00	0.00
Percent Reg Variance	0.07	0.11	0.09	0.11	0.19	0.30	0.11	0.03	0.11	0.18	0.10	0.12	0.04	0.06	0.11	0.10
Percent Dim2 Variance	0.06	0.18	0.08	0.09	0.05	0.09	0.08	0.07	0.20	0.30	0.27	0.13	0.25	0.17	0.26	0.12
Percent Resid. Variance	0.87	0.71	0.83	0.79	0.76	0.61	0.81	0.90	0.69	0.52	0.63	0.75	0.71	0.77	0.63	0.78

A1.8 Investment

TABLE A8: PARAMETER SUMMARY FOR EQUATION: INVESTMENT

	Short term variables									Long term variables				
	INPT	YR	PKR/PYR	YRWC	PYRE	RLR	YNN	dY(-1)	ECM	INPT	YR	PKR/PYR	YRWC	PYRE
Mean	0.00	0.91	-0.94	0.64	-0.09	-0.32	0.38	0.12	-5.43	0.87	-0.63	0.40	-0.18	-5.43
Standard Deviation	0.17	1.29	1.06	0.93	0.90	0.63	0.79	0.35	8.37	0.72	0.67	0.57	0.66	8.37
Minimum Value	-1.78	-0.50	-2.50	0.00	-2.50	-2.50	0.00	-0.50	-50.49	0.00	-2.50	0.00	-2.50	-50.49
Maximum Value	1.84	2.50	0.00	2.50	2.50	0.00	2.50	1.53	19.73	2.50	0.00	2.50	2.50	19.73
Percent Reg Variance	0.12	0.08	0.17	0.05	0.04	0.07	0.15	0.17	0.08	0.03	0.02	0.02	0.02	0.02
Percent Dim2 Variance	0.03	0.07	0.04	0.05	0.08	0.05	0.05	0.03	0.10	0.19	0.04	0.04	0.04	0.04
Percent Resid. Variance	0.86	0.85	0.78	0.90	0.87	0.88	0.80	0.80	0.83	0.79	0.94	0.94	0.94	0.94

A1.9 Labour participation rate

TABLE A9: PARAMETER SUMMARY FOR EQUATION: LABOUR PARTICIPATION RATE

	Short term variables								Long term variables					
	INPT	RSQ	RWSR	RUNR	RBNR	RSER	dY(-1)	ECM	INPT	RSQ	RWSR	RUNR	RBNR	RSER
Mean	-0.01	0.16	0.08	-0.01	-0.16	-0.00	0.42	-0.15	-5.42	0.49	0.11	-0.08	-0.12	-0.50
Standard Deviation	0.03	0.43	0.26	0.04	0.39	0.45	0.47	0.22	6.42	0.50	0.27	0.12	0.32	1.01
Minimum Value	-0.17	0.00	0.00	-0.32	-2.00	-2.00	-0.50	-0.95	-26.50	0.00	0.00	-0.73	-2.00	-2.00
Maximum Value	0.03	2.00	2.00	0.00	0.00	2.00	0.90	-0.05	2.65	2.00	2.00	0.00	0.00	2.00
Percent Reg Variance	0.45	0.59	0.35	0.33	0.57	0.38	0.84	0.76	0.44	0.44	0.27	0.45	0.28	0.37
Percent Dim2 Variance	0.16	0.04	0.03	0.03	0.06	0.01	0.01	0.02	0.41	0.39	0.02	0.23	0.16	0.16
Percent Resid. Variance	0.39	0.38	0.62	0.64	0.37	0.61	0.15	0.22	0.15	0.17	0.71	0.32	0.57	0.47

A1.10

A1.10 Prices of imported products

TABLE A10: PARAMETER SUMMARY FOR EQUATION: PRICES OF IMPORTED PRODUCTS

	Short term variables										Long term variables							
	INPT	PQRF	PQRE	PQWE	EX	YRULT	YRKC	YRKN	dY(-1)	ECM	INPT	PQRF	PQRE	PQWE	EX	YRULT	YRKC	YRKN
Mean	0.02	0.54	0.20	0.44	0.77	0.08	-0.29	-0.43	0.05	-0.32	1.42	0.51	0.02	0.33	0.86	0.05	-0.34	-0.36
Standard Deviation	0.17	0.89	0.60	0.85	1.09	0.22	0.76	0.84	0.38	0.30	8.02	0.44	0.22	0.44	0.32	0.16	0.66	0.69
Minimum Value	-1.57	0.00	0.00	0.00	0.00	0.00	-2.50	-2.50	-0.25	-0.95	-35.51	-2.50	-1.50	-1.50	0.00	-1.50	-2.50	-2.50
Maximum Value	1.71	2.50	2.50	2.50	2.50	0.90	0.00	0.00	0.95	0.00	63.70	2.50	2.50	2.50	2.50	1.00	0.00	0.00
Percent Reg Variance	0.09	0.04	0.10	0.08	0.10	0.11	0.13	0.04	0.03	0.05	0.02	0.02	0.04	0.02	0.02	0.03	0.02	0.03
Percent Dim2 Variance	0.06	0.11	0.06	0.10	0.06	0.07	0.06	0.08	0.05	0.12	0.03	0.42	0.09	0.22	0.03	0.15	0.03	0.26
Percent Resid. Variance	0.85	0.86	0.84	0.83	0.84	0.82	0.81	0.87	0.92	0.83	0.94	0.56	0.87	0.76	0.95	0.82	0.95	0.71

A1.11 Prices of export sales

TABLE A11: PARAMETER SUMMARY FOR EQUATION: PRICES OF EXPORT SALES

	Short term variables										Long term variables							
	INPT	PQRY	PQRE	PQWE	EX	YRULT	YRKC	YRKN	dY(-1)	ECM	INPT	PQRY	PQRE	PQWE	EX	YRULT	YRKC	YRKN
Mean	-0.06	0.00	0.60	1.04	0.75	0.10	0.35	0.33	0.06	-0.24	-1.58	0.00	0.46	0.49	0.95	-0.04	0.42	0.44
Standard Deviation	0.21	0.00	0.94	1.16	1.08	0.38	0.81	0.74	0.35	0.29	9.21	0.00	0.78	0.82	0.49	0.39	0.73	0.75
Minimum Value	-1.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.25	-0.95	-56.79	0.00	-2.50	-2.50	-1.50	-1.50	0.00	0.00
Maximum Value	2.60	0.00	2.50	2.50	2.50	2.50	2.50	2.50	0.95	0.00	67.39	0.00	2.50	2.50	2.50	2.50	2.50	2.50
Percent Reg Variance	0.13	.NaN	0.07	0.04	0.14	0.10	0.15	0.07	0.09	0.06	0.03	0.02	0.03	0.02	0.01	0.02	0.03	0.08
Percent Dim2 Variance	0.06	.NaN	0.10	0.26	0.06	0.04	0.06	0.08	0.05	0.09	0.04	0.07	0.18	0.01	0.18	0.15	0.06	0.20
Percent Resid. Variance	0.82	.NaN	0.83	0.70	0.80	0.86	0.79	0.85	0.87	0.85	0.93	0.91	0.79	0.96	0.80	0.83	0.92	0.73

A1.12 Prices of home sales by home producers

TABLE A12: PARAMETER SUMMARY FOR EQUATION: PRICES OF HOME SALES BY HOME PRODUCERS

	Short term variables							Long term variables							
	INPT	YRUC	PQRM	YRKC	YRKN	PQRMOIL	YYN	dY(-1)	ECM	INPT	YRUC	PQRM	YRKC	YRKN	PQRMOIL
Mean	0.00	0.24	0.12	0.39	0.24	0.15	0.13	0.11	-0.27	-1.60	0.23	0.43	0.33	0.29	0.27
Standard Deviation	0.36	0.43	0.42	0.47	0.39	0.23	1.29	0.35	0.26	4.82	0.32	0.36	0.37	0.35	0.31
Minimum Value	-3.05	-0.20	-0.20	0.00	0.00	0.00	-2.00	-0.25	-0.95	-20.29	-0.01	0.00	0.00	0.00	0.00
Maximum Value	4.10	0.95	0.95	1.00	1.00	0.60	3.00	0.95	0.00	26.59	1.00	1.00	1.00	1.00	1.00
Percent Reg Variance	0.04	0.11	0.04	0.17	0.08	0.04	0.02	0.10	0.06	0.02	0.05	0.08	0.02	0.05	0.15
Percent Dim2 Variance	0.04	0.08	0.05	0.05	0.07	0.09	0.03	0.06	0.14	0.04	0.05	0.14	0.04	0.06	0.16
Percent Resid. Variance	0.91	0.81	0.91	0.78	0.86	0.87	0.94	0.84	0.80	0.93	0.90	0.78	0.93	0.89	0.70

A1.13 Product exports to extra-EU regions

TABLE A13: PARAMETER SUMMARY FOR EQUATION: PRODUCT EXPORTS TO EXTRA-EU REGIONS

	Short term variables							Long term variables								
	INPT	QWXI	PQRX	PQRW	YRKC	YRKN	SVIM	dY(-1)	ECM	INPT	QWXI	PQRX	PQRW	YRKC	YRKN	SVIM
Mean	0.05	0.91	-0.26	0.32	0.36	0.43	0.01	0.07	-0.27	3.32	1.38	-0.05	0.05	0.49	0.16	-0.09
Standard Deviation	0.23	1.17	0.69	0.68	0.84	0.87	1.00	0.30	0.32	7.09	1.02	0.21	0.21	0.50	0.28	0.94
Minimum Value	-2.47	0.00	-2.50	0.00	0.00	0.00	-2.50	-0.25	-0.95	-62.80	0.00	-2.50	-0.01	-4.75	0.00	-2.50
Maximum Value	1.62	2.50	0.00	2.50	2.50	2.50	2.50	0.90	0.00	19.84	3.36	0.00	2.50	1.20	1.20	2.50
Percent Reg Variance	0.06	0.07	0.08	0.11	0.14	0.05	0.06	0.09	0.11	0.32	0.02	0.01	0.01	0.03	0.04	0.05
Percent Dim2 Variance	0.11	0.14	0.07	0.08	0.08	0.07	0.06	0.10	0.11	0.17	0.48	0.23	0.23	0.29	0.12	0.19
Percent Resid. Variance	0.83	0.79	0.85	0.82	0.78	0.87	0.87	0.82	0.78	0.51	0.50	0.76	0.76	0.68	0.84	0.76

A1.14 Product imports from extra-EU regions

TABLE A14: PARAMETER SUMMARY FOR EQUATION: PRODUCT IMPORTS FROM EXTRA-EU REGIONS

	Short term variables											Long term variables							
	INPT	QRDI	PQRM	PYH	EX	YRKC	YRKN	SVIM	YRN	dY(-1)	ECM	INPT	QRDI	PQRM	PYH	EX	YRKC	YRKN	SVIM
Mean	0.03	0.95	-0.48	0.31	-0.54	-0.27	-0.30	0.00	0.22	0.04	-0.28	-4.09	1.19	-0.32	0.32	0.00	-0.23	-0.47	0.00
Standard Deviation	0.16	1.00	0.70	0.69	0.96	0.72	0.70	0.00	0.62	0.26	0.33	9.18	0.85	0.56	0.56	0.00	0.53	0.75	0.00
Minimum Value	-1.54	0.00	-2.50	0.00	-2.50	-2.50	-2.50	0.00	0.00	-0.25	-0.95	-39.66	0.00	-2.50	-2.50	0.00	-2.50	-2.50	0.00
Maximum Value	2.16	2.50	0.00	2.50	0.00	0.00	0.00	0.00	2.50	0.90	0.00	31.34	2.50	2.50	2.50	0.00	0.01	0.00	0.04
Percent Reg Variance	0.12	0.04	0.04	0.05	0.14	0.12	0.04	.NaN	0.10	0.03	0.06	0.02	0.03	0.03	0.02	0.02	0.02	0.06	0.02
Percent Dim2 Variance	0.04	0.16	0.10	0.08	0.08	0.06	0.07	.NaN	0.06	0.04	0.12	0.05	0.47	0.25	0.00	0.04	0.05	0.25	0.09
Percent Resid. Variance	0.84	0.80	0.86	0.87	0.78	0.82	0.89	.NaN	0.84	0.93	0.82	0.93	0.50	0.73	0.98	0.94	0.93	0.69	0.89

A1.15 Product imports from EU regions

TABLE A15: PARAMETER SUMMARY FOR EQUATION: PRODUCT IMPORTS FROM EU REGIONS

	Short term variables											Long term variables							
	INPT	QRDI	PQRM	PYH	EX	YRKC	YRKN	SVIM	YRN	dY(-1)	ECM	INPT	QRDI	PQRM	PYH	EX	YRKC	YRKN	SVIM
Mean	0.03	0.95	-0.47	0.33	-0.52	-0.24	-0.30	-0.04	0.22	0.04	-0.33	-4.01	1.15	-0.31	0.31	0.00	-0.23	-0.44	0.20
Standard Deviation	0.17	1.01	0.70	0.72	0.95	0.68	0.70	0.76	0.62	0.25	0.35	9.04	0.84	0.50	0.50	0.00	0.54	0.74	0.72
Minimum Value	-1.59	0.00	-2.50	0.00	-2.50	-2.50	-2.50	-2.50	0.00	-0.25	-0.95	-44.53	0.00	-2.50	-2.50	0.00	-2.50	-2.50	-2.50
Maximum Value	2.15	2.50	0.00	2.50	0.00	0.00	0.00	2.50	2.50	0.90	0.00	30.50	2.50	2.50	2.50	0.00	0.01	0.00	2.50
Percent Reg Variance	0.09	0.04	0.04	0.03	0.15	0.12	0.04	0.05	0.09	0.05	0.06	0.03	0.04	0.04	0.04	0.02	0.02	0.06	0.06
Percent Dim2 Variance	0.03	0.18	0.10	0.09	0.09	0.06	0.12	0.04	0.06	0.06	0.12	0.05	0.48	0.26	0.24	0.04	0.05	0.25	0.18
Percent Resid. Variance	0.87	0.78	0.86	0.88	0.77	0.82	0.84	0.91	0.85	0.90	0.82	0.93	0.48	0.70	0.73	0.94	0.93	0.69	0.77

A1.16 Product exports to EU regions

TABLE A16: PARAMETER SUMMARY FOR EQUATION: PRODUCT EXPORTS TO EU REGIONS

	Short term variables								Long term variables							
	INPT	QZXI	PQRX	PQRZ	YRKC	YRKN	SVIM	dY(-1)	ECM	INPT	QZXI	PQRX	PQRZ	YRKC	YRKN	SVIM
Mean	0.04	0.91	-0.26	0.32	0.36	0.43	0.01	0.07	-0.27	3.37	1.38	-0.05	0.05	0.50	0.16	-0.09
Standard Deviation	0.23	1.18	0.69	0.68	0.84	0.86	1.00	0.30	0.32	6.82	1.02	0.21	0.21	0.47	0.28	0.94
Minimum Value	-2.47	0.00	-2.50	0.00	0.00	0.00	-2.50	-0.25	-0.95	-25.58	0.00	-2.50	0.00	0.00	0.00	-2.50
Maximum Value	1.62	2.50	0.00	2.50	2.50	2.50	2.50	0.90	0.00	19.84	2.50	0.00	2.50	1.20	1.20	2.50
Percent Reg Variance	0.07	0.03	0.08	0.10	0.10	0.07	0.08	0.06	0.07	0.25	0.02	0.04	0.04	0.04	0.06	0.08
Percent Dim2 Variance	0.09	0.13	0.06	0.14	0.08	0.07	0.04	0.07	0.14	0.14	0.57	0.17	0.17	0.20	0.10	0.23
Percent Resid. Variance	0.85	0.84	0.86	0.76	0.82	0.87	0.88	0.88	0.79	0.62	0.41	0.79	0.78	0.75	0.84	0.69

A1.17 Regional investment in dwellings

TABLE A17: PARAMETER SUMMARY FOR EQUATION: REGIONAL INVESTMENT IN DWELLINGS

	Short term variables								Long term variables					
	INPT	RRPD	RRI	CDEP	ODEP	RUNR	PRSC	dY(-1)	ECM	INPT	RRPD	RRI	CDEP	ODEP
Mean	-0.31	0.34	-1.65	0.07	1.24	-0.08	0.22	0.12	-0.29	-0.05	0.17	-1.71	-2.90	0.01
Standard Deviation	0.78	0.61	2.00	5.57	7.34	0.26	0.55	0.28	0.29	8.99	0.29	1.78	2.76	1.92
Minimum Value	-3.37	0.00	-5.00	-10.00	-10.00	-1.34	0.00	-0.48	-0.90	-26.93	0.00	-4.50	-9.44	-3.00
Maximum Value	0.15	2.22	0.00	10.00	10.00	0.00	2.06	0.90	0.00	13.89	1.23	0.00	0.00	3.00
Percent Reg Variance	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Percent Dim2 Variance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent Resid. Variance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

A1.18 Regional residual income

TABLE A18: PARAMETER SUMMARY FOR EQUATION: REGIONAL RESIDUAL INCOME

	Short term variables							Long term variables				
	INPT	RWS	INF	VYVM	RLR	dY(-1)	ECM	INPT	RWS	INF	VYVM	RLR
Mean	-0.30	-0.46	-0.98	1.02	0.27	0.31	-0.24	4.58	-0.07	-2.83	0.74	0.13
Standard Deviation	1.13	0.84	0.97	1.37	0.40	0.44	0.31	9.04	0.21	4.85	0.80	0.37
Minimum Value	-4.46	-2.93	-3.42	0.00	0.00	-0.90	-0.95	-27.79	-1.12	-24.45	0.00	0.00
Maximum Value	0.24	0.00	0.00	5.25	1.35	0.90	-0.05	13.88	0.00	0.00	3.74	1.97
Percent Reg Variance	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Percent Dim2 Variance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent Resid. Variance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

A1.19 Regional total consumers' expenditure

TABLE A19: PARAMETER SUMMARY FOR EQUATION: REGIONAL TOTAL CONSUMERS' EXPENDITURE

	Short term variables										Long term variables					
	INPT	RRPDP	RRLR	CDEP	ODEP	VD	RUNR	PRSC	dY(-1)	ECM	INPT	RRPDP	RRLR	CDEP	ODEP	VD
Mean	-0.04	0.38	-0.08	0.19	0.54	0.03	-0.03	-0.16	0.06	-0.25	1.45	1.00	-0.23	0.25	0.50	0.04
Standard Deviation	0.20	0.29	0.11	0.59	1.07	0.04	0.07	0.20	0.27	0.31	1.47	0.00	0.57	0.44	0.61	0.06
Minimum Value	-0.74	0.20	-0.40	0.00	0.00	0.00	-0.25	-0.62	-0.20	-0.95	-0.09	1.00	-3.00	0.00	0.00	0.00
Maximum Value	0.38	1.09	0.00	3.00	3.00	0.13	0.00	0.00	0.60	-0.05	6.00	1.00	0.00	2.22	3.00	0.27
Percent Reg Variance	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Percent Dim2 Variance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent Resid. Variance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

A1.20 Industry employment

TABLE A20: PARAMETER SUMMARY FOR EQUATION: INDUSTRY EMPLOYMENT

	Short term variables								Long term variables						
	INPT	YR	YRWC	YRH	PYRE	YRKC	YRKN	dY(-1)	ECM	INPT	YR	YRWC	YRH	PYRE	YRKC	YRKN
Mean	-0.00	0.40	-0.31	-0.40	-0.08	0.03	-0.01	0.14	-0.33	4.80	0.46	-0.33	-0.55	-0.05	-0.03	0.02
Standard Deviation	0.06	0.63	0.45	0.86	0.27	0.58	0.61	0.30	0.32	5.72	0.40	0.32	0.71	0.09	0.59	0.58
Minimum Value	-0.35	0.00	-2.00	-4.00	-3.00	-1.20	-1.20	-0.20	-0.95	-16.62	0.00	-1.50	-3.00	-0.98	-1.20	-1.20
Maximum Value	0.64	3.00	0.00	0.00	0.00	1.20	1.20	0.90	0.00	32.45	1.80	0.00	0.00	0.00	1.20	1.20
Percent Reg Variance	0.02	0.07	0.09	0.20	0.08	0.01	0.01	0.13	0.04	0.06	0.02	0.11	0.06	0.06	0.05	0.05
Percent Dim2 Variance	0.03	0.07	0.05	0.04	0.05	0.03	0.03	0.05	0.08	0.18	0.30	0.15	0.11	0.22	0.21	0.20
Percent Resid. Variance	0.94	0.86	0.87	0.76	0.87	0.96	0.96	0.82	0.88	0.75	0.68	0.73	0.84	0.72	0.74	0.75

A1.21 Hours worked

TABLE A21: PARAMETER SUMMARY FOR EQUATION: HOURS WORKED

	Short term variables						Long term variables				
	INPT	YRNH	YRKC	YRKN	YYN	dY(-1)	ECM	INPT	YRNH	YRKC	YRKN
Mean	0.02	0.97	-0.10	-0.10	-0.01	0.06	-0.36	0.08	0.97	-0.05	-0.05
Standard Deviation	0.19	0.17	0.17	0.17	0.43	0.27	0.32	1.37	0.17	0.10	0.10
Minimum Value	-0.28	0.00	-1.20	-1.20	-2.00	-0.60	-0.95	-7.76	0.00	-1.20	-1.20
Maximum Value	1.93	1.00	0.00	0.00	2.00	0.60	0.00	18.17	1.01	0.00	0.00
Percent Reg Variance	0.01	0.01	0.12	0.12	0.02	0.30	0.31	0.21	0.01	0.10	0.10
Percent Dim2 Variance	0.53	0.78	0.34	0.34	0.11	0.03	0.07	0.03	0.80	0.10	0.10
Percent Resid. Variance	0.46	0.20	0.54	0.54	0.88	0.68	0.62	0.76	0.19	0.80	0.80

A1.22 Normal industry output

TABLE A22: PARAMETER SUMMARY FOR EQUATION: NORMAL INDUSTRY OUTPUT

	Short term variables				Long term variables			
	INPT	YRY	YRX	dY(-1)	ECM	INPT	YRY	YRX
Mean	-0.01	1.47	0.51	0.18	-0.17	-1.93	0.00	0.96
Standard Deviation	0.25	1.41	1.68	0.59	0.11	6.69	0.00	0.19
Minimum Value	-0.44	0.00	-3.00	-0.95	-0.95	-16.49	0.00	0.00
Maximum Value	1.70	3.00	3.00	0.95	0.00	6.87	0.00	1.00
Percent Reg Variance	0.49	0.11	0.25	0.07	0.26	0.95	0.02	0.02
Percent Dim2 Variance	0.12	0.10	0.04	0.07	0.10	0.00	0.04	0.64
Percent Resid. Variance	0.38	0.79	0.72	0.86	0.65	0.04	0.94	0.34

A1.23 Average industry earnings

TABLE A23: PARAMETER SUMMARY FOR EQUATION: AVERAGE INDUSTRY EARNINGS

	Short term variables											Long term variables								
	INPT	YRWE	YXE	YPRO	RUNR	RBNR	APSC	ARET	DLAPSC	LYYN	dY(-1)	ECM	INPT	YRWE	YXE	YPRO	RUNR	RBNR	APSC	ARET
Mean	0.03	0.45	0.34	0.31	-0.13	0.13	0.96	0.00	0.00	-0.04	0.02	-0.32	-0.73	0.37	0.22	0.37	-0.07	0.40	0.96	0.00
Standard Deviation	0.11	0.44	0.42	0.33	0.36	0.39	0.18	0.00	0.65	1.27	0.24	0.27	1.76	0.35	0.29	0.34	0.19	0.75	0.19	0.00
Minimum Value	-0.67	0.00	0.00	0.00	-3.00	0.00	0.00	0.00	-1.70	-10.00	-0.40	-0.95	-21.44	-0.00	0.00	0.00	-2.92	0.00	0.00	-0.00
Maximum Value	1.35	1.00	1.00	0.80	0.00	1.70	1.00	0.00	1.70	10.00	0.60	0.00	15.49	1.00	1.00	1.00	0.00	5.00	1.00	0.00
Percent Reg Variance	0.19	0.22	0.10	0.14	0.17	0.20	0.02	.NaN	0.23	0.05	0.09	0.31	0.08	0.21	0.20	0.16	0.07	0.25	0.02	0.02
Percent Dim2 Variance	0.02	0.07	0.05	0.08	0.04	0.05	0.67	.NaN	0.03	0.04	0.04	0.06	0.04	0.13	0.09	0.15	0.09	0.14	0.73	0.04
Percent Resid. Variance	0.79	0.71	0.86	0.78	0.79	0.75	0.31	.NaN	0.73	0.91	0.87	0.63	0.88	0.66	0.71	0.68	0.84	0.61	0.25	0.94

Appendix B

Estimation of the E3ME Competitiveness Effects: Results

B1 Estimation of E3ME Competitiveness Effects: Results

B1.1 Results by Sector

TABLE B1: TOTAL FUEL USE FOR ENERGY (FR0) EQUATION

	(Short Run	)	(Long Run	)
	Price	Technology	Price	Technology
Industry	-0.28	-0.17	-0.24	-0.07
Transport	-0.22	-0.32	-0.64	-0.12
Household	-0.13	-0.08	-0.39	-0.02

Note(s) : Results shown are average elasticity for the EU-25.
Source(s) : Cambridge Econometrics.
Ref : E3ME C52F1A Dec 2005.

TABLE B2: REGIONAL EMPLOYMENT (YRE) EQUATION

	(	Short Run	)	(	Long Run	)
	Wages	ICT tech.	non-ICT tech.	Wages	ICT tech.	non-ICT tech.
Agriculture	-0.15	0.07	0.04	-0.48	-0.98	0.88
Energy	-0.48	-0.02	0.09	-0.4	0.16	-0.08
Manufacturing	-0.29	0.09	-0.04	-0.38	-0.26	0.23
Construction	-0.42	0.16	-0.12	-0.31	-0.13	0.05
Market Services	-0.26	0.01	0.00	-0.22	0.14	-0.11
Non-Market Services	-0.34	0.12	-0.11	-0.38	0.12	-0.09

Note(s) : Results shown are average elasticity for the EU-25.
Source(s) : Cambridge Econometrics.
Ref : E3ME C52F1A Dec 2005.

TABLE B3: INTRA EU EXPORTS (QIX) EQUATION

	(	Short Run	)	(	Long Run	)
	Price	ICT tech.	non-ICT tech.	Price	ICT tech.	non-ICT tech.
Agriculture	-0.03	0.94	0.68	-0.01	1.96	0.01
Energy	-0.06	1.80	0.62	-0.07	1.89	0.24
Manufacturing	-0.19	0.32	0.22	-0.10	0.99	0.19
Market Services	-0.04	0.53	0.6	-0.22	1.19	0.24

Note(s) : Results shown are average elasticity for the EU-25.
Source(s) : Cambridge Econometrics.
Ref : E3ME C52F1A Dec 2005.

TABLE B4: EXTRA EU EXPORTS (QEX) EQUATION

	(Short Run		)	(Long Run		)
	Price	ICT tech.	non-ICT tech.	Price	ICT tech.	non-ICT tech.
Agriculture	-0.46	0.26	1.11	-0.02	0.83	0.05
Energy	-0.35	1.36	0.31	-0.22	0.72	0.26
Manufacturing	-0.20	0.35	0.26	-0.01	0.49	0.13
Market Services	-0.12	0.81	0.41	-0.02	0.83	0.14

Note(s) : Results shown are average elasticity for the EU-25.
Source(s) : Cambridge Econometrics.
Ref : E3ME C52F1A Dec 2005.

TABLE B5: INTRA EU IMPORTS (QIM) EQUATION

	(Short Run		)	(Long Run		)
	Price	ICT tech.	non-ICT tech.	Price	ICT tech.	non-ICT tech.
Agriculture	-0.64	-0.51	-1.01	-0.49	-0.06	-1.3
Energy	-0.2	-0.98	-0.26	-0.19	-0.63	-0.55
Manufacturing	-0.4	-0.24	-0.21	-0.31	-0.19	-0.29
Market Services	-0.58	-0.58	-0.36	-0.62	-0.28	-0.85

Note(s) : Results shown are average elasticity for the EU-25.
Source(s) : Cambridge Econometrics.
Ref : E3ME C52F1A Dec 2005.

TABLE B6: EXTRA EU IMPORTS (QEM) EQUATION

	(Short Run		)	(Long Run		)
	Price	ICT tech.	non-ICT tech.	Price	ICT tech.	non-ICT tech.
Agriculture	-0.71	-1.06	-0.42	-0.26	-0.17	-1.53
Energy	-0.18	-1.02	-0.6	-0.09	-0.32	-0.5
Manufacturing	-0.41	-0.43	-0.27	-0.27	-0.32	-0.35
Market Services	-0.5	-0.43	-0.46	-0.45	-0.18	-0.99

Note(s) : Results shown are average elasticity for the EU-25.
Source(s) : Cambridge Econometrics.
Ref : E3ME C52F1A Dec 2005.

TABLE B7: EXPORT PRICE (PQX) EQUATION

	(Short Run	)	(Long Run	)
	ICT tech.	non-ICT tech.	ICT tech.	non-ICT tech.
Agriculture	0.39	1.1	0.03	1.49
Energy	0.22	1.3	0.49	0.73
Manufacturing	0.45	0.28	0.32	0.21
Market Services	0.5	0.51	0.53	0.51

Note(s) : Results shown are average elasticity for the EU-25.
Source(s) : Cambridge Econometrics.
Ref : E3ME C52F1A Dec 2005.

TABLE B8: IMPORT PRICE (PQM) EQUATION

	(Short Run	)	(Long Run	)
	ICT tech.	non-ICT tech.	ICT tech.	non-ICT tech.
Agriculture	-0.26	-0.53	-0.87	-0.33
Energy	-1.02	-0.81	-0.27	-1.74
Manufacturing	-0.27	-0.31	-0.17	-0.22
Market Services	-0.58	-0.68	-0.73	-0.39

Note(s) : Results shown are average elasticity for the EU-25.

Source(s) : Cambridge Econometrics.

Ref : E3ME C52F1A Dec 2005.

TABLE B9: INDUSTRIAL PRICE (PYH) EQUATION

	(Short Run	)	(Long Run	)
	ICT tech.	non-ICT tech.	ICT tech.	non-ICT tech.
Agriculture	0.5	0.3	0.28	0.6
Energy	0.27	0.55	0.34	0.34
Manufacturing	0.23	0.26	0.22	0.27
Construction	0.11	0.15	0.39	0.37
Market Services	0.29	0.27	0.46	0.28
Non-Market Services	0.33	0.25	0.49	0.38

Note(s) : Results shown are average elasticity for the EU-25.

Source(s) : Cambridge Econometrics.

Ref : E3ME C52F1A Dec 2005.

B1.2 Results by Region

TABLE B10: TOTAL FUEL USE FOR ENERGY (FR0) EQUATION

	(Short Run)		(Long Run)	
	Price	Technology	Price	Technology
BE	-0.1	-0.58	-0.32	-0.04
DK	-0.12	-0.1	-0.44	-0.07
DE	-0.4	-0.04	-0.38	-0.17
EL	-0.04	-0.16	-0.3	-0.03
ES	-0.26	-0.2	-0.38	-0.02
FR	-0.11	-0.2	-0.38	-0.3
IE	-0.49	-0.05	-0.57	0
IT	-0.2	-0.25	-0.41	-0.2
LX	-0.3	-0.03	-0.5	-0.07
NL	-0.36	-0.13	-0.36	-0.03
AT	-0.22	-0.24	-0.37	-0.23
PT	-0.17	-0.02	-0.37	-0.02
FI	-0.19	-0.06	-0.47	-0.04
SW	-0.38	-0.23	-0.37	-0.21
UK	-0.06	-0.35	-0.29	-0.24
CZ	-0.4	-0.02	-0.34	-0.15
EN	-0.4	-0.22	-0.32	-0.16
CY	-0.18	-0.91	-0.4	-0.72
LV	-0.25	-0.2	-0.4	-0.15
LT	-0.35	-0.21	-0.4	-0.15
HU	-0.18	-0.22	-0.36	-0.14
MT	-0.3	-1.65	-0.32	-0.14
PL	-0.19	-0.08	-0.34	-0.15
SI	-0.58	-0.06	-0.39	-0.12
SK	-0.61	-0.9	-0.41	-0.16
NO	-0.24	-0.02	-0.61	-0.01
CH	-0.22	-0.34	-0.54	-0.1

Note(s) : Results are an average of individual parameter estimates of the E3ME regions and sectors weighted by the dependent variable.

Source(s) : Cambridge Econometrics.

Ref : E3ME C52F1A Dec 2005.

TABLE B11: REGIONAL EMPLOYMENT (YRE) EQUATION

	(	Short Run	)	(	Long Run	)
	Wages	ICT tech.	non-ICT tech.	Wages	ICT tech.	non-ICT tech.
BE	-0.22	0.39	-0.46	-0.28	0.34	-0.33
DK	-0.67	0.09	-0.07	-0.75	-0.42	0.45
DE	-0.23	0.12	-0.04	-0.19	-0.07	0.17
EL	-0.15	0.48	-0.46	-0.1	-0.04	0.05
ES	-0.17	0.35	-0.27	-0.14	-0.16	0.14
FR	-0.22	0.41	-0.44	-0.31	0.15	-0.28
IE	-0.48	0.09	-0.03	-0.08	0.35	-0.28
IT	-0.4	-0.13	0.06	-0.46	-0.11	0.09
LX	-0.15	0	0.01	-0.25	0.23	-0.26
NL	-0.49	-0.21	0.16	-0.47	0.09	-0.05
AT	-0.31	-0.07	0.11	-0.17	-0.31	0.37
PT	-0.14	0.47	-0.36	-0.32	0.05	0.01
FI	-0.13	-0.09	0.12	-0.42	-0.27	0.27
SW	-0.11	0.14	-0.15	-0.22	-0.43	0.4
UK	-0.21	-0.3	0.31	-0.35	-0.07	0.02
CZ	-0.57	0	0.11	-0.35	-0.06	0.06
EN	-0.25	0	0.02	-0.37	-0.06	0.06
CY	-0.32	0	0	-0.34	-0.06	0.06
LV	-0.13	0	0.13	-0.37	-0.16	0.15
LT	-0.2	0	0.18	-0.39	-0.19	0.19
HU	-0.38	0	0.02	-0.36	-0.06	0.05
MT	-0.33	0	0.06	-0.35	0.02	-0.01
PL	-0.18	0	0.14	-0.38	-0.26	0.24
SI	-0.36	0	-0.07	-0.37	-0.13	0.13
SK	-0.48	0	0.08	-0.36	-0.05	0.05
NO	-0.19	-0.08	0.02	-0.48	-0.41	0.38
CH	-0.94	0	0.05	-0.84	0.62	-0.59

Note(s) : Results are an average of individual parameter estimates of the E3ME regions and sectors weighted by the dependent variable.

Source(s) : Cambridge Econometrics.

Ref : E3ME C52F1A Dec 2005.

TABLE B12: INTRA EU EXPORTS (QIX) EQUATION

	(	Short Run	)	(	Long Run	)
	Price	ICT tech.	non-ICT tech.	Price	ICT tech.	non-ICT tech.
BE	-0.1	0.24	0.27	-0.34	0.39	0.2
DK	-0.1	0.74	0.28	-0.14	1.2	0.2
DE	-0.38	0.06	0.19	-0.16	0.76	0.22
EL	-0.18	0.23	0.47	-0.27	0.27	0.3
ES	-0.36	0.21	0.15	-0.03	1	0.82
FR	-0.15	0.27	0.17	-0.06	1.07	0.29
IE	-0.01	0.18	0.08	-0.04	0.96	0.21
IT	-0.12	0.3	0.27	-0.06	0.73	1.04
LX	-0.52	0.29	0.09	-0.09	0.56	0.09
NL	-0.25	0.42	0.44	-0.1	0.62	0.37
AT	-0.4	0.13	0.19	-0.15	0.65	0.09
PT	-0.22	0.04	0.13	0	0.04	0.56
FI	-0.02	0.52	0.2	-0.01	0.73	0.1
SW	-0.11	0.14	0.54	-0.01	0.73	0.09
UK	-0.08	0.33	0.33	-0.03	0.65	0.25
CZ	-0.25	0	0.14	-0.08	0.64	0.33
EN	-0.22	0	0.75	-0.06	0.63	0.38
CY	-0.7	0	1.86	-0.05	0.58	0.44
LV	-0.52	0	0.5	-0.09	0.71	0.32
LT	-0.12	0	0.39	-0.09	0.68	0.35
HU	-0.07	0	0.28	-0.05	0.62	0.33
MT	-0.09	0	0.54	-0.11	0.69	0.29
PL	-0.03	0	0.04	-0.06	0.47	0.25
SI	-0.27	0	0.16	-0.7	-1.44	0.26
SK	-0.26	0	0.15	-0.08	0.62	0.34
NO	-0.06	0.47	0.09	-0.13	0.99	0.1
CH	-0.04	0.37	0.87	-0.02	0.46	0.49

Note(s) : Results are an average of individual parameter estimates of the E3ME regions and sectors weighted by the dependent variable.

Source(s) : Cambridge Econometrics.

Ref : E3ME C52F1A Dec 2005.

TABLE B13: EXTRA EU EXPORTS (QEX) EQUATION

	(	Short Run	)	(	Long Run	)
	Price	ICT tech.	non-ICT tech.	Price	ICT tech.	non-ICT tech.
BE	-0.17	0.83	0.09	-0.25	0.38	0.18
DK	-0.04	0.95	0.22	-0.04	0.78	0.13
DE	-0.42	0.14	0.06	-0.02	0.49	0.09
EL	-0.4	0.58	0.17	-0.01	0.23	0.3
ES	-0.31	0.25	0.38	-0.02	0.55	0.13
FR	-0.09	0.35	0.68	-0.03	0.59	0.32
IE	-0.35	0.17	0.67	0	0.5	0.19
IT	-0.05	0.18	0.29	-0.02	0.3	0.29
LX	-0.32	1.13	0.16	-0.08	0.59	0.14
NL	-0.08	1.22	0.1	-0.01	0.64	0.15
AT	-0.29	0.14	0.24	-0.05	0.4	0.28
PT	-0.04	0.08	0.42	0	0.14	0.24
FI	-0.18	0.52	0.27	-0.01	0.7	0.12
SW	-0.27	0.36	0.64	-0.02	0.3	0.21
UK	-0.06	0.31	0.36	0	0.25	0.08
CZ	-0.4	0	0.2	-0.04	0.44	0.21
EN	-0.22	0	0.7	-0.04	0.43	0.19
CY	-1.52	0	1.57	-0.07	0.46	0.19
LV	-0.03	0	0.29	-0.05	0.43	0.2
LT	-0.06	0	0.26	-0.05	0.43	0.19
HU	-0.17	0	1.28	-0.1	0.49	0.23
MT	-0.01	0	0.37	-0.05	0.42	0.2
PL	-0.33	0	0.31	-0.03	0.44	0.22
SI	-0.28	0	0.26	-0.04	0.43	0.18
SK	-0.3	0	0.33	-0.07	0.39	0.22
NO	-0.05	0.33	0.43	-0.02	0.7	0.21
CH	-0.04	0.13	0.26	-0.04	0.63	0.13

Note(s) : Results are an average of individual parameter estimates of the E3ME regions and sectors weighted by the dependent variable.

Source(s) : Cambridge Econometrics.

Ref : E3ME C52F1A Dec 2005.

TABLE B14: INTRA EU IMPORTS (QIM) EQUATION

	(	Short Run	)	(	Long Run	)
	Price	ICT tech.	non-ICT tech.	Price	ICT tech.	non-ICT tech.
BE	-0.36	-0.1	-0.3	-0.23	-0.14	-0.27
DK	-0.45	-0.39	-0.19	-0.27	-0.35	-0.22
DE	-0.38	-0.07	-0.13	-0.43	-0.11	-0.17
EL	-0.29	-0.93	-1.12	-0.02	-0.01	-1.57
ES	-0.3	-0.31	-0.2	-0.33	-0.04	-0.59
FR	-0.6	-0.22	-0.12	-0.43	-0.23	-0.42
IE	-0.77	-0.66	-0.22	-0.29	-0.12	-0.39
IT	-0.42	-0.85	-0.29	-0.45	-0.21	-0.51
LX	-0.67	-0.21	-0.08	-0.11	-0.01	-0.21
NL	-0.35	-0.2	-0.16	-0.22	-0.32	-0.28
AT	-0.52	-0.46	-0.5	-0.23	-0.49	-0.47
PT	-0.67	-1.05	-0.64	-0.33	-0.55	-0.69
FI	-0.45	-0.37	-0.08	-0.49	-0.13	-0.32
SW	-0.27	-0.14	-0.23	-0.38	-0.08	-0.35
UK	-0.36	-0.34	-0.28	-0.24	-0.28	-0.47
CZ	-0.68	0	-0.31	-0.29	-0.21	-0.41
EN	-0.87	0	-0.13	-0.26	-0.21	-0.38
CY	-0.2	0	-0.22	-0.26	-0.3	-0.43
LV	-0.4	0	-0.16	-0.29	-0.2	-0.41
LT	-0.51	0	-0.27	-0.3	-0.21	-0.42
HU	-0.19	0	-0.21	-0.28	-0.22	-0.39
MT	-0.04	0	-0.34	-0.29	-0.35	-0.49
PL	-0.23	0	-0.05	-0.26	-0.19	-0.38
SI	-0.73	0	-0.08	-0.42	12.89	-0.36
SK	-0.71	0	-0.06	-0.29	-0.19	-0.4
NO	-0.5	-0.86	-0.79	-0.25	-0.43	-0.59
CH	-0.61	-0.7	-1.18	-0.64	-0.95	-0.64

Note(s) : Results are an average of individual parameter estimates of the E3ME regions and sectors weighted by the dependent variable.

Source(s) : Cambridge Econometrics.

Ref : E3ME C52F1A Dec 2005.

TABLE B15: EXTRA EU IMPORTS (QEM) EQUATION

	(	Short Run	)	(	Long Run	)
	Price	ICT tech.	non-ICT tech.	Price	ICT tech.	non-ICT tech.
BE	-0.37	-0.23	-0.12	-0.13	-0.1	-0.21
DK	-0.34	-0.58	-0.24	-0.38	-0.54	-0.21
DE	-0.33	-0.13	-0.05	-0.27	-0.15	-0.21
EL	-0.21	-1.34	-0.71	-0.05	-0.12	-1.55
ES	-0.34	-0.92	-0.56	-0.2	-0.05	-0.67
FR	-0.35	-0.42	-0.27	-0.39	-0.27	-0.3
IE	-0.72	-0.17	-0.07	-0.19	-0.15	-0.15
IT	-0.46	-0.83	-0.73	-0.3	-0.2	-1.05
LX	-0.74	-0.32	-0.42	-0.31	-0.1	-0.31
NL	-0.25	-0.55	-0.22	-0.23	-0.41	-0.28
AT	-0.55	-0.28	-0.38	-0.34	-0.53	-0.48
PT	-0.42	-0.67	-0.48	-0.34	-0.56	-0.58
FI	-0.71	-0.29	-0.2	-0.28	-0.19	-0.27
SW	-0.47	-0.23	-0.62	-0.2	-0.05	-0.47
UK	-0.41	-0.77	-0.34	-0.34	-0.35	-0.78
CZ	-0.34	0	-0.23	-0.25	-0.31	-0.5
EN	-0.85	0	-0.29	-0.27	-0.28	-0.59
CY	-0.25	0	-0.6	-0.3	-0.27	-0.57
LV	-0.46	0	-0.21	-0.24	-0.27	-0.54
LT	-0.6	0	-0.22	-0.25	-0.28	-0.56
HU	-0.46	0	-0.05	-0.23	-0.27	-0.45
MT	-0.13	0	-0.65	-0.27	-0.27	-0.49
PL	-0.44	0	-0.09	-0.23	-0.33	-0.48
SI	-0.46	0	-0.13	-0.26	-0.27	-0.51
SK	-0.27	0	-0.05	-0.19	-0.35	-0.5
NO	-0.68	-0.65	-1.03	-0.19	-0.89	-0.29
CH	-0.78	-1.13	-0.93	-0.28	-0.78	-0.98

Note(s) : Results are an average of individual parameter estimates of the E3ME regions and sectors weighted by the dependent variable.

Source(s) : Cambridge Econometrics.

Ref : E3ME C52F1A Dec 2005.

TABLE B16: EXPORT PRICE (PQX) EQUATION

	(Short Run)		(Long Run)	
	ICT tech.	non-ICT tech.	ICT tech.	non-ICT tech.
BE	0.24	0.35	0.15	0.22
DK	0.76	0.74	0.51	0.3
DE	0.15	0.09	0.32	0.22
EL	0.54	0.32	0.3	0.29
ES	0.84	0.58	0.4	0.45
FR	0.43	0.35	0.27	0.27
IE	0.71	0.29	0	0
IT	0.68	0.24	0.28	0.37
LX	0.51	0.02	0.01	0
NL	0.63	1.02	0.79	0.39
AT	0.21	0.3	0.33	0.22
PT	0.78	2.89	0.21	0
FI	0.76	0.51	0.15	0.72
SW	0.37	0.42	0.19	0.15
UK	0.44	0.44	0.36	0.14
CZ	0	0.5	0.27	0.33
EN	0	0.69	0.29	0.31
CY	0	0.15	0.3	0.32
LV	0	0.35	0.26	0.29
LT	0	0.15	0.3	0.33
HU	0	0.17	0.87	0.31
MT	0	0.29	0.29	0.33
PL	0	0.09	0.24	0.29
SI	0	0.1	0.44	0.26
SK	0	0.29	0.31	0.35
NO	0.37	0.26	0.25	0.38
CH	1.5	0.92	0.5	0.8

Note(s) : Results are an average of individual parameter estimates of the E3ME regions and sectors weighted by the dependent variable.

Source(s) : Cambridge Econometrics.

Ref : E3ME C52F1A Dec 2005.

TABLE B17: IMPORT PRICE (PQM) EQUATION

	(Short Run	)	(Long Run	)
	ICT tech.	non-ICT tech.	ICT tech.	non-ICT tech.
BE	-0.57	-0.25	2.03	0.09
DK	-0.29	-0.4	0.11	0.09
DE	-0.33	-0.17	0.11	0.24
EL	-0.65	-0.36	0.15	0.1
ES	-0.63	-0.51	0.17	0.5
FR	-0.22	-0.51	0.57	0.17
IE	-0.1	-0.08	0.07	0.25
IT	-0.42	-0.22	0.18	0.12
LX	-0.12	0	0	0
NL	-0.12	-0.35	0.05	0.14
AT	-0.69	-0.15	0.19	0.12
PT	-0.86	-0.41	0.07	0.14
FI	-0.48	-0.14	0.1	0.06
SW	-0.37	-0.29	0.13	0.05
UK	-0.37	-0.44	0.08	0.45
CZ	0	-0.19	0.27	0.18
EN	0	-0.76	0.28	0.18
CY	0	-0.6	0.27	0.18
LV	0	-0.65	0.28	0.18
LT	0	-0.84	0.28	0.18
HU	0	-0.03	0.12	0.04
MT	0	-0.24	0.27	0.18
PL	0	-0.28	0.25	0.1
SI	0	-0.29	7.38	0.11
SK	0	-0.11	0.26	0.11
NO	-0.83	-0.36	0.07	0.06
CH	-0.6	-0.33	0.38	0.29

Note(s) : Results are an average of individual parameter estimates of the E3ME regions and sectors weighted by the dependent variable.

Source(s) : Cambridge Econometrics.

Ref : E3ME C52F1A Dec 2005.

TABLE B18: INDUSTRIAL PRICE (PYH) EQUATION

	(Short Run	)	(Long Run	)
	ICT tech.	non-ICT tech.	ICT tech.	non-ICT tech.
BE	0.46	0.16	0.43	0.22
DK	0.33	0.33	0.63	0.25
DE	0.1	0.2	0.18	0.08
EL	0.21	0.25	0.03	0.98
ES	0.18	0.39	0.33	0.5
FR	0.29	0.1	0.51	0.22
IE	0.11	0.43	0.36	0.43
IT	0.41	0.3	0.3	0.54
LX	0.53	0.17	0.41	0.23
NL	0.15	0.4	0.33	0.26
AT	0.24	0.37	0.43	0.23
PT	0.25	0.32	0.15	0.46
FI	0.28	0.07	0.39	0.1
SW	0.19	0.25	0.12	0.56
UK	0.21	0.39	0.58	0.41
CZ	0.52	0.12	0.36	0.34
EN	0.55	0.1	0.32	0.36
CY	0.56	0.12	0.36	0.3
LV	0.89	0.07	0.35	0.35
LT	0.6	0.14	0.35	0.35
HU	0.66	0.12	0.93	0.35
MT	0.67	0.11	0.51	0.3
PL	0.69	0.15	-0.02	0.33
SI	0.92	0.07	0.33	0.35
SK	0.7	0.18	0.38	0.34
NO	0.53	0.46	0.68	0.04
CH	0.56	0.31	0.69	0.17

Note(s) : Results are an average of individual parameter estimates of the E3ME regions and sectors weighted by the dependent variable.

Source(s) : Cambridge Econometrics.

Ref : E3ME C52F1A Dec 2005.

Appendix C

Incorporating New EU Member Economies in a Multisectoral, Multi-region Dynamic Model: Applying Shrinkage Estimation to E3ME

C1 Acknowledgements

This paper was written by James Reade and Michael Spicer in support of Cambridge Econometrics' contribution to the COMETR project (Competitiveness Effects of Environmental Tax reform) for the European Commission. CE is leader of work package 4 of the project. The authors gratefully acknowledge the help and advice given by Prof. Ron Smith of Birkbeck College, University of London.

C2 Summary

The 10 new member states of the EU present difficulties for estimating the multi-regional, multi-sectoral E3ME econometric model. Data are only for short time periods and of poor quality. It is essential for forecasting that parameter estimates lie within acceptable limits, but these are often breached for these new members.

- Shrinkage, an estimation technique used in the heterogeneous panel data literature, has been applied to these new members in E3ME, and some preliminary results are shown to support use. The basic idea is to restrict the parameters for the new member states to equal the mean results from independent estimation of the established members.
- Theoretical and practical advantages and disadvantages of this technique are presented. Notably, forecasting is improved, but other studies have shown that economic inference for the new members is not necessarily enhanced.
- Possible further uses of shrinkage are discussed in the context of the multi-dimensional panel data model E3ME. It is concluded that the shrinkage method in this specific example is useful, and may well prove fruitful in future estimations of E3ME parameters.

C3 Introduction

C3.1 Estimating E3ME

The complex nature of E3ME, as an energy-environment-economy model, places huge demands on data collection. The model comprises 22 sets of time-series equations estimated over 27 European regions, covering a wide range of variables such as energy demands by fuel type, industrial employment, import and export prices and consumer expenditure. Moreover, 41 sectors, 28 categories of consumer spending and 19 fuel users are distinguished. Each equation set has a given specification, and this is used for each region and second dimension (sector, category of spending etc). The number of stochastic equations to estimate is very large, but it is crucial for dynamic forecasting and scenario analysis that the general pattern of the results is consistent with a-priori beliefs and that individual coefficients fulfil any stability conditions.

C3.2 Adding new regions

Incorporating ten new EU-member economies into this large-scale macro-econometric framework presents a number of problems. Most of these economies continue to make the transition to a market economy. The short span of data available for each variable (if data exist at all) and its general poor quality makes the asymptotic properties of the parameters rather dubious (Erjavec, 2003). The Engle-Granger procedure for estimating long-run relationships in the model may also be problematic. Although estimates of the long-run coefficients are superconsistent (in the presence of cointegration), they suffer from very large small-sample biases. Moreover, long and short-run relationships in transition economies are particularly susceptible to change.

The current E3ME approach

The current E3ME approach is to restrict the coefficients to have the 'correct' sign and magnitude. This is not ideal because the implausible freely-estimated parameters may indicate a mis-specified model, in which case further research is needed. In some cases, poor data quality could be the problem. The availability of reliable data varies across countries and sectors; and it may be necessary to employ crude methods for splitting aggregates to more detailed categories for use in the model.

The shrinkage approach

The focus of this paper is an alternative approach to dealing with implausible parameter estimates across a large number of stochastic equations. Shrinkage estimation combines the results of independent estimation with averaged results. In this paper, the technique is applied to the employment equation set in E3ME; the equations are estimated as per the current approach, and then the averaged results from the EU-15 countries are combined with the individual coefficients for the new member states. As the full model is not yet complete using the shrinkage technique, forecast comparisons cannot be made; however, parameter estimates are compared.

It will be shown, for this equation set, that the shrinkage procedure succeeds in 'shrinking' implausible parameter values to more plausible ones.

C4 Shrinkage Methodology

C4.1 Estimating in heterogeneous panel datasets

The problem of heterogeneous panels of data, particularly ones with large cross-section and large time dimensions, has been much discussed in the literature (see Peseran & Smith, 1995). The issue is how to estimate parameters given this problem; methods for estimating differ widely, from simple OLS on each equation, to pooling data and running a single regression. The former implies every unit is different, but in large models could be very complicated and time consuming, while the latter suggests that all cross section units are identical in their behaviour, and may not be an appropriate assumption. Pooling has also been shown (Peseran and Smith, 1995) to provide inconsistent and biased estimators when serial correlation exists in the data.

Issues facing estimation in E3ME

For E3ME, the units of interest are regions; clearly when the model encompasses regions such as Germany, Ireland and Latvia, it seems wrong to suggest that units behave identically. However, running OLS on each unit can be problematic as well as complicated and resource costly; the data inadequacies in new member states of the EU lead to often wildly differing estimates of the same parameter over regions. While it seems plausible to suggest that this variation is due to differences between countries and specification problems, a non-negligible part is surely due to data problems. One solution, the current procedure for E3ME, is to place restrictions to constrain parameter values to be within 'reasonable' ranges. Another method is to 'shrink' estimators towards a weighted average of the units of the panel.

C4.2 Shrinkage estimators

The simple idea is that in a regression of unit *i* in a panel:

$$y_{it} = \beta_i x_{it} + u_{it},$$

one might use instead of the OLS estimate $\hat{\beta}_i$, an estimate that is a weighted average of $\hat{\beta}_i$ and the mean group estimator $\beta_i *$:

$$\beta_i * = \sum_i w_i \hat{\beta}_i .$$

This gives us:

$$\tilde{\beta}_i = Q_i \beta_i * + (1 - Q_i)\hat{\beta}_i ,$$

where Q_i is the weight, and for the N units in the panel we would have that:

$$\sum_i Q_i = 1 .$$

It is possible that only a subset of the N units would be used to construct the mean group estimator, and that the shrinkage is applied only to a subset of the units, possibly distinct from those that the mean group estimator is averaged over. The first possibility would give $w_i = 0$ for some i, and the second would imply $Q_i = 0$ for those equations where shrinkage is not applied.

Constructing the weights

A number of possible strategies could be implemented to construct the weight sets, using in-sample or out-of-sample data. In-sample data options include weighting based on estimation uncertainty, for example taking the residual variance for the regression on each unit or the standard error of a particular estimator. Other methods might be to construct quantitatively some kind of index of data quality based on the sample sets alone, perhaps related to years of data and missing values. Out-of-sample methods could be data-based, or could elicit information from other sources. Data-based methods might be to omit the last, say, l observations and use these as a kind of 'training' period over which to forecast knowing true outcomes and hence construct weights based on the forecast performance of each unit (although this might not be appropriate across cross section units). Non-data methods might be to take countries known for superior data length and quality and give these a stronger weight; however this is problematic and subjective. First, this would impose the structure of only the larger more established market economies on small, transitional economies; and second, given there are a number of countries in Europe that could feasibly be used based on data quality, a sub-criterion would presumably have to be used to weight the countries within the set chosen by data quality. Two things might be noted. First, there is no reason why a combination of criteria for weight constructions should not be used. Second, the reason why one weight might be small, implies that the other weight should be high (high residual variance implies low w_i and high Q_i).

Disadvantages of shrinkage

As with any estimation procedure, there are advantages and disadvantages. In terms of concerns, the estimated regression coefficient for a particular region reflects the data used in the regression for that region even though the data might be very short and imperfect. Information from outside the sample, from units of very different structure (see Stiglitz (1999) for an argument on the different nature of transition economies), is being used to change that in the sample.

Advantages

The problem of the unsatisfactory estimates of new regions is not solely data-related; part of the problem with the new EU states is inappropriately specified equations. The same equations from older members, based on theory that better reflects the kind of established market economies that they are, are applied to newer members; one imagines different variables will be significant for these different economies, and that given the rapidly changing economic environment in these countries, dummy variables might be necessary to correct for structural breaks. On the other hand, respecifying a particular equation would imply altering the structure of the economic model underlying E3ME, with implications much wider than the simple equation being estimated. Hence in the absence of the resources involved to individually respecify each new member equation, shrinkage provides a way of improving robustness, albeit at the expense of perhaps making new members look like old ones. It might further be argued that in the case of poor data, shrinkage could move estimates closer to the 'true' parameter values for each region given the large bias in each individual equation estimate.

Shrinkage and forecasting

Shrinkage estimators may also improve forecasting, as Monte Carlo simulations by Miller and Williams (2003) have indicated. Hendry and Clements (2004) have provided an explanation why this may be the case. It is not because the fit of the model has been enhanced; a more congruent model cannot be proved to forecast better. Shrinkage provides a way of 'intercept correcting', a method that makes forecasts more robust against structural breaks and hence forecast failure (see Clements and Hendry, 1996). This is different from improving our understanding of the underlying economic processes, as a distinction must be made between models that do this, and models that are used for forecasting.

More complicated panel data models

A separate issue is that E3ME is a multi-panel model; E3ME covers regions *and* industries over time. A natural question is upon which dimension, or both, should the shrinkage take place? One possible method to decide might be to consider which dimension has the more variation, and so analysis of variance could be used. We can decompose β_{ij} into:

$$\beta_{ij} = \beta + v_i + v_j,$$

where v_i and v_j are the unit specific components for each dimension. From our estimates from both dimensions we can calculate:

$$\overline{\beta} = (NJ)^{-1}\sum_j \sum_i \hat{\beta}_{ij},$$

$$\overline{\beta}_i = J^{-1}\sum_j \hat{\beta}_{ij},$$

$$\overline{\beta}_j = N^{-1}\sum_i \hat{\beta}_{ij}.$$

Then:

$$\hat{v}_i = \overline{\beta}_i - \overline{\beta},$$

$$\hat{v}_j = \overline{\beta}_j - \overline{\beta},$$

$$\hat{v}_{ij} = \hat{\beta}_{ij} - \overline{\beta} - \hat{v}_i - \hat{v}_j.$$

We can then do analysis of variance on:

$$\hat{\beta}_{ij} - \overline{\beta} = \hat{v}_{ij} - \hat{v}_i - \hat{v},$$

as they are all independent hence the estimated variance simplifies to:

$$(NJ)^{-1}\sum_i \sum_j \left(\hat{\beta}_{ij} - \overline{\beta}\right)^2 = (NJ)^{-1}\sum_i \sum_j v_{ij}^2 + (NJ)^{-1}\sum_i v_i^2 + (NJ)^{-1}\sum_j v_j^2$$

$$\hat{\sigma}^2 = \hat{\sigma}_{ij}^2 + \hat{\sigma}_i^2 + \hat{\sigma}_j^2.$$

The suggestion would then be to choose the dimension on which to shrink based on which dimension, *i* or *j*, contributes most to the overall estimated variance. One imagines it is feasible to carry out shrinkage along both dimensions if both dimensions show a strong level of variation. In the two dimensional dynamic panel case there are the individual regressions:

$$y_{ijt} = \beta_{ijt}x_{ijt} + u_{ijt},$$

and so the groups estimator might be:

$$\beta_{ij}* = \sum_i \sum_j w_{ij}\hat{\beta}_{ij},$$

where:

$$\sum_i \sum_j w_{ij} = 1,$$

or perhaps:

$$\sum_i w_i \sum_j w_j = 1,$$

with

$$\sum_j w_j = 1,$$

which would allow weights to sum to unity in each dimension. Then the shrinkage estimators might be written as:

$$\tilde{\beta}_{ij} = Q_{ij}\beta_{ij} * + (1 - Q_{ij})\hat{\beta}_{ij}.$$

Thus shrinkage can valuably be used in the context of new EU member states, provided one is clear the model is for forecasting and not for gleaning insights on the European economy.

C5 Shrinkage Estimation in E3ME

C5.1 Proposed method

This section reports on the results from applying shrinkage to the E3ME employment equations. The results are compared with those from the current procedure, in which all regions and sectors are estimated using the Engle-Granger two-step method (with restrictions placed on the magnitude and signs of some of the coefficients) and final equations are selected using the Akaike Information Criterion.

The shrinkage procedure used here is a special case of the more general technique discussed above. The shrinkage is carried out along the regional, but not the sectoral dimension. We justify this approach on the basis of the paucity of sectorally-disaggregated data for the new EU countries (which results in low degrees of freedom in the estimation) and its general poor quality. Shrinkage is only applied to the long-run equation in E3ME, and the rationale for this is that in the long run new member states are expected to converge towards older member states along these dimensions.

The mean group estimator is calculated by attaching a weight of 0 to the ten new members of the EU (NEU), and equal weights to the remaining countries:

$$\beta_i * = \sum_i w_i \hat{\beta}_i$$

$$where\ w_i = 0\ for\ i \in NEU\ and\ w_i = \frac{1}{N}\ for\ i \notin NEU$$

$$and\ NEU = \{new\ EU\ member\ states\};\ N = number\ of\ old\ member\ states$$

Even if one were to use the variance-covariance matrices of the residuals in each equation as proxies for uncertainty, one might expect the weights for the new countries to be much less than for the EU-15.

The weighting scheme used to construct the shrinkage parameters is correspondingly simple:

$$\tilde{\beta}_i = Q_i \beta^*{}_i + (1 - Q_i)\hat{\beta}_i$$

$$where\ Q_i = 0\ for\ i \notin NEU\ and\ Q_i = 1\ for\ i \in NEU$$

Thus coefficients in the new EU countries are shrunk to equal the mean group estimators; coefficients for the remaining countries are equal to the ones from the original estimation.

Shrinkage gives more useful estimates

As the full model is not yet complete using the shrinkage technique, forecast comparisons cannot be made; however, parameter estimates can be considered.

C5.2 Results

Table C5.2.1 reports the weighted average (the weights are employment shares in 2000) of the parameters for output and wages in the employment equations across all the industries in a particular region for four of the new member states (Poland, the Czech Republic, Hungary and Slovakia) before and after shrinkage is carried out. The two independent variables reported are output and wages in the long-run cointegrating relation, where the overall equation is estimated using the Engle-Granger procedure. It can be seen that before the shrinkage, long-run parameters for output are very large and suggest a strong (in Slovakia slightly more than proportional) reaction to output. These coefficients are reduced to more sensible levels after the shrinkage. It is not that these new parameters reflect truer estimates for these countries; more that they will likely aid more sensible forecasts for the model as a whole. The effect on wages is more varied, for some regions increasing the average coefficient, in others decreasing it.

In Table C5.2.2 regression coefficients from individual units of the panel are reported; the region is the Czech Republic and the four sectors are Coal, Mechanical Engineering and Professional Services. It is unlikely that in the long run employment responds to a 1% increase in output with a greater than 1% rise, yet the bold figures show where normal OLS regression for these sectors produced such implausible estimates. What was shown in Table C5.2.1 at the aggregate level is shown here for individual equations: implausible parameter values are reduced to more reasonable levels.

TABLE C1: WEIGHTED AVERAGE OF SHORT AND LONG RUN PARAMETERS FOR EMPLOYMENT OVER ALL INDUSTRIES FOR PARTICULAR REGION.

		Shrinkage		No shrinkage
	Output	Wages	Outp	Wages
CZ	0.57	-0.43	0.69	-0.77
HU	0.54	-0.42	0.79	-0.28
PL	0.47	-0.43	0.97	-0.41
SK	0.54	-0.44	0.99	-0.38

Source(s) : E3ME.

TABLE C2: PARAMETER ESTIMATES IN THE SECTORAL EMPLOYMENT EQUATIONS FOR THE CZECH REPUBLIC BEFORE AND AFTER SHRINKAGE

	Before	After	Before	After	Before	After
		Coal	Mechanical Engineering			Professional Services
Output	1.24	0.39	1.26	0.58	1.138	0.66
Wages	0.00	-0.38	0.00	-0.59	-0.09	-0.28

C6 Conclusions

In this paper the difficulties of incorporating new EU member states into the E3ME modelling framework have been outlined. It is important for forecasting and scenario analysis that individual coefficients fulfil any stability requirements, such as the marginal effect of output changes on employment being less than proportional. Poor data quality, such as that for new EU member states, jeopardises this, as the empirical results in this paper have shown. Shrinkage estimation has been outlined as a procedure to achieve this, and its advantages and disadvantages discussed. Notably, the strong forecasting properties have been outlined. In the case of the new EU member states, shrinkage seems to be a sensible option. However, if it is to be proposed as a more general technique to be used in E3ME modelling, one has to bear in mind that each individual coefficient will not reflect the economic conditions in any one region and/or sector, but a weighted average of the conditions over all regions and/or sectors and so the resulting model can only suitably be used for forecasting.

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Appendix D

The Processed Tax Data Inputs for E3ME

D The detailed tax data

Introduction

This section contains a full set of tables for the tax rates, revenues and revenue recycling methods that were used in the E3ME modelling. This is the data after the processing described in chapter 4. The rates and revenues relate only to the ETR part of the tax, not other existing taxes and excise duties.

The tax revenues were used in the baseline case to estimate effective tax rates (ie taking exemptions into consideration) and these were used in the analysis. The tax rates were used in the case with no exemptions where the full rate was charged.

All data are converted to the E3ME classifications. For tax rates and revenues this means the six fuels, for industry and households. These include both energy and CO2 taxes. For the revenue recycling this was a matrix with the five rows being the five revenue recycling methods (income taxes, employers' and employees' social security contributions, benefits and government investment). For the revenue recycling the data are presented as shares of the total revenues; the rows add up to one, ensuring that the revenue neutrality assumption is met.

The exception to this rule is revenues in Sweden, where more detailed data were available. These were incorporated directly into E3ME, using the Fuel User classification. A separate table has been created for each fuel.

The units for tax rates and revenues are consistent across sectors and countries, with the rates being expressed in Euros/toe and the revenues in millions of Euros. A negative value indicates that tax rates or revenues fell as a result of the tax reforms. All the tables cover the period 1994-2004.

D1 Denmark

TABLE D1: TAX RATES (HEAVY) IN DENMARK, E/TOE (HEAVY)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Industry - Coal	0.5	0.6	0.5	3.2	5.8	8.6	11.2	11.2	11.3	11.3	11.2
Industry - Oil (heating)	0	0	0	1.5	2.9	4.4	5.9	5.9	5.9	5.9	5.9
Industry - Gas	0	0	0	0	0	0	0	0	0	0	0
Industry - Electricity	1.3	1.5	1.5	9.1	16.9	24.9	32.6	32.6	32.7	32.7	32.7
Industry - petrol	33.1	123.4	185.2	184.3	191.7	265	280.5	297.8	316.9	316.8	316
Industry - diesel	44	89.8	91.4	101	100.2	103.4	174.2	174.3	203.8	203.8	203.2
Households - Coal	36.7	60.6	79.8	95.6	114.8	163.8	174	185.1	202.8	202.8	202.3
Households - Oil (heating)	0	5.5	4.7	1.5	1.1	25.5	28.3	33.7	39.8	39.8	39.5
Households - Gas	0	0	0	0	0	0.3	0.3	0.3	0.4	0.4	0.4
Households - Electricity	104.8	170.6	215.1	265.2	365.9	396.9	480.5	504.1	530.5	530.5	529.2
Households - petrol	33.1	123.4	185.2	184.3	191.7	265	280.5	297.8	316.9	316.8	316
Households - diesel	44	89.8	91.4	101	100.2	103.4	174.2	174.3	203.8	203.8	203.2

TABLE D2: TAX REVENUES IN DENMARK, MILLIONS OF EUROS

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Industry - Coal	43	42.3	68.9	111.2	149.2	238.5	294	301.9	313.5	349.5	329.4
Industry - Oil (heating)	0	81.3	146.9	131.3	183.5	250.1	244.3	297	314.6	356	390.8
Industry - Gas	6.2	6.8	9.4	5.9	0	0	0	0	0	0	0
Industry - Electricity	97	162.5	260.1	338	519.7	620.8	674.4	664.4	734.9	747.2	753.9
Industry - petrol	42.7	182.6	282.1	291	319.9	453.5	420.3	433.9	449.2	448.1	434.5
Industry - diesel	43.5	99.3	111.4	125	130.3	146.6	203.3	199.6	225.9	225.8	219.2
Households - Coal	28.3	27.1	46	25.1	12.2	7.5	0.1	3.1	-2.5	-1.3	1.6
Households - Oil (heating)	0	-0.1	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3
Households - Gas	0	0	0	0	0	0	0	0	0	0	0
Households - Electricity	10	13.5	25.8	16.9	13.8	12.9	9.3	11.9	8.5	9.1	10.4
Households - petrol	0	0	0	0	0	0	0	0	0	0	0
Households - diesel	0	0	0	0	0	0	0	0	0	0	0

TABLE D3: REVENUE RECYCLING IN DENMARK, SHARES

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Income Tax	0	0	0	0	0	0	0	0	0	0	0
Employers' Contributions	1	1	0.992	0.988	0.987	0.984	0.986	0.993	1	1	1
Employees' Contributions	0	0	0	0	0	0	0	0	0	0	0
Benefits	0	0	0	0	0	0	0	0	0	0	0
Investment	0	0	0.008	0.012	0.013	0.016	0.014	0.007	0	0	0

D2 Germany

TABLE D4: TAX RATES IN GERMANY, E/TOE

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Industry - Coal	0	0	0	0	0	0	0	0	0	0	0
Industry - Oil (heating)	0	0	0	0	0	3.3	3.3	3.3	3.3	9.9	9.9
Industry - Gas	0	0	0	0	0	4.7	4.7	4.7	4.7	25.6	25.6
Industry - Electricity	0	0	0	0	0	23.8	29.8	35.7	41.9	143	143
Industry - petrol	0	0	0	0	0	39.1	78.2	117.2	156.3	195.4	195.4
Industry - diesel	0	0	0	0	0	35.7	71.4	107	142.7	178.4	178.4
Households - Coal	0	0	0	0	0	0	0	0	0	0	0
Households - Oil (heating)	0	0	0	0	0	16.6	16.6	16.6	16.6	16.6	16.6
Households - Gas	0	0	0	0	0	19.8	19.8	19.8	19.8	43	43
Households - Electricity	0	0	0	0	0	119	148.6	178.4	208.2	238.4	238.4
Households - petrol	0	0	0	0	0	39.1	78.2	117.2	156.3	195.4	195.4
Households - diesel	0	0	0	0	0	35.7	71.4	107	142.7	178.4	178.4

TABLE D5: TAX REVENUES IN GERMANY, MILLIONS OF EUROS

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Industry - Coal	0	0	0	0	0	0	0	0	0	0	0
Industry - Oil (heating)	0	0	0	0	0	98.7	198.8	498.7	198.9	198.8	203.9
Industry - Gas	0	0	0	0	0	299.5	500	1200	1400	3400	3508.7
Industry - Electricity	0	0	0	0	0	1214.7	2178.9	2826.1	3340.4	4163.3	4271.5
Industry - petrol	0	0	0	0	0	800	1700	2000	2400	2400	2439.4
Industry - diesel	0	0	0	0	0	1100	2500	3700	5000	5700	5793.6
Households - Coal	0	0	0	0	0	0	0	0	0	0	0
Households - Oil (heating)	0	0	0	0	0	1.3	1.2	1.3	1.1	1.2	1.2
Households - Gas	0	0	0	0	0	0.5	0	0	0	0	0
Households - Electricity	0	0	0	0	0	585.3	1121.1	1473.9	1759.6	2336.7	2329
Households - petrol	0	0	0	0	0	0	0	0	0	0	0
Households - diesel	0	0	0	0	0	0	0	0	0	0	0

TABLE D6: REVENUE RECYCLING IN GERMANY, SHARES

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Income Tax	0	0	0	0	0	0.476	0.488	0.487	0.493	0.495	0.495
Employers' Contributions	0	0	0	0	0	0.476	0.488	0.487	0.493	0.495	0.495
Employees' Contributions	0	0	0	0	0	0	0	0	0	0	0
Benefits	0	0	0	0	0	0	0	0	0	0	0
Investment	0	0	0	0	0	0.049	0.024	0.026	0.013	0.01	0.011

D3 The Netherlands

TABLE D7: TAX RATES IN THE NETHRLANDS, E/TOE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Industry - Coal	0	0	0	0	-0.1	0.4	0.7	1.1	2.3	2.3	2.8
Industry - Oil (heating)	0	0	0	0	10.5	26.2	43.9	82.5	86	90.2	93.1
Industry - Gas	0	0	0	0	5.3	39.8	65.6	108	112.7	118.4	122.5
Industry - Electricity	0	0	0	0	1	106.6	278.1	523.5	544.3	588.1	605.9
Industry - petrol	0	0	0	0	0	0.3	0.6	0.8	1.3	1.8	1.8
Industry - diesel	0	0	0	0	0	0.3	0.6	0.8	1.3	1.9	1.9
Households - Coal	0	0	0	0	0	0	0	0	0	0	0
Households - Oil (heating)	0	0	0	0	0	0	0	0	0	0	0
Households - Gas	0	0	0	0	5.3	39.8	65.6	108	112.7	118.4	122.5
Households - Electricity	0	0	0	0	1	106.6	278.1	523.5	544.3	588.1	605.9
Households - petrol	0	0	0	0	0	0	0	0	0	0	0
Households - diesel	0	0	0	0	0	0	0	0	0	0	0

TABLE D8: TAX REVENUES IN THE NETHERLANDS, MILLIONS OF EUROS	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Industry - Coal	0	0	0	0	-0.7	3.4	6.3	9.5	20.9	22.2	28
Industry - Oil (heating)	0	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1
Industry - Gas	0	0	0	0	17.4	86	110.5	100.8	85	87.6	93.4
Industry - Electricity	0	0	0	0	0	22.3	60.8	136.5	114.8	112.3	123.7
Industry - petrol	0	0	0	0	0	1.9	3.6	5.3	8.4	12.3	13.1
Industry - diesel	0	0	0	0	0	1.7	3.2	4.8	7.8	11.3	12.1
Households - Coal	0	0	0	0	0	0	0	0	0	0	0
Households - Oil (heating)	0	0	0	0	0	0	0	0	0	0	0
Households - Gas	0	0	0	0	7	26.7	27.1	266.1	224.6	242.2	268.1
Households - Electricity	0	0	0	0	7.3	656.6	1390	1825.6	1537.2	1572.3	1748.5
Households - petrol	0	0	0	0	0	0	0	0	0	0	0
Households - diesel	0	0	0	0	0	0	0	0	0	0	0

TABLE D9: REVENUE RECYCLING IN THE NETHERLANDS, SHARES	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Income Tax	0	0	0	0	0	1	1	1	1	1	1
Employers' Contributions	0	0	0	0	0	0	0	0	0	0	0
Employees' Contributions	0	0	0	0	0	0	0	0	0	0	0
Benefits	0	0	0	0	0	0	0	0	0	0	0
Investment	0	0	0	0	0	0	0	0	0	0	0

D4 Finland

TABLE D10: TAX RATES IN FINLAND, E/TOE	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Industry - Coal	0	0	0	14.7	22.9	36	36	36	36	39.6	39.6
Industry - Oil (heating)	0	0	0	15	20	27.1	27.1	27.1	27.1	29.8	29.8
Industry - Gas	0	0	0	3.5	5.9	9.4	9.4	9.4	9.4	10.8	10.8
Industry - Electricity	0	0	0	46.5	39.5	48.8	48.8	48.8	48.8	51.2	51.2
Industry - petrol	0	0	0	0	52.2	42	42	42	42	78.9	78.9
Industry - diesel	0	0	0	0.3	29.9	29.6	29.6	29.6	29.6	49.8	49.8
Households - Coal	0	0	0	14.7	22.9	36	36	36	36	39.6	39.6
Households - Oil (heating)	0	0	0	15	20	27.1	27.1	27.1	27.1	29.8	29.8
Households - Gas	0	0	0	3.5	5.9	9.4	9.4	9.4	9.4	10.8	10.8
Households - Electricity	0	0	0	46.5	65.1	80.2	80.2	80.2	80.2	84.9	84.9
Households - petrol	0	0	0	0	52.2	42	42	42	42	78.9	78.9
Households - diesel	0	0	0	0.3	29.9	29.6	29.6	29.6	29.6	49.8	49.8

TABLE D11: TAX REVENUES IN FINLAND, EUROS	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Industry - Coal	0	0	0	17.9	20	25.6	27	32.2	31.3	32.1	30.6
Industry - Oil (heating)	0	0	0	68.7	97.4	127.2	109.9	122	90.1	100.5	94.4
Industry - Gas	0	0	0	10.2	19.5	31.2	31.9	34.6	34.4	43.8	46.2
Industry - Electricity	0	0	0	203.3	228.1	255.2	258.2	263.1	287.9	327.2	316.4
Industry - petrol	0	0	0	0	98.3	82.8	80	81.7	84.5	152.2	158.9
Industry - diesel	0	0	0	0.6	46.1	49.3	50.5	51.8	54.2	88.5	94.8
Households - Coal	0	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1
Households - Oil (heating)	0	0	0	2.4	3.2	0.8	1.9	1.5	1.5	1.4	1.4
Households - Gas	0	0	0	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
Households - Electricity	0	0	0	69.6	101.6	127.4	125.2	133.7	137.6	149	151.2
Households - petrol	0	0	0	0	0	0	0	0	0	0	0
Households - diesel	0	0	0	0	0	0	0	0	0	0	0

TABLE D12: REVENUE RECYCLING IN FINLAND, SHARES	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Income Tax	0	0	0	1	1	1	1	1	1	1	1
Employers' Contributions	0	0	0	0	0	0	0	0	0	0	0
Employees' Contributions	0	0	0	0	0	0	0	0	0	0	0
Benefits	0	0	0	0	0	0	0	0	0	0	0
Investment	0	0	0	0	0	0	0	0	0	0	0

D5 Sweden

TABLE D13: TAX RATES IN SWEDEN, E/TOE

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Industry - Coal	-118.9	-118.6	-111.9	-112.7	-71.3	-71	-66.5	-73.4	-71.9	-70.9	-70.6
Industry - Oil (heating)	-92.4	-92.3	-88.5	-89	-65.6	-65.4	-62.9	-66.8	-66	-65.4	-65.2
Industry - Gas	-70.4	-70.3	-65.9	-66.4	-40.9	-40.7	-38	-42.2	-41.3	-40.7	-40.5
Industry - Electricity	-64.9	-64.9	-64.9	-64.9	-64.9	-64.9	-64.9	-64.9	-64.9	-64.9	-58.5
Industry - petrol	124.2	128	203	209.3	219.2	221.3	254.8	200	223	238.2	249.3
Industry - diesel	181.8	197	240.5	241	243.5	244.7	297.4	276.8	291.2	300	319.5
Households - Coal	36.4	37.8	69.6	70.6	72.2	73	84.9	132.6	179.3	241	308.3
Households - Oil (heating)	20.4	21.4	42.4	45.5	49.6	50.1	58.7	79.7	107.3	142.6	181.2
Households - Gas	20.9	21.8	42	42.4	43.1	43.6	50.7	80.5	109	146.7	188.1
Households - Electricity	18.3	18.7	39.1	58.5	104.9	106	129.7	134	157.9	195.9	213.8
Households - petrol	124.2	128	203	209.3	219.2	221.3	254.8	200	223	238.2	249.3
Households - diesel	181.8	197	240.5	241	243.5	244.7	297.4	276.8	291.2	300	319.5

TABLE D14: TAX REVENUES IN SWEDEN, COAL

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Power own use & trans.	-30	-29.1	-42.5	-18	0.2	0.3	2.2	0	1	2.3	2.9
O.energy own use & tra	-38.7	-30.1	-36.6	-25.7	0.7	0.7	2.8	0.2	2.2	3.3	3.4
Iron & steel	-0.9	-0.7	-1	-2.1	-0.1	-0.1	0	-0.1	-0.3	-0.1	-0.1
Non-ferrous metals	-0.7	-0.7	-0.8	-0.9	-0.1	-0.1	0	-0.1	-0.1	-0.1	-0.1
Chemicals	0.5	0.3	0.3	0.3	0.3	0.3	0.2	0.4	0.7	0.7	0.7
Non-metallics nes	-6.6	-7.3	-7.8	-8.2	-1.5	-1.6	-0.1	-1.1	-1.2	-0.7	-0.7
Ore-extra.(non-energy)	-0.1	-0.1	-0.1	-0.2	0	0	0.1	0	0	0	0
Food, drink & tob.	-0.1	-0.2	0.2	-0.6	0.9	0.9	0.9	0.7	0.9	0.9	0.9
Tex., cloth. & footw.	0	0	0	0	0	0	0	0	0	0	0
Paper & pulp	-0.3	0.2	0.4	0.2	0.3	0.3	0.4	0.2	0.2	0.2	0.2
Engineering etc	0.3	0.1	0.2	-0.6	0.2	0.4	0.3	0.7	0.8	0.8	0.8
Other industry	0	0	0	0	0	0	0	0	0	0	0
Rail transport	0	0	0	0	0	0	0	0	0	0	0
Road transport	0	0	0	0	0	0	0	0	0	0	0
Air transport	0	0	0	0	0	0	0	0	0	0	0
Other transp. serv.	0.1	0.1	0	0	0	0	0	0	0	0	0
Households	0.8	0.5	0.7	0.2	0.4	0.2	0.1	0.1	0.1	0.2	0.2
Other final use	0	0	0	0	0	0	0	0	0	0	0
Non-energy use	0	0	0	0	0	0	0	0	0	0	0

TABLE D15: TAX REVENUES IN SWEDEN, OIL

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Power own use & trans.	-32.6	-28.1	-56.9	-22.6	-6.9	-4.1	-0.3	-2.6	-4	-3.9	-3.5
O.energy own use & tra	-21.7	-17	-21.2	-12.3	-2.3	-1.7	-0.2	-1.3	-1.5	-0.2	-0.3
Iron & steel	-2.5	-2.4	-3	-2.9	-0.6	-0.5	-0.1	-0.3	-0.4	-0.2	-0.3
Non-ferrous metals	-0.1	-0.1	-0.1	-0.1	0	0	0	0	0	0	0
Chemicals	-5.8	-5.9	-5.3	-5.8	-0.9	-0.7	-0.1	-0.9	-0.9	-0.6	-0.7
Non-metallics nes	-2.3	-1.7	-1.9	-2	-0.5	-1	-0.1	-0.5	-0.7	-0.5	-0.5
Ore-extra.(non-energy)	-0.1	-0.1	-0.2	-0.1	0	0	0	0	0	0	0
Food, drink & tob.	-6.8	-7.1	-9.5	-9.8	-1.6	-1.3	-0.1	-1	-1.2	-1.5	-1.3
Tex., cloth. & footw.	0	0	0	0	0	0	0	0	0	0	0
Paper & pulp	-7.3	-15.6	1.3	13.2	-2.1	-0.4	-0.1	-0.6	-0.7	-0.6	-1.1
Engineering etc	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9	-15.9
Other industry	0	0	0	0	0	0	0	0	0	0	0
Rail transport	0	0	0	-0.2	0	0	0	0	0	0	0
Road transport	0	0	0	0	0	0	0	0	0	0	0
Air transport	0	0	0	0	0	0	0	0	0	0	0
Other transp. serv.	8.8	21	3.2	7.6	0.9	0.7	0.1	0.7	0.9	0.9	0.9
Households	3.1	3.2	7.6	8.9	9.3	3.2	1.3	2.4	2.6	2	2.4
Other final use	0	0	0	0	0	0	0	0	0	0	0
Non-energy use	0	0	0	0	0	0	0	0	0	0	0

TABLE D16: TAX REVENUES IN SWEDEN, GAS

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Power own use & trans.	-10.7	-10.4	-9.2	-7.7	-1.7	-1.2	-0.2	-1	-1.6	-1.2	-1.6
O.energy own use & tra	-2.1	-1.5	-2	-2.2	-0.3	-0.2	0	-0.2	-0.2	-0.1	-0.2
Iron & steel	-0.2	-0.2	-0.3	-0.4	-0.1	0	0	0	0	0	0
Non-ferrous metals	0	0	-0.1	-0.1	0	0	0	0	0	0	0
Chemicals	-0.2	-0.2	-0.1	-0.1	0	0	0	0	0	0	0
Non-metallics nes	-0.3	-0.2	-0.6	-0.6	-0.1	-0.1	0	-0.3	-0.2	-0.2	-0.2
Ore-extra.(non-energy)	0	0	0	0	0	0	0	0	0	0	0
Food, drink & tob.	-4	-4.1	-5.4	-6.2	-1	-1.3	-0.1	-0.9	-1.1	-1.1	-1
Tex., cloth. & footw.	0	0	0	0	0	0	0	0	0	0	0
Paper & pulp	-0.8	-1.1	0.1	1.6	-0.1	0	0	-0.1	0	0	-0.1
Engineering etc	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9
Other industry	0	0	0	0	0	0	0	0	0	0	0
Rail transport	0	0	0	0	0	0	0	0	0	0	0
Road transport	0	0	0	0	0	0	0	0	0	0	0
Air transport	0	0	0	0	0	0	0	0	0	0	0
Other transp. serv.	0	0	0	0	0	0	0	0	0	0	0
Households	2.1	2.4	4.8	4.8	6.6	6.6	6.6	6.6	4.3	4.4	6.3
Other final use	0	0	0	0	0	0	0	0	0	0	0
Non-energy use	0	0	0	0	0	0	0	0	0	0	0

TABLE D17:TAX REVENUES IN SWEDEN, ELECTRICITY

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Power own use & trans.	-19.7	-22.5	-22.7	-25.4	-4.6	-4.6	-0.6	-3.5	-3.7	-2.3	-2.5
O.energy own use & tra	-40.8	-38.6	-35.1	-38.3	-7.1	-6.2	-0.9	-5.2	-6.1	-3.7	-3.9
Iron & steel	-5.8	-6.1	-6.8	-8.4	-1.9	-1.7	-0.3	-1.2	-1.3	-0.6	-0.7
Non-ferrous metals	-2.4	-2.3	-2.7	-3.5	-0.7	-0.6	-0.1	-0.5	-0.5	-0.4	-0.4
Chemicals	-1.3	-1.1	-1.2	-1.4	-0.4	-0.5	-0.1	-0.4	-0.4	-0.4	-0.4
Non-metallics nes	-2.5	-2.3	-2.8	-2.9	-0.9	-1.4	-0.1	-0.9	-0.8	-0.5	-0.5
Ore-extra.(non-energy)	-0.3	-0.4	-0.5	-0.5	-0.1	-0.1	0	-0.1	-0.1	0	0
Food, drink & tob.	-10.3	-10.1	-12.9	-14.3	-3.5	-3.4	-0.6	-3.5	-3.7	-3.3	-2.5
Tex., cloth. & footw.	0	0	0	0	0	0	0	0	0	0	0
Paper & pulp	-15.4	-19.4	-7.3	4.8	-4.7	-1.9	-0.3	-2.4	-2.5	-2	-2.9
Engineering etc	-71.6	-62.8	-89.3	-261	-100.6	-39.4	-5.2	-13.4	-18.6	-26.3	93.3
Other industry	0	0	0	0	0	0	0	0	0	0	0
Rail transport	-4.6	-4.2	-5	-21.1	-1.3	-0.5	-0.1	-1.2	-1.6	-1	-1.1
Road transport	-3.1	-3.3	-3.6	-4.4	-0.7	-0.8	-0.1	-0.6	-0.8	-0.5	-0.5
Air transport	-0.6	-0.6	-0.5	-0.6	-0.1	-0.1	0	-0.1	-0.1	-0.1	-0.1
Other transp. serv.	-9.3	-9.7	-10.2	-10.2	-1.9	-1.7	-0.3	-1.9	-2	-1.3	-1.4
Households	189.6	206	448.7	672.6	1094.5	1133.2	1366.5	1418.3	1681.4	2055.3	2246.5
Other final use	0	0	0	0	0	0	0	0	0	0	0
Non-energy use	0	0	0	0	0	0	0	0	0	0	0

TABLE D18: TAX REVENUES IN SWEDEN, PETROL

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Power own use & trans.	4	4.7	12.6	3	2.4	1.3	0.1	0.7	1.7	1.9	1.8
O.energy own use & tra	0	0	0	0	0	0	0	0	0	0	0
Iron & steel	0.4	0.4	0.8	1	0.2	0.2	0	0.1	0.1	0	0
Non-ferrous metals	0.1	0.1	0.2	0.2	0	0	0	0	0	0	0
Chemicals	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0
Non-metallics nes	0.7	0.7	1.5	1.5	0.5	1	0.1	0.3	0.4	0.3	0.4
Ore-extra.(non-energy)	0	0	0	0	0	0	0	0	0	0	0
Food, drink & tob.	2.1	2.7	6.1	7.6	1.6	1.8	0.2	1.4	1.6	1.9	1.4
Tex., cloth. & footw.	1.5	9.2	-8.7	-21.2	1.9	-0.3	0	0.3	0.2	0.3	0.8
Paper & pulp	0.2	0.2	0.3	0.4	0.1	0	0	0	0	0	0
Engineering etc	22.6	22.2	35.4	101.7	59.4	31.8	20.5	21.2	23.1	26.7	-16.1
Other industry	0	0	0	0	0	0	0	0	0	0	0
Rail transport	0.6	0.5	0.9	4.8	0.1	0	0	0.2	0.3	0.2	0.2
Road transport	22.5	32.9	121.5	135.4	217.7	207.2	201.8	130.2	132.2	140.6	138.7
Air transport	-0.3	-0.3	-0.3	-0.1	0	0	0	0	0	0	0
Other transp. serv.	-33.9	-36.1	-31.5	-26.8	-4.5	-4.1	-0.6	-3.2	-3.7	-2.7	-2.9
Households	5.8	6.8	27.4	27.3	38.6	31.8	26.1	15.9	14.1	14.1	13.9
Other final use	0	0	0	0	0	0	0	0	0	0	0
Non-energy use	0	0	0	0	0	0	0	0	0	0	0

TABLE D19: TAX REVENUES IN SWEDEN, DIESEL

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Power own use & trans.	3.9	4.8	10.6	2.6	2.1	1.3	0.1	1	2.2	2.4	2.3
O.energy own use & tra	0	0	0	0	0	0	0	0	0	0	0
Iron & steel	0.4	0.5	0.7	0.9	0.2	0.2	0	0.1	0.1	0.1	0.1
Non-ferrous metals	0.1	0.1	0.1	0.2	0	0	0	0	0	0	0
Chemicals	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0
Non-metallics nes	0.7	0.7	1.3	1.3	0.4	1	0.1	0.5	0.6	0.4	0.5
Ore-extra.(non-energy)	0	0	0	0	0	0	0	0	0	0	0
Food, drink & tob.	2.1	2.8	5.1	6.6	1.5	1.7	0.2	1.9	2.1	2.4	1.8
Tex., cloth. & footw.	1.4	9.5	-7.3	-18.3	1.7	-0.3	0	0.4	0.3	0.4	1.1
Paper & pulp	0.2	0.2	0.3	0.3	0.1	0	0	0	0	0	0
Engineering etc	22.1	15.8	28.9	133.8	53.2	20	2.6	5.8	8.8	14.5	-62.9
Other industry	0	0	0	0	0	0	0	0	0	0	0
Rail transport	0.6	0.5	0.8	4.1	0.1	0	0	0.2	0.4	0.2	0.3
Road transport	22	34	102.1	116.7	194.7	198.3	220.1	180.9	173.3	177.8	178.5
Air transport	-0.3	-0.3	-0.3	-0.1	0	0	0	-0.1	-0.1	0	0
Other transp. serv.	-33.2	-37.4	-26.5	-23.1	-4	-3.9	-0.7	-4.4	-4.8	-3.4	-3.7
Households	5.7	7	23	23.5	34.5	30.4	28.5	22.1	18.5	17.8	17.9
Other final use	0	0	0	0	0	0	0	0	0	0	0
Non-energy use	0	0	0	0	0	0	0	0	0	0	0

TABLE D20: REVENUE RECYCLING IN SWEDEN, SHARES

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Income Tax	1	1	1	1	1	1	1	1	1	1	1
Employers' Contributions	0	0	0	0	0	0	0	0	0	0	0
Employees' Contributions	0	0	0	0	0	0	0	0	0	0	0
Benefits	0	0	0	0	0	0	0	0	0	0	0
Investment	0	0	0	0	0	0	0	0	0	0	0

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TABLE D21: TAX RATES IN THE UK, E/TOE

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Industry - Coal	0	0	0	0	0	0	0	31	30.7	27.9	28.4
Industry - Oil (heating)	0	0	0	0	0	0	0	14.9	14.7	13.4	13.6
Industry - Gas	0	0	0	0	0	0	0	28.1	27.7	25.2	25.7
Industry - Electricity	0	0	0	0	0	0	0	80.4	79.5	72.3	73.7
Industry - petrol	0	0	0	0	0	0	0	26.8	26.5	24.1	24.5
Industry - diesel	0	0	0	0	0	0	0	21.6	21.4	19.4	19.8
Households - Coal	0	0	0	0	0	0	0	0	0	0	0
Households - Oil (heating)	0	0	0	0	0	0	0	0	0	0	0
Households - Gas	0	0	0	0	0	0	0	0	0	0	0
Households - Electricity	0	0	0	0	0	0	0	0	0	0	0
Households - petrol	0	0	0	0	0	0	0	0	0	0	0
Households - diesel	0	0	0	0	0	0	0	0	0	0	0

TABLE D22:TAX REVENUES IN THE UK, MILLIONS OF EUROS

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Industry - Coal	0	0	0	0	0	0	0	86.6	251.2	194.6	204.1
Industry - Oil (heating)	0	0	0	0	0	0	0	13.7	32.6	30.5	31.6
Industry - Gas	0	0	0	0	0	0	0	153.6	378.4	313.3	330.1
Industry - Electricity	0	0	0	0	0	0	0	147.9	369.8	314.2	335.1
Industry - petrol	0	0	0	0	0	0	0	85.9	211.1	174.8	186
Industry - diesel	0	0	0	0	0	0	0	52.6	129.3	107	113.9
Households - Coal	0	0	0	0	0	0	0	0	0	0	0
Households - Oil (heating)	0	0	0	0	0	0	0	0	0	0	0
Households - Gas	0	0	0	0	0	0	0	0	0	0	0
Households - Electricity	0	0	0	0	0	0	0	0	0	0	0
Households - petrol	0	0	0	0	0	0	0	0	0	0	0
Households - diesel	0	0	0	0	0	0	0	0	0	0	0

TABLE D23:REVENUE RECYCLING IN THE UK, SHARES

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Income Tax	0	0	0	0	0	0	0	0	0	0	0
Employers' Contributions	0	0	0	0	0	0	0	1	1	1	1
Employees' Contributions	0	0	0	0	0	0	0	0	0	0	0
Benefits	0	0	0	0	0	0	0	0	0	0	0
Investment	0	0	0	0	0	0	0	0	0	0	0

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TABLE D24: TAX RATES IN SLOVENIA, E/TOE

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Industry - Coal	0	0	0	0	0	0	0	0	0	0	0
Industry - Oil (heating)	0	0	0	0	0	0	0	0	0	0	0
Industry - Gas	0	0	0	0	0	22.4	57.1	83.9	68.9	62.1	58.1
Industry - Electricity	0	0	0	0	0	0	0	0	0	0	0
Industry - petrol	0	0	0	0	0	0	0	0	0	0	0
Industry - diesel	0	0	0	0	0	0	0	0	0	0	0
Households - Coal	0	0	0	0	0	0	0	0	0	0	0
Households - Oil (heating)	0	0	0	0	0	0	0	0	0	0	0
Households - Gas	0	0	0	0	0	43.9	107.6	88.5	83.9	76.4	74.8
Households - Electricity	0	0	0	0	0	0	0	0	0	0	0
Households - petrol	0	0	0	0	0	0	0	0	0	0	0
Households - diesel	0	0	0	0	0	0	0	0	0	0	0

TABLE D25: TAX REVENUES IN SLOVENIA, MILLIONS OF EUROS

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Industry - Coal	0	0	0	0	0	0	0	0	0	0	0
Industry - Oil (heating)	0	0	0	0	0	0	0	0	0	0	0
Industry - Gas	0	0	0	0	0	13.4	36.3	51.4	40.4	38.7	37.6
Industry - Electricity	0	0	0	0	0	0	0	0	0	0	0
Industry - petrol	0	0	0	0	0	0	0	0	0	0	0
Industry - diesel	0	0	0	0	0	0	0	0	0	0	0
Households - Coal	0	0	0	0	0	0	0	0	0	0	0
Households - Oil (heating)	0	0	0	0	0	0	0	0	0	0	0
Households - Gas	0	0	0	0	0	2.9	6.7	5.5	5.7	6.6	7.0
Households - Electricity	0	0	0	0	0	0	0	0	0	0	0
Households - petrol	0	0	0	0	0	0	0	0	0	0	0
Households - diesel	0	0	0	0	0	0	0	0	0	0	0

TABLE D26: REVENUE RECYCLING IN SLOVENIA, SHARES

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Income Tax	0	0	0	0	0	1	1	1	1	1	1
Employers' Contributions	0	0	0	0	0	0	0	0	0	0	0
Employees' Contributions	0	0	0	0	0	0	0	0	0	0	0
Benefits	0	0	0	0	0	0	0	0	0	0	0
Investment	0	0	0	0	0	0	0	0	0	0	0

Appendix E:

Detailed Scenario Results

E1 Detailed Scenario Results

Introduction

This section presents the detailed results of the scenarios, at the sectoral level (for the examined sectors and regions) and at the macro-level. These are discussed in detail in chapter 7. The four main scenarios are:

- Base Case
- Reference Case
- No Exemptions Case
- No Revenue-Recycling Case

E1.1 Base Case

TABLE E1 BASE CASE: FOOD, DRINK AND TOBACCO IN DENMARK

	1996	2000	2004	2008	2012
Output €m	14059.2	15522.5	17626.3	23661.0	30971.6
Output €m (2000)	14529.3	15427.5	16430.9	18809.6	22230.8
Value Added €m (2000)	3740.9	3910.9	4190.4	5098.5	6297.6
Wage Bill €m	2515.3	2908.4	3343.6	4001.8	4595.3
Energy Input €m	178.0	348.4	530.3	758.3	717.1
Employment th	82.7	79.1	74.8	72.7	72.5
Exports €m	7062.6	8135.4	7580.5	10606.7	13014.4
Exports €m (2000)	5593.9	8040.7	6813.9	8111.8	9533.9
Imports €m	2935.8	2641.9	2696.9	4726.3	6296.8
Imports €m (2000)	2592.5	2598.6	2659.8	3238.7	3921.1
Price output (Index)	0.968	1.006	1.073	1.258	1.393

TABLE E2 BASE CASE: FOOD, DRINK AND TOBACCO IN GERMANY

	1996	2000	2004	2008	2012
Output €m	125235.0	143252.5	154666.8	186370.7	222832.0
Output €m (2000)	127117.8	135574.8	126981.1	136101.3	153529.2
Value Added €m (2000)	35436.7	38540.0	38329.1	44188.5	51243.0
Wage Bill €m	17929.7	21205.9	21707.7	26840.3	34184.8
Energy Input €m	2475.3	3161.9	4015.0	4442.3	4729.0
Employment th	996.2	1062.2	989.2	939.8	920.6
Exports €m	17358.3	21555.7	29451.3	47493.3	71815.1
Exports €m (2000)	16206.9	21232.4	29711.8	40821.6	59209.7
Imports €m	21079.1	28031.0	30233.0	54232.4	71087.4
Imports €m (2000)	20398.6	27645.9	30368.6	37147.8	44152.3
Price output (Index)	0.985	1.057	1.218	1.369	1.451

TABLE E3 BASE CASE: FOOD, DRINK AND TOBACCO IN THE NETHERLANDS

	1996	2000	2004	2008	2012
Output €m	40738.7	47757.5	50277.5	57209.5	64371.5
Output €m (2000)	44064.5	47757.6	46755.0	52157.4	56570.8
Value Added €m (2000)	10574.0	10961.0	11116.6	10995.6	13234.2
Wage Bill €m	4366.9	5484.2	6279.8	6347.0	7231.1
Energy Input €m	412.1	547.0	810.0	950.7	958.0
Employment th	158.9	174.1	154.3	141.1	140.1
Exports €m	21437.3	25422.4	28013.5	37099.7	45954.0
Exports €m (2000)	18773.5	25422.4	25283.0	29656.0	33421.1
Imports €m	9535.1	11456.2	12179.4	19177.7	26514.8
Imports €m (2000)	9333.1	11302.9	12061.7	13159.9	16461.6
Price output (Index)	0.924	1.000	1.075	1.097	1.138

TABLE E4 BASE CASE: FOOD, DRINK AND TOBACCO IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	8106.2	6983.0	9224.4	12156.9	12774.1
Output	€m (2000)	7694.9	8030.8	8900.8	9553.6	9645.3
Value Added	€m (2000)	1717.0	1780.0	2042.1	2738.8	2921.3
Wage Bill	€m	1018.0	972.6	1147.9	1444.8	1620.2
Energy Input	€m	95.9	99.2	117.3	135.7	136.0
Employment	th	45.5	38.8	36.9	35.6	35.9
Exports	€m	815.2	765.9	1005.6	1664.2	2806.0
Exports	€m (2000)	485.1	803.8	1200.6	1574.9	2339.0
Imports	€m	1075.8	1625.7	1779.7	3011.0	5342.2
Imports	€m (2000)	872.4	1591.4	2044.9	2335.5	3846.1
Price output	(Index)	1.054	0.870	1.036	1.273	1.324

TABLE E5 BASE CASE: FOOD, DRINK AND TOBACCO IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	13488.2	15289.2	15431.6	17181.3	20788.5
Output	€m (2000)	14098.4	15310.5	14419.2	15847.3	19347.1
Value Added	€m (2000)	3999.1	4003.6	4408.1	4843.8	6124.6
Wage Bill	€m	1693.4	2042.9	2283.8	2664.0	3117.2
Energy Input	€m	124.1	149.9	155.4	160.7	132.5
Employment	th	63.9	63.3	60.5	59.3	59.1
Exports	€m	1368.1	2034.3	3132.5	3752.6	4460.5
Exports	€m (2000)	1194.0	2011.2	2745.1	2844.8	3212.7
Imports	€m	2344.0	2371.4	4874.4	8777.6	10662.6
Imports	€m (2000)	2286.7	2339.4	4024.5	4946.5	5492.2
Price output	(Index)	0.957	0.999	1.070	1.084	1.075

TABLE E6 BASE CASE: FOOD, DRINK AND TOBACCO IN THE UK

		1996	2000	2004	2008	2012
Output	€m	103644.5	109478.2	112381.1	118138.7	148412.1
Output	€m (2000)	94057.2	109366.5	109818.2	107496.0	127040.1
Value Added	€m (2000)	33342.0	33308.7	34700.2	33873.7	40489.2
Wage Bill	€m	14077.7	24580.8	20250.9	15602.0	22199.7
Energy Input	€m	1527.2	1227.3	1383.4	1922.0	1900.6
Employment	th	510.5	763.8	534.3	299.7	393.1
Exports	€m	14943.3	15710.6	17060.6	20683.5	21338.4
Exports	€m (2000)	14367.9	15525.0	14890.2	15549.7	15207.5
Imports	€m	21799.0	21975.5	24233.7	40479.1	49888.5
Imports	€m (2000)	15387.6	21690.6	23608.7	27028.1	30170.6
Price output	(Index)	1.102	1.001	1.023	1.099	1.168

TABLE E7 BASE CASE: FOOD, DRINK AND TOBACCO IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	1206.9	1584.4	3050.0	5793.8	8884.9
Output	€m (2000)	1506.3	1578.1	2219.4	2647.8	3042.5
Value Added	€m (2000)	496.5	510.1	751.9	1401.4	3329.0
Wage Bill	€m	222.0	237.2	379.0	560.2	799.5
Energy Input	€m	24.2	54.6	53.1	61.0	71.4
Employment	th	21.6	22.3	24.8	23.8	23.4
Exports	€m	206.3	324.2	579.9	856.3	1122.0
Exports	€m (2000)	248.3	321.6	370.3	485.9	577.7
Imports	€m	325.3	418.0	677.1	1094.6	1371.4
Imports	€m (2000)	394.8	411.7	641.8	713.3	784.0
Price output	(Index)	0.801	1.004	1.374	2.188	2.920

TABLE E8 BASE CASE: WOOD AND PAPER IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	1863.9	1986.6	2921.4	3451.2	4675.7
Output	€m (2000)	2288.4	2323.4	1845.6	1925.6	2648.9
Value Added	€m (2000)	1088.2	1221.0	1108.5	1071.4	1239.4
Wage Bill	€m	667.6	772.3	909.1	1006.7	1440.1
Energy Input	€m	50.1	59.1	95.1	113.6	110.5
Employment	th	20.9	18.8	19.8	16.8	19.3
Exports	€m	389.7	88.0	57.1	80.9	646.8
Exports	€m (2000)	355.8	107.2	86.3	120.1	594.0
Imports	€m	1986.6	2392.2	2953.2	4077.6	4254.1
Imports	€m (2000)	1879.3	1798.5	1746.3	1998.5	2359.7
Price output	(Index)	0.815	0.855	1.583	1.792	1.765

TABLE E9 BASE CASE: WOOD AND PAPER IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	43938.5	53298.2	59247.0	75183.6	78422.1
Output	€m (2000)	51885.8	60278.6	49120.5	58310.0	60926.5
Value Added	€m (2000)	16528.8	18170.0	19398.0	20720.4	16584.3
Wage Bill	€m	8776.3	9518.9	11032.5	12923.4	13838.7
Energy Input	€m	1650.8	2275.5	2886.1	3662.7	3735.7
Employment	th	364.1	332.4	347.5	351.8	311.8
Exports	€m	10269.9	16423.9	23815.3	33442.1	32784.4
Exports	€m (2000)	11591.5	17237.2	24029.6	28681.6	28925.2
Imports	€m	11492.3	15594.3	19660.1	23713.9	27049.7
Imports	€m (2000)	14343.4	16062.1	22969.7	23815.8	25970.6
Price output	(Index)	0.847	0.884	1.206	1.289	1.287

TABLE E10 BASE CASE: WOOD AND PAPER IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	5558.0	7812.9	11497.5	11969.3	8848.1
Output	€m (2000)	6700.3	8556.8	9479.5	9308.3	6902.0
Value Added	€m (2000)	2248.5	2587.0	3757.9	3316.9	2049.9
Wage Bill	€m	1293.9	1581.0	2069.1	2213.0	2009.9
Energy Input	€m	116.4	188.1	388.9	326.2	242.4
Employment	th	44.0	49.1	58.1	53.9	40.4
Exports	€m	3351.4	4378.5	5604.8	6533.4	6726.3
Exports	€m (2000)	4151.0	4548.0	4552.4	4677.8	4744.1
Imports	€m	5449.4	6263.7	5668.7	7734.6	10855.9
Imports	€m (2000)	5777.1	6538.0	6298.2	7505.1	10096.5
Price output	(Index)	0.830	0.913	1.213	1.286	1.282

TABLE E11 BASE CASE: WOOD AND PAPER IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	14059.7	20752.3	22239.0	20425.9	20507.9
Output	€m (2000)	16495.8	22026.6	23169.5	23681.2	25031.0
Value Added	€m (2000)	5240.0	6745.0	8064.0	8151.3	8940.0
Wage Bill	€m	1741.3	2168.5	2593.1	2797.3	2854.9
Energy Input	€m	881.7	1209.7	1595.0	1735.8	1594.1
Employment	th	65.6	69.2	70.2	62.7	59.3
Exports	€m	8839.0	13133.2	13731.2	16625.8	20079.5
Exports	€m (2000)	7844.8	13133.2	11961.0	13142.9	14230.7
Imports	€m	513.2	810.1	980.6	1119.9	1199.8
Imports	€m (2000)	733.2	834.4	986.7	954.7	978.3
Price output	(Index)	0.852	0.942	0.960	0.863	0.819

TABLE E12 BASE CASE: WOOD AND PAPER IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	15467.7	19230.9	25411.0	31256.5	35389.9
Output	€m (2000)	17463.5	21086.2	21774.2	24907.0	29477.5
Value Added	€m (2000)	5767.3	7010.7	8070.3	8221.5	7900.5
Wage Bill	€m	2353.0	2647.0	3146.9	3798.1	3312.4
Energy Input	€m	630.2	780.2	1016.6	1311.3	1282.6
Employment	th	81.6	76.3	76.4	73.1	54.0
Exports	€m	9552.5	11917.3	17638.3	20976.1	19123.7
Exports	€m (2000)	8241.3	12549.4	13413.3	15131.2	15591.8
Imports	€m	1233.5	1947.4	2231.6	3101.3	3501.5
Imports	€m (2000)	1491.4	2001.1	2313.0	2775.8	3067.5
Price output	(Index)	0.886	0.912	1.167	1.255	1.201

TABLE E13 BASE CASE: WOOD AND PAPER IN THE UK

	1996	2000	2004	2008	2012
Output €m	30068.1	30799.0	43222.7	41837.5	40696.9
Output €m (2000)	30780.8	34899.6	35666.3	34974.7	35374.0
Value Added €m (2000)	10465.0	10310.4	14696.1	7672.2	8231.5
Wage Bill €m	4715.7	6769.5	7196.4	9190.8	8573.4
Energy Input €m	1110.4	1189.3	1430.0	2047.9	1678.4
Employment th	348.2	388.8	322.7	289.3	248.8
Exports €m	5172.8	5232.6	6828.4	8386.4	8898.0
Exports €m (2000)	4814.3	5034.1	4929.4	5288.4	5493.8
Imports €m	11488.4	10839.8	11306.9	15814.8	16269.0
Imports €m (2000)	11133.7	12512.7	12639.8	13161.8	15263.1
Price output (Index)	0.977	0.882	1.212	1.196	1.151

TABLE E14 BASE CASE: WOOD AND PAPER IN SLOVENIA

	1996	2000	2004	2008	2012
Output €m	716.5	1023.4	1400.1	2138.4	2787.1
Output €m (2000)	956.1	1094.5	1137.1	1381.8	1544.3
Value Added €m (2000)	297.2	350.1	386.7	235.8	381.9
Wage Bill €m	153.5	164.9	304.1	310.2	322.6
Energy Input €m	47.7	80.9	71.7	88.3	101.4
Employment th	22.2	18.9	26.1	17.4	11.5
Exports €m	407.9	700.1	710.3	757.9	606.3
Exports €m (2000)	501.5	717.1	581.9	607.5	514.9
Imports €m	226.6	435.8	627.7	2073.9	1621.8
Imports €m (2000)	313.9	456.3	575.9	673.4	680.1
Price output (Index)	0.750	0.935	1.231	1.548	1.805

TABLE E15 BASE CASE: PHARMACEUTICALS IN DENMARK

	1996	2000	2004	2008	2012
Output €m	1982.8	3139.6	3594.0	4256.3	5027.5
Output €m (2000)	1799.8	3139.5	3659.8	4329.9	5093.7
Value Added €m (2000)	758.4	1801.4	1919.8	2676.7	2902.9
Wage Bill €m	493.0	641.5	940.6	1263.3	1496.4
Energy Input €m	7.7	22.6	30.6	34.9	29.3
Employment th	11.0	12.0	13.0	13.5	13.5
Exports €m	1860.1	3275.4	4885.7	7180.7	8898.5
Exports €m (2000)	2443.5	3204.4	3793.7	4640.9	5618.9
Imports €m	819.7	1394.4	2509.0	3514.8	4159.7
Imports €m (2000)	794.3	1428.4	1816.7	2260.2	2728.1
Price output (Index)	1.102	1.000	0.982	0.983	0.987

TABLE E16 BASE CASE: PHARMACEUTICALS IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	19259.8	23286.2	31369.9	38114.9	38585.6
Output	€m (2000)	21938.0	23993.5	26639.8	29041.3	28191.8
Value Added	€m (2000)	8212.5	8990.0	13982.3	15857.9	14104.9
Wage Bill	€m	4666.3	5779.5	6325.7	9317.5	11600.7
Energy Input	€m	1273.7	2098.0	2438.7	2098.3	1535.3
Employment	th	120.7	121.6	106.3	120.3	115.2
Exports	€m	9338.8	16228.5	25262.1	36146.5	41005.7
Exports	€m (2000)	11898.4	16584.0	21828.3	26226.8	28854.4
Imports	€m	6267.3	11768.5	26366.7	36516.2	46430.7
Imports	€m (2000)	7180.9	12056.7	15651.3	19373.0	24810.0
Price output	(Index)	0.878	0.971	1.178	1.312	1.369

TABLE E17 BASE CASE: PHARMACEUTICALS IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	5004.8	5667.8	6857.6	8260.7	9415.4
Output	€m (2000)	5744.9	6434.3	6332.0	6787.8	6763.9
Value Added	€m (2000)	1368.7	1557.0	1626.0	1992.2	1908.6
Wage Bill	€m	558.0	630.7	829.9	1032.5	1079.4
Energy Input	€m	0.7	1.5	2.7	2.6	2.1
Employment	th	14.9	15.1	16.8	18.0	15.6
Exports	€m	3547.3	4929.4	9631.2	13647.0	14949.6
Exports	€m (2000)	3956.6	5058.0	6424.3	7509.0	8072.9
Imports	€m	3479.7	4948.3	8991.3	12188.7	13892.4
Imports	€m (2000)	3561.8	5036.2	5933.9	7185.1	8218.4
Price output	(Index)	0.871	0.881	1.083	1.217	1.392

TABLE E18 BASE CASE: PHARMACEUTICALS IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	518.5	710.8	906.6	969.0	897.5
Output	€m (2000)	442.0	682.7	785.9	770.8	765.7
Value Added	€m (2000)	197.0	267.0	375.1	418.3	408.4
Wage Bill	€m	93.6	123.4	161.6	228.7	281.3
Energy Input	€m	24.3	45.9	67.5	65.0	51.1
Employment	th	4.1	4.3	4.2	4.5	4.6
Exports	€m	190.8	344.5	653.0	954.3	1203.1
Exports	€m (2000)	224.0	352.0	495.9	602.8	729.8
Imports	€m	559.3	891.0	1429.0	1867.2	2206.8
Imports	€m (2000)	504.8	916.5	1128.4	1310.0	1565.2
Price output	(Index)	1.173	1.041	1.154	1.257	1.172

TABLE E19 BASE CASE: PHARMACEUTICALS IN SWEDEN

	1996	2000	2004	2008	2012
Output €m	4105.8	5501.2	8609.3	11722.7	15195.9
Output €m (2000)	3972.3	5774.9	7023.9	8432.9	10618.8
Value Added €m (2000)	1959.8	3006.9	4085.4	5362.5	6880.0
Wage Bill €m	581.2	899.7	1211.9	1775.3	2568.8
Energy Input €m	11.1	11.8	21.6	27.6	28.2
Employment th	15.5	17.5	20.7	21.5	22.2
Exports €m	2460.5	4198.9	7142.1	11409.3	15382.3
Exports €m (2000)	2689.4	4288.0	6123.8	8249.5	10792.1
Imports €m	1221.5	1442.4	3160.1	4407.9	4941.3
Imports €m (2000)	996.5	1484.2	2165.6	2768.5	3137.5
Price output (Index)	1.034	0.953	1.226	1.390	1.431

TABLE E20 BASE CASE: PHARMACEUTICALS IN THE UK

	1996	2000	2004	2008	2012
Output €m	14869.4	18268.6	27449.2	32654.1	35499.8
Output €m (2000)	17338.6	19348.5	22339.1	22739.0	23876.2
Value Added €m (2000)	7527.2	8896.1	10663.9	8964.7	9755.3
Wage Bill €m	2724.9	4621.6	5679.0	8316.1	11716.2
Energy Input €m	188.5	182.4	194.4	314.0	331.9
Employment th	64.8	54.5	44.6	47.0	47.9
Exports €m	10016.9	12454.6	22051.3	37961.9	52404.6
Exports €m (2000)	8034.4	12696.1	20642.9	29681.4	39493.0
Imports €m	6523.8	9660.3	19199.6	29565.9	36371.4
Imports €m (2000)	5320.7	9942.9	18385.3	25023.4	31468.2
Price output (Index)	0.858	0.944	1.229	1.436	1.487

TABLE E21 BASE CASE: PHARMACEUTICALS IN SLOVENIA

	1996	2000	2004	2008	2012
Output €m	381.4	561.9	883.8	1474.6	2246.2
Output €m (2000)	485.2	561.9	839.3	1057.1	1249.3
Value Added €m (2000)	224.4	311.9	408.2	553.1	733.4
Wage Bill €m	98.4	115.8	195.7	301.7	457.3
Energy Input €m	0.2	0.2	0.7	1.2	1.5
Employment th	5.5	5.2	6.0	5.8	5.6
Exports €m	239.0	414.9	1239.3	1967.7	2650.6
Exports €m (2000)	453.9	429.4	1177.4	1577.5	1872.8
Imports €m	132.9	258.1	454.6	628.0	788.3
Imports €m (2000)	157.9	267.0	294.0	346.3	435.8
Price output (Index)	0.786	1.000	1.053	1.395	1.798

TABLE E22 BASE CASE: CHEMICALS NES IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	3277.3	4110.3	5192.4	7259.9	7256.3
Output	€m (2000)	2927.0	4016.9	5092.1	5836.8	6442.6
Value Added	€m (2000)	993.6	931.3	1376.9	2543.4	1843.1
Wage Bill	€m	613.0	628.9	736.5	936.9	1102.2
Energy Input	€m	110.9	227.6	327.9	353.6	278.1
Employment	th	15.9	14.0	13.7	14.8	15.6
Exports	€m	1975.9	2605.5	3325.7	4807.5	5049.3
Exports	€m (2000)	1887.0	2606.2	3185.0	3706.7	3963.9
Imports	€m	2833.1	2550.6	3138.0	5220.4	6776.2
Imports	€m (2000)	2106.7	2544.9	2907.9	3783.6	4664.5
Price output	(Index)	1.120	1.023	1.020	1.244	1.126

TABLE E23 BASE CASE: CHEMICALS NES IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	93546.7	101459.4	112553.5	138408.6	134686.1
Output	€m (2000)	96415.1	100706.2	119382.5	129590.5	147591.6
Value Added	€m (2000)	29769.9	30930.0	32730.0	102713.8	2301.5
Wage Bill	€m	19951.5	18809.5	19753.5	21446.3	24293.2
Energy Input	€m	4899.6	7594.1	8345.2	6298.4	4870.1
Employment	th	463.2	386.2	386.4	385.5	380.3
Exports	€m	43513.8	58093.2	73452.6	110888.3	117100.0
Exports	€m (2000)	38639.0	60051.8	77194.7	90573.5	97588.1
Imports	€m	27803.9	45767.5	48312.6	86495.7	100998.4
Imports	€m (2000)	30649.7	45100.7	43775.3	61233.9	67885.0
Price output	(Index)	0.970	1.008	0.943	1.068	0.913

TABLE E24 BASE CASE: CHEMICALS NES IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	22191.8	29590.2	30362.9	34039.6	35865.9
Output	€m (2000)	24734.9	29129.6	31151.3	34576.7	37565.9
Value Added	€m (2000)	5688.9	6892.0	903.4	1584.2	1656.5
Wage Bill	€m	2622.6	2682.4	3252.0	3273.1	3436.1
Energy Input	€m	1981.5	5671.5	12433.0	12340.9	10480.7
Employment	th	63.8	58.5	56.6	57.1	58.7
Exports	€m	21578.0	22224.8	28621.5	36424.9	42076.6
Exports	€m (2000)	17820.1	22224.8	24441.9	28324.2	29424.2
Imports	€m	13372.9	16440.3	20575.8	33118.0	40069.9
Imports	€m (2000)	11651.9	16756.1	20897.4	25525.1	29712.4
Price output	(Index)	0.897	1.016	0.975	0.985	0.955

TABLE E25 BASE CASE: CHEMICALS NES IN FINLAND

	1996	2000	2004	2008	2012
Output €m	4517.7	7328.6	5877.0	7529.6	7982.2
Output €m (2000)	4604.7	7037.9	5015.9	5056.9	5404.4
Value Added €m (2000)	1094.0	1275.0	1702.8	2408.7	2184.8
Wage Bill €m	453.3	588.3	642.8	809.4	905.4
Energy Input €m	340.3	581.0	539.8	597.5	532.8
Employment th	16.0	17.2	15.8	15.4	15.3
Exports €m	1906.7	3367.2	3093.8	3890.4	4445.1
Exports €m (2000)	2304.3	3324.2	2594.2	2726.9	2977.2
Imports €m	2001.2	2009.2	3431.7	4724.5	5191.5
Imports €m (2000)	1760.1	2024.4	2812.3	2935.1	3076.6
Price output (Index)	0.981	1.041	1.172	1.489	1.477

TABLE E26 BASE CASE: CHEMICALS NES IN SWEDEN

	1996	2000	2004	2008	2012
Output €m	5532.7	6646.3	7893.5	11858.7	13964.9
Output €m (2000)	5130.1	6299.2	7246.4	8273.2	9553.5
Value Added €m (2000)	1651.1	2184.2	2800.4	4084.8	4399.6
Wage Bill €m	715.9	893.1	1107.4	1686.7	2205.6
Energy Input €m	347.2	357.7	724.9	954.7	669.5
Employment th	22.2	21.9	21.0	23.3	23.1
Exports €m	1981.9	4086.0	5833.0	8746.0	9857.4
Exports €m (2000)	2826.0	3899.0	4782.9	5823.8	6625.7
Imports €m	4431.6	5382.9	7313.4	11372.5	13063.5
Imports €m (2000)	3442.3	5446.7	6005.4	7321.7	8052.1
Price output (Index)	1.079	1.055	1.089	1.433	1.462

TABLE E27 BASE CASE: CHEMICALS NES IN THE UK

	1996	2000	2004	2008	2012
Output €m	62113.0	57349.3	57123.1	75051.5	77556.2
Output €m (2000)	51081.4	55409.9	56678.5	57411.0	64888.3
Value Added €m (2000)	14345.1	16013.7	15641.4	12639.7	14952.8
Wage Bill €m	6178.8	9339.5	8840.5	13414.4	11345.7
Energy Input €m	2064.9	2225.3	2659.9	3408.9	3395.3
Employment th	218.3	223.9	164.2	165.4	156.4
Exports €m	29341.8	26686.1	32111.9	47840.3	48914.2
Exports €m (2000)	21269.1	26640.8	26001.3	29405.0	30220.4
Imports €m	27019.4	24726.0	29768.8	43046.3	46917.8
Imports €m (2000)	19745.3	24660.4	24466.1	26434.8	28050.2
Price output (Index)	1.216	1.035	1.008	1.307	1.195

TABLE E28 BASE CASE: CHEMICALS NES IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	537.7	856.0	1098.4	1649.3	2620.1
Output	€m (2000)	645.4	840.8	1012.6	1165.2	1391.0
Value Added	€m (2000)	186.4	231.7	225.6	103.7	250.2
Wage Bill	€m	97.6	104.5	141.1	216.0	339.8
Energy Input	€m	35.5	38.1	80.7	112.6	143.9
Employment	th	9.1	8.8	8.3	8.2	8.6
Exports	€m	354.1	613.2	914.6	1265.7	1543.0
Exports	€m (2000)	458.2	613.2	856.3	1114.2	1227.5
Imports	€m	640.8	968.6	1688.2	3092.6	4108.1
Imports	€m (2000)	741.4	963.1	1470.9	2080.2	2393.5
Price output	(Index)	0.833	1.018	1.085	1.416	1.884

TABLE E29 BASE CASE: NON-METALLIC MINERAL PRODUCTS IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	2027.6	2219.1	2867.8	3525.5	4678.6
Output	€m (2000)	2346.0	2466.2	2716.1	2978.9	3333.0
Value Added	€m (2000)	1022.8	1133.7	1236.3	1309.2	1881.0
Wage Bill	€m	600.3	784.7	893.6	1166.4	1528.1
Energy Input	€m	84.7	102.3	160.7	217.1	220.9
Employment	th	18.3	20.7	19.5	18.1	18.6
Exports	€m	557.9	697.3	646.6	684.3	640.5
Exports	€m (2000)	622.3	699.3	668.0	572.3	491.2
Imports	€m	503.1	663.1	737.9	1235.4	1560.2
Imports	€m (2000)	640.5	654.5	711.8	839.9	981.4
Price output	(Index)	0.864	0.900	1.056	1.184	1.404

TABLE E30 BASE CASE: NON-METALLIC MINERAL PRODUCTS IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	41340.1	43735.5	39178.7	44539.5	46647.2
Output	€m (2000)	40388.4	41680.0	37584.1	41744.0	43491.5
Value Added	€m (2000)	15771.3	16320.0	15148.2	17874.0	18630.1
Wage Bill	€m	9402.5	10087.0	9285.0	10205.5	10873.7
Energy Input	€m	3081.1	3311.6	4430.7	5287.6	5005.7
Employment	th	352.3	324.4	279.6	279.4	276.5
Exports	€m	5655.8	8197.6	10195.5	15579.0	20239.3
Exports	€m (2000)	6297.5	8159.5	10167.4	12930.2	15365.9
Imports	€m	5716.2	7456.8	8268.4	14069.3	18815.3
Imports	€m (2000)	5834.4	7449.6	9067.3	10959.9	13097.7
Price output	(Index)	1.024	1.049	1.042	1.067	1.073

TABLE E31 BASE CASE: NON-METALLIC MINERAL PRODUCTS IN THE NETHERLANDS

	1996	2000	2004	2008	2012
Output €m	4664.7	6140.0	7085.3	8706.2	10936.3
Output €m (2000)	5487.9	6520.4	6352.6	6972.9	7316.0
Value Added €m (2000)	2153.2	2508.0	2551.0	2603.8	3243.0
Wage Bill €m	1019.8	1251.6	1400.1	1636.2	1903.7
Energy Input €m	132.4	186.9	259.0	291.0	266.8
Employment th	37.8	37.5	35.7	35.4	34.8
Exports €m	1277.8	1455.2	1454.3	1923.3	2175.7
Exports €m (2000)	1298.4	1449.2	1551.0	1678.2	1745.3
Imports €m	1617.3	1886.6	2232.9	3433.3	4337.5
Imports €m (2000)	1602.3	1879.8	2227.7	2406.4	2799.5
Price output (Index)	0.850	0.942	1.115	1.249	1.495

TABLE E32 BASE CASE: NON-METALLIC MINERAL PRODUCTS IN FINLAND

	1996	2000	2004	2008	2012
Output €m	1555.3	2733.7	2790.2	3701.9	4247.7
Output €m (2000)	1832.6	2321.5	2524.6	2747.5	2918.6
Value Added €m (2000)	745.0	925.0	1175.2	1493.9	1601.3
Wage Bill €m	320.0	479.8	533.8	743.3	859.9
Energy Input €m	37.7	45.7	66.0	68.4	62.8
Employment th	14.1	18.7	16.1	13.9	11.8
Exports €m	385.4	561.4	825.2	1521.4	2189.9
Exports €m (2000)	322.5	536.6	847.1	1240.5	1625.1
Imports €m	284.9	432.1	544.1	893.1	975.0
Imports €m (2000)	376.2	431.5	494.5	563.2	561.3
Price output (Index)	0.849	1.178	1.105	1.347	1.455

TABLE E33 BASE CASE: NON-METALLIC MINERAL PRODUCTS IN SWEDEN

	1996	2000	2004	2008	2012
Output €m	2392.2	3030.4	3344.7	3996.7	4928.4
Output €m (2000)	2603.5	2959.2	3123.1	3383.1	3752.0
Value Added €m (2000)	994.4	1120.2	1326.4	1442.8	1754.7
Wage Bill €m	551.6	622.8	637.8	663.8	721.7
Energy Input €m	91.5	158.3	211.1	262.8	251.8
Employment th	19.4	18.3	17.4	15.4	14.3
Exports €m	581.0	749.4	948.3	1205.1	1388.2
Exports €m (2000)	543.5	744.8	1000.1	1067.4	1120.8
Imports €m	726.7	983.4	1323.9	2033.9	2401.3
Imports €m (2000)	690.0	978.2	1268.8	1364.0	1491.5
Price output (Index)	0.919	1.024	1.071	1.181	1.313

TABLE E34 BASE CASE: NON-METALLIC MINERAL PRODUCTS IN THE UK

		1996	2000	2004	2008	2012
Output	€m	18856.9	20843.5	21797.5	26586.5	28636.5
Output	€m (2000)	18572.0	20411.1	20428.7	20921.6	21722.6
Value Added	€m (2000)	7971.7	8226.7	7872.1	5620.1	7564.9
Wage Bill	€m	3832.7	5602.9	5903.2	7334.0	6847.9
Energy Input	€m	973.6	781.7	743.6	1218.5	1202.1
Employment	th	159.7	156.6	138.1	137.4	116.7
Exports	€m	3477.2	3196.4	3064.2	3812.9	3643.0
Exports	€m (2000)	3067.3	3181.5	2799.4	2822.4	2482.2
Imports	€m	3027.9	3580.1	4681.6	7450.5	9580.9
Imports	€m (2000)	2870.5	3570.9	4152.5	4694.2	5468.1
Price output	(Index)	1.015	1.021	1.067	1.271	1.318

TABLE E35 BASE CASE: NON-METALLIC MINERAL PRODUCTS IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	388.6	456.6	552.5	597.0	580.9
Output	€m (2000)	480.3	451.8	493.4	439.2	384.9
Value Added	€m (2000)	187.1	218.3	181.9	100.9	106.3
Wage Bill	€m	103.5	108.2	135.3	169.4	201.7
Energy Input	€m	42.6	73.7	67.8	86.5	100.0
Employment	th	12.2	10.6	10.7	9.2	7.2
Exports	€m	171.7	285.4	332.1	385.1	460.3
Exports	€m (2000)	184.1	284.6	250.3	265.4	291.0
Imports	€m	138.5	241.1	393.7	707.9	941.5
Imports	€m (2000)	168.7	239.1	321.7	392.4	450.8
Price output	(Index)	0.809	1.011	1.120	1.359	1.509

TABLE E36 BASE CASE: BASIC METALS IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	1190.1	1638.6	2037.7	2946.5	3541.6
Output	€m (2000)	1375.3	1640.9	1864.5	1912.1	1983.8
Value Added	€m (2000)	440.7	467.1	564.9	941.2	1158.6
Wage Bill	€m	320.8	374.7	542.1	700.7	865.3
Energy Input	€m	49.1	89.6	126.7	170.7	156.1
Employment	th	8.6	8.9	10.5	9.0	8.1
Exports	€m	661.4	1001.1	1124.7	1463.1	1580.8
Exports	€m (2000)	807.1	1007.4	1270.0	1292.7	1314.4
Imports	€m	1460.2	1995.5	1929.9	2940.9	3320.6
Imports	€m (2000)	1621.0	2010.7	2059.2	2122.4	2200.6
Price output	(Index)	0.865	0.999	1.093	1.541	1.785

TABLE E37 BASE CASE: BASIC METALS IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	45351.3	63434.5	62219.8	81470.0	86367.6
Output	€m (2000)	58590.9	63483.6	71791.1	77404.6	79272.8
Value Added	€m (2000)	15435.9	16330.0	14708.7	36296.2	42620.8
Wage Bill	€m	9566.3	10427.8	11639.2	12370.0	15247.4
Energy Input	€m	4511.4	5225.1	5985.8	6842.8	6337.7
Employment	th	292.2	266.8	254.9	271.2	264.9
Exports	€m	18116.0	27675.7	31715.5	47331.6	54824.8
Exports	€m (2000)	19697.1	27946.0	37955.8	46259.4	50492.5
Imports	€m	16270.4	26642.6	27451.7	50496.4	62328.3
Imports	€m (2000)	20929.6	26787.0	30289.6	37909.5	42643.2
Price output	(Index)	0.774	0.999	0.867	1.053	1.089

TABLE E38 BASE CASE: BASIC METALS IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	5299.6	7833.4	8905.4	13731.1	21225.7
Output	€m (2000)	6215.0	9557.3	9059.4	13114.7	18701.1
Value Added	€m (2000)	1804.5	2031.0	2941.1	4991.6	6746.4
Wage Bill	€m	979.5	1212.6	1640.7	2023.7	3126.9
Energy Input	€m	206.7	405.3	606.4	875.8	1038.2
Employment	th	26.8	28.5	30.0	27.6	31.6
Exports	€m	4544.1	6660.8	7695.5	14381.5	22038.4
Exports	€m (2000)	5240.3	6675.5	8309.2	12270.3	17735.7
Imports	€m	4674.0	5807.7	7187.3	12073.2	14590.8
Imports	€m (2000)	5631.1	5982.3	8187.1	9339.8	10444.4
Price output	(Index)	0.853	0.820	0.983	1.047	1.135

TABLE E39 BASE CASE: BASIC METALS IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	4576.4	7320.8	6543.7	6932.7	6497.2
Output	€m (2000)	5534.2	7332.5	7327.0	6773.1	6598.1
Value Added	€m (2000)	1077.0	1308.0	605.3	8369.2	1463.2
Wage Bill	€m	477.2	580.7	627.0	801.3	888.7
Energy Input	€m	251.0	519.2	939.7	1326.7	1053.9
Employment	th	17.1	16.9	15.7	15.1	14.5
Exports	€m	2362.5	3867.7	4257.3	6469.1	7099.3
Exports	€m (2000)	2579.7	3900.8	4686.7	5590.6	5769.2
Imports	€m	1384.7	2012.4	2058.1	4550.3	5193.2
Imports	€m (2000)	1273.4	2032.1	2184.8	3250.6	3352.1
Price output	(Index)	0.827	0.998	0.893	1.024	0.985

TABLE E40 BASE CASE: BASIC METALS IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	7468.7	10051.0	9577.6	11641.8	12604.7
Output	€m (2000)	8299.0	10058.2	9810.6	9619.6	9715.9
Value Added	€m (2000)	2029.1	2313.4	2205.1	2630.1	2761.0
Wage Bill	€m	998.6	1172.2	1225.3	1449.0	1664.1
Energy Input	€m	352.7	542.2	754.5	903.8	681.4
Employment	th	32.2	30.5	29.7	30.4	31.5
Exports	€m	4345.1	5520.7	7365.4	10410.3	11406.2
Exports	€m (2000)	3970.3	5556.0	6965.0	7993.3	8369.2
Imports	€m	2963.2	4226.3	5115.9	9470.3	11332.4
Imports	€m (2000)	3170.3	4258.4	4887.8	6144.4	6738.4
Price output	(Index)	0.900	0.999	0.976	1.210	1.297

TABLE E41 BASE CASE: BASIC METALS IN THE UK

		1996	2000	2004	2008	2012
Output	€m	32248.1	27630.4	25429.1	29334.3	34986.9
Output	€m (2000)	27343.5	27624.8	27629.2	24205.6	27993.1
Value Added	€m (2000)	6220.3	6500.6	6725.2	7609.8	9042.3
Wage Bill	€m	4022.2	5098.6	3625.1	6127.2	9656.4
Energy Input	€m	1537.0	866.7	843.6	990.4	1020.8
Employment	th	149.8	123.2	104.1	138.3	240.3
Exports	€m	12942.6	9462.6	9095.3	16459.2	18526.7
Exports	€m (2000)	10791.8	9554.7	9368.5	12619.2	13213.2
Imports	€m	13671.1	11718.2	10903.4	22932.9	25094.4
Imports	€m (2000)	10248.7	11947.5	10926.5	14881.3	14679.0
Price output	(Index)	1.179	1.000	0.920	1.212	1.250

TABLE E42 BASE CASE: BASIC METALS IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	427.1	961.9	8.8	13.9	16.9
Output	€m (2000)	567.6	964.7	8.9	9.3	9.4
Value Added	€m (2000)	133.0	205.0	1.1	2.0	2.1
Wage Bill	€m	88.4	103.9	10.5	11.9	16.9
Energy Input	€m	37.8	85.0	1.7	2.3	2.6
Employment	th	10.4	8.7	0.7	0.5	0.5
Exports	€m	328.8	712.3	673.0	809.7	887.7
Exports	€m (2000)	427.3	716.7	689.9	678.6	720.1
Imports	€m	398.8	697.0	2629.4	11396.7	18878.9
Imports	€m (2000)	549.9	697.0	2423.4	7774.0	11001.7
Price output	(Index)	0.752	0.997	0.983	1.500	1.795

TABLE E43 BASE CASE: MACRO RESULTS FOR GERMANY

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	195612.9	214248.0	218253.8	257451.6	318047.8
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1948.8	2120.0	2185.0	2270.7	2388.4
GDP deflator 2000=1	1.0	1.1	1.0	1.1	1.2
SC cons. €bn (2000)	1127.7	1198.3	1217.1	1233.3	1284.0
PSC 2000=1	1.0	1.1	1.1	1.1	1.2
SK invest. €bn (2000)	434.4	490.9	410.8	459.8	474.6
PSK 2000=1	1.1	1.0	1.0	1.1	1.1
SX €bn (2000)	454.3	631.9	763.9	921.2	1020.9
PSX 2000=1	0.9	1.0	1.1	1.3	1.3
SM €bn (2000)	431.7	550.5	604.4	738.8	825.0
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	222792.5	256130.7	309510.3	261249.8	249689.5
CO2 mtC-eq	189172.0	218235.5	269746.3	220640.2	210649.3
FR003IS fuel use mtoe	9930.0	10753.9	8143.0	8308.7	8052.4
FR004NF fuel use mtoe	2638.0	2788.6	2781.9	3120.6	3225.7
FR005NM fuel use mtoe	29610.6	31256.9	24206.3	18394.3	12975.9
FR010PP fuel use mtoe	4347.1	4530.6	4411.6	4375.2	4194.8
FCO2(03) IS mtC-eq	13659.8	14375.8	11317.3	10862.5	10611.5
FCO2(04) NF mtC-eq	771.6	879.7	914.0	1083.1	1181.1
FCO2(05) NM mtC-eq	4810.0	3748.0	4000.1	3830.3	3288.6
FCO2(10) PP mtC-eq	1087.4	1212.7	997.3	886.0	823.1

TABLE E44 BASE CASE: MACRO RESULTS FOR FRANCE

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.3	0.3	0.3	0.3	0.3
Empl tax revs RERS	152270.0	157941.4	188000.8	228964.2	276799.8
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1257.1	1401.1	1462.8	1584.1	1759.3
GDP deflator 2000=1	1.0	1.1	1.2	1.3	1.3
SC cons. €bn (2000)	725.8	783.6	842.5	891.4	969.4
PSC 2000=1	0.9	1.1	1.2	1.3	1.4
SK invest. €bn (2000)	228.8	268.7	308.6	327.8	376.2
PSK 2000=1	1.0	1.1	1.2	1.2	1.2
SX €bn (2000)	270.4	386.0	374.9	452.2	508.6
PSX 2000=1	1.0	1.0	1.1	1.3	1.4
SM €bn (2000)	276.0	380.5	422.6	500.9	561.2
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	130974.2	150312.3	146595.1	172844.7	128043.7
CO2 mtC-eq	92838.4	112011.4	108801.8	131278.5	93430.6
FR003IS fuel use mtoe	5961.8	5299.4	5240.5	5147.1	4578.3
FR004NF fuel use mtoe	1580.2	1647.7	1403.5	1637.2	1684.8
FR005NM fuel use mtoe	17950.5	20696.7	18004.6	16562.7	16945.3
FR010PP fuel use mtoe	3427.4	3759.0	4052.3	3680.5	3684.0
FCO2(03) IS mtC-eq	7159.6	6135.3	6974.1	6591.8	6341.1
FCO2(04) NF mtC-eq	475.4	567.4	626.9	745.8	802.5
FCO2(05) NM mtC-eq	2282.6	2440.4	2452.6	2345.3	2445.8
FCO2(10) PP mtC-eq	1310.6	1399.5	1477.9	1284.5	1348.6

TABLE E45 BASE CASE: MACRO RESULTS FOR ITALY

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	44095.2	58849.6	79237.1	111347.7	146015.2
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	522.9	610.1	676.3	728.4	812.0
GDP deflator 2000=1	0.9	1.0	1.2	1.4	1.4
SC cons. €bn (2000)	336.8	398.0	426.9	457.5	519.6
PSC 2000=1	0.9	1.0	1.2	1.4	1.5
SK invest. €bn (2000)	110.5	153.6	182.0	220.9	237.2
PSK 2000=1	0.9	1.0	1.2	1.3	1.2
SX €bn (2000)	112.7	165.3	181.0	208.9	245.4
PSX 2000=1	0.9	1.0	1.1	1.3	1.4
SM €bn (2000)	118.2	192.0	215.1	258.5	305.2
PSM 2000=1	0.9	1.0	1.1	1.2	1.3
GHG mtC-eq	74466.9	89240.2	95337.4	95483.5	94510.8
CO2 mtC-eq	65703.9	78720.0	84593.7	85772.2	85312.7
FR003IS fuel use mtoe	2795.1	3605.0	4914.8	5198.7	5052.1
FR004NF fuel use mtoe	1011.7	1155.0	1656.8	1744.8	1826.5
FR005NM fuel use mtoe	7447.8	9656.6	8759.4	8228.5	8755.1
FR010PP fuel use mtoe	1821.4	2564.9	3206.7	3278.1	3104.7
FCO2(03) IS mtC-eq	2789.2	3051.0	3458.0	3282.3	3093.8
FCO2(04) NF mtC-eq	303.7	369.2	500.3	528.1	555.8
FCO2(05) NM mtC-eq	1459.8	1166.3	1151.7	1092.1	1056.3
FCO2(10) PP mtC-eq	654.8	880.3	831.7	701.3	643.1

TABLE E46 BASE CASE: MACRO RESULTS FOR SPAIN

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.4	0.3	0.3	0.3	0.3
Empl tax revs RERS	106111.1	109395.0	140753.6	199122.0	231793.5
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1070.9	1176.4	1253.7	1352.9	1417.9
GDP deflator 2000=1	0.9	1.0	1.2	1.5	1.4
SC cons. €bn (2000)	648.9	733.0	742.6	768.0	836.7
PSC 2000=1	0.9	1.0	1.2	1.5	1.4
SK invest. €bn (2000)	178.0	225.6	236.6	275.1	267.6
PSK 2000=1	1.0	1.0	1.3	1.5	1.4
SX €bn (2000)	244.6	321.7	341.9	386.6	410.5
PSX 2000=1	1.0	1.0	1.1	1.3	1.4
SM €bn (2000)	225.6	327.5	324.2	354.6	404.3
PSM 2000=1	0.9	1.0	1.1	1.2	1.2
GHG mtC-eq	122784.9	126659.6	130712.8	130975.7	131459.2
CO2 mtC-eq	111998.8	115212.4	118985.0	119455.1	119501.0
FR003IS fuel use mtoe	4837.5	5446.9	5700.1	5776.1	5282.3
FR004NF fuel use mtoe	867.3	939.2	891.7	1064.6	1082.4
FR005NM fuel use mtoe	11906.2	11539.0	11621.4	10315.4	8965.1
FR010PP fuel use mtoe	2469.9	2642.3	2733.6	2810.1	2686.9
FCO2(03) IS mtC-eq	5449.2	4733.4	4130.4	4398.2	3806.6
FCO2(04) NF mtC-eq	262.2	387.0	374.0	440.7	437.9
FCO2(05) NM mtC-eq	1673.4	1188.6	1360.8	1276.2	1171.7
FCO2(10) PP mtC-eq	857.1	823.9	830.5	834.6	804.3

TABLE E47 BASE CASE: MACRO RESULTS FOR UK

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.1	0.1	0.1	0.1	0.1
Empl tax revs RERS	38569.6	65524.1	74852.6	114603.0	121627.9
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1424.7	1804.3	1860.6	1958.9	2181.9
GDP deflator 2000=1	1.0	0.9	1.1	1.4	1.4
SC cons. €bn (2000)	952.1	1145.2	1202.5	1222.7	1390.3
PSC 2000=1	0.9	0.9	1.0	1.3	1.3
SK invest. €bn (2000)	185.1	280.7	318.6	375.3	419.7
PSK 2000=1	1.1	0.9	1.0	1.2	1.2
SX €bn (2000)	310.8	446.2	454.6	507.6	534.7
PSX 2000=1	1.5	1.1	1.3	1.5	1.7
SM €bn (2000)	286.9	369.7	430.4	514.3	587.2
PSM 2000=1	1.2	1.0	1.1	1.2	1.3
GHG mtC-eq	183165.8	204356.2	199729.1	175905.7	170805.4
CO2 mtC-eq	168515.5	189878.1	183592.3	160056.5	153784.3
FR003IS fuel use mtoe	4667.6	4167.1	3496.3	2947.5	3249.1
FR004NF fuel use mtoe	1204.8	1121.6	1078.8	1122.1	1138.9
FR005NM fuel use mtoe	14078.7	15807.6	14405.9	12576.9	9661.0
FR010PP fuel use mtoe	2532.4	2630.3	2768.9	2563.6	2488.2
FCO2(03) IS mtC-eq	7127.5	6200.5	5472.9	4092.7	4493.2
FCO2(04) NF mtC-eq	481.5	502.0	486.1	528.2	536.6
FCO2(05) NM mtC-eq	2182.7	3163.4	3013.9	2909.3	3032.2
FCO2(10) PP mtC-eq	884.3	473.8	566.8	565.0	535.4

TABLE E48 BASE CASE: MACRO RESULTS FOR REST OF EU15

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.1	0.1	0.1	0.1	0.1
Empl tax revs RERS	78668.6	97948.7	117814.9	146873.6	177977.2
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1526.9	1818.4	1967.2	2190.0	2389.2
GDP deflator 2000=1	0.9	1.0	1.2	1.3	1.3
SC cons. €bn (2000)	850.6	969.9	1057.6	1142.7	1263.6
PSC 2000=1	0.9	1.0	1.1	1.3	1.3
SK invest. €bn (2000)	291.5	388.0	424.9	485.7	530.6
PSK 2000=1	0.9	1.1	1.2	1.2	1.2
SX €bn (2000)	652.1	906.8	1003.2	1170.0	1301.1
PSX 2000=1	0.9	1.1	1.2	1.4	1.4
SM €bn (2000)	618.1	829.4	923.5	1051.8	1184.4
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	212425.2	218731.0	231000.7	213469.3	212187.6
CO2 mtC-eq	187397.5	198818.8	211702.2	197552.3	196152.9
FR003IS fuel use mtoe	7994.3	9020.2	9505.2	9171.5	8764.3
FR004NF fuel use mtoe	2900.4	3421.2	3077.1	3564.9	4212.5
FR005NM fuel use mtoe	25295.8	29743.1	28853.7	29766.9	29016.8
FR010PP fuel use mtoe	15172.3	18288.0	18090.9	18863.9	20227.2
FCO2(03) IS mtC-eq	11419.7	11283.8	12291.5	10247.8	9690.4
FCO2(04) NF mtC-eq	1043.8	1319.3	1444.3	1640.7	1784.1
FCO2(05) NM mtC-eq	3800.8	4336.2	4426.7	4418.8	4293.1
FCO2(10) PP mtC-eq	2334.2	2367.5	2411.8	2230.1	2083.0

TABLE E49 BASE CASE: MACRO RESULTS FOR POLAND

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	7538.2	10969.9	15515.5	29727.7	47555.1
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	157.3	170.0	182.8	209.5	242.2
GDP deflator 2000=1	0.6	1.0	1.3	1.7	1.9
SC cons. €bn (2000)	113.9	115.8	132.2	152.2	182.6
PSC 2000=1	0.6	1.0	1.3	1.9	2.2
SK invest. €bn (2000)	23.1	23.2	24.7	31.3	36.8
PSK 2000=1	0.7	1.0	1.1	1.3	1.2
SX €bn (2000)	32.9	50.1	65.5	84.4	91.0
PSX 2000=1	0.6	1.1	1.2	1.3	1.4
SM €bn (2000)	37.1	47.4	66.9	88.2	101.1
PSM 2000=1	0.8	1.1	1.2	1.4	1.5
GHG mtC-eq	120294.4	106938.8	103320.6	105078.0	110666.0
CO2 mtC-eq	89730.3	81332.3	76342.7	76905.8	80422.6
FR003IS fuel use mtoe	4932.3	4508.7	3223.2	2855.0	2683.7
FR004NF fuel use mtoe	824.0	779.2	693.5	619.3	614.3
FR005NM fuel use mtoe	7272.5	6913.5	6641.2	7282.8	8152.8
FR010PP fuel use mtoe	1156.6	1008.8	1133.2	1057.0	997.2
FCO2(03) IS mtC-eq	5918.4	5083.7	4144.1	3550.7	3264.7
FCO2(04) NF mtC-eq	566.9	495.4	459.5	405.9	352.9
FCO2(05) NM mtC-eq	2385.0	2384.4	2156.8	1977.2	1933.9
FCO2(10) PP mtC-eq	727.6	631.8	596.6	493.1	396.1

TABLE E50 BASE CASE: MACRO RESULTS FOR REST OF EU10

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	29179.4	38326.4	52217.0	83313.2	124887.1
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	393.6	453.4	492.3	574.2	649.3
GDP deflator 2000=1	0.8	1.0	1.2	1.5	1.6
SC cons. €bn (2000)	207.2	236.8	266.9	294.3	336.6
PSC 2000=1	0.8	1.0	1.1	1.5	1.8
SK invest. €bn (2000)	82.4	99.3	115.7	144.6	166.8
PSK 2000=1	0.9	1.1	1.3	1.5	1.5
SX €bn (2000)	138.6	208.3	276.2	339.2	382.1
PSX 2000=1	0.9	1.0	1.2	1.3	1.4
SM €bn (2000)	139.8	215.8	289.6	356.3	404.8
PSM 2000=1	0.9	1.0	1.2	1.3	1.3
GHG mtC-eq	109594.5	101096.7	100387.4	100128.1	102629.8
CO2 mtC-eq	89761.9	82311.7	81779.6	81418.1	83830.6
FR003IS fuel use mtoe	6287.8	5337.7	5245.7	4772.5	4355.2
FR004NF fuel use mtoe	1222.6	1010.1	1135.9	1176.6	1207.9
FR005NM fuel use mtoe	9592.7	9099.7	8801.4	9251.8	9167.3
FR010PP fuel use mtoe	7019.5	7724.5	7454.2	8983.7	10548.5
FCO2(03) IS mtC-eq	7756.1	6883.5	6488.0	5504.2	4956.8
FCO2(04) NF mtC-eq	602.5	544.8	815.1	685.8	733.5
FCO2(05) NM mtC-eq	999.6	1626.4	1848.2	1896.3	1755.5
FCO2(10) PP mtC-eq	1298.6	1136.4	1297.9	1414.5	1241.7

TABLE E51 BASE CASE: MACRO RESULTS FOR EU15

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	615327.3	703906.8	818912.8	0.9	1272261.1
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	7751.3	8930.4	9405.6	10085.0	10948.7
GDP deflator 2000=1	0.9	1.0	1.1	1.3	1.3
SC cons. €bn (2000)	4641.9	5227.9	5489.2	5715.6	6263.5
PSC 2000=1	0.9	1.0	1.1	1.3	1.3
SK invest. €bn (2000)	1428.2	1807.6	1881.6	2144.5	2305.7
PSK 2000=1	1.0	1.0	1.1	1.2	1.2
SX €bn (2000)	2044.7	2857.8	3119.4	3646.6	4021.3
PSX 2000=1	1.0	1.0	1.2	1.3	1.4
SM €bn (2000)	1956.5	2649.4	2920.2	3419.0	3867.3
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	946609.4	1045430.1	0.4	0.6	986696.2
CO2 mtC-eq	815626.0	912876.2	977421.3	914755.0	858830.9
FR003IS fuel use mtoe	36186.4	38292.4	36999.9	36549.6	34978.6
FR004NF fuel use mtoe	10202.4	11073.3	10889.7	12254.3	13170.7
FR005NM fuel use mtoe	106289.6	118699.9	105851.4	95844.7	86319.1
FR010PP fuel use mtoe	29770.5	34415.1	35263.9	35571.4	36385.8
FCO2(03) IS mtC-eq	47605.1	45779.7	43644.1	39475.4	38036.6
FCO2(04) NF mtC-eq	3338.2	4024.7	4345.7	4966.7	5298.0
FCO2(05) NM mtC-eq	16209.3	16043.0	16405.8	15872.1	15287.7
FCO2(10) PP mtC-eq	7128.5	7157.7	7116.0	6501.5	6237.5

TABLE E52 BASE CASE: MACRO RESULTS FOR EU10

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	20753.5	29002.3	44355.5	84444.9	137721.5
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	324.3	358.8	400.0	473.1	537.2
GDP deflator 2000=1	0.6	1.0	1.2	1.7	2.0
SC cons. €bn (2000)	206.5	224.8	265.0	304.0	356.1
PSC 2000=1	0.7	1.0	1.2	1.8	2.2
SK invest. €bn (2000)	65.7	70.5	84.6	107.6	127.1
PSK 2000=1	0.7	1.0	1.2	1.5	1.4
SX €bn (2000)	103.4	162.1	230.8	295.2	332.3
PSX 2000=1	0.7	1.1	1.1	1.3	1.3
SM €bn (2000)	112.4	173.8	258.7	332.5	386.5
PSM 2000=1	0.8	1.0	1.2	1.3	1.4
GHG mtC-eq	213217.0	192573.4	187448.4	190944.3	197269.7
CO2 mtC-eq	164943.6	150033.7	143865.2	146143.3	150341.7
FR003IS fuel use mtoe	9963.7	8630.6	7155.6	6424.5	5972.6
FR004NF fuel use mtoe	1736.8	1484.8	1520.1	1495.5	1541.1
FR005NM fuel use mtoe	15020.5	14518.3	13054.6	13978.2	15179.4
FR010PP fuel use mtoe	2537.5	2259.1	2530.1	2465.0	2537.3
FCO2(03) IS mtC-eq	12148.7	10559.0	9201.0	7937.9	7114.4
FCO2(04) NF mtC-eq	1102.0	928.9	1137.8	940.2	931.5
FCO2(05) NM mtC-eq	3272.6	3846.6	3806.5	3664.5	3470.6
FCO2(10) PP mtC-eq	1507.0	1241.5	1378.5	1310.2	1200.3

TABLE E53 BASE CASE: MACRO RESULTS FOR EU25

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	636080.7	732909.1	863268.4	0.6	1409982.5
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	8075.6	9289.2	9805.6	10558.1	11485.9
GDP deflator 2000=1	0.9	1.0	1.1	1.3	1.4
SC cons. €bn (2000)	4848.4	5452.7	5754.1	6019.6	6619.6
PSC 2000=1	0.9	1.0	1.1	1.3	1.4
SK invest. €bn (2000)	1493.9	1878.0	1966.2	2252.2	2432.8
PSK 2000=1	1.0	1.0	1.1	1.2	1.2
SX €bn (2000)	2148.2	3019.9	3350.2	3941.7	4353.5
PSX 2000=1	1.0	1.0	1.2	1.3	1.4
SM €bn (2000)	2068.9	2823.3	3178.9	3751.5	4253.8
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	0.3	1238003.5	0.9	0.8	1183966.0
CO2 mtC-eq	980569.5	1062910.0	0.4	0.3	1009172.6
FR003IS fuel use mtoe	46150.0	46923.0	44155.4	42974.1	40951.2
FR004NF fuel use mtoe	11939.1	12558.1	12409.9	13749.8	14711.8
FR005NM fuel use mtoe	121310.0	133218.2	118905.9	109822.9	101498.5
FR010PP fuel use mtoe	32307.9	36674.2	37794.1	38036.4	38923.1
FCO2(03) IS mtC-eq	59753.8	56338.7	52845.1	47413.3	45151.0
FCO2(04) NF mtC-eq	4440.2	4953.6	5483.5	5906.9	6229.6
FCO2(05) NM mtC-eq	19481.9	19889.7	20212.4	19536.6	18758.3
FCO2(10) PP mtC-eq	8635.5	8399.1	8494.5	7811.7	7437.9

TABLE E54 BASE CASE: MACRO RESULTS FOR EUROZONE 11

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	576108.7	639431.6	753662.7	984741.1	1234395.8
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	6165.6	6930.7	7345.1	7928.1	8548.8
GDP deflator 2000=1	0.9	1.0	1.2	1.3	1.4
SC cons. €bn (2000)	3621.8	4008.4	4226.8	4442.0	4826.8
PSC 2000=1	0.9	1.0	1.1	1.3	1.4
SK invest. €bn (2000)	1228.8	1488.1	1520.4	1725.9	1841.7
PSK 2000=1	1.0	1.0	1.2	1.2	1.2
SX €bn (2000)	1710.7	2399.4	2701.3	3209.3	3570.4
PSX 2000=1	0.9	1.0	1.1	1.3	1.4
SM €bn (2000)	1653.9	2281.3	2559.8	3019.9	3427.9
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	920675.0	977794.6	0.0	0.9	954052.3
CO2 mtC-eq	759802.8	820700.6	878218.5	842709.6	800012.6
FR003IS fuel use mtoe	40020.8	41263.0	38994.4	38423.1	36211.8
FR004NF fuel use mtoe	9732.1	10313.2	10169.4	11364.3	12274.5
FR005NM fuel use mtoe	104750.5	115214.1	101379.1	93713.8	88513.6
FR010PP fuel use mtoe	23860.5	27315.6	28661.0	27555.3	27074.3
FCO2(03) IS mtC-eq	51002.6	48626.4	45822.2	42076.2	39421.6
FCO2(04) NF mtC-eq	3459.5	3878.3	4401.9	4736.8	5002.8
FCO2(05) NM mtC-eq	17001.3	16348.7	16769.9	16185.7	15257.1
FCO2(10) PP mtC-eq	7112.0	7291.3	7278.9	6526.1	6348.9

TABLE E55 BASE CASE: MACRO RESULTS FOR DENMARK

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.0	0.0	0.0	0.0	0.0
Empl tax revs RERS	243.9	263.4	228.9	299.9	370.8
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	151.8	166.8	177.5	197.0	217.4
GDP deflator 2000=1	0.9	1.0	1.1	1.3	1.4
SC cons. €bn (2000)	79.3	79.4	85.6	95.3	108.3
PSC 2000=1	0.9	1.1	1.2	1.4	1.5
SK invest. €bn (2000)	22.7	28.5	31.8	36.5	42.4
PSK 2000=1	1.1	1.3	1.3	1.5	1.5
SX €bn (2000)	46.4	59.0	63.5	73.2	83.1
PSX 2000=1	0.9	1.0	1.0	1.2	1.3
SM €bn (2000)	40.2	47.5	51.9	61.3	72.5
PSM 2000=1	1.0	1.2	1.3	1.4	1.4
GHG mtC-eq	17403.9	15998.8	14788.2	12947.9	13821.1
CO2 mtC-eq	15793.1	14329.1	13221.4	11581.1	12203.0
FR003IS fuel use mtoe	105.5	88.2	82.9	89.3	87.0
FR004NF fuel use mtoe	15.5	16.4	18.4	20.0	22.3
FR005NM fuel use mtoe	253.2	264.3	242.3	214.7	234.7
FR010PP fuel use mtoe	138.7	84.9	117.3	123.3	115.1
FCO2(03) IS mtC-eq	37.1	23.2	30.4	31.0	26.2
FCO2(04) NF mtC-eq	11.5	4.4	4.8	5.8	6.1
FCO2(05) NM mtC-eq	92.6	88.2	76.2	54.2	52.4
FCO2(10) PP mtC-eq	56.9	22.1	49.2	38.7	29.8

TABLE E56 BASE CASE: MACRO RESULTS FOR IRELAND

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.1	0.1	0.1	0.1	0.1
Empl tax revs RERS	1553.9	2657.8	3725.9	4512.8	5457.3
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	70.6	104.9	135.4	164.4	188.2
GDP deflator 2000=1	0.8	1.0	1.1	1.1	1.2
SC cons. €bn (2000)	39.0	52.7	61.9	72.4	82.2
PSC 2000=1	0.9	1.0	1.1	1.1	1.2
SK invest. €bn (2000)	13.7	25.6	30.7	36.2	41.2
PSK 2000=1	0.8	1.0	1.1	1.1	1.1
SX €bn (2000)	50.1	85.0	103.2	129.0	156.3
PSX 2000=1	0.8	1.0	1.0	1.1	1.2
SM €bn (2000)	28.4	56.3	61.8	76.2	91.6
PSM 2000=1	1.1	1.0	0.9	1.0	1.1
GHG mtC-eq	12596.4	12101.0	12867.5	13401.7	13682.9
CO2 mtC-eq	9340.0	11148.6	11890.7	12399.8	12669.1
FR003IS fuel use mtoe	46.8	55.4	5.0	3.8	3.9
FR004NF fuel use mtoe	669.7	683.8	209.1	245.9	250.3
FR005NM fuel use mtoe	689.7	762.2	333.2	353.7	361.3
FR010PP fuel use mtoe	171.3	186.3	20.6	18.9	18.6
FCO2(03) IS mtC-eq	19.5	16.2	18.6	19.8	20.6
FCO2(04) NF mtC-eq	222.7	218.3	316.8	407.8	465.7
FCO2(05) NM mtC-eq	139.2	199.5	223.9	230.3	222.7
FCO2(10) PP mtC-eq	9.4	8.6	15.1	10.7	7.5

TABLE E57 BASE CASE: MACRO RESULTS FOR THE NETHERLANDS

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.0	0.0	0.0	0.0	0.0
Empl tax revs RERS	4523.6	5920.6	6275.3	7544.4	9111.7
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	347.9	418.7	445.0	477.6	493.8
GDP deflator 2000=1	0.9	1.0	1.2	1.3	1.3
SC cons. €bn (2000)	171.9	203.2	217.4	219.1	236.4
PSC 2000=1	0.9	1.0	1.1	1.2	1.4
SK invest. €bn (2000)	69.5	91.5	100.8	108.0	117.0
PSK 2000=1	0.9	1.0	1.1	1.2	1.2
SX €bn (2000)	173.8	231.2	245.4	283.2	308.5
PSX 2000=1	0.9	1.0	1.1	1.3	1.3
SM €bn (2000)	156.1	205.4	227.8	253.6	288.2
PSM 2000=1	0.9	1.0	1.0	1.1	1.2
GHG mtC-eq	54574.8	57453.6	51581.3	47917.6	47827.2
CO2 mtC-eq	45108.3	49039.1	45204.7	42351.8	42475.7
FR003IS fuel use mtoe	948.9	1161.2	1290.8	1414.0	1500.6
FR004NF fuel use mtoe	542.6	893.9	929.1	1215.0	1796.8
FR005NM fuel use mtoe	12083.2	13071.3	13608.3	13810.9	13400.4
FR010PP fuel use mtoe	719.6	937.2	1305.6	863.2	991.5
FCO2(03) IS mtC-eq	2056.2	2209.3	2096.7	2192.7	2333.7
FCO2(04) NF mtC-eq	74.4	123.1	92.8	110.2	127.6
FCO2(05) NM mtC-eq	1721.5	1988.1	1906.3	1866.7	1710.5
FCO2(10) PP mtC-eq	107.9	171.2	198.0	91.2	131.9

TABLE E58 BASE CASE: MACRO RESULTS FOR FINLAND

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	9862.5	10781.3	12927.1	16356.0	18879.9
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	106.5	132.5	144.7	158.2	177.6
GDP deflator 2000=1	1.0	1.0	1.1	1.1	1.2
SC cons. €bn (2000)	57.0	66.2	75.7	81.3	90.7
PSC 2000=1	0.9	1.0	1.1	1.3	1.3
SK invest. €bn (2000)	18.0	25.6	26.4	29.0	31.1
PSK 2000=1	1.0	1.2	1.2	1.3	1.4
SX €bn (2000)	36.2	57.6	62.6	72.6	82.0
PSX 2000=1	1.0	1.0	1.0	1.2	1.2
SM €bn (2000)	28.0	39.0	45.9	48.7	56.8
PSM 2000=1	0.9	1.0	1.1	1.6	1.6
GHG mtC-eq	17611.0	17884.1	22040.8	15589.0	13862.1
CO2 mtC-eq	15418.1	16181.4	19464.0	14573.0	12931.5
FR003IS fuel use mtoe	919.2	1011.3	1148.6	1137.7	1194.2
FR004NF fuel use mtoe	184.5	191.8	253.6	252.7	221.0
FR005NM fuel use mtoe	1721.3	1628.5	1230.7	1152.8	1136.1
FR010PP fuel use mtoe	5853.8	7595.1	7286.7	6617.4	6368.3
FCO2(03) IS mtC-eq	1433.7	1584.0	1525.9	1261.7	1358.9
FCO2(04) NF mtC-eq	31.1	30.7	30.5	32.1	28.4
FCO2(05) NM mtC-eq	197.2	280.9	300.4	216.8	176.8
FCO2(10) PP mtC-eq	1042.8	982.1	932.8	797.1	815.4

TABLE E59 BASE CASE: MACRO RESULTS FOR SWEDEN

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	15964.1	20294.0	23376.9	28596.0	34720.6
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	226.6	264.6	275.1	310.5	354.3
GDP deflator 2000=1	0.9	1.0	1.2	1.3	1.3
SC cons. €bn (2000)	114.6	127.8	134.1	142.5	163.0
PSC 2000=1	0.9	1.0	1.0	1.1	1.2
SK invest. €bn (2000)	39.8	52.0	55.8	68.3	76.5
PSK 2000=1	0.9	1.2	1.3	1.4	1.4
SX €bn (2000)	68.0	96.3	110.8	128.4	140.9
PSX 2000=1	1.0	1.0	1.4	1.5	1.5
SM €bn (2000)	64.5	89.3	97.8	112.1	119.4
PSM 2000=1	1.0	1.1	1.2	1.4	1.4
GHG mtC-eq	16671.9	15462.1	16259.6	14261.9	16026.1
CO2 mtC-eq	14548.6	13610.4	14257.1	12180.6	13911.6
FR003IS fuel use mtoe	1256.5	1215.7	1313.3	1203.1	1066.3
FR004NF fuel use mtoe	309.7	304.6	309.2	300.4	281.2
FR005NM fuel use mtoe	1844.7	1494.8	2388.0	2556.4	2140.8
FR010PP fuel use mtoe	5638.7	6474.2	6057.2	7575.7	9008.4
FCO2(03) IS mtC-eq	1525.8	1408.2	1431.2	1117.0	1107.1
FCO2(04) NF mtC-eq	67.4	111.2	136.8	151.5	154.8
FCO2(05) NM mtC-eq	112.0	164.1	198.5	209.0	218.8
FCO2(10) PP mtC-eq	519.2	526.8	516.0	597.3	437.5

TABLE E60 BASE CASE: MACRO RESULTS FOR SLOVENIA

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.3	0.3	0.3
Empl tax revs RERS	1700.1	2918.7	4529.7	6896.8	10395.1
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	16.4	17.0	21.6	21.1	22.7
GDP deflator 2000=1	0.7	1.0	1.5	1.9	2.2
SC cons. €bn (2000)	11.1	11.3	15.0	16.1	18.5
PSC 2000=1	0.8	1.3	1.4	2.1	2.5
SK invest. €bn (2000)	3.0	3.6	4.7	5.1	5.4
PSK 2000=1	0.8	1.0	1.2	1.7	1.7
SX €bn (2000)	8.6	11.6	15.0	18.7	21.6
PSX 2000=1	0.7	1.0	1.3	1.5	1.6
SM €bn (2000)	8.4	11.9	17.3	25.4	31.5
PSM 2000=1	0.8	1.4	1.2	1.4	1.5
GHG mtC-eq	4144.1	4519.2	4595.1	4412.4	4262.5
CO2 mtC-eq	3446.9	3777.6	3898.4	3740.6	3627.0
FR003IS fuel use mtoe	164.1	160.1	132.4	125.6	118.5
FR004NF fuel use mtoe	106.9	121.1	176.9	160.4	155.1
FR005NM fuel use mtoe	291.9	217.1	219.4	252.8	252.6
FR010PP fuel use mtoe	121.6	260.5	253.0	257.4	272.3
FCO2(03) IS mtC-eq	89.2	84.5	79.6	75.7	70.1
FCO2(04) NF mtC-eq	207.4	101.8	286.2	173.8	187.2
FCO2(05) NM mtC-eq	45.2	42.1	28.2	37.5	32.9
FCO2(10) PP mtC-eq	58.4	121.6	107.2	129.2	130.2

E1.2 Reference Case

TABLE E61 REFERENCE CASE: FOOD, DRINK AND TOBACCO IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	14050.6	15473.1	17512.3	23438.7	30687.6
Output	€m (2000)	14520.0	15381.8	16324.8	18621.3	22008.5
Value Added	€m (2000)	3740.9	3910.9	4158.5	5046.1	6232.1
Wage Bill	€m	2511.0	2899.3	3327.6	3980.8	4567.0
Energy Input	€m	178.6	350.0	540.5	769.0	732.2
Employment	th	82.6	78.9	74.5	72.4	72.1
Exports	€m	7059.7	8103.1	7517.6	10458.1	12821.1
Exports	€m (2000)	5592.0	8012.1	6758.4	7992.2	9387.7
Imports	€m	2932.8	2634.9	2679.3	4689.3	6244.4
Imports	€m (2000)	2590.0	2592.6	2641.6	3209.7	3884.3
Price output	2000=1	0.968	1.006	1.073	1.259	1.394

TABLE E62 REFERENCE CASE: FOOD, DRINK AND TOBACCO IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	125231.1	142725.6	153727.2	185123.5	221240.7
Output	€m (2000)	127114.6	135247.9	126273.3	134782.9	152221.9
Value Added	€m (2000)	35436.7	38540.0	38035.3	43779.4	50749.4
Wage Bill	€m	17929.1	21092.1	21841.7	27131.2	34437.3
Energy Input	€m	2475.2	3152.6	4001.5	4456.7	4742.7
Employment	th	996.2	1058.5	983.2	940.3	918.7
Exports	€m	17356.4	21474.1	29359.2	47276.1	71497.6
Exports	€m (2000)	16205.7	21161.7	29626.6	40610.8	58910.8
Imports	€m	21077.8	27910.0	30049.2	53899.8	70767.5
Imports	€m (2000)	20398.0	27538.0	30186.1	36889.0	43916.9
Price output	2000=1	0.985	1.055	1.217	1.373	1.453

TABLE E63 REFERENCE CASE: FOOD, DRINK AND TOBACCO IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	40736.5	47568.8	50209.4	56983.8	64095.8
Output	€m (2000)	44062.0	47568.8	46695.2	51978.0	56370.3
Value Added	€m (2000)	10574.0	10961.0	11123.9	10967.4	13185.7
Wage Bill	€m	4366.9	5474.8	6270.6	6320.5	7201.9
Energy Input	€m	412.1	543.4	808.2	946.6	953.5
Employment	th	158.9	173.8	154.1	140.5	139.5
Exports	€m	21436.5	25363.5	27873.2	36774.5	45577.7
Exports	€m (2000)	18772.8	25363.5	25156.3	29396.1	33147.4
Imports	€m	9535.8	11280.2	11937.1	18825.8	26139.9
Imports	€m (2000)	9334.1	11133.6	11816.3	12900.1	16209.7
Price output	2000=1	0.924	1.000	1.075	1.096	1.137

TABLE E64 REFERENCE CASE: FOOD, DRINK AND TOBACCO IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	8106.7	6882.7	9123.9	12107.5	12680.2
Output	€m (2000)	7694.8	7996.9	8844.1	9506.1	9574.3
Value Added	€m (2000)	1717.0	1780.0	2017.1	2724.9	2896.9
Wage Bill	€m	1018.0	962.9	1137.3	1435.5	1614.4
Energy Input	€m	95.9	99.2	117.3	136.2	136.1
Employment	th	45.5	38.6	36.7	35.5	35.8
Exports	€m	815.1	758.9	995.5	1641.4	2786.4
Exports	€m (2000)	485.1	799.3	1190.9	1552.4	2317.9
Imports	€m	1075.6	1608.3	1745.0	2934.2	5270.9
Imports	€m (2000)	872.3	1575.0	2004.0	2272.9	3793.1
Price output	2000=1	1.054	0.861	1.032	1.274	1.324

TABLE E65 REFERENCE CASE: FOOD, DRINK AND TOBACCO IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	13468.6	14939.7	14557.5	16107.0	19495.4
Output	€m (2000)	14073.1	15060.1	13832.4	15244.1	18691.0
Value Added	€m (2000)	3999.1	4003.6	4153.6	4538.1	5741.7
Wage Bill	€m	1683.3	2005.7	2177.9	2545.5	3003.8
Energy Input	€m	126.2	154.2	154.4	157.6	130.1
Employment	th	63.9	63.1	59.9	58.8	58.7
Exports	€m	1363.0	1998.1	3015.0	3571.9	4354.1
Exports	€m (2000)	1189.6	1976.1	2642.7	2706.8	3135.4
Imports	€m	2351.3	2417.9	4875.1	8789.2	10677.5
Imports	€m (2000)	2293.8	2386.7	4024.5	4946.5	5492.2
Price output	2000=1	0.957	0.992	1.052	1.057	1.043

TABLE E66 REFERENCE CASE: FOOD, DRINK AND TOBACCO IN THE UK

		1996	2000	2004	2008	2012
Output	€m	103642.7	109428.9	112352.2	117869.4	148112.1
Output	€m (2000)	94055.9	109322.8	109798.1	107256.3	126791.0
Value Added	€m (2000)	33342.0	33308.7	34702.3	33809.9	40424.3
Wage Bill	€m	14076.8	24567.0	20195.8	15436.4	21945.5
Energy Input	€m	1527.2	1227.0	1369.2	1886.0	1868.2
Employment	th	510.5	763.3	533.6	296.0	388.6
Exports	€m	14942.7	15700.4	17014.4	20580.9	21212.8
Exports	€m (2000)	14367.8	15520.4	14853.2	15468.6	15113.8
Imports	€m	21798.2	21966.9	24229.7	40499.8	49908.3
Imports	€m (2000)	15387.6	21690.6	23608.7	27028.1	30170.6
Price output	2000=1	1.102	1.001	1.023	1.099	1.168

TABLE E67 REFERENCE CASE: FOOD, DRINK AND TOBACCO IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	1206.8	1581.3	3040.5	5767.1	8840.2
Output	€m (2000)	1506.2	1574.8	2213.3	2638.8	3031.2
Value Added	€m (2000)	496.5	510.1	752.2	1394.3	3313.1
Wage Bill	€m	222.0	237.1	378.6	559.1	797.9
Energy Input	€m	24.2	53.9	52.6	61.2	71.7
Employment	th	21.6	22.3	24.8	23.8	23.4
Exports	€m	206.3	323.9	578.4	853.2	1118.2
Exports	€m (2000)	248.3	321.4	369.6	485.0	576.9
Imports	€m	325.3	417.0	674.7	1089.7	1365.3
Imports	€m (2000)	394.8	410.9	639.3	709.2	779.5
Price output	2000=1	0.801	1.004	1.374	2.186	2.916

TABLE E68 REFERENCE CASE: WOOD AND PAPER IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	1862.9	1988.6	2929.4	3456.5	4659.9
Output	€m (2000)	2288.1	2321.8	1840.2	1917.4	2617.3
Value Added	€m (2000)	1088.2	1221.0	1123.9	1080.8	1247.0
Wage Bill	€m	663.4	770.6	910.1	1008.8	1434.0
Energy Input	€m	52.6	62.6	94.9	119.1	116.0
Employment	th	20.8	18.8	19.8	16.8	19.2
Exports	€m	389.4	87.8	56.9	79.6	618.6
Exports	€m (2000)	355.7	107.1	86.1	118.9	570.5
Imports	€m	1986.1	2390.8	2953.1	4078.8	4276.1
Imports	€m (2000)	1879.1	1797.4	1741.8	1990.1	2346.2
Price output	2000=1	0.814	0.857	1.592	1.803	1.781

TABLE E69 REFERENCE CASE: WOOD AND PAPER IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	43928.8	53283.9	59387.4	75140.9	78436.8
Output	€m (2000)	51893.8	60179.2	49036.8	58108.9	60759.9
Value Added	€m (2000)	16528.8	18170.0	19949.4	21137.0	16958.1
Wage Bill	€m	8774.4	9502.3	11195.3	13016.7	13994.2
Energy Input	€m	1651.0	2301.0	2913.1	3712.1	3791.3
Employment	th	364.1	332.7	348.3	350.7	312.2
Exports	€m	10266.6	16429.5	23973.2	33664.3	33022.0
Exports	€m (2000)	11591.1	17238.0	24097.1	28808.5	29083.1
Imports	€m	11484.9	15596.0	19749.1	23830.2	27189.7
Imports	€m (2000)	14336.8	16069.5	23075.2	23932.7	26086.6
Price output	2000=1	0.847	0.885	1.211	1.293	1.291

TABLE E70 REFERENCE CASE: WOOD AND PAPER IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	5554.6	7804.0	11567.5	12019.8	8911.3
Output	€m (2000)	6698.3	8541.5	9505.2	9319.1	6931.9
Value Added	€m (2000)	2248.5	2587.0	3800.1	3347.8	2077.0
Wage Bill	€m	1293.7	1580.5	2075.7	2218.8	2017.2
Energy Input	€m	116.4	188.9	389.4	326.2	243.6
Employment	th	43.9	49.1	58.2	54.0	40.6
Exports	€m	3350.5	4376.5	5604.3	6533.7	6731.9
Exports	€m (2000)	4151.0	4548.0	4552.4	4677.8	4744.1
Imports	€m	5449.2	6248.1	5648.0	7706.2	10812.6
Imports	€m (2000)	5778.4	6524.7	6272.5	7477.2	10044.4
Price output	2000=1	0.829	0.914	1.217	1.290	1.286

TABLE E71 REFERENCE CASE: WOOD AND PAPER IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	14057.6	20760.5	22283.4	20457.0	20534.5
Output	€m (2000)	16495.7	22020.3	23156.3	23671.0	25022.3
Value Added	€m (2000)	5240.0	6745.0	8019.3	8117.5	8907.7
Wage Bill	€m	1741.2	2164.1	2588.4	2791.0	2848.6
Energy Input	€m	881.7	1240.6	1650.9	1787.3	1635.8
Employment	th	65.6	69.3	70.4	62.8	59.3
Exports	€m	8839.0	13133.2	13731.2	16625.8	20079.5
Exports	€m (2000)	7844.8	13133.2	11961.0	13142.9	14230.7
Imports	€m	513.1	809.3	981.0	1120.2	1201.5
Imports	€m (2000)	733.2	834.0	987.1	954.5	978.4
Price output	2000=1	0.852	0.943	0.962	0.864	0.821

TABLE E72 REFERENCE CASE: WOOD AND PAPER IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	15453.3	19219.1	25447.8	31411.0	35637.9
Output	€m (2000)	17464.1	21068.3	21733.3	24877.9	29428.1
Value Added	€m (2000)	5767.3	7010.7	8121.1	8324.3	8056.4
Wage Bill	€m	2334.8	2617.5	3045.8	3694.4	3287.6
Energy Input	€m	636.5	777.9	1013.3	1306.6	1279.7
Employment	th	81.4	76.5	76.8	73.8	55.2
Exports	€m	9540.1	11907.7	17669.5	21109.0	19343.8
Exports	€m (2000)	8241.3	12549.4	13413.3	15131.2	15591.8
Imports	€m	1233.9	1943.2	2224.8	3097.9	3493.8
Imports	€m (2000)	1491.6	1997.9	2306.8	2770.7	3056.8
Price output	2000=1	0.885	0.912	1.171	1.263	1.211

TABLE E73 REFERENCE CASE: WOOD AND PAPER IN THE UK

		1996	2000	2004	2008	2012
Output	€m	30056.6	30840.6	43417.2	41992.1	40834.2
Output	€m (2000)	30780.1	34897.3	35650.9	34936.2	35303.9
Value Added	€m (2000)	10465.0	10310.4	14884.3	7824.4	8355.3
Wage Bill	€m	4715.9	6768.0	7194.8	9195.1	8579.1
Energy Input	€m	1110.3	1189.1	1426.1	2033.4	1670.0
Employment	th	348.2	388.7	323.1	289.3	248.9
Exports	€m	5171.8	5228.1	6828.4	8383.6	8904.1
Exports	€m (2000)	4814.1	5031.5	4929.3	5285.4	5492.3
Imports	€m	11486.6	10829.8	11321.8	15853.8	16330.7
Imports	€m (2000)	11134.3	12507.3	12659.0	13186.1	15297.6
Price output	2000=1	0.977	0.884	1.218	1.202	1.157

TABLE E74 REFERENCE CASE: WOOD AND PAPER IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	716.1	1023.2	1404.1	2143.8	2796.3
Output	€m (2000)	955.8	1093.8	1136.6	1379.8	1541.3
Value Added	€m (2000)	297.2	350.1	391.7	244.1	398.0
Wage Bill	€m	153.5	164.9	304.9	311.2	323.9
Energy Input	€m	47.7	81.3	71.7	88.4	101.7
Employment	th	22.2	18.9	26.2	17.4	11.6
Exports	€m	407.6	700.0	712.7	758.9	607.4
Exports	€m (2000)	501.3	717.2	583.4	607.6	514.7
Imports	€m	226.5	435.3	634.1	2090.3	1618.2
Imports	€m (2000)	313.8	456.4	577.2	673.9	680.6
Price output	2000=1	0.749	0.935	1.235	1.554	1.814

TABLE E75 REFERENCE CASE: PHARMACEUTICALS IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	1982.7	3139.0	3591.1	4251.3	5021.4
Output	€m (2000)	1799.7	3138.9	3656.9	4324.8	5087.5
Value Added	€m (2000)	758.4	1801.4	1911.0	2658.9	2889.5
Wage Bill	€m	491.1	637.2	926.6	1247.2	1476.5
Energy Input	€m	7.9	24.5	35.2	39.3	32.8
Employment	th	11.0	12.0	13.0	13.5	13.5
Exports	€m	1860.0	3275.2	4885.4	7171.4	8895.6
Exports	€m (2000)	2443.5	3204.4	3793.7	4640.9	5618.9
Imports	€m	819.4	1393.3	2503.1	3497.5	4142.4
Imports	€m (2000)	794.1	1427.5	1812.3	2252.1	2717.7
Price output	2000=1	1.102	1.000	0.982	0.983	0.987

TABLE E76 REFERENCE CASE: PHARMACEUTICALS IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	19258.5	23271.4	31407.7	38032.5	38517.2
Output	€m (2000)	21936.8	23981.3	26645.3	28999.3	28147.3
Value Added	€m (2000)	8212.5	8990.0	14036.6	15776.3	14066.9
Wage Bill	€m	4665.6	5765.8	6339.7	9277.7	11570.6
Energy Input	€m	1273.6	2097.3	2457.9	2107.5	1538.5
Employment	th	120.7	121.5	105.4	118.8	114.0
Exports	€m	9337.1	16226.6	25269.0	36107.7	40997.6
Exports	€m (2000)	11898.4	16584.0	21828.3	26226.8	28854.4
Imports	€m	6267.0	11762.1	26368.8	36468.4	46371.8
Imports	€m (2000)	7182.0	12052.0	15649.3	19370.0	24784.9
Price output	2000=1	0.878	0.970	1.179	1.312	1.368

TABLE E77 REFERENCE CASE: PHARMACEUTICALS IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	5003.6	5645.9	6862.0	8250.7	9417.3
Output	€m (2000)	5744.8	6415.1	6336.1	6779.5	6765.3
Value Added	€m (2000)	1368.7	1557.0	1627.6	1986.7	1908.8
Wage Bill	€m	558.0	629.3	832.0	1029.2	1081.7
Energy Input	€m	0.7	1.5	2.7	2.6	2.1
Employment	th	14.9	15.0	16.9	17.9	15.6
Exports	€m	3546.5	4928.6	9632.4	13629.7	14945.4
Exports	€m (2000)	3956.6	5058.0	6424.3	7509.0	8072.9
Imports	€m	3478.9	4937.5	8993.8	12160.6	13890.9
Imports	€m (2000)	3561.8	5025.9	5934.9	7176.8	8220.6
Price output	2000=1	0.871	0.880	1.083	1.217	1.392

TABLE E78 REFERENCE CASE: PHARMACEUTICALS IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	518.4	701.5	897.6	960.2	893.3
Output	€m (2000)	442.0	681.5	784.8	768.6	763.1
Value Added	€m (2000)	197.0	267.0	369.6	413.3	405.3
Wage Bill	€m	93.6	123.0	160.8	227.8	280.3
Energy Input	€m	24.3	47.6	69.5	65.5	51.1
Employment	th	4.1	4.3	4.2	4.5	4.6
Exports	€m	190.8	344.4	653.0	953.2	1202.8
Exports	€m (2000)	224.0	352.0	495.9	602.8	729.8
Imports	€m	559.2	889.9	1426.5	1861.2	2201.0
Imports	€m (2000)	504.7	915.6	1126.2	1307.6	1561.4
Price output	2000=1	1.173	1.029	1.144	1.249	1.171

TABLE E79 REFERENCE CASE: PHARMACEUTICALS IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	4107.3	5495.2	8609.2	11730.4	15185.5
Output	€m (2000)	3972.7	5777.7	7027.2	8443.9	10615.0
Value Added	€m (2000)	1959.8	3006.9	4090.6	5368.0	6875.6
Wage Bill	€m	578.2	888.2	1169.6	1717.6	2502.3
Energy Input	€m	11.4	11.8	21.5	27.4	27.9
Employment	th	15.6	17.5	20.7	21.5	22.3
Exports	€m	2460.1	4198.1	7141.7	11396.3	15377.3
Exports	€m (2000)	2689.4	4288.0	6123.8	8249.5	10792.1
Imports	€m	1220.7	1442.7	3155.1	4402.2	4940.5
Imports	€m (2000)	996.5	1483.3	2163.6	2769.6	3137.4
Price output	2000=1	1.034	0.951	1.225	1.389	1.431

TABLE E80 REFERENCE CASE: PHARMACEUTICALS IN THE UK

		1996	2000	2004	2008	2012
Output	€m	14867.9	18263.2	27422.1	32612.2	35482.9
Output	€m (2000)	17338.6	19347.2	22338.7	22734.8	23870.7
Value Added	€m (2000)	7527.2	8896.1	10661.9	8945.1	9741.9
Wage Bill	€m	2724.7	4620.9	5666.7	8309.2	11698.5
Energy Input	€m	188.5	182.4	195.3	314.6	332.4
Employment	th	64.8	54.5	44.6	47.0	47.9
Exports	€m	10015.2	12453.0	22053.5	37920.3	52391.7
Exports	€m (2000)	8034.4	12696.1	20642.9	29681.4	39493.0
Imports	€m	6522.2	9658.7	19203.7	29522.3	36366.6
Imports	€m (2000)	5320.7	9942.9	18385.3	25023.4	31468.2
Price output	2000=1	0.858	0.944	1.228	1.435	1.486

TABLE E81 REFERENCE CASE: PHARMACEUTICALS IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	381.1	561.9	884.0	1473.7	2246.5
Output	€m (2000)	485.1	561.9	839.6	1056.4	1249.4
Value Added	€m (2000)	224.4	311.9	408.4	552.5	733.3
Wage Bill	€m	98.4	115.8	195.8	301.5	457.3
Energy Input	€m	0.2	0.3	0.7	1.2	1.5
Employment	th	5.5	5.2	6.0	5.8	5.6
Exports	€m	239.0	414.9	1239.5	1966.1	2649.7
Exports	€m (2000)	453.9	429.4	1177.4	1577.5	1872.8
Imports	€m	132.9	258.1	454.6	627.3	788.1
Imports	€m (2000)	157.9	267.0	293.9	346.5	435.8
Price output	2000=1	0.786	1.000	1.053	1.395	1.798

TABLE E82 REFERENCE CASE: CHEMICALS NES IN DENMARK

	1996	2000	2004	2008	2012
Output €m	3274.7	4104.3	5174.2	7247.5	7237.8
Output €m (2000)	2927.0	4016.3	5090.8	5835.4	6441.7
Value Added €m (2000)	993.6	931.3	1330.5	2499.9	1806.3
Wage Bill €m	612.5	627.8	735.7	936.9	1102.9
Energy Input €m	112.8	246.1	378.0	399.1	311.5
Employment th	15.9	14.0	13.7	14.8	15.6
Exports €m	1974.6	2601.3	3317.5	4794.5	5029.2
Exports €m (2000)	1887.0	2605.6	3183.4	3703.1	3959.1
Imports €m	2831.2	2544.2	3120.9	5183.1	6714.7
Imports €m (2000)	2106.8	2542.8	2899.3	3765.7	4640.6
Price output 2000=1	1.119	1.022	1.016	1.242	1.124

TABLE E83 REFERENCE CASE: CHEMICALS NES IN GERMANY

	1996	2000	2004	2008	2012
Output €m	93476.0	101176.0	111745.5	137212.9	133652.3
Output €m (2000)	96415.7	100640.8	119379.5	129476.0	147253.6
Value Added €m (2000)	29769.9	30930.0	33117.0	102624.4	2653.3
Wage Bill €m	19946.4	18732.7	19661.4	21222.8	24038.5
Energy Input €m	4899.7	7589.7	8425.7	6343.5	4884.1
Employment th	463.1	385.7	381.5	379.1	373.9
Exports €m	43487.1	57913.9	72804.5	109711.1	116133.0
Exports €m (2000)	38639.1	60033.3	77140.5	90557.9	97478.7
Imports €m	27787.0	45686.0	48155.2	86206.9	100638.0
Imports €m (2000)	30649.5	45091.8	43712.9	61198.7	67938.7
Price output 2000=1	0.970	1.005	0.936	1.060	0.908

TABLE E84 REFERENCE CASE: CHEMICALS NES IN THE NETHERLANDS

	1996	2000	2004	2008	2012
Output €m	22191.3	29519.4	30329.4	33979.2	35838.7
Output €m (2000)	24734.5	29069.0	31152.4	34523.3	37549.9
Value Added €m (2000)	5688.9	6892.0	818.1	1559.1	1608.9
Wage Bill €m	2622.6	2682.4	3240.8	3271.7	3435.9
Energy Input €m	1981.4	5639.6	12560.4	12349.3	10515.3
Employment th	63.8	58.5	56.4	57.1	58.7
Exports €m	21578.1	22180.2	28594.0	36326.1	42045.7
Exports €m (2000)	17820.1	22180.2	24418.5	28247.4	29402.6
Imports €m	13363.5	16423.3	20503.5	33023.1	39937.1
Imports €m (2000)	11652.0	16753.5	20872.0	25489.6	29689.6
Price output 2000=1	0.897	1.016	0.974	0.984	0.954

TABLE E85 REFERENCE CASE: CHEMICALS NES IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	4514.0	7305.3	5837.8	7490.6	7930.3
Output	€m (2000)	4604.4	7024.8	5000.5	5040.4	5382.7
Value Added	€m (2000)	1094.0	1275.0	1727.2	2451.5	2223.6
Wage Bill	€m	453.2	586.5	639.5	807.4	901.0
Energy Input	€m	340.2	604.7	556.4	603.0	532.7
Employment	th	16.0	17.3	15.8	15.5	15.3
Exports	€m	1905.5	3356.6	3083.6	3875.5	4421.3
Exports	€m (2000)	2304.2	3318.4	2591.3	2723.6	2971.2
Imports	€m	1999.8	2004.8	3422.8	4712.3	5170.6
Imports	€m (2000)	1760.2	2023.1	2812.3	2935.1	3076.6
Price output	2000=1	0.980	1.040	1.168	1.486	1.473

TABLE E86 REFERENCE CASE: CHEMICALS NES IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	5525.9	6629.1	7835.8	11833.0	13901.3
Output	€m (2000)	5128.7	6290.6	7213.1	8263.3	9529.0
Value Added	€m (2000)	1651.1	2184.2	2778.0	4079.3	4379.6
Wage Bill	€m	713.4	884.1	1078.5	1645.0	2153.6
Energy Input	€m	356.2	355.0	716.9	942.6	663.1
Employment	th	22.3	22.0	21.3	23.6	23.2
Exports	€m	1980.3	4080.7	5818.8	8731.6	9826.6
Exports	€m (2000)	2826.0	3898.6	4781.3	5819.8	6619.9
Imports	€m	4427.9	5362.1	7251.0	11250.3	12875.9
Imports	€m (2000)	3441.7	5434.1	5967.5	7259.9	7966.8
Price output	2000=1	1.077	1.054	1.086	1.432	1.459

TABLE E87 REFERENCE CASE: CHEMICALS NES IN THE UK

		1996	2000	2004	2008	2012
Output	€m	62062.7	57259.5	56958.0	74976.1	77367.2
Output	€m (2000)	51081.6	55393.1	56718.4	57413.9	64862.0
Value Added	€m (2000)	14345.1	16013.7	15713.9	12762.8	14974.0
Wage Bill	€m	6177.9	9333.8	8818.5	13364.8	11373.2
Energy Input	€m	2064.8	2224.4	2657.7	3394.6	3377.7
Employment	th	218.3	223.8	164.0	165.4	156.4
Exports	€m	29320.3	26648.5	32035.5	47761.2	48774.8
Exports	€m (2000)	21269.1	26637.0	25981.6	29384.9	30206.6
Imports	€m	26995.6	24675.3	29678.9	42908.9	46742.7
Imports	€m (2000)	19745.3	24660.4	24466.1	26434.8	28050.2
Price output	2000=1	1.215	1.034	1.004	1.306	1.193

TABLE E88 REFERENCE CASE: CHEMICALS NES IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	537.6	855.8	1098.3	1651.0	2624.4
Output	€m (2000)	645.4	840.9	1013.3	1165.5	1392.0
Value Added	€m (2000)	186.4	231.7	232.5	118.6	266.6
Wage Bill	€m	97.6	104.5	141.1	216.1	340.1
Energy Input	€m	35.5	38.8	81.3	112.9	143.9
Employment	th	9.1	8.8	8.3	8.2	8.6
Exports	€m	354.0	612.9	914.0	1265.0	1541.8
Exports	€m (2000)	458.1	612.9	855.8	1113.6	1226.5
Imports	€m	640.3	966.4	1681.6	3081.8	4085.9
Imports	€m (2000)	741.2	962.3	1468.9	2078.2	2389.9
Price output	2000=1	0.833	1.018	1.084	1.417	1.885

TABLE E89 REFERENCE CASE: NON-METALLIC MINERAL PRODUCTS IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	2028.7	2216.8	2855.9	3510.2	4668.5
Output	€m (2000)	2346.0	2466.3	2714.0	2974.5	3328.2
Value Added	€m (2000)	1022.8	1133.7	1257.6	1319.0	1886.5
Wage Bill	€m	595.6	776.7	885.9	1162.4	1525.7
Energy Input	€m	88.8	110.3	144.0	211.0	231.9
Employment	th	18.2	20.5	19.3	18.1	18.6
Exports	€m	557.9	696.6	644.8	683.1	639.6
Exports	€m (2000)	622.3	699.3	668.0	572.3	491.1
Imports	€m	503.1	662.4	734.9	1230.0	1553.5
Imports	€m (2000)	640.5	654.6	710.9	837.7	978.5
Price output	2000=1	0.865	0.899	1.052	1.180	1.403

TABLE E90 REFERENCE CASE: NON-METALLIC MINERAL PRODUCTS IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	41339.4	43644.7	39105.3	44379.3	46507.8
Output	€m (2000)	40388.2	41666.4	37688.6	41767.1	43514.5
Value Added	€m (2000)	15771.3	16320.0	15467.2	18246.9	19120.8
Wage Bill	€m	9402.1	10043.7	9335.2	10227.0	10906.9
Energy Input	€m	3081.0	3352.2	4434.6	5304.1	5008.6
Employment	th	352.3	324.0	279.4	278.6	276.0
Exports	€m	5655.8	8190.0	10172.8	15555.8	20212.5
Exports	€m (2000)	6297.5	8158.6	10167.0	12929.4	15363.2
Imports	€m	5716.2	7453.3	8262.1	14024.1	18749.3
Imports	€m (2000)	5834.4	7452.5	9090.9	10937.8	13062.3
Price output	2000=1	1.024	1.048	1.038	1.063	1.069

TABLE E91 REFERENCE CASE: NON-METALLIC MINERAL PRODUCTS IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	4664.9	6136.6	7063.1	8688.6	10912.0
Output	€m (2000)	5487.9	6508.3	6349.3	6965.7	7305.3
Value Added	€m (2000)	2153.2	2508.0	2541.7	2602.2	3240.8
Wage Bill	€m	1019.8	1250.4	1398.2	1635.1	1902.6
Energy Input	€m	132.4	186.3	258.6	290.3	266.1
Employment	th	37.8	37.4	35.7	35.4	34.8
Exports	€m	1277.8	1453.2	1449.1	1919.3	2172.7
Exports	€m (2000)	1298.4	1448.7	1549.6	1677.5	1745.2
Imports	€m	1617.4	1887.6	2226.4	3430.8	4334.3
Imports	€m (2000)	1602.4	1882.5	2226.8	2408.7	2801.0
Price output	2000=1	0.850	0.943	1.112	1.247	1.494

TABLE E92 REFERENCE CASE: NON-METALLIC MINERAL PRODUCTS IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	1555.3	2707.5	2754.1	3659.6	4188.5
Output	€m (2000)	1832.6	2314.8	2511.1	2727.0	2890.8
Value Added	€m (2000)	745.0	925.0	1167.2	1485.3	1586.3
Wage Bill	€m	320.0	475.4	527.8	738.2	853.3
Energy Input	€m	37.7	48.4	69.8	70.2	64.5
Employment	th	14.1	18.6	16.0	13.9	11.7
Exports	€m	385.4	554.5	810.0	1488.5	2143.3
Exports	€m (2000)	322.5	535.2	837.2	1219.3	1598.2
Imports	€m	284.9	433.4	539.5	880.2	961.7
Imports	€m (2000)	376.2	432.9	491.5	556.1	554.2
Price output	2000=1	0.849	1.170	1.097	1.342	1.449

TABLE E93 REFERENCE CASE: NON-METALLIC MINERAL PRODUCTS IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	2389.4	3007.0	3299.3	3959.3	4889.6
Output	€m (2000)	2601.2	2953.3	3113.5	3375.9	3741.9
Value Added	€m (2000)	994.4	1120.2	1297.3	1420.2	1734.3
Wage Bill	€m	548.7	610.9	609.4	636.6	698.5
Energy Input	€m	91.4	155.9	211.4	264.0	253.0
Employment	th	19.4	18.2	17.3	15.3	14.3
Exports	€m	581.0	748.2	945.0	1200.2	1383.0
Exports	€m (2000)	543.5	744.3	999.2	1065.7	1119.6
Imports	€m	726.5	978.5	1311.9	2016.1	2379.9
Imports	€m (2000)	689.8	974.4	1260.2	1354.2	1479.8
Price output	2000=1	0.919	1.018	1.060	1.173	1.307

TABLE E94 REFERENCE CASE: NON-METALLIC MINERAL PRODUCTS IN THE UK

		1996	2000	2004	2008	2012
Output	€m	18857.5	20826.2	21738.9	26560.1	28632.8
Output	€m (2000)	18571.8	20409.3	20434.1	20927.7	21728.1
Value Added	€m (2000)	7971.7	8226.7	7900.8	5645.9	7604.7
Wage Bill	€m	3832.8	5600.2	5885.7	7325.2	6843.8
Energy Input	€m	973.5	781.5	748.6	1241.4	1211.0
Employment	th	159.7	156.6	138.0	137.4	116.7
Exports	€m	3477.2	3193.3	3056.3	3812.5	3642.7
Exports	€m (2000)	3067.3	3180.6	2799.2	2826.0	2483.6
Imports	€m	3027.9	3577.1	4672.9	7439.5	9564.2
Imports	€m (2000)	2870.5	3570.9	4154.8	4694.7	5465.2
Price output	2000=1	1.015	1.020	1.064	1.269	1.318

TABLE E95 REFERENCE CASE: NON-METALLIC MINERAL PRODUCTS IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	388.7	456.1	551.5	595.4	578.6
Output	€m (2000)	480.3	451.4	493.3	438.6	383.9
Value Added	€m (2000)	187.1	218.3	182.7	101.5	105.8
Wage Bill	€m	103.5	108.1	135.1	169.2	201.5
Energy Input	€m	42.6	75.1	68.6	87.1	100.1
Employment	th	12.2	10.6	10.7	9.2	7.2
Exports	€m	171.7	285.1	332.0	384.6	459.7
Exports	€m (2000)	184.1	284.5	250.5	265.3	290.9
Imports	€m	138.5	240.9	392.8	706.8	940.3
Imports	€m (2000)	168.7	239.1	321.8	392.3	450.7
Price output	2000=1	0.809	1.010	1.118	1.358	1.507

TABLE E96 REFERENCE CASE: BASIC METALS IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	1190.4	1635.5	2026.0	2921.1	3505.9
Output	€m (2000)	1375.5	1641.2	1863.1	1906.7	1974.7
Value Added	€m (2000)	440.7	467.1	562.5	923.6	1138.8
Wage Bill	€m	319.9	373.8	540.4	698.5	861.1
Energy Input	€m	51.6	94.9	128.7	181.0	168.9
Employment	th	8.6	8.8	10.5	8.9	8.1
Exports	€m	661.4	999.2	1119.3	1458.1	1575.9
Exports	€m (2000)	807.1	1007.5	1270.0	1292.8	1313.8
Imports	€m	1460.8	1991.8	1917.7	2921.1	3299.4
Imports	€m (2000)	1621.6	2011.1	2056.7	2115.7	2192.5
Price output	2000=1	0.865	0.997	1.087	1.532	1.775

TABLE E97 REFERENCE CASE: BASIC METALS IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	45351.9	63307.7	62049.7	81163.1	86117.5
Output	€m (2000)	58590.3	63478.7	71896.2	77363.5	79197.3
Value Added	€m (2000)	15435.9	16330.0	15744.8	38010.6	45261.1
Wage Bill	€m	9566.3	10402.9	11548.7	12286.6	15161.1
Energy Input	€m	4511.2	5258.3	6107.5	7028.0	6507.0
Employment	th	292.2	266.6	254.1	270.3	263.7
Exports	€m	18116.2	27631.3	31585.5	47214.9	54719.1
Exports	€m (2000)	19697.1	27946.0	37955.8	46259.4	50492.5
Imports	€m	16270.5	26600.4	27340.6	50346.6	62187.2
Imports	€m (2000)	20929.6	26787.0	30289.6	37909.5	42643.2
Price output	2000=1	0.774	0.997	0.863	1.049	1.087

TABLE E98 REFERENCE CASE: BASIC METALS IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	5299.8	7806.3	8850.1	13574.6	20769.3
Output	€m (2000)	6215.1	9537.5	9003.1	12965.2	18298.9
Value Added	€m (2000)	1804.5	2031.0	2910.3	4917.1	6587.4
Wage Bill	€m	979.5	1213.0	1633.8	2013.5	3095.4
Energy Input	€m	206.7	406.5	605.7	869.4	1021.8
Employment	th	26.8	28.5	29.9	27.5	31.3
Exports	€m	4544.1	6641.6	7617.0	14192.7	21588.6
Exports	€m (2000)	5240.2	6669.0	8265.8	12154.5	17424.1
Imports	€m	4674.1	5802.2	7158.3	12041.5	14569.4
Imports	€m (2000)	5631.1	5985.1	8187.1	9339.8	10444.4
Price output	2000=1	0.853	0.819	0.983	1.047	1.135

TABLE E99 REFERENCE CASE: BASIC METALS IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	4576.4	7298.0	6504.1	6900.3	6468.2
Output	€m (2000)	5534.1	7326.8	7321.3	6768.9	6588.0
Value Added	€m (2000)	1077.0	1308.0	659.9	8294.9	1451.0
Wage Bill	€m	477.2	578.5	624.2	798.6	886.4
Energy Input	€m	251.0	516.6	937.7	1327.6	1051.5
Employment	th	17.1	16.9	15.7	15.1	14.5
Exports	€m	2362.4	3849.3	4220.9	6424.0	7058.5
Exports	€m (2000)	2579.6	3892.0	4673.3	5572.5	5751.6
Imports	€m	1384.6	2001.8	2036.5	4508.3	5155.6
Imports	€m (2000)	1273.3	2024.6	2171.2	3230.9	3336.1
Price output	2000=1	0.827	0.996	0.888	1.019	0.982

TABLE E100 REFERENCE CASE: BASIC METALS IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	7468.6	10023.9	9524.3	11605.8	12572.2
Output	€m (2000)	8297.2	10054.0	9802.9	9614.4	9700.4
Value Added	€m (2000)	2029.1	2313.4	2189.0	2625.5	2762.3
Wage Bill	€m	995.1	1162.4	1197.2	1424.9	1646.7
Energy Input	€m	352.2	540.8	750.3	898.2	678.3
Employment	th	32.3	30.7	30.1	31.0	32.1
Exports	€m	4346.2	5507.7	7327.9	10386.9	11400.3
Exports	€m (2000)	3970.3	5556.0	6965.0	7993.3	8369.2
Imports	€m	2962.0	4212.4	5084.6	9423.2	11286.4
Imports	€m (2000)	3168.9	4252.1	4880.8	6133.4	6727.4
Price output	2000=1	0.900	0.997	0.972	1.207	1.296

TABLE E101 REFERENCE CASE: BASIC METALS IN THE UK

		1996	2000	2004	2008	2012
Output	€m	32247.0	27607.3	25313.1	29175.4	34843.3
Output	€m (2000)	27342.1	27655.7	27672.4	24183.2	27953.8
Value Added	€m (2000)	6220.3	6500.6	6673.4	7538.7	8965.8
Wage Bill	€m	4022.1	5096.4	3605.5	6098.0	9546.1
Energy Input	€m	1536.8	868.3	863.1	1022.1	1062.6
Employment	th	149.8	123.2	103.7	136.7	236.8
Exports	€m	12941.7	9452.0	8990.1	16331.0	18448.2
Exports	€m (2000)	10791.0	9558.8	9344.3	12582.3	13208.9
Imports	€m	13671.7	11680.3	10824.4	22850.2	25068.8
Imports	€m (2000)	10249.1	11926.2	10895.2	14866.5	14704.6
Price output	2000=1	1.179	0.998	0.915	1.206	1.246

TABLE E102 REFERENCE CASE: BASIC METALS IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	427.0	960.5	8.7	13.9	16.8
Output	€m (2000)	567.6	965.0	8.9	9.3	9.4
Value Added	€m (2000)	133.0	205.0	1.1	2.0	2.1
Wage Bill	€m	88.4	103.8	10.5	11.9	16.9
Energy Input	€m	37.8	85.1	1.7	2.3	2.5
Employment	th	10.4	8.7	0.7	0.5	0.5
Exports	€m	328.8	711.2	670.4	807.4	885.1
Exports	€m (2000)	427.3	716.7	690.4	678.6	719.3
Imports	€m	398.8	696.6	2621.7	11381.6	18824.1
Imports	€m (2000)	549.9	696.6	2416.3	7763.7	10969.7
Price output	2000=1	0.752	0.995	0.979	1.496	1.792

TABLE E103 REFERENCE CASE: MACRO RESULTS FOR GERMANY

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	195603.8	217504.4	227441.6	266781.9	328078.0
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1948.8	2118.9	2183.9	2264.2	2379.2
GDP deflator 2000=1	1.0	1.1	1.0	1.1	1.2
SC cons. €bn (2000)	1127.7	1196.9	1212.7	1225.3	1273.8
PSC 2000=1	1.0	1.1	1.1	1.1	1.2
SK invest. €bn (2000)	434.4	491.2	414.7	460.8	475.2
PSK 2000=1	1.1	1.0	1.0	1.1	1.1
SX €bn (2000)	454.2	631.8	763.9	921.0	1020.5
PSX 2000=1	0.9	1.0	1.1	1.3	1.3
SM €bn (2000)	431.7	550.3	605.0	738.2	824.2
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	222793.9	257918.6	321489.9	268438.8	258607.7
CO2 mtC-eq	189174.1	220189.9	281330.2	227380.3	218895.4
FR003IS fuel use mtoe	9929.9	10767.9	8358.6	8600.2	8349.7
FR004NF fuel use mtoe	2637.9	2792.0	2853.7	3225.0	3352.4
FR005NM fuel use mtoe	29610.4	31284.3	24629.7	18831.3	13325.8
FR010PP fuel use mtoe	4347.1	4536.5	4486.9	4481.2	4306.9
FCO2(03) IS mtC-eq	13659.8	14320.5	11416.5	11037.7	10787.7
FCO2(04) NF mtC-eq	771.6	868.7	945.4	1138.5	1254.1
FCO2(05) NM mtC-eq	4809.8	3752.4	4077.5	3937.6	3393.0
FCO2(10) PP mtC-eq	1087.4	1195.3	1003.5	898.8	840.0

TABLE E104 REFERENCE CASE: MACRO RESULTS FOR FRANCE

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.3	0.3	0.3	0.3	0.3
Empl tax revs RERS	152268.3	157950.6	188022.4	229050.8	276824.5
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1257.1	1401.0	1462.8	1583.3	1758.8
GDP deflator 2000=1	1.0	1.1	1.2	1.3	1.3
SC cons. €bn (2000)	725.8	783.5	842.5	890.9	969.1
PSC 2000=1	0.9	1.1	1.2	1.3	1.4
SK invest. €bn (2000)	228.8	268.7	308.5	327.7	376.5
PSK 2000=1	1.0	1.1	1.2	1.2	1.2
SX €bn (2000)	270.4	385.9	374.8	451.8	508.1
PSX 2000=1	1.0	1.0	1.1	1.3	1.4
SM €bn (2000)	276.0	380.4	422.4	500.7	561.2
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	130973.3	150318.1	146668.9	173040.7	127801.8
CO2 mtC-eq	92837.6	112015.9	108869.1	131451.9	93219.3
FR003IS fuel use mtoe	5961.4	5298.9	5240.6	5147.7	4576.4
FR004NF fuel use mtoe	1580.2	1647.7	1403.6	1637.4	1684.9
FR005NM fuel use mtoe	17951.6	20692.2	18025.5	16558.7	16939.5
FR010PP fuel use mtoe	3427.4	3759.2	4052.8	3678.9	3681.5
FCO2(03) IS mtC-eq	7159.3	6136.3	6977.0	6594.1	6339.0
FCO2(04) NF mtC-eq	475.4	567.4	626.9	745.8	802.5
FCO2(05) NM mtC-eq	2282.7	2439.9	2455.7	2344.9	2444.7
FCO2(10) PP mtC-eq	1310.7	1399.5	1478.0	1283.8	1347.7

TABLE E105 REFERENCE CASE: MACRO RESULTS FOR ITALY

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	44095.9	58829.0	79189.3	111252.2	145988.3
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	522.9	610.1	676.2	728.2	811.6
GDP deflator 2000=1	0.9	1.0	1.2	1.4	1.4
SC cons. €bn (2000)	336.8	398.0	426.9	457.4	519.4
PSC 2000=1	0.9	1.0	1.2	1.4	1.5
SK invest. €bn (2000)	110.5	153.5	181.8	220.6	237.1
PSK 2000=1	0.9	1.0	1.2	1.2	1.2
SX €bn (2000)	112.7	165.2	180.9	208.7	245.3
PSX 2000=1	0.9	1.0	1.1	1.3	1.4
SM €bn (2000)	118.2	192.0	215.0	258.1	305.2
PSM 2000=1	0.9	1.0	1.1	1.2	1.3
GHG mtC-eq	74465.7	89241.1	95331.2	95410.9	94478.3
CO2 mtC-eq	65702.7	78720.0	84596.5	85721.5	85291.5
FR003IS fuel use mtoe	2795.1	3603.8	4910.7	5192.0	5044.0
FR004NF fuel use mtoe	1011.7	1155.3	1656.5	1742.2	1824.8
FR005NM fuel use mtoe	7447.9	9656.4	8748.2	8234.7	8745.6
FR010PP fuel use mtoe	1821.6	2565.2	3201.6	3264.4	3100.8
FCO2(03) IS mtC-eq	2789.2	3049.4	3455.1	3279.1	3089.9
FCO2(04) NF mtC-eq	303.7	369.5	500.7	527.6	555.5
FCO2(05) NM mtC-eq	1459.8	1166.3	1150.1	1093.1	1055.1
FCO2(10) PP mtC-eq	654.9	880.4	830.6	698.2	641.9

TABLE E106 REFERENCE CASE: MACRO RESULTS FOR SPAIN

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.4	0.3	0.3	0.3	0.3
Empl tax revs RERS	106110.0	109385.4	140761.3	199173.3	231810.3
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1070.9	1176.4	1253.5	1352.1	1417.0
GDP deflator 2000=1	0.9	1.0	1.2	1.5	1.4
SC cons. €bn (2000)	648.9	733.0	742.6	767.7	836.3
PSC 2000=1	0.9	1.0	1.2	1.5	1.4
SK invest. €bn (2000)	178.0	225.6	236.7	275.1	267.5
PSK 2000=1	1.0	1.0	1.3	1.5	1.3
SX €bn (2000)	244.6	321.5	341.7	386.1	410.0
PSX 2000=1	1.0	1.0	1.1	1.3	1.4
SM €bn (2000)	225.6	327.4	324.2	354.6	404.3
PSM 2000=1	0.9	1.0	1.1	1.2	1.2
GHG mtC-eq	122784.8	126660.0	130709.4	130981.3	131473.8
CO2 mtC-eq	111998.8	115212.8	118982.3	119460.3	119514.4
FR003IS fuel use mtoe	4837.5	5446.6	5700.5	5774.5	5280.5
FR004NF fuel use mtoe	867.2	939.2	891.3	1064.5	1081.8
FR005NM fuel use mtoe	11906.1	11537.4	11620.9	10302.9	8956.7
FR010PP fuel use mtoe	2469.9	2642.3	2733.7	2810.2	2687.1
FCO2(03) IS mtC-eq	5449.2	4733.1	4130.9	4396.6	3804.9
FCO2(04) NF mtC-eq	262.2	387.1	373.6	440.7	437.5
FCO2(05) NM mtC-eq	1673.4	1188.4	1360.7	1274.5	1170.5
FCO2(10) PP mtC-eq	857.1	823.9	830.5	834.7	804.4

TABLE E107 REFERENCE CASE: MACRO RESULTS FOR UK

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.1	0.1	0.1	0.1	0.1
Empl tax revs RERS	38568.4	65523.4	75962.0	116153.1	123426.9
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1424.7	1804.1	1860.5	1957.8	2179.9
GDP deflator 2000=1	1.0	0.9	1.1	1.4	1.4
SC cons. €bn (2000)	952.1	1145.1	1202.8	1222.5	1389.4
PSC 2000=1	0.9	0.9	1.0	1.3	1.3
SK invest. €bn (2000)	185.0	280.7	318.8	375.4	419.9
PSK 2000=1	1.1	0.9	1.0	1.2	1.2
SX €bn (2000)	310.7	446.0	454.6	507.3	534.4
PSX 2000=1	1.5	1.1	1.3	1.5	1.7
SM €bn (2000)	286.9	369.6	431.1	515.2	588.2
PSM 2000=1	1.2	1.0	1.1	1.2	1.3
GHG mtC-eq	183170.0	204600.0	203839.2	180272.5	174241.6
CO2 mtC-eq	168519.4	190113.3	187510.1	164227.3	157099.8
FR003IS fuel use mtoe	4667.4	4171.8	3589.8	3026.8	3351.4
FR004NF fuel use mtoe	1204.8	1121.6	1090.0	1137.1	1155.7
FR005NM fuel use mtoe	14078.7	15806.0	14480.2	12630.8	9706.5
FR010PP fuel use mtoe	2532.4	2630.2	2787.1	2581.7	2509.2
FCO2(03) IS mtC-eq	7127.7	6203.3	5603.0	4176.0	4602.2
FCO2(04) NF mtC-eq	481.6	501.9	502.8	545.0	554.0
FCO2(05) NM mtC-eq	2182.9	3163.6	3030.2	2923.3	3049.8
FCO2(10) PP mtC-eq	884.3	473.7	575.7	573.3	547.0

TABLE E108 REFERENCE CASE: MACRO RESULTS FOR REST OF EU15

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.1	0.1	0.1	0.1	0.1
Empl tax revs RERS	79365.7	99073.6	118450.6	147460.2	178982.8
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1527.1	1817.8	1965.3	2187.2	2384.3
GDP deflator 2000=1	0.9	1.0	1.2	1.3	1.3
SC cons. €bn (2000)	850.9	969.7	1056.5	1140.6	1259.4
PSC 2000=1	0.9	1.0	1.1	1.2	1.3
SK invest. €bn (2000)	291.4	387.5	424.1	484.9	529.7
PSK 2000=1	0.9	1.1	1.2	1.2	1.2
SX €bn (2000)	652.0	906.3	1002.6	1168.5	1299.4
PSX 2000=1	0.9	1.1	1.2	1.4	1.4
SM €bn (2000)	618.0	828.8	922.9	1050.1	1182.4
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	212949.5	220955.9	234304.8	216263.3	215594.6
CO2 mtC-eq	187858.4	200718.0	214245.6	199755.6	198872.9
FR003IS fuel use mtoe	7988.9	9041.4	9508.6	9167.6	8753.9
FR004NF fuel use mtoe	2894.8	3434.1	3090.6	3565.1	4192.3
FR005NM fuel use mtoe	25329.6	29798.6	28973.5	29802.0	29068.2
FR010PP fuel use mtoe	15159.7	18606.8	18406.6	19120.2	20478.7
FCO2(03) IS mtC-eq	11414.3	11329.5	12311.3	10243.0	9684.7
FCO2(04) NF mtC-eq	1042.9	1319.6	1445.3	1642.2	1785.4
FCO2(05) NM mtC-eq	3802.4	4354.1	4457.7	4427.2	4303.9
FCO2(10) PP mtC-eq	2333.3	2414.5	2468.7	2265.4	2117.3

TABLE E109 REFERENCE CASE: MACRO RESULTS FOR POLAND

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	7538.1	10968.7	15516.2	29746.4	47589.2
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	157.3	169.9	182.8	209.4	242.2
GDP deflator 2000=1	0.6	1.0	1.3	1.7	1.9
SC cons. €bn (2000)	113.9	115.8	132.1	152.2	182.5
PSC 2000=1	0.6	1.0	1.3	1.9	2.2
SK invest. €bn (2000)	23.1	23.2	24.7	31.3	36.8
PSK 2000=1	0.7	1.0	1.1	1.3	1.2
SX €bn (2000)	32.9	50.1	65.5	84.4	91.0
PSX 2000=1	0.6	1.1	1.2	1.3	1.4
SM €bn (2000)	37.1	47.4	66.9	88.2	101.1
PSM 2000=1	0.8	1.1	1.2	1.4	1.5
GHG mtC-eq	120294.8	106936.8	103317.5	105076.7	110663.8
CO2 mtC-eq	89730.6	81330.4	76339.5	76903.8	80420.2
FR003IS fuel use mtoe	4932.4	4508.4	3222.8	2854.8	2683.5
FR004NF fuel use mtoe	824.0	779.2	693.4	619.3	614.3
FR005NM fuel use mtoe	7272.5	6913.0	6640.6	7282.3	8152.2
FR010PP fuel use mtoe	1156.6	1008.8	1133.0	1056.9	997.1
FCO2(03) IS mtC-eq	5918.5	5083.4	4143.7	3550.4	3264.5
FCO2(04) NF mtC-eq	566.9	495.4	459.5	405.9	352.8
FCO2(05) NM mtC-eq	2385.0	2384.3	2156.6	1977.1	1933.8
FCO2(10) PP mtC-eq	727.6	631.8	596.6	493.1	396.1

TABLE E110 REFERENCE CASE: MACRO RESULTS FOR REST OF EU10

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	29096.5	38023.0	51331.4	82268.2	123774.6
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	393.8	453.6	492.7	573.7	647.4
GDP deflator 2000=1	0.8	1.0	1.2	1.5	1.6
SC cons. €bn (2000)	207.5	237.2	267.4	293.9	334.3
PSC 2000=1	0.8	1.0	1.1	1.5	1.7
SK invest. €bn (2000)	82.3	98.9	115.2	143.9	166.3
PSK 2000=1	0.9	1.1	1.3	1.5	1.5
SX €bn (2000)	138.6	208.2	276.1	339.0	381.9
PSX 2000=1	0.9	1.0	1.2	1.3	1.4
SM €bn (2000)	139.8	215.6	289.1	355.6	403.7
PSM 2000=1	0.9	1.0	1.2	1.3	1.3
GHG mtC-eq	109908.1	101707.4	100972.2	101095.3	103781.9
CO2 mtC-eq	90066.9	82805.9	82057.2	81933.7	84503.4
FR003IS fuel use mtoe	6278.9	5335.6	5244.3	4772.5	4354.3
FR004NF fuel use mtoe	1216.8	1011.1	1136.0	1176.5	1208.2
FR005NM fuel use mtoe	9624.2	9100.4	8805.1	9254.5	9167.2
FR010PP fuel use mtoe	7001.0	7701.0	7425.7	8958.2	10512.6
FCO2(03) IS mtC-eq	7751.6	6876.3	6486.1	5503.9	4955.5
FCO2(04) NF mtC-eq	601.8	544.7	814.8	685.8	733.6
FCO2(05) NM mtC-eq	1001.5	1626.8	1849.9	1897.6	1757.4
FCO2(10) PP mtC-eq	1296.9	1128.6	1294.1	1410.8	1241.2

TABLE E111 REFERENCE CASE: MACRO RESULTS FOR EU15

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	616012.0	708266.3	829827.3	0.6	1285110.8
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	7751.5	8928.1	9402.1	10072.8	10930.8
GDP deflator 2000=1	0.9	1.0	1.1	1.3	1.3
SC cons. €bn (2000)	4642.3	5226.2	5483.9	5704.4	6247.4
PSC 2000=1	0.9	1.0	1.1	1.3	1.3
SK invest. €bn (2000)	1428.1	1807.2	1884.6	2144.5	2305.8
PSK 2000=1	1.0	1.0	1.1	1.2	1.2
SX €bn (2000)	2044.7	2856.6	3118.6	3643.4	4017.6
PSX 2000=1	1.0	1.0	1.2	1.3	1.4
SM €bn (2000)	1956.4	2648.5	2920.6	3416.9	3865.6
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	947137.2	1049693.8	0.5	0.6	1002197.8
CO2 mtC-eq	816091.2	916970.0	995533.6	927996.9	872893.4
FR003IS fuel use mtoe	36180.2	38330.5	37308.8	36908.7	35355.9
FR004NF fuel use mtoe	10196.6	11090.0	10985.7	12371.3	13291.9
FR005NM fuel use mtoe	106324.3	118774.9	106477.9	96360.4	86742.3
FR010PP fuel use mtoe	29758.1	34740.2	35668.8	35936.7	36764.2
FCO2(03) IS mtC-eq	47599.4	45772.1	43893.8	39726.6	38308.4
FCO2(04) NF mtC-eq	3337.3	4014.2	4394.6	5039.8	5389.0
FCO2(05) NM mtC-eq	16211.0	16064.8	16531.9	16000.6	15417.0
FCO2(10) PP mtC-eq	7127.7	7187.3	7187.0	6554.3	6298.3

TABLE E112 REFERENCE CASE: MACRO RESULTS FOR EU10

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	20753.1	28998.5	44355.5	84464.2	137762.5
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	324.3	358.8	400.0	473.1	537.2
GDP deflator 2000=1	0.6	1.0	1.2	1.7	2.0
SC cons. €bn (2000)	206.5	224.8	264.9	303.9	356.0
PSC 2000=1	0.7	1.0	1.2	1.8	2.2
SK invest. €bn (2000)	65.7	70.5	84.6	107.6	127.1
PSK 2000=1	0.7	1.0	1.2	1.5	1.4
SX €bn (2000)	103.4	162.1	230.9	295.1	332.2
PSX 2000=1	0.7	1.1	1.1	1.3	1.3
SM €bn (2000)	112.4	173.8	258.7	332.4	386.3
PSM 2000=1	0.8	1.0	1.2	1.3	1.4
GHG mtC-eq	213217.0	192572.0	187445.0	190943.4	197281.1
CO2 mtC-eq	164943.8	150034.3	143862.6	146141.4	150351.7
FR003IS fuel use mtoe	9963.7	8630.4	7156.2	6424.1	5972.5
FR004NF fuel use mtoe	1736.8	1484.8	1520.0	1495.5	1541.4
FR005NM fuel use mtoe	15020.5	14522.1	13062.6	13984.8	15186.9
FR010PP fuel use mtoe	2537.5	2259.4	2529.7	2464.8	2537.2
FCO2(03) IS mtC-eq	12148.7	10558.7	9201.6	7937.4	7114.3
FCO2(04) NF mtC-eq	1102.0	928.9	1137.7	940.2	931.6
FCO2(05) NM mtC-eq	3272.6	3847.3	3808.4	3666.0	3473.0
FCO2(10) PP mtC-eq	1507.0	1241.2	1377.0	1309.2	1199.7

TABLE E113 REFERENCE CASE: MACRO RESULTS FOR EU25

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	636765.1	737264.8	874182.9	0.5	1422873.1
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	8075.8	9286.9	9802.1	10545.8	11467.9
GDP deflator 2000=1	0.9	1.0	1.1	1.3	1.4
SC cons. €bn (2000)	4848.7	5451.0	5748.8	6008.4	6603.4
PSC 2000=1	0.9	1.0	1.1	1.3	1.4
SK invest. €bn (2000)	1493.8	1877.7	1969.1	2252.2	2432.9
PSK 2000=1	1.0	1.0	1.1	1.2	1.2
SX €bn (2000)	2148.1	3018.7	3349.5	3938.6	4349.8
PSX 2000=1	1.0	1.0	1.2	1.3	1.4
SM €bn (2000)	2068.8	2822.3	3179.3	3749.4	4251.9
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	0.1	1242265.8	0.4	0.0	1199478.8
CO2 mtC-eq	981035.0	1067004.4	0.3	0.3	1023245.1
FR003IS fuel use mtoe	46143.9	46961.0	44465.0	43332.8	41328.4
FR004NF fuel use mtoe	11933.4	12574.8	12505.7	13866.8	14833.3
FR005NM fuel use mtoe	121344.8	133297.0	119540.5	110345.2	101929.2
FR010PP fuel use mtoe	32295.6	36999.6	38198.5	38401.5	39301.4
FCO2(03) IS mtC-eq	59748.1	56330.9	53095.5	47664.0	45422.7
FCO2(04) NF mtC-eq	4439.3	4943.1	5532.3	5979.9	6320.5
FCO2(05) NM mtC-eq	19483.6	19912.1	20340.3	19666.6	18890.0
FCO2(10) PP mtC-eq	8634.6	8428.5	8564.0	7863.4	7498.0

TABLE E114 REFERENCE CASE: MACRO RESULTS FOR EUROZONE 11

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	576096.0	642586.1	762731.3	994052.1	1244403.0
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	6165.6	6928.5	7341.8	7918.1	8535.6
GDP deflator 2000=1	0.9	1.0	1.1	1.3	1.3
SC cons. €bn (2000)	3621.8	4006.4	4221.1	4431.9	4814.5
PSC 2000=1	0.9	1.0	1.1	1.3	1.4
SK invest. €bn (2000)	1228.7	1488.1	1523.9	1726.5	1842.2
PSK 2000=1	1.0	1.0	1.2	1.2	1.2
SX €bn (2000)	1710.7	2398.5	2700.6	3206.7	3567.3
PSX 2000=1	0.9	1.0	1.1	1.3	1.4
SM €bn (2000)	1653.9	2280.6	2560.2	3017.9	3426.2
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	920675.1	980629.6	0.3	0.3	964499.2
CO2 mtC-eq	759805.0	823604.7	891667.9	851008.3	809726.8
FR003IS fuel use mtoe	40020.3	41298.9	39216.3	38701.9	36486.2
FR004NF fuel use mtoe	9732.1	10328.8	10253.6	11466.1	12379.0
FR005NM fuel use mtoe	104751.9	115280.5	101920.4	94175.8	88893.7
FR010PP fuel use mtoe	23860.4	27662.4	29078.3	27923.9	27464.0
FCO2(03) IS mtC-eq	51002.4	48625.1	45947.2	42244.9	39587.0
FCO2(04) NF mtC-eq	3459.4	3868.1	4434.3	4793.2	5076.4
FCO2(05) NM mtC-eq	17001.3	16365.1	16877.2	16302.9	15371.6
FCO2(10) PP mtC-eq	7112.0	7328.1	7343.0	6571.1	6397.0

TABLE E115 REFERENCE CASE: MACRO RESULTS FOR DENMARK

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.0	0.0	0.0	0.0	0.0
Empl tax revs RERS	1024.7	1766.0	1850.4	2013.2	2574.5
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	151.9	166.7	177.0	196.3	216.4
GDP deflator 2000=1	0.9	1.0	1.1	1.3	1.4
SC cons. €bn (2000)	79.4	79.4	85.1	94.7	107.4
PSC 2000=1	0.9	1.1	1.2	1.4	1.5
SK invest. €bn (2000)	22.7	28.5	31.8	36.4	42.3
PSK 2000=1	1.1	1.3	1.3	1.5	1.5
SX €bn (2000)	46.4	59.0	63.4	73.0	82.8
PSX 2000=1	0.9	1.0	1.0	1.2	1.3
SM €bn (2000)	40.2	47.5	51.8	61.1	72.2
PSM 2000=1	1.0	1.2	1.3	1.4	1.4
GHG mtC-eq	17613.5	16572.0	15345.2	13252.3	14312.2
CO2 mtC-eq	15947.2	14792.5	13687.2	11836.2	12585.5
FR003IS fuel use mtoe	109.0	87.7	79.4	89.7	88.5
FR004NF fuel use mtoe	15.6	16.6	18.8	20.2	22.6
FR005NM fuel use mtoe	255.1	281.7	266.3	225.5	248.0
FR010PP fuel use mtoe	145.1	87.5	114.4	127.0	118.6
FCO2(03) IS mtC-eq	36.0	21.2	28.6	30.0	24.8
FCO2(04) NF mtC-eq	11.3	4.3	4.8	5.7	5.9
FCO2(05) NM mtC-eq	92.2	94.4	81.0	53.4	52.8
FCO2(10) PP mtC-eq	57.7	22.3	47.9	39.7	30.2

TABLE E116 REFERENCE CASE: MACRO RESULTS FOR IRELAND

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.1	0.1	0.1	0.1	0.1
Empl tax revs RERS	1553.9	2657.8	3725.9	4512.8	5457.3
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	70.6	104.9	135.4	164.4	188.2
GDP deflator 2000=1	0.8	1.0	1.1	1.1	1.2
SC cons. €bn (2000)	39.0	52.7	61.9	72.4	82.2
PSC 2000=1	0.9	1.0	1.1	1.1	1.2
SK invest. €bn (2000)	13.7	25.6	30.7	36.2	41.2
PSK 2000=1	0.8	1.0	1.1	1.1	1.1
SX €bn (2000)	50.1	85.0	103.2	129.0	156.3
PSX 2000=1	0.8	1.0	1.0	1.1	1.2
SM €bn (2000)	28.4	56.3	61.8	76.2	91.6
PSM 2000=1	1.1	1.0	0.9	1.0	1.1
GHG mtC-eq	12596.4	12101.0	12867.5	13401.7	13682.9
CO2 mtC-eq	9340.0	11148.6	11890.7	12399.8	12669.1
FR003IS fuel use mtoe	46.8	55.4	5.0	3.8	3.9
FR004NF fuel use mtoe	669.7	683.8	209.1	245.9	250.3
FR005NM fuel use mtoe	689.7	762.2	333.2	353.7	361.3
FR010PP fuel use mtoe	171.3	186.3	20.6	18.9	18.6
FCO2(03) IS mtC-eq	19.5	16.2	18.6	19.8	20.6
FCO2(04) NF mtC-eq	222.7	218.3	316.8	407.8	465.7
FCO2(05) NM mtC-eq	139.2	199.5	223.9	230.3	222.7
FCO2(10) PP mtC-eq	9.4	8.6	15.1	10.7	7.5

TABLE E117 REFERENCE CASE: MACRO RESULTS FOR THE NETHERLANDS

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.0	0.0	0.0	0.0	0.0
Empl tax revs RERS	4523.6	5893.3	6248.4	7508.5	9063.7
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	347.9	418.7	444.6	476.7	492.5
GDP deflator 2000=1	0.9	1.0	1.2	1.3	1.3
SC cons. €bn (2000)	171.9	203.1	217.0	218.4	235.5
PSC 2000=1	0.9	1.0	1.1	1.2	1.3
SK invest. €bn (2000)	69.5	91.4	100.7	108.0	116.9
PSK 2000=1	0.9	1.0	1.1	1.2	1.2
SX €bn (2000)	173.8	231.0	245.3	282.6	307.7
PSX 2000=1	0.9	1.0	1.1	1.3	1.3
SM €bn (2000)	156.1	205.0	227.7	253.2	287.7
PSM 2000=1	0.9	1.0	1.0	1.1	1.2
GHG mtC-eq	54575.1	57752.8	52343.3	48721.6	48808.4
CO2 mtC-eq	45108.6	49323.3	45935.4	43133.2	43431.1
FR003IS fuel use mtoe	948.9	1173.0	1299.1	1412.8	1490.1
FR004NF fuel use mtoe	542.6	899.9	929.7	1207.8	1770.1
FR005NM fuel use mtoe	12083.0	13047.0	13673.9	13819.5	13428.7
FR010PP fuel use mtoe	719.8	955.1	1309.1	863.5	994.2
FCO2(03) IS mtC-eq	2056.1	2222.5	2101.9	2191.0	2324.4
FCO2(04) NF mtC-eq	74.4	122.3	92.1	109.8	127.2
FCO2(05) NM mtC-eq	1721.5	1985.6	1919.6	1870.1	1716.4
FCO2(10) PP mtC-eq	108.0	174.8	198.1	91.1	132.2

TABLE E118 REFERENCE CASE: MACRO RESULTS FOR FINLAND

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	9862.3	10734.9	12863.9	16293.5	18817.8
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	106.5	131.9	143.4	157.4	176.7
GDP deflator 2000=1	1.0	1.0	1.1	1.1	1.2
SC cons. €bn (2000)	57.0	65.7	74.9	80.6	89.9
PSC 2000=1	0.9	1.0	1.1	1.3	1.3
SK invest. €bn (2000)	18.0	25.6	26.3	29.0	31.0
PSK 2000=1	1.0	1.2	1.2	1.3	1.4
SX €bn (2000)	36.2	57.5	62.6	72.5	81.9
PSX 2000=1	1.0	1.0	1.0	1.2	1.2
SM €bn (2000)	28.0	39.1	46.3	48.7	56.7
PSM 2000=1	0.9	1.0	1.1	1.6	1.6
GHG mtC-eq	17609.6	18624.5	23424.0	16296.5	14627.7
CO2 mtC-eq	15417.9	16840.7	20520.4	15216.0	13625.4
FR003IS fuel use mtoe	919.2	1025.1	1153.6	1136.4	1194.7
FR004NF fuel use mtoe	184.5	197.5	265.8	259.5	226.8
FR005NM fuel use mtoe	1721.2	1687.3	1259.5	1175.5	1159.9
FR010PP fuel use mtoe	5853.2	7917.1	7630.2	6896.3	6649.7
FCO2(03) IS mtC-eq	1433.7	1629.0	1545.7	1257.8	1361.4
FCO2(04) NF mtC-eq	31.1	31.8	32.0	33.3	29.3
FCO2(05) NM mtC-eq	197.2	294.7	312.5	222.9	182.7
FCO2(10) PP mtC-eq	1042.7	1033.0	993.2	834.4	848.9

TABLE E119 REFERENCE CASE: MACRO RESULTS FOR SWEDEN

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	15881.5	19993.3	22492.0	27550.4	33601.2
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	226.8	264.8	275.5	310.1	352.4
GDP deflator 2000=1	0.9	1.0	1.2	1.2	1.2
SC cons. €bn (2000)	114.8	128.2	134.6	142.2	160.9
PSC 2000=1	0.9	1.0	1.0	1.1	1.2
SK invest. €bn (2000)	39.7	51.6	55.3	67.6	76.0
PSK 2000=1	0.9	1.2	1.3	1.4	1.4
SX €bn (2000)	68.0	96.2	110.8	128.3	140.8
PSX 2000=1	1.0	1.0	1.4	1.5	1.5
SM €bn (2000)	64.4	89.2	97.3	111.3	118.4
PSM 2000=1	1.0	1.1	1.2	1.4	1.4
GHG mtC-eq	16985.9	16072.3	16844.7	15228.6	17164.7
CO2 mtC-eq	14853.7	14102.0	14534.1	12696.1	14571.9
FR003IS fuel use mtoe	1247.5	1213.5	1311.0	1203.2	1065.3
FR004NF fuel use mtoe	304.0	305.5	309.4	300.3	281.1
FR005NM fuel use mtoe	1876.2	1491.4	2383.0	2552.0	2132.6
FR010PP fuel use mtoe	5620.1	6450.4	6029.1	7550.3	8972.5
FCO2(03) IS mtC-eq	1521.4	1400.9	1428.2	1116.9	1105.7
FCO2(04) NF mtC-eq	66.8	111.2	136.6	151.5	154.9
FCO2(05) NM mtC-eq	113.9	163.8	198.1	208.7	218.1
FCO2(10) PP mtC-eq	517.5	519.2	513.7	594.7	437.6

TABLE E120 REFERENCE CASE: MACRO RESULTS FOR SLOVENIA

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.3	0.3	0.3
Empl tax revs RERS	1700.0	2918.3	4529.5	6895.6	10391.6
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	16.4	17.0	21.6	21.1	22.7
GDP deflator 2000=1	0.7	1.0	1.5	1.9	2.2
SC cons. €bn (2000)	11.1	11.3	15.0	16.0	18.4
PSC 2000=1	0.8	1.3	1.4	2.1	2.5
SK invest. €bn (2000)	3.0	3.6	4.7	5.1	5.4
PSK 2000=1	0.8	1.0	1.2	1.7	1.7
SX €bn (2000)	8.6	11.6	15.0	18.7	21.6
PSX 2000=1	0.7	1.0	1.3	1.5	1.6
SM €bn (2000)	8.4	11.9	17.3	25.4	31.5
PSM 2000=1	0.8	1.4	1.2	1.4	1.5
GHG mtC-eq	4144.1	4521.4	4597.6	4416.7	4268.1
CO2 mtC-eq	3446.9	3780.4	3901.3	3745.0	3632.8
FR003IS fuel use mtoe	164.1	160.1	132.4	125.6	118.5
FR004NF fuel use mtoe	106.9	121.1	176.9	160.4	155.1
FR005NM fuel use mtoe	291.9	221.5	228.0	260.3	259.5
FR010PP fuel use mtoe	121.6	260.9	252.8	257.3	272.3
FCO2(03) IS mtC-eq	89.2	84.5	79.6	75.7	70.1
FCO2(04) NF mtC-eq	207.4	101.8	286.0	173.8	187.2
FCO2(05) NM mtC-eq	45.2	42.9	30.3	39.4	34.8
FCO2(10) PP mtC-eq	58.4	121.3	105.8	128.2	129.6

E1.3 No Exemptions Case

TABLE E121 NO EXEMPTIONS CASE: FOOD, DRINK AND TOBACCO IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	14073.5	15578.5	17738.2	23871.9	31229.1
Output	€m (2000)	14546.9	15481.1	16533.5	18985.1	22429.2
Value Added	€m (2000)	3740.9	3910.9	4212.9	5139.2	6341.0
Wage Bill	€m	2524.7	2920.8	3356.9	4013.4	4613.9
Energy Input	€m	178.8	351.8	544.6	783.3	748.8
Employment	th	82.7	79.1	74.9	72.8	72.7
Exports	€m	7065.7	8168.4	7644.2	10752.9	13198.9
Exports	€m (2000)	5597.3	8071.2	6868.5	8225.5	9668.2
Imports	€m	2941.1	2650.6	2714.2	4762.0	6344.0
Imports	€m (2000)	2597.5	2606.5	2677.0	3264.8	3952.0
Price output	2000=1	0.968	1.006	1.073	1.257	1.392

TABLE E122 NO EXEMPTIONS CASE: FOOD, DRINK AND TOBACCO IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	125238.2	143670.1	155715.1	188111.0	225097.4
Output	€m (2000)	127122.1	136055.5	128040.1	137578.9	155091.1
Value Added	€m (2000)	35436.7	38540.0	38599.0	44630.7	51796.7
Wage Bill	€m	17930.5	21331.6	21675.7	26834.5	34202.8
Energy Input	€m	2475.4	3159.4	4019.4	4452.8	4735.0
Employment	th	996.2	1065.9	993.9	944.0	924.8
Exports	€m	17358.9	21759.3	29893.1	48043.4	72405.6
Exports	€m (2000)	16208.7	21425.6	30136.5	41291.4	59688.8
Imports	€m	21078.9	28131.6	30455.5	54709.2	71618.4
Imports	€m (2000)	20399.9	27737.1	30581.5	37482.9	44485.2
Price output	2000=1	0.985	1.056	1.216	1.367	1.451

TABLE E123 NO EXEMPTIONS CASE: FOOD, DRINK AND TOBACCO IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	40738.7	48113.9	50483.6	57508.4	64516.7
Output	€m (2000)	44064.3	48113.9	46947.1	52414.1	56640.2
Value Added	€m (2000)	10574.0	10961.0	10466.2	10282.2	12406.1
Wage Bill	€m	4367.0	5497.7	6301.9	6341.4	7213.1
Energy Input	€m	412.1	564.6	828.0	933.9	932.7
Employment	th	158.9	174.5	154.9	141.0	139.8
Exports	€m	21437.9	25439.7	28117.0	37400.8	46306.8
Exports	€m (2000)	18774.1	25439.7	25376.4	29896.8	33677.7
Imports	€m	9535.5	11983.0	13482.6	20685.4	28169.1
Imports	€m (2000)	9334.3	11819.1	13353.7	14207.2	17499.3
Price output	2000=1	0.924	1.000	1.075	1.097	1.139

TABLE E124 NO EXEMPTIONS CASE: FOOD, DRINK AND TOBACCO IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	8105.6	6990.6	9250.9	12048.9	12690.2
Output	€m (2000)	7694.9	8037.7	8938.3	9560.0	9671.4
Value Added	€m (2000)	1717.0	1780.0	2049.9	2714.6	2902.0
Wage Bill	€m	1018.0	973.2	1147.6	1442.4	1609.8
Energy Input	€m	95.9	101.3	121.4	138.7	139.2
Employment	th	45.5	38.8	36.8	35.4	35.5
Exports	€m	815.2	765.3	1002.7	1655.0	2763.2
Exports	€m (2000)	485.2	803.7	1200.9	1578.2	2327.5
Imports	€m	1075.9	1634.5	1809.4	3083.5	5370.6
Imports	€m (2000)	872.5	1599.4	2078.5	2392.5	3860.2
Price output	2000=1	1.053	0.870	1.035	1.260	1.312

TABLE E125 NO EXEMPTIONS CASE: FOOD, DRINK AND TOBACCO IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	13475.6	15197.5	15278.8	16887.4	20374.5
Output	€m (2000)	14091.1	15233.8	14314.9	15671.9	19075.7
Value Added	€m (2000)	3999.1	4003.6	4364.5	4761.1	6002.6
Wage Bill	€m	1693.0	2039.8	2278.2	2652.4	3101.5
Energy Input	€m	124.1	149.2	154.2	158.6	130.6
Employment	th	63.9	63.2	60.4	59.1	58.9
Exports	€m	1368.1	2030.2	3131.8	3773.6	4462.1
Exports	€m (2000)	1194.0	2006.7	2743.4	2860.2	3213.2
Imports	€m	2343.8	2376.8	4876.6	8776.6	10663.8
Imports	€m (2000)	2286.7	2344.1	4024.5	4946.5	5492.2
Price output	2000=1	0.956	0.998	1.067	1.078	1.068

TABLE E126 NO EXEMPTIONS CASE: FOOD, DRINK AND TOBACCO IN THE UK

		1996	2000	2004	2008	2012
Output	€m	103644.1	109532.6	112533.2	118538.4	148595.0
Output	€m (2000)	94057.7	109417.1	109948.9	107831.8	127165.8
Value Added	€m (2000)	33342.0	33308.7	34769.1	34006.2	40558.1
Wage Bill	€m	14077.9	24608.1	20379.6	15810.5	22225.4
Energy Input	€m	1527.2	1227.4	1367.8	1902.3	1881.8
Employment	th	510.5	764.6	537.2	304.9	393.2
Exports	€m	14942.4	15719.8	17172.2	20883.3	21546.9
Exports	€m (2000)	14368.1	15530.3	14979.8	15694.2	15351.8
Imports	€m	21797.4	21981.4	24243.7	40479.9	49898.2
Imports	€m (2000)	15387.6	21690.6	23608.7	27028.1	30170.6
Price output	2000=1	1.102	1.001	1.024	1.099	1.169

TABLE E127 NO EXEMPTIONS CASE: FOOD, DRINK AND TOBACCO IN SLOVENIA

	1996	2000	2004	2008	2012
Output €m	1206.9	1588.7	3057.8	5804.9	8892.6
Output €m (2000)	1506.4	1582.3	2224.3	2652.3	3044.6
Value Added €m (2000)	496.5	510.1	758.0	1407.2	3336.9
Wage Bill €m	222.0	237.4	379.4	560.7	799.9
Energy Input €m	24.2	54.6	52.8	60.9	71.5
Employment th	21.6	22.3	24.8	23.8	23.4
Exports €m	206.3	324.5	581.4	858.6	1123.7
Exports €m (2000)	248.3	321.9	371.0	486.7	578.4
Imports €m	325.3	419.4	679.3	1096.8	1373.0
Imports €m (2000)	394.9	413.0	643.8	715.1	785.2
Price output 2000=1	0.801	1.004	1.375	2.189	2.921

TABLE E128 NO EXEMPTIONS CASE: WOOD AND PAPER IN DENMARK

	1996	2000	2004	2008	2012
Output €m	1864.0	1991.3	2922.1	3450.6	4716.9
Output €m (2000)	2288.7	2325.4	1850.6	1933.0	2689.5
Value Added €m (2000)	1088.2	1221.0	1112.4	1070.8	1247.2
Wage Bill €m	671.8	777.5	911.1	1003.6	1450.4
Energy Input €m	52.4	62.0	96.0	119.1	118.1
Employment th	20.9	18.9	19.8	16.7	19.3
Exports €m	389.8	88.2	57.4	82.4	686.3
Exports €m (2000)	356.0	107.4	86.6	121.4	626.4
Imports €m	1986.6	2394.1	2954.7	4076.8	4226.5
Imports €m (2000)	1879.4	1799.9	1750.4	2005.8	2373.1
Price output 2000=1	0.814	0.856	1.579	1.785	1.754

TABLE E129 NO EXEMPTIONS CASE: WOOD AND PAPER IN GERMANY

	1996	2000	2004	2008	2012
Output €m	43936.9	53473.5	59424.6	75637.2	78816.8
Output €m (2000)	51887.4	60352.0	49308.3	58699.3	61254.1
Value Added €m (2000)	16528.8	18170.0	19443.9	20826.9	16655.9
Wage Bill €m	8776.1	9568.1	11022.0	12919.1	13815.5
Energy Input €m	1650.9	2294.2	2886.1	3682.5	3746.9
Employment th	364.1	333.3	349.4	353.3	312.6
Exports €m	10269.5	16495.7	23869.8	33574.4	32849.7
Exports €m (2000)	11591.5	17256.4	24068.4	28734.2	28951.3
Imports €m	11491.5	15639.6	19667.6	23681.7	27059.8
Imports €m (2000)	14342.7	16101.1	22973.3	23792.3	25985.8
Price output 2000=1	0.847	0.886	1.205	1.289	1.287

TABLE E130 NO EXEMPTIONS CASE: WOOD AND PAPER IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	5557.3	7826.9	11453.3	11922.6	8784.7
Output	€m (2000)	6699.8	8562.3	9455.7	9293.3	6860.6
Value Added	€m (2000)	2248.5	2587.0	3515.3	3129.3	1862.2
Wage Bill	€m	1293.8	1580.4	2066.9	2206.8	2000.5
Energy Input	€m	116.4	176.2	393.9	321.5	237.3
Employment	th	44.0	49.1	58.0	53.8	40.2
Exports	€m	3351.3	4382.4	5607.5	6530.0	6725.3
Exports	€m (2000)	4151.0	4548.0	4552.4	4677.8	4744.1
Imports	€m	5449.6	6315.6	5734.9	7814.4	10959.1
Imports	€m (2000)	5777.5	6584.5	6379.9	7589.3	10199.8
Price output	2000=1	0.830	0.914	1.211	1.283	1.281

TABLE E131 NO EXEMPTIONS CASE: WOOD AND PAPER IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	14059.3	20770.5	22234.9	20408.8	20500.3
Output	€m (2000)	16495.9	22034.1	23192.8	23694.1	25042.3
Value Added	€m (2000)	5240.0	6745.0	8077.7	8154.0	8943.3
Wage Bill	€m	1741.3	2170.6	2597.0	2801.7	2860.4
Energy Input	€m	881.7	1231.8	1633.9	1754.4	1614.1
Employment	th	65.6	69.2	70.1	62.6	59.3
Exports	€m	8839.0	13133.2	13731.2	16625.8	20079.5
Exports	€m (2000)	7844.8	13133.2	11961.0	13142.9	14230.7
Imports	€m	513.2	810.9	981.8	1120.4	1199.9
Imports	€m (2000)	733.2	834.9	987.7	955.7	978.9
Price output	2000=1	0.852	0.943	0.959	0.861	0.819

TABLE E132 NO EXEMPTIONS CASE: WOOD AND PAPER IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	15465.6	19236.0	25372.1	31175.0	35314.0
Output	€m (2000)	17461.6	21069.6	21750.5	24874.8	29441.0
Value Added	€m (2000)	5767.3	7010.7	8053.1	8195.5	7878.8
Wage Bill	€m	2352.7	2647.1	3145.8	3796.0	3317.2
Energy Input	€m	630.2	780.4	1016.9	1310.8	1283.0
Employment	th	81.6	76.3	76.4	73.2	54.1
Exports	€m	9552.2	11925.3	17649.4	20986.5	19146.8
Exports	€m (2000)	8241.3	12549.4	13413.3	15131.2	15591.8
Imports	€m	1233.1	1945.6	2226.6	3092.6	3489.4
Imports	€m (2000)	1491.1	1997.9	2309.3	2770.4	3059.5
Price output	2000=1	0.886	0.913	1.167	1.253	1.200

TABLE E133 NO EXEMPTIONS CASE: WOOD AND PAPER IN THE UK

	1996	2000	2004	2008	2012
Output €m	30066.0	30844.1	43128.4	41695.4	40600.5
Output €m (2000)	30780.8	34902.5	35662.8	34967.6	35364.0
Value Added €m (2000)	10465.0	10310.4	14590.0	7560.8	8140.6
Wage Bill €m	4715.7	6770.8	7201.9	9189.9	8579.1
Energy Input €m	1110.4	1189.2	1408.5	2027.6	1647.0
Employment th	348.2	388.9	322.9	289.8	248.7
Exports €m	5172.8	5238.1	6833.1	8392.9	8902.5
Exports €m (2000)	4814.3	5037.0	4932.4	5295.4	5498.6
Imports €m	11488.1	10851.3	11319.7	15828.1	16265.2
Imports €m (2000)	11133.7	12517.2	12649.6	13183.7	15281.4
Price output 2000=1	0.977	0.884	1.209	1.192	1.148

TABLE E134 NO EXEMPTIONS CASE: WOOD AND PAPER IN SLOVENIA

	1996	2000	2004	2008	2012
Output €m	716.5	1026.4	1399.9	2135.8	2781.3
Output €m (2000)	956.0	1096.9	1138.1	1384.0	1544.7
Value Added €m (2000)	297.2	350.1	388.4	242.4	383.3
Wage Bill €m	153.5	165.0	303.8	309.3	321.9
Energy Input €m	47.7	81.1	71.6	88.2	101.4
Employment th	22.2	18.9	26.1	17.3	11.5
Exports €m	407.9	702.1	711.2	759.8	607.8
Exports €m (2000)	501.5	719.0	582.3	608.8	515.7
Imports €m	226.6	437.6	626.7	2041.7	1622.1
Imports €m (2000)	313.9	457.0	575.7	673.6	680.8
Price output 2000=1	0.749	0.936	1.230	1.543	1.801

TABLE E135 NO EXEMPTIONS CASE: PHARMACEUTICALS IN DENMARK

	1996	2000	2004	2008	2012
Output €m	1983.1	3140.4	3596.5	4260.9	5032.8
Output €m (2000)	1800.0	3140.3	3662.4	4334.6	5099.1
Value Added €m (2000)	758.4	1801.4	1918.2	2681.1	2907.6
Wage Bill €m	495.2	645.1	949.2	1274.9	1510.1
Energy Input €m	7.8	24.2	34.4	38.5	32.3
Employment th	11.0	12.0	13.0	13.6	13.5
Exports €m	1860.1	3276.7	4888.6	7189.7	8907.9
Exports €m (2000)	2443.5	3204.4	3793.7	4640.9	5618.9
Imports €m	820.0	1396.3	2515.7	3531.2	4178.8
Imports €m (2000)	794.6	1429.6	1820.6	2267.6	2737.0
Price output 2000=1	1.102	1.000	0.982	0.983	0.987

TABLE E136 NO EXEMPTIONS CASE: PHARMACEUTICALS IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	19259.8	23318.1	31377.5	38235.8	38706.8
Output	€m (2000)	21938.0	24016.4	26654.4	29107.4	28255.6
Value Added	€m (2000)	8212.5	8990.0	13950.4	15934.9	14163.0
Wage Bill	€m	4666.4	5793.9	6320.7	9373.8	11652.2
Energy Input	€m	1273.7	2101.0	2442.4	2108.1	1538.6
Employment	th	120.7	121.6	106.6	121.4	116.0
Exports	€m	9338.7	16235.8	25271.0	36186.0	41041.5
Exports	€m (2000)	11898.4	16584.0	21828.3	26226.8	28854.4
Imports	€m	6267.3	11776.6	26376.9	36585.0	46538.7
Imports	€m (2000)	7180.9	12058.8	15652.6	19385.4	24840.8
Price output	2000=1	0.878	0.971	1.177	1.314	1.370

TABLE E137 NO EXEMPTIONS CASE: PHARMACEUTICALS IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	5004.6	5750.7	6880.9	8141.4	9134.6
Output	€m (2000)	5744.9	6457.1	6353.5	6689.7	6562.2
Value Added	€m (2000)	1368.7	1557.0	1636.4	1964.8	1852.6
Wage Bill	€m	558.0	636.6	829.8	1032.1	1066.9
Energy Input	€m	0.7	1.6	2.4	2.2	1.8
Employment	th	14.9	15.2	16.8	18.0	15.4
Exports	€m	3547.2	4932.1	9636.6	13664.1	14966.9
Exports	€m (2000)	3956.6	5058.0	6424.3	7509.0	8072.9
Imports	€m	3479.6	4960.9	8978.2	12085.0	13633.9
Imports	€m (2000)	3561.8	5047.6	5923.5	7114.3	8055.2
Price output	2000=1	0.871	0.891	1.083	1.217	1.392

TABLE E138 NO EXEMPTIONS CASE: PHARMACEUTICALS IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	518.5	711.9	909.3	974.9	900.5
Output	€m (2000)	442.0	683.4	788.1	772.8	767.4
Value Added	€m (2000)	197.0	267.0	376.7	421.0	409.7
Wage Bill	€m	93.6	123.6	162.0	229.4	282.2
Energy Input	€m	24.3	46.3	67.7	65.6	52.1
Employment	th	4.1	4.3	4.2	4.5	4.6
Exports	€m	190.8	344.6	653.3	955.3	1204.2
Exports	€m (2000)	224.0	352.0	495.9	602.8	729.8
Imports	€m	559.3	892.2	1433.2	1873.2	2213.0
Imports	€m (2000)	504.8	917.3	1131.2	1312.5	1567.9
Price output	2000=1	1.173	1.042	1.154	1.262	1.173

TABLE E139 NO EXEMPTIONS CASE: PHARMACEUTICALS IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	4106.0	5499.5	8601.3	11693.1	15171.3
Output	€m (2000)	3971.7	5770.5	7017.5	8409.4	10592.6
Value Added	€m (2000)	1959.8	3006.9	4082.3	5349.5	6863.6
Wage Bill	€m	581.2	899.4	1211.1	1772.2	2565.9
Energy Input	€m	11.1	11.8	21.5	27.5	28.1
Employment	th	15.5	17.5	20.7	21.5	22.2
Exports	€m	2460.5	4200.8	7145.4	11421.5	15395.5
Exports	€m (2000)	2689.4	4288.0	6123.8	8249.5	10792.1
Imports	€m	1221.5	1442.7	3158.7	4418.3	4945.8
Imports	€m (2000)	996.5	1483.6	2163.9	2771.3	3136.7
Price output	2000=1	1.034	0.953	1.226	1.391	1.432

TABLE E140 NO EXEMPTIONS CASE: PHARMACEUTICALS IN THE UK

		1996	2000	2004	2008	2012
Output	€m	14869.6	18271.0	27465.7	32695.4	35533.4
Output	€m (2000)	17338.6	19349.9	22342.3	22743.0	23876.9
Value Added	€m (2000)	7527.2	8896.1	10675.0	9002.0	9769.4
Wage Bill	€m	2724.9	4622.3	5689.6	8313.1	11735.8
Energy Input	€m	188.5	182.4	191.8	309.1	328.2
Employment	th	64.8	54.5	44.6	47.0	47.9
Exports	€m	10016.8	12459.8	22061.6	38003.3	52452.5
Exports	€m (2000)	8034.4	12696.1	20642.9	29681.4	39493.0
Imports	€m	6523.7	9665.7	19209.0	29602.6	36406.2
Imports	€m (2000)	5320.7	9942.9	18385.3	25023.4	31468.2
Price output	2000=1	0.858	0.944	1.229	1.438	1.488

TABLE E141 NO EXEMPTIONS CASE: PHARMACEUTICALS IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	381.3	562.1	884.0	1475.2	2246.1
Output	€m (2000)	485.2	562.1	839.5	1057.5	1249.2
Value Added	€m (2000)	224.4	311.9	408.3	553.8	734.0
Wage Bill	€m	98.4	115.8	195.7	301.9	457.5
Energy Input	€m	0.2	0.2	0.7	1.2	1.5
Employment	th	5.5	5.2	6.0	5.8	5.6
Exports	€m	239.0	415.0	1239.7	1969.6	2653.2
Exports	€m (2000)	453.9	429.4	1177.4	1577.5	1872.8
Imports	€m	132.9	258.2	454.7	628.5	788.9
Imports	€m (2000)	157.9	267.0	293.8	346.1	435.7
Price output	2000=1	0.786	1.000	1.053	1.395	1.798

TABLE E142 NO EXEMPTIONS CASE: CHEMICALS NES IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	3277.3	4115.6	5200.1	7258.7	7265.8
Output	€m (2000)	2927.0	4017.1	5092.5	5839.5	6444.1
Value Added	€m (2000)	993.6	931.3	1363.9	2523.2	1848.8
Wage Bill	€m	614.7	631.9	740.0	937.7	1103.8
Energy Input	€m	112.6	243.4	368.2	390.5	306.4
Employment	th	15.9	14.0	13.7	14.8	15.6
Exports	€m	1975.9	2609.3	3326.6	4813.0	5060.3
Exports	€m (2000)	1887.0	2606.5	3185.7	3711.1	3968.9
Imports	€m	2832.5	2558.7	3147.5	5240.1	6816.3
Imports	€m (2000)	2106.2	2547.7	2916.7	3799.1	4686.4
Price output	2000=1	1.120	1.025	1.021	1.243	1.127

TABLE E143 NO EXEMPTIONS CASE: CHEMICALS NES IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	93549.0	101589.2	112624.5	138308.2	134898.4
Output	€m (2000)	96414.6	100842.7	119299.1	129761.0	147799.6
Value Added	€m (2000)	29769.9	30930.0	33111.3	102149.5	2382.0
Wage Bill	€m	19952.1	18885.5	19728.8	21519.8	24362.5
Energy Input	€m	4899.6	7608.3	8347.3	6327.5	4873.5
Employment	th	463.2	386.2	386.8	387.0	381.8
Exports	€m	43514.1	58058.2	73494.0	110726.6	117203.7
Exports	€m (2000)	38638.8	60075.9	77236.9	90640.9	97687.6
Imports	€m	27805.0	45857.2	48438.0	86653.3	101280.5
Imports	€m (2000)	30650.1	45062.0	43945.0	61330.9	67997.9
Price output	2000=1	0.970	1.007	0.944	1.066	0.913

TABLE E144 NO EXEMPTIONS CASE: CHEMICALS NES IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	22192.0	29677.1	30494.6	34026.4	35857.1
Output	€m (2000)	24734.8	29207.0	31241.9	34567.5	37514.7
Value Added	€m (2000)	5688.9	6892.0	2528.3	3354.7	3859.0
Wage Bill	€m	2622.6	2697.2	3272.3	3278.5	3442.6
Energy Input	€m	1981.5	5751.3	10939.1	10757.2	8961.9
Employment	th	63.8	58.8	57.0	57.2	58.8
Exports	€m	21578.2	22273.8	28877.7	36504.8	42171.5
Exports	€m (2000)	17820.2	22273.8	24660.7	28386.3	29490.6
Imports	€m	13373.4	16490.8	20733.2	33268.3	40318.7
Imports	€m (2000)	11652.1	16768.7	21052.7	25630.1	29853.0
Price output	2000=1	0.897	1.016	0.976	0.984	0.956

TABLE E145 NO EXEMPTIONS CASE: CHEMICALS NES IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	4517.8	7345.3	5908.5	7554.4	8016.0
Output	€m (2000)	4604.6	7045.8	5033.2	5073.7	5417.4
Value Added	€m (2000)	1094.0	1275.0	1729.3	2418.4	2199.9
Wage Bill	€m	453.3	589.3	645.1	810.7	908.2
Energy Input	€m	340.3	588.7	543.2	606.1	544.6
Employment	th	16.0	17.3	15.8	15.4	15.3
Exports	€m	1906.7	3377.0	3098.1	3903.1	4460.2
Exports	€m (2000)	2304.3	3329.5	2596.7	2732.6	2980.1
Imports	€m	2001.2	2014.3	3431.4	4724.0	5198.0
Imports	€m (2000)	1760.1	2026.2	2812.3	2935.1	3076.6
Price output	2000=1	0.981	1.043	1.174	1.489	1.480

TABLE E146 NO EXEMPTIONS CASE: CHEMICALS NES IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	5532.1	6652.2	7899.5	11842.2	13964.8
Output	€m (2000)	5129.5	6297.2	7242.5	8265.9	9544.2
Value Added	€m (2000)	1651.1	2184.2	2805.4	4079.1	4402.8
Wage Bill	€m	715.8	893.3	1107.4	1684.3	2204.3
Energy Input	€m	347.1	357.6	724.2	954.3	669.7
Employment	th	22.2	21.9	21.0	23.3	23.1
Exports	€m	1981.9	4091.4	5834.1	8747.7	9869.6
Exports	€m (2000)	2826.0	3899.0	4783.2	5825.6	6628.6
Imports	€m	4431.4	5388.0	7303.7	11351.3	13042.9
Imports	€m (2000)	3442.1	5440.6	5997.5	7308.1	8028.5
Price output	2000=1	1.079	1.056	1.091	1.433	1.463

TABLE E147 NO EXEMPTIONS CASE: CHEMICALS NES IN THE UK

		1996	2000	2004	2008	2012
Output	€m	62114.8	57438.6	57242.5	75070.9	77689.4
Output	€m (2000)	51080.9	55426.6	56667.9	57463.2	64913.4
Value Added	€m (2000)	14345.1	16013.7	15564.3	12478.0	14818.0
Wage Bill	€m	6178.9	9330.3	8847.8	13481.7	11339.9
Energy Input	€m	2064.9	2225.8	2640.8	3380.2	3374.1
Employment	th	218.3	223.9	164.3	165.4	156.3
Exports	€m	29342.6	26729.4	32159.1	47887.3	49026.4
Exports	€m (2000)	21269.1	26644.2	26021.9	29434.3	30252.3
Imports	€m	27020.3	24768.4	29749.6	43070.9	46967.6
Imports	€m (2000)	19745.3	24660.4	24466.1	26434.8	28050.2
Price output	2000=1	1.216	1.036	1.010	1.306	1.197

TABLE E148 NO EXEMPTIONS CASE: CHEMICALS NES IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	537.7	856.1	1098.8	1649.9	2618.7
Output	€m (2000)	645.4	840.7	1012.3	1165.5	1390.7
Value Added	€m (2000)	186.4	231.7	228.6	110.4	255.1
Wage Bill	€m	97.6	104.5	141.1	216.0	339.7
Energy Input	€m	35.5	38.2	81.2	112.2	143.6
Employment	th	9.1	8.8	8.3	8.2	8.6
Exports	€m	354.1	613.5	914.6	1265.7	1543.7
Exports	€m (2000)	458.2	613.5	856.4	1114.2	1228.1
Imports	€m	640.8	971.0	1688.9	3090.5	4114.3
Imports	€m (2000)	741.4	963.9	1471.3	2079.9	2394.1
Price output	2000=1	0.833	1.018	1.085	1.416	1.883

TABLE E149 NO EXEMPTIONS CASE: NON-METALLIC MINERAL PRODUCTS IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	2025.1	2220.2	2870.9	3530.5	4681.8
Output	€m (2000)	2345.8	2466.8	2717.8	2982.4	3337.1
Value Added	€m (2000)	1022.8	1133.7	1263.6	1330.4	1891.8
Wage Bill	€m	603.6	789.7	900.1	1173.9	1533.2
Energy Input	€m	88.4	109.0	148.7	213.4	230.4
Employment	th	18.3	20.8	19.5	18.2	18.6
Exports	€m	557.9	697.5	646.6	684.5	640.9
Exports	€m (2000)	622.3	699.3	668.0	572.3	491.2
Imports	€m	503.1	663.5	738.7	1238.1	1564.6
Imports	€m (2000)	640.4	654.8	712.5	841.6	983.7
Price output	2000=1	0.863	0.900	1.056	1.184	1.403

TABLE E150 NO EXEMPTIONS CASE: NON-METALLIC MINERAL PRODUCTS IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	41339.8	43757.2	39129.3	44569.3	46706.1
Output	€m (2000)	40388.3	41739.0	37618.9	41847.0	43607.2
Value Added	€m (2000)	15771.3	16320.0	15145.8	17885.5	18674.7
Wage Bill	€m	9402.6	10123.5	9278.4	10219.9	10885.8
Energy Input	€m	3081.2	3340.5	4397.0	5275.9	5002.8
Employment	th	352.3	325.1	280.5	280.5	277.4
Exports	€m	5655.6	8200.9	10200.0	15586.5	20255.6
Exports	€m (2000)	6297.5	8160.9	10170.1	12933.8	15370.9
Imports	€m	5716.3	7454.4	8253.1	14060.6	18819.4
Imports	€m (2000)	5834.7	7448.1	9051.5	10956.3	13100.4
Price output	2000=1	1.024	1.048	1.040	1.065	1.071

TABLE E151 NO EXEMPTIONS CASE: NON-METALLIC MINERAL PRODUCTS IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	4664.7	6147.9	7175.8	8819.4	11135.2
Output	€m (2000)	5487.8	6542.3	6306.3	6916.2	7262.4
Value Added	€m (2000)	2153.2	2508.0	2515.8	2575.1	3272.7
Wage Bill	€m	1019.8	1249.4	1405.1	1664.0	1940.6
Energy Input	€m	132.4	189.0	258.1	288.8	263.5
Employment	th	37.8	37.4	35.9	36.0	35.5
Exports	€m	1277.7	1454.6	1453.7	1925.2	2182.3
Exports	€m (2000)	1298.4	1447.8	1549.5	1678.7	1748.9
Imports	€m	1617.3	1885.0	2272.1	3479.1	4412.9
Imports	€m (2000)	1602.4	1877.6	2266.2	2438.2	2847.7
Price output	2000=1	0.850	0.940	1.138	1.275	1.533

TABLE E152 NO EXEMPTIONS CASE: NON-METALLIC MINERAL PRODUCTS IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	1555.3	2757.3	2837.1	3768.8	4360.0
Output	€m (2000)	1832.6	2326.1	2539.1	2775.4	2967.8
Value Added	€m (2000)	745.0	925.0	1207.7	1532.0	1657.8
Wage Bill	€m	320.0	482.7	541.0	752.1	871.9
Energy Input	€m	37.7	46.0	66.7	69.1	63.9
Employment	th	14.1	18.8	16.3	14.1	11.9
Exports	€m	385.4	567.5	842.9	1567.5	2284.0
Exports	€m (2000)	322.5	537.4	855.0	1268.1	1676.3
Imports	€m	284.8	430.3	543.4	904.6	995.7
Imports	€m (2000)	376.2	430.0	494.3	570.5	573.1
Price output	2000=1	0.849	1.185	1.117	1.358	1.469

TABLE E153 NO EXEMPTIONS CASE: NON-METALLIC MINERAL PRODUCTS IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	2391.7	3027.2	3339.2	3987.7	4915.5
Output	€m (2000)	2603.1	2957.0	3120.1	3378.0	3745.6
Value Added	€m (2000)	994.4	1120.2	1322.2	1437.7	1748.1
Wage Bill	€m	551.5	622.3	637.0	662.1	720.0
Energy Input	€m	91.5	158.3	210.9	262.5	251.3
Employment	th	19.4	18.3	17.4	15.4	14.3
Exports	€m	580.9	749.6	948.3	1205.2	1388.5
Exports	€m (2000)	543.5	744.8	1000.1	1067.4	1120.7
Imports	€m	726.5	982.6	1321.8	2027.8	2394.5
Imports	€m (2000)	689.9	977.1	1266.9	1359.8	1486.6
Price output	2000=1	0.919	1.024	1.070	1.181	1.312

TABLE E154 NO EXEMPTIONS CASE: NON-METALLIC MINERAL PRODUCTS IN THE UK

		1996	2000	2004	2008	2012
Output	€m	18856.2	20848.4	21797.7	26580.7	28653.6
Output	€m (2000)	18571.9	20414.0	20426.4	20926.1	21725.9
Value Added	€m (2000)	7971.7	8226.7	7848.4	5586.9	7534.7
Wage Bill	€m	3832.6	5603.7	5905.9	7340.5	6856.6
Energy Input	€m	973.6	781.8	737.7	1211.9	1189.5
Employment	th	159.7	156.6	138.0	137.6	116.8
Exports	€m	3477.1	3198.1	3066.9	3818.7	3652.1
Exports	€m (2000)	3067.3	3182.7	2802.0	2827.8	2487.2
Imports	€m	3027.8	3581.0	4682.5	7455.1	9586.6
Imports	€m (2000)	2870.5	3571.1	4153.0	4698.2	5468.5
Price output	2000=1	1.015	1.021	1.067	1.270	1.319

TABLE E155 NO EXEMPTIONS CASE: NON-METALLIC MINERAL PRODUCTS IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	388.6	457.2	552.2	596.9	581.4
Output	€m (2000)	480.3	452.3	493.0	439.2	385.1
Value Added	€m (2000)	187.1	218.3	182.4	101.7	106.4
Wage Bill	€m	103.5	108.2	135.4	169.3	201.7
Energy Input	€m	42.6	74.0	67.9	86.5	100.0
Employment	th	12.2	10.6	10.7	9.2	7.2
Exports	€m	171.7	285.6	332.2	385.4	460.7
Exports	€m (2000)	184.1	284.7	250.3	265.6	291.2
Imports	€m	138.5	241.2	393.7	707.8	941.4
Imports	€m (2000)	168.7	239.1	321.7	392.3	450.7
Price output	2000=1	0.809	1.011	1.120	1.359	1.510

TABLE E156 NO EXEMPTIONS CASE: BASIC METALS IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	1189.7	1638.7	2046.4	2967.5	3597.7
Output	€m (2000)	1374.9	1641.3	1866.5	1918.2	1994.3
Value Added	€m (2000)	440.7	467.1	574.6	953.4	1189.8
Wage Bill	€m	322.3	376.4	545.0	703.9	871.3
Energy Input	€m	51.2	94.0	128.9	179.7	167.8
Employment	th	8.6	8.9	10.5	9.0	8.2
Exports	€m	661.4	1001.3	1128.2	1467.3	1590.0
Exports	€m (2000)	807.1	1007.4	1270.3	1293.6	1316.0
Imports	€m	1459.4	1996.4	1938.5	2956.9	3349.5
Imports	€m (2000)	1620.2	2011.2	2062.2	2128.9	2209.1
Price output	2000=1	0.865	0.999	1.096	1.547	1.804

TABLE E157 NO EXEMPTIONS CASE: BASIC METALS IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	45349.2	63462.7	62402.4	81765.2	87111.8
Output	€m (2000)	58590.5	63527.2	71812.9	77528.3	79463.9
Value Added	€m (2000)	15435.9	16330.0	15053.0	36863.8	44728.2
Wage Bill	€m	9566.3	10413.5	11767.6	12467.4	15370.7
Energy Input	€m	4511.5	5261.9	6010.0	6894.1	6357.7
Employment	th	292.2	266.7	254.4	270.3	264.9
Exports	€m	18115.7	27679.0	31795.6	47417.2	55039.8
Exports	€m (2000)	19697.1	27946.0	37955.8	46259.4	50492.5
Imports	€m	16270.0	26645.8	27516.2	50592.9	62575.6
Imports	€m (2000)	20929.6	26787.0	30289.6	37909.5	42643.2
Price output	2000=1	0.774	0.999	0.869	1.055	1.096

TABLE E158 NO EXEMPTIONS CASE: BASIC METALS IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	5299.1	7815.7	8685.5	13407.2	20654.0
Output	€m (2000)	6214.7	9554.7	8835.7	12805.3	18197.3
Value Added	€m (2000)	1804.5	2031.0	2370.6	4086.2	5398.7
Wage Bill	€m	979.5	1201.8	1624.0	2021.1	3093.5
Energy Input	€m	206.7	391.5	543.8	781.3	934.0
Employment	th	26.8	28.2	29.7	27.6	31.3
Exports	€m	4543.9	6637.2	7553.8	14144.2	21658.5
Exports	€m (2000)	5240.2	6657.1	8132.1	12039.1	17347.8
Imports	€m	4673.9	5812.4	7213.2	12102.0	14669.8
Imports	€m (2000)	5631.1	5968.7	8187.1	9339.8	10444.4
Price output	2000=1	0.853	0.818	0.983	1.047	1.135

TABLE E159 NO EXEMPTIONS CASE: BASIC METALS IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	4576.1	7321.4	6562.1	6951.5	6534.2
Output	€m (2000)	5534.1	7334.6	7327.7	6775.9	6596.6
Value Added	€m (2000)	1077.0	1308.0	601.6	8395.3	1470.4
Wage Bill	€m	477.2	581.5	628.7	803.6	891.3
Energy Input	€m	251.0	522.3	952.7	1333.9	1061.7
Employment	th	17.1	16.9	15.7	15.1	14.5
Exports	€m	2362.3	3868.1	4268.8	6495.1	7163.7
Exports	€m (2000)	2579.5	3900.8	4686.6	5600.6	5795.0
Imports	€m	1384.6	2016.5	2073.7	4585.8	5273.2
Imports	€m (2000)	1273.3	2036.0	2195.9	3268.0	3389.2
Price output	2000=1	0.827	0.998	0.895	1.026	0.991

TABLE E160 NO EXEMPTIONS CASE: BASIC METALS IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	7467.9	10045.8	9596.6	11649.2	12639.7
Output	€m (2000)	8298.3	10054.8	9803.4	9607.5	9699.4
Value Added	€m (2000)	2029.1	2313.4	2216.2	2638.1	2781.5
Wage Bill	€m	998.5	1171.9	1226.4	1449.0	1667.1
Energy Input	€m	352.7	542.3	754.0	902.8	680.1
Employment	th	32.2	30.5	29.7	30.4	31.6
Exports	€m	4345.0	5521.4	7384.0	10430.5	11452.9
Exports	€m (2000)	3970.3	5556.0	6965.0	7993.3	8369.2
Imports	€m	2963.1	4225.5	5129.7	9490.3	11384.2
Imports	€m (2000)	3170.2	4256.9	4887.8	6144.4	6740.9
Price output	2000=1	0.900	0.999	0.979	1.212	1.303

TABLE E161 NO EXEMPTIONS CASE: BASIC METALS IN THE UK

		1996	2000	2004	2008	2012
Output	€m	32247.5	27636.3	25452.1	29348.7	35094.6
Output	€m (2000)	27344.2	27640.4	27586.7	24220.1	27899.1
Value Added	€m (2000)	6220.3	6500.6	6733.3	7608.5	9063.7
Wage Bill	€m	4022.0	5097.9	3646.4	6090.0	9726.6
Energy Input	€m	1537.1	867.5	840.3	997.0	1027.4
Employment	th	149.8	123.2	104.6	138.7	241.6
Exports	€m	12942.7	9464.3	9101.7	16463.7	18607.9
Exports	€m (2000)	10792.2	9556.6	9356.9	12645.9	13215.1
Imports	€m	13670.1	11712.0	10943.2	22982.9	25325.6
Imports	€m (2000)	10248.2	11941.4	10942.1	14903.8	14747.2
Price output	2000=1	1.179	1.000	0.923	1.212	1.258

TABLE E162 NO EXEMPTIONS CASE: BASIC METALS IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	427.1	962.8	8.8	14.0	17.0
Output	€m (2000)	567.6	965.7	8.9	9.3	9.4
Value Added	€m (2000)	133.0	205.0	1.1	2.0	2.1
Wage Bill	€m	88.4	103.9	10.5	11.9	16.9
Energy Input	€m	37.8	85.0	1.7	2.3	2.6
Employment	th	10.4	8.7	0.7	0.5	0.5
Exports	€m	328.8	712.6	675.6	813.2	894.8
Exports	€m (2000)	427.3	717.0	690.4	679.6	721.9
Imports	€m	398.8	697.1	2633.9	11404.6	18957.1
Imports	€m (2000)	549.9	697.1	2427.6	7779.4	11047.3
Price output	2000=1	0.752	0.997	0.986	1.505	1.805

TABLE E163 NO EXEMPTIONS CASE: MACRO RESULTS FOR GERMANY

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	195619.1	213479.4	211701.9	250774.2	311004.8
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1948.8	2120.6	2188.1	2278.8	2398.9
GDP deflator 2000=1	1.0	1.1	1.0	1.1	1.2
SC cons. €bn (2000)	1127.7	1198.2	1220.3	1240.6	1294.0
PSC 2000=1	1.0	1.1	1.1	1.1	1.2
SK invest. €bn (2000)	434.4	491.9	411.0	461.4	476.5
PSK 2000=1	1.1	1.0	1.0	1.1	1.1
SX €bn (2000)	454.3	632.1	764.4	921.9	1021.7
PSX 2000=1	0.9	1.0	1.1	1.3	1.3
SM €bn (2000)	431.7	550.9	605.2	740.4	827.2
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	222792.6	255723.9	305608.0	255428.1	243594.9
CO2 mtC-eq	189171.0	217462.2	266044.7	215571.6	205251.2
FR003IS fuel use mtoe	9930.0	10787.1	8235.7	8400.3	8120.7
FR004NF fuel use mtoe	2638.0	2793.3	2805.7	3148.2	3243.9
FR005NM fuel use mtoe	29610.5	31309.4	24374.5	18537.6	13063.1
FR010PP fuel use mtoe	4347.1	4532.4	4446.2	4399.9	4212.7
FCO2(03) IS mtC-eq	13659.8	14384.3	11423.4	10922.1	10654.5
FCO2(04) NF mtC-eq	771.7	873.5	934.7	1113.0	1211.0
FCO2(05) NM mtC-eq	4810.0	3752.1	4034.2	3862.0	3315.3
FCO2(10) PP mtC-eq	1087.4	1200.9	1011.4	891.6	826.8

TABLE E164 NO EXEMPTIONS CASE: MACRO RESULTS FOR FRANCE

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.3	0.3	0.3	0.3	0.3
Empl tax revs RERS	152269.0	157953.8	187933.3	228942.4	276938.5
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1257.1	1401.3	1463.1	1585.3	1759.6
GDP deflator 2000=1	1.0	1.1	1.2	1.3	1.3
SC cons. €bn (2000)	725.8	783.6	842.5	891.8	969.4
PSC 2000=1	0.9	1.1	1.2	1.3	1.4
SK invest. €bn (2000)	228.8	268.7	308.7	328.0	375.8
PSK 2000=1	1.0	1.1	1.2	1.2	1.2
SX €bn (2000)	270.4	386.1	375.2	453.0	509.5
PSX 2000=1	1.0	1.0	1.1	1.3	1.4
SM €bn (2000)	276.0	380.5	422.8	501.1	561.5
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	130978.5	150342.3	146462.9	172381.8	128464.8
CO2 mtC-eq	92842.3	112040.8	108680.3	130866.6	93795.4
FR003IS fuel use mtoe	5961.9	5300.2	5240.2	5147.7	4563.8
FR004NF fuel use mtoe	1580.2	1647.6	1403.4	1637.1	1684.7
FR005NM fuel use mtoe	17950.5	20700.8	18000.1	16575.5	16940.8
FR010PP fuel use mtoe	3427.4	3758.9	4051.7	3681.1	3686.3
FCO2(03) IS mtC-eq	7159.7	6135.2	6971.1	6587.5	6326.0
FCO2(04) NF mtC-eq	475.4	567.4	626.9	745.8	802.5
FCO2(05) NM mtC-eq	2282.6	2441.0	2451.8	2347.2	2445.4
FCO2(10) PP mtC-eq	1310.6	1399.4	1477.9	1284.7	1349.4

TABLE E165 NO EXEMPTIONS CASE: MACRO RESULTS FOR ITALY

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	44094.6	58860.7	79286.8	111370.9	146031.2
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	522.9	610.1	676.5	728.3	812.0
GDP deflator 2000=1	0.9	1.0	1.2	1.4	1.4
SC cons. €bn (2000)	336.8	398.0	426.8	457.5	519.2
PSC 2000=1	0.9	1.0	1.2	1.4	1.5
SK invest. €bn (2000)	110.6	153.6	182.1	221.0	237.1
PSK 2000=1	0.9	1.0	1.2	1.2	1.2
SX €bn (2000)	112.7	165.3	181.2	209.1	245.6
PSX 2000=1	0.9	1.0	1.1	1.3	1.4
SM €bn (2000)	118.2	192.0	215.3	258.9	305.0
PSM 2000=1	0.9	1.0	1.1	1.2	1.3
GHG mtC-eq	74467.7	89246.3	95350.3	95515.7	94548.7
CO2 mtC-eq	65704.8	78726.3	84601.5	85793.1	85343.7
FR003IS fuel use mtoe	2795.1	3605.0	4918.4	5201.7	5059.1
FR004NF fuel use mtoe	1011.7	1155.0	1656.4	1745.7	1824.4
FR005NM fuel use mtoe	7447.8	9657.6	8808.4	8197.0	8807.6
FR010PP fuel use mtoe	1821.5	2563.8	3211.4	3286.6	3108.4
FCO2(03) IS mtC-eq	2789.2	3050.7	3461.9	3283.6	3099.4
FCO2(04) NF mtC-eq	303.7	369.3	499.6	528.1	553.5
FCO2(05) NM mtC-eq	1459.8	1166.4	1158.9	1087.2	1063.5
FCO2(10) PP mtC-eq	654.8	879.9	832.8	703.3	644.0

TABLE E166 NO EXEMPTIONS CASE: MACRO RESULTS FOR SPAIN

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.4	0.3	0.3	0.3	0.3
Empl tax revs RERS	106110.7	109406.7	140775.4	199119.8	231882.6
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1070.9	1176.5	1254.4	1353.9	1419.1
GDP deflator 2000=1	0.9	1.0	1.2	1.5	1.4
SC cons. €bn (2000)	648.9	733.0	742.7	768.2	836.8
PSC 2000=1	0.9	1.0	1.2	1.5	1.4
SK invest. €bn (2000)	178.0	225.6	236.7	275.2	267.7
PSK 2000=1	1.0	1.0	1.3	1.5	1.4
SX €bn (2000)	244.6	321.8	342.4	387.4	411.2
PSX 2000=1	1.0	1.0	1.1	1.3	1.4
SM €bn (2000)	225.6	327.6	324.1	354.7	404.2
PSM 2000=1	0.9	1.0	1.1	1.2	1.2
GHG mtC-eq	122785.7	126659.9	130720.4	130992.9	131465.4
CO2 mtC-eq	111999.5	115212.6	118991.4	119469.7	119504.1
FR003IS fuel use mtoe	4837.5	5447.4	5702.8	5777.3	5284.1
FR004NF fuel use mtoe	867.3	939.2	892.3	1064.4	1082.8
FR005NM fuel use mtoe	11906.2	11541.3	11649.9	10334.9	8985.0
FR010PP fuel use mtoe	2469.9	2642.3	2733.6	2809.9	2686.7
FCO2(03) IS mtC-eq	5449.1	4734.1	4133.0	4399.3	3808.3
FCO2(04) NF mtC-eq	262.3	387.1	374.6	440.6	438.2
FCO2(05) NM mtC-eq	1673.4	1188.8	1364.3	1278.9	1174.4
FCO2(10) PP mtC-eq	857.1	823.9	830.5	834.5	804.3

TABLE E167 NO EXEMPTIONS CASE: MACRO RESULTS FOR UK

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.1	0.1	0.1	0.1	0.1
Empl tax revs RERS	38569.7	65548.3	73838.5	113184.8	120451.8
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1424.7	1804.7	1860.8	1959.7	2182.2
GDP deflator 2000=1	1.0	0.9	1.1	1.4	1.4
SC cons. €bn (2000)	952.1	1145.2	1202.8	1222.8	1390.0
PSC 2000=1	0.9	0.9	1.0	1.3	1.3
SK invest. €bn (2000)	185.1	280.8	318.5	375.3	419.6
PSK 2000=1	1.1	0.9	1.0	1.2	1.2
SX €bn (2000)	310.8	446.5	454.5	508.3	535.2
PSX 2000=1	1.5	1.1	1.3	1.5	1.7
SM €bn (2000)	286.9	369.7	430.4	514.4	587.1
PSM 2000=1	1.2	1.0	1.1	1.2	1.3
GHG mtC-eq	183163.9	204372.1	198359.5	175206.9	170119.7
CO2 mtC-eq	168513.7	189892.2	182309.9	159394.7	153135.4
FR003IS fuel use mtoe	4667.7	4169.3	3514.5	2973.7	3281.4
FR004NF fuel use mtoe	1204.8	1121.6	1071.9	1112.3	1126.1
FR005NM fuel use mtoe	14078.5	15809.4	14296.3	12465.3	9565.1
FR010PP fuel use mtoe	2532.4	2630.5	2742.1	2538.6	2464.7
FCO2(03) IS mtC-eq	7127.6	6202.2	5504.0	4120.1	4528.8
FCO2(04) NF mtC-eq	481.5	502.0	492.0	526.3	533.7
FCO2(05) NM mtC-eq	2182.7	3163.2	2985.3	2880.5	2998.8
FCO2(10) PP mtC-eq	884.3	473.8	568.7	566.1	540.6

TABLE E168 NO EXEMPTIONS CASE: MACRO RESULTS FOR REST OF EU15

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.1	0.1	0.1	0.1	0.1
Empl tax revs RERS	78171.6	97249.3	116983.7	145790.4	176837.0
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1526.7	1819.1	1972.3	2196.0	2395.9
GDP deflator 2000=1	0.9	1.0	1.2	1.3	1.3
SC cons. €bn (2000)	850.4	970.2	1063.0	1149.3	1269.8
PSC 2000=1	0.9	1.0	1.1	1.3	1.3
SK invest. €bn (2000)	291.5	388.0	425.2	485.0	530.4
PSK 2000=1	0.9	1.1	1.2	1.2	1.2
SX €bn (2000)	652.1	907.9	1003.5	1171.1	1302.7
PSX 2000=1	0.9	1.1	1.2	1.4	1.4
SM €bn (2000)	618.1	830.2	924.5	1052.8	1185.1
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	212136.3	214855.9	224906.7	208706.4	206771.8
CO2 mtC-eq	187181.6	195229.8	206022.6	193065.4	191096.7
FR003IS fuel use mtoe	7997.3	8909.2	9235.1	8915.2	8500.7
FR004NF fuel use mtoe	2900.5	3346.1	2937.5	3393.3	3956.8
FR005NM fuel use mtoe	25297.3	29579.9	27527.8	28253.4	27422.1
FR010PP fuel use mtoe	15176.9	18076.5	17934.9	18740.0	20116.2
FCO2(03) IS mtC-eq	11418.7	11155.5	12032.8	10022.2	9436.1
FCO2(04) NF mtC-eq	1043.6	1325.2	1447.0	1638.8	1784.7
FCO2(05) NM mtC-eq	3800.7	4300.6	4175.3	4124.7	4007.2
FCO2(10) PP mtC-eq	2335.1	2326.3	2406.8	2219.5	2076.0

TABLE E169 NO EXEMPTIONS CASE: MACRO RESULTS FOR POLAND

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	7538.1	10970.6	15510.1	29714.4	47549.0
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	157.3	170.0	182.8	209.6	242.4
GDP deflator 2000=1	0.6	1.0	1.3	1.7	1.9
SC cons. €bn (2000)	113.9	115.8	132.2	152.3	182.7
PSC 2000=1	0.6	1.0	1.3	1.9	2.2
SK invest. €bn (2000)	23.1	23.2	24.6	31.3	36.8
PSK 2000=1	0.7	1.0	1.1	1.3	1.2
SX €bn (2000)	32.9	50.1	65.5	84.4	91.2
PSX 2000=1	0.6	1.1	1.2	1.3	1.4
SM €bn (2000)	37.1	47.4	66.9	88.2	101.1
PSM 2000=1	0.8	1.1	1.2	1.4	1.5
GHG mtC-eq	120294.7	106939.7	103323.4	105083.7	110677.2
CO2 mtC-eq	89730.5	81333.2	76345.5	76912.0	80432.7
FR003IS fuel use mtoe	4932.4	4508.8	3223.5	2855.7	2684.6
FR004NF fuel use mtoe	824.0	779.3	693.5	619.4	614.5
FR005NM fuel use mtoe	7272.5	6913.7	6641.8	7284.4	8155.5
FR010PP fuel use mtoe	1156.6	1008.9	1133.3	1057.2	997.5
FCO2(03) IS mtC-eq	5918.5	5083.8	4144.4	3551.5	3265.8
FCO2(04) NF mtC-eq	566.9	495.4	459.6	406.0	353.0
FCO2(05) NM mtC-eq	2385.0	2384.5	2157.0	1977.6	1934.7
FCO2(10) PP mtC-eq	727.6	631.8	596.7	493.1	396.2

TABLE E170 NO EXEMPTIONS CASE: MACRO RESULTS FOR REST OF EU10

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	29176.4	38306.3	52179.4	83206.9	124731.6
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	393.5	452.8	491.2	572.9	647.4
GDP deflator 2000=1	0.8	1.0	1.2	1.5	1.6
SC cons. €bn (2000)	207.1	236.1	265.6	292.7	334.3
PSC 2000=1	0.8	1.0	1.1	1.5	1.8
SK invest. €bn (2000)	82.4	99.2	115.7	144.6	166.6
PSK 2000=1	0.9	1.1	1.3	1.5	1.5
SX €bn (2000)	138.6	208.4	276.2	339.4	382.5
PSX 2000=1	0.9	1.0	1.2	1.3	1.4
SM €bn (2000)	139.8	215.7	289.5	356.2	404.6
PSM 2000=1	0.9	1.0	1.2	1.3	1.3
GHG mtC-eq	109592.6	101083.1	100340.3	100056.9	102511.7
CO2 mtC-eq	89760.5	82300.8	81740.2	81359.5	83728.3
FR003IS fuel use mtoe	6287.7	5338.1	5245.2	4771.8	4353.8
FR004NF fuel use mtoe	1222.6	1010.2	1135.9	1176.3	1207.7
FR005NM fuel use mtoe	9592.5	9099.6	8802.3	9249.6	9166.6
FR010PP fuel use mtoe	7018.5	7717.7	7444.9	8967.6	10529.6
FCO2(03) IS mtC-eq	7756.0	6883.9	6487.7	5503.8	4956.1
FCO2(04) NF mtC-eq	602.5	544.8	814.7	685.7	733.4
FCO2(05) NM mtC-eq	999.6	1626.4	1848.6	1896.5	1755.5
FCO2(10) PP mtC-eq	1298.6	1135.4	1296.7	1413.7	1240.9

TABLE E171 NO EXEMPTIONS CASE: MACRO RESULTS FOR EU15

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	614834.6	702498.1	810519.6	0.5	1263145.9
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	7751.1	8932.4	9415.1	10102.0	10967.7
GDP deflator 2000=1	0.9	1.0	1.1	1.3	1.3
SC cons. €bn (2000)	4641.7	5228.2	5498.1	5730.2	6279.3
PSC 2000=1	0.9	1.0	1.1	1.3	1.3
SK invest. €bn (2000)	1428.3	1808.5	1882.3	2145.8	2307.1
PSK 2000=1	1.0	1.0	1.1	1.2	1.2
SX €bn (2000)	2044.7	2859.9	3121.2	3650.8	4026.0
PSX 2000=1	1.0	1.0	1.2	1.3	1.4
SM €bn (2000)	1956.5	2650.9	2922.2	3422.2	3870.1
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	946324.6	1041200.5	0.9	0.8	974965.3
CO2 mtC-eq	815412.9	908564.0	966650.4	904161.1	848126.4
FR003IS fuel use mtoe	36189.5	38218.3	36846.7	36415.8	34809.8
FR004NF fuel use mtoe	10202.4	11002.9	10767.2	12101.1	12918.7
FR005NM fuel use mtoe	106290.9	118598.4	104657.0	94363.7	84783.7
FR010PP fuel use mtoe	29775.2	34204.4	35120.0	35456.1	36275.1
FCO2(03) IS mtC-eq	47604.1	45662.0	43526.3	39334.8	37853.0
FCO2(04) NF mtC-eq	3338.1	4024.4	4374.7	4992.6	5323.5
FCO2(05) NM mtC-eq	16209.1	16012.2	16169.9	15580.5	15004.6
FCO2(10) PP mtC-eq	7129.4	7104.2	7128.1	6499.8	6241.2

TABLE E172 NO EXEMPTIONS CASE: MACRO RESULTS FOR EU10

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	20753.4	29005.4	44353.3	84424.9	137704.5
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	324.3	358.9	400.0	473.3	537.4
GDP deflator 2000=1	0.6	1.0	1.2	1.7	2.0
SC cons. €bn (2000)	206.5	224.8	265.0	304.1	356.2
PSC 2000=1	0.7	1.0	1.2	1.8	2.2
SK invest. €bn (2000)	65.7	70.5	84.6	107.6	127.1
PSK 2000=1	0.7	1.0	1.2	1.5	1.4
SX €bn (2000)	103.4	162.2	230.9	295.4	332.7
PSX 2000=1	0.7	1.1	1.1	1.3	1.3
SM €bn (2000)	112.4	173.9	258.7	332.6	386.8
PSM 2000=1	0.8	1.0	1.2	1.3	1.4
GHG mtC-eq	213217.3	192577.8	187453.5	190952.6	197280.5
CO2 mtC-eq	164943.8	150036.8	143870.2	146153.0	150352.2
FR003IS fuel use mtoe	9963.7	8631.2	7156.2	6425.8	5974.2
FR004NF fuel use mtoe	1736.8	1484.8	1520.2	1495.4	1541.1
FR005NM fuel use mtoe	15020.5	14519.4	13059.2	13982.5	15183.8
FR010PP fuel use mtoe	2537.5	2259.2	2530.3	2465.2	2537.6
FCO2(03) IS mtC-eq	12148.7	10559.7	9201.7	7939.4	7116.2
FCO2(04) NF mtC-eq	1102.0	928.9	1137.5	940.3	931.7
FCO2(05) NM mtC-eq	3272.6	3846.9	3807.5	3665.6	3471.6
FCO2(10) PP mtC-eq	1507.0	1241.4	1378.1	1310.0	1200.2

TABLE E173 NO EXEMPTIONS CASE: MACRO RESULTS FOR EU25

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	635587.9	731503.5	854872.8	0.3	1400850.3
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	8075.4	9291.2	9815.1	10575.3	11505.0
GDP deflator 2000=1	0.9	1.0	1.1	1.3	1.4
SC cons. €bn (2000)	4848.2	5453.0	5763.0	6034.3	6635.4
PSC 2000=1	0.9	1.0	1.1	1.3	1.4
SK invest. €bn (2000)	1493.9	1879.0	1966.9	2253.5	2434.2
PSK 2000=1	1.0	1.0	1.1	1.2	1.2
SX €bn (2000)	2148.2	3022.1	3352.1	3946.2	4358.6
PSX 2000=1	1.0	1.0	1.2	1.3	1.4
SM €bn (2000)	2068.9	2824.7	3180.9	3754.9	4257.0
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	0.9	1233778.4	0.3	0.3	1172245.8
CO2 mtC-eq	980356.8	1058600.9	0.5	0.1	998478.6
FR003IS fuel use mtoe	46153.2	46849.4	44002.9	42841.6	40783.9
FR004NF fuel use mtoe	11939.2	12487.7	12287.4	13596.5	14459.9
FR005NM fuel use mtoe	121311.4	133117.8	117716.2	108346.1	99967.6
FR010PP fuel use mtoe	32312.7	36463.6	37650.2	37921.3	38812.7
FCO2(03) IS mtC-eq	59752.8	56221.7	52728.0	47274.2	44969.2
FCO2(04) NF mtC-eq	4440.1	4953.4	5512.2	5932.9	6255.2
FCO2(05) NM mtC-eq	19481.7	19859.0	19977.3	19246.1	18476.2
FCO2(10) PP mtC-eq	8636.4	8345.6	8506.2	7809.8	7441.4

TABLE E174 NO EXEMPTIONS CASE: MACRO RESULTS FOR EUROZONE 11

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	576112.6	638759.4	747200.3	978144.4	1227732.5
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	6165.7	6933.0	7355.6	7945.4	8568.9
GDP deflator 2000=1	0.9	1.0	1.2	1.3	1.4
SC cons. €bn (2000)	3621.8	4009.5	4236.6	4457.9	4844.6
PSC 2000=1	0.9	1.0	1.1	1.3	1.4
SK invest. €bn (2000)	1228.8	1489.1	1521.4	1727.1	1843.2
PSK 2000=1	1.0	1.0	1.2	1.2	1.2
SX €bn (2000)	1710.7	2401.2	2703.1	3212.7	3574.6
PSX 2000=1	0.9	1.0	1.1	1.3	1.4
SM €bn (2000)	1653.9	2282.9	2562.0	3023.3	3431.3
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	920681.5	974078.9	0.8	992860.9	943817.7
CO2 mtC-eq	759807.6	816759.1	869173.8	833137.4	790574.2
FR003IS fuel use mtoe	40020.9	41187.6	38827.1	38265.5	36012.8
FR004NF fuel use mtoe	9732.2	10242.5	10053.7	11220.5	12034.9
FR005NM fuel use mtoe	104750.3	115097.9	100283.1	92344.7	87069.5
FR010PP fuel use mtoe	23860.5	27109.6	28554.4	27477.6	27002.4
FCO2(03) IS mtC-eq	51002.6	48509.5	45676.1	41911.7	39206.9
FCO2(04) NF mtC-eq	3459.5	3878.2	4424.9	4764.8	5031.6
FCO2(05) NM mtC-eq	17001.3	16313.1	16560.2	15925.0	15008.2
FCO2(10) PP mtC-eq	7112.0	7238.6	7289.8	6522.5	6347.2

TABLE E175 NO EXEMPTIONS CASE: MACRO RESULTS FOR DENMARK

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	-0.0	-0.0	-0.0	-0.0	-0.0
Empl tax revs RERS	-249.9	-471.7	-649.3	-784.9	-777.5
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	151.7	166.6	177.6	197.4	217.9
GDP deflator 2000=1	0.9	1.0	1.1	1.3	1.4
SC cons. €bn (2000)	79.2	79.2	85.6	95.6	108.8
PSC 2000=1	0.9	1.1	1.2	1.4	1.5
SK invest. €bn (2000)	22.7	28.5	31.9	36.6	42.6
PSK 2000=1	1.1	1.3	1.3	1.5	1.5
SX €bn (2000)	46.4	59.1	63.6	73.4	83.3
PSX 2000=1	0.9	1.0	1.0	1.2	1.3
SM €bn (2000)	40.1	47.5	52.0	61.5	72.8
PSM 2000=1	1.0	1.2	1.2	1.4	1.4
GHG mtC-eq	17116.9	15490.4	14253.8	12558.1	13138.9
CO2 mtC-eq	15578.6	13960.6	12824.4	11293.1	11699.1
FR003IS fuel use mtoe	108.5	87.8	80.4	89.7	88.5
FR004NF fuel use mtoe	15.6	16.6	18.7	20.3	22.7
FR005NM fuel use mtoe	255.0	279.2	261.2	223.7	246.2
FR010PP fuel use mtoe	144.5	87.0	116.3	127.0	119.0
FCO2(03) IS mtC-eq	36.2	21.6	29.0	30.1	25.0
FCO2(04) NF mtC-eq	11.4	4.4	4.8	5.8	6.0
FCO2(05) NM mtC-eq	92.4	93.4	79.8	53.6	52.8
FCO2(10) PP mtC-eq	57.8	22.3	48.8	39.8	30.4

TABLE E176 NO EXEMPTIONS CASE: MACRO RESULTS FOR IRELAND

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.1	0.1	0.1	0.1	0.1
Empl tax revs RERS	1553.9	2657.8	3725.9	4512.8	5457.3
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	70.6	104.9	135.4	164.4	188.2
GDP deflator 2000=1	0.8	1.0	1.1	1.1	1.2
SC cons. €bn (2000)	39.0	52.7	61.9	72.4	82.2
PSC 2000=1	0.9	1.0	1.1	1.1	1.2
SK invest. €bn (2000)	13.7	25.6	30.7	36.2	41.2
PSK 2000=1	0.8	1.0	1.1	1.1	1.1
SX €bn (2000)	50.1	85.0	103.2	129.0	156.3
PSX 2000=1	0.8	1.0	1.0	1.1	1.2
SM €bn (2000)	28.4	56.3	61.8	76.2	91.6
PSM 2000=1	1.1	1.0	0.9	1.0	1.1
GHG mtC-eq	12596.4	12101.0	12867.5	13401.7	13682.9
CO2 mtC-eq	9340.0	11148.6	11890.7	12399.8	12669.1
FR003IS fuel use mtoe	46.8	55.4	5.0	3.8	3.9
FR004NF fuel use mtoe	669.7	683.8	209.1	245.9	250.3
FR005NM fuel use mtoe	689.7	762.2	333.2	353.7	361.3
FR010PP fuel use mtoe	171.3	186.3	20.6	18.9	18.6
FCO2(03) IS mtC-eq	19.5	16.2	18.6	19.8	20.6
FCO2(04) NF mtC-eq	222.7	218.3	316.8	407.8	465.7
FCO2(05) NM mtC-eq	139.2	199.5	223.9	230.3	222.7
FCO2(10) PP mtC-eq	9.4	8.6	15.1	10.7	7.5

TABLE E177 NO EXEMPTIONS CASE: MACRO RESULTS FOR THE NETHERLANDS

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.0	0.0	0.0	0.0	0.0
Empl tax revs RERS	4523.6	5960.9	6307.3	7565.8	9154.7
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	347.9	420.0	450.3	483.7	501.0
GDP deflator 2000=1	0.9	1.0	1.2	1.3	1.3
SC cons. €bn (2000)	171.9	204.3	223.3	226.4	243.7
PSC 2000=1	0.9	1.0	1.1	1.3	1.4
SK invest. €bn (2000)	69.5	91.5	101.0	107.2	116.7
PSK 2000=1	0.9	1.0	1.1	1.2	1.2
SX €bn (2000)	173.8	232.1	245.2	283.2	309.0
PSX 2000=1	0.9	1.0	1.1	1.3	1.3
SM €bn (2000)	156.1	206.1	228.5	253.9	288.5
PSM 2000=1	0.9	1.0	1.0	1.1	1.2
GHG mtC-eq	54574.7	54330.5	46748.1	43906.1	43427.7
CO2 mtC-eq	45108.2	46007.0	40532.3	38459.8	38203.4
FR003IS fuel use mtoe	948.9	1046.6	1019.5	1160.4	1232.9
FR004NF fuel use mtoe	542.6	818.3	790.5	1046.4	1541.4
FR005NM fuel use mtoe	12083.1	12895.2	12280.3	12293.8	11786.6
FR010PP fuel use mtoe	719.6	748.6	1239.2	796.9	926.0
FCO2(03) IS mtC-eq	2056.2	2072.7	1840.4	1975.8	2079.8
FCO2(04) NF mtC-eq	74.3	129.0	96.1	109.3	129.2
FCO2(05) NM mtC-eq	1721.5	1946.5	1653.3	1574.9	1423.6
FCO2(10) PP mtC-eq	107.9	133.3	206.1	86.5	129.0

TABLE E178 NO EXEMPTIONS CASE: MACRO RESULTS FOR FINLAND

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	9862.3	10797.0	12971.6	16415.0	18948.2
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	106.5	132.6	145.3	158.6	178.0
GDP deflator 2000=1	1.0	1.0	1.1	1.1	1.2
SC cons. €bn (2000)	57.0	66.3	76.3	81.7	91.0
PSC 2000=1	0.9	1.0	1.1	1.3	1.3
SK invest. €bn (2000)	18.0	25.7	26.5	29.1	31.2
PSK 2000=1	1.0	1.2	1.2	1.3	1.4
SX €bn (2000)	36.2	57.6	62.6	72.7	82.0
PSX 2000=1	1.0	1.0	1.0	1.2	1.2
SM €bn (2000)	28.0	39.0	45.9	48.8	56.9
PSM 2000=1	0.9	1.0	1.1	1.6	1.6
GHG mtC-eq	17611.0	17658.4	21378.5	15302.1	13619.5
CO2 mtC-eq	15418.1	16006.7	18903.6	14325.3	12727.2
FR003IS fuel use mtoe	919.2	1014.7	1148.3	1135.4	1194.4
FR004NF fuel use mtoe	184.5	192.0	252.4	249.8	220.7
FR005NM fuel use mtoe	1721.3	1630.3	1222.6	1154.6	1138.9
FR010PP fuel use mtoe	5853.8	7576.8	7207.0	6570.8	6336.6
FCO2(03) IS mtC-eq	1433.7	1592.6	1518.9	1257.1	1358.7
FCO2(04) NF mtC-eq	31.1	30.8	30.4	31.6	28.4
FCO2(05) NM mtC-eq	197.2	282.2	300.1	216.9	177.3
FCO2(10) PP mtC-eq	1042.8	979.5	920.7	790.5	811.2

TABLE E179 NO EXEMPTIONS CASE: MACRO RESULTS FOR SWEDEN

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	15961.1	20271.5	23336.2	28496.3	34576.1
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	226.6	263.9	274.0	309.2	352.4
GDP deflator 2000=1	0.9	1.0	1.2	1.3	1.2
SC cons. €bn (2000)	114.5	127.1	132.8	140.9	160.8
PSC 2000=1	0.9	1.0	1.0	1.1	1.2
SK invest. €bn (2000)	39.8	51.9	55.8	68.2	76.4
PSK 2000=1	0.9	1.2	1.3	1.4	1.4
SX €bn (2000)	68.0	96.3	110.9	128.4	140.9
PSX 2000=1	1.0	1.0	1.4	1.5	1.5
SM €bn (2000)	64.5	89.2	97.6	111.8	118.9
PSM 2000=1	1.0	1.1	1.2	1.4	1.4
GHG mtC-eq	16670.0	15445.0	16210.2	14188.0	15908.4
CO2 mtC-eq	14547.2	13597.2	14215.5	12118.5	13808.8
FR003IS fuel use mtoe	1256.4	1215.7	1312.4	1201.6	1064.2
FR004NF fuel use mtoe	309.8	304.7	309.2	300.3	281.1
FR005NM fuel use mtoe	1844.5	1493.9	2384.9	2551.5	2138.4
FR010PP fuel use mtoe	5637.6	6467.3	6047.9	7559.6	8989.5
FCO2(03) IS mtC-eq	1525.7	1408.1	1430.4	1115.9	1105.6
FCO2(04) NF mtC-eq	67.4	111.2	136.8	151.4	154.7
FCO2(05) NM mtC-eq	112.0	164.0	198.2	208.6	218.6
FCO2(10) PP mtC-eq	519.2	525.8	515.3	596.8	436.9

TABLE E180 NO EXEMPTIONS CASE: MACRO RESULTS FOR SLOVENIA

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.3	0.3	0.3
Empl tax revs RERS	1700.1	2918.7	4528.4	6894.3	10393.4
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	16.4	17.0	21.6	21.1	22.7
GDP deflator 2000=1	0.7	1.0	1.5	1.9	2.2
SC cons. €bn (2000)	11.1	11.3	15.0	16.1	18.4
PSC 2000=1	0.8	1.3	1.4	2.1	2.5
SK invest. €bn (2000)	3.0	3.6	4.7	5.1	5.4
PSK 2000=1	0.8	1.0	1.2	1.7	1.7
SX €bn (2000)	8.6	11.6	15.0	18.7	21.6
PSX 2000=1	0.7	1.0	1.3	1.5	1.6
SM €bn (2000)	8.4	11.9	17.3	25.4	31.6
PSM 2000=1	0.8	1.4	1.2	1.4	1.5
GHG mtC-eq	4144.1	4520.0	4595.3	4413.0	4261.1
CO2 mtC-eq	3446.9	3778.5	3898.7	3741.1	3625.8
FR003IS fuel use mtoe	164.1	160.1	132.4	125.6	118.5
FR004NF fuel use mtoe	106.9	121.1	176.9	160.4	155.1
FR005NM fuel use mtoe	291.9	217.7	223.4	255.7	254.9
FR010PP fuel use mtoe	121.6	260.6	252.9	257.3	272.3
FCO2(03) IS mtC-eq	89.2	84.5	79.6	75.7	70.1
FCO2(04) NF mtC-eq	207.4	101.8	285.9	173.8	187.2
FCO2(05) NM mtC-eq	45.2	42.2	29.0	38.3	33.5
FCO2(10) PP mtC-eq	58.4	121.5	106.7	128.8	130.0

E1.4 No Revenue Recycling Case

TABLE E181 NO REVENUE RECYCLING CASE: FOOD, DRINK AND TOBACCO IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	14054.5	15507.0	17612.7	23624.3	30939.2
Output	€m (2000)	14525.3	15417.8	16428.2	18786.0	22212.5
Value Added	€m (2000)	3740.9	3910.9	4182.3	5085.7	6282.3
Wage Bill	€m	2511.7	2905.6	3341.0	3999.2	4592.6
Energy Input	€m	178.6	350.6	543.7	776.8	741.3
Employment	th	82.7	79.1	74.9	72.8	72.5
Exports	€m	7060.1	8121.5	7567.7	10577.4	12982.5
Exports	€m (2000)	5592.8	8032.5	6812.8	8096.4	9518.9
Imports	€m	2934.5	2639.7	2692.4	4717.5	6288.8
Imports	€m (2000)	2591.5	2598.0	2659.2	3235.2	3919.5
Price output	2000=1	0.968	1.006	1.072	1.258	1.393

TABLE E182 NO REVENUE RECYCLING CASE: FOOD, DRINK AND TOBACCO IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	125230.8	142898.1	153979.5	185798.5	222370.6
Output	€m (2000)	127115.8	135559.8	127239.7	136131.7	153712.9
Value Added	€m (2000)	35436.7	38540.0	38125.2	43980.2	51052.4
Wage Bill	€m	17929.2	21150.9	21546.0	26774.5	34024.7
Energy Input	€m	2475.2	3152.4	3997.7	4453.0	4740.6
Employment	th	996.2	1061.9	987.2	943.8	921.5
Exports	€m	17356.5	21551.6	29512.9	47556.3	71886.1
Exports	€m (2000)	16206.4	21242.8	29816.1	40914.0	59329.4
Imports	€m	21077.3	27951.3	30090.8	53998.8	70842.4
Imports	€m (2000)	20398.4	27585.5	30269.9	37023.8	44045.0
Price output	2000=1	0.985	1.054	1.210	1.365	1.447

TABLE E183 NO REVENUE RECYCLING CASE: FOOD, DRINK AND TOBACCO IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	40737.2	47777.2	50507.8	57328.3	64437.6
Output	€m (2000)	44062.7	47777.2	46971.9	52284.8	56645.5
Value Added	€m (2000)	10574.0	10961.0	11212.1	11054.4	13293.4
Wage Bill	€m	4366.9	5485.6	6311.1	6370.9	7255.7
Energy Input	€m	412.1	546.0	813.6	952.8	958.9
Employment	th	158.9	174.1	155.1	141.6	140.6
Exports	€m	21436.9	25427.6	28063.7	37047.9	45929.5
Exports	€m (2000)	18773.2	25427.7	25328.3	29614.6	33403.3
Imports	€m	9535.4	11445.9	12242.5	19273.6	26714.4
Imports	€m (2000)	9334.2	11301.4	12145.4	13237.0	16600.9
Price output	2000=1	0.924	1.000	1.075	1.097	1.138

TABLE E184 NO REVENUE RECYCLING CASE: FOOD, DRINK AND TOBACCO IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	8106.5	7051.8	9377.5	12385.7	12872.8
Output	€m (2000)	7694.8	8046.4	8919.9	9584.8	9636.9
Value Added	€m (2000)	1717.0	1780.0	2073.4	2787.8	2941.0
Wage Bill	€m	1018.0	975.4	1161.9	1464.3	1636.9
Energy Input	€m	95.9	99.8	118.1	137.2	136.9
Employment	th	45.5	39.0	37.5	36.2	36.3
Exports	€m	815.1	769.2	1021.9	1696.9	2873.0
Exports	€m (2000)	485.1	804.5	1208.5	1585.3	2364.8
Imports	€m	1075.6	1617.8	1767.5	2986.6	5364.7
Imports	€m (2000)	872.3	1585.3	2036.2	2319.7	3878.1
Price output	2000=1	1.054	0.876	1.051	1.292	1.336

TABLE E185 NO REVENUE RECYCLING CASE: FOOD, DRINK AND TOBACCO IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	13481.0	15039.2	14746.3	16449.5	19960.9
Output	€m (2000)	14080.7	15149.2	13991.3	15491.3	19021.6
Value Added	€m (2000)	3999.1	4003.6	4207.4	4634.4	5878.7
Wage Bill	€m	1683.6	2008.6	2181.8	2552.2	3012.4
Energy Input	€m	126.3	155.0	156.1	160.5	132.5
Employment	th	63.9	63.1	60.0	59.0	58.9
Exports	€m	1362.9	2004.7	3042.6	3605.5	4412.7
Exports	€m (2000)	1189.6	1983.0	2669.2	2734.9	3180.8
Imports	€m	2351.3	2411.8	4868.4	8773.5	10657.5
Imports	€m (2000)	2293.9	2381.2	4024.5	4946.5	5492.2
Price output	2000=1	0.957	0.993	1.054	1.062	1.049

TABLE E186 NO REVENUE RECYCLING CASE: FOOD, DRINK AND TOBACCO IN THE UK

		1996	2000	2004	2008	2012
Output	€m	103643.6	109463.7	112364.3	118071.1	148377.7
Output	€m (2000)	94057.2	109360.8	109821.0	107446.2	127024.1
Value Added	€m (2000)	33342.0	33308.7	34708.4	33872.1	40500.8
Wage Bill	€m	14077.3	24579.2	20258.3	15619.6	22209.9
Energy Input	€m	1527.2	1226.9	1371.5	1892.4	1871.9
Employment	th	510.5	763.9	534.5	299.6	393.4
Exports	€m	14942.1	15700.7	17049.8	20674.5	21326.9
Exports	€m (2000)	14367.8	15523.9	14899.0	15555.2	15211.9
Imports	€m	21797.3	21961.7	24202.2	40446.6	49846.4
Imports	€m (2000)	15387.6	21690.6	23608.7	27028.1	30170.6
Price output	2000=1	1.102	1.001	1.023	1.099	1.168

TABLE E187 NO REVENUE RECYCLING CASE: FOOD, DRINK AND TOBACCO IN SLOVENIA

	1996	2000	2004	2008	2012
Output €m	1206.8	1584.0	3048.6	5786.1	8873.5
Output €m (2000)	1506.2	1577.5	2218.8	2646.6	3041.8
Value Added €m (2000)	496.5	510.1	755.0	1401.6	3327.8
Wage Bill €m	222.0	237.2	379.0	559.9	799.2
Energy Input €m	24.2	54.0	52.6	61.2	71.8
Employment th	21.6	22.3	24.8	23.8	23.4
Exports €m	206.3	324.1	579.8	855.8	1121.6
Exports €m (2000)	248.3	321.7	370.4	485.8	577.7
Imports €m	325.3	417.8	676.3	1092.3	1368.9
Imports €m (2000)	394.8	411.8	641.9	712.5	783.4
Price output 2000=1	0.801	1.004	1.374	2.186	2.917

TABLE E188 NO REVENUE RECYCLING CASE: WOOD AND PAPER IN DENMARK

	1996	2000	2004	2008	2012
Output €m	1863.8	1993.2	2949.9	3478.4	4711.1
Output €m (2000)	2289.1	2324.7	1846.5	1925.2	2648.7
Value Added €m (2000)	1088.2	1221.0	1137.0	1092.7	1262.9
Wage Bill €m	666.2	771.7	912.1	1008.5	1440.9
Energy Input €m	52.6	62.6	95.2	119.5	117.3
Employment th	20.9	18.8	19.9	16.9	19.3
Exports €m	389.7	88.1	57.2	80.9	646.4
Exports €m (2000)	356.0	107.3	86.4	120.1	593.6
Imports €m	1986.3	2391.8	2952.4	4074.4	4253.4
Imports €m (2000)	1879.7	1799.5	1747.0	1998.0	2359.9
Price output 2000=1	0.814	0.857	1.598	1.807	1.779

TABLE E189 NO REVENUE RECYCLING CASE: WOOD AND PAPER IN GERMANY

	1996	2000	2004	2008	2012
Output €m	43928.7	53393.2	59335.2	75233.1	78555.5
Output €m (2000)	51893.7	60239.4	48973.4	58158.1	60774.7
Value Added €m (2000)	16528.8	18170.0	19967.4	21214.5	17082.5
Wage Bill €m	8774.4	9531.6	11095.0	12901.0	13820.7
Energy Input €m	1650.9	2301.2	2905.0	3702.3	3777.9
Employment th	364.1	333.9	351.3	353.6	313.0
Exports €m	10266.3	16457.0	23837.9	33420.9	32823.5
Exports €m (2000)	11591.1	17248.8	24071.8	28729.4	28985.4
Imports €m	11484.8	15618.7	19828.0	23899.8	27268.8
Imports €m (2000)	14337.0	16093.6	23171.4	24015.5	26181.9
Price output 2000=1	0.847	0.886	1.212	1.294	1.293

TABLE E190 NO REVENUE RECYCLING CASE: WOOD AND PAPER IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	5554.4	7819.7	11597.2	12037.3	8888.7
Output	€m (2000)	6698.1	8555.8	9511.1	9324.1	6913.9
Value Added	€m (2000)	2248.5	2587.0	3819.0	3358.8	2074.6
Wage Bill	€m	1293.7	1582.0	2077.9	2220.5	2015.3
Energy Input	€m	116.4	189.0	389.3	326.2	242.8
Employment	th	43.9	49.2	58.3	54.1	40.5
Exports	€m	3350.5	4376.3	5602.9	6529.1	6726.0
Exports	€m (2000)	4151.0	4548.0	4552.4	4677.8	4744.1
Imports	€m	5449.3	6252.0	5665.5	7740.0	10869.7
Imports	€m (2000)	5778.6	6528.8	6297.6	7516.2	10105.4
Price output	2000=1	0.829	0.914	1.219	1.291	1.286

TABLE E191 NO REVENUE RECYCLING CASE: WOOD AND PAPER IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	14057.6	20791.7	22347.5	20489.1	20554.5
Output	€m (2000)	16495.7	22047.0	23190.3	23698.6	25043.2
Value Added	€m (2000)	5240.0	6745.0	8044.1	8131.8	8917.4
Wage Bill	€m	1741.2	2166.4	2592.9	2794.2	2850.4
Energy Input	€m	881.7	1239.7	1652.2	1787.5	1636.0
Employment	th	65.6	69.3	70.4	62.8	59.3
Exports	€m	8839.0	13133.2	13731.2	16625.8	20079.5
Exports	€m (2000)	7844.8	13133.2	11961.0	13142.9	14230.7
Imports	€m	513.1	811.0	982.8	1121.5	1201.9
Imports	€m (2000)	733.2	835.7	989.3	956.7	980.2
Price output	2000=1	0.852	0.943	0.964	0.865	0.821

TABLE E192 NO REVENUE RECYCLING CASE: WOOD AND PAPER IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	15454.4	19244.4	25511.8	31489.6	35732.1
Output	€m (2000)	17466.0	21086.4	21760.1	24912.2	29465.9
Value Added	€m (2000)	5767.3	7010.7	8147.9	8353.7	8091.6
Wage Bill	€m	2335.1	2620.0	3045.1	3696.5	3287.2
Energy Input	€m	636.5	777.6	1012.4	1304.7	1277.0
Employment	th	81.4	76.6	76.8	73.8	55.2
Exports	€m	9540.0	11909.7	17670.7	21113.2	19346.6
Exports	€m (2000)	8241.3	12549.4	13413.3	15131.2	15591.8
Imports	€m	1234.2	1947.2	2228.3	3107.1	3503.4
Imports	€m (2000)	1492.0	2001.9	2313.0	2781.2	3068.6
Price output	2000=1	0.885	0.913	1.172	1.264	1.213

TABLE E193 NO REVENUE RECYCLING CASE: WOOD AND PAPER IN THE UK

		1996	2000	2004	2008	2012
Output	€m	30056.7	30865.2	43528.9	42025.1	40819.3
Output	€m (2000)	30780.1	34893.9	35635.7	34898.3	35230.1
Value Added	€m (2000)	10465.0	10310.4	14927.4	7844.5	8379.1
Wage Bill	€m	4715.9	6770.3	7202.4	9200.8	8575.3
Energy Input	€m	1110.3	1188.8	1430.1	2043.6	1672.9
Employment	th	348.2	388.9	323.1	289.5	248.9
Exports	€m	5171.7	5229.8	6826.7	8381.5	8898.3
Exports	€m (2000)	4814.2	5033.4	4929.7	5288.4	5494.0
Imports	€m	11486.5	10836.2	11323.4	15891.4	16368.0
Imports	€m (2000)	11134.4	12516.2	12666.2	13227.2	15377.8
Price output	2000=1	0.977	0.884	1.222	1.204	1.159

TABLE E194 NO REVENUE RECYCLING CASE: WOOD AND PAPER IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	716.1	1024.1	1403.0	2143.2	2799.4
Output	€m (2000)	955.8	1094.5	1133.7	1377.2	1540.5
Value Added	€m (2000)	297.2	350.1	392.4	248.8	397.3
Wage Bill	€m	153.5	165.0	305.6	311.6	324.1
Energy Input	€m	47.7	81.3	71.6	88.2	101.6
Employment	th	22.2	18.9	26.2	17.4	11.6
Exports	€m	407.6	700.4	709.9	756.0	606.8
Exports	€m (2000)	501.3	717.7	581.2	606.0	514.7
Imports	€m	226.5	436.0	630.5	2068.3	1635.9
Imports	€m (2000)	313.8	456.7	577.4	674.9	682.2
Price output	2000=1	0.749	0.936	1.238	1.556	1.817

TABLE E195 NO REVENUE RECYCLING CASE: PHARMACEUTICALS IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	1982.8	3139.7	3594.0	4255.7	5027.3
Output	€m (2000)	1799.8	3139.6	3659.9	4329.3	5093.5
Value Added	€m (2000)	758.4	1801.4	1910.3	2664.7	2894.0
Wage Bill	€m	492.4	640.9	938.4	1260.9	1495.1
Energy Input	€m	7.9	24.5	35.2	39.3	32.8
Employment	th	11.0	12.0	13.0	13.6	13.5
Exports	€m	1859.6	3274.0	4880.7	7173.0	8893.3
Exports	€m (2000)	2443.5	3204.4	3793.7	4640.9	5618.9
Imports	€m	819.5	1393.8	2505.9	3508.4	4155.2
Imports	€m (2000)	794.3	1428.5	1816.8	2259.3	2727.7
Price output	2000=1	1.102	1.000	0.982	0.983	0.987

TABLE E196 NO REVENUE RECYCLING CASE: PHARMACEUTICALS IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	19258.0	23270.1	31335.2	38085.7	38589.0
Output	€m (2000)	21936.6	23990.5	26643.6	29049.9	28209.7
Value Added	€m (2000)	8212.5	8990.0	13972.0	15844.0	14124.6
Wage Bill	€m	4665.5	5768.3	6304.9	9295.1	11587.7
Energy Input	€m	1273.6	2099.1	2455.2	2110.4	1539.4
Employment	th	120.7	121.6	106.5	120.8	115.7
Exports	€m	9336.8	16221.9	25238.2	36110.9	40983.3
Exports	€m (2000)	11898.4	16584.0	21828.3	26226.8	28854.4
Imports	€m	6266.9	11765.9	26356.7	36492.3	46383.2
Imports	€m (2000)	7182.1	12059.7	15664.8	19385.9	24805.8
Price output	2000=1	0.878	0.970	1.176	1.311	1.368

TABLE E197 NO REVENUE RECYCLING CASE: PHARMACEUTICALS IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	5003.3	5651.7	6878.0	8285.2	9438.8
Output	€m (2000)	5744.8	6418.5	6350.9	6807.9	6780.8
Value Added	€m (2000)	1368.7	1557.0	1630.4	1997.5	1913.9
Wage Bill	€m	558.0	629.5	832.2	1030.6	1080.6
Energy Input	€m	0.7	1.5	2.7	2.6	2.1
Employment	th	14.9	15.0	16.9	18.0	15.6
Exports	€m	3546.4	4927.1	9620.5	13631.2	14939.5
Exports	€m (2000)	3956.6	5058.0	6424.3	7509.0	8072.9
Imports	€m	3478.8	4936.6	8992.4	12185.5	13896.0
Imports	€m (2000)	3561.8	5026.3	5942.0	7193.6	8230.0
Price output	2000=1	0.871	0.880	1.083	1.217	1.392

TABLE E198 NO REVENUE RECYCLING CASE: PHARMACEUTICALS IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	518.4	703.3	899.4	964.6	896.6
Output	€m (2000)	442.0	683.6	787.5	772.1	766.5
Value Added	€m (2000)	197.0	267.0	370.2	415.0	406.7
Wage Bill	€m	93.6	123.1	161.1	227.9	280.4
Energy Input	€m	24.3	47.7	70.0	66.0	51.5
Employment	th	4.1	4.3	4.2	4.5	4.6
Exports	€m	190.8	344.3	652.3	953.3	1202.4
Exports	€m (2000)	224.0	352.0	495.9	602.8	729.8
Imports	€m	559.2	891.4	1429.0	1867.2	2205.8
Imports	€m (2000)	504.7	917.5	1129.9	1311.8	1565.8
Price output	2000=1	1.173	1.029	1.142	1.249	1.170

TABLE E199 NO REVENUE RECYCLING CASE: PHARMACEUTICALS IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	4107.0	5498.1	8615.4	11774.9	15218.3
Output	€m (2000)	3973.3	5782.9	7037.4	8468.5	10641.1
Value Added	€m (2000)	1959.8	3006.9	4096.4	5390.9	6900.3
Wage Bill	€m	578.3	888.3	1168.9	1717.2	2499.8
Energy Input	€m	11.4	11.8	21.5	27.4	28.0
Employment	th	15.6	17.5	20.7	21.6	22.3
Exports	€m	2460.0	4197.1	7134.4	11397.4	15372.7
Exports	€m (2000)	2689.4	4288.0	6123.8	8249.5	10792.1
Imports	€m	1220.6	1442.9	3152.2	4399.4	4941.1
Imports	€m (2000)	996.5	1483.9	2164.9	2768.7	3140.6
Price output	2000=1	1.034	0.951	1.224	1.390	1.430

TABLE E200 NO REVENUE RECYCLING CASE: PHARMACEUTICALS IN THE UK

		1996	2000	2004	2008	2012
Output	€m	14867.7	18263.3	27420.1	32620.0	35478.2
Output	€m (2000)	17338.6	19348.3	22338.8	22737.7	23875.1
Value Added	€m (2000)	7527.2	8896.1	10648.4	8945.5	9745.0
Wage Bill	€m	2724.6	4620.5	5675.5	8316.6	11709.5
Energy Input	€m	188.5	182.4	196.1	317.2	334.8
Employment	th	64.8	54.5	44.6	47.0	47.9
Exports	€m	10014.9	12450.2	22030.8	37924.5	52375.1
Exports	€m (2000)	8034.4	12696.1	20642.9	29681.4	39493.0
Imports	€m	6521.9	9655.6	19169.2	29521.1	36341.4
Imports	€m (2000)	5320.7	9942.9	18385.3	25023.4	31468.2
Price output	2000=1	0.858	0.944	1.228	1.435	1.486

TABLE E201 NO REVENUE RECYCLING CASE: PHARMACEUTICALS IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	381.1	561.8	883.7	1474.5	2246.6
Output	€m (2000)	485.1	561.8	839.2	1057.0	1249.5
Value Added	€m (2000)	224.4	311.9	408.1	553.0	733.4
Wage Bill	€m	98.4	115.8	195.7	301.6	457.3
Energy Input	€m	0.2	0.3	0.7	1.2	1.5
Employment	th	5.5	5.2	6.0	5.8	5.6
Exports	€m	239.0	414.8	1238.4	1966.5	2649.9
Exports	€m (2000)	453.9	429.4	1177.4	1577.5	1872.8
Imports	€m	132.9	258.0	454.2	627.4	787.8
Imports	€m (2000)	157.9	267.1	294.1	346.5	435.8
Price output	2000=1	0.785	1.000	1.053	1.395	1.798

TABLE E202 NO REVENUE RECYCLING CASE: CHEMICALS NES IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	3275.0	4100.9	5172.0	7242.2	7243.3
Output	€m (2000)	2927.0	4016.7	5091.8	5836.4	6442.0
Value Added	€m (2000)	993.6	931.3	1329.7	2497.0	1817.7
Wage Bill	€m	612.6	627.8	735.4	936.1	1100.8
Energy Input	€m	112.8	246.0	377.7	398.7	311.3
Employment	th	15.9	14.0	13.7	14.8	15.6
Exports	€m	1974.7	2600.9	3316.6	4796.3	5037.6
Exports	€m (2000)	1887.0	2606.0	3184.7	3706.2	3963.7
Imports	€m	2832.3	2546.4	3128.4	5201.5	6755.9
Imports	€m (2000)	2107.4	2545.8	2909.3	3783.5	4666.9
Price output	2000=1	1.119	1.021	1.016	1.241	1.124

TABLE E203 NO REVENUE RECYCLING CASE: CHEMICALS NES IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	93483.2	101110.9	111572.0	137142.9	133746.6
Output	€m (2000)	96415.6	100734.3	119350.8	129564.2	147428.2
Value Added	€m (2000)	29769.9	30930.0	33121.2	102731.9	2768.0
Wage Bill	€m	19946.9	18765.3	19579.2	21236.1	24085.9
Energy Input	€m	4899.7	7601.2	8412.4	6344.3	4876.5
Employment	th	463.1	386.0	385.0	384.0	379.2
Exports	€m	43489.8	57841.6	72673.5	109643.4	116107.2
Exports	€m (2000)	38639.0	60041.0	77131.9	90592.4	97539.0
Imports	€m	27788.7	45670.8	48133.4	86299.0	100803.9
Imports	€m (2000)	30649.5	45064.1	43794.1	61328.1	68023.6
Price output	2000=1	0.970	1.004	0.935	1.059	0.907

TABLE E204 NO REVENUE RECYCLING CASE: CHEMICALS NES IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	22191.3	29509.1	30351.0	34031.2	35864.2
Output	€m (2000)	24734.5	29071.3	31181.8	34586.1	37570.0
Value Added	€m (2000)	5688.9	6892.0	808.9	1540.5	1610.0
Wage Bill	€m	2622.6	2676.0	3239.7	3270.2	3436.3
Energy Input	€m	1981.4	5643.2	12583.2	12397.2	10518.7
Employment	th	63.8	58.3	56.4	57.1	58.7
Exports	€m	21578.0	22156.3	28595.0	36385.9	42074.7
Exports	€m (2000)	17820.1	22156.3	24419.3	28293.8	29422.9
Imports	€m	13364.5	16398.8	20475.6	33004.5	39986.0
Imports	€m (2000)	11652.0	16738.2	20860.1	25496.6	29713.6
Price output	2000=1	0.897	1.015	0.973	0.984	0.955

TABLE E205 NO REVENUE RECYCLING CASE: CHEMICALS NES IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	4514.3	7314.2	5860.3	7524.5	7972.2
Output	€m (2000)	4604.4	7040.2	5021.0	5064.5	5404.7
Value Added	€m (2000)	1094.0	1275.0	1729.9	2457.7	2239.6
Wage Bill	€m	453.2	587.5	641.1	808.7	903.5
Energy Input	€m	340.2	606.1	560.0	607.4	536.2
Employment	th	16.0	17.3	15.8	15.5	15.3
Exports	€m	1905.7	3361.4	3086.2	3885.0	4434.9
Exports	€m (2000)	2304.3	3322.8	2592.7	2728.3	2975.3
Imports	€m	2000.0	2005.8	3418.3	4707.2	5174.1
Imports	€m (2000)	1760.2	2025.2	2812.3	2935.1	3076.6
Price output	2000=1	0.980	1.039	1.167	1.486	1.475

TABLE E206 NO REVENUE RECYCLING CASE: CHEMICALS NES IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	5527.2	6627.7	7837.8	11840.5	13927.4
Output	€m (2000)	5129.2	6294.6	7219.5	8273.8	9541.1
Value Added	€m (2000)	1651.1	2184.2	2778.5	4082.7	4391.6
Wage Bill	€m	713.5	884.2	1078.4	1645.4	2154.3
Energy Input	€m	356.3	355.1	716.9	942.0	662.6
Employment	th	22.3	22.0	21.3	23.6	23.2
Exports	€m	1980.5	4080.1	5816.4	8732.0	9836.1
Exports	€m (2000)	2826.0	3898.7	4781.9	5821.3	6622.7
Imports	€m	4428.5	5365.2	7257.0	11272.7	12934.9
Imports	€m (2000)	3441.9	5439.3	5979.6	7282.4	7999.1
Price output	2000=1	1.078	1.053	1.086	1.431	1.460

TABLE E207 NO REVENUE RECYCLING CASE: CHEMICALS NES IN THE UK

		1996	2000	2004	2008	2012
Output	€m	62068.2	57201.4	56876.0	74890.7	77438.6
Output	€m (2000)	51081.6	55402.9	56673.1	57419.7	64881.6
Value Added	€m (2000)	14345.1	16013.7	15602.6	12657.4	15003.2
Wage Bill	€m	6177.7	9333.4	8818.5	13373.4	11351.4
Energy Input	€m	2064.8	2224.9	2669.4	3428.7	3412.8
Employment	th	218.3	223.8	164.0	165.4	156.4
Exports	€m	29322.8	26641.1	32018.8	47734.7	48807.6
Exports	€m (2000)	21269.1	26638.7	25990.1	29398.1	30213.2
Imports	€m	26998.2	24663.9	29636.8	42865.1	46779.0
Imports	€m (2000)	19745.3	24660.4	24466.1	26434.8	28050.2
Price output	2000=1	1.215	1.033	1.004	1.304	1.194

TABLE E208 NO REVENUE RECYCLING CASE: CHEMICALS NES IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	537.6	855.4	1098.3	1651.8	2622.5
Output	€m (2000)	645.4	841.0	1013.4	1165.9	1391.5
Value Added	€m (2000)	186.4	231.7	232.8	119.6	265.5
Wage Bill	€m	97.6	104.4	141.1	216.2	340.0
Energy Input	€m	35.5	38.8	81.3	112.9	143.9
Employment	th	9.1	8.8	8.3	8.2	8.6
Exports	€m	354.0	612.9	913.8	1264.8	1542.3
Exports	€m (2000)	458.1	612.9	855.6	1113.4	1226.9
Imports	€m	640.3	966.3	1679.7	3077.9	4089.9
Imports	€m (2000)	741.3	962.4	1468.5	2078.1	2391.6
Price output	2000=1	0.833	1.017	1.084	1.417	1.885

TABLE E209 NO REVENUE RECYCLING CASE: NON-METALLIC MINERAL PRODUCTS IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	2029.3	2218.5	2857.7	3512.3	4663.6
Output	€m (2000)	2346.6	2468.1	2717.0	2978.7	3333.3
Value Added	€m (2000)	1022.8	1133.7	1258.5	1319.8	1880.6
Wage Bill	€m	600.3	784.6	890.8	1163.0	1526.0
Energy Input	€m	88.8	110.1	144.0	211.0	232.0
Employment	th	18.3	20.7	19.4	18.1	18.6
Exports	€m	557.9	696.4	644.0	682.1	638.6
Exports	€m (2000)	622.3	699.4	668.0	572.3	491.2
Imports	€m	503.3	662.9	735.3	1231.0	1555.3
Imports	€m (2000)	640.7	655.3	712.1	839.8	981.5
Price output	2000=1	0.865	0.899	1.052	1.179	1.399

TABLE E210 NO REVENUE RECYCLING CASE: NON-METALLIC MINERAL PRODUCTS IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	13679.4	20006.9	28614.3	41362.0	52503.2
Output	€m (2000)	15609.3	21094.7	22684.9	24312.4	26391.7
Value Added	€m (2000)	6023.1	8117.0	8651.3	10467.5	11706.3
Wage Bill	€m	2646.3	3700.6	4590.3	7019.9	9026.4
Energy Input	€m	1076.4	1282.4	1835.8	2206.1	2135.7
Employment	th	168.4	196.6	202.7	222.5	245.6
Exports	€m	2663.7	4210.2	5471.4	7546.6	9245.2
Exports	€m (2000)	3092.1	4198.3	5135.8	5869.2	6579.2
Imports	€m	1149.7	1921.1	2931.6	4860.9	6285.2
Imports	€m (2000)	1314.8	1912.3	2492.6	2966.4	3521.3
Price output	2000=1	0.900	0.900	1.300	1.700	2.000

TABLE E211 NO REVENUE RECYCLING CASE: NON-METALLIC MINERAL PRODUCTS IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	4664.9	6134.9	7059.0	8679.4	10907.0
Output	€m (2000)	5487.9	6516.3	6356.8	6974.2	7313.0
Value Added	€m (2000)	2153.2	2508.0	2535.3	2592.6	3235.3
Wage Bill	€m	1019.8	1249.4	1396.0	1632.6	1901.3
Energy Input	€m	132.4	186.6	258.9	290.7	266.3
Employment	th	37.8	37.4	35.6	35.3	34.7
Exports	€m	1277.8	1452.2	1446.6	1915.1	2168.0
Exports	€m (2000)	1298.4	1448.1	1548.8	1676.3	1744.0
Imports	€m	1617.4	1884.9	2224.4	3427.7	4334.2
Imports	€m (2000)	1602.4	1880.4	2227.7	2411.0	2807.2
Price output	2000=1	0.850	0.942	1.111	1.244	1.492

TABLE E212 NO REVENUE RECYCLING CASE: NON-METALLIC MINERAL PRODUCTS IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	1555.3	2712.3	2760.2	3668.9	4202.9
Output	€m (2000)	1832.6	2317.7	2516.3	2733.7	2899.7
Value Added	€m (2000)	745.0	925.0	1169.6	1488.6	1592.6
Wage Bill	€m	320.0	476.1	529.1	739.5	854.8
Energy Input	€m	37.7	48.3	70.0	70.4	64.8
Employment	th	14.1	18.6	16.0	13.9	11.8
Exports	€m	385.4	554.7	811.0	1492.1	2151.7
Exports	€m (2000)	322.5	535.5	838.4	1222.4	1604.2
Imports	€m	284.8	435.0	540.8	882.0	964.1
Imports	€m (2000)	376.2	434.6	493.4	558.3	556.9
Price output	2000=1	0.849	1.170	1.097	1.342	1.449

TABLE E213 NO REVENUE RECYCLING CASE: NON-METALLIC MINERAL PRODUCTS IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	2389.9	3011.2	3301.9	3964.5	4897.8
Output	€m (2000)	2601.5	2956.0	3117.0	3381.7	3749.1
Value Added	€m (2000)	994.4	1120.2	1298.4	1422.5	1737.5
Wage Bill	€m	548.7	611.3	609.4	636.8	698.7
Energy Input	€m	91.4	156.0	211.4	264.1	253.2
Employment	th	19.4	18.2	17.3	15.3	14.3
Exports	€m	581.0	748.0	944.2	1198.9	1381.5
Exports	€m (2000)	543.5	744.3	999.3	1065.7	1119.6
Imports	€m	726.6	979.5	1312.4	2020.4	2384.8
Imports	€m (2000)	689.9	975.8	1263.2	1359.9	1486.0
Price output	2000=1	0.919	1.019	1.059	1.172	1.306

TABLE E214 NO REVENUE RECYCLING CASE: NON-METALLIC MINERAL PRODUCTS IN THE UK

		1996	2000	2004	2008	2012
Output	€m	18857.2	20818.9	21707.6	26507.8	28562.7
Output	€m (2000)	18571.8	20410.3	20428.5	20925.5	21724.5
Value Added	€m (2000)	7971.7	8226.7	7851.7	5594.7	7564.0
Wage Bill	€m	3832.7	5598.5	5884.6	7317.1	6833.5
Energy Input	€m	973.5	781.4	750.2	1251.2	1215.5
Employment	th	159.7	156.6	137.9	137.2	116.6
Exports	€m	3477.2	3192.5	3053.4	3807.8	3640.6
Exports	€m (2000)	3067.3	3180.6	2798.8	2826.9	2487.5
Imports	€m	3027.9	3576.3	4668.2	7435.5	9567.2
Imports	€m (2000)	2870.5	3570.9	4153.8	4697.2	5473.6
Price output	2000=1	1.015	1.020	1.063	1.267	1.315

TABLE E215 NO REVENUE RECYCLING CASE: NON-METALLIC MINERAL PRODUCTS IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	388.7	456.3	551.3	595.9	580.2
Output	€m (2000)	480.3	451.7	493.3	439.2	385.0
Value Added	€m (2000)	187.1	218.3	182.6	101.7	106.1
Wage Bill	€m	103.5	108.1	135.1	169.1	201.5
Energy Input	€m	42.6	75.1	68.6	87.0	100.2
Employment	th	12.2	10.6	10.7	9.2	7.2
Exports	€m	171.7	285.1	331.8	384.7	459.8
Exports	€m (2000)	184.1	284.5	250.4	265.5	291.1
Imports	€m	138.5	240.9	392.5	706.0	939.1
Imports	€m (2000)	168.7	239.1	321.9	392.5	451.0
Price output	2000=1	0.809	1.010	1.117	1.357	1.507

TABLE E216 NO REVENUE RECYCLING CASE: BASIC METALS IN DENMARK

		1996	2000	2004	2008	2012
Output	€m	1190.5	1635.6	2029.7	2938.2	3541.1
Output	€m (2000)	1375.7	1642.0	1865.9	1914.1	1987.7
Value Added	€m (2000)	440.7	467.1	564.7	933.5	1156.4
Wage Bill	€m	320.2	374.5	541.5	699.8	865.1
Energy Input	€m	51.6	94.9	128.9	181.3	169.5
Employment	th	8.6	8.9	10.5	9.0	8.2
Exports	€m	661.4	998.9	1119.3	1458.4	1577.6
Exports	€m (2000)	807.1	1007.5	1270.4	1293.9	1316.3
Imports	€m	1461.0	1992.5	1920.7	2929.4	3311.4
Imports	€m (2000)	1621.9	2012.7	2061.0	2123.4	2202.6
Price output	2000=1	0.865	0.996	1.088	1.535	1.782

TABLE E217 NO REVENUE RECYCLING CASE: BASIC METALS IN GERMANY

		1996	2000	2004	2008	2012
Output	€m	45351.4	63294.8	62077.8	81356.0	86336.0
Output	€m (2000)	58590.5	63496.4	71944.0	77549.1	79408.8
Value Added	€m (2000)	15435.9	16330.0	15900.6	38529.9	46054.2
Wage Bill	€m	9566.1	10397.1	11575.0	12333.2	15229.3
Energy Input	€m	4511.2	5269.3	6094.4	7027.9	6499.1
Employment	th	292.2	266.8	254.8	271.4	265.4
Exports	€m	18115.9	27620.7	31574.0	47181.4	54685.7
Exports	€m (2000)	19697.1	27946.0	37955.8	46259.4	50492.5
Imports	€m	16270.2	26591.6	27331.8	50317.6	62142.2
Imports	€m (2000)	20929.6	26787.0	30289.6	37909.5	42643.2
Price output	2000=1	0.774	0.997	0.863	1.049	1.087

TABLE E218 NO REVENUE RECYCLING CASE: BASIC METALS IN THE NETHERLANDS

		1996	2000	2004	2008	2012
Output	€m	5299.7	7804.5	8867.1	13620.4	20904.9
Output	€m (2000)	6215.0	9544.0	9020.5	13008.9	18418.4
Value Added	€m (2000)	1804.5	2031.0	2915.7	4932.6	6627.4
Wage Bill	€m	979.5	1212.4	1634.9	2014.5	3103.0
Energy Input	€m	206.7	406.7	606.1	871.5	1027.1
Employment	th	26.8	28.5	29.9	27.5	31.4
Exports	€m	4544.0	6637.1	7619.2	14212.2	21674.8
Exports	€m (2000)	5240.2	6667.2	8271.0	12179.2	17508.3
Imports	€m	4674.0	5796.8	7153.9	12030.7	14553.1
Imports	€m (2000)	5631.1	5981.0	8187.1	9339.8	10444.4
Price output	2000=1	0.853	0.818	0.983	1.047	1.135

TABLE E219 NO REVENUE RECYCLING CASE: BASIC METALS IN FINLAND

		1996	2000	2004	2008	2012
Output	€m	4576.3	7300.1	6507.4	6904.6	6474.6
Output	€m (2000)	5534.1	7332.4	7327.0	6775.1	6596.5
Value Added	€m (2000)	1077.0	1308.0	658.1	8304.8	1453.6
Wage Bill	€m	477.2	579.1	625.3	799.4	886.9
Energy Input	€m	251.0	516.6	937.7	1327.3	1051.4
Employment	th	17.1	16.9	15.7	15.1	14.5
Exports	€m	2362.4	3848.2	4225.7	6440.9	7077.6
Exports	€m (2000)	2579.6	3892.4	4680.3	5590.7	5772.0
Imports	€m	1384.6	2007.0	2048.6	4540.4	5188.6
Imports	€m (2000)	1273.3	2030.4	2185.0	3255.8	3359.9
Price output	2000=1	0.827	0.996	0.888	1.019	0.982

TABLE E220 NO REVENUE RECYCLING CASE: BASIC METALS IN SWEDEN

		1996	2000	2004	2008	2012
Output	€m	7469.0	10024.7	9528.1	11620.1	12586.8
Output	€m (2000)	8298.0	10059.4	9811.3	9630.4	9714.8
Value Added	€m (2000)	2029.1	2313.4	2189.4	2629.8	2767.0
Wage Bill	€m	995.1	1162.3	1196.5	1424.3	1645.5
Energy Input	€m	352.2	540.8	750.4	898.7	678.7
Employment	th	32.3	30.7	30.1	31.0	32.1
Exports	€m	4346.1	5505.6	7325.2	10381.2	11393.4
Exports	€m (2000)	3970.3	5556.0	6965.0	7993.3	8369.2
Imports	€m	2962.0	4211.6	5084.4	9417.9	11287.1
Imports	€m (2000)	3168.9	4253.0	4882.5	6134.4	6733.2
Price output	2000=1	0.900	0.997	0.971	1.207	1.296

TABLE E221 NO REVENUE RECYCLING CASE: BASIC METALS IN THE UK

		1996	2000	2004	2008	2012
Output	€m	32247.1	27606.2	25320.9	29282.8	34923.3
Output	€m (2000)	27342.6	27669.3	27669.0	24264.6	28017.7
Value Added	€m (2000)	6220.3	6500.6	6674.8	7565.9	8987.7
Wage Bill	€m	4022.2	5093.1	3633.4	6152.9	9676.4
Energy Input	€m	1536.8	869.0	866.8	1033.6	1067.9
Employment	th	149.8	123.2	104.3	138.6	241.2
Exports	€m	12941.8	9450.2	9009.1	16390.3	18466.1
Exports	€m (2000)	10791.2	9561.5	9350.8	12621.1	13213.8
Imports	€m	13671.3	11670.2	10818.7	22807.1	24998.2
Imports	€m (2000)	10248.9	11921.0	10883.4	14841.1	14662.8
Price output	(Index)	1.179	0.998	0.915	1.207	1.246

TABLE E222 NO REVENUE RECYCLING CASE: BASIC METALS IN SLOVENIA

		1996	2000	2004	2008	2012
Output	€m	427.0	960.5	8.7	13.9	16.8
Output	€m (2000)	567.6	965.4	8.9	9.3	9.4
Value Added	€m (2000)	133.0	205.0	1.1	2.0	2.1
Wage Bill	€m	88.4	103.8	10.5	11.9	16.9
Energy Input	€m	37.8	85.1	1.7	2.3	2.5
Employment	th	10.4	8.7	0.7	0.5	0.5
Exports	€m	328.8	710.9	670.6	808.7	887.5
Exports	€m (2000)	427.3	716.7	690.9	680.0	721.7
Imports	€m	398.8	696.6	2623.8	11396.4	18886.0
Imports	€m (2000)	549.9	696.6	2418.2	7773.8	11005.8
Price output	2000=1	0.752	0.995	0.978	1.495	1.791

TABLE E223 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR GERMANY

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	195603.1	213802.8	217280.1	256200.6	316733.6
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1948.8	2120.9	2188.4	2274.8	2392.1
GDP deflator 2000=1	1.0	1.1	1.0	1.1	1.2
SC cons. €bn (2000)	1127.7	1199.2	1219.0	1236.1	1287.0
PSC 2000=1	1.0	1.1	1.1	1.1	1.2
SK invest. €bn (2000)	434.4	491.0	413.2	462.0	476.8
PSK 2000=1	1.1	1.0	1.0	1.1	1.1
SX €bn (2000)	454.2	631.9	764.1	921.4	1021.1
PSX 2000=1	0.9	1.0	1.1	1.3	1.3
SM €bn (2000)	431.7	550.5	605.6	739.8	826.7
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	222794.1	257823.9	321886.1	269482.3	260200.4
CO2 mtC-eq	189174.4	220103.1	281676.4	228296.3	220361.2
FR003IS fuel use mtoe	9930.0	10782.9	8363.7	8615.4	8357.2
FR004NF fuel use mtoe	2637.9	2795.6	2855.3	3232.2	3350.5
FR005NM fuel use mtoe	29610.4	31311.9	24619.4	18853.0	13344.1
FR010PP fuel use mtoe	4347.1	4536.5	4486.6	4481.4	4307.2
FCO2(03) IS mtC-eq	13659.9	14337.3	11431.3	11050.7	10797.7
FCO2(04) NF mtC-eq	771.6	870.0	947.4	1140.7	1253.0
FCO2(05) NM mtC-eq	4809.8	3754.0	4075.8	3940.7	3399.5
FCO2(10) PP mtC-eq	1087.4	1195.1	1003.4	898.9	840.4

TABLE E224 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR FRANCE

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.3	0.3	0.3	0.3	0.3
Empl tax revs RERS	152267.3	157935.4	187981.3	228950.5	276750.7
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1257.1	1401.0	1462.9	1583.8	1759.9
GDP deflator 2000=1	1.0	1.1	1.2	1.3	1.3
SC cons. €bn (2000)	725.8	783.6	842.6	891.3	969.6
PSC 2000=1	0.9	1.1	1.2	1.3	1.4
SK invest. €bn (2000)	228.8	268.7	308.5	327.5	376.5
PSK 2000=1	1.0	1.1	1.2	1.2	1.2
SX €bn (2000)	270.4	385.9	375.1	452.5	509.2
PSX 2000=1	1.0	1.0	1.1	1.3	1.4
SM €bn (2000)	276.0	380.4	422.6	501.0	561.7
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	130973.7	150333.0	146704.1	173444.8	127574.6
CO2 mtC-eq	92838.0	112031.1	108903.1	131813.0	93022.6
FR003IS fuel use mtoe	5961.4	5298.8	5241.8	5147.3	4576.1
FR004NF fuel use mtoe	1580.2	1647.7	1403.5	1637.3	1684.8
FR005NM fuel use mtoe	17951.5	20701.7	18014.5	16566.9	16943.5
FR010PP fuel use mtoe	3427.4	3759.0	4050.2	3678.1	3681.8
FCO2(03) IS mtC-eq	7159.3	6136.3	6979.3	6596.0	6339.9
FCO2(04) NF mtC-eq	475.4	567.4	626.9	745.8	802.5
FCO2(05) NM mtC-eq	2282.7	2441.1	2454.1	2346.1	2445.3
FCO2(10) PP mtC-eq	1310.7	1399.4	1477.3	1283.8	1348.0

TABLE E225 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR ITALY

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	44096.2	58832.2	79229.1	111351.7	146010.3
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	522.9	610.1	676.4	728.4	811.8
GDP deflator 2000=1	0.9	1.0	1.2	1.4	1.4
SC cons. €bn (2000)	336.8	398.0	427.0	457.6	519.7
PSC 2000=1	0.9	1.0	1.2	1.4	1.5
SK invest. €bn (2000)	110.5	153.5	181.8	220.6	237.1
PSK 2000=1	0.9	1.0	1.2	1.2	1.2
SX €bn (2000)	112.7	165.3	181.1	209.0	245.5
PSX 2000=1	0.9	1.0	1.1	1.3	1.4
SM €bn (2000)	118.2	192.0	215.2	258.4	305.5
PSM 2000=1	0.9	1.0	1.1	1.2	1.3
GHG mtC-eq	74465.7	89241.6	95339.6	95450.9	94495.5
CO2 mtC-eq	65702.7	78720.7	84599.5	85753.3	85302.1
FR003IS fuel use mtoe	2795.1	3603.6	4911.1	5194.5	5046.2
FR004NF fuel use mtoe	1011.7	1155.4	1656.8	1743.1	1825.4
FR005NM fuel use mtoe	7447.9	9655.9	8713.0	8246.9	8718.1
FR010PP fuel use mtoe	1821.6	2564.8	3200.5	3266.5	3101.6
FCO2(03) IS mtC-eq	2789.2	3049.1	3455.4	3280.8	3091.1
FCO2(04) NF mtC-eq	303.7	369.6	500.8	527.9	555.6
FCO2(05) NM mtC-eq	1459.8	1166.2	1145.0	1095.2	1051.3
FCO2(10) PP mtC-eq	654.9	880.2	830.2	698.7	642.2

TABLE E226 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR SPAIN

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.4	0.3	0.3	0.3	0.3
Empl tax revs RERS	106109.8	109377.8	140714.7	199091.9	231728.1
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1070.9	1176.4	1253.9	1353.2	1418.1
GDP deflator 2000=1	0.9	1.0	1.2	1.5	1.4
SC cons. €bn (2000)	648.9	733.0	742.7	768.0	836.8
PSC 2000=1	0.9	1.0	1.2	1.5	1.4
SK invest. €bn (2000)	178.0	225.6	236.7	275.2	267.6
PSK 2000=1	1.0	1.0	1.3	1.5	1.3
SX €bn (2000)	244.6	321.6	342.2	387.0	410.8
PSX 2000=1	1.0	1.0	1.1	1.3	1.4
SM €bn (2000)	225.6	327.5	324.4	354.9	404.6
PSM 2000=1	0.9	1.0	1.1	1.2	1.2
GHG mtC-eq	122784.8	126662.7	130711.8	130978.6	131457.3
CO2 mtC-eq	111998.8	115215.5	118984.1	119457.5	119499.4
FR003IS fuel use mtoe	4837.5	5446.9	5701.2	5776.2	5281.4
FR004NF fuel use mtoe	867.2	939.3	891.3	1064.8	1082.3
FR005NM fuel use mtoe	11906.0	11538.5	11623.2	10306.6	8954.1
FR010PP fuel use mtoe	2469.9	2642.3	2733.7	2810.0	2686.8
FCO2(03) IS mtC-eq	5449.2	4733.5	4131.8	4398.4	3805.8
FCO2(04) NF mtC-eq	262.2	387.2	373.6	440.8	437.8
FCO2(05) NM mtC-eq	1673.4	1188.5	1361.0	1275.1	1170.2
FCO2(10) PP mtC-eq	857.1	823.9	830.5	834.6	804.3

TABLE E227 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR UK

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.1	0.1	0.1	0.1	0.1
Empl tax revs RERS	38568.1	65512.3	74813.6	114613.5	121600.4
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1424.7	1804.4	1861.1	1959.4	2182.0
GDP deflator 2000=1	1.0	0.9	1.1	1.4	1.4
SC cons. €bn (2000)	952.1	1145.2	1202.8	1222.9	1390.3
PSC 2000=1	0.9	0.9	1.0	1.3	1.3
SK invest. €bn (2000)	185.0	280.7	318.6	375.3	419.8
PSK 2000=1	1.1	0.9	1.0	1.2	1.2
SX €bn (2000)	310.8	446.2	454.8	508.0	535.0
PSX 2000=1	1.5	1.1	1.3	1.5	1.7
SM €bn (2000)	286.9	369.6	430.4	514.5	587.5
PSM 2000=1	1.2	1.0	1.1	1.2	1.3
GHG mtC-eq	183170.6	204384.1	199985.3	176197.1	171141.8
CO2 mtC-eq	168520.0	189904.7	183849.1	160345.6	154118.7
FR003IS fuel use mtoe	4667.4	4173.9	3587.2	3036.2	3359.2
FR004NF fuel use mtoe	1204.8	1121.6	1089.8	1136.7	1155.5
FR005NM fuel use mtoe	14078.7	15808.6	14476.0	12651.3	9728.0
FR010PP fuel use mtoe	2532.4	2630.2	2786.1	2580.7	2508.0
FCO2(03) IS mtC-eq	7127.7	6204.6	5592.9	4184.2	4613.5
FCO2(04) NF mtC-eq	481.6	501.8	503.2	545.3	554.4
FCO2(05) NM mtC-eq	2182.9	3164.3	3031.5	2930.3	3058.0
FCO2(10) PP mtC-eq	884.3	473.8	576.8	574.1	547.5

TABLE E228 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR REST OF EU15

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.1	0.1	0.1	0.1	0.1
Empl tax revs RERS	78587.2	97615.5	116889.9	145808.3	176862.2
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	1527.2	1819.5	1969.3	2192.4	2390.6
GDP deflator 2000=1	0.9	1.0	1.2	1.3	1.3
SC cons. €bn (2000)	851.0	971.6	1061.0	1146.0	1265.9
PSC 2000=1	0.9	1.0	1.1	1.2	1.3
SK invest. €bn (2000)	291.4	387.6	424.4	485.3	530.3
PSK 2000=1	0.9	1.1	1.2	1.2	1.2
SX €bn (2000)	652.0	906.6	1003.5	1170.2	1301.4
PSX 2000=1	0.9	1.1	1.2	1.4	1.4
SM €bn (2000)	618.1	829.4	924.6	1052.5	1185.2
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	212950.9	220970.1	234472.1	216507.9	215858.9
CO2 mtC-eq	187859.6	200728.5	214395.4	199973.7	199106.9
FR003IS fuel use mtoe	7988.9	9041.0	9507.7	9170.1	8758.1
FR004NF fuel use mtoe	2894.7	3433.7	3091.9	3568.5	4203.0
FR005NM fuel use mtoe	25329.6	29801.5	28997.9	29856.8	29093.9
FR010PP fuel use mtoe	15160.7	18615.3	18428.2	19150.0	20510.5
FCO2(03) IS mtC-eq	11414.3	11329.2	12308.5	10242.9	9685.3
FCO2(04) NF mtC-eq	1042.9	1319.6	1445.3	1642.0	1785.1
FCO2(05) NM mtC-eq	3802.4	4355.3	4463.0	4436.5	4308.0
FCO2(10) PP mtC-eq	2333.3	2415.5	2471.3	2267.6	2119.6

TABLE E229 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR POLAND

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	7538.1	10966.9	15504.5	29715.5	47543.5
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	157.3	170.0	182.8	209.5	242.2
GDP deflator 2000=1	0.6	1.0	1.3	1.7	1.9
SC cons. €bn (2000)	113.9	115.8	132.2	152.2	182.5
PSC 2000=1	0.6	1.0	1.3	1.9	2.2
SK invest. €bn (2000)	23.1	23.2	24.6	31.3	36.8
PSK 2000=1	0.7	1.0	1.1	1.3	1.2
SX €bn (2000)	32.9	50.1	65.5	84.4	91.1
PSX 2000=1	0.6	1.1	1.2	1.3	1.4
SM €bn (2000)	37.1	47.4	66.9	88.2	101.1
PSM 2000=1	0.8	1.1	1.2	1.4	1.5
GHG mtC-eq	120294.8	106936.2	103316.4	105076.4	110665.0
CO2 mtC-eq	89730.7	81329.8	76338.6	76903.8	80421.3
FR003IS fuel use mtoe	4932.4	4508.3	3222.7	2854.8	2683.6
FR004NF fuel use mtoe	824.0	779.2	693.4	619.3	614.3
FR005NM fuel use mtoe	7272.5	6912.9	6640.3	7282.3	8152.5
FR010PP fuel use mtoe	1156.6	1008.8	1133.0	1056.9	997.2
FCO2(03) IS mtC-eq	5918.5	5083.3	4143.6	3550.5	3264.6
FCO2(04) NF mtC-eq	566.9	495.3	459.4	405.9	352.9
FCO2(05) NM mtC-eq	2385.0	2384.2	2156.5	1977.1	1933.9
FCO2(10) PP mtC-eq	727.6	631.8	596.6	493.0	396.1

TABLE E230 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR REST OF EU10

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	29099.4	38043.4	51349.2	82308.5	123838.7
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	393.8	454.3	494.0	575.5	649.7
GDP deflator 2000=1	0.8	1.0	1.2	1.5	1.6
SC cons. €bn (2000)	207.5	237.9	268.8	295.8	336.8
PSC 2000=1	0.8	1.0	1.1	1.5	1.7
SK invest. €bn (2000)	82.3	99.0	115.2	144.1	166.5
PSK 2000=1	0.9	1.1	1.3	1.5	1.5
SX €bn (2000)	138.6	208.3	276.2	339.4	382.4
PSX 2000=1	0.9	1.0	1.2	1.3	1.4
SM €bn (2000)	139.8	215.7	289.4	356.2	404.6
PSM 2000=1	0.9	1.0	1.2	1.3	1.3
GHG mtC-eq	109909.9	101728.5	101037.4	101189.9	103902.1
CO2 mtC-eq	90068.2	82821.7	82111.4	82012.2	84605.3
FR003IS fuel use mtoe	6279.0	5335.9	5245.4	4775.2	4355.8
FR004NF fuel use mtoe	1216.8	1010.9	1136.0	1176.4	1207.7
FR005NM fuel use mtoe	9624.3	9101.4	8808.3	9259.7	9167.8
FR010PP fuel use mtoe	7002.0	7708.2	7435.7	8975.0	10531.9
FCO2(03) IS mtC-eq	7751.7	6876.8	6487.2	5506.3	4956.7
FCO2(04) NF mtC-eq	601.8	544.7	814.9	685.9	733.6
FCO2(05) NM mtC-eq	1001.5	1627.0	1850.1	1897.8	1755.9
FCO2(10) PP mtC-eq	1296.9	1129.3	1295.2	1411.5	1242.2

TABLE E231 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR EU15

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	615231.8	703075.9	816908.8	0.4	1269685.4
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	7751.6	8932.3	9412.0	10092.1	10954.6
GDP deflator 2000=1	0.9	1.0	1.1	1.3	1.3
SC cons. €bn (2000)	4642.4	5230.7	5495.2	5721.8	6269.1
PSC 2000=1	0.9	1.0	1.1	1.3	1.3
SK invest. €bn (2000)	1428.1	1807.1	1883.2	2145.9	2308.1
PSK 2000=1	1.0	1.0	1.1	1.2	1.2
SX €bn (2000)	2044.7	2857.5	3120.7	3648.1	4023.0
PSX 2000=1	1.0	1.0	1.2	1.3	1.4
SM €bn (2000)	1956.4	2649.5	2922.8	3421.1	3871.2
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	947139.6	1049415.4	0.9	0.6	1000728.4
CO2 mtC-eq	816093.4	916703.4	992407.6	925639.2	871410.9
FR003IS fuel use mtoe	36180.3	38347.2	37312.7	36939.7	35378.2
FR004NF fuel use mtoe	10196.6	11093.4	10988.6	12382.5	13301.5
FR005NM fuel use mtoe	106324.0	118818.1	106444.0	96481.6	86781.7
FR010PP fuel use mtoe	29759.1	34748.0	35685.3	35966.8	36795.9
FCO2(03) IS mtC-eq	47599.5	45790.0	43899.3	39753.0	38333.3
FCO2(04) NF mtC-eq	3337.3	4015.6	4397.2	5042.6	5388.4
FCO2(05) NM mtC-eq	16210.9	16069.5	16530.4	16023.8	15432.3
FCO2(10) PP mtC-eq	7127.7	7187.9	7189.5	6557.8	6302.0

TABLE E232 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR EU10

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	20753.0	28996.2	44340.2	84422.2	137693.5
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	324.3	358.8	400.0	473.2	537.3
GDP deflator 2000=1	0.6	1.0	1.2	1.7	2.0
SC cons. €bn (2000)	206.5	224.8	265.0	304.0	356.1
PSC 2000=1	0.7	1.0	1.2	1.8	2.2
SK invest. €bn (2000)	65.7	70.5	84.6	107.6	127.1
PSK 2000=1	0.7	1.0	1.2	1.5	1.4
SX €bn (2000)	103.4	162.1	230.9	295.4	332.6
PSX 2000=1	0.7	1.1	1.1	1.3	1.3
SM €bn (2000)	112.4	173.8	258.8	332.7	386.7
PSM 2000=1	0.8	1.0	1.1	1.3	1.4
GHG mtC-eq	213217.0	192572.5	187444.6	190944.2	197267.2
CO2 mtC-eq	164943.8	150034.1	143861.8	146142.7	150339.7
FR003IS fuel use mtoe	9963.7	8630.4	7156.2	6424.9	5972.3
FR004NF fuel use mtoe	1736.8	1484.7	1519.9	1495.3	1540.9
FR005NM fuel use mtoe	15020.5	14522.0	13062.3	13984.6	15184.1
FR010PP fuel use mtoe	2537.5	2259.4	2529.8	2464.9	2537.2
FCO2(03) IS mtC-eq	12148.7	10558.7	9201.5	7938.5	7114.1
FCO2(04) NF mtC-eq	1102.0	928.9	1137.7	940.1	931.4
FCO2(05) NM mtC-eq	3272.6	3847.3	3808.2	3665.8	3471.3
FCO2(10) PP mtC-eq	1507.0	1241.2	1377.1	1309.2	1199.7

TABLE E233 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR EU25

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	635984.8	732072.1	861249.1	0.4	1407378.8
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	8075.9	9291.1	9812.0	10565.3	11491.8
GDP deflator 2000=1	0.9	1.0	1.1	1.3	1.4
SC cons. €bn (2000)	4848.8	5455.5	5760.2	6025.8	6625.2
PSC 2000=1	0.9	1.0	1.1	1.3	1.4
SK invest. €bn (2000)	1493.8	1877.6	1967.8	2253.5	2435.2
PSK 2000=1	1.0	1.0	1.1	1.2	1.2
SX €bn (2000)	2148.1	3019.6	3351.6	3943.6	4355.6
PSX 2000=1	1.0	1.0	1.2	1.3	1.4
SM €bn (2000)	2068.9	2823.4	3181.6	3753.8	4257.9
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	0.6	1241987.9	0.5	0.6	1197995.5
CO2 mtC-eq	981037.2	1066737.5	0.3	0.9	1021750.6
FR003IS fuel use mtoe	46144.0	46977.6	44468.8	43364.6	41350.5
FR004NF fuel use mtoe	11933.4	12578.1	12508.6	13877.8	14842.4
FR005NM fuel use mtoe	121344.6	133340.0	119506.3	110466.2	101965.8
FR010PP fuel use mtoe	32296.6	37007.4	38215.1	38431.7	39333.1
FCO2(03) IS mtC-eq	59748.3	56348.7	53100.8	47691.4	45447.4
FCO2(04) NF mtC-eq	4439.3	4944.5	5534.9	5982.7	6319.8
FCO2(05) NM mtC-eq	19483.5	19916.7	20338.6	19689.6	18903.6
FCO2(10) PP mtC-eq	8634.6	8429.1	8566.5	7867.0	7501.7

TABLE E234 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR EUROZONE 11

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	576094.1	638886.4	752546.0	983356.8	1232851.8
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	6165.6	6931.6	7349.4	7933.6	8554.2
GDP deflator 2000=1	0.9	1.0	1.1	1.3	1.3
SC cons. €bn (2000)	3621.8	4009.9	4230.6	4446.5	4832.1
PSC 2000=1	0.9	1.0	1.1	1.3	1.4
SK invest. €bn (2000)	1228.7	1487.9	1522.6	1727.8	1844.3
PSK 2000=1	1.0	1.0	1.2	1.2	1.2
SX €bn (2000)	1710.7	2399.2	2702.4	3210.7	3572.1
PSX 2000=1	0.9	1.0	1.1	1.3	1.4
SM €bn (2000)	1653.9	2281.5	2562.8	3022.4	3432.0
PSM 2000=1	0.9	1.0	1.1	1.3	1.3
GHG mtC-eq	920675.1	980547.6	0.1	0.8	965932.9
CO2 mtC-eq	759805.1	823530.6	892131.6	852430.3	811057.4
FR003IS fuel use mtoe	40020.4	41313.2	39221.8	38722.5	36498.8
FR004NF fuel use mtoe	9732.1	10332.3	10256.6	11477.4	12388.1
FR005NM fuel use mtoe	104751.5	115320.1	101887.1	94270.9	88905.2
FR010PP fuel use mtoe	23860.4	27663.0	29085.7	27938.1	27477.1
FCO2(03) IS mtC-eq	51002.5	48641.2	45961.5	42262.7	39598.9
FCO2(04) NF mtC-eq	3459.4	3869.5	4436.4	4795.5	5075.1
FCO2(05) NM mtC-eq	17001.3	16369.0	16874.0	16318.5	15376.6
FCO2(10) PP mtC-eq	7112.0	7328.0	7343.4	6573.1	6399.0

TABLE E235 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR DENMARK

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.0	0.0	0.0	0.0	0.0
Empl tax revs RERS	243.6	263.2	228.8	299.6	370.5
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	151.9	166.8	177.6	197.1	217.4
GDP deflator 2000=1	0.9	1.0	1.1	1.3	1.4
SC cons. €bn (2000)	79.4	79.5	85.6	95.3	108.3
PSC 2000=1	0.9	1.1	1.2	1.4	1.5
SK invest. €bn (2000)	22.7	28.5	31.9	36.5	42.5
PSK 2000=1	1.1	1.3	1.3	1.5	1.5
SX €bn (2000)	46.4	59.0	63.5	73.2	83.1
PSX 2000=1	0.9	1.0	1.0	1.2	1.3
SM €bn (2000)	40.2	47.5	51.9	61.3	72.6
PSM 2000=1	1.0	1.2	1.2	1.4	1.4
GHG mtC-eq	17613.5	16572.2	15363.0	13282.3	14359.8
CO2 mtC-eq	15947.4	14793.0	13703.4	11862.4	12626.6
FR003IS fuel use mtoe	108.9	87.6	79.5	89.7	88.5
FR004NF fuel use mtoe	15.6	16.6	18.8	20.3	22.7
FR005NM fuel use mtoe	255.1	281.6	266.2	225.5	248.0
FR010PP fuel use mtoe	145.1	87.5	114.8	127.4	119.1
FCO2(03) IS mtC-eq	36.0	21.2	28.6	30.0	24.8
FCO2(04) NF mtC-eq	11.3	4.3	4.8	5.7	5.9
FCO2(05) NM mtC-eq	92.2	94.3	80.9	53.4	52.8
FCO2(10) PP mtC-eq	57.7	22.3	48.0	39.9	30.3

TABLE E236 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR IRELAND

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.1	0.1	0.1	0.1	0.1
Empl tax revs RERS	1553.9	2657.8	3725.9	4512.8	5457.3
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	70.6	104.9	135.4	164.4	188.2
GDP deflator 2000=1	0.8	1.0	1.1	1.1	1.2
SC cons. €bn (2000)	39.0	52.7	61.9	72.4	82.2
PSC 2000=1	0.9	1.0	1.1	1.1	1.2
SK invest. €bn (2000)	13.7	25.6	30.7	36.2	41.2
PSK 2000=1	0.8	1.0	1.1	1.1	1.1
SX €bn (2000)	50.1	85.0	103.2	129.0	156.3
PSX 2000=1	0.8	1.0	1.0	1.1	1.2
SM €bn (2000)	28.4	56.3	61.8	76.2	91.6
PSM 2000=1	1.1	1.0	0.9	1.0	1.1
GHG mtC-eq	12596.4	12101.0	12867.5	13401.7	13682.9
CO2 mtC-eq	9340.0	11148.6	11890.7	12399.8	12669.1
FR003IS fuel use mtoe	46.8	55.4	5.0	3.8	3.9
FR004NF fuel use mtoe	669.7	683.8	209.1	245.9	250.3
FR005NM fuel use mtoe	689.7	762.2	333.2	353.7	361.3
FR010PP fuel use mtoe	171.3	186.3	20.6	18.9	18.6
FCO2(03) IS mtC-eq	19.5	16.2	18.6	19.8	20.6
FCO2(04) NF mtC-eq	222.7	218.3	316.8	407.8	465.7
FCO2(05) NM mtC-eq	139.2	199.5	223.9	230.3	222.7
FCO2(10) PP mtC-eq	9.4	8.6	15.1	10.7	7.5

TABLE E237 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR THE NETHERLANDS

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.0	0.0	0.0	0.0	0.0
Empl tax revs RERS	4523.6	5897.2	6254.0	7516.1	9073.6
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	347.9	419.0	445.9	478.7	494.9
GDP deflator 2000=1	0.9	1.0	1.2	1.3	1.3
SC cons. €bn (2000)	171.9	203.6	218.7	220.7	238.1
PSC 2000=1	0.9	1.0	1.1	1.2	1.3
SK invest. €bn (2000)	69.5	91.3	100.8	108.2	117.1
PSK 2000=1	0.9	1.0	1.1	1.2	1.2
SX €bn (2000)	173.8	231.1	245.6	283.2	308.5
PSX 2000=1	0.9	1.0	1.1	1.3	1.3
SM €bn (2000)	156.1	205.2	228.4	254.3	288.9
PSM 2000=1	0.9	1.0	1.0	1.1	1.2
GHG mtC-eq	54575.1	57737.8	52374.4	48774.2	48856.5
CO2 mtC-eq	45108.6	49309.7	45966.3	43185.6	43478.8
FR003IS fuel use mtoe	948.8	1173.0	1299.1	1415.6	1496.2
FR004NF fuel use mtoe	542.6	899.6	930.9	1211.0	1780.8
FR005NM fuel use mtoe	12082.9	13050.1	13694.9	13860.7	13438.3
FR010PP fuel use mtoe	719.8	954.2	1310.4	865.1	996.6
FCO2(03) IS mtC-eq	2056.1	2222.5	2102.0	2193.6	2330.1
FCO2(04) NF mtC-eq	74.4	122.3	92.1	109.8	127.2
FCO2(05) NM mtC-eq	1721.5	1986.2	1923.3	1877.0	1717.7
FCO2(10) PP mtC-eq	108.0	174.6	198.2	91.2	132.5

TABLE E238 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR FINLAND

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	9862.2	10755.7	12899.0	16329.8	18850.3
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	106.5	132.4	144.1	158.1	177.4
GDP deflator 2000=1	1.0	1.0	1.1	1.1	1.2
SC cons. €bn (2000)	57.0	66.4	75.8	81.4	90.8
PSC 2000=1	0.9	1.0	1.1	1.3	1.3
SK invest. €bn (2000)	18.0	25.6	26.3	29.0	31.1
PSK 2000=1	1.0	1.2	1.2	1.3	1.4
SX €bn (2000)	36.2	57.6	62.6	72.6	82.0
PSX 2000=1	1.0	1.0	1.0	1.2	1.2
SM €bn (2000)	28.0	39.2	46.4	48.9	57.0
PSM 2000=1	0.9	1.0	1.1	1.6	1.6
GHG mtC-eq	17609.6	18643.6	23484.5	16366.2	14688.5
CO2 mtC-eq	15417.9	16857.5	20576.0	15278.8	13680.5
FR003IS fuel use mtoe	919.2	1025.1	1153.5	1136.5	1194.7
FR004NF fuel use mtoe	184.5	197.5	265.9	259.7	227.1
FR005NM fuel use mtoe	1721.2	1691.3	1266.4	1182.9	1166.3
FR010PP fuel use mtoe	5853.2	7919.5	7639.9	6905.8	6658.6
FCO2(03) IS mtC-eq	1433.7	1629.0	1545.5	1257.9	1361.5
FCO2(04) NF mtC-eq	31.1	31.8	32.0	33.3	29.4
FCO2(05) NM mtC-eq	197.2	295.8	315.2	225.2	184.5
FCO2(10) PP mtC-eq	1042.7	1033.4	994.5	835.4	849.8

TABLE E239 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR SWEDEN

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.2	0.2	0.2
Empl tax revs RERS	15884.5	20014.2	22513.5	27601.9	33688.7
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	226.9	265.4	276.8	311.7	354.6
GDP deflator 2000=1	0.9	1.0	1.2	1.2	1.2
SC cons. €bn (2000)	114.9	128.9	136.0	144.0	163.3
PSC 2000=1	0.9	1.0	1.0	1.1	1.2
SK invest. €bn (2000)	39.7	51.7	55.3	67.7	76.2
PSK 2000=1	0.9	1.2	1.3	1.4	1.4
SX €bn (2000)	68.0	96.3	110.8	128.4	140.9
PSX 2000=1	1.0	1.0	1.4	1.5	1.5
SM €bn (2000)	64.4	89.3	97.5	111.7	118.9
PSM 2000=1	1.0	1.1	1.2	1.4	1.4
GHG mtC-eq	16987.8	16092.1	16909.1	15322.1	17299.9
CO2 mtC-eq	14855.1	14117.4	14588.2	12773.3	14686.8
FR003IS fuel use mtoe	1247.6	1213.8	1312.0	1205.1	1067.0
FR004NF fuel use mtoe	304.0	305.3	309.4	300.4	281.1
FR005NM fuel use mtoe	1876.3	1492.3	2386.4	2557.4	2136.2
FR010PP fuel use mtoe	5621.2	6457.6	6038.9	7567.0	8991.8
FCO2(03) IS mtC-eq	1521.4	1401.4	1429.3	1118.3	1107.2
FCO2(04) NF mtC-eq	66.7	111.2	136.7	151.6	155.0
FCO2(05) NM mtC-eq	113.9	163.9	198.3	209.1	218.4
FCO2(10) PP mtC-eq	517.6	519.9	514.6	595.3	438.6

TABLE E240 NO REVENUE RECYCLING CASE: MACRO RESULTS FOR SLOVENIA

	1996	2000	2004	2008	2012
Empl tax rate RERS/RWS	0.2	0.2	0.3	0.3	0.3
Empl tax revs RERS	1700.0	2918.1	4529.9	6896.3	10393.9
$/euro rate	1.3	0.9	1.2	1.3	1.2
£/euro rate	0.8	0.6	0.7	0.7	0.7
GDP €bn (2000)	16.4	17.0	21.6	21.1	22.7
GDP deflator 2000=1	0.7	1.0	1.5	1.9	2.2
SC cons. €bn (2000)	11.1	11.3	15.0	16.1	18.5
PSC 2000=1	0.8	1.3	1.4	2.1	2.5
SK invest. €bn (2000)	3.0	3.6	4.7	5.1	5.4
PSK 2000=1	0.8	1.0	1.2	1.7	1.7
SX €bn (2000)	8.6	11.6	15.0	18.7	21.6
PSX 2000=1	0.7	1.0	1.3	1.5	1.6
SM €bn (2000)	8.4	11.9	17.3	25.4	31.5
PSM 2000=1	0.8	1.4	1.2	1.4	1.5
GHG mtC-eq	4144.1	4521.6	4598.5	4417.4	4269.1
CO2 mtC-eq	3446.9	3780.6	3902.2	3745.7	3633.8
FR003IS fuel use mtoe	164.1	160.1	132.4	125.6	118.5
FR004NF fuel use mtoe	106.9	121.1	176.9	160.4	155.1
FR005NM fuel use mtoe	291.9	221.5	228.0	260.4	259.4
FR010PP fuel use mtoe	121.6	260.9	252.7	257.3	272.3
FCO2(03) IS mtC-eq	89.2	84.5	79.6	75.7	70.1
FCO2(04) NF mtC-eq	207.4	101.8	286.0	173.8	187.2
FCO2(05) NM mtC-eq	45.2	42.9	30.3	39.4	34.7
FCO2(10) PP mtC-eq	58.4	121.3	105.8	128.2	129.6

E3ME 4: an Energy–Environment–Economy Model for Europe

A Non–Technical Description

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Contents

Executive Summary

- The E3ME model provides the most appropriate framework within which to analyse the competitiveness effects of environmental tax reform (ETR) and to undertake, from an ex-post perspective, a comprehensive sectoral analysis of Europe's environmental tax reforms.

- The model can produce EU-wide analysis, capturing short and long-run effects with particular emphasis on competitiveness. It provides a rigorous basis for comparing the short and long-term costs of environmental tax reform and for undertaking scenario analysis.

- The model captures the inter-industry effects, with a great deal of detail and also deals with the dynamic effects of alternative ETR scenarios for output, employment, external trade, investment in capital and R&D. It can analyse long-term structural change in energy demand and supply and in the whole economy, by focusing on the contribution of research and development, and associated technological innovation, to the dynamics of growth and change.

- Because it models E3 interactions, E3ME has the advantage of dealing with energy, the environment, population and the economy within one modelling framework without the problems of model linkages encountered by other approaches.

- The model is based on a system of dynamic equations estimated on annual data and calibrated to recent outcomes.

- In the context of COMETR, E3ME provides an EU and industry-wide approach that can measure direct and indirect effects of ETR on the sectors and regions of interest. The model provides a consistent framework for analysing the effects on capital accumulation and employment and can identify the ETR effects on costs of different technologies. The differential impact on tax-reform-member-states and non-ETR-member-states can be assessed under the E3ME framework. The model also allows ex-ante and ex-post scenario analysis under various green tax reform packages, such as options to mitigate the competitiveness effects of ETR.

1 Introduction

European contribution

The E3ME model has been built by an international European team under a succession of contracts in the JOULE/THERMIE and Fourth Framework programmes. The projects 'Completion and Extension of E3ME'[1] and 'Applications of E3ME'[2], were completed in 1999. The 2001 contract, 'Sectoral Economic Analysis and Forecasts'[3], generated an update of the E3ME industry output, products and investment classifications to bring the model into compliance with the European System of Accounts, ESA 95. This leads to significant disaggregation of the service sector. The 2003 contract, Tipmac[4], led to a full development of the E3ME transport module to include detailed country models for several modes of passenger and freight transport. Finally, Seamate (2003/2004)[5] has led to the improvement of the E3ME technology indices. E3ME is the latest in a succession of models developed for energy-economy and, later, E3 interactions in Europe, starting with EXPLOR, built in the 1970s, then HERMES in the 1980s. Each model has required substantial resources from international teams and each model has learned from earlier problems and developed new techniques[6].

E3 modelling system

Using the International Dynamic Input-Output Modelling language (IDIOM), E3ME is designed from the outset to encompass E3 interactions in a regional model of the EU. This has been possible through the use of new, low-cost, powerful personal computers, and software capable of managing large inter-related data sets. New techniques have been developed to estimate, interpret and present the equations of the model, while keeping its structure simple and understandable.

The E3ME approach

E3ME combines the features of an annual short- and medium-term sectoral model estimated by formal econometric methods with the detail and some of the methods of the Computable General Equilibrium (CGE) models that provide analysis of the movement of the long-term outcomes for key E3 indicators in response to policy changes. It can be used for dynamic policy simulation and for forecasting and projecting over the medium and long terms. As such, it is a valuable tool for E3 policy analysis in Europe. Compared to other existing models targeted at achieving the same goals, the advantages of the E3ME model would seem to be found in three areas:

Model disaggregation

The detailed nature of the model allows the representation of fairly complex scenarios, especially those that are differentiated according to sector and to country. Similarly, the impact of any policy measure can be represented in a detailed way.

Econometric pedigree

The econometric grounding of the model makes it better able to represent and forecast performance in the short to medium run. It therefore provides information that is closer to the time horizon of many policy makers than pure CGE models.

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[1] European Commission contract no: JOS3-CT95-0011

[2] European Commission contract no: JOS3-CT97-0019

[3] European Commission contract no: B2000/A7050/001

[4] European Commission contract No GRD1/2000/25347-SI2.316061

[5] European Commission contract no. IST-2000-31104

[6] A description of the recent EU projects involving E3ME model is in section 7.3 in Appendix B.

E3 linkages An interaction (two-way feedback) between the economy, energy demand/supply and environmental emissions is an undoubted advantage over other models, which may either ignore the interaction completely or only assume a one-way causation.

Model data sources Like its predecessors, E3ME 4 is an estimated model, based on international data sources such as EUROSTAT and OECD.

2 Objectives of E3ME

2.1 Policy Analysis within E3ME

Short and long-term effects of E3 policies E3ME is intended to meet an expressed need of researchers and policy makers for a framework for analysing the long-term implications of E3 policies, especially those concerning R&D and environmental taxation and regulation. The model is also capable of addressing the short-term and medium-term economic effects as well as, more broadly, the long-term effects of such policies, such as those from the supply side of the labour market. In the context of COMETR the model enables an analysis to 2010.

European Industry-Energy analysis E3ME is a detailed model of 41 product/industrial sectors, compatible with ESA95 accounting classifications, and with the disaggregation of energy and environment industries for which the energy-environment-economy interactions are central. In particular, the industry classification distinguishes wood and paper, chemicals (excluding pharmaceuticals), non-metallic mineral products, and basic metals. It also has a linked set of 17 fuel-using sectors, including the energy-intensive sectors of iron and steel, non-ferrous metals, chemicals, mineral products and ore extraction (see Appendix A).

Extension to New Member States E3ME version 4.0 is currently being developed by Cambridge Econometrics. The objective is to update the model to include more recent data and to incorporate the new members of the European Union. The data base is being extended to cover the years to 2003 and the price base year will be 2000, thus bringing up to date the input-output structures and prices of the economies covered by the model. The incorporation of the new members is a major extension of the model, which will increase the number of regions covered from 19 in version 3.0 to 27 in the new version, and will make the comparison of the effects of green tax reform more consistent and comprehensive. Furthermore, this comparison covers all sectors of the economy in addition to the energy-intensive sectors. The updated model will also provide a more accurate picture of green tax reform issues like carbon leakage between EU countries.

2.2 Role of E3ME in COMETR

Competitiveness effects of green tax reforms E3ME is the most appropriate framework in which to analyse the competitiveness effects of green tax reform and to undertake a comprehensive sectoral analysis of Europe's environmental tax reforms from an ex-post perspective, that is, from a perspective where the actual experiences of green tax reforms across Europe feed into the model. Given E3ME's detailed modelling framework and its highly disaggregated databanks, the actual green tax reforms as implemented in some European countries (Germany, Finland, Denmark, Netherlands, Sweden, UK and Slovenia) can be faithfully reproduced and simulated at a high level of detail. E3ME model, therefore, is able to capture inter-industry and other indirect effects of environmental tax regimes through an EU-wide analysis. In particular, international competitiveness effects can be studied as well: the dynamics of external trade, employment, output and investment in capital and R&D can be tracked along various tax reform scenarios as section 3.3 will illustrate. These effects cannot be easily accounted for in a bottom-up approach.

Short- and long-run effects of the green tax reforms

The top-down approach that characterizes the E3ME model allows for an analysis of short-run and long-run costs and benefits of the green tax reforms as implemented by some European countries. This analysis constitutes one of the main objectives of COMETR project. In fact, the green tax reform changes not only tax rates, but because of change in input demands, it also changes tax base. The effects of the green tax reforms on tax base are both short and long term: the short-term effect comes from immediate change of the composition of input costs.

Long-term inter-sectoral effects on capital accumulation and employment

The dynamic long-term effects are due to the fact that the reform affects the path of capital accumulation in the sectors and also changes incentives for firms to invest in new technology and development. Not only the revenues but also the costs for the public sector are affected, because the changes in employment and/or real wages in the targeted sectors have effects on mandatory social security costs. The change in the sectors' costs due to a change of input composition leads to a different position of the sectors in the international markets. So, the effects of the reform on external position of the sectors, and any implication it has for the single market, are of great interest to EU policy makers and they can be also modelled and studied within the E3ME framework. From the long-term perspective, the effects of the reform on dynamics of technological change and investment in physical capital will be modelled[7].

Effects of ETR on non-ETR states and sectors

Moreover, the model allows for a focused analysis not only of the impact of the reform on the competitiveness of the threatened sectors but also of consequent responses: for instance, a focused analysis of the response of real wage and employment to the reform in these sectors can be carried out, together with the analysis of the possible impacts of sectoral adjustments in environmental tax reform (ETR) states on the similar sectors in non-ETR states.

Interactions with the economic actors

Further, various possibilities of co-operation among governments, trade unions and companies in these sectors can be modelled within E3ME in order to assess how co-operation among these economic actors can possibly overcome negative effects such as high unemployment and loss of competitiveness.

Modelling the EU green tax regimes

In the E3ME framework, not only ex-post but also ex-ante policy scenario analysis can be carried out. The latter involves the construction of a projected baseline for the main variables and the elaboration of possible policy options in terms, for instance, of tax regimes. Within the model, various components of the green tax reform packages can be studied:

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[7] These issues will be addressed considering the so-called "Porter hypothesis". Porter's hypothesis is that environmental policy (especially green tax reform) can increase the international competitiveness of domestic industries in the long run, since the firms are forced to adopt new, energy-savings technologies as a response to increase of the energy prices. The underlying assumption is that that the new environmentally friendly technologies lead to a decrease of unit costs in the long-run perspective. However even if Porter's hypothesis holds, there may be significant short–term transition costs, which the policymakers may be able to reduce e.g. using tax refunds or supporting 'green' R&D policies.

- the tax or levy without any exemptions or special treatment for the industries most affected and without any compensating measures, such as reductions in employment taxes;
- the tax with the exemptions and including special treatment;
- the tax, the exemptions and the compensating reduction in another tax.

Thus, the modelling of green tax scenarios will make it possible to explore issues like how common practices to mitigate the competitiveness impacts (as tax refunds, exemptions, revenue recycling etc) generated by the green tax reforms can affect the output, inputs and profits of the targeted sectors. Finally, the extension of the E3ME model to include new member states will permit a more accurate and comprehensive estimate of the carbon leakage from countries with green tax reforms to other countries in Europe.

3 A description of E3ME

3.1 The Theoretical Background to E3ME

Economic activity undertaken by persons, households, firms and other groups has effects on other groups after a time lag, and the effects persist into future generations, although many of the effects soon become so small as to be negligible. But there are many actors, and the effects, both beneficial and damaging, accumulate in economic and physical stocks. The effects are transmitted through the environment (with externalities such as greenhouse gas emissions contributing to global warming), through the economy and the price and money system (via the markets for labour and commodities), and through the global transport and information networks. The markets transmit effects in three main ways: through the level of activity creating demand for inputs of materials, fuels and labour; through wages and prices affecting incomes; and through incomes leading in turn to further demands for goods and services. These interdependencies suggest that an E3 model should be comprehensive, and include many linkages between different parts of the economic and energy systems.

These economic and energy systems have the following characteristics: economies and diseconomies of scale in both production and consumption; markets with different degrees of competition; the prevalence of institutional behaviour whose aim may be maximisation, but may also be the satisfaction of more restricted objectives; and rapid and uneven changes in technology and consumer preferences, certainly within the time scale of greenhouse gas mitigation policy. Labour markets in particular may be characterised by long-term unemployment. An E3 model capable of representing these features must therefore be flexible, capable of embodying a variety of behaviours and of simulating a dynamic system. This approach can be contrasted with that adopted by general equilibrium models: they typically assume constant returns to scale; perfect competition in all markets; maximisation of social welfare measured by total discounted private consumption; no involuntary unemployment; and exogenous technical progress following a constant time trend (see Barker, 1998, for a more detailed discussion).

3.2 E3ME as an E3 Model

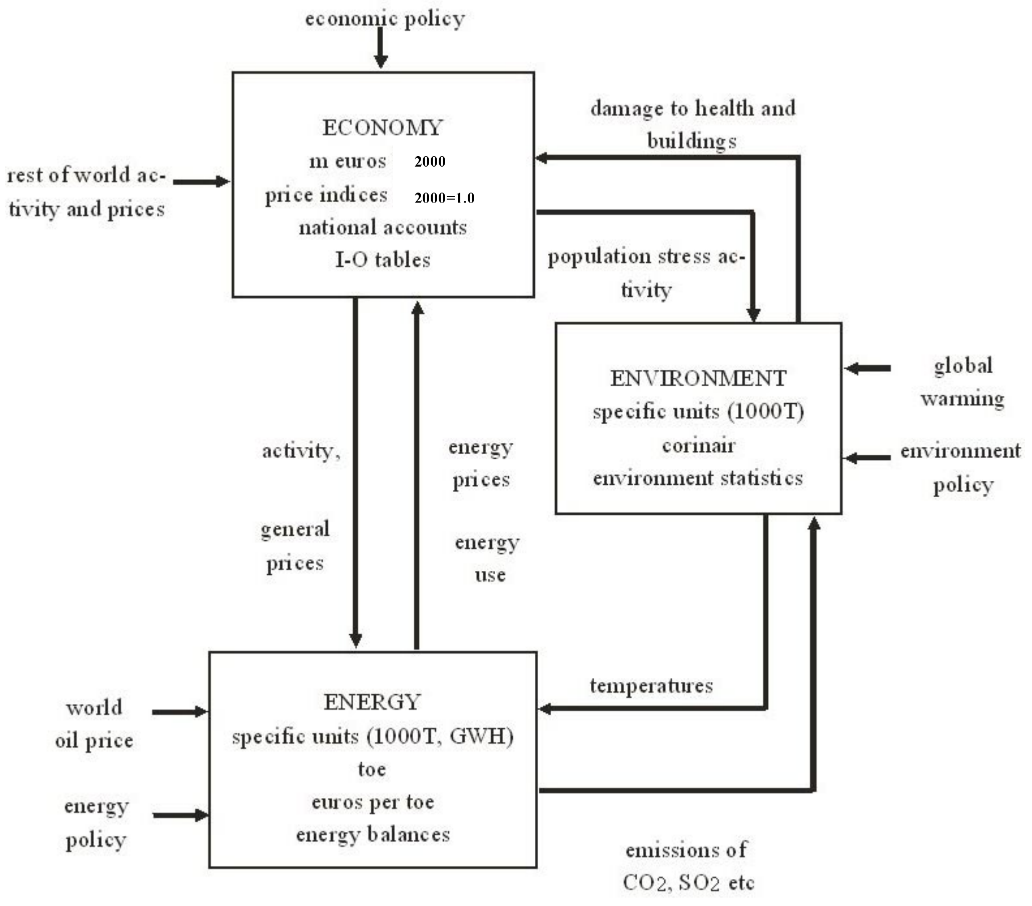
The E3ME model comprises:

- the accounting balances for commodities from input-output tables, for energy carriers from energy balances and for institutional incomes and expenditures from the national accounts
- environmental emission flows
- 22 sets of time-series econometric equations (aggregate energy demands, fuel substitution equations for coal, heavy oil, gas and electricity; intra-EU and extra-EU commodity exports and imports; total consumers' expenditure; disaggregated consumers' expenditure; industrial fixed investment; industrial employment; industrial hours worked; labour participation; industrial prices; export and import prices; industrial wage rates; residual incomes; investment in dwellings; and normal output equations)
- Energy supplies and population stocks and flows are treated as exogenous.

The E3 interactions

Figure 3.1 below shows how the three components (modules) of the model - energy, environment and economy - fit together. Each component is shown in its own box with its own units of account and sources of data. Each data set has been constructed by statistical offices to conform with accounting conventions. Exogenous factors coming from outside the modelling framework are shown on the outside edge of the chart as inputs into each component. For the EU economy, these factors are economic activity and prices in non-EU world areas and economic policy (including tax rates, growth in government expenditures, interest rates and exchange rates). For the energy system, the outside factors are the world oil prices and energy policy (including regulation of energy industries). For the environment component, exogenous factors include policies such as reduction in SO2 emissions by means of end-of-pipe filters from large combustion plants. The linkages between the components of the model are shown explicitly by the arrows that indicate which values are transmitted between components.

Figure 3.1 E3ME as an E3 model

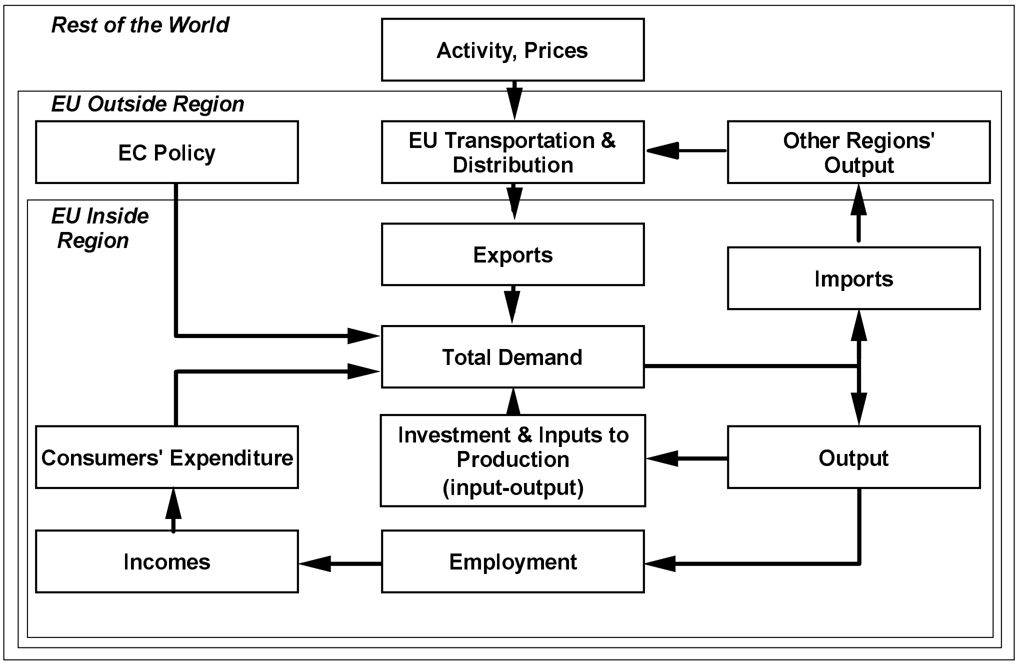


The economy module provides measures of economic activity and general price levels to the energy module; the energy module provides measures of emissions of the main air pollutants to the environment module, which in turn gives measures of damage to health and buildings (this effect is not yet included in the formal model). The economy module also provides measures of population stress (numbers of households, demands for water etc) to the environment module, which in turn will give an indication of the extent to which global temperatures are expected to rise in different long-term scenarios (this linkage is also not yet included in the model). The energy module provides detailed prices levels for energy carriers distinguished in the economy module and the overall price of energy as well as energy use in the economy.

3.3 The E3ME Regional Econometric Input-Output Model

Figure 3.2 below shows how the economic module is solved as an integrated EU regional model. Most of the economic variables shown in the chart are at a 41-industry level. The whole system is solved simultaneously for all industries and all 27 regions. The chart shows interactions at three spatial levels: the outermost area is the rest of the world; the next level is the European Union outside the region/country in question; and finally, the inside level contains the relationships within the region/country.

Figure 3.2 EU Economy solution



The chart shows three loops or circuits of economic interdependence, which are described in some detail below. These are the export loop, the output-investment loop and the income loop.

The Export Loop

The export loop runs from the EU transport and distribution network to the region's exports, then to total demand. The region's imports feed into other EU regions' exports and output and finally to these other regions' demand from the EU pool and back to the exports of the region in question.

Treatment of international trade

An important part of the modelling concerns international trade. The basic assumption is that, for most commodities, there is a European 'pool' into which each region supplies part of its production and from which each region satisfies part of its demand. This might be compared to national electricity supplies and demands: each power plant supplies to the national grid and each user draws power from the grid and it is not possible or necessary to link a particular supply to a particular demand.

The demand for a region's exports of a commodity is related to three factors:

- domestic demand for the commodity in all the other EU regions, weighted by their economic distance from the region in question
- activity in the main external EU export markets, as measured by GDP or industrial production
- relative prices, including the effects of exchange rate changes.

Economic distance

Economic distance is measured by special distance variable. For a given region, this variable is normalised to be 1 for the home region and values less than one for external regions. The economic distance to other regions is inversely proportional to trade between the regions. In E3ME regional imports are determined for the demand and relative prices by commodity and region. In addition, measures of innovation (eg patenting activity or spending on R&D) have been introduced into the trade equations to pick up an important long-term dynamic effect on economic development.

The Output-Investment Loop

The output-investment loop includes industrial demand for goods and services and runs from total demand to output and then to investment and back to total demand. For each region, total demand for the gross output of goods and services is formed from industrial demand, consumers' expenditure, government consumption, investment (fixed domestic capital formation and stockbuilding) and exports. These totals are divided between imports and output depending on relative prices, levels of activity and utilisation of capacity. Industrial demand represents the inputs of goods and services from other industries required for current production, and is calculated using input-output coefficients. The coefficients are calculated as inputs of commodities from whatever source, including imports, per unit of gross industrial output.

Determination of investment demand

Forecast changes in output are important determinants of investment in the model. Investment in new equipment and new buildings is one of the ways in which companies adjust to the new challenges introduced by energy and environmental policies. Consequently, the quality of the data and the way data are modelled are of great importance to the performance of the whole model. Regional investment by the investing industry is determined in the model as intertemporal choices depending on capacity output and investment prices. When investment by user industry is determined, it is converted, using coefficients derived from input-output tables, into demands on the industries producing the investment goods and services, mainly engineering and construction. These demands then constitute one of the components of total demand.

Accumulation of knowledge and technology

Gross fixed investment, enhanced by R&D expenditure in constant prices, is accumulated to provide a measure of the technological capital stock. This avoids problems with the usual definition of the capital stock and lack of data on economic scrapping. The accumulation measure is designed to get round the worst of these problems. Investment is central to the determination of long-term growth and the model embodies a theory of endogenous growth which underlies the long-term behaviour of the trade and employment equations.

The Income Loop

In the income loop, industrial output generates employment and incomes, which leads to further consumers' expenditure, adding to total demand. Changes in output are used to determine changes in employment, along with changes in real wage costs, interest rates and energy costs. With wage rates explained by price levels and conditions in the labour market, the wage and salary payments by industry can be calculated from the industrial employment levels. These are some of the largest payments to the personal sector, but not the only ones. There are also payments of interest and dividends, transfers from government in the form of state pensions, unemployment benefits and other social security benefits. The model contains provisions for the modelling of receipts and payments for seven institutional sectors, including the personal sector, government, and the company sector. Payments made by the personal sector include mortgage interest payments and personal income taxes. Personal disposable income is calculated from these accounts, and deflated by the consumer price index to give real personal disposable income.

Determination of consumers' demand

Totals of consumer spending by region are derived from consumption functions estimated from time-series data (this is a similar treatment to that adopted in the HERMES model). These equations relate consumption to regional personal disposable income, a measure of wealth for the personal sector, inflation and interest rates. Sets of equations have been estimated from time-series data relating the spending per capita to the national spending using the CBS[8] version of the consumption allocation system. The incorporation of this system into the solution is complex: the allocation system has been adapted to provide the long-run income and relative price parameters in a two-stage procedure, with a standardised co-integrating equation including demographic effects providing the dynamic solution. The substitution between categories as a result of changes in relative prices is achieved at the regional level.

3.4 Energy-Environment Links

Top-Down and Bottom-Up Methodologies

E3ME is intended to be an integrated top-down, bottom-up model of E3 interaction. In particular, a detailed engineering-based treatment is planned for the electricity supply industry (ESI), the demand for energy by the domestic sector, and transportation. The current version of the model is top-down, but it is important to be aware of the comparative strengths and weaknesses of the two approaches. Top-down economic analyses and bottom-up engineering analyses of changes in the pattern of energy consumption possess distinct intellectual origins and distinct strengths and weaknesses (see Barker, Ekins and Johnstone, 1995).

A Top-Down Submodel of Energy Use

The energy submodel in E3ME is constructed, estimated and solved for 19 fuel users, 12 energy carriers (termed fuels for convenience below) and 27 regions. Figure 3.3 shows the inputs from the economy and the environment into the components of the submodel and Figure 3.4 shows the feedback from the submodel to the rest of the economy.

Determination of fuel demand

Aggregate energy demand, shown at the top of Figure 3.3 below, is determined by a set of co-integrating equations[9], whose the main explanatory variables are:

- economic activity in each of the 19 fuel users
- average energy prices by the fuel users relative to the overall price levels
- technological variables, represented by R&D expenditure in key industries producing energy-using equipment and vehicles

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[8] Centraal Bureau voor de Statistiek (CBS, Bracke and Mayermans, 1997) allocation of consumption, where consumption of any one good is a function of its price, the average real consumption and the price of each of the other (n-1) commodities.

[9] Cointegration is an econometric technique that defines a long-run relationship between two variables resulting in a form of 'equilibrium'. For instance, if income and consumption are cointegrated, then any shock (expected or unexpected) affecting temporary these two variables is gradually absorbed since in the long-run they return to their 'equilibrium' levels. Note that a cointegration relationship is much stronger relationship than a simple correlation: two variables can show similar patterns simply because they are driven by some common factors but without necessarily being involved in a long-run relationship.

Figure 3.3 E3ME Economy–Environment input to Energy

Fuel substitution

Fuel use equations are estimated for four fuels - coal, heavy oils, gas and electricity – and the four sets of equations are estimated for the fuel users in each region. These equations are intended to allow substitution between these energy carriers by users on the basis of relative prices, although overall fuel use and the technological variables are allowed to affect the choice. Since the substitution equations cover only four of the twelve fuels, the remaining fuels are determined as fixed ratios to aggregate energy use. The final set of fuels used must then be scaled to ensure that it adds up to the aggregate energy demand (for each fuel user and each region).

Emissions Submodel

The emissions submodel calculates air pollution generated from end-use of different fuels and from primary use of fuels in the energy industries themselves, particularly electricity generation. Provision is made for emissions to the atmosphere of carbon dioxide (CO2), sulphur dioxide (SO2), nitrogen oxides (NOX), carbon monoxide (CO), methane (CH4), black smoke (PM10), volatile organic compounds (VOC), nuclear emissions to air, lead emissions to air, chlorofluorocarbons (CFCs) and the other four greenhouse gases: nitrous oxide (N2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF6). These four gases together with CO2 and CH4 constitute the six greenhouse gases (GHGs) monitored under the Kyoto protocol. CO2 has been modelled in E3ME from the outset. However, more recently, the emissions modelling has been extended to include many other atmospheric emissions (see Bruvoll, Ellingsen and Rosendahl, 2000) so that the results can include:

- effects on non-CO2 GHGs (especially those in the Kyoto protocol - CH4, N2O, HFC, PFC, SF6);
- ancillary benefits relating to reduction in associated emissions eg PM10, SO2, NOx.

CO2 emissions

Emissions data for CO2 are available for fuel users of solid fuels, oil products and gas separately. The energy submodel estimates of fuel by fuel user are aggregated into these groups (solid, oil and gas) and emission coefficients (tonnes of carbon in CO2 emitted per toe) are calculated and stored. The coefficients are calculated for each year when data are available, then used at their last historical values to project future emissions. Other emissions data are available at various levels of disaggregation from a number of sources and have been constructed carefully to ensure consistency.

Feedback to the Rest of the Economy

Figure 3.4 shows the main feedbacks from the energy submodel to the rest of the economy. Changes in consumers' expenditures on fuels and petrol are formed from changes in fuel use estimated in the energy submodel, although the levels are calibrated on historical time-series data. The model software provides an option for choosing either the consumers' expenditure equation solution, or the energy equation solution. Whichever option is chosen, total consumer demand in constant values matches the results of the aggregate consumption function, with any residual held in the unallocated category of consumers' expenditure. The other feedbacks all affect industrial, including electricity, demand via changes in the input-output coefficients.

Figure 3.4 E3ME feedbacks from the Energy model

3.5 Parameter Estimation

The econometric model has a complete specification of the long-term solution in the form of an estimated equation that has long-term restrictions imposed on its parameters. Economic theory, for example the recent theories of endogenous growth, informs the specification of the long-term equations and hence properties of the model; dynamic equations that embody these long-term properties are estimated by econometric methods to allow the model to provide forecasts. The method utilises developments in time-series econometrics, in which dynamic relationships are specified in terms of error correction models (ECM) that allow dynamic convergence to a long-term outcome. The specific functional form of the equations is based on the econometric techniques of cointegration and error-correction, particularly as promoted by Engle and Granger (1987) and Hendry et al (1984).

4 Conclusion

E3ME is a dynamic estimated time-series cross-section model of Western Europe covering the EU 25 member states and Norway and Switzerland. E3ME 4 is a fully integrated E3 model with detailed sectoral coverage including 41 industrial sectors, 19 fuel users and 12 energy carriers. The model is intended to meet an expressed need of researchers and policy makers for a framework for analysing the long-term implications of E3 policies, especially those concerning R&D and environmental taxation and regulation. The model is also capable of addressing the short-term and medium-term economic effects as well as, more broadly, the long-term effects of such policies. The current version of E3ME is capable of forecasting annual macroeconomic effects, energy use and emissions in the period up to 2010.

5 References

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6 Appendix A: E3ME Classifications

6.1 The System of Accounts and E3ME classifications

The accounting structure within IDIOM (International Dynamic Input-Output Modelling language) on which E3ME is based is that of the EUROSTAT System of Accounts 1995 (ESA95). The IDIOM functional classifications can be identified with accounts in the ESA95 with the exception of investment, area, employment and energy-use classifications. One of the characteristics of the ESA and E3ME is the disaggregation of economic variables. The industry and commodity classifications are in terms of industries or their principal products and are defined on the NACE Rev.1 1990 (see table 6.1) and cover all EU member states (EU -25) plus Norway and Switzerland (see table 6.2).

Energy – Environment Classifications

Aside from the classifications relating to the economy side (see table 6.3), there are a number of energy-environment variables (see table 6.4) and classifications that are an important feature of the model and that cannot be found in any official statistical source like EUROSTAT or OECD. In fact, these energy-environment classifications allow E3ME model to better analyse and forecast the energy flows and their environmental impacts, in order to provide specific policy recommendations. These classifications are:

- Fuel Users (classification FU, see table 6.5)
- Fuel Types (classification J, see table 6.6)
- Energy Technologies (classification ET, table 6.7)
- Environmental Emissions (classification EM, table 6.8)
- Environmental Emission Sources (classification ES, table 6.9)

These are derived from other classifications system, sometimes more aggregated or disaggregated, such as Eurostat and IEA (based on ISIC).

Input – Output Tables

A new set of input-output tables were received from Eurostat for 1995 covering each Member State at the NACE-25 level (now expanded to the E3ME3 42 sectors) on the following areas:

- domestic production
- imports from EC member countries
- imports from third countries

Evolution of E3ME Classifications

The evolution of the E3ME classifications and databases has been characterised by the desire to cover more disaggregated sectors on one hand and the adoption of several additional classifications (energy-environment as mentioned above) on the other hand. E3ME classifications and datasets evolved (and continue to evolve) according to the objectives of the several projects and policy applications (usually Commission-funded, see section 7.3) involving the model.

DG EcFIN project in 2001

Cambridge Econometrics was commissioned by DG EcFIN in 2001 to provide EU sectoral forecast analysis up to 2005[10]. The main objective of the project was to analyse and forecast the expected sectoral change at both member state and EU level. The project aimed to go beyond the descriptive and backward-looking EUROSTAT publication 'Panorama of EU Industry' and provide more forward-looking and model-based sectoral information. This required: the set up of a more disaggregated classification than NACE 25 sector level to 41, in particular with the breakdown of the services sector, in order to analyse the reason why some sectors grow faster than others[11]; the move from NACE 25 to the new NACE Rev.1. sectoral level. The resulting classification was not exactly compatible with NACE Rev. 1 but a re-classification matrix was constructed to provide a straightforward mechanism for switching from one aggregation to another.

In general, in each application of the E3ME model, Cambridge Econometrics has always ensured that the main classification and input-output tables and datasets used into the model are consistent, compatible and comparable with EUROSTAT and other reputable international statistical sources.

6.2 Data sources

The following sections only give a summary of data sources used in the E3ME model. The data need to be consistent across countries and in the same units. For monetary data the euro is used. The data are updated as and when new data become available. For each set of the model variables there are four possible groups of data sources with the following ranking:

Primary choice

EUROSTAT is always the first choice which establishes a comparable basis across member states. Even where EUROSTAT data are incomplete or believed to be of poor quality, the EUROSTAT definitions are adopted and the data are improved via other sources. This allows the inclusion of improved EUROSTAT on an annual basis.

Second choice

Data from the AMECO database are used in order to make the EUROSTAT total consistent with an accepted macroeconomic total, and also to provide limited sectoral information.

Third choice

When EUROSTAT data are not available or need to be improved, internationally available sources such as OECD or IMF are consulted. This enables any of the team members to update the database without having to collect data from national statistics. International sources are also important for data covering the world areas outside the E3ME regions.

Fourth choice

Once data sources such as OECD and IMF have been exhausted, National official statistics and other data sources are used to update the remaining missing series and gaps in EUROSTAT.

As indicated above data from official source are always preferred and are used in the most comprehensive possible way. In E3ME version 3 various sets of data were

[10] The project 'Sectoral Economic analysis and forecasts up to the year 2005'. Call for tender no. II/99/011. Service contract no.B2000/A7050/001.

[11] The E3ME classification was based on the NACE 25 sector level with further disaggregation of the fuel and power sectors, leading to 32 sectors. The EcFin funded project allowed for an extension of sectoral coverage from 32 to 41 sectors.

calculated by other means as explained in the next paragraphs. This was due to lack of data of time or sectoral coverage. In the present version of E3ME (E3ME v4 under development) similar procedures will be applied to construct the data.

Trade data There were only a few years for the service sectors from the EUROSTAT data. Data providing information on destination of exports and origin of imports for the manufacturing sectors has been used to improve the databank coverage. Due to the way in which trade is modelled within E3ME, ie via a European pool rather than as a series of bilateral relationships, an aggregated version has been put onto the time series databank and used in equation estimation. Trade data for the service sectors then was constructed using a combination of trends in origin and destination structure for the UK and a cross-section of regional trade provided for 1995.

Energy fuel use The energy data in physical units 1978-95 have been provided for the model by DGXVII for the 15 member states of the EU in the form of spreadsheets one for each year. These have been processed into time series, with the 34 energy carriers aggregated into the 11 energy types in E3ME, and some inconsistencies (comparing items year by year) have been removed. These data have been supplemented by data from the OECD's energy balances, both for Norway and Switzerland and for earlier years.

In some cases, earlier data 1968-77 have been spliced on to the 1978-95 data. These earlier data come from the EUROSTAT CRONOS database which was far from complete and discovered to be inconsistent. Very obvious structural breaks existed in the data. A method was adopted whereby the main totals were examined and the DG Energy was informed about the problems encountered.

Energy price data The price data were compiled using a series of sources. The basis of all the data was the OECD/IEA Energy Statistics publication. OECD/IEA provide incomplete, delivered price (with and without tax) time series for distillate (light) oil, electricity, natural gas, steam coal, and coke. EWI has assembled these data into time series in local currency from 1968 to 1995 for most countries of interest. The model uses three kinds of energy prices: end-user energy prices excluding taxes (1968-95), end-user energy prices including taxes (1968-95) and minimum energy prices (1990-2012), which is generated by assumptions. Prices exist for 21 fuel types. Initially, data were obtained for 1978-94 for 14 countries. This was extended later to 17 countries (excluding IN & DO) and to 1968-97. There was a serious problem of missing values in these series and data improvement work had to be undertaken. Average EU import prices for crude oil, steam coal, coke, and natural gas were also available from OECD for selected years. These average import prices of primary fuels are designated the world prices with missing values obtained by extrapolation using price growth rates reported by Digest of UK Energy Statistics, for imported oil and gas, and by the Canadian Government, for coal and coke.

Temperature data These were needed for the earlier versions of the energy equations. There was considerable difficulty in obtaining any data for the period 1960-95 on an annual, consistent basis. EUROSTAT's Monthly Energy Statistics contained mean degree days for the period 1980 to 1995. EUROSTAT's Energy Statistics Yearbook contained data from 1960 to 1975 in deviation from long-term mean. We also had a consistent series for the UK from 1960 to 1995 in deviation from long-term mean. By regressing the mean degree days on the deviation from long-term mean, a data series was created. In the current specification of the equations, the temperature variable has been dropped.

CO2 emissions by fuel and fuel user

Data were purchased from the OECD covering all E3ME countries at a sufficient level of disaggregation to allow reclassification to the E3ME fuel type and fuel user categories. From the time series available, two years (1972 and 1996) were chosen. A second set of data for total CO2 emissions by country for the period 1960-96 were also extracted. These data are then used by the model to create emission coefficients which relate to particular fuel types and users, which should in turn make the link between energy use and CO2 output more accurate.

Other greenhouse gas emissions and pollutants data

Data on the five other greenhouse gases, some of which are relevant in the context of secondary benefits rather than global warming potential, were collected by Statistics Norway. This represents an important step forward, as the Kyoto Protocol places restrictions on all six GHGs, not only CO2, and so it is a requirement to include measurement in analysis of climate policies. A full description of the method used to construct the data, the sources used, and their incorporation in the model, is included in one of the model working papers (Inclusion of 6 greenhouse gases and other pollutants into the E3ME model).

6.3 Classification Tables

Table 6.1 - Unified E3ME40: Products (Q) and Industries (Y)

	Full industry heading	2-letter ID	NACE REV 1.1
1	Agriculture etc	AG	01,02,05
2	Coal	CO	10
3	Oil & Gas etc	OG	11,12
4	Other Mining	MI	13,14
5	Food, Drink & Tobacco	FD	15,16
6	Textiles, Clothing & Leather	TC	17,18,19
7	Wood & Paper	WP	20,21
8	Printing & Publishing	PP	22
9	Manufactured Fuels	MF	23
10	Pharmaceuticals	PH	24.4
11	Chemicals nes	CH	24(ex24.4)
12	Rubber & Plastics	RP	25
13	Non-Metallic Mineral Products	NM	26
14	Basic Metals	BM	27
15	Metal Goods	MG	28
16	Mechanical Engineering	MA	29
17	Electronics	IT	30,32
18	Electrical Engineering & Instruments	EI	31,33
19	Motor Vehicles	MV	34
20	Other Transport Equipment	TE	35
21	Manufacturing nes	OM	36,37
22	Electricity	EL	40.1
23	Gas Supply	GS	40.2,40.3
24	Water Supply	WA	41
25	Construction	CN	45
26	Distribution	DT	50,51
27	Retailing	RT	52
28	Hotels & Catering	HC	55
29	Land Transport etc	LT	60,63
30	Water Transport	WT	61
31	Air Transport	AT	62
32	Communications	CM	64
33	Banking & Finance	BF	65,67
34	Insurance	IN	66
35	Computing Services	CS	72
36	Professional Services	PS	70,71,73,74.1-74.4
37	Other Business Services	OB	74.5-74.8
38	Public Administration & Defence	PA	75
39	Education	ED	80
40	Health & Social Work	HS	85
41	Miscellaneous Services	OS	90 to 93,95,99
42	Unallocated	UN	

Table 6.2 - E3ME4.0: 27 European Regions (RE)

1	Belgium	(BE)
2	Denmark	(DK)
3	Germany	(DE)
4	Greece	(EL)
5	Spain	(ES)
6	France	(FR)
7	Ireland	(IE)
8	Italy	(IT)
9	Luxembourg	(LX)
10	Netherlands	(NL)
11	Austria	(AT)
12	Portugal	(PT)
13	Finland	(FI)
14	Sweden	(SW)
15	UK	(UK)
16	Czech Rep.	(CZ)
17	Estonia	(EN)
18	Cyprus	(CY)
19	Latvia	(LV)
20	Lithuania	(LT)
21	Hungary	(HU)
22	Malta	(MT)
23	Poland	(PL)
24	Slovenia	(SI)
25	Slovakia	(SK)
26	Norway	(NO)
27	Switzerland	(CH)

Table 6.3: Economic Variables

Name	Region	Units	Description
RGFR	all	(%)	Government financial balance as % of GDP
X_??	??	(m € 2000)	Total exports by industry
M_??	??	(m € 2000)	Total imports by industry
YVM_??	??	(m € 2000)	Gross value added at market prices by industry
Q_??	??	(m € 2000)	Total output by industry
YRD_??	??	(m € 2000)	Total R&D expenditure by industry
VX_??	??	(m €)	Total exports by industry
VM_??	??	(m €)	Total imports by industry
VYVM_??	??	(m €)	Gross value added at market prices by industry
VYVF_??	??	(m €)	Gross value added at factor prices by industry
YLC_??	??	(m €)	Industrial labour costs
VQ_??	??	(m €)	Total output by industry
VYRD_??	??	(m €)	Total R&D expenditure by industry
YRE_??	??	(000)	Total employment by industry
YEE_??	??	(000)	Total salary earners by industry
YH_??	??	hours	Average hours worked per week by industry
YNH_??	??	hours	Normal hours worked per week by industry
C_??	??	(m € 2000)	Consumers' expenditures by category
VC_??	??	(m €)	Consumers' expenditures by category
CRVD_??	??	(standard rate=1)	Consumers' exp. VAT differentials
G_??	??	(m € 2000)	Government current expenditure
VG_??	??	(m €)	Government current expenditure
K_??	??	(m € 2000)	Gross fixed capital formation, by ownership branch
VK_??	??	(m €)	Gross fixed capital formation, by ownership branch
POP_??	??	(000)	Population by age group in thousands
LG_??	??	(000)	Labour force by gender
RUNR	all	(ratios)	Standardised OECD regional unemployment rates (not %)
RERS	all	(m)	Regional employers contributions to social security
REES	all	(m)	Regional employees contributions to social security
RDTX	all	(m)	Regional deductions for income tax
RITX	all	(m)	Regional indirect tax revenues
RBEN	all	(m)	Regional social security receipts
RGDI	all	(m)	Regional gross disposable incomes (QUEST)
V_??	??	(m € 2000)	Gross fixed capital formation, by asset
VV_??	??	(m €)	Gross fixed capital formation, by asset

Note(s): [1] "??" indicates that the variable is to be collected for all 27 regions (see table 2); "all" indicates that the variable includes all 27 regions.

[2] Actuals = data derived from external sources such as IEA, OECD, IMF etc.

Table 6.4: Energy-Environment Variables

Name	Region[1]	Units	Description
FU01_??	??	(000)	Actuals for coal demand (FRCT)
FU02_??	??	(000)	Actuals for coke
FU03_??	??	(000)	Actuals for lignite
FU04_??	??	(000)	Actuals for heavy fuel oil demand (FROT)
FU05_??	??	(000)	Actuals for middle distillates
FU06_??	??	(000)	Actuals for natural gas demand (FRGT)
FU07_??	??	(000)	Actuals for derived gas
FU08_??	??	(000)	Actuals for electricity demand (FRET)
FU09_??	??	(000)	Actuals for nuclear fuels
FU10_??	??	(000)	Actuals for crude oil
FU11_??	??	(000)	Actuals for Steam & other
EPRT_??	??	(00=1.0)	Average fuel prices (ecus/toe) including tax
EPR_??	??	(00=1.0)	Average (across uses) fuel prices (ecus/toe) ex tax
RMST	all	(000)	Regional motor spirit used for road transport in th toe
RDET	19	(000)	Regional DERV used for road transport in th toe
RULR	21	rate	Rate of unleaded fuel
JREA??	all	(000)	Fuel use by electricity th toe
RDTM	0	(ratios)	Regional deviation of temperature from 30-year mean
RCO2	all	(000)	Emissions of carbon dioxide th tonnes carbon
RSO2	all	(000)	Emissions of sulfure dioxide th tonnes
RNOX	all	(000)	Emissions of nitrogen oxides th tonnes
RCO	all	(000)	Emissions of carbon monoxide th tonnes
RCH4	all	(000)	Emissions of methane th tonnes
RBS	all	(000)	Emissions of black smoke th tonnes
RVOC	all	(000)	Emissions of volatile organic compounds th tonnes
RN2O	all	(000)	Emissions of nitrous oxide th tonnes
RHFC	all	(000)	Emissions of hidrofluoride carbon th tonnes
RPFC	all	(000)	Emissions of pentafluoride carbon th tonnes
RSF6	all	(000)	Emissions of sulfur fluoride th tonnes

Note(s): [1] "??" indicates that the variable is to be collected for all 27 regions (see table 2); "all" indicates that the variable includes all 27 regions.

[2] Actuals = data derived from external sources such as IEA, OECD, IMF etc.

	Table 6.5 - E3ME4.0: Energy Users (FU)		ISIC Rev 3.1	Unified 42-sectors
1	Power own use & transformation	EL	401	22
2	O. energy own use & transformation	OE	23,402,403	2,3,9,23
3	Iron and steel	IS	271, 2731	.66*14
4	Non-ferrous metals	NF	272, 2732	.34*14
5	Chemicals	CH	24	10,11
6	Non-metallics nes	NM	26	13
7	Ore-extraction (non-energy)	OE	13,14	4
8	Food, drink and tobacco	FD	15,16	5
9	Tex., clothing & footw	TC	17,18,19	6
10	Paper and pulp	PP	21,22	.9*7,8
11	Engineering etc	EE	28 to 35	15 to 20
12	Other industry	OI	20,25,36,37,45	.1*7,12,21,25
13	Rail transport	RA	60.1	.15*29
14	Road transport	RO	60.2,60.3	.75*29
15	Air transport	AT	62	31
16	Other transport services	OT	61,63	.1*29,30
17	Households	HH	95	
18	Other final use	OF	1-5,41,50-55,64-93	1,24,26-29,32-41
19	Non-energy use	NE		

Table 6.6: E3ME4.0: Energy Carriers (J)

1	Hard coal	HC	Hard coal
2	Other coal etc	OC	Lignite/Brown Coal/Sub-Bituminous Coal, Coking Coal, Other Bituminous Coal & Anthracite, Sub-Bituminous Coal, Lignite/Brown Coal, Peat, Patent Fuel, Coke Oven Coke and Lignite Coke, Gas Coke, BKB, and Charcoal.
3	Crude oil etc	CO	Crude/NGL/Feedstocks/Non-Crude, Crude Oil, Refinery Feedstocks, Additives/Blending Components, Inputs other than Crude or NGL, Refinery Gas, Ethane, and Liquefied Petroleum Gases.
4	Heavy fuel oil	HO	Heavy Fuel Oil, Naphtha, White Spirit & SBP, Lubricants, Bitumen, Paraffin Waxes, Petroleum Coke, and Other Petroleum Products.
5	Middle distillates	MO	Motor Gasoline, Aviation Gasoline, Gasoline type Jet Fuel, Kerosene type Jet Fuel, Other Kerosene, and Gas/Diesel Oil.
6	Other gas	OG	Gas Works Gas, Coke Oven Gas, Blast Furnace Gas, and Oxygen Steel Furnace Gas.
7	Natural gas	NG	Natural Gas, and Natural Gas Liquids.
8	Electricity	EL	Electricity
9	Heat	HE	Heat
10	Combusible waste	CW	Industrial Wastes, Municipal Wastes Renewables, Municipal Wastes Non-Renewables, and Non-specified Primary Biomass and Wastes.
11	Biofuels	BF	Primary Solid Biomass, Biogas, and Liquid Biomass.
12	Hydrogen	HY	Hydrogen

Table 6.7: E3ME4.0: Energy Technology (ET)

1	Coal-clean	CC
2	Coal-dirty	CD
3	Oil fuels-clean	OC
4	Oil fuels-dirty	OD
5	Gas-central	GC
6	Gas-micro CHP	GM
7	Gas-f.c. vehicle	GV
8	Nuclear electricity	NE
9	Hydro electricity	HE
10	Biomass crops	BC
11	Biomass wastes: CHP	BW
12	Wind-intermittent	WI
13	Wind-with storage	WS
14	Solar PV-intermittent	SI
15	Solar PV-with storage	SS
16	Solar Thrml-intermittent	TI
17	Solar Thrml-w/gas	TG
18	Solar Thrml-w/storage	TS
19	Marine-intermittent	MI
20	Marine-with storage	MS
21	Geothermal	GE
22	Coal - with sequestration	CS
23	Gas - with sequestration	GS
24	Hydrogen-central	HC
25	Hydrogen-micro CHP	HM
26	Hydrogen-f.c. vehicles	HV
27	Transmission	TM
28	Batteries/storage	BS

Table 6.8: E3ME4.0: Atmospheric Emissions (EM)

1	Carbon dioxide (GHG)	CO2
2	Sulphur dioxide	SO2
3	Nitrogen oxides	NOX
4	Carbon monoxide	CO
5	Methane (GHG)	CH4
6	Particulates	PM10
7	VOCs	VOC
8	Radiation - air	RAD
9	Lead - air	LEAD
10	CFCs	CFCs
11	N2O (GHG)	N2O
12	HFCs (GHG)	HFCs
13	PFCs (GHG)	PFCs
14	SF6 (GHG)	SF6

Table 6.9: E3ME40: Emission Sources (ES)

1	Power generation	EL
2	Energy & transformation industries	ET
3	Other industry	OI
4	Transport	TR
5	Other fuel combustion	OF
6	Fugitive fuel emissions	FF
7	Industrial processes	IP
8	Solvent & other product use	SO
9	Agriculture	AG
10	Waste treatment disposal	WA
11	Other	OT

7 Appendix B: E3ME References and Publications

7.1 Journal Publications based on the E3ME Model

de-Ramon, Sebastian and Richard Lewney (2004) 'Macroeconomic and Structural Impacts of IST', *International Journal of Technology, Policy and Management* (IJTPM), forthcoming.

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Barker, Terry (1999). 'Achieving a 10% cut in Europe's carbon dioxide emissions using additional excise duties: coordinated, uncoordinated and unilateral action using the econometric model E3ME', *Economic Systems Research*, Vol. 11, No. 4: 401-421.

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7.2 Citations of E3ME model in External Working Papers

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2 Gardiner, B (1993) Software Survey, CE.

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43 Barker, T S and B Gardiner (1994) Employment, wage formation and pricing in the European Union: empirical modelling of environmental tax reform, Department of Applied Economics and CE.

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7.3 EU projects involving E3ME Model

COMETR (Competitiveness Effects of Enviromental Tax reforms). is a Specific Targeted Research Project (STREP) supported by financing from the EU's Sixth Framework Programme for Research (FP6). COMETR is coordinated by the Department of Policy Analysis at the National Environmental Research Institute in Denmark and has 6 partners. COMETR runs from December 2004 through to November 2006. The project will advance the debate on competitiveness effects by undertaking the first comprehensive sectoral analysis of Europe's environmental tax reforms from an ex-post perspective. It will use modelling frameworks as well as case studies concerning the existing tax reforms which have taken place in the EU and Candidate countries. Webpage: http://www2.dmu.dk/cometr/index.htm.

TranSust (The Transition to Sustainable Economic Structures). TranSust provides a communication platform for researchers interested in modelling the transition to sustainable economic structures. Based on the experience with existing models the following issues are addressed: 1) sharing of information about existing models in a peer review; 2) assessing the comparative advantages of various model designs; 3) identifying research tasks for modelling sustainable economic structures. Webpage: www.transust.org.

SEAMATE (Socio-Economic Analysis and Macro-modelling of Adapting to information Technologies in Europe). The objective of SEAMATE - Socio-Economic Analysis and Macro-modelling of Adapting to information Technologies in Europe - is to analyse the overall economic impact of Information Society Technology (IST) within the context of the European Union (EU) and national policies. This objective is accomplished through a structured programme of work, conducted over a period of two years (2002-2003). Webpage: http://www.seamate.net/index.shtml

TIPMAC (Transport Infrastructure and Policy: a macroeconomic analysis for the EU). This project analysed the role of transport in macroeconomic development and employment. It combined transport and macroeconomic modelling to quantify the indirect macroeconomic impacts of transport infrastructure investment (TEN-T) and transport pricing policies (e.g. marginal social cost pricing) in the EU. The project started on May 2001 and ended on December 2003. See: http://europa.eu.int/comm/dgs/energy_transport/rtd/5/index_en.htm.

Completion and Extension of E3ME - JOULE III (Non Nuclear Non-Nuclear Energy - R&D Component, Fourth Framework Programme 1995-1997, contract JOS3-CT95-0011, €1,108K). The project addresses a task in the Workprogramme Non-Nuclear Energy - JOULE-THERMIE (1994-1998), the "completion ... of the E3 models developed within JOULE II". In addition, it is proposed to extend the model to include the new member states of the EU, plus Norway and Switzerland, and to introduce new modelling of the supply side. The purpose of the model is to provide a framework for evaluating different policies, particularly those aimed at achieving sustainable energy use over the long term. A main task of the model is the evaluation of policies reducing anthropogenic emissions of greenhouse gases (GG) in Europe by 10 to 20% over the period until 2020. See: http://dbs.cordis.lu/fep-cgi/srchidadb?ACTION=D&SESSION=57992005-2-21&DOC=4&TBL=EN_PROJ&RCN=EP_DUR:24&CALLER=PROJ_JOULE.

Other projects under this Framework are:

- Applications of E3ME: Industrial Benefits and Costs of GHG Abatement Strategies EC DG XII Fourth Framework Programme 1998-99 JOS3-CT97-0019.

- E3ME An energy-environment-economy model for Europe EC DG XII Fourth Framework Programme1992-95 JOU2-CT92-0203.