Trade flows and cost structure analysis for exposed industries in the EU-27

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Table of Contents

1 Introduction

The EU proposal on the improvement and extension of the current EU Directive on Emissions Trading (2003/87/EC) provides a number of criteria to be taken into account to determine the risk of 'carbon leakage', i.e. (re)location of greenhouse gas emitting activities from the EU to third countries where industry is not subject to carbon constraints and thereby increasing global emissions. These include:

- Increase in production costs induced by the EU Emissions Trading Scheme (ETS).
- High trade intensity with non-EU countries.
- The extent to which it is possible to reduce emissions or electricity consumption.
- Ability to pass increased costs, i.e. market structure, international competition etc.
- Profit margins as potential indicator of long-run investment and/or relocation decisions.
- The effect of energy and climate policy outside the EU.

These criteria determine the extent to which it is possible for a sector or sub-sector concerned to pass on the cost of the required allowances in product prices without significant loss of market share to less carbon efficient installations outside the Community.

In this paper, we focus on the criteria of exposure to international competition and cost structure of a number of selected sectors. These include those sectors that have been identified in previous studies covering Germany, UK and the Netherlands to be most likely exposed to distortions in competitiveness due to both high EU ETS induced costs increase and high trade intensity (see chapter 2). In the analysis of carbon pricing effects, a particular distinction is made between direct and indirect cost effects of the EU ETS. Direct costs are related to emissions for which operators are obliged to surrender EU allowances for, i.e. energy and process emissions. The analysis of increases in indirect costs is limited to the most relevant case, i.e. effects of higher electricity prices. Indirect cost increases are considered to be more challenging to tackle as emissions occur in upstream processes and the CO2 price share in increased electricity prices is difficult to determine.

These analyses have shown that distortion of competitiveness is likely for a small number of sectors only, including to a varying extent the production of aluminium, basic iron and steel and ferro-alloys, fertilizers and nitrogen compounds, other basic inorganic chemicals and paper and paperboard.

To that effect, we conduct an in-depth sectoral analysis for each of the sectors under consideration. In a first step, this includes a description of the production processes along the value chain, of the input structure with its main inputs and the energy use. Furthermore, an analysis of the cost components is conducted for several countries within the EU.

In a second step, we analyze the trade flows of these sectors for the aggregate European Union (EU-27) as it is foreseen in the current proposal for the EU emissions trading directive, as voted in the European Parliament on the 17 December 2008 (European Parliament 2008). The analysis serves to determine the position in the international market. We calculate the trade intensities and identify the main trading partners and rank them according to trade activity over the past five years. Furthermore, the trade structure of imports and exports is looked at. Throughout, the methodology, data capture and restrictions particularly with respect to data classification and conversion have to be borne in mind (see Annex A).

2 Carbon pricing effects and trade intensity

The proposal of the revised EU emissions trading directive (European Parliament 2008) includes a definition on when a sector or sub-sector is deemed to be exposed to a significant risk of carbon leakage and therefore may qualify to benefit from support measures such as free allocation or financial compensation. Two criteria are established; first, the sum of direct and indirect additional costs induced by the ETS, calculated as proportion of the gross value added (GVA), equals or exceeds 5% and sec-ond, the non-EU trade intensity is above 10%.

$$TradeIntensity = \frac{Exports_{regional} + imports_{regional}}{turnover + imports_{total}}$$

The trade intensity indicator relates the sum of traded goods (value of imports + ex-ports) to total market supply (annual turnover + total imports) in the EU as a whole. Additionally, a sector or sub-sector is deemed exposed if either the sum of direct and indirect cost is at least 30% or if the non-EU trade intensity is above 30%.

Recently, several studies have been conducted on the potential effects of the EU ETS on competitiveness. The results of four studies focussing on different countries/the EU are compared in this chapter: Graichen et al. (2008) (Germany), Hourcade and Neuhoff et al. (2007) (UK), de Bruyn et al. (2008) (Netherlands) and the European Commission (2008a & 2008b) (EU 27). As the studies on the UK, Germany and the Netherlands were published before the proposal of the directive, they relate to different thresholds or slightly different criteria.

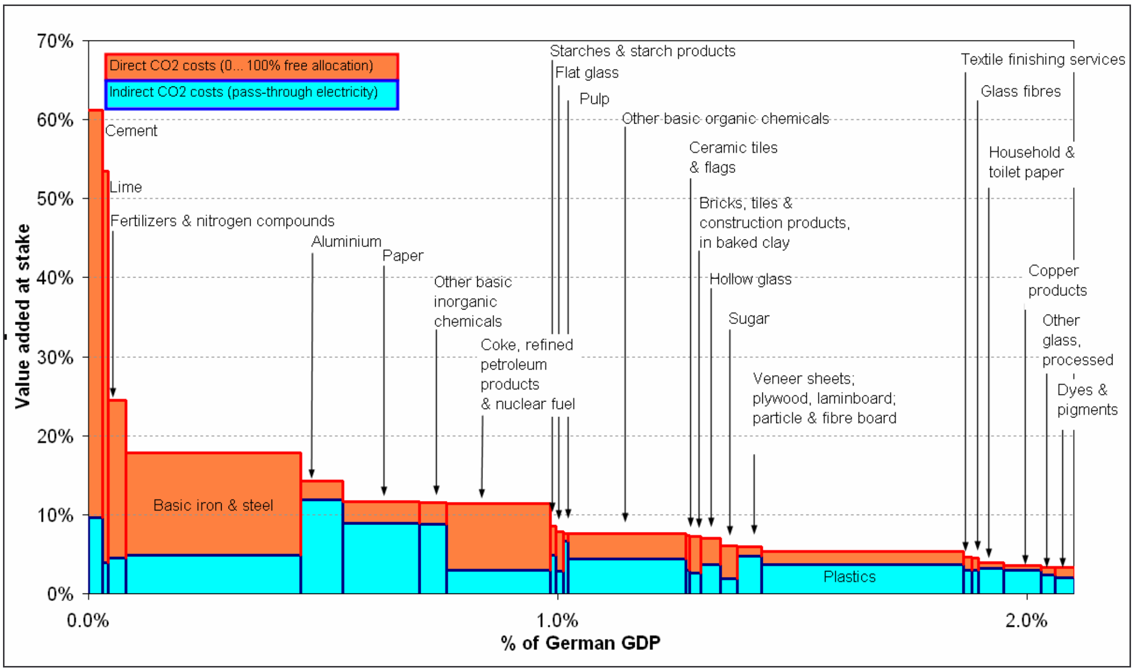
The studies of Hourcade and Neuhoff et al. (2007) for the UK and of Graichen et al. (2008) on Germany are based on identical criteria and carried out for industrial sectors at 4-digit level in the NACE classification. De Bruyn et al. (2008) use two to four digits, whereas the Commission Services (2008) assess products based on one or more sub-sectors at 8-digit level.

The analyses of direct and indirect cost effects for the UK and Germany are based on the concept of 'value at stake'. The maximum value at stake is defined as the sum of potential direct and indirect costs in relation to the gross value added (GVA) of a given industrial sector.

The country studies assume an average EU allowance price of 20 Euro per tonne of CO2, whereas the EU study applies 30 Euro for the analysis. Indirect costs are calcu-lated by multiplying the electricity consumption of an industrial sector and the estimated pass-through of CO2 costs to electricity prices . Direct costs of an industrial sector de-pend on the emission intensity of production. Energy emissions are calculated using fuel input and emission factors. Process emissions for Germany are based on data from the German GHG inventory for the following sectors: cement; lime, fertilizers and aluminium ; process emissions for the UK are estimated based on direct and indirect emissions for Climate Change Agreement installations published by DEFRA. Direct and indirect costs are presented as shares of gross value added at market prices .

The analysis for 2005 shows that for most industrial sectors covered by the EU ETS the maximum gross value added at stake is below 2% in Germany. For those sectors with a maximum value at stake of 2% or more, Figure 1 shows their value at stake in relation to their share in GDP.

Figure 1 Value at stake relative to GDP (Germany, 2005)

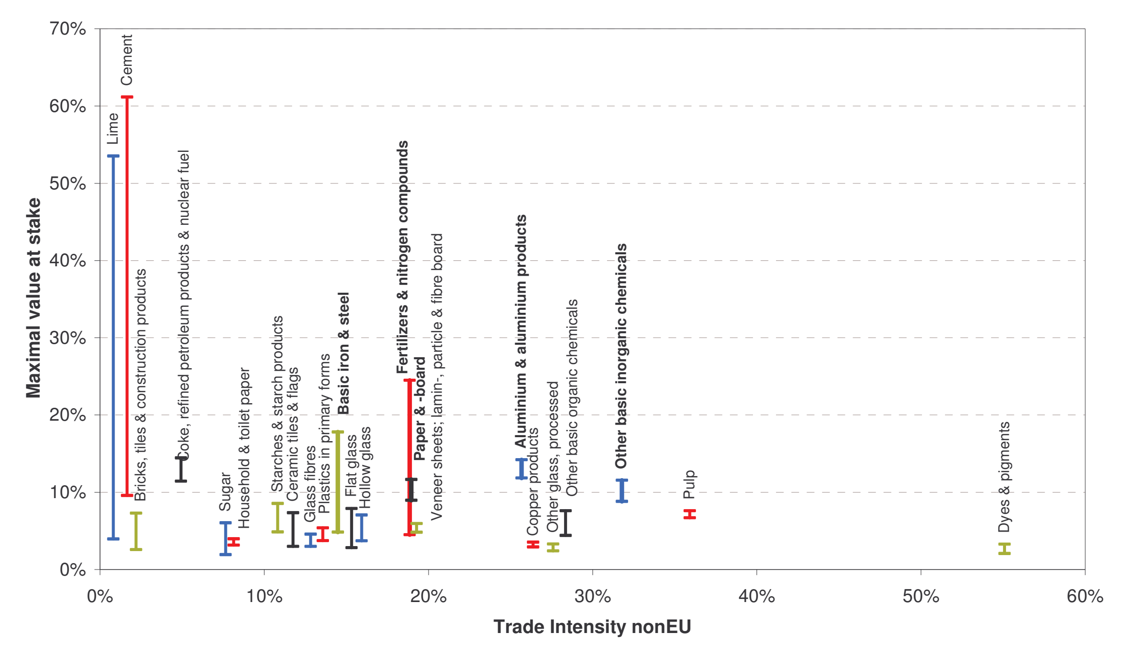


Source: Graichen et al. (2008)

For those sectors for which the potential value at stake depends mostly on the increase of electricity prices (indirect CO2 costs), a change in allocation rules would not solve the potential production cost increase these sectors are facing. This refers to the production of aluminium, paper, other basic inorganic chemicals or veneer sheets, plywood, laminboard, particle and fibre board production. The directive therefore foresees the possibility of temporary compensation by EU Member States of certain installations "which have been determined to be exposed to a significant risk of carbon leakage related to greenhouse gas emissions passed on in electricity prices for these costs" (European Parliament 2008).

For those sectors with high direct CO2 costs, it must be borne in mind that the maxi-mum value at stake is based on the assumption of full auctioning of emissions allowances. Direct costs (red bars) could be lower if part or all of the allowances were allocated for free, depending on whether, and to what extent, the concept of opportunity costs is applied.

Figure 2 Trade intensity and maximum value at stake (relative to GVA) for German sectors

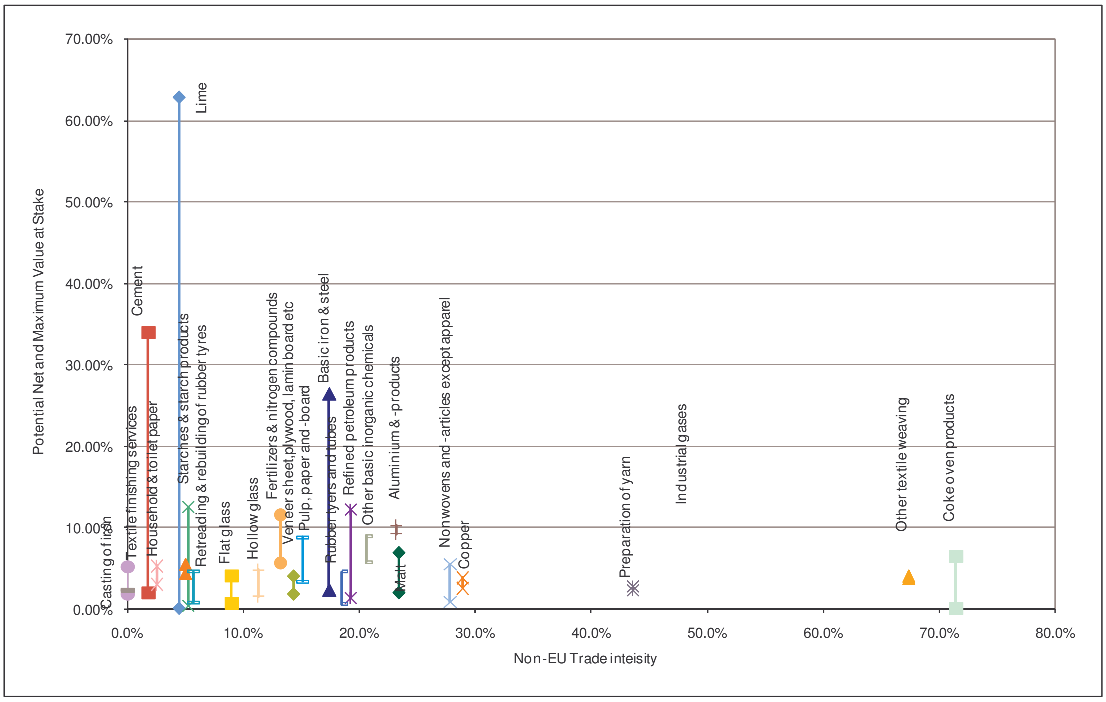


Note: Assuming 20 EUR/t CO2 carbon price, and corresponding 19 EUR/MWh electric-ity price increase, 2005 data.

Source: Graichen et al. (2008)

The trade intensity indicator used relates the sum of traded goods with countries out-side of the EU to total market supply (the sum of domestic production and total imports of the country under consideration). Figure 2 and Figure 3 provide an assessment of the potential cost increase (value at stake) and the trade intensity for a number of EU ETS sectors in Germany and the UK. The lower end of each bar depicts the indirect cost increase from anticipated electricity price increases with the ETS, relative to gross value added (GVA). The upper end of each bar reflects in addition the direct cost in-creases relative to GVA, due to CO2 emissions in combustion and process. The horizontal axis shows the trade intensity with non-EU countries of each of these sectors.

Figure 3 Trade intensity and maximum value at stake (relative to GVA) for UK sectors



Note: Assuming 20 EUR/ t CO2 carbon price, and corresponding 10 EUR/MWh electric-ity price Increase, 2004 data.

Source: Graichen et al. (2008), adapted from Hourcade and Neuhoff et al. (2007)

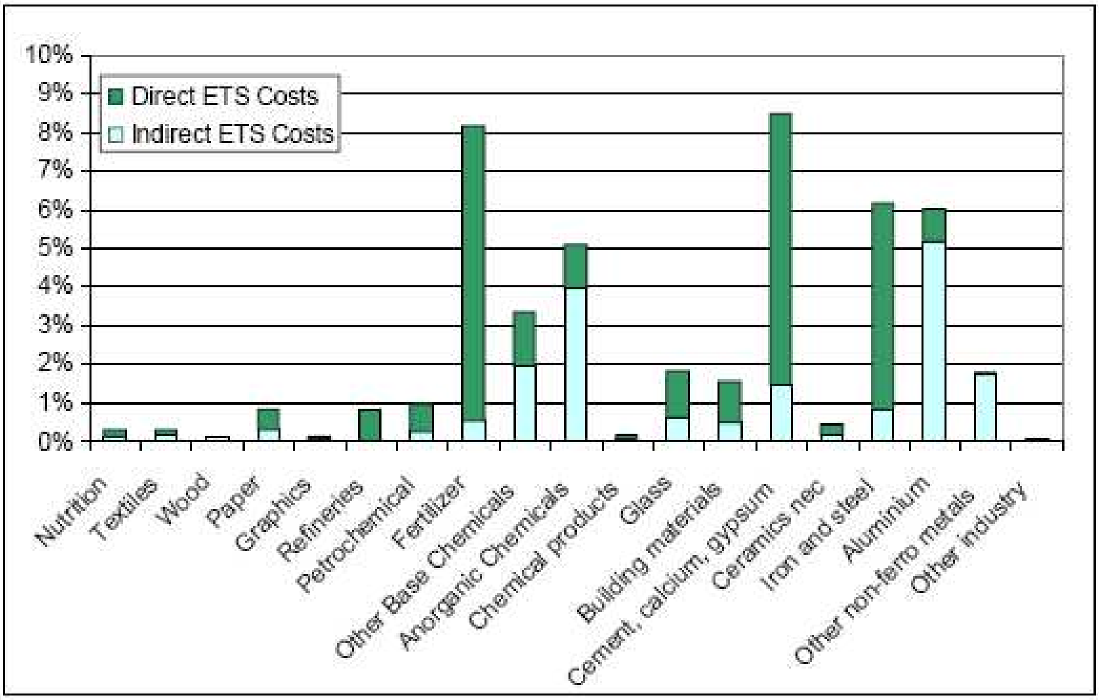
The analysis of trade intensities and value at stake shows that, in 2004/2005, a small number of sectors may in fact be exposed to distortions in competitiveness due to both high trade intensity and high value at stake (values over 10% for both criteria). For Ger-many, these may include the production of "basic iron and steel"; "fertilizers and nitro-gen compounds"; "paper and paperboard"; "aluminium and aluminium products" and "other basic inorganic chemicals". In the UK, "paper and paperboard" as well as "other basic inorganic chemicals" show lower values at stake because of lower carbon intensity in the electricity sector and may thus be less likely to be exposed to distortions. At the same time, in the UK, trade intensity with non-EU countries is higher than in Ger-many, therefore additional sectors may be considered at risk in the UK only. This in-cludes "refined petroleum products". For almost all sectors, the direct ETS costs are the driving factor, with the exception of aluminium as well as to a lesser extent paper and paperboard and other basic inorganic chemicals, which stand out in terms of indirect impact.

A number of other sectors reveal a high intensity of trade but low value at stake, which implies that the increase in product costs due to the EU ETS is relatively small and negative effects on competitiveness may not be likely. Similarly, sectors with high EU ETS related cost effects but low trade intensity are not expected to be significantly threatened by distortions in international competitiveness.

For the sectors that reveal high values at stake and high trade intensities, market positions are likely to change under the EU ETS due to increased production costs and high exposure to international competition. Firms may need to adjust their activities which may involve shifting production - or even relocating their business activity - to countries without comparable mitigation policies, which would imply carbon leakage.

Finally, when deciding on which sectors are highly exposed to possible distortions in competitiveness and which measures should be implemented to address competitive-ness and leakage it should be kept in mind that CO2 costs are only one of multiple factors affecting companies' production and investment decisions. Other factors that may deserve detailed investigation include product differentiation and market segmentation within a sector (including specialty products), close cooperation with domes-tic/European partners and intra-firm trade, differences across countries in the costs for labor and other input factors, in infrastructure quality, transportation costs, political and legal environment, or exchange rate risks.

Figure 4 Potential cost price increase as a percentage of sectors' total costs for Dutch manufacturing sectors. Scenario with full auctioning.



Note: Assuming 20 EUR/ t CO2 carbon price, and 14 EUR/MWh electricity price in-crease.
Source: de Bruyn et al. (2008)

A recent study conducted for the Netherlands (de Bruyn et al. 2008) also assesses the direct and indirect costs increase in response to the EU ETS (see Figure 4). Their methodology differs slightly as they relate ETS cost increases to total costs for each sector. This generally implies smaller scale cost effects. Nonetheless, they reveal similar results. The five sectors with highest total costs increase are cement, fertilizers, iron and steel, aluminium and inorganic chemicals. For the first three sectors, the direct ETS costs are the driving factor, for the latter two it is again the indirect ETS costs. This study, however, uses a broader classification of sectors ranging from two to four digit resolutions. The broader sector classification may therefore mask the higher or lower impacts experienced at sub-sector levels.

Eventually, the Commission Services have presented their methodology and preliminary results (European Commission 2008a & 2008b) for the EU 27 as a whole. The analysis of potentially exposed sectors follows a comparable approach, i.e. trade intensity in conjunction with direct and indirect ETS effects. However, a carbon price of 30 EUR per tonne of CO2 in combination with a full pass-through of the allowance costs to electricity prices is assumed, which implies higher CO2 cost effects. The methodology differs slightly in the way that they relate the industries' additional costs to product prices, which generally implies smaller effects compared to an assessment based on GVA.

For a range of selected products a combination of official and industry data has been used to allow for a more disaggregated level of analysis. In general, the higher disaggregation might imply much different effects for single products compared to their sector aggregate. Notably, different production processes relate to very distinct CO2 costs. Nevertheless, this approach reveals comparable results for single products which be-long to the industry classes named above (see Table 1, values for products belonging to the five sectors identified beforehand). Furthermore, these results include at upper positions also products of the sectors cement, ceramic and pulp.

The comparison of the four studies shows that even though methodologies, price assumptions and geographic coverage differ between the studies some sectors can be identified as deemed at risk for carbon leakage. These include the sectors covered in this study, i.e. production of aluminium, basic iron and steel and ferro-alloys, fertilizers and nitrogen compounds, other basic inorganic chemicals and paper and paperboard. For other sectors the result depends on the thresholds and the price assumptions chosen as these relate directly to the CO2 induced price increase.

Table 1 CO2 cost and trade intensity for selected representative products (EU 27)

Sector	PRODCOM	Product	Process	Total CO2 cost/price ratio (year average)	(X+M) /(P+M)
chemicals	24131111	Chlorine		35%	N/A
chemicals	24153030, 24153030	ammonium nitrate	integrated process of AN starting from ammonia from steam reforming of natural gas	25%	16%
chemicals	24151075, 24151077	ammonia	steam reforming (83%); partial oxidation (16.5%); water electrolysis (0.5%)	22%	N/A
chemicals	24131111	Chlorine	Mercury + Diaphragm + Membrane	16%	N/A
chemicals	241315	Sodium hydroxide	Mercury + Diaphragm + Membrane	5%	5%
non ferrous metal	27421130, 27421153	Primary Aluminium	Electrolysis EEA average	17%	62%
non ferrous metal	27421130, 27421153	Primary Aluminium	Electrolysis EU average	16%	62%
non ferrous metal	27421200	Alumina	Bayer Process	16%	74%
non ferrous metal	27422230, 27422250, 27422630, 27422650, 28112370	Extrusion Aluminium	Extrusion Press	1%	14%
non ferrous metal	27421155	Recycled Aluminium	Direct fired furnaces	1%	6%
non ferrous metal	27422430, 27422450	Rolling Aluminium	Hot and cold rolling	0%	27%
pulp and paper	21111415	Pulp for newsprint TMP	TMP	12%	96%
pulp and paper	21121150	Paper for newsprint TMP	TMP	9%	23%
pulp and paper	21122250	Packaging virgin pulp unbleached kraftliner	sulphate	9%	34%
pulp and paper	21111313, 21111315, 21111353, 21111355	Pulp Sulphite	Sulphite	8%	30%
pulp and paper	21111430	Pulp CTMP	CTMP	8%	46%
pulp and paper	21111213, 21111215, 21111253, 21111255	Pulp Sulphate	Sulphate	8%	43%
pulp and paper	21111419	Pulp for newsprint ground-wood	Ground-wood	7%	27%
pulp and paper	21121410, 21121435, 21121439, 21121450	Paper uncoated sulphite	Sulphite	7%	15%
pulp and paper	21122520, 21122540	Packaging RCF testliner	RCF	6%	8%
pulp and paper	21121410, 21121435, 21121439, 21121450	Paper uncoated sulphate	Sulphate	6%	15%
pulp and paper	21121150	Paper for newsprint RCF	RCF	4%	23%
pulp and paper	21122335, 21122337, 21123065, 21125430, 21125453, 21125455, 21125459, 21125655, 21125659	Packaging RCF cartonboard	RCF	3%	37%
pulp and paper	21122130, 21122155, 21122157, 21122190, 21221110, 21221133, 21221135, 21221150	Tissue RCF	RCF	2%	8%
pulp and paper	21122130, 21122155, 21122157, 21122190, 21221110, 21221133, 21221135, 21221150	Tissue virgin pulp	sulphate	2%	8%
steel and iron	27106020	Hot rolled coil (total)	BOF	16%	30%
steel and iron	27103110, 27103310	slabs	BOF	15%	54%
steel and iron	27107229	Hot dipped metallic coated	BOF	13%	18%
steel and iron	27108110, 27108120, 27108130, 27108140, 27108190, 27108210, 27108299	Wire Rod	EAF	5%	21%
steel and iron	27108319	Rebar	EAF	5%	16%
steel and iron	27104159	Stainless Cold Rolled	EAF	1%	33%

Source: European Commission (2008b)

3 In-depth sectoral analysis

In the following analysis the potentially exposed sectors include the production of aluminium (NACE 27.42), basic iron and steel and ferro-alloys (NACE 27.10), fertilizers and nitrogen compounds (NACE 24.15), other basic inorganic chemicals (NACE 24.13) and paper and paperboard (NACE 21.12).

Each sectoral chapter includes a description of the production processes along the value chain, of the input structure with its main inputs, the energy use as well as an analysis of the cost components. Moreover, the respective trade flows of the EU with non-EU partners are analysed for the years 2003 to 2007.

As an introductory overview from the trade perspective table 2 shows the sizes of the total trade volumes of the five potentially exposed sectors for the EU-27. All of them have grown, in parts rapidly, between 2003 and 2007. Since 2005 the basic iron and steel's trade volume outweighs the sum of the other four sectors.

Table 2 Trade volumes of the five potentially exposed sectors for the EU-27, 2003-2007

Potentially exposed sector	**NACE**	**EU-27 trade volume [million EUR]**				
		2003	**2004**	**2005**	**2006**	**2007**
Basic iron & steel and ferro-alloys	27.10	113 983	163 293	178 276	215 279	258 893
Paper & paperboard	21.12	83 499	85 738	85 408	91 533	96 970
Aluminium	27.42	50 170	54 736	59 574	80 986	88 189
Other basic inorganic chemicals	24.13	17 254	18 194	19 136	21 762	24 965
Fertilizers & nitrogen compounds	24.15	11 446	11 884	13 218	13 929	16 477

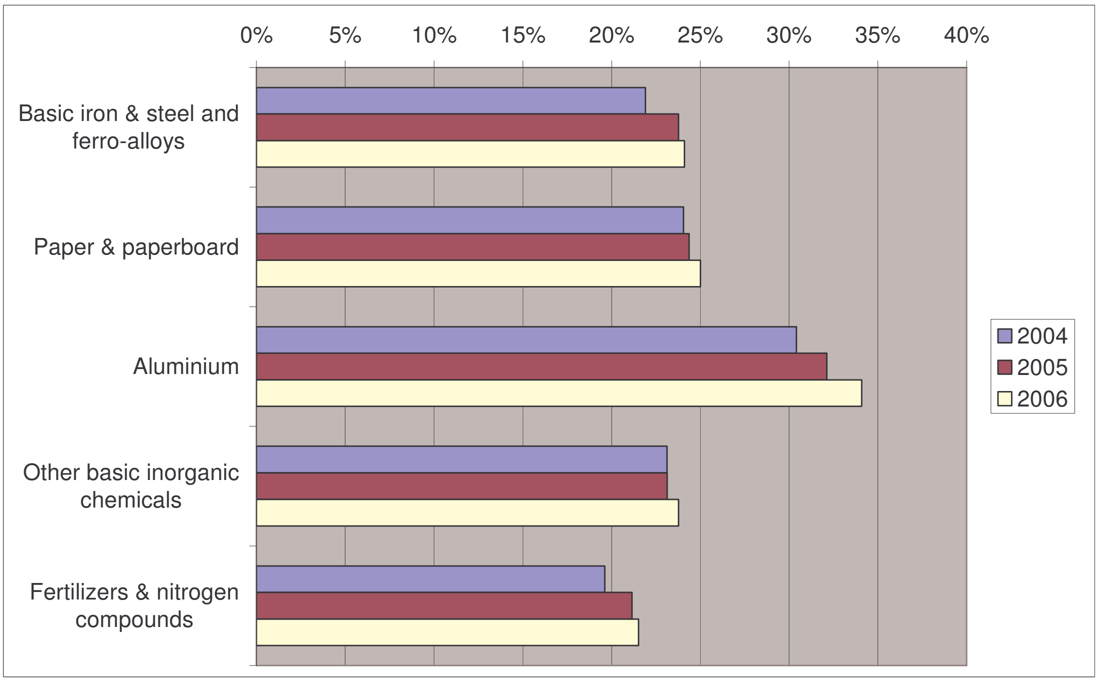
Note: All data at current prices

Source: Calculations by Öko-Institut based on Eurostat (2009)

However, growth in trade volumes also derives from rising world market prices. Therefore, the relation to turnover is needed in order to allow for a thorough comparison of trade intensities (see table 2). Over the years 2004 to 2006 isolated high increases in trade volume occur, i.e. aluminium (+48%), basic iron and steel (+32%), other basic inorganic chemicals (+20%), fertilizers and nitrogen compounds (+17%), paper and paperboard (+7%). However, during the same period[1] it can be seen that trade intensities change only slightly with a maximum rise of 3.7% in the aluminium sector (see Figure 5).

[1] Data for the 2007 is not available yet.

Figure 5 *EU trade intensity in the five potentially exposed sectors*



Note: Estimated data is included in the calculations for paper & paperboard 2004, other basic inorganic chemicals 2005. Estimated and unreliable or uncertain data is included in the calculations for basic iron &steel 2004 and paper & paperboard 2005.

Source: Calculations by Öko-Institut based on Eurostat (2009)

Table 3 allows for closer look at the underlying export and import intensities and reveals that, similarly, only slight changes occur. On the one hand, changes of trade intensities in the sectors aluminium (30.4% in 2004 to 34.1% in 2006) and basic iron and steel (21.9% in 2004 to 24.1% in 2006) are mainly due to rising import intensities (see *Table* 3). On the other hand, changes in the fertilizers and nitrogen compounds sector (19.6% in 2004 to 21.5% in 2006) mainly result from rising export intensity.

Table 3 *EU export and import intensities in the five potentially exposed sectors*

Potentially exposed sector	**NACE**	**Export intensity**			**Import intensity**		
		2004	**2005**	**2006**	**2004**	**2005**	**2006**
Basic iron & steel and ferro-alloys	27.10	12%	13%	12%	10%	11%	13%
Paper & paperboard	21.12	18%	18%	19%	6%	6%	6%
Aluminium	27.42	10%	12%	11%	20%	21%	24%
Other basic inorganic chemicals	24.13	10%	9%	10%	13%	14%	14%
Fertilizers & nitrogen compounds	24.15	6%	8%	8%	14%	13%	14%

Note: Estimated data is included in the calculations for paper & paperboard 2004, other basic inorganic chemicals 2005. Estimated and unreliable or uncertain data is included in the calculations for basic iron &steel 2004 and paper & paperboard 2005.

Source: Calculations by Öko-Institut based on Eurostat (2009)

3.1 Aluminium

Aluminium can be produced through primary or secondary processing. In the primary aluminium industry the main process steps include 1) bauxite mining, 2) production of alumina, 3) production of aluminium, and 4) fabrication aluminium products through casting, rolling and extrusion. In the secondary process aluminium is produced by remelting aluminium scrap.

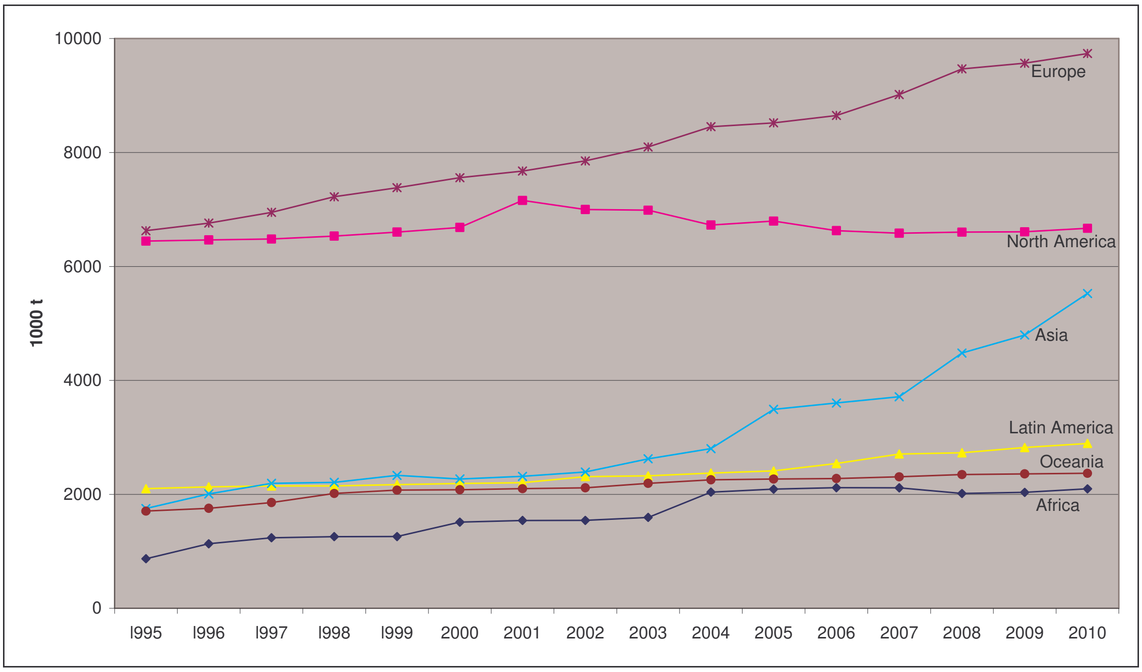
In the primary process, bauxite, after mining, is converted to alumina. Most of the world's alumina production is based on the Bayer process. Bauxite (aluminium contain-ing ore) is converted alumina by treating it with sodium hydroxide at high temperature and pressure.

Alumina is then electrolytically reduced to primary aluminium using the worldwide adopted Hall-Heroult process. To feed the electrolysis cells (smelter) a conversion from high voltage AC to low-voltage DC is required. Carbon anodes, either in form of pre-baked anodes, which are produced in a separate process and require less electricity in the smelter, or Söderberg paste, are used for the reaction. The electrodes of the electrolysis can be partly recycled and used as feedstock for further anode production. The crude, hot aluminium can be cast into intermediate products (e.g. ingots), and processed into final products.

Along the production chain, primary aluminium requires four to six tonnes of bauxite, transformed into two tonnes of aluminium oxide (Al_2O_3), also called alumina, and further transformed into one tonne of final aluminium metal. On average, the specific energy consumption in Europe is about 15.8 kWh/kg end product which is higher than in all other regions . Because of the high energy intensity, smelting plants are usually located near (or on-site) abundant electricity generating plants, such as hydro-electric based plants.

In 2007, 24.8 Mt of primary aluminium were produced worldwide whereof roughly one third was produced in Europe (including non-EU countries e.g. Island and Norway) . The production in Europe has remained rather stable over the past years whereas in Asia it has increased significantly (from 2.7 Mt in 2004 to 3.7 Mt in 2007). Taking into account the alumina production capacity under construction, the trend is expected to continue for Asia (see Figure 6).

Figure 6 Production capacity for primary aluminium (1995-2010)



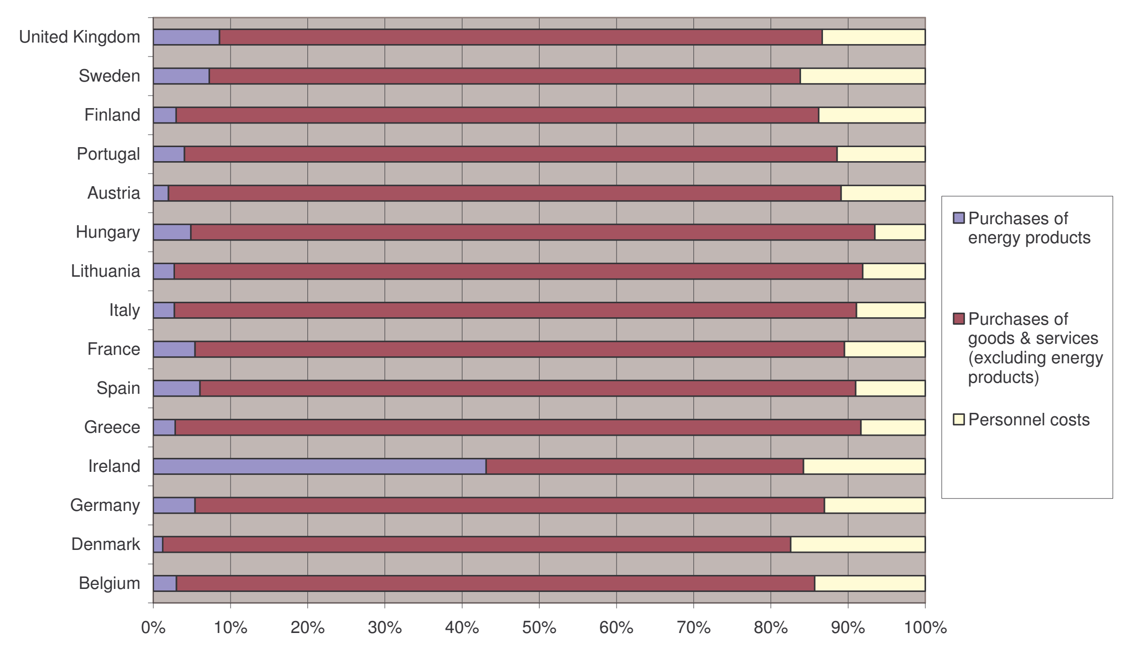
Note: Primary aluminium annual production capacity is the weight of primary aluminium which, it is estimated, could be produced in a period of one year. It includes the capacity of existing plant, irrespective of whether the plant is operating or idle, and the capacity of new plant physically under construction.

Source: IAI website (accessed 15 January 2009). Last update 20 August 2008.

Over the years, secondary aluminium production (recycling) has become more and more important, as it needs only 5% of the energy input required for primary aluminium production. Secondary aluminium production involves a scrap processing step and subsequent remelting before it can be further produced. No difference exists between primary and recycled aluminium in terms of quality or properties.

The breakdown of operational expenditure in the 'manufacture of aluminium' (both primary and secondary, NACE 27.42) into three blocks (purchases of energy products, personnel costs and all other purchases of goods and services) varies across EU coun-tries (see Figure 7). The share spent on energy products (including all energy products used as fuel as well as electricity and heat) varies from 1% (Denmark) to 9% (United Kingdom). Ireland has an exceptional high share of more than 40%. The share spent on personnel costs varies from 7% (Hungary) to 17% (Denmark) . The personnel costs in four Eastern and Middle European Member States where values are available (Czech Republic, Lithuania, Hungary and Poland) are at the lower end (7%-8%).

Figure 7 Breakdown of operational costs in the EU aluminium production (2006)



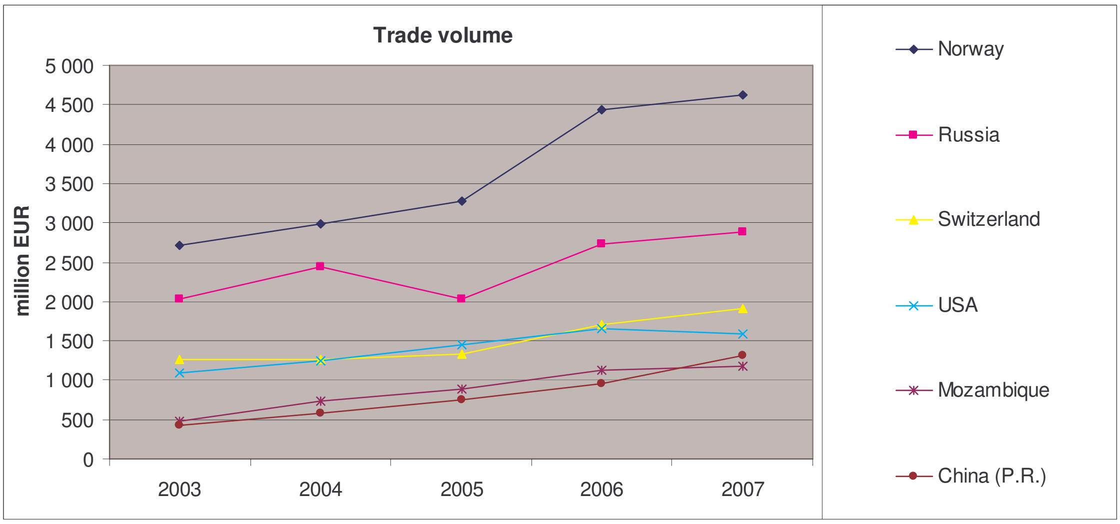
Note: Only EU Member States with complete data are included.

Source: Eurostat, SBS (date of extraction 14 January 2009)

The values for the sector at NACE 4-digit level mask the great differences of energy intensity of the different production processes. The analysis carried out by the European Commission (2008b) is based on a higher disaggregation level. There are notable differences of the total CO2 cost to price ratio between production of primary aluminium and alumina on the one hand (16%-17%) and the extrusion, recycling and rolling aluminium on the other hand (0%-1%) (see Table 1).

The trade volume of aluminium (NACE 27.42) is the second highest of the five potentially exposed sectors. It has risen by 76% from 50,170 million EUR in 2003 to 88,189 million EUR in 2007 (see Table 2). Yet, the intra-EU trade share has been stable at 72% during this period. The six main non-EU partners are Norway , Russia, Switzer-land, the USA, China (P.R.) and Mozambique (see Figure 8). These account for 15%, i.e. 13,491 million EUR or more than half of non-EU trade in 2007.

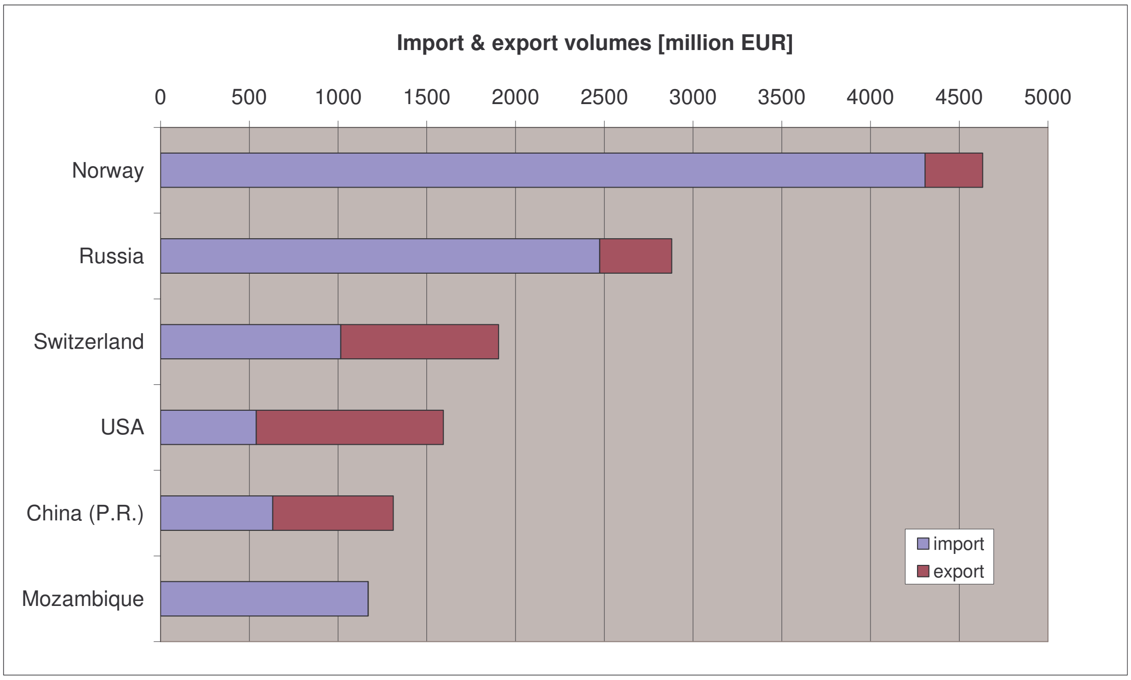
Figure 8 Aluminium, main non-EU trading partners, 2003-2007



Source: Calculations by Öko-Institut based on Eurostat (2009)

The non-EU trade structure in this sector has been dominated by imports over the years. Their share sank from 67% in 2003 to 64% in 2005, but has risen since to 72% in 2007. Figure 9 shows the respective import and export shares of the six main non-EU partners in 2007. Norway and Russia dominate trade volume and imports. The USA, Switzerland and China (P.R.) show a rather balanced ratio between import and export, whereas Mozambique is a considerable import partner only.

Figure 9 Aluminium, import and export shares of main non-EU trading partners, 2007



Source: Calculations by Öko-Institut based on Eurostat (2009)

3.2 Basic iron and steel and ferro-alloys

Iron and steel production is among the most energy-intensive industries in the majority of industrialized countries and is responsible for a large share of greenhouse gas emissions. Out of 1,343.5 million metric tons of crude steel produced worldwide in 2007, 15.7% was manufactured in the EU 27[2]. With an output of 48.5 million metric tons of crude steel in 2007, Germany is the largest producer in the EU and ranks position 7 worldwide, following China, Japan, the USA, Russia, India and South Korea.

The two main processes to produce crude steel are (1) the integrated route of producing crude steel in a two-step blast furnace/basic oxygen process (BOF) based mainly on iron ore and coke, and (2) the electric arc furnace route (EAF) based on scrap steel and electricity. They differ mainly with respect to fuel and raw material input, production technology and scale, and variety and quality of steel products.

For the production of BOF steel in integrated steelworks two steps may be distinguished. First, starting from iron ore, pig iron is produced in blast furnaces which are fed with sinter, coke and additives. In the second step, pig iron is converted to steel in a basic oxygen furnace. In the alternative EAF route, steel is made in electric arc furnaces where scrap is melted into crude steel.

For the EAF route, electricity is the principal energy input. In comparison, for the BOF route coke is the main fuel and used, in particular, to generate thermal heat for the conversion process. In addition, coke also serves as reducing agent for the reduction of the iron oxide into metallic iron. Many integrated steelworks include a coking plant on site, where coke is produced from coal via heating in the absence of air (pyrolysis), yielding coke as primary product, as well as coke oven gas and liquid products like tars.

To produce finished steel that can be sold on the final market, crude steel needs to be further processed, i.e. metallurgically treated, cast, rolled and shaped. The most relevant final products are made from rolled steel.

BOF steel typically allows for a wider variety of products as it is newly produced from iron ore and does not contain alloy elements. In contrast, EAF steel made from scrap contains alloy elements that are brought into the product with the scrap, which cannot easily be separated from the steel. Hence, EAF steel is usually considered to be of lower quality than BOF steel. Consequently, BOF steel tends to be transformed into rather flat products, such as sheets for car manufacturing, while EAF steel is used for long products such as concrete reinforcing bars in the construction sector. There are, however, options to improve the quality of EAF steel e.g. by adding highly pure iron produced via the DRI route to the input. This allows diluting the concentration of undesired alloy elements.

Additionally, the introduction of new downstream processing (casting) technologies allows EAF plants to compete in market segments that were traditionally reserved for integrated mills (Worrell and Biermans 2005, In: Graichen et al. 2008). A major advantage of scrap-based steel making is its lower energy consumption and higher flexibility. No products from other on-site installations are needed, and it can economically produce steel at substantially smaller scales than the integrated route. Scrap-based electric arc furnaces are often referred to as mini-mills. According to the Worldsteel association (2008) the share of EAF in the EU 27 is on average 40%. It is substantially higher in some EU member states like Spain (78%) or Italy (63%) and

[2] See http://www.worldsteel.org/?action=newsdetail&jaar=2008&id=228 (accessed 15 January 2009).

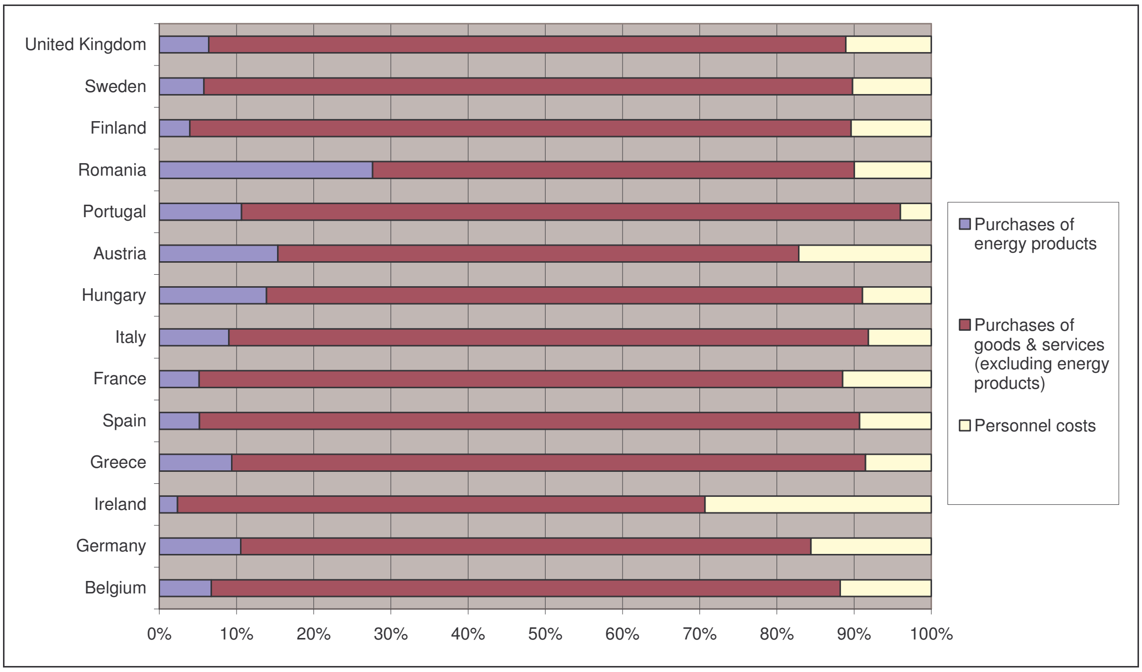
lower in others, such as Germany (31%). Some EU Member States (Greece, Luxembourg, Portugal and Slovenia) produce all crude steel using the EAF process.

The energy use for the production of BOF steel is 6-7 times higher than for EAF steel. According to the energy inputs reported in BREF steel (2001) the energy input per ton of steel produced in integrated steelworks is 16.1 GJ whereas the production of one ton EAF steel consumes 2.5 GJ. For Germany, the biggest steel producer in Europe, the values are slightly higher for BOF steel (17.4 GJ/t) and lower for EAF steel (2.3 GJ/t) (Graichen et al., 2008). The investment costs per ton of crude steel produced via the BOF route are 2 to 3 times higher than via the EAF route (Neuhoff, Matthes et al. 2008).

The sector 'manufacture of basic iron and steel and ferro-alloys' (NACE 27.10) comprises not only the operation of blast furnaces, steel converters and mills, but also the production of ferro-alloys, semi-finished products of steel and the manufacture of hot-rolled bars, to cite some. The breakdown of operational expenditure in the sector in EU countries (see figure 10) shows that personnel costs account for 10% of total expenditure in most Member States. The highest share of personnel costs is reported for Ireland (29%) and the lowest for Portugal (4%). The share of purchases of energy products in total expenditure vary widely between countries (Romania: 28%; Ireland 2%). reasons for this differences include different steel production processes, efficiency of the plants as well as local prices for energy products.

The Commission's Non-Paper (2008b) distinguishes six different representative products in the iron and steel sector. The CO_2 cost to product price ratio for the three products produced via the BOF route (hot roiled coil, slabs and hot dipped metallic coated) ranges from 13% to 16% whereas the ratio for the three products manufactured via the EAF process (wire rod, rebar and stainless cold rolled) is significantly lower (1% to 5%) (see table 1).

Figure 10 Breakdown of operational costs in the EU basic iron & steel production (2006)

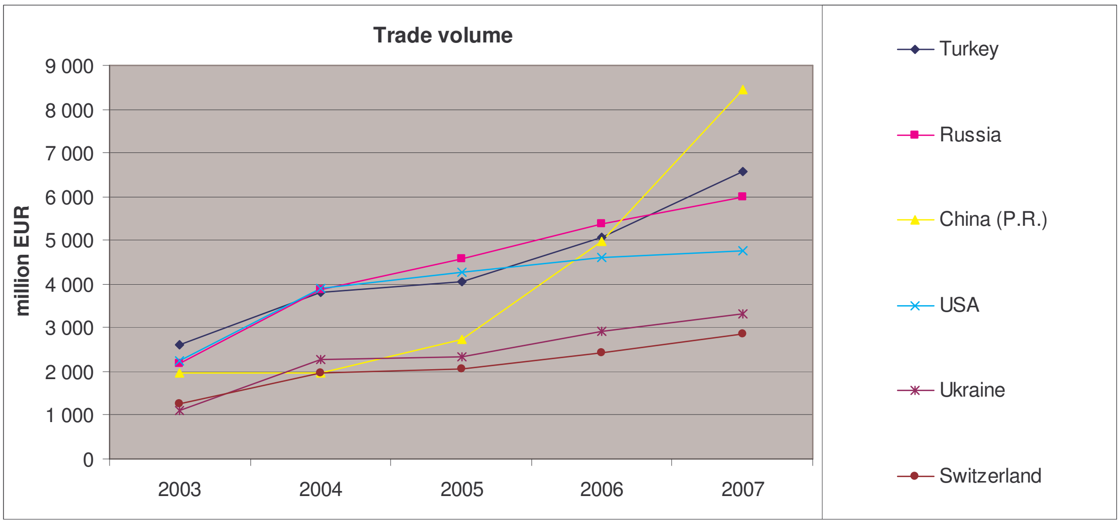


Note: Only EU Member States with complete data are included.

Source: Eurostat, SBS (date of extraction 14 January 2009)

The trade volume of basic iron and steel and ferro-alloys (NACE 27.10) is by far the highest of the five potentially exposed sectors in the EU 27. It has more than doubled from 113,983 million EUR in 2003 to 258,893 million EUR in 2007 (see table 2). Yet, the share of intra-EU trade has been rather stable at around 77% during this period. The six main non-EU trading partners are China, Turkey, Russia, the USA, Ukraine and Switzerland, which together make up 12% in 2007, i.e. 31,947 million EUR or half of non-EU trade (see figure 11).

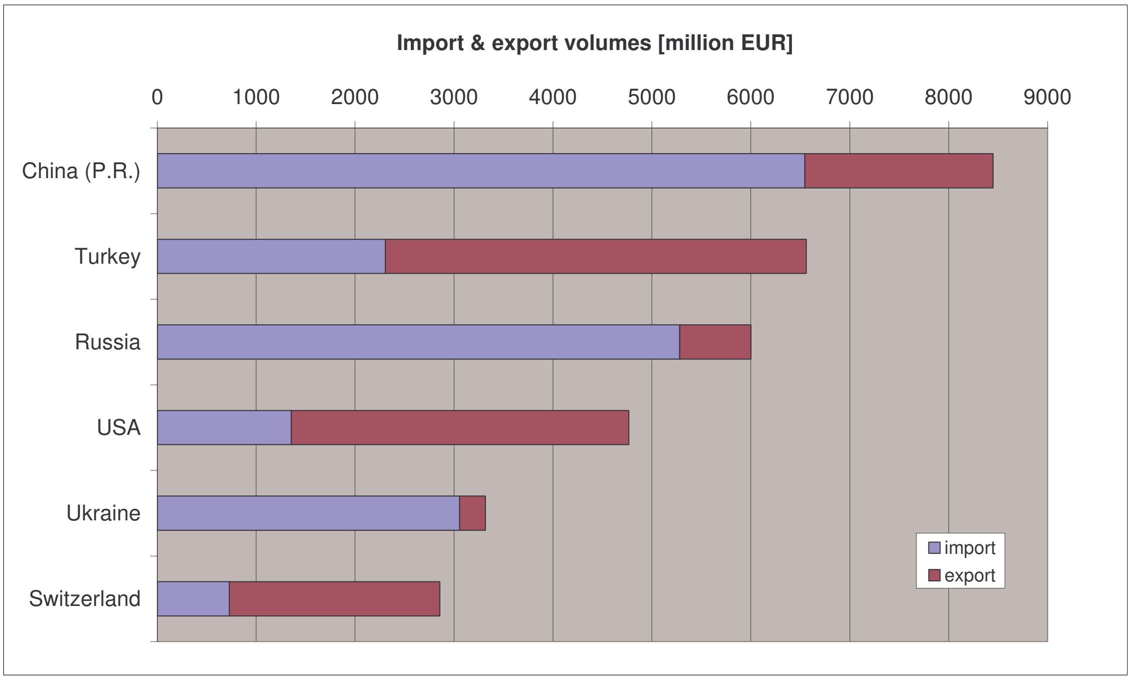
Figure 11 Iron & steel, main non-EU trading partners, 2003-2007



Source: Calculations by Öko-Institut based on Eurostat (2009)

The non-EU trade structure in this sector was in favour of exports (56%) in 2003, whereas roles have constantly changed in favour of imports (57%) till 2007. Figure 12 specifies the import and export shares of the main non-EU trading partners for the year 2007. It reveals China, Russia and Ukraine as main sources of imports and Turkey and the USA as main destinations for exports.

Figure 12 Iron & steel, import and export shares of main non-EU trading partners, 2007



Source: Calculations by Öko-Institut based on Eurostat (2009)

3.3 Fertilizers and nitrogen compounds

About 1.4 % of total world consumption of fossil energy (not including combustion of wood) goes into the production of ammonia, roughly 83 % of which is used for fertilizers (e.g. Bhattacharjee 2006, Gielen 2007). The remainder mostly serves as a building block for the synthesis of many pharmaceuticals. As such, ammonia may be applied as a gas or converted to other chemical forms such as urea and applied either in granular form or in solution.
Ammonia is typically produced by the Haber-Bosch method consisting of the subsequent three steps (Ullmann 2008):

1. Production of a mixture of hydrogen, carbon monoxide and nitrogen by first converting natural gas or liquefied petroleum gas (i.e. propane and butane) or petroleum naphtha into gaseous hydrogen and then removing the sulphur compounds. Catalytic steam reforming then leads to hydrogen plus carbon monoxide.
2. The water gas shift reaction is used to convert the carbon monoxide into carbon dioxide and more hydrogen from the process gas.
3. The hydrogen is then catalytically reacted with nitrogen to form anhydrous liquid ammonia in the so called ammonia synthesis loop.

Since the 1930s, when steam reforming of hydrocarbons for ammonia production started, specific energy consumption per ton of ammonia has come down from more than 80 GJ/t to best available technology levels of about 28 GJ/t (Rafiqul 2005). The average specific energy use in Western European countries is around 35 GJ/t and in Central European Countries significantly higher at 43.6 GJ/t. Comparing worldwide the average energy use of gas based ammonia production only, Central European Countries requires most energy per ton and China produces most efficiently (34 GJ/t) (IEA 2007). The first stage is the most energy-intensive one accounting for more than half of total specific energy use and almost three quarters in modern plants (Rafiqul 2005). In general, though, specific consumption levels depend on the type of feedstock used. Using natural gas requires the lowest and the gasification of coal the highest specific energy use (Ullmann 2008, Rafiqul et al. 2005). 70.5% of world ammonia production is based on gas, 8.5% on oil and 21% on coal (IEA 2007). If natural gas is used, about 80% are typically consumed as reformer feed and 20% as reformer fuel.

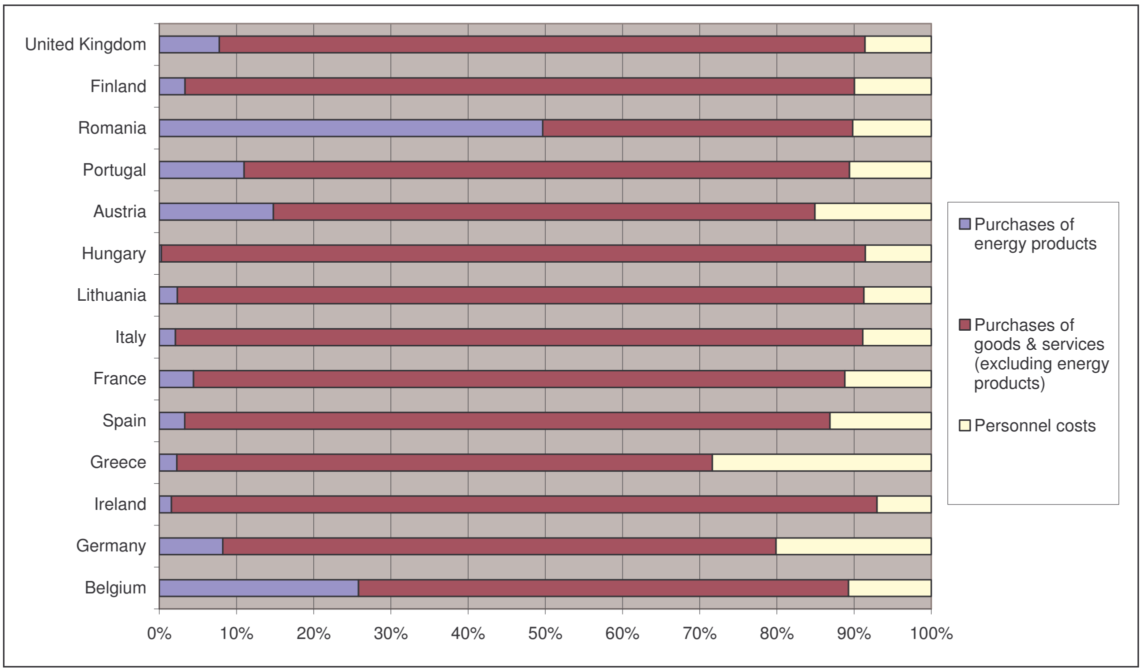
In a benchmark study conducted by the International Fertilizer Industry Association the energy efficiency of 66 ammonia plants aged one to 35 years were compared. The average energy use ranged from 28 – 35 GJ/t of ammonia. CO_2 emissions ranged from 1.5 – 3.1 t CO_2/t ammonia. Two thirds of the average CO_2 emissions (2.1 t CO_2/t ammonia) were process related and one third energy related (IEA 2007).

Alternatively, ammonia may also be formed as a by-product in coking plants. But less than one percent of total ammonia is produced via this route, and none in the USA or in Europe.

Natural gas costs account for 70-90% of the production cost of ammonia (IEA 2007); consequently, the energy efficiency of the plants influences the production cost structure significantly. The share of energy cost in operational expenditure ranges from 2% (Ireland, Greece, Italy and Lithuania) to 50% (Romania). The comparison cost structures in the sector 'manufacture of fertilizers and nitrogen compounds' (NACE 24.15) shows that the share of personnel costs in total operational expenditure varies from 28% (Greece) to 7% (Ireland) (see figure 13).

The analysis of representative products carried out by the European Commission (2008b) distinguishes two products only; ammonium nitrate and ammonia. The value for the CO_2 cost to product price ratio for both products is comparable at 22%-25% (see table 1).

Figure 13 Breakdown of operational costs in the EU production of fertilizers and nitrogen compounds (2006)



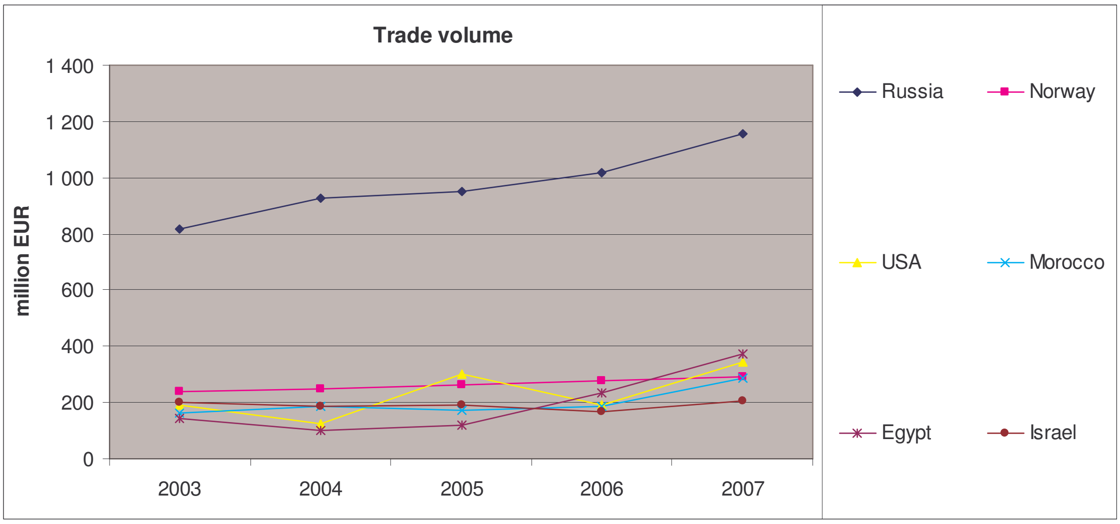
Note: Only EU Member States with complete data are included.

Source: Eurostat, SBS (date of extraction 14 January 2009)

Trade in fertilizers and nitrogen compounds (NACE 24.15) is the smallest of the five potentially exposed sectors in the EU 27. Yet, it has grown by 44% from 11,446 million EUR in 2003 to 16,477 million EUR in 2007 (see table 2). The intra-EU share of the trade volume was around 69% during this period. Russia is by far the most important non-EU trade partner. Other major ones are Egypt, the USA, Norway[3], Morocco and Israel (see figure 14). Together they resemble 16%, i.e. 2,660 million EUR or half of non-EU trade in 2007.

[3] Norway's potential comparative advantage will disappear by the time of being part of the EU ETS.

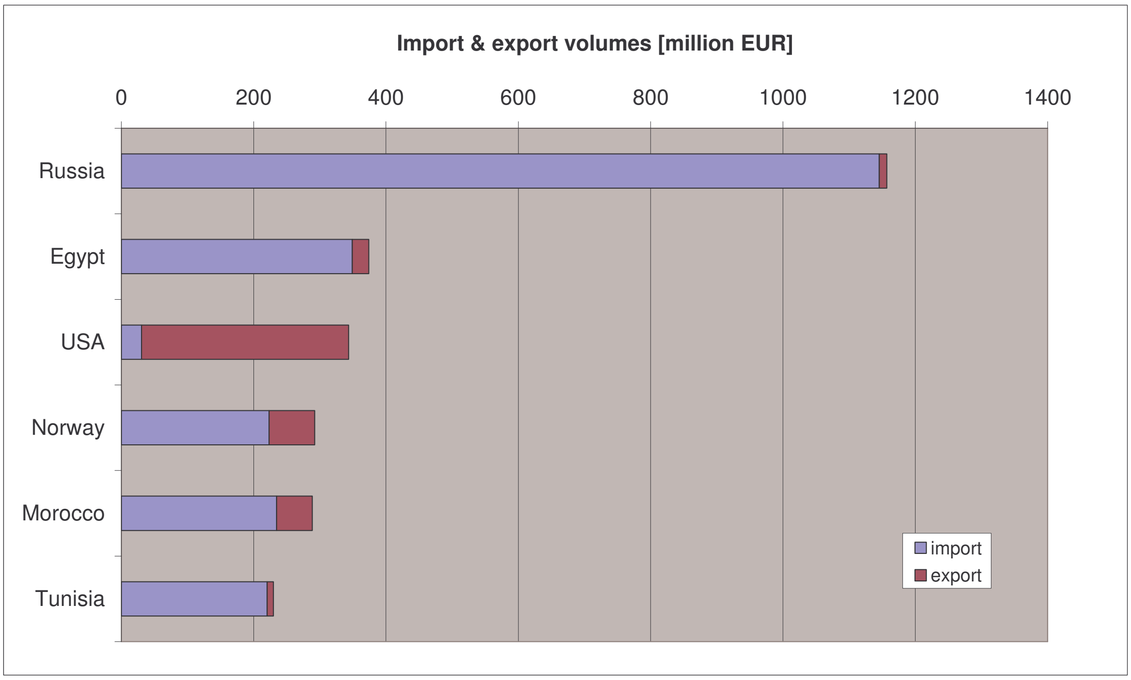
Figure 14 Fertilizers and nitrogen compounds, main non-EU trading partners, 2003-2007



Source: Calculations by Öko-Institut based on Eurostat (2009)

The non-EU trade structure in this sector has been dominated by imports (66%) over the years. Hereby, Russia is by far the main country of origin followed by Egypt, Morocco, Norway and Tunisia which has replaced Israel in the positions by trade volume and by import in the year 2007. The main export destination is the USA (see figure 15).

Figure 15 Fertilizers and nitrogen compounds, import and export shares of main non-EU trading partners, 2007



Source: Calculations by Öko-Institut based on Eurostat (2009)

3.4 Other basic inorganic chemicals

Chlorine and Sodium Hydroxide

Chlorine is a primary chemical which accounts for about two-thirds of the chemical industry's turnover. It is produced through electrolysis, i.e. via passing an electric current through a solution of brine (= common salt dissolved in water). The main co-products of this process are chlorine gas (Cl_2) and caustic soda (= sodium hydroxide, NaOH). Chlorine gas is widely used for pharmaceuticals, medical devices, windows, flooring and pipes. Caustic soda is an alkali and used in the food industry, textile production, for soap and other cleaning agents, water treatment and effluent control.

Chlorine is produced via one of three alternative electrolysis processes: the membrane process, the diaphragm process and the mercury-cell process. Of these processes, the mercury process uses the most electricity, but no steam. In Europe about half of the chlorine is produced via the mercury cell process (IEA 2007). However, it is being phased out for environmental reasons and typically replaced by the membrane process. Thermal energy is required to concentrate the sodium hydroxide (to a 50% solution), whereby – as indicated above – hydrogen is produced as a by-product. The specific energy consumption of the different production processes are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 4 Energy use of Chlorine Production Processes

	Electricity Consumption GJel /t Cl2	Steam Consumption GJ/t Cl2
Mercury process	11.8	0.0
Diaphragm process	10.0	2.2
Membrane process	8.6 – 9.2	0.6

Note: Membrane process range reflects current densities of 0.3 and 0.4 A/cm2, respectively.

Source: IEA (2007)

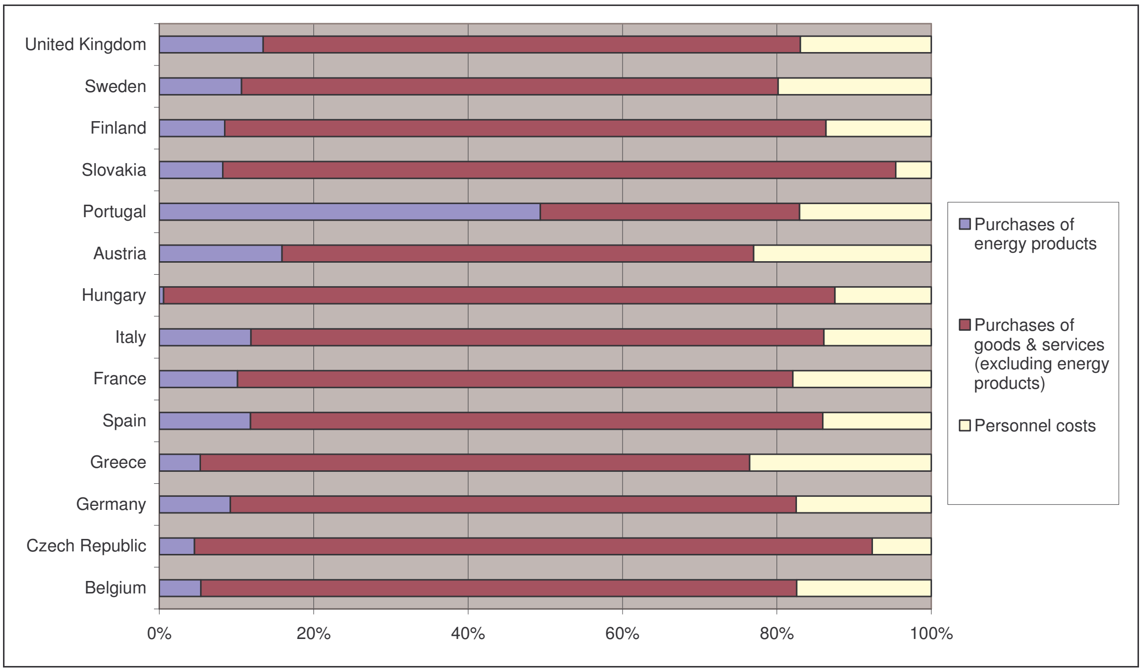
Production of sodium carbonate

Sodium carbonate (soda) is the most important sodium salt and used for the manufacturing of glass (50 %), in the chemical production (23 %), for paper (5 %) and for the production of soap (5 %) (Roempp 2008). The main production process for the production of soda is the Solvay process. The main stages are brine purification, limestone burning and lime slaking, ammonia absorption, precipitation of bicarbonate, filtration of bicarbonate, calcination of bicarbonate and recovery of ammonia. About one third of worldwide soda produced is manufactured in the EU synthetically. In the USA (accounting for 27% of total soda production in 2004) production is based on natural soda ash deposits and soda recovery from lakes; which is less energy intensive and less costly. Using best available technique, the energy use for the synthetic production is about 10-12 GJ/t soda ash (IEA 2007).

Production of calcium carbide

Calcium carbide is produced via an electric arc furnace loaded with a mixture of lime and coke at very high temperatures (2000°C). Calcium carbide can be processed at high temperature to calcium cyanamide, which is used as fertilizer. Other applications include manufacture of acetylene, a feedstock for the chemical industry mainly in the production of polyvinyl chloride, steelmaking and for carbide lamps.
The Non-Paper of the Commission assesses two representative products in the sector 'other inorganic chemicals'; the production of chlorine and sodium hydroxide. The CO_2 cost to price ratio for sodium hydroxide is quantified with 5%. Two values are given for Chlorine (16% and 35%) without further explication of the differences (see table 1).
The analysis of operational expenditure in the sector again shows major differences between the shares of purchases of energy products. While for most Member States the values range between 5% and 13%, in Portugal nearly have of the operational cost is spent on the purchases of energy products (see figure 16).

Figure 16 Breakdown of operational costs in the EU production of other basic inorganic chemicals (2006)



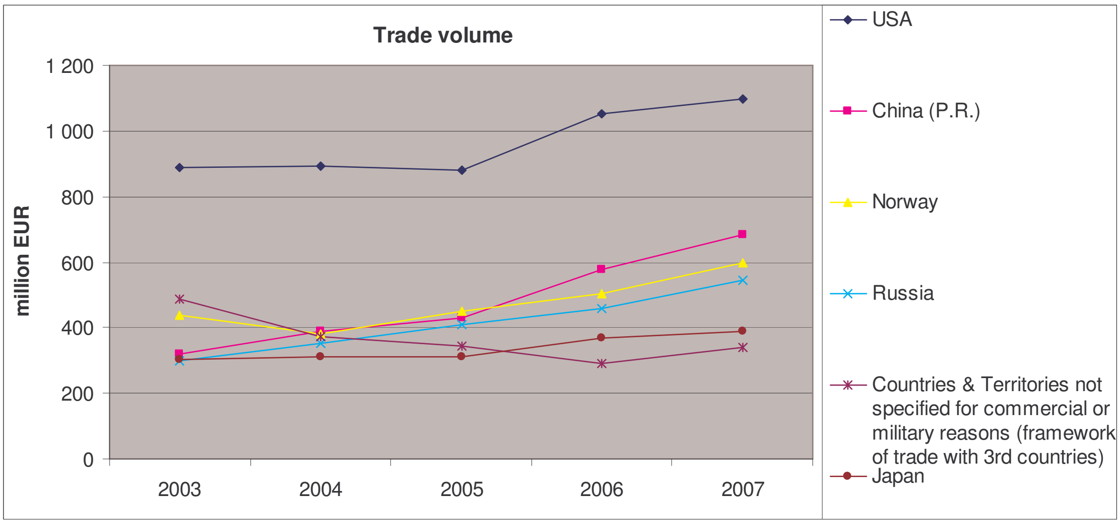
Note: Only EU Member States with complete data are included.
Source: Eurostat, SBS (date of extraction 14 January 2009)

The trade volume of other basic inorganic chemicals (NACE 24.13) is the second smallest of the five sectors. However, it has grown by 47% from 17,254 million EUR in 2003 to 24,965 million EUR in 2007 (see table 2). Hereby, the share of intra-EU trade has been rather constant at 71%. The main non-EU trading partners are the USA, China (P.R.), Norway[4], Russia and Japan (see figure 17). Furthermore, countries and territories not specified for commercial or military

[4] Norway's potential comparative advantage will disappear by the time of being part of the EU ETS.

reasons (within the framework of trade with third countries) claim a considerable position in trade, but it cannot be said if this is a group or a single country. Altogether, these six partners make up 15%, i.e. 3,681 million EUR or half of non-EU trade in 2007.

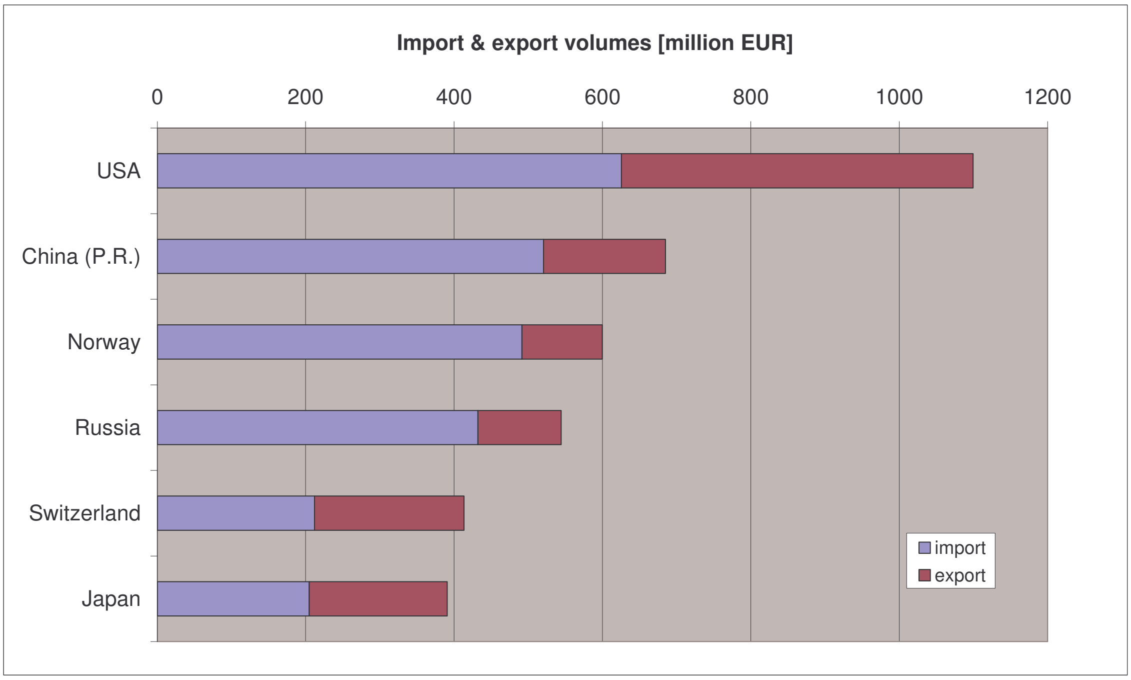
Figure 17 Other basic inorganic chemicals, main non-EU trading partners, 2003-2007



Source: Calculations by Öko-Institut based on Eurostat (2009)

The structure of non-EU trade in this sector is slightly in favour of imports (58%) which claim nearly the same size over the years. The USA is the major non-EU import and export partner. A balanced ratio also show Japan and Switzerland which has replaced the fifth position of countries and territories not specified for commercial or military reasons (within the framework of trade with third countries) in the year 2007. China (P.R.), Norway and Russia are mainly import partners, but claim shares comparable to the one of the USA (see figure 18).

Figure 18 Other basic inorganic chemicals, import and export shares of main non-EU trading partners, 2007



Source: Calculations by Öko-Institut based on Eurostat (2009).

3.5 Paper and paperboard

Paper production takes place in two main steps: transformation of raw materials into fibrous materials called pulp, and transformation of pulp together with filler materials and additives into paper.

The two main raw materials for pulp production are wood and recovered paper. Two thirds of the wood comes from forestry, one third consists of saw mill by-products. After debarking and chipping the wood, there are two main, distinctly different, ways of transforming it into pulp: chemical pulping and mechanical pulping. Mechanical pulp production is virtually always located on the site of the actual paper plant. Chemical pulp is produced in either integrated or non-integrated market pulp plants.

Recovered paper is typically used by paper mills located in the region where the paper is collected. The process consists of repulping, screening, washing and disperging the fibres. Depending on their destination, a more extensive recycling includes several de-inking measures.

Besides these fibrous materials, non fibrous filler materials which are low in energy use such as kaolin and calcium carbonate are used to a considerable and growing extent.

The actual paper production starts with mixing and conditioning a blend of these materials suitable for the intended specific product (stock preparation). In the paper machine, the fibre suspension is pumped on a wire where the sheet formation takes place as the water drains from the wire. Then it is mechanically further dewatered by pressing in press rolls and finally dried by steam heated cylinders. Depending on the paper grade the paper can then be calendared and coated before it is shipped to customers.

In 2006 30% of worldwide paper was produced in Europe (including Norway and Switzerland), 36% in Asia and 27% in North America. Within Europe Germany is the largest paper producer, followed by Finland, Sweden, Italy and France. The German paper industry exhibits a rather high recovered paper utilization rate (66%) compared to the EU-25 average (48%). Indeed, the actual recovery rate of 77% is even more elevated (EU-25: 61%) (VDP 2007). Finland and Sweden are the main European producers and exporters of pulp. Europe is a net importer of pulp and a net exporter of paper (CEPI 2008).
Typical energy use for the various processes and process steps in the pulp and paper production is displayed in table 5. The share of biomass in the primary energy consumption in the European pulp and paper industry is 52%. This is mainly due to the use of black liquor, a by product of chemical pulping which is burnt to produce heat and electricity (CEPI 2008).

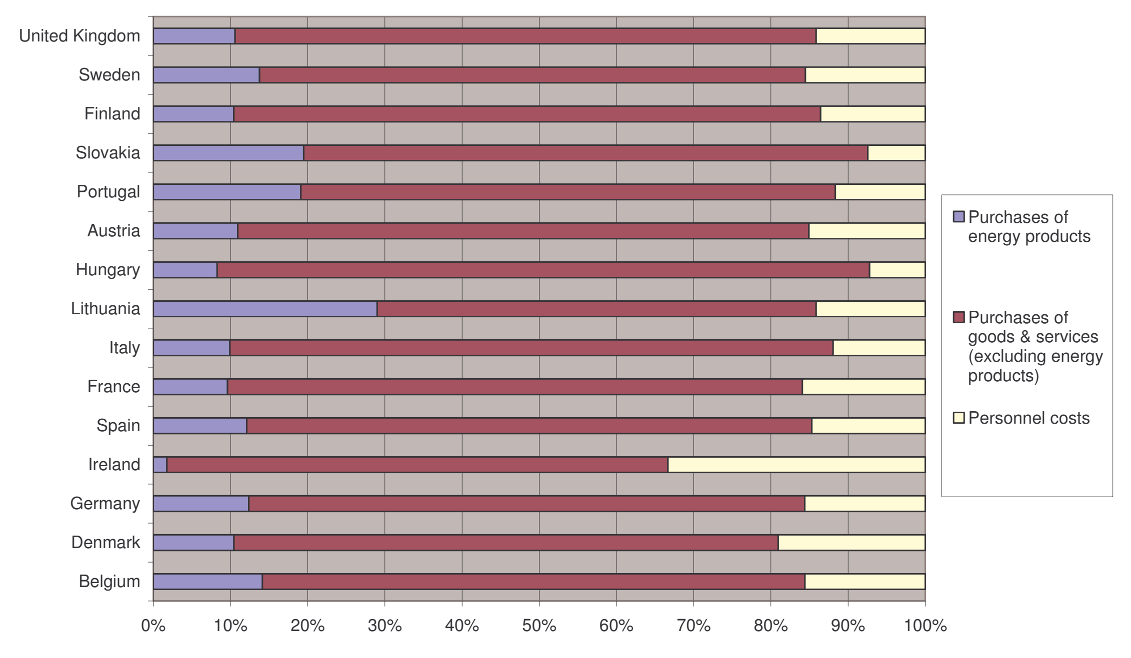
Table 1 Typical energy use for pulp and paper production

Process	**Product**	**Steam demand (GJ/t of product)**	**Net electricity import (GJ/t of product)**
Mechanical pulp	Pulp		7.3
Thermo-mechanical pulp	Pulp	-3.4*	8.3
Market chemical pulp mill – softwood	Pulp	14.3	0.7
Market chemical pulp mill – hardwood	Pulp	13.0	0.9
Waste-paper preparation	Pulp	0.3	0.7
Extensive waste-paper preparation	Pulp	0.5	1.2
Papermaking via paper machine (average)	Paper	5.1	2.2
Integrated chemical pulp and fine paper mill – softwood	Paper Pulp	19.3 12.1+	2.8 1.8+
Integrated chemical pulp and fine paper mill – hardwood	Paper Pulp	16.1 12.9+	2.5 2.0+
*negative sign reflects bonus for recovered heat +Share of energy use attributable to pulp			

Source: Graichen et al. 2008 based on International Energy Agency 2006

The breakdown of operational costs in the sector 'manufacture of paper and paperboard' (NACE 21.12; excluding pulp; see figure 19) exhibits a share of energy expenditure ranging from 8% (Hungary) to 29% (Lithuania). The value for Ireland is exceptionally low for 2006, which might be due to the low degree of specialization (66% share of the principal activity in turnover); in 2001 and 2002 the degree of specialization was around 90% and the share of purchases of energy products in total expenditure 13% (2001) and 7.5% (2002). The share of personnel costs range from 7% (Hungary and Slovakia) to 19% (Denmark).
The analysis carried out by the European Commission (2008b) distinguishes eight typical products in the sector of paper and paperboard (and additionally six types of pulp). The CO_2 cost to product price ratio for paper products ranges from 2%-9% whereas for pulp the values are within this range at the upper end (7%-9%).

Figure 19 Breakdown of operational costs in the EU production of paper and paperboard (2006)



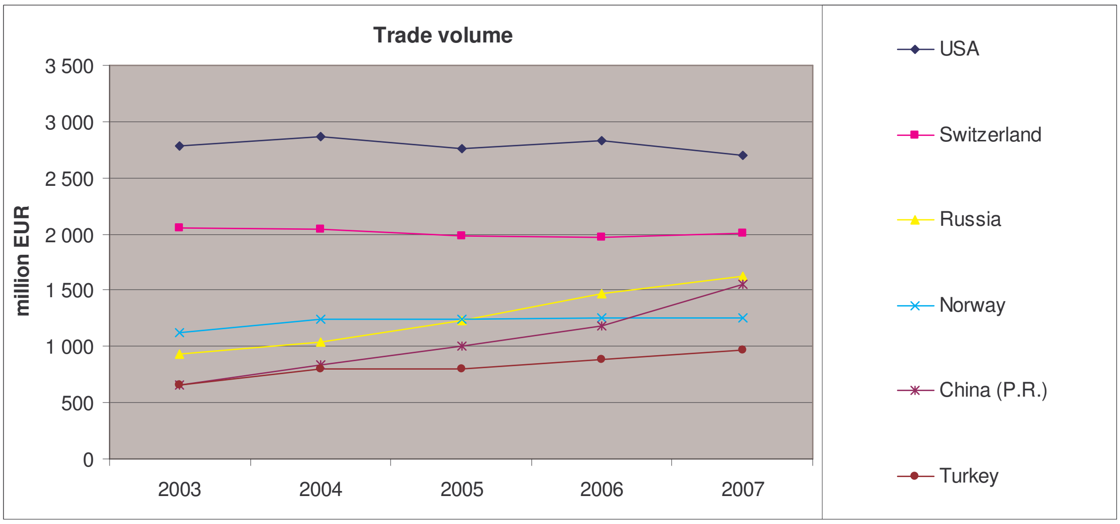
Note: Only EU Member States with complete data are included.

Source: Eurostat, SBS (date of extraction 14 January 2009)

Trade in paper and paperboard (NACE 21.12) claims the median position of the five sectors. Its size is about one third in relation to iron and steel, but four times as high as the one of fertilizers and nitrogen compounds. It has risen by 16% from 83,499 million EUR in 2003 to 96,970 million EUR in 2007 (see table 2). The share of intra-EU trade has been quite stable at 80% over this period. The six main non-EU partners are the USA, Switzerland, Russia, China (P.R.), Norway[5] and Turkey, which make up 10%, i.e. 10,102 million EUR or half of non-EU trade in 2007 (see figure 20).

[5] Norway's potential comparative advantage will disappear by the time of being part of the EU ETS.

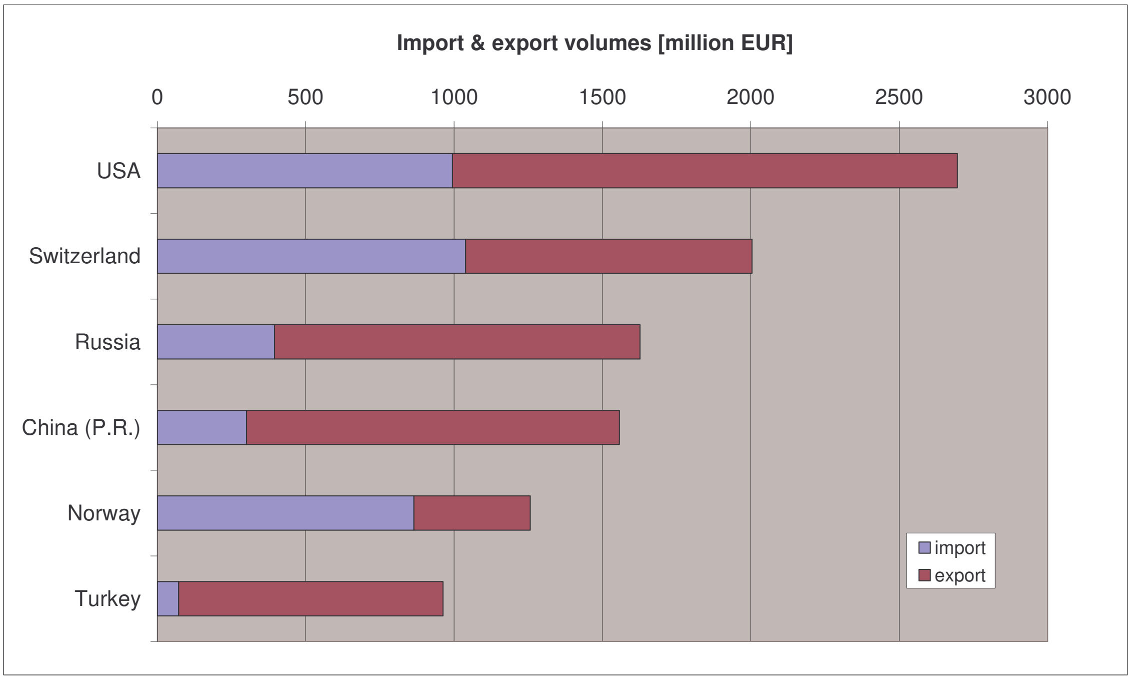
Figure 20 Paper & paperboard, main non-EU trading partners, 2003-2007



Source: Calculations by Öko-Institut based on Eurostat (2009)

The structure of non-EU trade in this sector has been dominated by exports (74%), whose main destinations are the USA, China (P.R.), Russia, Switzerland and Turkey. Imports mainly come from Switzerland, the USA and Norway (see figure 21).

Figure 21 Paper & paperboard, import and export shares of main non-EU trading partners, 2007



Source: Calculations by Öko-Institut based on Eurostat (2009)

4. Summary and conclusions

The EU proposal on the improvement and extension of the current EU Directive on Emissions Trading (2003/87/EC) provides a number of criteria to be taken into account to determine the risk of 'carbon leakage', i.e. (re)location of greenhouse gas emitting activities from the EU to third countries where industry is not subject to carbon constraints and thereby increasing global emissions. These include indicators for the increase in production costs induced by the EU ETS and for trade intensity with non-EU countries. The two quantitative criteria (complemented by several qualitative criteria) define whether a sector or sub-sector is deemed to be exposed to a significant risk of carbon leakage and therefore may qualify to benefit from support measures such as free allocation or financial compensation.

The analysis of studies concerning carbon pricing effects shows that their results are mainly comparable, even though the indicators differ slightly from the directive's definition. Most of these analyses point out that distortion of competitiveness is likely for a small number of sectors only. According to the analyses' results this paper dealt with the five potentially most exposed sectors, i.e. aluminium, basic iron and steel and ferro-alloys, fertilizers and nitrogen compounds, other basic inorganic chemicals and paper and paperboard. A number of other sectors differ to a varying extent for the indicators of value at stake and trade intensity, depending on the methodology and geographical coverage used. The denomination as exposed is subject to the respective thresholds and greatly influenced by two basic assumptions: the CO_2 price and the pass-through rate on electricity prices.

The analysis of cost structures shows that even between EU countries the expenditure for the purchases of energy and energy products, a proxy to the impact of carbon pricing on the production cost, differs widely. The specific energy used for production varies due to different production processes as well as due to the efficiency of the installations. Additionally the analysis of the cost structure at NACE 4-digit-level masks the differences of product mix between Member States. The interpretation of these figures is therefore very limited without further research. One major discussion, both scientifically and politically, in the upcoming months will therefore be the definition of sub-sectors to be assessed to qualify for special treatment in the European Emissions Trading Scheme. The sectors should also be chosen in a way that the potential for strategic optimization of allocation by installations claiming to belong to one or the other sector is small.

The analysis of trade flows allows for drawing four principal conclusions. First, the total trade volumes of the five potentially exposed sectors in the EU-27 have grown, in parts rapidly, during the analysed period. Since 2005 the basic iron and steel sector's trade volume equals the sum of the other four. However, trade intensities change only slightly. Thus, the growth of trade volume seems to be mainly driven by higher world market prices. Second, the shares of intra-EU trade in total trade have been rather constant for all of the considered sectors during this period. Third, the main trading partners of the EU-27 are similar across the sectors, or more detailed (see Annex B):

- in all of the five sectors the USA and Russia are major partners,
- in four sectors three countries, i.e. China, Norway and Switzerland, claim major parts,

- in two sectors Turkey plays a major role,
- six countries, i.e. Mozambique, Ukraine, Japan, Morocco, Egypt and Israel claim a major position in one sector each.

Fourth, big changes of trade partners' positions have been rare during the period 2003 to 2007. Hereby, only the rise of China in the iron and steel sector is a particularly notable example. Starting from a fourth position in this sector in 2005 China is the main trading partner in 2007 due to sextupled imports into the EU[6].

Beyond it, the introduction of the EU ETS in 2005 and its prevision mark roughly four years of carbon pricing effects for the period 2003 to 2007. It appears that during this time-span little has changed in the structure of trade flows of the five potentially exposed sectors.

The directive also calls for an assessment of the effect of climate and energy politics outside of the EU when considering exemptions from auctioning and financial compensation. The trade flow analysis illustrates that a comparable carbon constraint in a rather limited number of countries could change the picture significantly. Norway is a good example as it is going to be included in the EU ETS. Therefore the trade intensity analysis should normally exclude the trade to Norway (as well as Iceland and Lichtenstein) as these countries join the EU ETS and their industries have no comparative advantage compared to other EU industries anymore.

Finally, when deciding on which sectors are highly exposed to possible distortions in competitiveness and which measures should be implemented to address competitiveness and leakage it should be kept in mind that CO_2 costs are only one of multiple factors affecting companies' production and investment decisions. Other factors that may deserve detailed investigation include product differentiation and market segmentation within a sector (including specialty products), close cooperation with domestic/European partners and intra-firm trade, differences across countries in the costs for labour and other input factors, in infrastructure quality, transportation costs, political and legal environment, or exchange rate risks.

[6] Imports from China to the EU: 948 million EUR (2005); 3,123 Million EUR (2006); 6,547 million EUR (2007).

5. Literature

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Annex A: Methodology, data capture and restrictions

The trade flow and cost structure analyses focus on those sectors that are potentially exposed to carbon leakage. Hereby, the sectoral denominations refer to the ones of the NACE[7] nomenclature, which has been used in previous analyses on carbon pricing effects on competitiveness.

NACE is the classification of economic activities in the European Community. Trade data, however, is surveyed according to products. Correspondingly, other nomenclatures exist which cannot be directly compared to activity data on production. To that effect, data from different classifications has to be merged. In this process, the selection and the conversion of nomenclatures are crucial factors. NACE was set in this context due to its deployment in previous studies on competitiveness. For trade data the Combined Nomenclature (CN) of the European Community was selected to be most suitable to be converted[8].

However, general data restrictions remain, which mainly base on the problem of definite classification of activities and products in different nomenclature systems. These refer to:

- the survey and classification of economic activities per se,
- the conversion of trade data for products to classes of economic activities,
- the updating of nomenclatures.

Generally speaking, it has to be borne in mind that an industry makes (and imports/exports) some products that are the products of other industries.

Specific data restrictions might apply due to the setting of system boundaries of the sectors in question. This refers to the selection of NACE classes as the respective scope. In previous studies these were mainly used due to appropriate data availability. For some if not all sectors a further selection as well as a higher disaggregation of economic activity classes is actually needed in order to draw a more sophisticated picture of the potential carbon leakage problem. Though, this goes beyond the scope of this paper.

Furthermore, by merging CN and NACE the large selection of codes was chosen, i.e. in the case that a given CN code can be broken down between two or more NACE classes it was included. Therefore, the presented trade figures mark the upper limit.

[7] NACE (Nomenclature statistique des activités économiques dans la Communauté européenne) is the Classification of Economic Activities in the European Community.

[8] The conversion is based on tables provided by Eurostat Unit G3 "International trade-Production".

Annex B: Ranking by trade volume of the six main non-EU partners in the five potentially exposed sectors, 2003-2007

	NACE	USA	Russia	China	Norway	Switzer-land	Turkey	Mozam-bique	Ukraine	C&T not specified*	Japan	Morocco	Egypt	Israel	Tunisia
Aluminium	**27.42**	4	2	6	1	3		5							
Basic iron & steel and ferro-alloys	**27.10**	4	2	3		6	1		5						
Other basic inorganic chemicals	**24.13**	1	4	2	3	(7)				5	6				
Fertilizers & nitrogen compounds	**24.15**	3	1		2							4	5	6	(7)
Paper & paperboard	**21.12**	1	3	5	4	2	6								

* Countries and territories not specified for commercial or military reasons (within the framework of trade with third countries) - it cannot be said if this is a group or a single country

Source: Calculations by Öko-Institut based on Eurostat (2009)

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