

In early 2013, in the context of the work for the 2030 climate and energy framework debate, DG CLIMA commissioned a study to investigate whether there is factual evidence for the occurrence of carbon leakage over phases 1 and 2 of the EU ETS (2005-2012).

The study focuses on energy intensive sectors such as iron and steel, non-ferrous metals, refineries, cement, lime, pulp and paper.

The study is based on publicly available and industry data, and an earlier draft was discussed with EU industry representatives.

The general conclusions of the study are that there is no evidence detected for the occurrence of carbon leakage as defined by the ETS Directive in the period of application of the EU ETS, 2005-2012. In some, but not all, assessed sectors increasing imports and/or decreasing exports were observed, driven mainly by global demand developments, and input price differences.

This study is a property of the Commission, but it does not constitute a Commission document. It cannot be quoted as expressing the Commission position.

Carbon Leakage Evidence Project

Factsheets for selected sectors

Client: European Commission, DG Climate Action

Rotterdam, 23 September 2013



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Introduction

In 2013 a consortium of partners led by ECORYS was commissioned by DG Climate Action to provide assistance in the development of the 2030 climate and energy framework. A key output of the project was a set of factsheets for a selection of sectors. The factsheets present historical data on the structure, performance, and competitiveness of the sector in question and assess the degree to which carbon leakage may have occurred. They were assembled using publicly available data; draft versions were commented by European industry representatives.

The factsheets are prefaced with a summary of findings and conclusions.

1 General conclusions and common issues from industry factsheets

We have been asked by the European Commission to investigate if there is any evidence for carbon leakage in the past two ETS periods. We have been looking backward based on the available data. We have not investigated the possible impact of future ETS developments.

1.1 Production leakage / production relocation

We found no evidence for any carbon leakage – according to the ETS Directive, defined as production relocation due to the ETS – in the past two ETS periods. In some, but not all, assessed sectors we observe increasing imports and/or decreasing exports. However, the reasons for these developments can mainly be found in

- Global demand developments (discussed below in sections on investment relocation), and
- Input price differences (discussed below in section on energy cost).

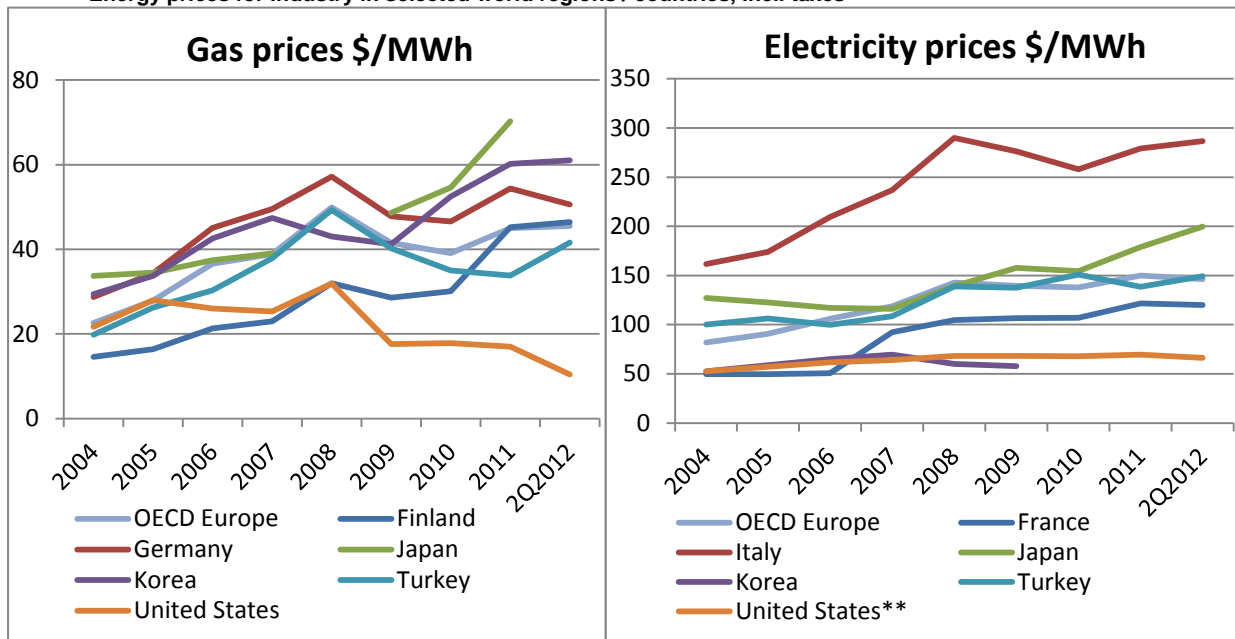
Regarding the ETS costs as a driver for production shift, there are several nuances to be made:

- The **direct costs** that actually occurred were very limited.
 - Both in the first and the second period abundant availability of ETS and international credits depressed prices. So the actually occurred costs were very limited. The current low allowance price is mainly caused by higher than required allocation (small part) and lower than expected emissions. The emissions were lower mainly because of lower production; however, one part may be explained by carbon reducing actions by industry. Industry is not able to give any data on this to underline this argument.
 - Both in the first and the second period most allowances were allocated to installations for free. The main goal of the free allocation in the first two phases was to avoid carbon leakage; apparently, this was successful. As data showed, more credits were issued than actual emissions verified.
- The power sector was able to pass through a large part of their (opportunity) cost, leading to increased **indirect costs** – due to increased electricity prices – and those, according to industry, were quite a relevant factor.

1.2 Energy cost

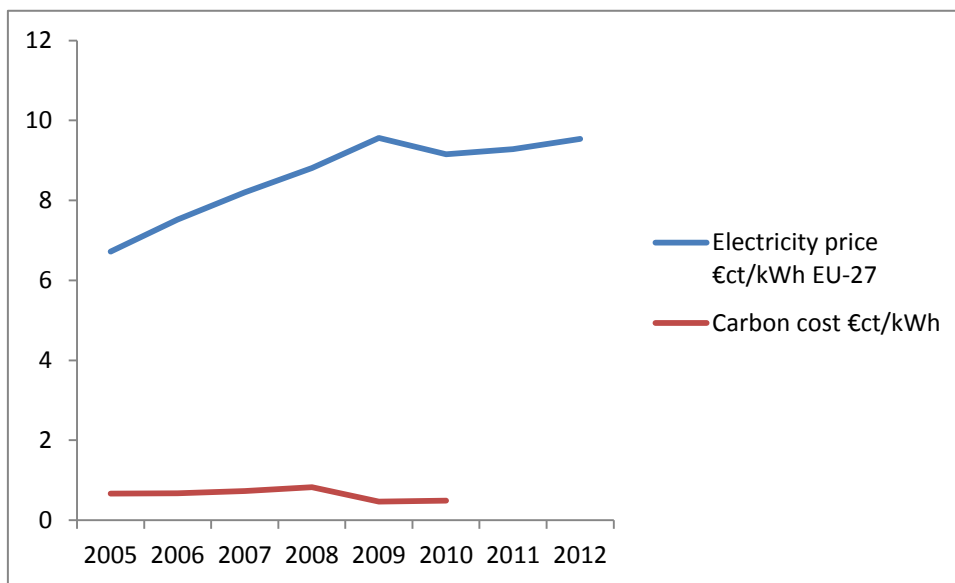
Energy discussions play a major role in the overall situation for industry and are always on the background of Carbon leakage discussions. Be it cheap shale gas in the US and Middle East or subsidised coal in China, the impact of energy prices is real; the relation with carbon costs however is much less relevant as can be seen in the pictures below. It should be noted that the energy prices within Europe vary considerably as well. In the discussions with industry, costs for renewable energy support were also frequently mentioned.

Energy prices for industry in selected world regions / countries, incl. taxes



Source: IEA Energy Prices & Taxes, 4th quarter 2012.¹

Electricity prices for industrial consumers in the EU-27, excluding taxes; compared to carbon cost for electricity production



Source: Eurostat Energy Statistics, EEX, EEA, IEA.²

¹ Definition: Prices and taxes for the industry sector are the average of amounts paid for the industrial and manufacturing sectors.

** Electricity price data for the US excludes taxes.

Note that there are data gaps for Japanese gas price data and Korean electricity price data.

In order to show the range within the EU, data for the EU countries with the highest and lowest prices are shown in both graphs.

² Electricity prices shown are the average prices in Euro per kWh without taxes applicable for the first semester of each year for medium size industrial consumers (Consumption Band Ic with annual consumption between 500 and 2000 MWh). Until 2007 the prices are referring to the status on 1st January of each year for medium size consumers (Standard Consumer Ic with annual consumption of 2 000 MWh). Note that prices can be expected to be lower for large size industrial consumers.

Carbon cost is calculated by taking data from IEA on carbon emissions per kWh of electricity in OECD Europe; this quite precisely coincides with EU-27 data from the EEA, but has less data gaps. These values are multiplied by the EU allowance unit forward price (ETS emission forward price, used here because it is more stable than the spot price).

1.3 Investment leakage / investment relocation

A new element, sometimes raised by industry stakeholders in the debate surrounding carbon leakage, is the issue of investment relocation, and to what extent that may have a link to climate policies/ETS. The term in itself is quite vague and may have different meanings to different persons. In this study we did not measure investment patterns, since such a wide topic would merit an exhaustive separate study. Nevertheless, it can be concluded from a general observation of public information and interviews with industry that there are indications for investment relocation from the EU to the rest of the world in certain sectors. The industry is arguing that carbon costs are one of the reasons for this. Based on the limited information available so far, carbon cost may be one factor that can not be excluded, even when compared to other drivers carbon costs are a minor factor.

There are strong indications of increased production capacity outside Europe making parts of Europe's industry lose global market share. This is overall not a surprising evolution, given the rapid growth in demand in many emerging markets. In other words, these investments have been driven strongly by the demand side. Sometimes (not often) we also observe increasing imports. In many cases the European (global) companies are participating/investing in this growth outside Europe. Some possible explanations:

- Europe's economy is mature, showing no population growth and little economic growth where other parts of the world are growing more rapidly. Emerging economies create economically beneficial circumstances to attract new industry (like Europe did actively in the 50 and 60's).
- Lower energy prices and lower regulatory cost (amongst others lower environmental standards) support these developments, whereas political stability, low regulatory risk and currency risk balance this.
- Most industry has heavy upfront investments (sunk costs) so they will not quickly move production. The lead-times for moving industrial production facilities are easily over 10 years.
- When a company takes an investment decision the *perception* of *future* prices for carbon will play a role, not the real or past prices. Perception of high future prices could affect investment decisions.

Shift in consumption to other regions (e.g. Asia) is a strong driver of changing market shares. Most industries indicated that closeness to market was a major factor. If demand increases in a certain area, it is likely that investment moves there – depending on input and transport costs.

In order to get a better picture of the trends in investment relocation, its main drivers, and more precisely the role of carbon costs, an additional in-depth study is required. Such a question would require a more thorough and more long-term analysis, because at this point definite conclusions about so called investment leakage cannot be drawn. In addition, investment decisions are especially related to expectations, and less to existing policies. Therefore planned policies and regulatory (un)certainly play a major role here. Uncertainty has many faces and plays in all countries. It is not only an issue in economies: like the EU - that already has policies that may be changed in the future - also countries that do not have policies or strict regulations may introduce them in the medium term. Therefore, a study analysing investment leakage should be again in close cooperation with industry in order to get a clear picture of their expectations both with respect to regulation and with respect to world markets. Based on both quantitative and qualitative evidence, it should then give relative weights per industry to the different possible drivers for investment relocation.

1.4 Transport cost

It is interesting to note that 'closeness to the market' is as well a driver to move to e.g. Asia, as well as a driver to stay in Europe. Transport (cost) is a limiting factor for production relocation (assuming that this production serves European demand), but can potentially be a driver for investment relocation (following demand developments).

The heavier the product and the lower the value, the closer you want to produce to the consumption. But the transport costs are at the moment (due to overcapacity) extremely low, and many produced goods have such a high value that transport is not a very relevant factor. It is rather the case that transport costs follow trade activity, not the other way around. Only for cement, clay and lime transport costs play a major role. It is worth noting that also transportability plays a role. Many chemical substances cannot be transported easily due to the very nature of these goods. Combined with the very integrated production in the chemical sector it is hard to predict how changing energy prices will overall affect this sector. But in the short term both concentration (also within Europe) and moving towards regions with cheap gas prices seem likely.

1.5 Data quality

It was not always easy to get the right data. Both the national and Eurostat data quality and availability were not always adapted to the needs for our work. Especially the mismatch between ETS activity definitions and NACE codes makes it sometimes difficult to interpret the Eurostat data. The national electricity data per sector are incomplete and we are not sure of the overall quality of the information received from the member states. We think all this is relatively easy to solve by including the right obligations for data collecting in the next ETS directive.

1.6 Conclusion

The project has not found concrete evidence for carbon leakage – defined as production relocation due to ETS costs – in the first two ETS periods. However we think there are indications that this can change in the third period. On top of the main drivers of production location, such as shift in demand and higher energy prices, high carbon prices – if only prevalent in Europe – will make global competition (a little bit) harder for European industry.

2 Manufacture of basic iron and steel and of ferro-alloys

2.1 Introduction to sector – structure and performance indicators

2.1.1 Scope and current leakage list position

For the purposes of this factsheet, the iron & steel sector is defined according to NACE Rev. 2 code 24.10 (in NACE Rev. 1.1: 27.10), as Manufacture of basic iron and steel and of ferro-alloys.

There are two main production routes of crude steel – blast furnace / basic oxygen furnace (BF-BOF) production from virgin iron, and electric arc furnace (EAF) production mainly using scrap steel, but also capable of primary production. Each requires different inputs, specializes in different outputs, and is organized differently. In general, the products in the iron and steel industry can be classified into long products (beams, bars, rods, wire – rolled from blooms and billets) and flat products (steel plates, coiled sheets – rolled from slabs). Primary steel production specializes in products with high quality requirements (often flat), while secondary steel production is better suited for lower added value, bulky products (Mohr et al., 2009).

The numerous activities of integrated steelworks fall under different NACE codes and also different activities according to the EU-ETS directives. The following table provides an overview of the activities included in the ETS according to Annex I of the 2003 ETS Directive and its 2005 clarification (for the period 2008-2012) as well as the corresponding NACE codes.

Table 2.1 Classification of the iron and steel industry according to Annex I of the ETS Directive and NACE Rev. 2 activities

Annex I category of activities, with clarification	NACE code (Rev. 1)	NACE code (Rev. 2)	Description (NACE Rev. 2)
Installations for the production of pig iron or steel (primary or secondary fusion) including continuous casting, with a capacity exceeding 2,5 tonnes per hour.	27.10	24.10	Manufacture of basic iron and steel and of ferro-alloys (<i>includes activities such as direct reduction of iron ore, production of pig iron in molten or solid form, conversion of pig iron into steel, manufacture of ferroalloys and manufacture of steel products</i>)
Combustion installations with a rated thermal input exceeding 20 MW (except hazardous or municipal waste installations) <i>Clarification 2005: These combustion installations involve crackers, carbon black, flaring, furnaces and integrated steelworks, including rolling mills, re-heaters, annealing furnaces and pickling</i>	27.31	24.31	Cold drawing of bars
	27.32	24.32	Cold rolling of narrow strip
	27.33	24.33	Cold forming or folding
	27.34	24.34	Cold drawing of wire
	27.51	24.51	Casting of iron
	27.52	24.52	Casting of steel
28.4	25.5	Forging, pressing, stamping and roll-forming of metal; powder metallurgy	
steelworks, including rolling mills, re-heaters, annealing furnaces and pickling	40.11	35.11	Production of electricity
Coke ovens	23.10	19.10	Manufacture of coke oven products

Annex I category of activities, with clarification	NACE code (Rev. 1)	NACE code (Rev. 2)	Description (NACE Rev. 2)
Metal ore (including sulphide ore) roasting or sintering installations	13.10	7.10	Mining of iron ores

Source: Own elaboration based on European Commission (2003/87/EC), European Commission (COM(2005) 703 final), Ecofys et al. (2009), Eurostat (2008), Reinaud (2008).

It has to be noted that in the NACE methodology, companies are classified according to their main activity. Therefore, activities such as sintering, coking of coal, casting, rolling etc. are registered under NACE 24.10 when they are carried out in an integrated steel plant (Ecofys et al., 2009). It also should be mentioned that production of ferro-alloys (in a narrower definition than NACE 24.10) was not included in the first two phases of the EU-ETS.

Manufacture of basic iron and steel and of ferro-alloys according to NACE Rev. 1.1 code 27.10 is on the current carbon leakage list (valid 2013-2014) and qualified according to both quantitative criteria, with a combined direct and indirect carbon cost of 12.7% of gross value added and a non-EU trade intensity of 32.3%.

Table 2.2 Status in current leakage list, values for carbon cost as % of GVA and non-EU trade intensity

NACE 1.1 Code	Direct Cost	Indirect Cost	Total Cost	Trade Intensity
27.10	6.5%	3.6%	10.6%	32.3%

Source: European Commission (2009), SEC(2009) 1710 final.

2.1.2 Technology overview

Raw steel can be produced out of (usually a combination of) four **input materials**:

- **Raw or pig iron** is produced from **iron ore, coke and limestone** in a blast furnace (BF) and usually cast into ingots, so-called pig iron, or transferred directly as hot metal to a steel furnace.
- **Direct Reduced Iron (DRI)** technology transforms **iron ore** using **gas** instead of coke as a fuel in ironmaking, resulting in lower quality iron.
- **Scrap** – recycled steel – is another important input, again with quality compromises due to the tramp metal which occurs in scrap.
- **Ferro-alloys** are used to add more chemical elements into molten metal, to produce different grades of steel. Ferro-alloys are produced from **e.g. manganese, chrome and nickel** in a submerged electric arc furnace with high **electricity** consumption.

Starting from these inputs, there are two main **production routes** for raw steel.

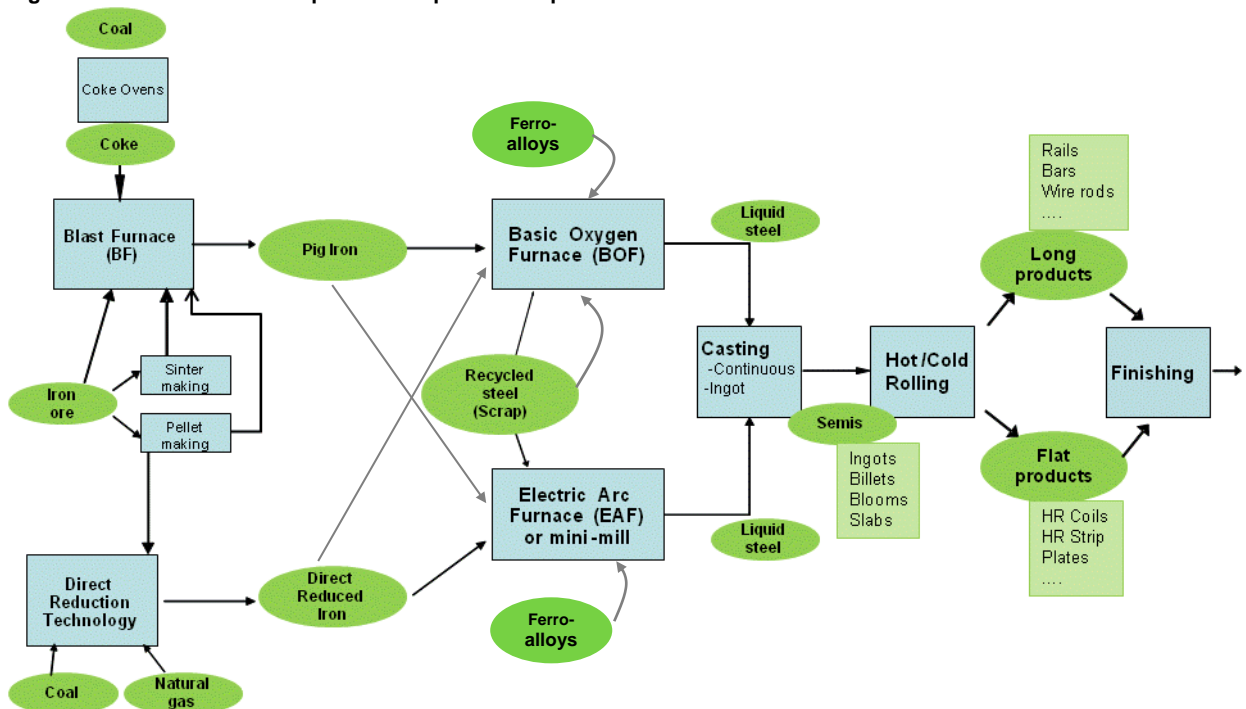
- The **basic oxygen furnace (BOF)** technology relies on the BF pre-process and transforms **raw iron** into steel by removing impurities in a basic oxygen furnace, where **limestone** and **other flux** are added to the raw iron together with high purity oxygen. The outputs are molten steel and slag. As further inputs, BOFs can use **scrap steel or DRI** (up to 30%; a certain amount of scrap is necessary as a cooling agent), and other metals/**ferro-alloys** can be added to create alloy steel. BF-BOF technology exhibits strong economies of scale and profits from integration of production processes. Consequently, the installations are very large (at least 2 million tonnes steel production per year), have very long investment cycles, and they often integrate many upstream processes such as coke ovens, electricity production, and sintering (Ecofys et al., 2009). The main energy inputs for the BOF route are **coal and coke**.
- The **electric arc furnace (EAF)** technology is completely different; it melts **scrap** and/or **DRI** through heat created by an electric arc. Thus its main inputs are scrap and DRI (which are perfect substitutes in EAF mills given a certain scrap quality) as well as **electricity**, although it

also uses raw iron and energy fuels in small quantities. EAF mills tend to be small, flexible and less integrated. Due to the tramp metal which occurs in scrap metal, it is more difficult for EAF mills to produce high-quality products. Therefore EAFs tend to specialize in bulky, especially long products. DRI can contribute to improving the quality of EAF steel, but is very uncommon in Europe because its cost effectiveness mainly depends on the gas price, which is comparatively high in Europe (Mohr et al, 2009). The main energy input for European EAF production sites is thus **electricity**.

Used in 90% of crude steel production worldwide, continuous casting is dominant in the further processing of steel. Following the casting, semi-finished products are rolled into final products.

The figure below shows the different production routes with transformation installations (in blue) and their inputs, semi-finished products, and outputs (in green). An overview of the BF-BOF production process showing the CO₂ emissions at different production stages is included in chapter 1.3.4, Carbon costs.

Figure 2.1 Main activities and products in production process

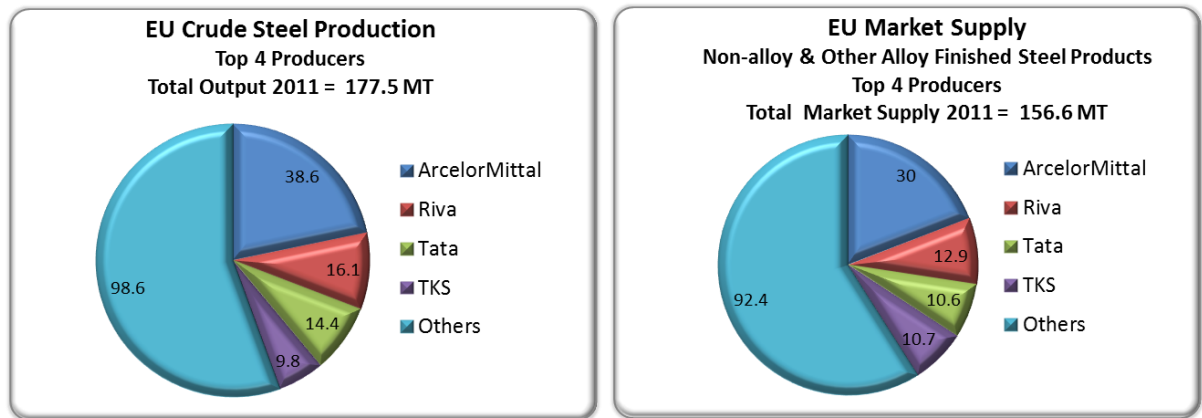


Source: Own elaboration based on a Eurofer overview, used in Ecorys (2008). Grey arrows indicate relatively smaller streams.

2.1.3 Sector overview: facts and figures

Manufacture of iron and steel and ferro-alloys employed 334,744 people in the EU-25 in 2010, which equals 1.26% of employment in total manufacturing. The value of production equalled €143 billion, which represents 2.49% of total manufacturing production value. Moya & Pardo (2013) report 88 blast furnaces, 41 BOF plants, and 232 EAF plants in the EU-27. These are complemented by e.g. 62 coke plants, 50 sinter plants, as well as around 550 different mills of different types (Moya & Pardo, 2013) and around 2000 facilities for casting (Ecorys, 2013).

Figure 2.2 Market structure EU 2011: Production and Supply (=production – exports + imports)

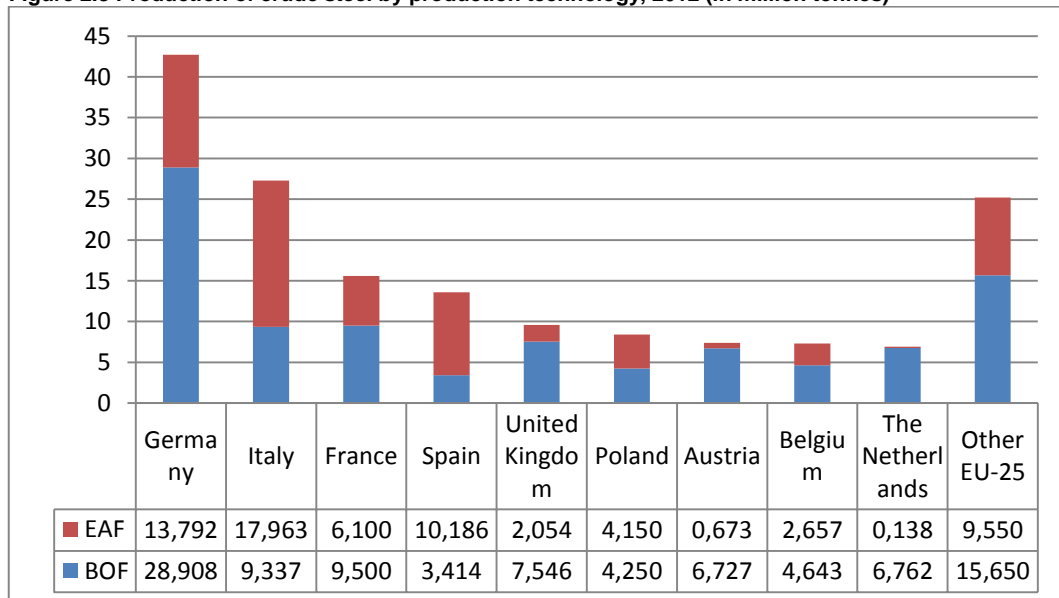


Source: Eurofer (2013)

According to Eurofer (2013), the top 4 steel producers in the EU accounted for 44.5% of total EU crude steel production (based on 2011 output). The largest producer is ArcelorMittal, followed at a distance by Riva, Tata and ThyssenKruppStahl (TKS); Tata and TKS rely only on the BF-BOF technology. Smaller players are usually active on the EAF market and in ferro-alloys. A total of 80 companies report to Eurofer; the ferro-alloys and silicon sector is represented by 23 companies.

In geographical terms, the iron and steel sector in the EU-25 is dominated by Germany, with a production value of €35 billion in 2010 and 77,630 employees (equal to 25 and 23% of total EU-25 iron & steel production value and employment, respectively).³

Figure 2.3 Production of crude steel by production technology, 2012 (in million tonnes)



Source: Ecorys based on World Steel, 2013.

2.1.4 Installations under ETS

According to the EU-ETS emission registry (CITL/EUTL), 403 installations active in the manufacturing of iron and steel and ferro-alloys fell under the ETS in 2005 (out of 7,038 in total)

³ Source: Eurostat SBS.

manufacturing, or 5.78%).⁴ According to CAEF, the European Foundry Association, there are some 2,000 foundries (casting facilities) in the EU (Ecorys, 2013), of which most are not in the ETS.⁵

Ecofys et al. (2009) provide the installation numbers in more detail; note that here, integrated plants likely appear several times as they are active in several stages of the production process. According to Eurofer⁶, many installations' NACE codes are misreferenced in the CITL, but the exact impact of this is unclear. Compared to the number of facilities identified in the EU-27 by Moya & Pardo (2013), the number for hot metal production coincides with the reported number of BOF plants; for all other activities, the number of installations under ETS appears to be lower than the identified number of existing facilities; this may be due to 'misreferencing' or a missing split between activities of integrated plants.

Table 2.3 Iron & steel installations under the ETS

Activity	Number of ETS installations, EU27 ¹
Coke production	42
Sinter production	32
Hot metal production ²	41
Electric arc furnaces (EAF)	Ca. 200
Further processing of steel ³	Ca. 1100
Foundries ⁴	Ca. 40

¹There is an overlap in the number of coke, sinter and hot metal installations, due to integrated production sites.

²Hot metal production implies here the blast furnace as well as the basic oxygen furnace operation and continuous casting.

³These installations split up into 500 hot rolling and about 600 processing plants.

⁴Figure contains only CAEF members included in the ETS. In addition there are about 5200 non-ETS installations in Europe. Source: Ecofys et al. (2009).

2.2 Evidence of production shift / relocation

2.2.1 Production shift

Production data from Eurostat unfortunately is unreliable due to double counting of products at different production steps. Therefore to show development of steel production in the EU, we use Eurofer data, which shows finished steel products (long and flat).⁷ Production of flat products is about twice the volume of that of long products. After the crisis year of 2009, production volumes have not quite reached the pre-crisis level yet.

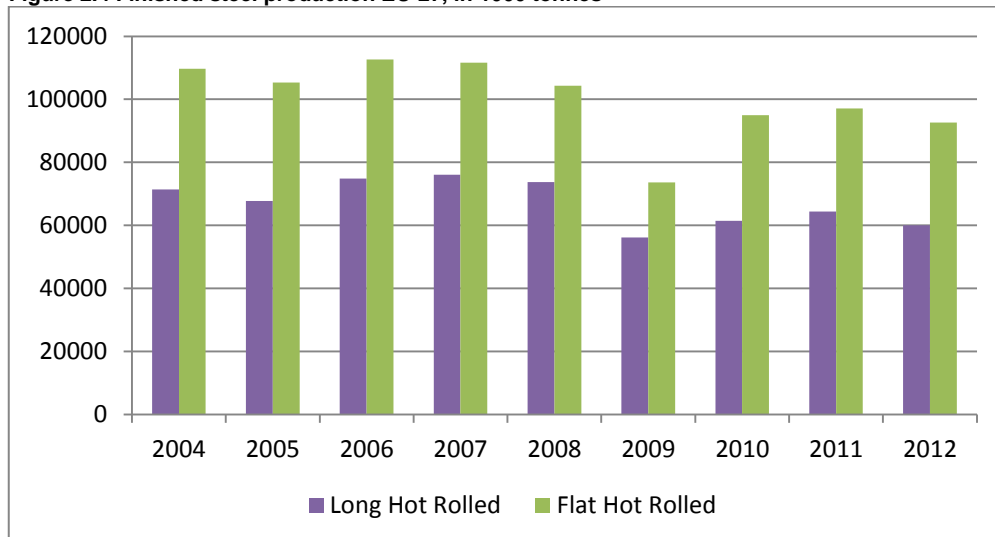
⁴ Source: CITL database, NACE code matching done by Oeko based on matching list from DG ENTR.

⁵ As shown in the footnotes to the copied table, Ecofys et al. (2009) report 5200 non-ETS installations in Europe, but it is not clear whether they refer to foundries or also other facilities.

⁶ Mentioned in stakeholder meeting.

⁷ Unfortunately, Eurofer data does not make a clear distinction between semi-finished and finished products.

Figure 2.4 Finished steel production EU-27, in 1000 tonnes



Source: Eurofer (2009 and 2013)

PRODCOM data on imports and exports is more reliable than its production data (because double counting is not an issue here). They are therefore used here in order to rely on as much public data as possible and because semi-finished products can be shown here. To account for different products, their underlying different production processes and their possibly different trade position,

Figure 2.5 and Figure 2.6 show imports and exports of the EU-25 for four categories of products: ferro-alloys, semi-finished products (such as ingots and other primary forms), flat products (flat-rolled products, plates and sheets, etc.), and long products (bars, rods, sections, etc.). Note that the jumps in 2008 may be due to revisions in classification of NACE/PRODCOM codes. Nevertheless, general patterns of imports and exports can be seen.

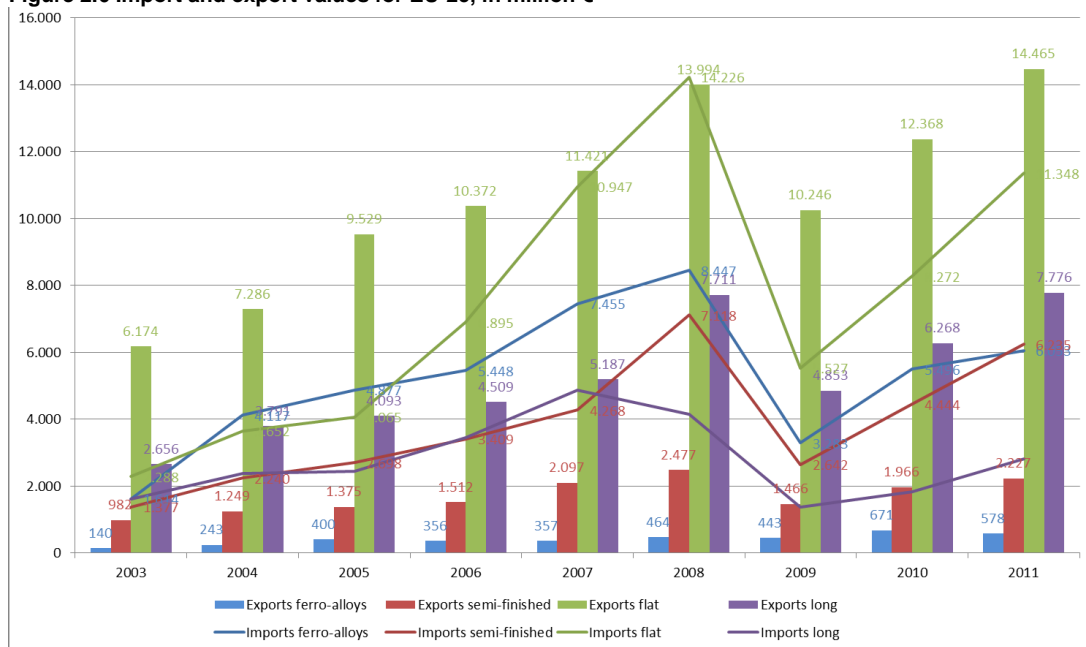
Imports of flat products have steadily risen since 2005, showing a sharp drop in 2009, while exports showed a somewhat smoother development. In semi-finished products, the EU-25 exhibits an increasing net importer position. This reflects the trend whereby trade in semi-finished products is increasing and exports are dominated by emerging economies (UN Comtrade, 2011). Note that the EU-25 in 2011 was a net importer of flat products in volumes, but a net exporter in values. This implies that higher value products are being exported which could point towards exports of high-quality niche products, although according to Eurofer, the main part of trade is in highly competitive commodities. Exports of long products also show a rising trend. Eurofer explains this by the practice of southern European steelworks to increasingly export to Northern African states because of shrinking European demand.⁸

⁸ Both statements were made during the stakeholder meeting, 19 July 2013.

Figure 2.5 Import and export quantities for EU-25, in 1000 tonnes



Figure 2.6 Import and export values for EU-25, in million €



Worldsteel data from the International Iron and Steel Institute confirms these figures, showing trade in aggregate semi-finished and finished products, and can serve to bring the global picture in.

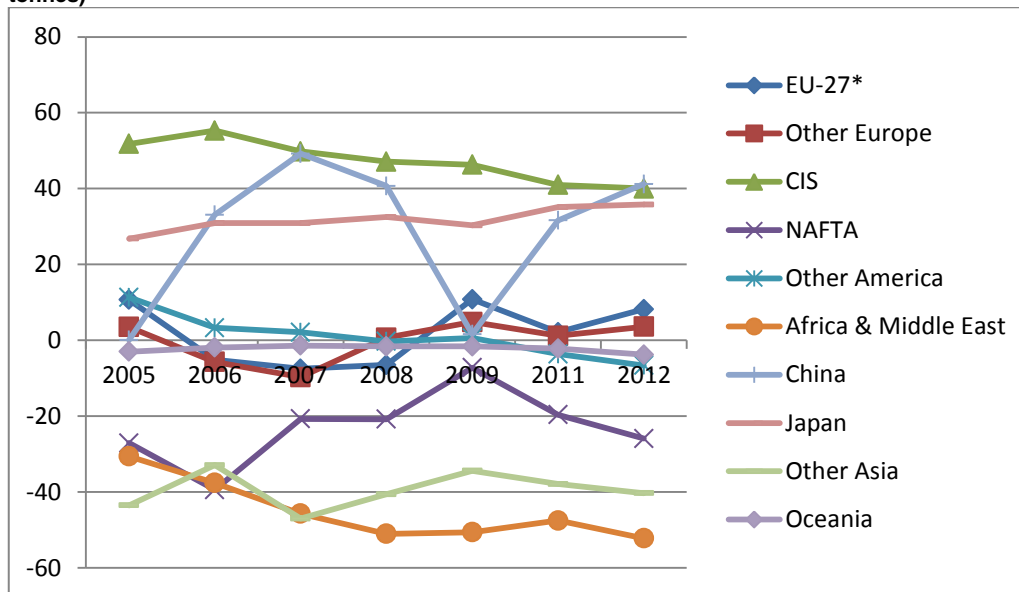
Figure 2.7 shows net exports of world regions with the rest of the world. (Note that there is a data gap for 2010). The graph shows that the EU was a net importer of semi-finished and finished steel products between 2006 and 2008 due to the EU-27's increasing demand and China's increasing production;⁹ however, the EU-27 reversed in 2009 and stabilized as a relatively small net exporter afterwards. It is also interesting to see that the CIS region¹⁰ (led by Russia and Ukraine) has

⁹ Ecorys (2008) reports that capacity utilization rates in the EU in 2007 were around 85%, which is roughly the maximum that can be achieved, so additional demand had to be covered by imports.

¹⁰ CIS stands for Commonwealth of Independent States, an organization representing the successor states of the Soviet Union. The abbreviation CIS is often used for the group of successor states, somewhat regardless of their actual member status in the association. Technically, CIS comprises of Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia,

continually been the largest net exporter, albeit with a slow decrease in net exports since 2006. Its main export destination is the EU with 17 million tonnes in 2012. Most of Japan's stable exports go to the rest of Asia.

Figure 2.7 Net exports of selected regions in semi-finished and finished steel products (in million tonnes)



*EU-27 refers to EU-27 from 2007 only, before the data pertains to EU-25.

Source: Own representation based on "World Steel in Figures". Published by International Iron and Steel Institute (2007, 2008); Worldsteel (2009-2013).

Note that there is a data gap in 2010.

In terms of a broader view of carbon leakage, it is also interesting to look at "indirect trade in steel", defined by Worldsteel as "exports and imports of goods that contain steel" (Worldsteel, 2012). Consumption of goods containing steel thus reflect the "true use of steel" and their trade reflects more accurately the trade in embodied emissions between countries. According to Worldsteel data, the EU's share of world indirect steel exports has decreased from 43% in 2000 to 36% in 2010, mostly mirroring an increasing Asian market share. The NAFTA and CIS regions also saw their indirect steel export share lowered in this period. The share of EU-27 imports of indirect steel has also decreased between 2000 and 2010, from 46% to 42%. Asia and other emerging economies have increased their share here. These figures cannot be used to draw conclusions on absolute quantities of indirect steel trade. However, the lower decrease in the import share of indirect steel for the EU-27 suggests a relatively stable domestic demand for products containing steel and a slightly falling (relative) demand abroad for EU products containing steel.

2.2.2 Investment and worldwide capacity trends

Most capacity investments especially before the crisis have occurred in Asia. Combined with the loss in production because of the economic downturn, this has led to a situation of worldwide overcapacity which leads to competitive pressure. OECD figures (below) underline the capacity development in non-OECD countries (for both production routes). According to EuroAlliages, a similar observation can be made for ferro-alloys, with countries like China and Russia increasing their capacities.

Tajikistan, and Uzbekistan. When grouping the countries for statistics, usually "participating states" (Turkmenistan, Ukraine) and former member states (Georgia) are included in the calculations, This is also the case in Worldsteel data. The main steel producing "CIS" countries under this definition are Russia and Ukraine, followed at a distance by Kazakhstan and Belarus.

Table 2.3 Development of steelmaking capacity worldwide (in million tonnes)

	2000	2005	2009	Changes 2000-2009	
				million tons	%
Non-OECD	466.2	785.3	1153.9	687.7	147.5
Non-OECD Europe	15.0	17.3	18.0	3.0	20.1
CIS	124.7	124.5	143.1	18.4	14.8
Latin America	46.4	53.9	62.7	16.2	34.9
Africa	25.4	29.8	31.4	5.9	23.2
Middle East	14.0	19.0	28.1	14.0	99.7
Asia	240.6	540.9	870.7	630.1	261.9
China	149.6	424.0	725.0	575.4	384.6
Other Asia	91.0	116.9	145.7	54.7	60.1
OECD	605.0	569.0	638.3	33.3	5.5
NAFTA	154.1	144.8	155.8	1.7	1.1
Japan	146.9	124.1	129.9	-17.0	-11.6
Korea	49.7	53.2	64.2	14.5	29.2
EU	241.8	244.7	250.0	8.2	3.4

Source: OECD (2011), Developments in Steelmaking Capacity of Non-OECD Economies 2010, OECD Publishing; OECD Steel Committee (2010), Developments in world steelmaking capacity, presentation at 69th Steel Committee Meeting.

2.3 Drivers for (production) relocation

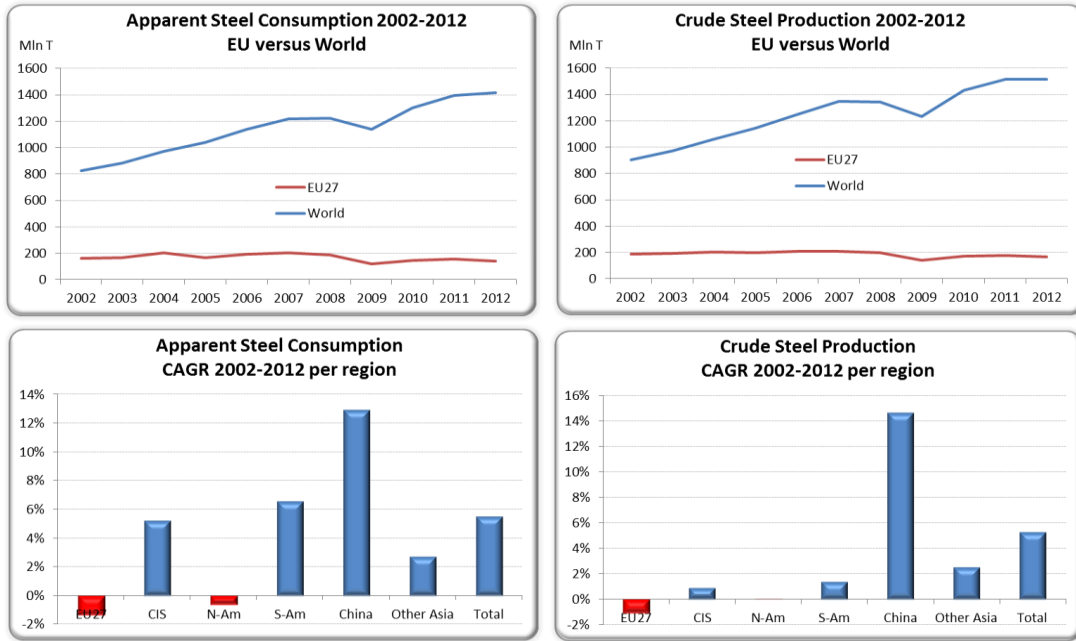
2.3.1 Worldwide production and demand

As Figure 2.7 suggests, changes in trade flows of the EU can mainly be attributed to changes in domestic demand (especially between 2006 and 2009) and in the development of China being able to satisfy both the rapidly increasing Asian demand and to become a net exporter of steel.

Development of consumption and production capacity in Asia therefore plays the main role in explaining shifting market shares. This is illustrated by figures for apparent steel consumption¹¹ and crude steel production in the selected period. But we can also observe that European production and consumption was quite stable, or even slightly increasing, before the economic crisis.

¹¹ Apparent steel consumption is defined as production less exports plus imports. It is opposed to the concept of „true steel use“, which reflects the use of products containing steel (cfr. Paragraph on indirect trade in steel).

Figure 2.8 Worldwide steel consumption and production (million tonnes / compound annual growth rates)



Source: Eurofer (2013).

Looking at demand in general, it is important to note that steel products are intermediate goods and the demand for steel is derived from demand for steel-containing products. Demand for end-products can significantly affect prices and profit margins and underlines the industry’s procyclicality (cpr. Dröge, 2013).

Demand also depends on the development status of a certain region. A study by BCG (2013) commissioned by the Steel Institute VDEh shows how steel intensity (steel per GDP) exhibits an inverted U-shape when plotted against GDP per capita: with beginning industrialisation, steel intensity increases quickly; but with further development, steel consumption increases more slowly than the rest of the economy, making the curve move downwards. In the end, for mature markets, the curve shows a slightly declining steel intensity due to efficiency gains in the use of steel. This relationship between GDP and steel consumption can provide a background for the developments we observe: high growth rates in China, constant consumption in the mature EU markets.

In addition, demand depends on the type of product. High-quality special products are mainly purchased by high-volume and high-quality end-users, such as the automotive industry. These large buyers usually purchase steel directly from makers on the basis of negotiated contracts and have significant bargaining power (Ecorys, 2008). They also often cooperate directly on product development and production schedule; in this case demand is less elastic and geographical proximity can be a competitive advantage factor (Eurofer, 2013).

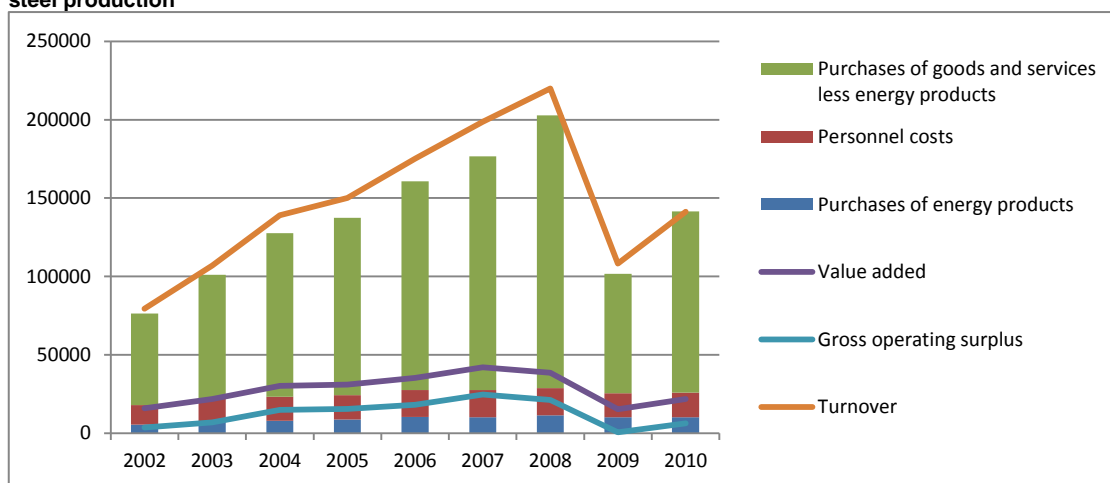
Low-volume customers mostly buy steel as a commodity based on spot prices. Their demand is therefore more elastic and centres around standardised homogenous low added value products (Eurofer, 2013). However, especially for large long products, geographical proximity again plays a role because of transport costs (Reinaud, 2008; Dröge, 2012) – this is reflected in the fact that the main export market of CIS countries is Europe, while for Japan it is Asia.

2.3.2 Variable costs

Energy and raw material inputs are the most important cost factor in the production of iron and steel. For the BF-BOF route, these mainly consist of coking coal and iron ore, and to a limited extent scrap and fluxes. In the EAF route, the main drivers of variable costs are electricity and scrap.

Figure 2.9 shows the development of variable costs in the sector according to Eurostat SBS figures, together with turnover, gross operating surplus and value added. They show that material inputs (here: mainly iron ore and scrap) account for the largest part of the costs and their purchase also is clearly related to output. Unfortunately the definition of energy products is not quite clear and this can only give a rough picture.

Figure 2.9 Development of costs, gross operating surplus, value added, and turnover in EU-27 iron and steel production



Source: Eurostat SBS.¹²

The main variable inputs for the industry are iron ore, coal / coke, scrap, and electricity. Heavy growth in demand for and production of steel in emerging economies, such as China, India and Brazil, have caused raw material prices, such as iron ore and scrap metal, to increase heavily.

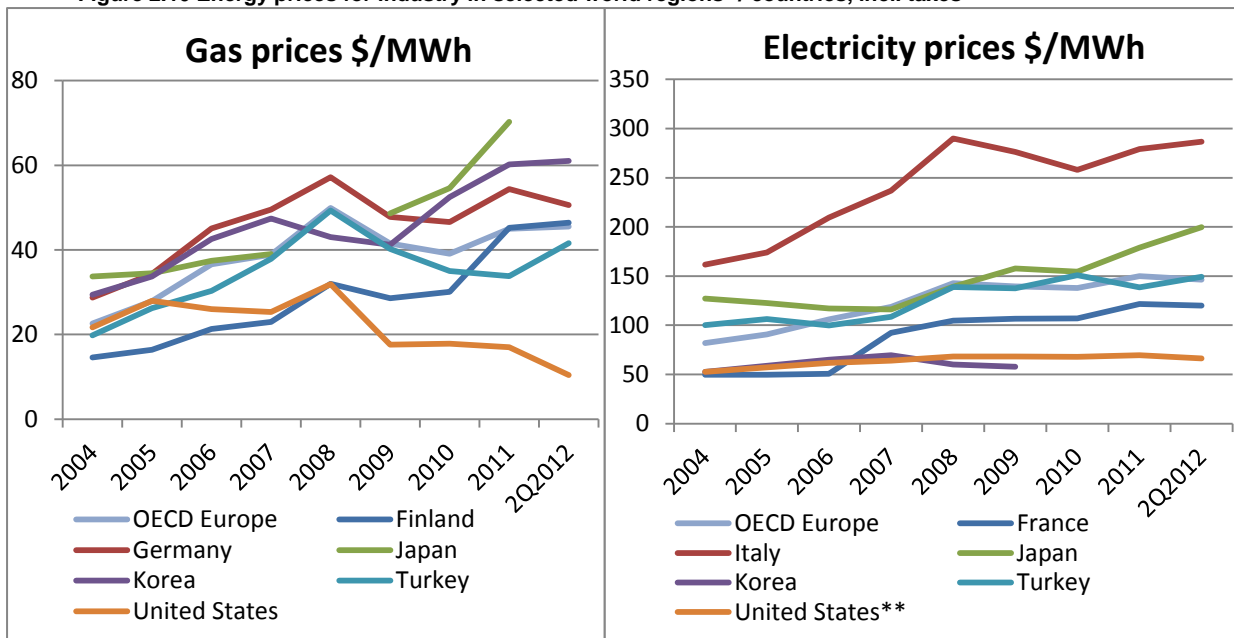
The pressure on prices and availability of raw materials is something that all countries and producers face and conditions are unlikely to change substantially in the near future. As prices are set globally, the price increase has been more or less the same for all producers. Thus, increased input prices do not per se create a competitive disadvantage vis-à-vis other countries/producers outside the EU. However, in countries where state aid and subsidies are still in place (e.g., Russia, Ukraine, and China) such pressures may be partially alleviated through state support. (Ecorys, 2008). Already in 2006, the European Commission concluded that the EU's dependency on ore imports is contributing to a shift in steel production towards third countries offering more attractive production conditions in terms of better raw material supplies and cheaper energy (European Commission, 2006).

¹² Note that data for CZ are missing for 2002, 2005, and 2007-2010; data for DK are missing for the whole period; data for GR are missing in 2002, 2008, and 2010; data for IE are missing for 2002; data for LV are missing for the whole period; data for LT are missing for 2002 and 2005-2008; data for LU are missing for 2005-2010; data for MT are missing for 2002-2004, 2006, and 2008-2010; data for PT are missing for 2004 and 2007; data for SK are missing for the whole period; data for SI are missing for 2003 and 2004; data for NL are missing for 2002-2008 and 2010.

Regarding scrap, it is noteworthy that in contrast to iron ore, the EU is a large “producer” (recovery agent) of scrap. Global trade in scrap has increased considerably over the past decade in line with growth in global steel production. Despite being a globally traded commodity, however, scrap is also the most restricted steelmaking raw material, subject to export restrictions in the form of especially export taxes ranging from 15-40% by at least 14 countries. The EU is a net exporter of steel scrap, and its steel recovery industry (at the treatment stage) is fairly concentrated, with seven companies providing some 40% of the total steel scrap delivered to the steelworks or foundries in 2010 (JRC, 2010). EU demand for recycled steel is roughly equal to the world average; however, it is not nearly as high as e.g. Turkey’s demand, where steel scrap contributed close to 85% of raw material inputs for steel production, due to the fact that its installed production capacity is almost entirely made up of EAF (Ecorys et al., 2013). The majority of the EU’s scrap exports go to Turkey. Steel scrap demand in countries with high EAF-based production can affect global prices of scrap to the extent that they will not correlate anymore to prices of e.g. iron ore. This situation was observed end of 2011, when iron ore prices dropped due to falling demand in China (large installed capacity of BOF), while scrap prices remained stable due to the continued strong steel production in Turkey (Ecorys et al., 2013). This implies a potentially diverging raw material cost situation for BOF and EAF producers.

In addition, electricity prices can create substantial competitiveness differences especially for the EAF production route and for ferro-alloys. Electricity prices vary significantly between world regions and even between EU countries (IEA, 2010); in addition, they increased in the EU-ETS countries due to the (partial) pass-through of the (opportunity) cost of the power sector.¹³ As the companies usually agree on electricity prices in bilateral contracts, however, it is likely that such a price increase did not immediately happen, and there is no estimate available for the actual price change they faced (see also Figure 2.11).

Figure 2.10 Energy prices for industry in selected world regions / countries, incl. taxes



Source: IEA Energy Prices & Taxes, 4th quarter 2012.¹⁴

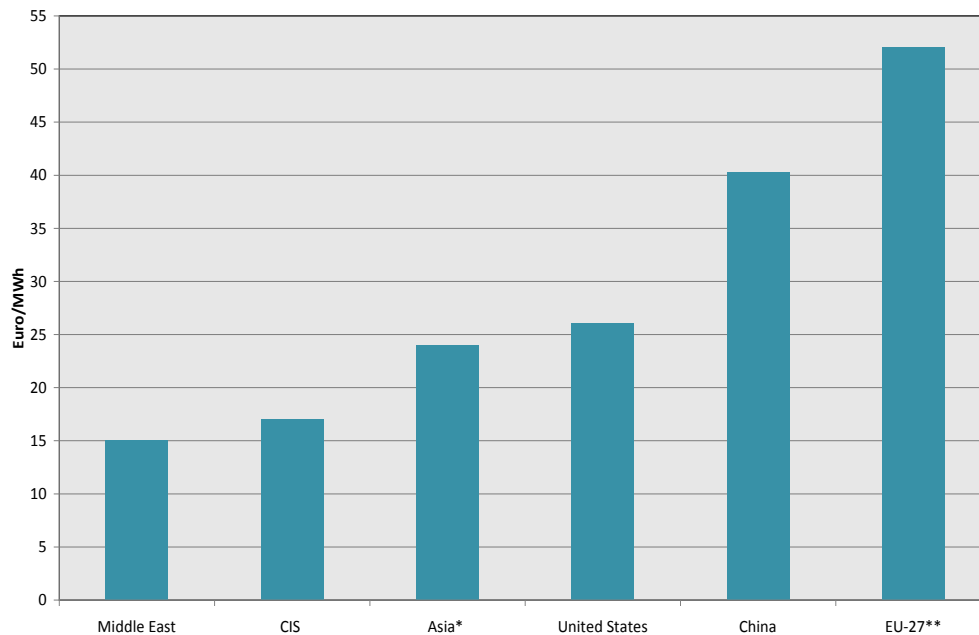
¹³ According to Reinaud (2008), studies estimate the pass-through rates of ETS (opportunity) costs in the power sector between 39 and 95%. ECN (2008) estimated pass-through rates of 38-83% with regression analyses, with some outliers above 100%.

¹⁴ Definition: Prices and taxes for the industry sector are the average of amounts paid for the industrial and manufacturing sectors.

Both electricity and gas prices roughly doubled in most countries in the selected period, except for the US. It should be noted though that the dollar lost about 20% of its value against the Euro in the same time frame, so part of the cross-country differences can also be explained by currency fluctuations.

The actual prices paid by very large industrial consumers (such as EAF plants) can be lower due to their large-volume contracts with discounts. As an approximation, the next figure shows electricity prices paid by aluminium smelters in different world regions in 2009-2010. It has the additional advantage of showing separate figures for CIS, Asia and China.

Figure 2.11 Average final electricity prices for aluminium smelters in selected regions



Source: Own calculations based on CRU data (www.crugroup.com) and information from stakeholders

* The figure for Asia does not include China

** The figure for EU27 is an average for the smelters in Western Europe (excluding Norway and Iceland)

Although the extent to which electricity producers passed through CO₂ costs into electricity prices is uncertain, empirical analyses have shown that the EU ETS has increased electricity prices (Keppler et al., 2010; Fell, 2010; Fell et al., 2013). The order of magnitude compared to other electricity price drivers is low though, as can be seen in the picture below. It should be noted that the energy prices within Europe vary considerably as well.

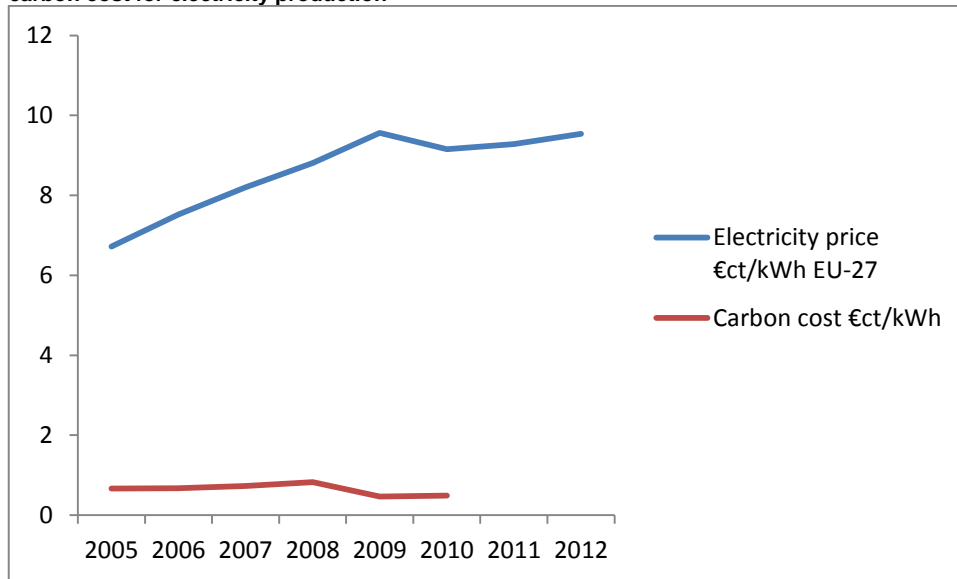
** Electricity price data for the US excludes taxes.

Note that there are data gaps for Japanese gas price data and Korean electricity price data.

OECD Europe comprises Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

In order to show the range within the EU, data for the EU countries with the highest and lowest prices are shown in both graphs.

Figure 2.12 Electricity prices for industrial consumers in the EU-27, excluding taxes; compared to carbon cost for electricity production



Source: Eurostat Energy Statistics, EEX, EEA, IEA.¹⁵

Electricity prices shown are the average national prices in Euro per kWh without taxes applicable for the first semester of each year for medium size industrial consumers (Consumption Band Ic with annual consumption between 500 and 2000 MWh). Until 2007 the prices are referring to the status on 1st January of each year for medium size consumers (Standard Consumer Ic with annual consumption of 2 000 MWh). Note that figures may still differ due to tax differences, and prices can be expected to be lower for large size industrial consumers. Also note that there are some data gaps (e.g. Italy 2008 and 2009). "EUA Y+1" refers to the forward price of an EU allowance unit (ETS emission forward price, used here because it is more stable than the spot price).

In addition to raw materials, transport costs are a cost factor. The steel industry is a transport-intensive industry as the industry produces heavy and often bulky goods, and almost 30% of all finished steel products pass from one country to another worldwide. Thus, transport costs amount to 5% to 15% of the selling price of the products (Ecorys, 2008). Looking at seaborne trade – largely relevant for international competitiveness questions – shipment of steel products between Argentina and Spain cost around 85\$ per tonne in September 2012, and shipment of pig iron between Russia and Germany was at around 14\$ per tonne (Metal Expert, 2012). Notably, these prices fluctuate heavily over time. However, it can clearly be observed (cpr. World Steel 2011, 2012) that main trade flows in the iron & steel sector take place between countries that are geographically close (e.g. Turkey / CIS with EU, EU-internally, or Japan-Asia). According to EuroAlliages, transport costs account for less than 5% of the costs in the ferro-alloys sector and are therefore not significant there.

2.3.3 Fixed costs

Apart from variable costs, fixed (capital) costs are important for the iron and steel sector. In the context of carbon leakage and (production) relocation, there are three main issues to mention:

- The BF-BOF production route requires very large facilities – integrated plants need a capacity of 2 million tonnes per year to be profitable. They have very long investment cycles (approximately 40 years) and low flexibility; it is difficult (and thus expensive) to adjust production to demand

¹⁵ Electricity prices shown are the average prices in Euro per kWh without taxes applicable for the first semester of each year for medium size industrial consumers (Consumption Band Ic with annual consumption between 500 and 2000 MWh). Until 2007 the prices are referring to the status on 1st January of each year for medium size consumers (Standard Consumer Ic with annual consumption of 2 000 MWh). Note that prices can be expected to be lower for large size industrial consumers. Carbon cost is calculated by taking data from IEA on carbon emissions per kWh of electricity in OECD Europe; this quite precisely coincides with EU-27 data from the EEA, but has less data gaps. These values are multiplied by the EU allowance unit forward price (ETS emission forward price, used here because it is more stable than the spot price).

because of the cost and structural stress associated with heating and cooling of the furnaces. The high capital costs are an important barrier to exit. (Ecorys, 2008; Dröge, 2013)

- In contrast to the BF-BOF route, variable costs are much more important for the EAF route, which requires less capital investment and where costs are dominated by expenditures for scrap and electricity.
- In general, however, fixed costs are more important in the context of investment relocation than production relocation.

2.3.4 Carbon costs

Emissions

Emissions vary greatly depending on the production process, and within each production process also depend on the product. Reinaud (2004 and 2008), IEA Clean Coal Centre (2012), Dröge (2012) as well as a study by BCG (2013) commissioned by the Steel Institute VDEh provide some indication for the situation in the EU-27. Note that these figures do not include the process emissions of ferro-alloy production.

Table 2.4 Emissions per product

Production process / product	CO ₂ emissions per ton of output	Source	Reference year	Electricity emissions
BOF: hot rolled coil	2.35 t	Reinaud (2008)	Unknown / 2008	Not included
BOF: slabs	1.95 t	Reinaud (2008)	Unknown / 2008	Not included
BOF: crude steel	1.888 t	BCG (2013)	2010	Included
BOF	1.7–1.8t	IEA CCC (2012)	Unknown / 2011	Included
BOF	1.5-2.5t	Dröge (2012)	2009	Included
EAF: hot rolled coil	0.36 t	Reinaud (2008)	Unknown / 2008	Not included
EAF: crude steel	0.455 t	BCG (2013)	2010	Included
EAF	0.4t	IEA CCC (2012)	Unknown / 2011	Included
EAF	0.4t	Dröge (2012)	2009	Included
DRI-EAF	2.5t	IEA CCC (2012)	Unknown / 2011	Included
DRI-EAF	1.1-2.5t	Dröge (2012)	2009	Included

Source: Own elaboration based on Reinaud (2008), IEA Clean Coal Centre (2012), Dröge (2012) and BCG (2013). The emission intensity of the DRI process depends on whether coal or gas is used as a fuel.

According to Worrell et al. (1999), indirect emissions from electricity account for about half of the emissions in the EAF route (if hot rolling is included in the calculations, which accounts for the other half of the emissions). Note that in the case of BOF production, emissions from electricity generation can partly take place at the plant site itself, if waste gases are combusted for electricity generation internally. Sometimes waste gases are also sold to external electricity producers (Ecofys et al., 2009; Reinaud, 2004). However, almost all integrated plants are net importers of electricity.

Moya & Pardo (2013) provide a breakdown of energy consumption and emissions along the production chain (including emissions from electricity and excluding ferro-alloys). Eurofer (2013) stress that emissions concentrate on the upper part of the value chain, where the profit margin is lower and international competition is higher (see section above – increasing imports of semi-finished products). According to EuroAlliages, the same is true for ferro-alloys, which are also on the upper part of the value chain.

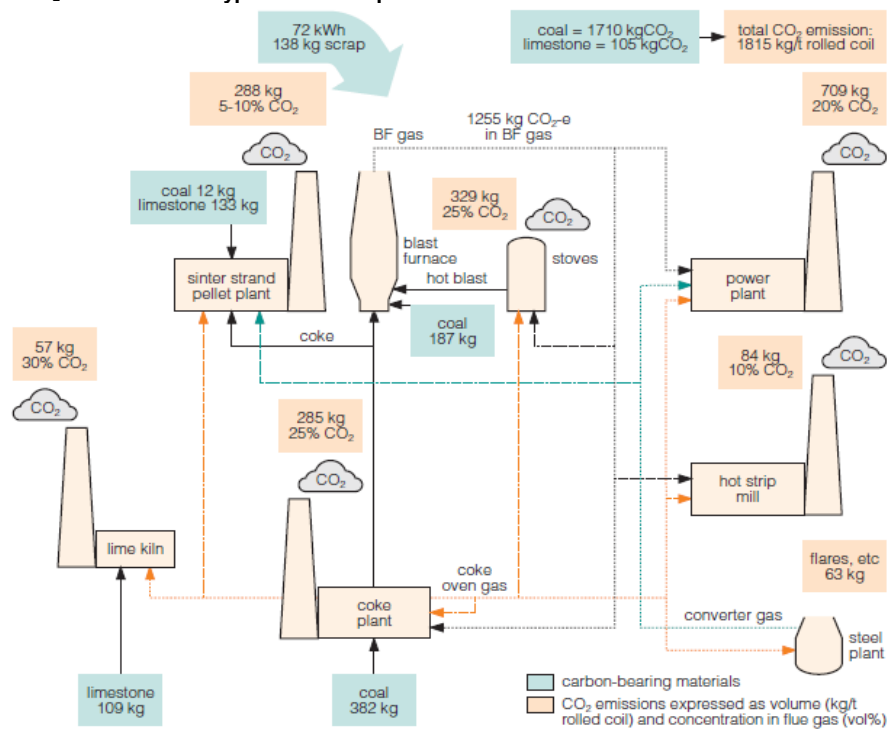
Table 2.5 Energy consumption and emissions along the value chain, based on current pathways for iron & steel production in Europe

	Direct energy		Direct CO ₂ emission	
	GJ/t product	GJ/MWh	t CO ₂ /t product	t CO ₂ /MWh
Power plant		12.173		2.057
Coke plant	6.539		0.794	
Sinter plant	1.549		0.200	
Pellet plant	0.901		0.057	
Blast furnace	12.309		1.219	
BOS plant	-0.853		0.181	
Electric arc furnace	2.505		0.098	
Boom, slab and billet mill	1.783		0.088	
Hot strip mill	1.700		0.082	
Plate mill	1.905		0.098	
Section mill	1.828		0.084	
Pickling mill	0.222		0.004	
Cold mine	0.743		0.008	
Annealing	1.086		0.049	
Hot dip metal coating	1.491		0.059	
Electrolytic metal coating	2.619		0.046	
Organic coating	0.049		0.003	

^aValues for EAF are based on an electricity consumption of 1.73 GJ/t, gas use of 0.29 GJ/t and additional fuel energy use of 0.485 GJ/t
Source: Moya & Pardo (2013).

A picture from IEA Clean Coal Centre (2012) shows the emissions of a typical BF-BOF plant in the context of the production processes (Figure 2.13 CO₂ emissions in a typical BF-BOF plant).

Figure 2.13 CO₂ emissions in a typical BF-BOF plant



Source: IEA Clean Coal Centre (2012)

Cost of compliance with ETS

Using data from the EEA data viewer (based on the ETS registry data) and production data from Eurofer, the emissions that occurred in the iron and steel sector and the freely allocated allowances can be shown in relation to production.

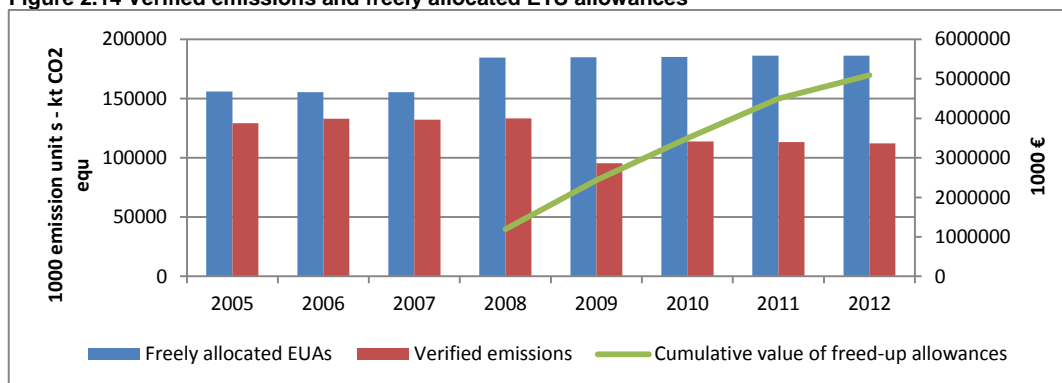
Table 2.5 Emissions in the I&S sector in the EU

	2005	2006	2007	2008	2009	2010	2011
Verified emissions (1000 t CO ₂ equ)	129.288	132.833	132.175	133.101	95.408	113.651	113.347
Freely allocated emissions allowances	155.956	155.394	155.409	184.681	184.921	185.150	186.243
Production of hot rolled steel (1000 tonnes)	173.079	187.548	187.669	178.073	129.795	156.435	161.429
Average CO ₂ intensity (t/t)	0,75	0,71	0,70	0,75	0,74	0,73	0,70

Sources: EEA data viewer, Eurofer. Note that the EEA data refer to “production of pig iron or steel” and both emissions and allowances related to other activities in steelmaking may be excluded.

For every year under the EU ETS thus far, the verified emissions in the iron & steel sector as a whole were lower than the allocation of free EUAs for that year. During 2008-2012, mainly due to the economic downturn, almost 360 million tonnes CO₂-eq were built up from the excess of EUAs, which if valued by the yearly average price result in freed-up allowances of roughly €5 billion.

Figure 2.14 Verified emissions and freely allocated ETS allowances



Source: EEA data viewer.

It has to be noted though that

- Free allocation was administered by member states and potentially varied between installations;
- This large amount of freed-up allowances only concerns direct emissions. Large electricity consumers – especially EAF plants – faced price increases of electricity due to the ETS (indirect costs). It is therefore especially important to make a distinction between BOF and EAF producers in the context of ETS costs between 2005 and 2012.
- From an opportunity cost perspective, the ETS – regardless of the allocation method of allowances – influences production decisions in favour of EAF, because the price of allowances is factored in production decisions and the EAF route is less emission intensive.

- Excess emissions allowances from the second ETS trading period can be banked into the third ETS trading period, if the corresponding activity was included in the ETS in the first two phases.

Emission abatement possibilities

According to Moya & Pardo (2013), there are several Best Available Technologies (BATs) which have been implemented in some European plants, and could contribute to emission reductions under retrofitting of existing installations, for example:

- Coke dry quenching (using the energy from hot coke cooling)
- BOF Waste Heat and Gas Recovery
- Sinter Plant Waste Gas Heat Recovery
- Scrap pre-heating (reduces power consumption in EAF plants)
- Oxy-fuel burners (reduce electricity consumption in EAF plants).

Other options that are readily available, but have not been introduced in Europe yet are:

- State-of-the-art power plants on the integrated steel production site
- Optimized Sinter Pellet Ratio (a higher pellet concentration would reduce emissions)
- Pulverised Coal Injection (lower coke use) – most major sites are equipped with such systems, but do not use a sufficient injection rate
- Corex, Finex, Midrex and HYL (in DRI production).

In different scenarios in Moya & Pardo (2013), it becomes clear that efficiency gains based on these BATs can lead to some emission reductions, of which the switch to more efficient on-site power plants plays the largest role. The table below shows the estimated reduction in energy consumption and direct CO₂ emissions for those major BATs which was used for the scenarios.

Table 2.6 Estimated reduction in energy consumption and CO₂ emissions per 1 t product or 1 MWh for selected BATs

	Direct energy		Direct CO ₂ emission	
	GJ/t product	GJ/MWh	t CO ₂ /t product	t CO ₂ /MWh
State of the art power plant		-2.83		-0.442
Coke dry quenching	-1.463		-0.010	
BOF waste heat and gas recovery	-0.908		-0.040	
Continuous casting	-1.727		-0.085	
Scrap pre-heating	-0.288		0.000	
Sinter plant waste heat recovery	-0.387		-0.012	
Optimized sinter pellet ratio - iron ore ^a	-0.359		-0.032	
Oxy-fuel burners	0.013		0.008	
Pulverised coal injection	0.126		-0.026	
Top gas recovery turbine	-0.108		0.000	
Stove waste gas heat recovery	-0.160		-0.015	
Optimized sinter pellet ratio – iron making	0.000		0.000	

^aSavings in the sinter manufacture per 1 t sinter in the blast furnace before the application of this BAT.

Source: Moya & Pardo (2013)

For the backward-looking exercise of this factsheet, the technology options of the EAF route are most interesting, because these plants were affected by indirect costs and reduction of electricity consumption can be one way to alleviate this effect. For example, at the time of the study, 99 scrap pre-heating system were in operation in the EU, and 136 oxy-fuel burners (Moya & Pardo, 2013);

but it is not clear when they were installed and whether this was a response to ETS costs. The investment costs of such systems, based on a plant capacity of 0.5 million tonnes per year, are €2.3 million for scrap pre-heating and €2.8 million for oxy-fuel burners. Scrap pre-heating saves 0.9 GJ in primary energy input per tonne of output, while oxy-fuel burners increase primary energy use by 0.013 GJ (Moya & Pardo, 2013); the important effect of these BATs with respect to input prices and the ETS is that they reduce electricity consumption.

2.3.5 Relevant policies

As a result of the heavy price competition from China, the European Commission announced an anti-dumping duty of 24% on wire rod from China in 2008, which became valid in August 2009 (for 5 years). In the environment of the global economic crisis, the effect of this measure is hard to single out. Anti-dumping duties are also common in the ferro-alloys sector.

In reaction to the economic crisis, many countries introduced or increased import tariffs or non-tariff measures. Examples, to be found in OECD (2009), are increases of import tariffs/ taxes in Egypt, Russia, Vietnam, Turkey, Indonesia and a reinstatement of duties in the UAE, all effective in end-2008 or early 2009. Many Asian economies introduced non-tariff trade measures (NTMs) such as licensing requirements and standards, among them India, Indonesia and Thailand. While the exact duration of these measures differs, it is notable that some of them came on top of already existing trade barriers (such as a 5% import duty in Russia on certain steel products), while others were new.

China and India also introduced export-facilitating measures in 2008/2009, such as elimination of export taxes and introduction of VAT export rebates. Anti-dumping investigations were ongoing worldwide in the same period (OECD, 2009).

In recent years, Russia has implemented high export duties on a number of commodities that are important for EU importers, such as wood, ferrous and non-ferrous metal scraps (EC/DG TRADE, 2011).

2.4 Synthesis

Using all of the evidence from the previous sections, the following tables provide a short overview of the main important sector characteristics and potential drivers of relocation.

Table 2.6 Evidence for (production) relocation

Indicator for (production) relocation	Trend	Additional information on trend
Net imports	Slight increase: Increase until 2008, drop during 2009, afterwards increase again	Net import changes appear largely driven by domestic demand fluctuations and by increasing imports of semi-finished products. Measured in values, net exports for finished products can be observed.
Net indirect imports	The EU's share in indirect imports has decreased less than the share in indirect exports	(No information on absolute values and no information on whether this trend is related to recession)
Investment activity in EU compared to outside EU	Decrease in relative investment	China has built up significant production capacity in recent years, Brazil is growing as well

Indicator for (production) relocation	Trend	Additional information on trend
Summary: evidence for (production) relocation	mixed	Evidence for investment relocation, but little evidence for production shift on top of these developments

Table 2.7 Drivers for (production) relocation

Drivers for (production) relocation	Assessment	Justification of assessment
Carbon cost	Only indirect costs	Direct costs were negative due to large value of freed-up allowances in the first two trading periods; indirect costs affected producers with high electricity use (EAF plants and ferro-alloy producers)
Abatement options compared to carbon cost	Some efficiency improvement options for EAF and BOF plants have been used and presumably mitigated the indirect cost effect for some EAF plants. They could still be installed in other plants.	Some efficiency improvements appear to be cost-effective in all production routes and could be used to alleviate part of any (indirect or opportunity) carbon cost. Technologies for large reductions are only expected to be available after 2020
Other costs: Raw materials	Relevant	Although raw materials (iron ore and scrap) are theoretically traded on world markets, EU producers may face competitive disadvantages vis-à-vis countries with raw material extraction and/or subsidies; lower transport costs with Asia as destination encourage scrap shippings there
Other costs: Energy inputs	Relevant	Although energy inputs (especially coking coal and gas) are theoretically traded on world markets, EU producers may face competitive disadvantages vis-à-vis countries with raw material extraction and/or subsidies. Gas price differences encourage DRI-EAF production outside the EU
Other costs: Labour	Not relevant	Small share of total costs
Other costs: Electricity	Important	Especially for EAF plants and ferro-alloys, electricity is a crucial variable cost
Pass through of costs	Mixed	Possible to some extent for high-quality products, difficult for commodities with high international competition
World demand	Important	EU demand has slightly decreased, while demand from BRIC and Middle East states has increased (CAGR 2002-2012 in apparent steel consumption was more than 12% in China, more than 6% in South America, and around -1% in EU-27)
Transport costs	Can give some competitive advantage to EU producers as	Costs for seaborne trade fluctuate heavily. In general transport costs are around 5-15% of

Drivers for (production) relocation	Assessment	Justification of assessment
	they are close to home markets, and to geographically close competitors	the selling price. Looking at bilateral trade relations, geographical proximity does seem to play a role. In this sense the main competitors are those that are geographically close to the EU (Russia, Ukraine, Turkey)
Trade & investment agreements	Some role	Most of trade takes place within EU trade union. Anti-dumping duties against China for one specific product in place. Several anti-dumping measures for ferro-alloys in place. Other countries (e.g. Brazil and China) have import restrictions or export support schemes.
Summary: CO ₂ cost among the relevant drivers?	No	The main drivers of steel / ferro-alloys production relocation appear to be shift of world demand and raw material / electricity costs

2.5 References

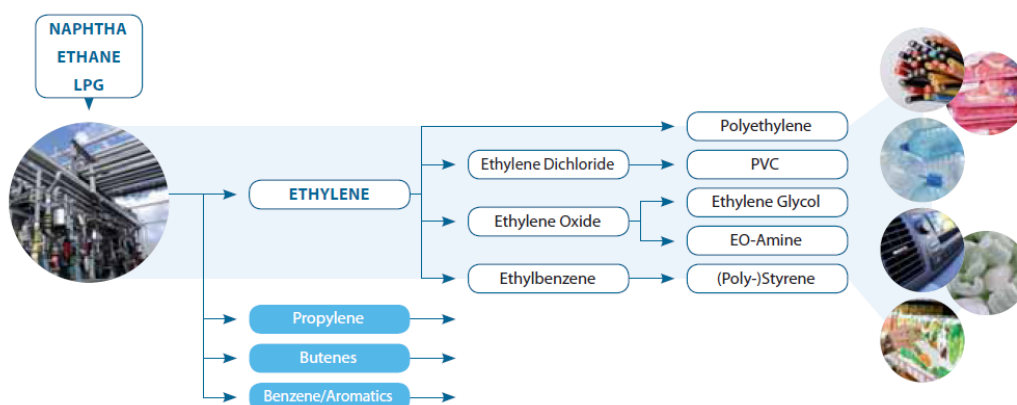
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3 Manufacture of organic and inorganic chemicals

The European chemical sector is a complicated and heavily integrated industry. Many products and intermediate products are made at the same time in one installation, making it difficult to distinguish the different products made. As an example Figure 3.1 shows several inputs and outputs of the ethylene value chain. The products of this and other chains are used in more than 90% of consumer goods used in the European market. CEFIC describes 20 customer sectors that are using the output of the chemical industry, ranging from furniture to health and social work.¹⁶

Figure 3.1 Ethylene Value Chain



Source: EC(2009) High Level Group on the competitiveness of the European Chemical Industry

The EU chemical industry produces a wide range of products and intermediate products. Some of the steps in the production chain are very energy intensive with the intermediate products having a high CO₂ intensity. Not all these intermediate products are easy and/or cheap to transport i.e. because the substances are gaseous. Therefore, trade is concentrated on a limited number of intermediate chemical products as listed in table 1.5 at the end of this fact sheet. In this analysis we will provide a short introduction to the EU chemical sector and subsequently we will focus on a limited number of substances that have a high CO₂-intensity and are easy to transport.

This factsheet is only looking backwards to the period 2005 to 2010 and is focusing on the potential risk of carbon leakage within that timeframe. The analysis is also restricted to impact of the EU ETS and not including effects of other climate policies (i.e. costs of renewable energy policies).

3.1 Scope and current carbon leakage list position

The chemical industry is covered by the NACE codes 20.11 through 20.17. For this analysis we focus on the following codes:

- 20.13: Manufacture of other inorganic basic chemicals
- 20.14: Manufacture of other organic basic chemicals
- 20.16: Manufacture of plastics in primary forms.

¹⁶ Cefic, Ecofys (2013) European chemistry for growth. Unlocking a competitive, low carbon and energy efficient future

The argument to concentrate only on these NACE codes is the limited means available for this study. For the same reason many tables and graphs in this factsheet are focused on one NACE code (organic basic chemicals). Of course, the conclusions made in this factsheet only apply for the elements of the chemical industry that are covered by these three NACE codes.

Most of the chemical industry was included in the EU ETS since the start of the ETS in 2005. See the activity table below for details.

Table 3.1 Activities of the chemical industry that fell under the EU ETS

Annex I category of activities, with clarification	NACE code (Rev. 2)	Description (NACE Rev. 2)
From phase I: Energy activities (Combustion installations with rated thermal input exceeding 20 MW, except hazardous or municipal waste installations) <i>The chemicals industry uses steam from combustion installations.</i>	20.13	Manufacture of other inorganic basic chemicals
	20.14	Manufacture of other organic basic chemicals
	20.15	Manufacture of plastics in primary forms
Clarification for phase II: production sites producing ethylene and propylene (steam crackers) with a production capacity exceeding 50000 t per year	20.14	Manufacture of other organic basic chemicals
	20.16	Manufacture of plastics in primary forms
Clarification for phase II: Combustion plants producing carbon black with a thermal input exceeding 20 MW	20.13	Manufacture of other inorganic basic chemicals
	20.14	Manufacture of other organic basic chemicals
	20.15	Manufacture of plastics in primary forms

The direct carbon costs (costs that emerge due to the purchase of allowances) as a percentage of GVA (output minus intermediate consumption at purchaser prices)¹⁷ for the three NACE codes vary between 4.8% for inorganic basic chemicals to 1.4% for plastics in primary forms. Indirect carbon costs (i.e. increased electricity costs) are in a similar range. Trade intensity (total value of exports and imports divided by the total value of its turnover and imports)¹⁸, for chemicals in pure states and derivatives, varies between 27.1% and 46.3% which is slightly below the average trade intensity of all manufactured goods in 2009 (45.8%) (Table 1.2). Moreover, it can be observed that, the trade intensity depends highly on the physical state of the substances. Gaseous chemicals are much more difficult to handle and thus more cost-intensive to transport than liquid or solid chemicals.

Table 3.2 Status in current leakage list, values for carbon cost and trade intensity

NACE Code	Direct Cost/GVA	Indirect Cost/GVA	Total Cost/GVA	Trade Intensity
20.13	4.8 %	6.0 %	11.9%	31.7 %
20.14	2.5 %	2.2 %	5.4 %	46.3 %
20.16	1.4 %	1.7 %	3.0 %	27.1 %

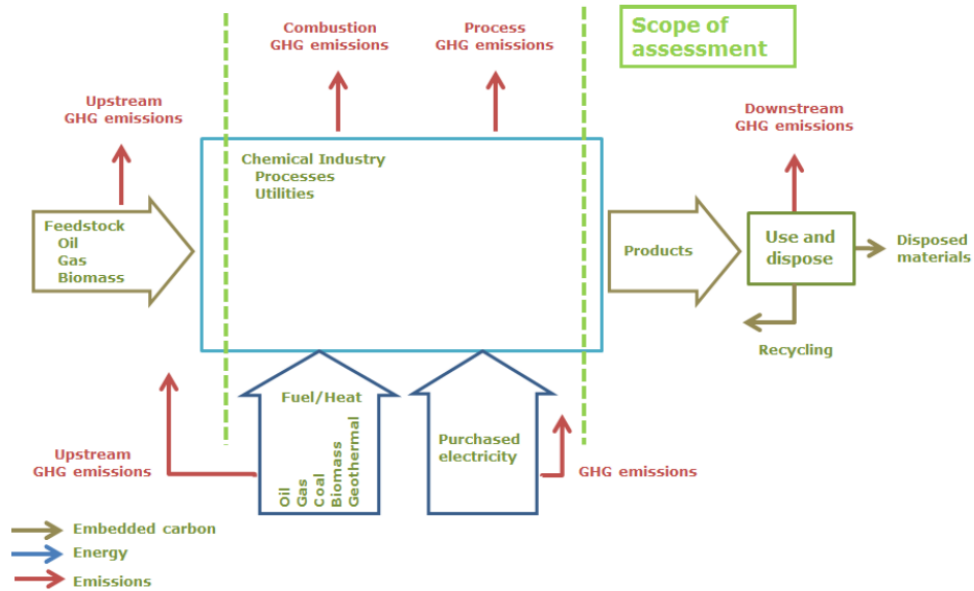
Source: EC (2009a)

¹⁷ Glossary: Gross value added at market prices - Statistics Explained (2013/8/2)

¹⁸ EC (2009a) Accompanying document to the Commission Decision determining a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage pursuant to Article 10a (13) of Directive 2003/87/EC

Figure 3.2 provides an overview of the Greenhouse gas (GHG) emissions produced during the entire product chain for chemicals. The emissions of the chemical industry are depicted in “Scope of assessment”. Other GHG emissions are the responsibility of other sectors upstream or downstream.

Figure 3.2 GHG emissions during the value chain

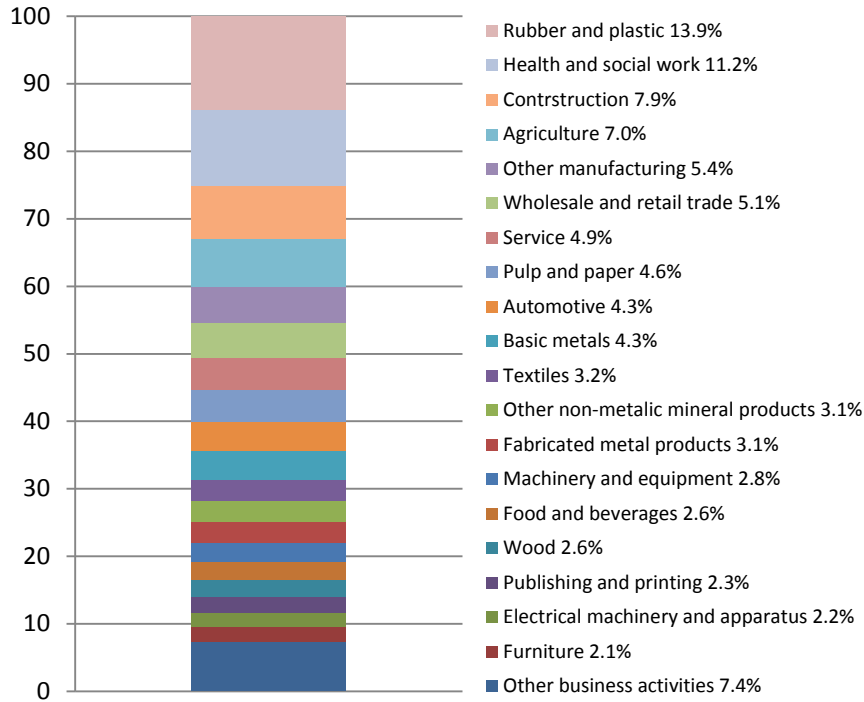


Source: Cefic, Ecofys (2013) European chemistry for growth. Unlocking a competitive, low carbon and energy efficient future

3.2 Characteristics of sector

Products of the chemical sector are used in the majority of everyday (consumer) goods. The main industrial customers are the rubber and plastic converting industry, and the construction and pulp and paper sector. Figure 3.3 presents the output of the chemical sector by customer as percentage.

Figure 3.3 Output of the chemical sector by customer segment

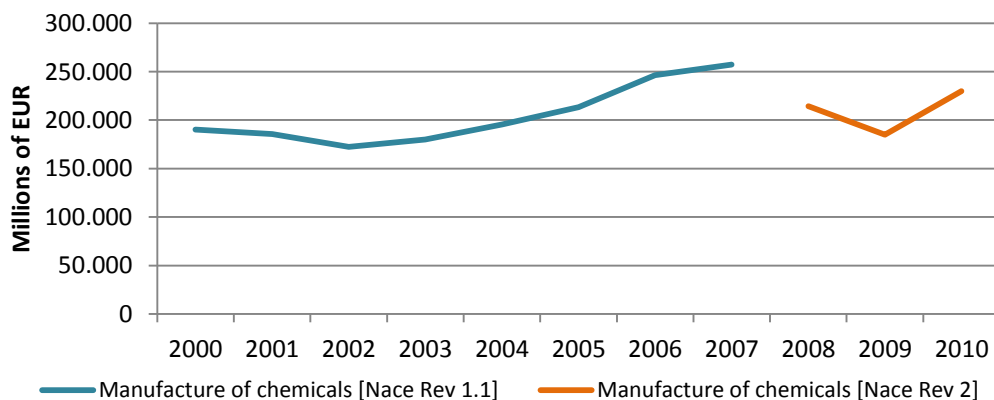


Source: Cefic, Ecorys (2013)

In 2010, 1.2 million people were employed by the European chemical sector, producing a total turnover of EUR 491 billion.¹⁹ For the manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber (NACE 20.1) 469,195 people were employed in 2010. Of these 150,907 (32%) are working in SMEs (up to 250 employees) and 318,288 (68%) in large companies.²⁰ The main share thereof is employed in the Petrochemicals, Basic Inorganics and Polymers sector (60%), with Specialty and Consumer Chemicals representing the remaining 40%.²¹

As many other industry sectors, the chemical industry was severely affected by the crisis in 2008. However, after the crisis the sector recovered fast with a 9.8% growth rate in 2010 compared to 2009. Polymers and basic inorganics registered the fastest rebounds in 2010.

Figure 3.4 Production value of chemicals in the EU-25



Source: Eurostat (2013)

Sector definition: Data represents NACE 20.13, 20.14 and 20.16

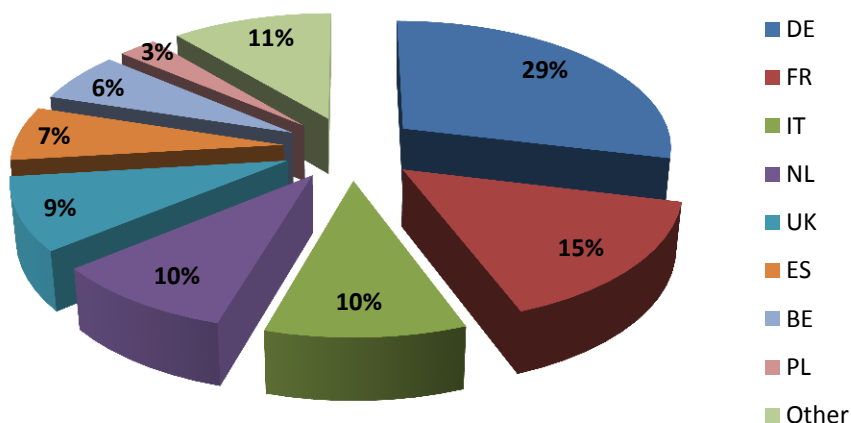
¹⁹ Cefic (2011) Facts and Figures 2011 - The European chemical industry in a worldwide perspective

²⁰ Eurostat (2013) Structural Business Statistics Database

²¹ Cefic, Ecorys (2013)

On a geographical scale, Germany remains the largest chemicals producer in Europe, followed by France, Italy and the Netherlands. In 2010, these four Member States generated together 64% of the total EU chemicals sales, valued at EUR 315 billion.²²

Figure 3.5 Geographical distribution of organic chemical production



Source: Cefic (2012) Facts and Figures 2012 - The European chemical industry in a worldwide perspective
Sector definition: Data represents all chemical products except pharmaceuticals

Operating in a relatively competitive global environment, the chemical sector heavily depends on its production costs. This includes energy, feedstock, and labour costs. In comparison to the average industrial worker, the labour force employed in the chemicals industry is more qualified and personnel costs are 56% higher than the average of other manufacturing sectors in the EU.²³

Table 3.3 Comparison of simple cash manufacturing cost structures in 2010 between the manufacture of organic chemicals and total manufacturing

SBS Indicator	Manufacture of organic chemicals	Total manufacturing
Personnel costs	10.5 %	17.4 %
Purchases of energy products	4.9 %	2.2 %
Total purchases of goods and services (excluding purchase of energy products)	84.6 %	80.4 %

Source: Eurostat (2013)

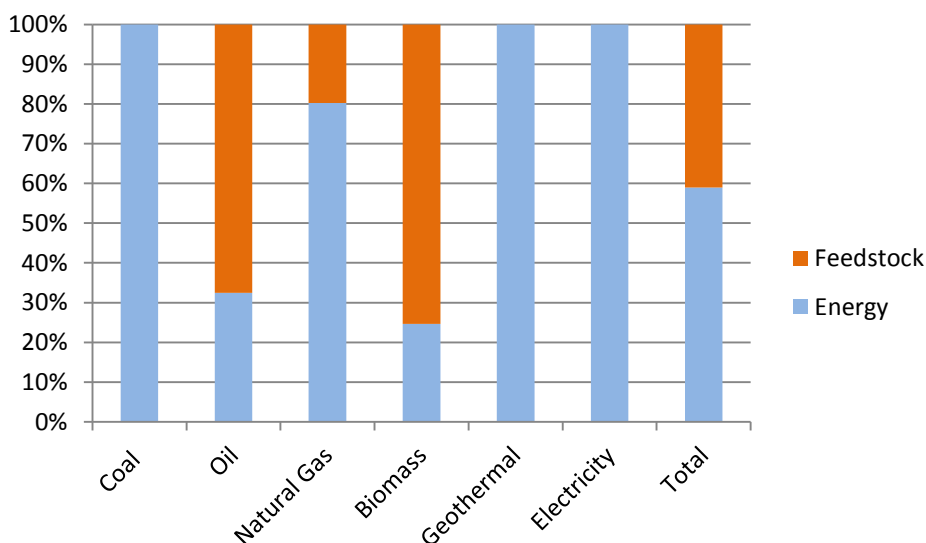
A large part of the feedstock and energy use in the chemical industry can be allocated to a few steps in the production processes: the steam cracker process, the production of ammonia (the key building block for the fertiliser industry) and the production of chlorine. These three processes are together responsible for approximately one third of energy use (excluding feedstock use).²⁴ Figure 3.6 provides an overview for the use of different material either for energy production or as feedstock. This share does not influence the CO₂ emissions, because carbon based material used as feedstock is captured inside the new product and thus is not relevant for the EU ETS.

²² Cefic (2011)

²³ Cefic (2012) Facts and Figures 2012 - The European chemical industry in a worldwide perspective

²⁴ Cefic, Ecofys (2013)

Figure 3.6 Feedstock and energy use by the European chemical industry in 2010



Source: Cefic, Ecofys 2013

The inorganic part of the chemical industry producing chlorine derived products uses a different technology. Chlorine is produced in the chlor-alkali process using a membrane cell, a diaphragm cell or a mercury cell. The electrolysis process uses electricity as energy source. The mercury cell technology is being phased out for environmental and health reasons (mercury poisoning).

3.3 Evidence of production shift / relocation

Regarding production, import and export flows, the EU-27 is the leading actor in the world, representing 41% of global trade in chemicals in 2010.²⁵ This generated a trade surplus of EUR 47 billion, with 40% generated in the Specialty and Consumer Chemicals subsectors.²⁶ Apart from China, the European Union has a surplus with each main trading region. These were in 2010: Rest of Europe (surplus of EUR 13bn), North America (EUR 11,2bn), and Asia (excluding China and Japan) (EUR 8bn). However, raw material and energy-intensive sub-sectors show significant erosion and find their global competitive position at risk. Most affected are the basic organics such as petrochemicals, as well as basic inorganics such as fertilizers. According to the SBS-data, in 2010, around 4,143 chemical enterprises were operating in the three sectors (NACE 20.13, 20.14, 20.16) in the EU-25, generating together EUR 6.4 billion of gross investment in tangible goods²⁷ (Included are new and existing tangible capital goods, whether bought from third parties or produced for own use having a useful life of more than one).²⁸

Figure 3.7 provides a comparison between the EU-25 production, import and export level. EU-25 export of chemicals is rising continuously, even in the crisis years. But import is fluctuating in line with the EU-25 output of the chemical industry. Between 2000 and 2005, world chemical consumption increased about 2.1% and between 2005-2010 world consumption increased about 0.7%.²⁹

²⁵ Cefic (2011)

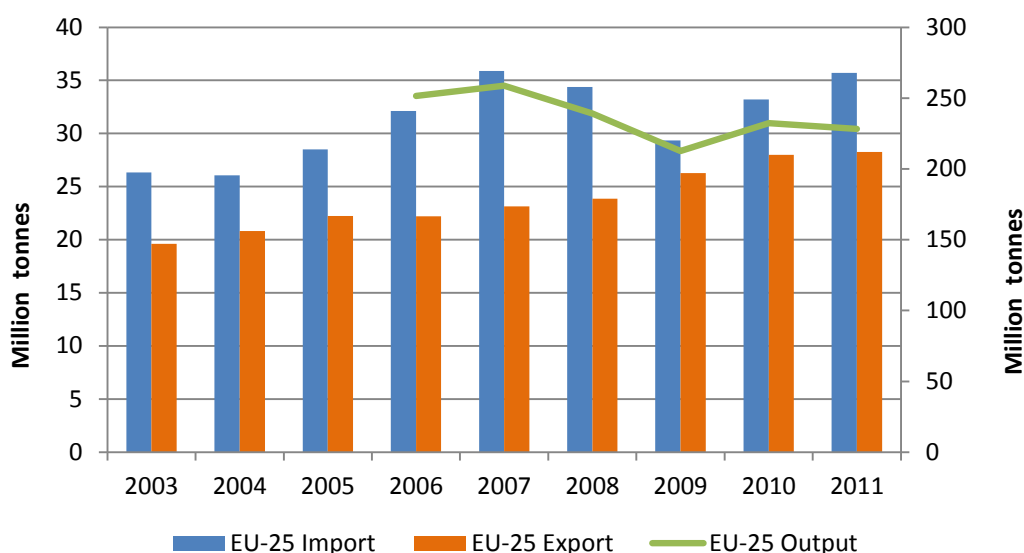
²⁶ Cefic, Ecofys (2013)

²⁷ Eurostat (2013)

²⁸ Glossary: Gross investment in tangible goods - SBS - Statistics Explained (2013/8/2)

²⁹ Cefic (2011)

Figure 3.7 Comparison of EU-25 output for basic chemicals with import and exports of the EU-25



Source: Prodcorn/Eurostat (2013)
Sector definition: Data represents NACE 20.13, 20.14 and 20.16

Table 3.4 provides a comparison of the investment as a proportion of turnover for the manufacture of organic chemicals and total manufacturing. The chemical industry investments are in general more than twice the total manufacturing. Furthermore, there is a decrease in investments between 2003 and 2006, with higher share of investment from 2008 onwards. Based on the data from SBS it is hard to interpret where this shift is coming from.

Table 3.4 Comparison of the Investment as a proportion of turnover for the manufacture of chemicals with total manufacturing in the EU-25

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Chemicals	2.1%	1.9%	2.1%	1.8%	1.3%	1.4%	1.4%	1.4%	1.8%	1.6%	1.2%
Total manufacturing	4%	4%	3%	4%	4%	3%	3%	3%	3%	3%	3%

Source: Eurostat (2013)
Sector definition: Data represents NACE 20.13, 20.14 and 20.16

3.4 Drivers for (production) relocation

3.4.1 Development of costs

Over the last years, the EU chemicals industry has taken crucial restructuring and cost-saving measures in order to improve its competitiveness. The focus has been on the dominating cost components: energy and raw material. Energy use has been reduced from 69.2 million tonnes of oil equivalent (TOE) in 1990 to 50.4 TOE in 2009 (27.2%), for natural gas, the reduction has been from 27.0 to 16.9 TOE (37.4%), and the amount of oil decreased from 18.1 to 15.0 TOE (16.0%).³⁰

The energy consumption in 2010 was responsible for the emission of 132 Mt CO₂ from combustion, i.e. heat generation, 43 Mt CO₂eq were emitted during the production process, i.e. N₂O emissions from nitric acid and other chemicals, and 59 Mt CO₂ were indirect CO₂ emissions associated with power consumption.³¹ Nevertheless, the European chemical industry still accounts for 12% of total

³⁰ Cefic (2011)

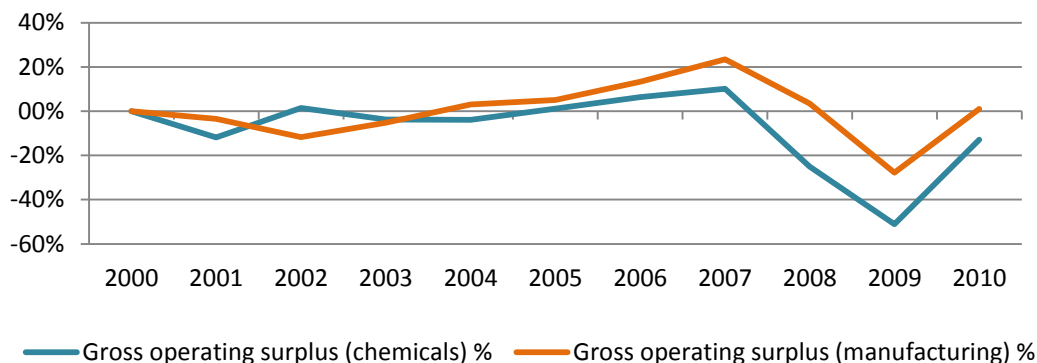
³¹ Cefic, Ecofys (2013)

EU energy demand and for approximately 30% of all EU industrial energy use (energy and feedstock).³² Most of this energy is used for a small number of intermediate compounds, of which ethylene is the most important one.

Due to the free allocation of emission allowances in the first and second trading rounds of the EU ETS – differing between Member States – it is hard to calculate any direct effects of the EU ETS on the chemical sector. It is interesting to note that even though free allocation presumably prevented a negative effect on international competitiveness in general, the EU ETS created an opportunity cost which may have incentivized a shift in substances being produced. By increasing the electricity costs, the EU ETS has influenced production costs indirectly. The future-oriented calculation for the current carbon leakage list estimated the costs from direct and indirect cost to be on a similar level.

The operating surplus for organic chemicals and total manufacturing (Figure 3.8) stayed relatively stable between 2000 and 2007. During the crisis, both total manufacturing and chemical operating surplus have been decreasing with a recovery in 2009. In the SBS data, the gross operating surplus is defined as the “total turnover minus personnel costs. It is generated by operating activities after the labour factor input has been recompensed.”³³ It can also be seen that the chemical industry was hit harder by the crisis (drop of 50%) than the manufacturing sector as a whole.

Figure 3.8 Operating surplus for chemicals and total manufacturing



Source: Eurostat (2013)

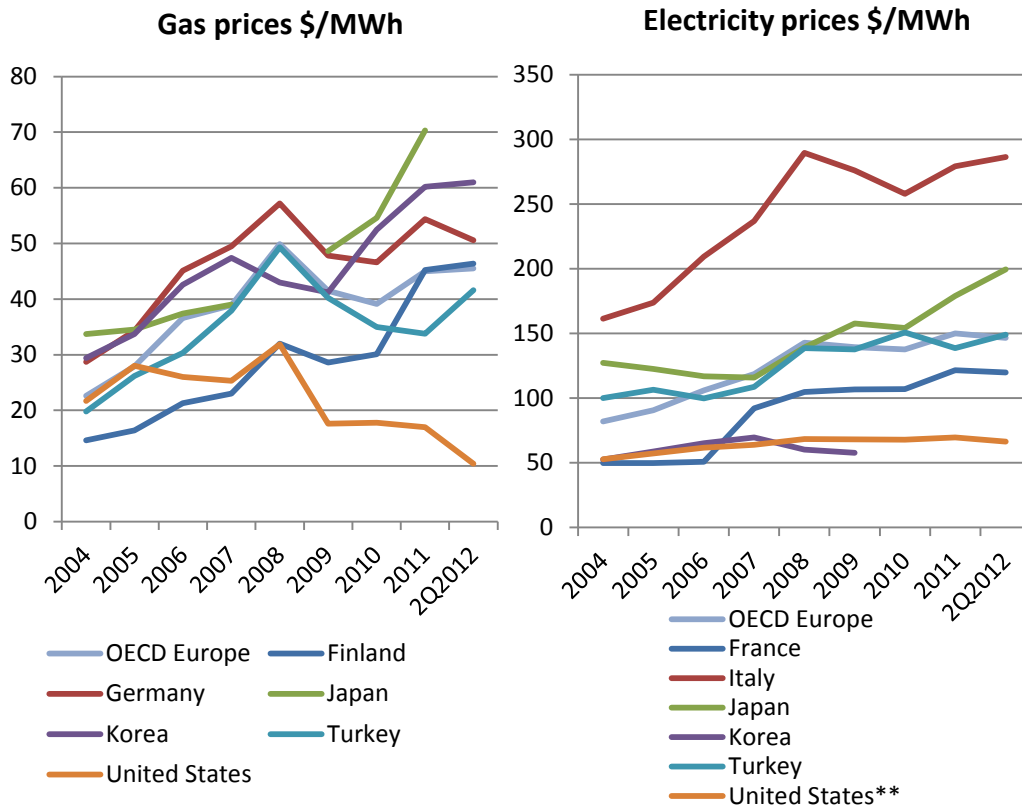
Sector definition: Data represents NACE 20.13, 20.14 and 20.16

Like all energy-intensive sectors, the chemical industry is influenced by long-term and recent cost differences for energy. The Middle East has large natural gas reserves that are hard to export. It is not economical to build pipelines to transport the gas to the markets. This so called “stranded gas” is often used to produce easy to transport energy intensive materials. This process has been going on for decades. New is the fact that also North America has exploited large low cost shale gas, shale oil and gas liquid reserves. The natural gas prices in the US are now much lower than in Europe or Japan. For companies investing in new chemical plants that could be fuelled with natural gas this is an important consideration.

³² EC (2009c) Final Report of the High Level Group on the Competitiveness of the European chemicals industry

³³ Glossary: Gross operating surplus - SBS - Statistics Explained (2013/8/1)

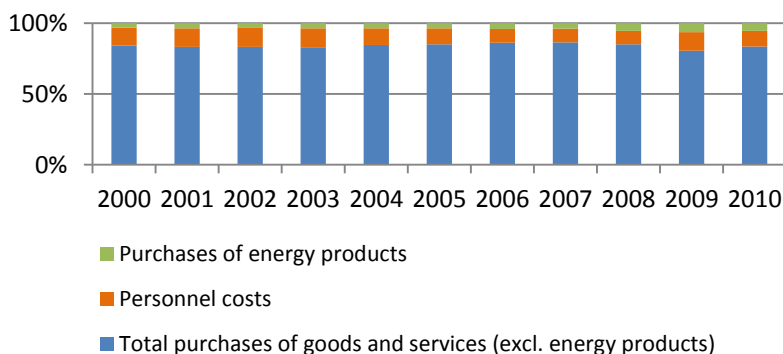
Figure 3.9 Energy prices in different global regions



Source: IEA Energy Prices & Taxes, 4th quarter 2012.

For electricity there are also considerable price differences in the world. Countries with large hydropower production are more attractive for electricity intensive industries like the chlorine industry. Europe has some low cost areas (France) but as a whole the electricity costs in the EU are on the global average. In the US the prices are lower. So in general the economic circumstances for the chemical industry in Europe are challenging. Production with existing plants will continue, but new investments are expected to shift to regions with low energy costs. The chemical sector based on oil feedstock (i.e. polypropylene and polyethylene) is highly integrated and clustered to avoid transport costs and to increase plant efficiency, including energy efficiency. World demand in this sector is expected to grow of which the Middle East (due to feedstock advantages) and China (due to strong growth in demand) are expected to benefit most and thus currently increasing their production volume. Ethane based production, practiced in the Middle East, is expected to take up to 15-20% of the ethylene downstream market in the coming years.

Figure 3.10 Cost structure for the chemical industry EU-25



Source: Eurostat (2013) Sector definition: Data represents NACE 20.13, 20.14 and 20.16

shows the costs structure for organic chemicals according to the Eurostat Structural Business Statistics. More than 80% of the costs are accumulated in the purchase of goods and services. The second largest share is held by personnel costs, followed by energy costs. However, these figures are not representative for the entire sector. Electrochemical processes (i.e. the chlor-alkali industry) use large amounts of electricity (up to 60% of total production costs).³⁴ Additionally, this sector has to deal with high restructuring costs emerging from a shift from mercury cells to membrane technology.

3.4.2 CO₂ intensive intermediate products

Carbon leakage could also occur in the form of import of CO₂ intensive intermediate products. In this case only a part of the production process would move to regions with less stringent climate policies. So it is relevant to analyse the trade in these substances to look if any carbon leakage could be perceived.

We selected 11 products that are CO₂ intensive according to Bergmann et al. (EC 2007), two of them are discussed below more in detail (Ethylene and Mono Ethylene Glycol). These substances and their main characteristics are listed in Table 1.5.

Table 3.5 Selected CO₂ intensive intermediate products

Substance	NACE	Harmonised System (HS)-code	Cost € /ton ³⁵	CO ₂ intensity of production ton CO ₂ /ton ²²	Liquid, gas or Solid (L, G, S)	Transport mode
Chlorine	20.13. 2111	280110	210	0.65	G	Road/train
Ethylene	20.14. 1130	290121	900	1.9	G	Gas tanker
Propylene	20.14. 1140	290122	850	2.9	G	Gas tanker
Butadiene	20.14. 1165	290124	920	9.8	G	Gas tanker
Ethylene Oxide	20.14. 6373	290321	890	3.7	G	Road/train
Mono ethylene glycol (MEG)	20.14. 2310	290531	810	4.6	L	Tanker
Vinyl Chloride Monomer	20.14. 1371	291010	600	1.6	G	Gas tanker
Ethylene Dichloride (EDC)	20.14. 1353	290315	-	-	L	Tanker
Caustic soda	20.13. 2525	281511	-	-	S	Bulk carrier
Polypropylene	20.16. 5130	390110	1190	3.3	S	Bulk carrier
High-density Polyethylene	20.16. 10	390120	400	2.2	S	Bulk carrier

As can be seen in Figure 3.1, ethylene is one of the main starting products for several other chemical substances presented in the table above. The majority of ethylene made in the Middle East is converted either to polyethylene (3 types – LDPE, LLDPE, and HDPE -- comprising 60% of global ethylene use) or ethylene glycol (over 10%).³⁶ The increasing trade with the Middle East

³⁴ EC (2009b)

³⁵ Bergmann et al. (2007) Imposing a unilateral carbon constraint on energy-intensive industries and its impact on their international competitiveness

³⁶ William R. Young (2012) Ethylene Profitability Outlook Positive.

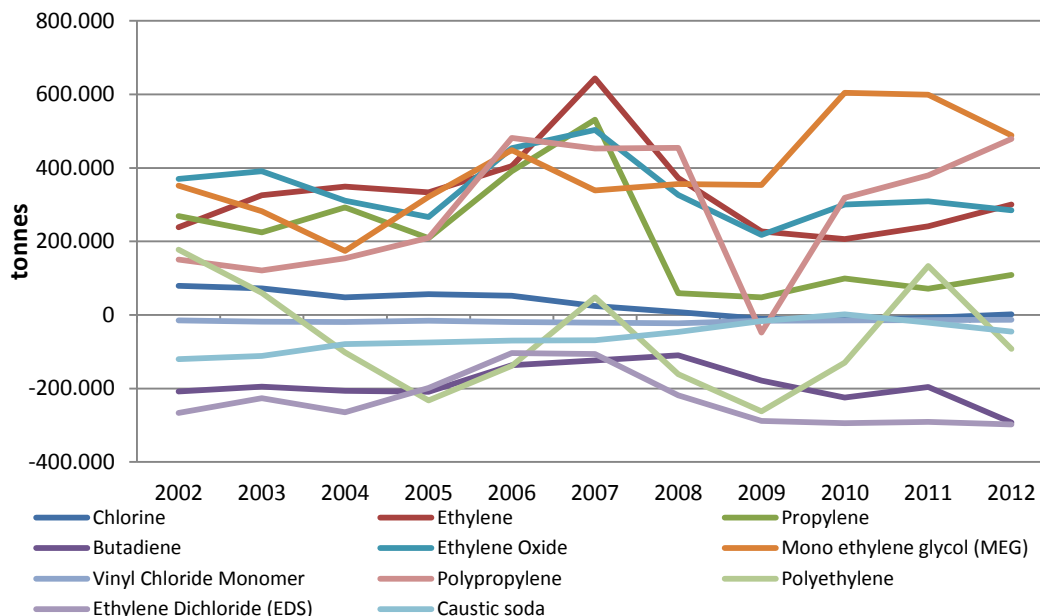
indicates that this region uses its feedstock availability, namely petroleum and natural gas, to develop and extend an integrated chemicals value chain to strengthen its position on the global market for basic chemicals. Due to the high transport cost of ethylene the market price of ethylene differs substantially per region: in the Middle East 300 USD/ton and in the rest of the world 750-1250 USD/ton. The US takes a middle position with 625 USD/ton. These differences didn't emerge in the last years and thus cannot only be caused by climate policies.

Transport of most of the selected substances, above all ethylene, is only possible with special tankers. As a result most of the pure substances are processed to derivatives directly at the production site and transported afterwards.

As an example, the transportation costs for polyethylene typically range from 80 to 160 EUR/ton and thus are much lower than for ethylene.³⁷ The CO₂ cost would have to be considerably higher than the transport costs to be responsible for carbon leakage. As we see in the Table 4 the carbon intensity of polyethylene is 2.2 ton CO₂/ton PE. Transport costs can be expressed as 36 to 72 EUR/ton CO₂. This gives an indication of the CO₂ cost level that could cause leakage. If the production of polyethylene would shift from Europe to the Gulf region, the scale of the bulk transport would become larger and the costs lower. Due to the low density of polyethylene pellets we expect that the transport costs will stay in the range given by Headwaters et al.³⁸

In the net import of various chemical products is shown. Whereas Butadiene, Ethylene Dichloride, Vinyl Chloride Monomer and Caustic soda are always net exporters, the other chemicals are net importers. For most of the chemicals a peak can be observed in 2007 followed by a drop in 2008 and 2009. The graph shows that the net imports of most substances in 2012 is at the same level or lower than in 2002.

Figure 3.11 Net import of specific chemicals



Source: Eurostat (2013)

³⁷ William R. Young (2012)

³⁸ William R. Young (2012)

An outstanding exception is MEG (Mono ethylene glycol). The net import of this chemical is gradually increasing. In 2012 it was 40% higher than in 2002. The main reason could be that Mono Ethylene Glycol (MEG) is one of the selected chemicals that can easily be transported. It is a liquid and is used to produce PET for bottles, etc. Ethylene Glycol is based on Ethylene, which means that countries with access to cheap (stranded) Natural Gas have a significant competitive advantage. In addition, Ethylene Glycol is considered as the cheapest way to export Ethylene in the absence of pipelines. Europe already imports more than half of its Ethylene Glycol demand and the share is expected to increase as European plants will focus on higher value Ethylene (Oxide) derivatives.³⁹

3.5 Synthesis

The chemical industry in the European Union has to work under challenging economic circumstances. They have to operate in an open market with relatively high energy costs and stringent environmental standards. But at the same time the integration of installations, the highly educated labour force and the safe political climate are important advantages. The low gas prices in North America and the Middle East are attracting new investments in that regions while investments in the EU are decreasing. The carbon costs in the EU are not helping in this process.

On the other hand it is clear that the carbon costs must be much higher than 20 EUR/ton CO₂ to make transport of CO₂ intensive materials cost effective. Transport is often complex and expensive. Only a few intermediate substances (i.e. liquids) could be cost effectively transported at CO₂ cost levels of 20 to 50 EUR/ton. In the evaluation period covered by this study the CO₂ prices have not been at such a level. Concluding it can be stated that the EU ETS could not be the sole cause for the shift in investments or the increase of import of MEG and the reduced export of VCM. The main driver for relocation of production sides seems to be costs for energy and feedstock. Additionally, EU ETS could foster this process and thus give an incentive to relocate production of certain substances, even if certificates are allocated for free. This would result in a shift in relative importance of substances, concentrating on a lower CO₂ output and thus creating income from the disposal of certificates.

Table 3.6 Evidence for (production) relocation

Indicator for (production) relocation	Trend	Additional information on trend
Net imports	Constant for all substances except for MEG that has increased 40%	Less increase than in previous years
Investment activity in EU compared to outside EU	Old capacity is not always renewed.	More new installations are being built outside Europe
Summary: evidence for (production) relocation	mixed	

Table 3.7 Drivers for (production) relocation

Drivers for (production) relocation	Assessment	Justification of assessment
Carbon cost	No influence on most substances except for MEG	Both indirect and direct carbon costs have been low
Abatement options compared to	CCS at power plant would cost 50 to	Average abatement cost is

³⁹ EU Trade monitor

Drivers for (production) relocation	Assessment	Justification of assessment
carbon cost	100 €/ton	higher than average carbon price, so the carbon price (row above) is the decisive factor
Other costs: fossil fuels: Gas (as part of the feedstock and for energy production), Oil (Middle East and parts of Asia less affected) and Electricity (for chlor-alkali-industry, electricity costs > 60% of production cost).	Strong influence: The high gas price in Europe has made the industry less competitive compared to North America and the Middle east	Energy and feedstock makes up to 50% of the total production costs. However, between 1990 and 2005 the energy consumption decreased about 42%. ⁴⁰
Other costs: Labour	Not that important	
Other costs: Intermediate inputs	Important, the chemical industry is highly integrated	The plants produce also many substances that are less CO ₂ intensive or have a higher added value
Pass through of costs	Below the intercontinental transport costs it is merely internal European competition	Pass-through of additional costs is only possible as far as transport costs for import of intermediate materials are not exceeded. Plastics and organic chemicals have a relatively high elasticity (Armington elasticity around 7) whereas inorganic are less elastic (around 1.7).
World demand	Important	EU demand has slightly decreased, while demand from BRIC states has increased. This holds especially true for China, where the sales in 2010 were as high as in Europe and the US combined. ⁴¹
Trade & investment agreements	Expected to be important	There are duties on different substances, however these relate on the individual material. In the case of MEG, where the import increased about 40%, no important import duty could be identified.
Summary: CO ₂ cost among the relevant drivers?	No	The main drivers appear to be gas and electricity cost differences and shift in demand

⁴⁰ Ecorys (2009) Study on European Energy-Intensive Industries – The Usefulness of Estimating Sectoral Price Elasticities

⁴¹ Cefic (2012).

3.6 References

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4 Glass and glass products

4.1 Scope and current leakage list position

4.1.1 Sector definition

The definition of the glass and glass products sector, based on the NACE classification, is presented in the table below.

Table 4.1 Definition of the sector on NACE Rev.2 and NACE Rev. 1.1

NACE Rev. 2 Classification	NACE Rev. 1.1 Classification
23.1 Manufacture of glass and glass products <i>incorporating</i>	26.1 Manufacture of glass and glass products <i>incorporating</i>
23.11 - Manufacture of flat glass	26.11 Manufacture of flat glass
23.12 – Shaping and processing of flat glass	26.12 Shaping and processing of flat glass
23.13 – Manufacture of hollow glass	26.13 Manufacture of hollow glass
23.14 – Manufacture of glass fibres	26.14 Manufacture of glass fibres
23.19 – Manufacture and processing of other glass, including technical glassware	26.15 Manufacture and processing of other glass, including technical glassware

Sources:

Eurostat (2008), *NACE Rev.2 Statistical classification of economic activities in the European Community*, Luxembourg: Office for Official Publications of the European Communities

Eurostat, Correspondence table NACE Rev. 2 - NACE Rev. 1.1 at:

http://epp.eurostat.ec.europa.eu/portal/page/portal/nace_rev2/documents/52249E90762B69F8E0440003BA9322F9.xls.

4.1.2 Type and homogeneity of products

The glass and glass products sector as a whole (NACE Rev.2 23.1) produces a wide range of products with a diverse range of applications. These include flat glass products such as glass panes for windows and doors, mirrors, and insulating units, which are used heavily as inputs into the automotive and construction industries; bottles, jars and other glass packaging products (hollow glass), which are used, *inter alia*, in the food & drink, pharmaceutical and cosmetics industries; drinking glasses, bowls, plates, cookware and decorative items (hollow glass) used by households and the catering sector; glass fibre threads, filaments, mats, voiles etc. (glass fibres) used principally in the production of composite materials with a wide range of industrial applications. The glass fibre sector also includes the manufacture of glass wool, which is used for insulation. The glass sector also includes the production of special glass products such as laboratory glassware, optical glass, and extra-thin glass for use in electronic applications (other glass).

It is worth noting that in contrast to other types of glass, the flat glass sector covers two sub-sectors: 23.11 Manufacture of flat glass and 23.12 Shaping and processing of flat glass. The former covers the upstream production process that converts raw material inputs into sheets of glass and includes melting, refining and bathing. The latter covers downstream treatment activities, such as offline coating, laminating and toughening.

The above list indicates some notable differences between the sectors and their products: some glass products are used as intermediate inputs to other production processes while others are finished goods purchased by households and other sectors; the range of industries using glass as an input to production is diverse; some glass products have a much higher added-value than others and this is particularly true for special glass and products subject to stringent quality standards.

4.1.3 Glass production

Over 95% of all glass products are either soda-lime glass, lead crystal and crystal glass or borosilicate glass. Special glass, which covers thousands of different formulations, accounts for the remaining 5% of glass production. With very few exceptions, the principal raw material in the production of glass is silicon dioxide (SiO₂) (also referred to as silica or sand). Sand is an abundant raw material but most deposits are not sufficiently pure enough to be used in commercial glass making, because the melting point is too high. As a result, fluxing agents, such as sodium oxide, are used to lower the melting temperature.

The vast majority of industrially produced glass is soda-lime glass. Soda-lime glass is typically composed of: 71-75% silicon dioxide (SiO₂); 12-16% sodium oxide (or soda (Na₂O), from soda ash) and 10-15% calcium oxide (or lime (CaO), from calcium carbonate). Other compounds (e.g. magnesium oxide, lead oxide or potassium oxide) are then added in low levels to determine the specific properties of the glass.

Increasingly, glass cullet (recycled glass) is being used as a raw material. The cullet can be either waste produced in-house that is fed back into the production cycle or glass that has been recycled by consumers. Cullet requires less energy to melt than virgin raw materials and is required in smaller quantities, but the key challenge is to ensure the quality of any cullet going into the production process.

In addition to these solid raw materials, the production of glass also involves various gases (including hydrogen, nitrogen, oxygen, sulphur dioxide) and liquids (including phenol and strong mineral acids).

Raw materials are normally stored in bulk on site. In continuous production processes, raw materials are transferred to intermediate storage towers and then weighed out, very often automatically, to produce a precisely formulated 'batch'. The batch is then mixed and transferred to the furnace for melting. The same happens in discontinuous processes except that batch production tends to be on a smaller scale and is more likely to be done manually.

The melting process involves various chemical reactions and physical processes and can be divided into the following phases: heating; primary melting; fining and homogenisation; and conditioning. In batch melting, these steps are carried out in sequence but in continuous furnaces they occur simultaneously.

The main energy sources used in making glass are natural gas, fuel oil and, to a lesser extent, electricity: in 2005 only around 7% of furnaces in the EU were electric while around 15% of total energy consumption was in the form of electricity; fuel oil accounted for 30% and natural gas 55%⁴². Fuel oil is favoured because it gives a better heat transfer to the melt but, compared to gas, most fuel oils require preheating. However, many large furnaces are equipped to run on both and across the industry as a whole the use of gas is increasing because of its purity, ease of control and because it does not require storage facilities.

4.1.4 EU ETS coverage

With the exception of sub-sector 23.12 Shaping and processing of flat glass, the sub-sectors fall within the scope of the EU ETS. The product definitions and system boundaries used to identify what fell under the EU ETS mean that the flat glass processing sector was not formally included in the scope of the EU ETS⁴³. Unless denoted otherwise, any reference to the glass sector in this

⁴² EC (2013), *Best Available Techniques (BAT) Reference Document for the Manufacture of Glass*, Luxembourg: Publications Office of the European Union, available at: http://eippcb.jrc.ec.europa.eu/reference/BREF/GLS_Adopted_03_2012.pdf

⁴³ Unless they exceed the rated thermal input in which case they would qualify in their own right as a combustion process. Additionally, where such treatments are applied 'online' they would be considered as part of the upstream process.

factsheet implies only the glass sector covered by the EU ETS, i.e. NACE 23.1 minus 23.12. On this basis 417 installations were covered by the EU ETS.

4.1.5 Status in the current leakage list

The original carbon leakage assessment was carried out at the 4-digit NACE level, using the NACE 1.1 revision. The results for the glass sector are presented in the table below.

Table 4.2 Quantitative assessment for original carbon leakage list (2009)

NACE Rev. 1.1 sector	Direct Cost	Indirect Cost	Total Cost	Trade Intensity
26.11 (Flat glass - production)	6.2%	1.8%	8.0%	21%
26.12 (Flat glass - processing)	<5%	0.8%	<5%	13.5%
26.13 (Hollow glass)	4.7%	2.6%	7.3%	24.3%
26.14 (Glass fibres)	0.8%	2.1%	3.6%	23.4%
26.15 (Other glass)	0.8%	1.6%	2.4%	49.1%
Article 10a(15) threshold			≥5%	AND >10%
Article 10a(16) threshold			≥30%	OR >30%

Sources:

EC (2009), Impact assessment of Commission Decision determining a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage pursuant to Article 10a (13) of Directive 2003/87/EC (2010/2/EU) , SEC(2009) 1710⁴⁴,

Based on the quantitative criteria set out in Article 10a(15) of Directive 2003/87/EC⁴⁵, the flat glass (production) and hollow glass sectors are included on the first carbon leakage list⁴⁶ because in both cases the trade intensity and total CO₂ cost (as a proportion of GVA) exceeded the combined assessment thresholds (see Table 4.2). Meanwhile, the other glass sector was included on the original carbon leakage list because, in line with Article 10a(16) of Directive 2003/87/EC, the trade intensity exceeded the assessment threshold of 30%; the total CO₂ cost is below the Article 10a(15) and Article 10a(16) thresholds.

The glass fibres sector produces glass fibres for reinforcement and glass fibres for insulation. In the original quantitative assessment, the reinforcement sub-sector was deemed to be at risk, but the insulation sub-sector was not assessed to be at risk. The combined assessment meant that the glass fibres sector as a whole satisfied neither of the quantitative criteria (trade intensity was assessed at more than 10% but less than 30% while the total CO₂ cost (as a proportion of GVA) was assessed at less than 5%) and was not on the original carbon leakage list. However, in 2012, the insulation sector was quantitatively assessed to be at risk of carbon leakage⁴⁷. As such, the whole glass fibres sector was deemed to be exposed to carbon leakage and added to the carbon leakage list.

The product definitions and system boundaries used to identify what fell under the EU ETS mean that the flat glass processing sector was not formally included in the scope of the EU ETS. Nevertheless, its exposure to carbon leakage was assessed and the results indicate that it was not at risk of carbon leakage at the time.

⁴⁴ Available at: http://ec.europa.eu/clima/policies/ets/cap/leakage/docs/sec_2009_1710_en.pdf

⁴⁵ Available at: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2003L0087:20090625:EN:PDF>

⁴⁶ Available at: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:001:0010:0018:EN:PDF>

⁴⁷ C(2012) 5715, Commission Decision of 17.8.2012 amending Decisions 2010/2/EU and 2011/278/EU as regards the sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage, available at: http://ec.europa.eu/clima/policies/ets/cap/leakage/docs/2012_08_17_amending_en.pdf

4.2 Characteristics of sector

4.2.1 Production value and employment

In 2010 the glass sector was responsible for €26bn of production and employed 180,000 in the EU25. This equates to 0.5% of total manufacturing production in the EU25 (€5,755bn in 2010) and 0.75% of all manufacturing employees (26.6m in 2010). The glass processing sector (23.12) on its own was responsible for more than half of glass sector production (€14bn of production) and employed around 101,000 in the EU25 in 2010.

Activity in the glass sector as a whole⁴⁸ (NACE 23.1) was spread across roughly 13,250 enterprises in 2010 of which around 98% were SMEs (1-249 employees), thereof roughly 80% were micro-enterprises (less than 10 employees). SMEs were responsible for around 40% of production in 2010. The remaining 2% of enterprises were large (250 employees or more) and they accounted for 60% of production.

Across the Member States, Germany accounted for around 20% of production and employment in the glass sector in 2010, the largest shares of any Member State. France accounted for around 17.5% of employment and production; Italy accounted for a similar share of production (16%) but a smaller share of employment (around 11%). Spain and the UK were both responsible for 7-9% of production and 5-7% of employment in 2010. Together, these five Member States accounted for just over 70% of total production and 60% of all employment in the EU25. The ten new Member States that joined the EU in 2004 were responsible for around 11% of production and 24% of employment in 2010, with Poland and the Czech Republic dominating that bloc.

4.2.2 Key producers and general cost structure

Cost structure

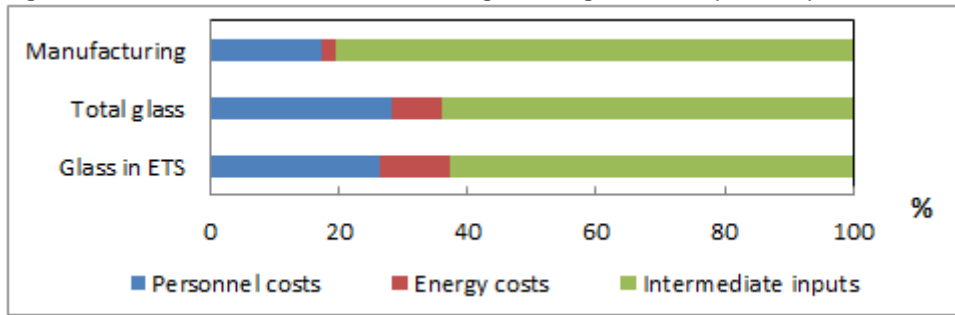
A breakdown of the cost base (comprising personnel costs, energy costs and intermediate input costs) for the total glass sector (including 23.12), the glass sector covered by the EU ETS (excluding 23.12) and manufacturing in the EU in 2010 is presented in Figure 4.1⁴⁹. In all cases intermediate inputs are the largest cost item and energy costs are the smallest cost item. But compared to manufacturing, personnel and energy costs in either definition of the glass sector account for a considerably larger combined share of the cost base and intermediate inputs make up a smaller share. Energy costs accounted for just over 2% of the total cost base in manufacturing but 11% in the glass sector covered by the EU ETS in 2010⁵⁰. For the total glass sector (including 23.12), energy costs accounted for 8% of total costs, with energy costs in the flat glass processing sector (23.12) accounting for just 3% of total costs in 2010.

⁴⁸ Data on industry structure by firm size only go to the 3-digit NACE level, e.g. 23.1. As such, it is not possible to discuss the structure of individual glass sub-sectors.

⁴⁹ A lack of data is a key issue associated with calculating the cost structure for the glass sector. The calculation of costs for the glass sector covered by the EU ETS requires data for 23.12 to be subtracted from 23.1. There is a paucity of data for 23.12 and so the calculations have used data only for Member States for which data are available on a consistent basis. As result the estimates quoted and used to create the chart are not for the EU25 but a group of 19 Member States.

⁵⁰ It is likely that the estimate of 11% underestimates the share of total costs that are attributable to energy. This is because there appears to be some misallocation of activities under 23.12 to 23.11 in the Structural Business Statistics database. Given the considerably lower share of energy costs in total costs for 23.12, this is likely to lower the averages for 23.11 and the glass sector covered by the EU ETS. NSG Group (2011) reports that in flat glass production energy costs account for around a third of the overall delivered cost.

Figure 4.1 Breakdown of costs in manufacturing and the glass sector (EU, 2010)



Sources:

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2

The largest companies operating in the glass and glass products sector are listed in the table below.

Table 4.3 Key EU and non-EU producers of glass and glass products

	Container glass	Fat glass	Domestic glass	Glass fibres (reinforcement)	Glass fibres (insulation)	Special glass
EU producer	<ul style="list-style-type: none"> Ardagh Group BA Glass Bormiolo Rocco Stölzle Glass Group Verallia (Saint Gobain) Vidrala 	<ul style="list-style-type: none"> Saint Gobain Interpane (AGC Europe) Sangalli Vetro^a 	<ul style="list-style-type: none"> Arc International Riedel Bormiolo Rocco Stölzle Glass Group Rosenthal RCR Cristalleria Italiana Durobor 	<ul style="list-style-type: none"> 3B Ahlstrom Lanxess P-D FibreGlass Group 	<ul style="list-style-type: none"> Knauf Insulation Paroc Pfleiderer Rockwool International Saint-Gobain Ursa 	<ul style="list-style-type: none"> Schott Osram TGI Philips
Non-EU producer	<ul style="list-style-type: none"> Owens-Illinois Vetropack 	<ul style="list-style-type: none"> Pilkington-NSG AGC Glass Europe Guardian Euroglas (Glas Troesch) Sisecam 	<ul style="list-style-type: none"> Libbey Pasabahce (Sisecam) 	<ul style="list-style-type: none"> Johns Manville Owens Corning PPG Industries 	<ul style="list-style-type: none"> Owens Corning 	<ul style="list-style-type: none"> Corning AGC NEG Hoya

Notes: ^a Sangalli Vetro is 50% owned by Glass Wall (Russia).

Sources:

EC (2013), Best Available Techniques (BAT) Reference Document for the Manufacture of Glass, Luxembourg: Publications Office of the European Union;

EC (2008), *Competitiveness of the Glass Sector*, available at: http://ec.europa.eu/enterprise/newsroom/cf_getdocument.cfm?doc_id=4044; Glass for Europe.

Supply chains

Table 4.4 illustrates the key customers or markets for the glass sub-sectors.

Typically, glass producers are faced with more powerful suppliers and customers. Many customer industries, such as automotive, engineering or retailing, are dominated by large multinational companies. Meanwhile, upstream the glass sector is faced with large, often integrated, suppliers of raw materials who, in some cases, operate in an oligopolistic market, and this means glass producers have little or no bargaining power. The production of soda ash and other compounds in Europe, for example, is dominated by just a handful of (global) suppliers (Solvay, Tata Chemicals, Ciech, Novacarb, Soda Sanayii (Sisecam)).

Table 4.4 Key customers/markets for the different glass sub-sectors

Glass sub-sector	Type of product	Types of customers
Flat glass	Rolled glass Float glass	<ul style="list-style-type: none"> Patterned or wired glass for greenhouses, bathroom windows, photovoltaic panels Glazing's for construction and automotive industries
Container glass	Packaging	<ul style="list-style-type: none"> Beverage industry Food industry Perfume and cosmetics industry Pharmaceuticals industry
Domestic glass	Glasses, tableware, ornaments	<ul style="list-style-type: none"> Principally consumers through retailers (department stores or specialists), but increasingly directly
Glass fibres	Reinforcement fibres	<ul style="list-style-type: none"> Used by a diverse customer base in developing composite materials: construction; electrical and electronics; automotive; industrial machinery
Glass fibres	Insulation rolls and slabs	<ul style="list-style-type: none"> Construction companies: for thermal insulation; heating and ventilation; fire protection; acoustics
Special glass	Glass tubes Glass ceramics	<ul style="list-style-type: none"> Producers of pharmaceutical and medical applications; solar energy receivers Producers of cook-top and fireplace windows; consumer products, such as coffee pots, cookware; laboratory vessels; components of chemical plants.

Sources:

EC (2013), Best Available Techniques (BAT) Reference Document for the Manufacture of Glass, Luxembourg: Publications Office of the European Union;

EC (2008), *Competitiveness of the Glass Sector*, available at: http://ec.europa.eu/enterprise/newsroom/ctf_getdocument.cfm?doc_id=4044.

In some cases, such as where producers of domestic glass sell to smaller specialist retailers (dedicated glass specialists as opposed to department stores or other general retailers) the glass producer may have more bargaining power, but must pick up more of the distribution/searching costs, which are typically around 15% of total costs⁵¹. Along with the heavy reliance of some sub-sectors on a few industries, this means firms in all parts of the glass sector have historically struggled to repel supplier cost increases or pass on cost increases to the customer.

4.3 Evidence of production shift / relocation

4.3.1 Number of enterprises

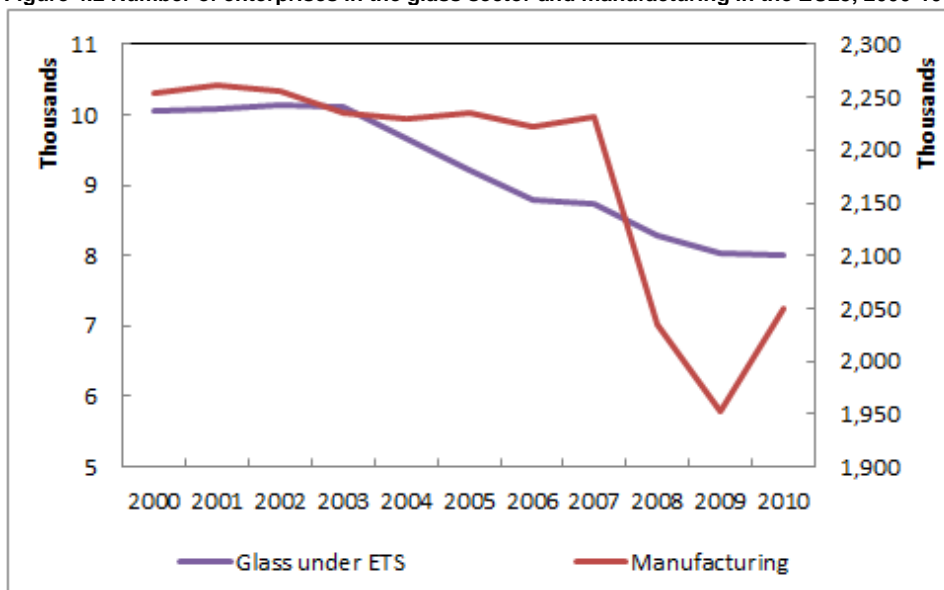
Figure 4.2 shows that the number of enterprises in the glass sector in the EU25 held up at around 10,000 over 2000-03, before declining at a steady rate to around 8,000 in 2010, as production has become increasingly concentrated. This is in sharp contrast to manufacturing as a whole, where

⁵¹ NSG Group (2011), *NSG Group and the flat glass industry 2011*

the number of enterprises held up at around 2.2m over 2000-07, before falling sharply during the economic crisis to just over 1.9m in 2009. The number of enterprises in the glass sector declined at much the same rate during the crisis as it did prior to the crisis. The data show that while the number of enterprises in manufacturing rebounded in 2010 as demand recovered, the number of enterprises in the glass sector fell further. This trend in the glass sector has been driven by consolidation, especially in the flat and container glass sub-sectors, in a bid to remain competitive in a fierce, cost-driven global market. Much of this has been driven by increasing competition from producers outside the EU.

Corresponding numbers for the glass processing sector (23.12) show that the number of enterprises held up at around 8,000 over 2000-06, before falling to around 7,400 enterprises in 2010, overall a smaller contraction than in the rest of the glass sector.

Figure 4.2 Number of enterprises in the glass sector and manufacturing in the EU25, 2000-10



Notes: Data for 2000-07 are based on the NACE 1.1 classification; data for 2008-10 are based on NACE 2 classification.

Sources:

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics on manufacturing subsections DA-DE and total manufacturing (NACE Rev. 1.1, D), database: sbs_na_2a_dade

Figure 4.3 Value of glass production, exports and imports in the EU25, 2000-11



Sources:

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2;

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics on manufacturing subsections DA-DE and total manufacturing (NACE Rev. 1.1, D), database: sbs_na_2a_dade;

Eurostat, *Comext* database.

By and large, the value of production in the EU25 increased steadily over 2000-08 (from €28bn to just over €32bn), with a small, brief fall in 2002 only (see Figure 4.3). Production contracted sharply in 2009 (falling by around 23%) in the wake of the global economic crisis but increased again in 2010. The average growth over 2009-11 (2.75% pa) was faster than the average rate over 2000-08 (2% pa), although the value in 2011 was still around 20% below the peak reached in 2008.

Over 2000-08, EU25 exports grew at a slightly slower pace than production, at 1.25% pa, and as a result the export share of production fell over the period, by 0.5 percentage points to 13.5%. Import growth was much stronger over the same period, at 5.5% pa, as competition from lower-cost overseas producers across all sub-sectors intensified. For example, EU25 imports of glass covered by the EU ETS from UAE and Belarus increased by 100-200% between 2000 and 2008, while imports from Russia, Ukraine and China increased by 74%, 233% and over 400% respectively over the same period. The prices of imports (in terms of euros per tonne⁵²) from these countries were generally lower than the prices of EU25-produced products, with Ukraine, UAE and Belarus averaging €400-500 per tonne in 2008, Russia averaging just under €700 per tonne and China averaging around €1,000 per tonne. EU25-produced glass products averaged around €1,500 per tonne in 2008, with some specific commodities averaging two-times or four-times that average. In the post-crisis period, export and import growth has been strong, at around 10% pa and 13% pa respectively over 2009-11. With production growing at around 2.75% pa over 2009-11, this means the export share of production picked up, to 16.5% in 2011. The continued increase in imports over 2010 and 2011 reflect continued growth in production outside the EU and, in some sectors, a reduction in overall EU capacity through extended repairs and other shutdowns.

⁵² These figures are derived from the Comext database, by dividing the value of imports (in euros) by the quantity of imports (in kilograms). It was not possible to derive exactly comparable figures for the EU25 based on production because some production quantities are given in pieces or m². The figure given for the EU25 is based on those commodities for which production volumes are reported in kilograms or tonnes.

Comparison to outside the EU25

Table 4.5 presents growth rates for total glass production (NACE 23.1) in selected major producers and countries bordering the EU⁵³. The scope of the data is wider than the glass sector covered by the EU ETS (because it includes 23.12). Nonetheless it provides some insight into the wider trends in global glass production and provides a comparison of the growth in total glass production in the EU25 with that in developed, developing and some neighbouring countries.

The key point the table illustrates is that total glass production has grown at much faster rates in developing and neighbouring countries than in the EU25 and other developed producers: production in China increased by nearly 400% between 2003 and 2008, in Russia glass production increased by nearly 900% between 2000 and 2008, and in Ukraine glass production increased by around 400% over the same period; by contrast, the increases in production in the EU25 and Japan were far smaller, at 23% over 2000-08 and 11% over 2000-7 respectively, while glass production in the US was 3% lower in 2007 than in 2000.

Table 4.5 Change in total glass (NACE 23.1) production in selected countries

	Brazil	China	Georgia	India	Japan	Morocco	S. Korea	Russia	Turkey	Ukraine	US	EU25
Over	2000-'07	2003-'08	2000-'08	2000-'07	2000-'07	2000-'08	2000-'06	2000-'08	2000-'05	2000-'08	2000-'07	2000-'08
% change	86	394	295	131	11	112	104	863	104	410	-3	23

Notes: The table presents the change in production (by value) between 2000 and last year for which data are available for the whole glass sector (NACE 23.1).

Sources:

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2;

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics on manufacturing subsections DA-DE and total manufacturing (NACE Rev. 1.1, D), database: sbs_na_2a_dade;

UNIDO, *Industrial Demand Supply* database.

The limited data that are available⁵⁴ indicate that total glass production in the developing or neighbouring countries of China, Russia, Ukraine, Morocco and Albania increased by 20-30% in 2010, compared to an increase of 5% in total glass production (NACE 23.1) in the EU25.

Table 4.6 Change in total glass (NACE 23.1) exports and imports in selected countries

	Brazil	China	Georgia	India	Japan	Morocco	S. Korea	Russia	Turkey	Ukraine	US	EU25
% change between 2000 and 2008												
Exports	83	671	110	276	73	30	22	206	169	248	33	14
Imports	175	143	340	354	77	265	215	558	259	1112	28	49

Notes: The table presents the change in exports/imports (by value) between 2000 and 2008 for the whole glass sector (NACE 23.1).

Sources:

Eurostat, *Comext* database;

UNIDO, *Industrial Demand Supply* database.

Table 4.6 presents growth rates for total glass exports and imports (by value) in selected major producers and countries bordering the EU25 between 2000 and 2008. The table suggests that the EU25 glass sector's share of the global market fell over the period as exports from developing and neighbouring countries increased by much more than EU25 exports. At the same time, total imports of glass and glass products into countries such as Russia, Turkey and Ukraine, far outpaced the growth of glass exports from the EU25, suggesting the EU25 glass sector failed to capitalise on the rapid growth in demand in other parts of the world (see Table 4.7).

⁵³ Comprehensive and consistent data for world production of glass under the ETS were not available, but consistent data for total glass production (NACE 23.1) in selected countries were available from the UNIDO Industrial Demand Supply database.

⁵⁴ UNIDO, *INDSTAT* database.

Table 4.7 Change in total glass (NACE 23.1) consumption in selected countries

	Brazil	China	Georgia	India	Japan	Morocco	S Korea	Russia	Turkey	Ukraine	US
over:	2000-07	2003-08	2000-08	2000-07	2000-07	2000-08	2000-06	2000-08	2000-05	2000-08	2000-07
% change	84	352	352	140	8	204	129	927	133	640	-1

	Brazil	China	Georgia	India	Japan	Morocco	S. Korea	Russia	Turkey	Ukraine	US
Over	2000- '07	2003- '08	2000- '08	2000 - '07	2000- '07	2000-'08	2000-'06	2000-'08	2000-'05	2000-'08	2000-'07
% change	84	352	352	140	8	204	129	927	133	640	-1

Notes: The table presents the change in consumption (by value) between 2000 and last year for which data are available for the whole glass sector (NACE 23.1).

Sources:

UNIDO, *Industrial Demand Supply* database.

4.3.3 Investment trends

An increase in 2003 aside, the overall trend in investment (gross investment in tangible goods) in the glass sector in the EU25 over 2000-05 was one of decline, with the level (in nominal terms) falling by around 25% between 2000 and 2005 (see Table 4.8). This was broadly in line with the trend observed in manufacturing, although the decline in manufacturing investment was not as strong (a 14% fall between 2000 and 2005).

Investment in both the glass sector and manufacturing as a whole increased by 17-20% over 2005-07. Investment in both fell back between 2007 and 2010, but the glass sector experienced a sharper fall. Between 2008 and 2010 (when the second phase of the EU ETS was in operation) investment in the glass sector fell by around a third while investment in manufacturing fell by 15%. It is worth noting that the global economic crisis unfolded in this period and the cyclical industries and drivers on which the glass industry is heavily dependent, such as construction, contracted sharply during this period.

Table 4.8 Investment in the glass sector and manufacturing in the EU25, 2000-10

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Glass											
Investment (€/m)	2.421	2.379	2.276	2.454	2.100	1.819	2.111	2.176	2.229	1.737	1.430
Investment/GOS (%)	55.9	51.4	57.6	58.2	49.5	44.8	48.9	43.2	51.0	68.6	37.6
Manufacturing											
Investment (€/m)	248.25	250.369	227.43	213.291	215.287	214.359	229.610	250.702	228.753	200.845	195.441
Investment/GOS (%)	44.1	46.1	44.3	40.5	37.6	36.7	36.4	36.6	39.4	50.1	34.2

Notes: GOS = Gross operating surplus, used here as a broad measure of profits.

Sources:

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2;

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics on manufacturing subsections DA-DE and total manufacturing (NACE Rev. 1.1, D), database: sbs_na_2a_dade;

The investment rate (investment as a share of the gross operating surplus) was typically higher in the glass sector over 2000-10, than in manufacturing as a whole, but the trend in both was similar: a gentle decline between 2001 or 2002 and 2007, with a pick-up in 2008 and 2009 followed by a sharp fall in 2010, as investment in both continued falling while the gross operating surplus picked up. The difference in the investment rate before and after the crisis is larger for the glass sector, indicating it was hit harder by the crisis than manufacturing as a whole.

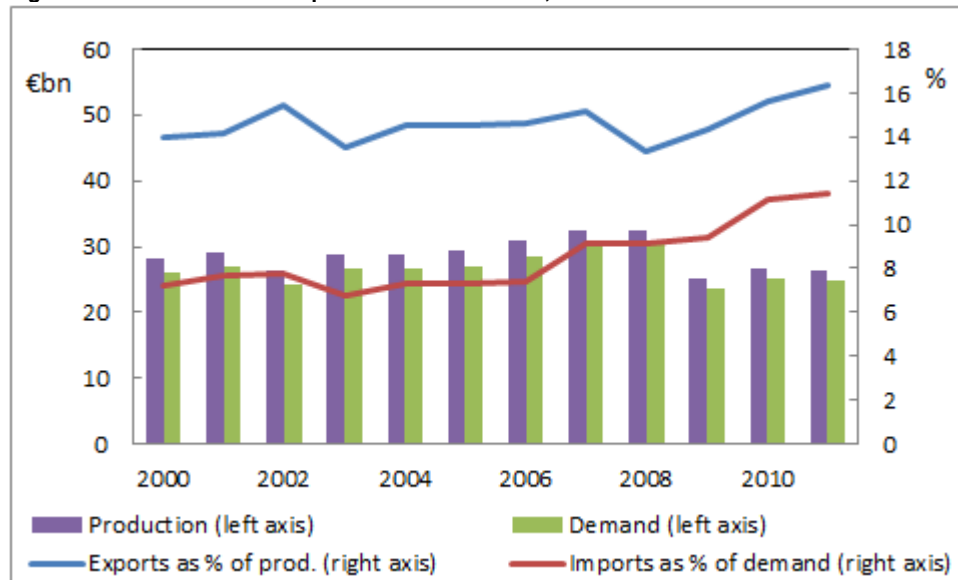
Outside the EU, there was significant expansion of production capacity across several glass sub-sectors in the latter half of the decade. Between 2004 and 2009 around 5.7 mt of new or expanded production capacity came on line⁵⁵ (around 3 mt in container glass; around 2.5 mt in flat glass), in neighbouring or bordering countries of the EU, e.g. Russia, Ukraine; and the Middle East, with nearly two-thirds of it in Russia. At the same time, these investments are not all driven by domestic firms or industries. The Chinese glass producer CPIC built a new glass fibre (insulation) plant in Bahrain, which, upon completion in 2012, has a production capacity of 200,000 tonnes. Elsewhere, Cevital MFG in Algeria has one float in operation and plans to have five floats in operation by 2018/19. Much of the production from the existing operation is exported to the EU through distribution channels set up in Spain and Italy, benefitting from the import regime known as the Generalised Scheme of Preferences EU for access to EU market. EU flat glass imports from Algeria totalled €16m in 2011, compared to exports of around €4m.

4.4 Drivers for relocation

4.4.1 Trends in demand

Over 2000-08, EU25 demand for glass products (in nominal value terms) increased gradually from €26bn to €31bn (see

Figure 4.4 Glass demand and production in the EU25, 2000-11



Sources:

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2;

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics on manufacturing subsections DA-DE and total manufacturing (NACE Rev. 1.1, D), database: sbs_na_2a_dade;

Eurostat, *Comext* database.

Figure 4.4); it fell back in 2009 and has recovered slowly since then. Domestic demand was equivalent to around 93% of glass production in the EU25 over 2000-07 (although some of that demand was met by imports and some production was exported), and the ratio picked up slightly following the economic crisis.

Import growth was much stronger over the same period, at 5½% pa, as competition from overseas producers intensified. As a result the share of EU demand met by imports increased from 7% to 9% between 2000 and 2008. However, export demand grew more slowly up to 2008 as a result of

⁵⁵ EC (2008), *Competitiveness of the Glass Sector*, available at: http://ec.europa.eu/enterprise/newsroom/cf/getdocument.cfm?doc_id=4044.

increased international competition (the EU's share of imports into the US, Russia, China and UAE (the EU's major export markets) was flat or fell between 2000 and 2008⁵⁶), counterfeiting and because of market access barriers in developing countries⁵⁷. This made it difficult for the EU glass sector to offset increased import competition by exporting more.

Following the crisis, demand grew by around 2.75% pa over 2009-11 (compared to 2.25% pa over 2000-08). Imports have grown by around 13% pa during this time resulting in the share of demand met by imports rising to reach 11.5% in 2011. However, share of the production being exported also increased during this period, providing some respite to the sector.

EU producers have found it difficult to capitalise on the strong growth in world demand (see Table 4.7) because many developing countries imposed various types of tariff and non-tariff (compulsory testing and certification, local health and safety regulations, political relations, restrictions on imports of final goods that contain glass, e.g. whisky imports in India) barriers that hindered access for EU producers. Given this, rapid growth in world demand appears to have been a driver for relocation, as a means to gain access to these markets: Glaverbel (now part of AGC Glass Europe) opened a float glass complex in Russia in 2004 and expanded it further in 2009 with the addition of, at the time, the largest float plant in the world⁵⁸, while NSG-Pilkington opened float glass plants in Russia (as Pilkington) in 2005, China (Chuangshu plant) in 2007⁵⁹ and an automotive glass plant in India in 2008⁶⁰. NSG-Pilkington now has 16 float lines in China, compared to eleven in the EU. However, demand in the EU remained fairly healthy, even if it did grow at a slower pace and an increasing share of that demand is being met by imports. A large share of EU25 imports now comes from China (over 40%) (see Table 4.9). Despite fast growth of imports into the EU25 from some neighbouring countries, they could not keep up with the growth in imports from China and so their shares of EU25 imports barely moved over 2000-10. The key peripheral regions are Turkey, Croatia and Russia, where operating and compliance costs are often lower. Thus, cost pressures as a result of increasing competition from non-EU producers in EU and third markets appear just as a strong driver for relocation.

Table 4.9 Selected countries shares of extra-EU25 imports of glass, 2000-10

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
US	27.8	27.2	19.7	18.0	16.6	15.5	15.4	14.0	13.0	12.5	13.6
Japan	12.5	12.0	12.3	9.8	8.9	7.0	5.9	4.8	4.6	4.4	5.7
China	10.1	11.1	14.6	18.9	23.4	29.5	32.9	37.8	38.8	40.0	41.2
India	1.8	2.1	2.5	2.8	2.6	2.6	2.8	2.9	2.8	2.4	2.4
S. Korea	2.7	4.1	3.3	2.7	2.0	2.2	1.4	1.0	1.2	0.8	0.8
Turkey	9.9	10.0	12.1	12.1	11.6	10.3	9.7	8.0	8.3	9.1	8.0
Croatia	1.7	1.4	1.5	1.7	1.5	1.4	1.5	1.3	1.3	1.5	1.6
Russia	1.3	1.2	0.8	0.7	1.0	0.8	1.2	1.5	1.5	2.0	1.7
Tunisia	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.2	0.3	0.4	0.4
Ukraine	0.4	0.5	0.4	0.4	0.4	0.5	0.4	0.8	0.8	0.8	0.7
Algeria								0.0	0.3	0.4	0.5
Belarus	0.4	0.6	0.6	0.7	0.6	0.8	0.8	0.8	0.6	0.6	0.6

Notes: Data are for the glass sector under the EU ETS (NACE 23.1 – NACE 23.12).

Sources: Eurostat, *Comext* database.

⁵⁶ Eurostat *Comext* database; UN *Comtrade* database.

⁵⁷ EC (2008), *Competitiveness of the Glass Sector*, available at:

http://ec.europa.eu/enterprise/newsroom/cf/getdocument.cfm?doc_id=4044

⁵⁸ For example, Glaverbel (now part of AGC Glass Europe), <http://www.agc-glass.eu/English/Homepage/News/Press-room/Press-Detail-Page/page.aspx/979?pressitemid=454>

⁵⁹ From: <http://www.nsg.com/en/media/announcements-2007/pilkingtons-new-plant-in-china-started-its-commercial-operation>

⁶⁰ From <http://www.nsg.com/en/media/announcements-2007/pilkington-to-start-construction-of-automotive-plant-in-vizag-india>

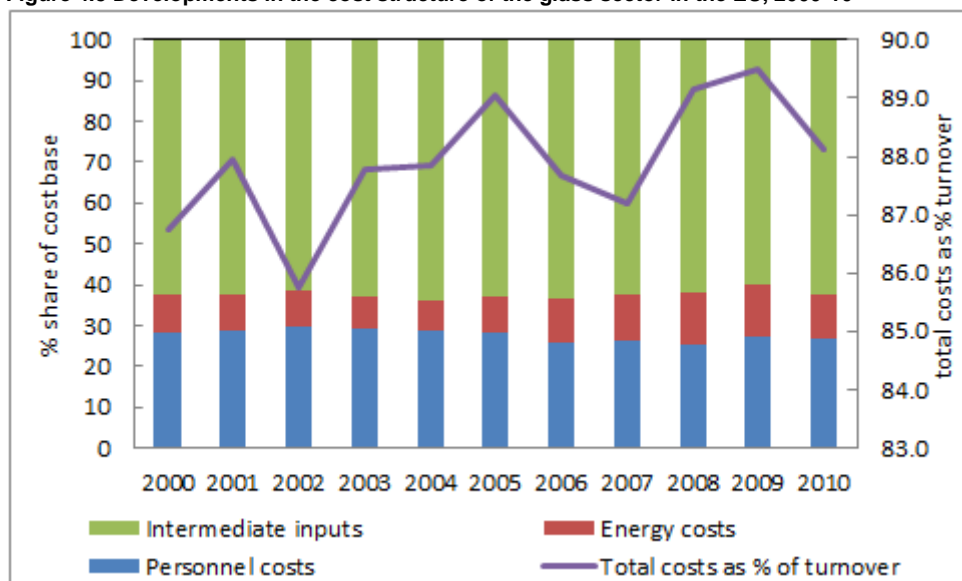
4.4.2 Development of cost structure

For the whole glass sector (including 23.12) in the EU25, total costs increased steadily at a rate of just over 2.75% pa over 2000-08 (from around €36bn pa in 2000 to €46bn in 2008), whilst production grew by around 2.5% pa. Total costs for the whole glass sector fell by 18% in 2009, as production contracted and led to a marked decline in intermediate input costs as fewer raw materials were required. The decline in labour costs was not so strong, as employers tried to hold onto workers rather than let them go. The decline in energy costs was also not as strong, as production facilities continued to operate at lower utilisation rates (rather than being shut down completely) and oil prices rose steadily. Total costs picked up by around 5% in 2010, in line with production.

An absence of data at the 4-digit NACE level means it is not possible to get consistent data for costs in the glass sector that is covered by the EU ETS at the EU25 level. Estimates of the cost structure for the glass sector covered by the EU ETS have been derived using the limited data available⁶¹, and are presented in Figure 4.5. These data indicate that total costs as a share of turnover have increased gradually from an average of 87% over 2000-04, to 88% over 2005-07 and 89% over 2008-10; although, as the chart shows, the trend has fluctuated. This was offset by 1-2 percentage point falls in profitability over the period. Over 2000-10 the shares of costs attributable to intermediate inputs and personnel costs fell while the share attributable to energy inputs increased.

The share of costs attributable to intermediate inputs averaged around 62.75% over 2000-04. This increased slightly over 2005-07 but fell back to 61.5% over 2008-10. The share of total costs accounted for by personnel costs fell markedly from an average of 29% over 2000-04 to 27% over 2005-07 and was largely unchanged thereafter.

Figure 4.5 Developments in the cost structure of the glass sector in the EU, 2000-10



Sources:

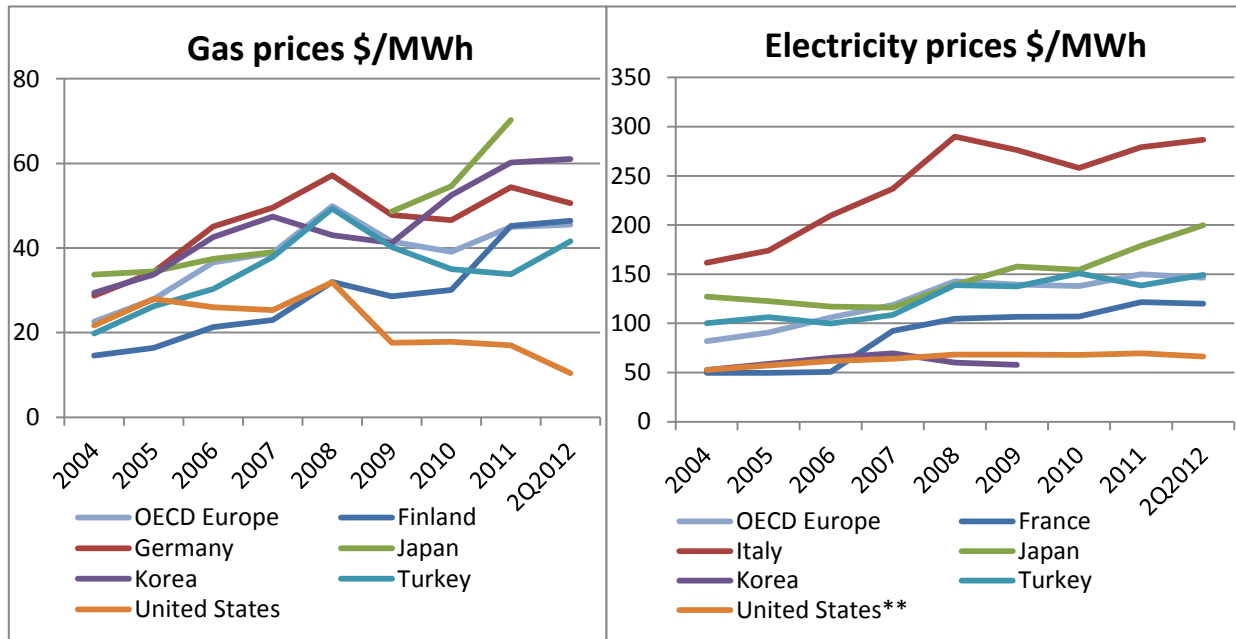
Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2;

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics on manufacturing subsections DA-DE and total manufacturing (NACE Rev. 1.1, D), database: sbs_na_2a_dade;

Eurostat, *Comext* database.

⁶¹ This means that while the various cost components and turnover have been estimated on a consistent basis within any one year, across years the geographic coverage varies depending on how many Member States data were available for. Typically estimates are based on data for 15-20 Member States. However, in earlier years it can be as low as 11-13 Member States and so figures for these years should be treated with caution. For that reason it is misleading to analyse levels and instead we focus our analysis on shares, on the assumption that these data are still broadly representative of the EU, at least in the more recent years.

Figure 4.6 Developments in energy and EUA prices, 2004-12



Notes: There are data gaps for Japanese gas price data and Korean electricity price data.

OECD Europe comprises Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

In order to show the range within the EU, data for the EU countries with the highest and lowest prices are shown in both graphs.

Definition: Prices and taxes for the industry sector are the average of amounts paid for the industrial and manufacturing sectors.

** Electricity price data for the US excludes taxes.

Sources: IEA Energy Prices & Taxes, 4th quarter 2012.

Energy costs accounted for just over 8% of total costs over 2000-04. This increased to 10% over 2005-07 and increased further to 12% over 2008-10. This was driven by sustained rises in energy prices over 2003-10. Median electricity and gas prices broadly doubled (see Figure 4.6), with much of the increase occurring over 2004-08. This coincided with a sharp rise in the forward price of ETS allowances, which rose from around 7 cents per kWh in 2004 to roughly 15 cents per kWh in 2008. In the wake of the global economic crisis it has fallen back, to around 5 cents per kWh in 2012 and this has coincided with a period of more stable electricity and gas prices.

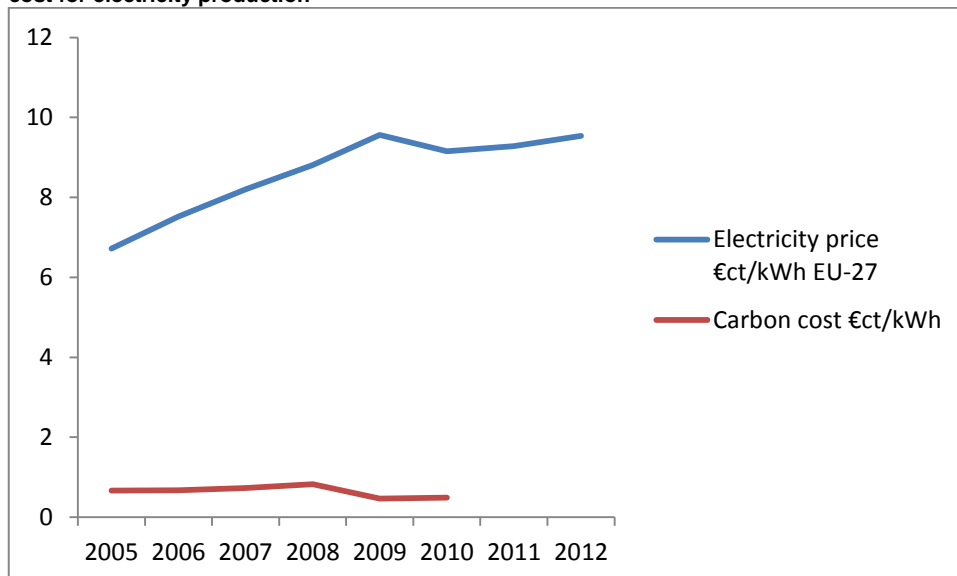
Given that around 30% of the glass sector's energy consumption comes from fuel oils, it is also worth recognising that crude oil prices increased from just under \$30 per barrel in 2003 to around \$80 per barrel in 2010, although these are of course globally set prices.

Figure 4.6 shows that the differences between EU gas and electricity prices (OECD Europe) and non-EU energy prices are mixed. Over 2004-11 energy prices in Turkey were similar to EU prices (OECD Europe) over the period, with the exception that a gap in gas prices has opened up since 2009 as a result of falling gas prices in Turkey in 2010 and 2011. Since 2009, the EU has enjoyed lower gas prices compared to Japan and Korea, where prices have soared since 2009. Electricity prices in Japan have also edged ahead since 2010. Electricity prices for the US exclude taxes, so are not comparable. However, EU gas prices have compared unfavourably to prices in the US and that the price gap has widened over time.

Although the extent to which electricity producers passed through CO₂ costs into electricity prices is uncertain, empirical analyses have shown that the EU ETS has increased electricity prices (Keppler et al., 2010; Fell, 2010; Fell et al., 2013). The order of magnitude compared to other electricity price

drivers is low though, as can be seen in the picture below. It should be noted that the energy prices within Europe vary considerably as well.

Figure 4.7 Electricity prices for industrial consumers in the EU-27, excluding taxes; compared to carbon cost for electricity production



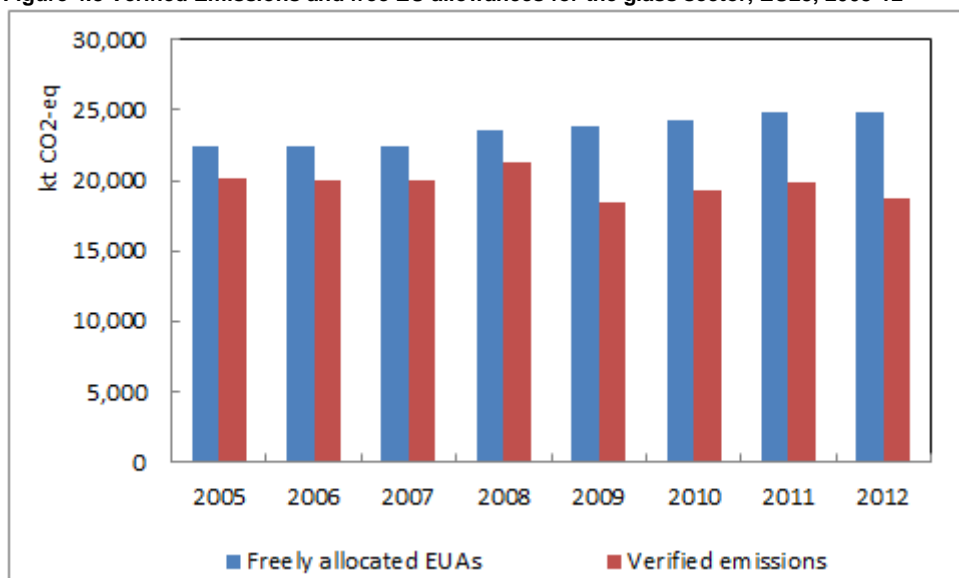
Source: Eurostat Energy Statistics, EEX, EEA, IEA.⁶²

4.4.3 The glass sector under the EU ETS

Figure 4.8 provides a comparison of the verified direct emissions arising from production in the glass sector and the sector's annual allocation of free EU allowances (EUA) over 2005-12. It shows that in every year under the ETS verified emissions in the sector were lower than the allocated allowances, with the gap widening from 2009 onwards, partly as a result of a production falling in response to the economic crisis. Consequently, between 2008 and 2012, around 24,000 kt CO₂-eq of EUAs were not required by those glass producers participating in the ETS.

⁶² Electricity prices shown are the average prices in Euro per kWh without taxes applicable for the first semester of each year for medium size industrial consumers (Consumption Band Ic with annual consumption between 500 and 2000 MWh). Until 2007 the prices are referring to the status on 1st January of each year for medium size consumers (Standard Consumer Ic with annual consumption of 2 000 MWh). Note that prices can be expected to be lower for large size industrial consumers. Carbon cost is calculated by taking data from IEA on carbon emissions per kWh of electricity in OECD Europe; this quite precisely coincides with EU-27 data from the EEA, but has less data gaps. These values are multiplied by the EU allowance unit forward price (ETS emission forward price, used here because it is more stable than the spot price).

Figure 4.8 Verified Emissions and free EU allowances for the glass sector, EU25, 2005-12



Notes: Definition of glass sector includes glass fibres.

Sources: EEA.

Cost of compliance with ETS

The recent trend in the direct cost of compliance with the ETS is presented in Table 4.10. This shows the net balance of free EUAs not required by the glass sector and the value of that balance based on the price for allowances (using the year ahead spot price). The price for EUAs fell substantially from €23.20 in 2008 to €13.82 in 2009 and has yet to recover. At the same time, while the allocation of allowances increased gradually over 2008-12, emissions fell markedly in 2009 and have yet to return to pre-crisis levels. The result of this consistent under-requirement by the sector is a balance of unrequired allowances, worth around €320m in total by 2012.

Table 4.10 Trend in the direct cost of ETS compliance in the glass sector in the EU25, 2008-12

	2008	2009	2010	2011	2012
Allowances allocated (kt CO ₂ -eq)	23,628	23,878	24,222	24,811	24,797
Allowances required (kt CO ₂ -eq)	21,237	18,475	19,318	19,867	18,784
Balance (kt CO ₂ -eq)	2,391	5,403	4,904	4,944	6,013
Cumulative balance (kt CO ₂ -eq)	2,391	7,794	12,698	17,643	23,655
EUA Y+1 (€)	23.20	13.82	14.85	13.83	7.95
Balance value (€m)	55.5	74.7	72.8	68.4	47.8
Cum. balance value (€m)	55.5	130.1	203.0	271.4	319.2

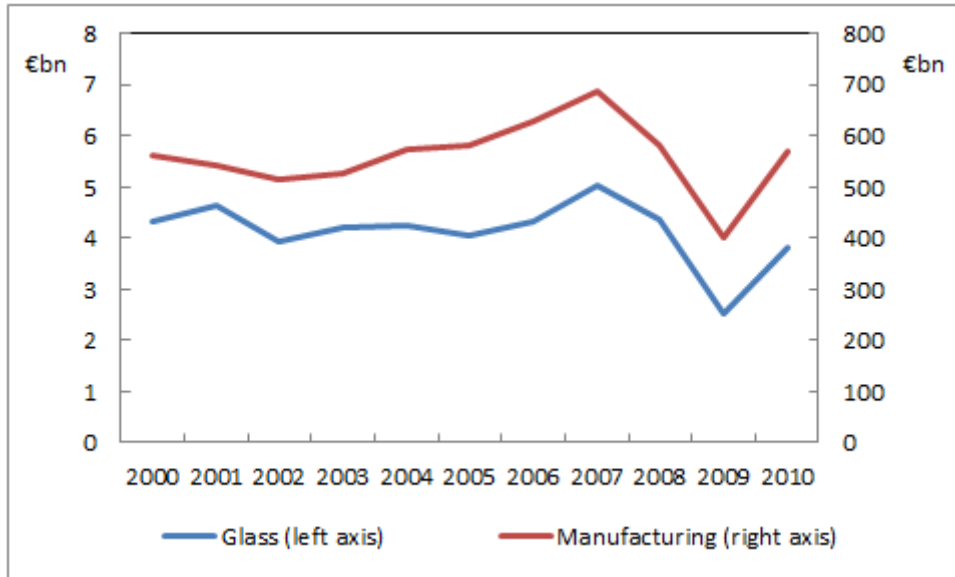
Sources: EEX; EEA.

4.4.4 Development of profits

In 2000, the glass sector generated profits (gross operating surplus) of €4.3bn, which accounted for just under 1% of profits generated by total manufacturing (€562bn).

Figure 4.9 shows that over 2000-10 the level of profits in the glass sectors moved broadly in line with those for manufacturing as a whole; the key differences being that profits in the glass sector rose more slowly between 2002 and 2007, and suffered a deeper fall between 2007 and 2009 (a fall of 50% compared to just over 40% in manufacturing). The recovery in profit levels in 2010 was slightly stronger in the glass sector.

Figure 4.9 Gross operating surplus in the glass sector and manufacturing, EU25, 2000-10



Sources:

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2;

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics on manufacturing subsections DA-DE and total manufacturing (NACE Rev. 1.1, D), database: sbs_na_2a_dade.

Profitability, as measured by the gross operating rate (gross operating surplus as a share of turnover), was and remains higher in the glass sector than the average for manufacturing as a whole. Over 2000-04, the gross operating rate in the glass sector averaged around 14.5% compared to 9.5% in manufacturing (see Table 4.11). Profitability in the glass sector declined in 2005 and although it picked up in 2007 the average over 2005-07 was 0.75 percentage points lower than over 2000-04. In manufacturing, profitability averaged around 9.5% over 2000-04 and 2005-07. The second phase of the EU ETS was in operation over 2008-12, but data are available only for 2008-10, a period distorted by the global economic crisis. Profitability in the glass sector and manufacturing fell in both 2008 and 2009, before recovering in 2010, but the glass sector experienced stronger swings. Overall, average profitability in the glass sector (and manufacturing) was lower over 2008-10 than over 2005-07; although average profitability in the hollow glass sub-sector was not.

Table 4.11 Trend in the gross operating rate in the glass sector and manufacturing, 2000-10

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Glass (%)	14.9	15.4	14.4	14.0	14.0	13.2	13.3	14.8	13.4	9.3	13.3
Manufacturing (%)	9.9	9.4	8.8	9.1	9.5	9.3	9.3	9.5	8.3	7.0	9.0

Sources:

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2;

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics on manufacturing subsections DA-DE and total manufacturing (NACE Rev. 1.1, D), database: sbs_na_2a_dade.

4.5 Synthesis

Table 4.12 Evidence for (production) relocation

Indicator for (production) relocation	Trend	Additional information on trend
Net imports	Are negative over 2000-11. Stable up to 2008, then increase (become less negative) thereafter.	EU is a stable exporter of glass
Investment activity in EU compared to outside EU	Value of investment largely flat over 2000-03. Fell sharply in 2004 and 2005. Recovered over 2006-08, but fell sharply in 2009 and yet to recover to pre-crisis levels	Strong growth in production capacity in countries neighbouring the EU and in Middle East. Some of these are key sources of imports into EU, e.g. Turkey.
Number of ETS installations	Number of enterprises has been in steady decline since 2003. The rate of decline does not appear to have been affected by the global economic crisis or the introduction of the EU ETS.	
Summary: evidence for (production) relocation	mixed	

Table 4.13 Evidence for (production) relocation

Drivers for (production) relocation	Assessment	Justification of assessment
Carbon cost	No influence	Direct carbon costs have generally been low (as a share of value added) and fell back after the crisis. Furthermore, not all of the free EUAs were required.
Other costs: fossil fuels and energy prices	Low-moderate	Evidence indicates that energy cost share of total costs has increased over the period. This looks to have been driven in part by rising oil prices (for those plants reliant on fuel oil), which are set globally, and rising electricity and gas prices. Electricity and gas prices in some countries were lower or increased by less; in others however, energy prices were higher or increased by more. In addition, keeping plants operating at lower utilisation rates rather than closing them helped boost energy cost share of total costs as other input costs declined by more.
Other costs: Labour	Mixed	Evidence indicates that labour cost share of total costs has fallen over the period. Higher labour costs in the EU compared to other non-EU producers apply a certain pressure for relocation, given the pressure to contain costs in the face of strong international competition and limited scope for price increases. However, the degree of expertise and specialisation offered in parts of the European industry reduces this.
Other costs: Intermediate inputs	Little influence	Evidence indicates that intermediate input cost share of total costs has fallen over the period, although the decline is small. Production of several raw materials is dominated by a

Drivers for (production) relocation	Assessment	Justification of assessment
		handful of producers with strong bargaining power.
Pass through of costs	Some evidence in the data	Profitability has fallen as share of costs in turnover has increased. High level of competition from lower-cost overseas producers; larger customers/suppliers, often in concentrated industries; and high dependence of some sub-sectors on some industries, make it difficult for the industry to pass on costs. However, profitability in hollow glass appears to have held up over 2008-10.
World demand	Partly	Growth in world demand, especially in developing economies has been strong, but share of EU production exported barely changed up to 2008, in part because of restrictions on market access. This encourages relocation as a means to access the market. But across all sub-sectors some production in non-EU countries is being exported into the EU to meet EU demand. So strong growth in demand outside the EU cannot be the only driver of relocation.
Summary: CO ₂ cost among the relevant drivers?	No	The main drivers appear to be shifts in world demand and pressure on margins (compared to non-EU producers) arising from operating costs (especially energy) and compliance costs. Indirect costs through increased electricity prices may have played a role – but electricity accounts for a relatively small share of energy consumption in the sector (15%).

4.6 References

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Eurostat: Structural Business Statistics database, Annual detailed enterprise statistics on manufacturing subsections DA-DE and total manufacturing (NACE Rev. 1.1, D), database: sbs_na_2a_dade, accessible from: http://epp.eurostat.ec.europa.eu/portal/page/portal/european_business/introduction

Glass for Europe (June 2010): Position Paper on the float glass CO2 emission benchmark in the context of the EU Emissions Trading Scheme (ETS), available at: http://www.glassforeurope.com/images/cont/167_69231_file.pdf

NSG Group (2011): NSG Group and the flat glass industry 2011.

5 Manufacture of Lime and Plaster

5.1 Scope and current leakage list position

The manufacture of lime and plaster has been merged into one code under the NACE Rev 2 classification (Table 5.1).

Table 5.1 NACE classification of the lime and plaster sector

NACE Rev 1.1. Classification	NACE Rev 2 Classification
26.52 Manufacture of lime	23.52 Manufacture of lime and plaster
26.53 Manufacture of plaster	23.52 Manufacture of lime and plaster

Source: Eurostat (2008)

Lime is used in a variety of different products and applications. For example, 'lime and its derivatives are used as a fluxing agent in steel refining, as a binder in building and construction, and in water treatment to precipitate impurities. Lime is also used extensively for the neutralisation of acidic components of industrial effluent and flue-gases' (JRC, 2013). 'Lime is a low cost but bulky material, so it tends to be transported only over relatively short distances' (JRC, 2013). Products of the gypsum industry are plaster, plasterboards (which includes a wide range of standard and specialty products), gypsum fibreboard and gypsum blocks, which are all used in the building sector (Eurogypsum, 2007). 'Gypsum is also an essential ingredient in cement production, where it is used as a retarding agent' (Ecofys et al, 2009).

Since the EU ETS started in 2005, the number of lime installations that have participated in the scheme is 260.⁶³ Out of these 18 lime installations have closed after the year 2005; however 19 new installations have opened up until the year 2012. Another 7 installations will enter the scheme from 2013 onwards. In the carbon leakage list, the manufacture of lime was defined as being at a significant risk of carbon leakage due to the direct costs associated with the production process (Table 5.2).⁶⁴

Table 5.2 Status in current leakage list, values for carbon cost and trade intensity

NACE Code	Direct Cost	Indirect Cost	Total Cost	Trade Intensity
26.52	62.3 %	2.8 %	65.2 %	2.6 %
26.53	>5 % and <30 %	3.1 %	>5 % and <30 %	6.5 %

Source: COM (2009)

5.2 Characteristics of sector

The manufacture of lime and plaster plays an important role in adding value and creating jobs in the EU-25. Important characteristics of the manufacture of lime and plaster in the EU-25 for the year 2010 include⁶⁵:

- Turnover: €4.1 billion (Eurostat, 2013)

⁶³ The number of installations was calculated as part of a NACE matching exercise, which was completed for the European Commission. Included within this figure are 24 installations from Bulgaria, Romania and UK that entered the EU ETS in 2007. Additional lime kilns are to be found in other sectors (namely the manufacture of sugar (NACE rev.2 sector 10.81).

⁶⁴ The EU Climate Change Committee approved on the 10th of July 2013 the addition of two sectors (plaster and plasterboard) and four sub-sectors to the current list of sectors deemed exposed to significant risk of carbon leakage for the period 2009-2014. Assuming the European Parliament and Council raise no objections, this addition will imply higher free allocation of emission allowances for these sectors and sub-sectors for the year 2014 (DG CLIMA, 2013).

⁶⁵ Turnover, Employees and Added Value calculated for the EU-25 by subtracting values for Bulgaria and Romania from the EU-27 value provided by Eurostat (2013).

- Employees: 165,039 (Eurostat, 2013)
- Added value: €1.3 billion (Eurostat, 2013)

5.2.1 Lime

The lime industry in Europe is characterised by the existence of several large producers⁶⁶ in the region operating on a global stage, giving them access to international best practice and technology, and markets for a wide range of applications.

Production process and energy consumption

The raw material for lime production is limestone, which accounts for 10 % of the total world volume of sedimentary rock (JRC, 2013). 'Lime includes quicklime and slaked lime and this term 'lime' is synonymous with the term 'lime products. Quicklime, or so-called 'burned lime', is calcium oxide (CaO) produced by the decarbonisation of limestone (CaCO₃). Slaked lime is produced by reacting or 'slaking' quicklime with water and consists mainly of calcium hydroxide (Ca(OH)₂). Slaked lime includes hydrated lime (dry calcium hydroxide powder), milk of lime and lime putty (dispersions of calcium hydroxide particles in water). However, 90 % of the total amount produced is lime and 10 % dolime' (JRC, 2013).

'In the lime or dolime production process the blocks of limestone or dolomite from the quarry are blasted, crushed and sorted by size in screening plants. At this stage part is used directly as aggregates for road construction, for concrete or other applications. Part is ground to lime fertiliser or pulverised into limestone powder, used in applications such as for cleaning flue gases, for animal feed or for fillers in many products (concrete, asphalt, carpetbacking etc.). The rest of the high quality limestone, with a defined particle size, is calcined in a lime burning plant at a temperature of 900-1200°C, at which temperature it is decarbonised in either vertical shaft or horizontal rotary kilns fired by gas, oil, coal, coke or other fuels.⁶⁷ During that process, carbonate is converted into oxide (CaO or CaMgO₂) and CO₂ is released' (IMA Europe, 2013). Gas and solid fossil fuels account for the majority of fuel input to lime production, but fuel oils and waste fuels are also used (NERA, 2008). According to the JRC (2013), the distribution of fuels used in lime burning in the EU-27 in 2003 included gas fossil (43 %), solid fossil (41 %), liquid fossil (7 %), waste (8 %) and biomass (1 %). Table 5.3 provides an overview of the main characteristics of the different lime kilns.

Table 5.3 Characteristics of lime kilns

	Typical Output (t/day)	Heat Use (GJ/t of lime)	Electricity Use (kWh/t of lime)
LRK	160-1500	6.4-9.2	18-25
PRK	100-1500	5.1-7.8	17-45
PFRK	100-600	3.6-4.2	20-40
ASK	30-300	3.8-4.6	18-35
MFSK	60-200	3.8-4.7	5-15

Source: NERA (2008)

Table 5.4 provides an overview of the product benchmarks related to the lime sector, which reflects the average greenhouse gas emission performance of the 10 % best performing installations in the EU producing that product.

⁶⁶ Germany and Italy account for 21 % and 19 % respectively of quicklime and hydrated lime that was produced within the EU-27 in 2011 (USGS, 2013).

⁶⁷ There are six general categories of kilns referred to in the BAT Reference note for lime: Long rotary kiln (LRK), Rotary kiln with preheater (PRK), Parallel flow regenerative kiln (PFRK), Annular shaft kiln (ASK), Mixed-feed shaft kiln (MFSK) and other kilns (OK)

Table 5.4 Benchmark values for products in the lime sector

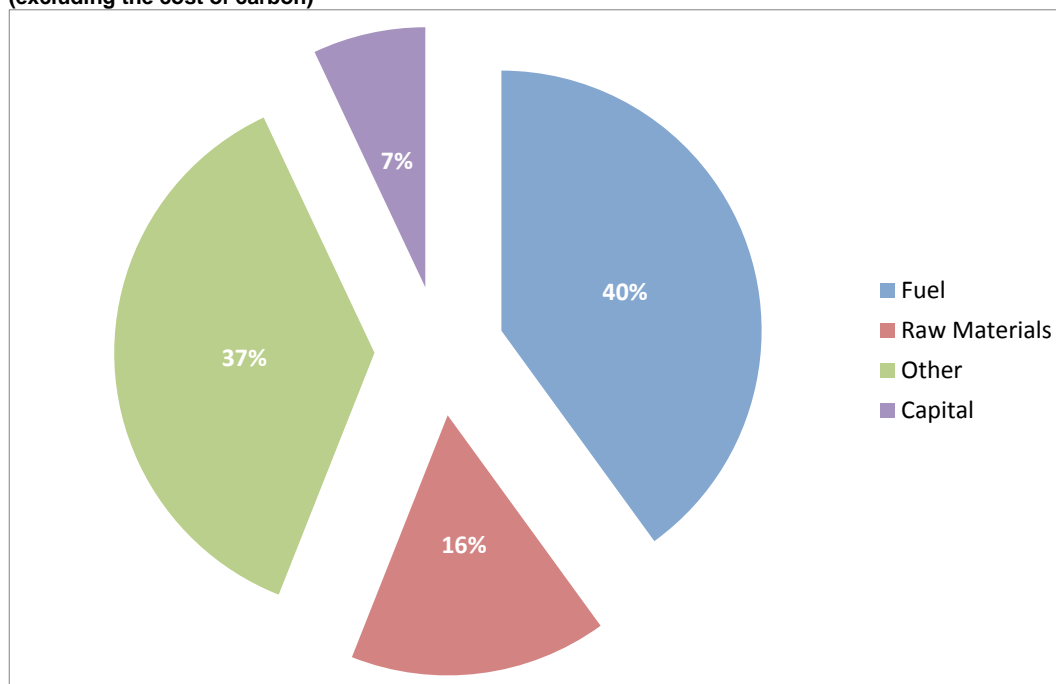
	Benchmark Value (allowances / t)
Lime	0.954
Dolime	1.072

Source: COM (2011)

Cost structure

Figure 5.1 shows the average cost shares of lime production in 2006 for a 'representative' European producer (excluding the cost of carbon). Fuel costs represent the majority of the total long term production costs⁶⁸ (including capital cost) in the lime industry (40 %) followed by the purchase of raw materials (16 %), other costs including operation and maintenance, labour costs and company overheads (37 %) and capital depreciation (7 %). It is important to acknowledge that production costs vary from one firm to another within the lime industry.

Figure 5.1 Average cost shares of lime production in 2006 for a 'representative' European producer (excluding the cost of carbon)



Source: NERA (2008)

5.2.2 Gypsum

The European gypsum market, thirty years ago, primarily consisted of Small and Medium Sized Enterprises (SMEs) that mainly produced building plaster and stucco for local markets. With the emergence of plasterboard in the 1980s the market grew considerably and the need for high capital investments, equipment, R&D and securing access to natural resources led to a consolidation process within the European gypsum industry (Eurogypsum). As a consequence, there are currently three main operators within the European gypsum industry that cover approximately 80 % of the gypsum product market. In particular SMEs are very active in Spain in plaster powder manufacturing and within the country there are 26 quarries and 33 plants (powder plants, plaster blocks and ceiling tiles) in operation (Eurogypsum).⁶⁹

⁶⁸ 'Total long-term production costs, excluding any emission costs, are just under €60 per tonne of 3 mm lime produced' (NERA, 2008).

⁶⁹ In 2011, Spain accounted for 43 % of the total gypsum production within the EU-27 (USGS, 2013).

Production process and energy consumption

The mineral gypsum is calcium sulphate dihydrate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), which is extracted from either open-cast or underground mines using pillar and stall mining methods (Eurogypsum, 2007) and subsequently ground to a powder. The powder is dried until a water content of 0.5% is reached. The resulting raw can be sold as a soil conditioner, then called land plaster. If the raw gypsum is heated ("calcined") at 150°C to 165°C, three-quarters of its combined water is removed to produce hemi-hydrate plaster ($\text{CaSO}_4 \cdot 1/2\text{H}_2\text{O}$), commonly known as stucco or 'Plaster of Paris'. When this powder is mixed with water the resulting paste sets hard as the water recombines to produce gypsum again. Higher calcination temperatures produce so called anhydrite, which has a lower reaction with water. In a last production step, the plaster can be mixed with water and other components (additives, accelerators, etc.) to produce gypsum blocks, or, if pressed between two sheets of paper, plasterboard⁷⁰ (Ecofys et al, 2009).

Table 5.5 provides an overview of the product benchmarks related to the gypsum sector, which reflects the average greenhouse gas emission performance of the 10 % best performing installations in the EU producing that product.

Table 5.5 Benchmark values for products in the gypsum sector

	Benchmark Value (allowances / t)
Plaster	0.048
Dried secondary gypsum	0.017
Plasterboard	0.131

Source: COM (2011)

5.3 Evidence of production shift / relocation

5.3.1 Development of production and import/export

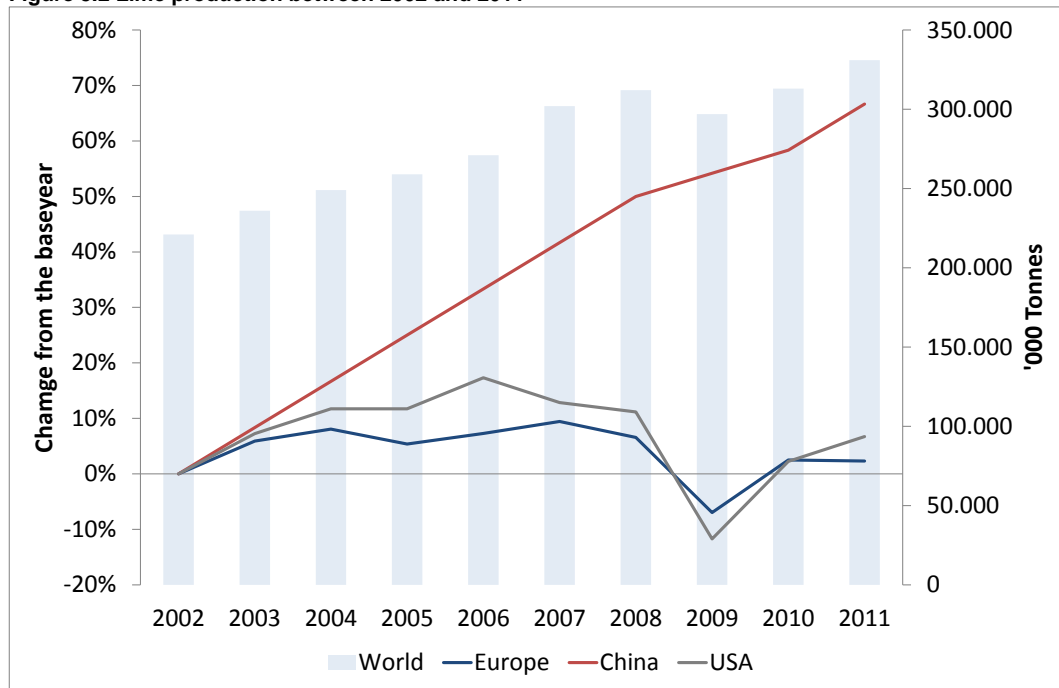
Global production of lime has increased from 221 Mt in 2002 to 331 Mt in 2011, which represents an increase of 50 % from annual production levels in 2002 (Figure 5.2). It is evident that the economic recession contributed to a decline in production in 2009, however the abrupt fall in production has been followed by a return to growth in 2010 and 2011. Figure 5.2 also illustrates that China's production of lime has increased substantially from 120 Mt in 2002 to 200 Mt in 2011 accounting for 60 % of the world's total production.⁷¹ In contrast, Europe⁷² and the USA have both experienced lower growth between 2002 and 2008, a major reduction in 2009 which has not returned to pre-crisis growth levels. This has seen their share of total lime production decline to 10% and 6% respectively. Figure 5.3 shows that the EU-27 is a net exporter of lime, however imports have grown throughout the 2000 to 2012 period. It is also important to acknowledge that traded volumes are very low compared to levels of production.

⁷⁰ According to Lafarge (2008) energy costs account for 25 % of the production cost (i.e. on a cash cost basis) for the manufacture of wallboard gypsum. No detailed cost structure data was made available by Eurogypsum.

⁷¹ The EuLA expressed their concerns about the quality of the monitoring data for Chinese production.

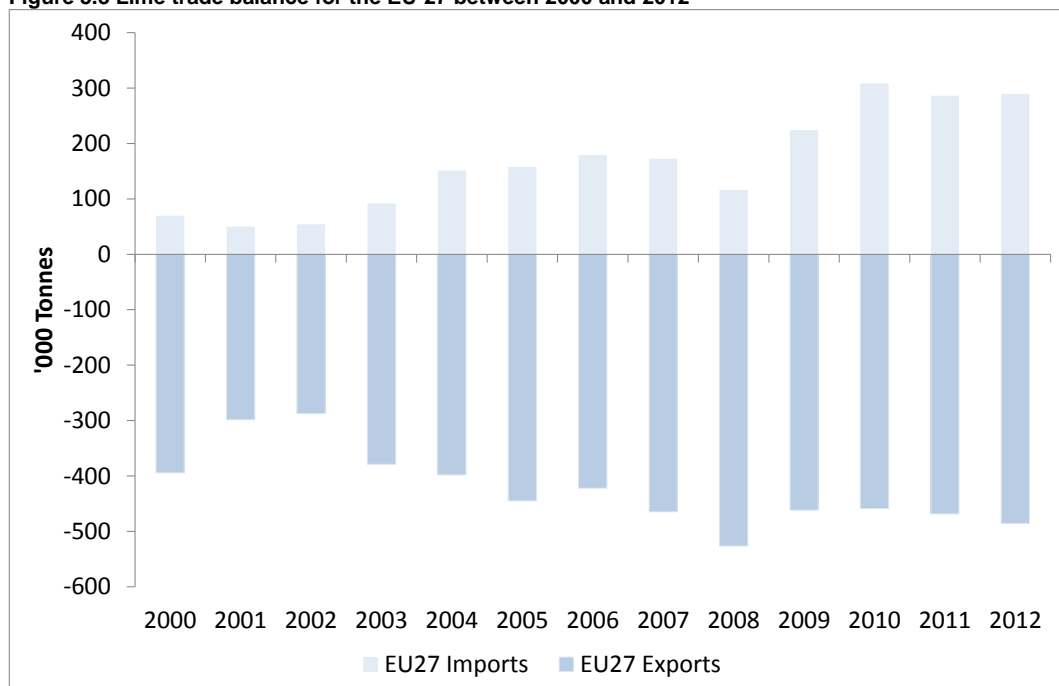
⁷² The USGS (2013) dataset does not have information on all EU Member States for lime production.

Figure 5.2 Lime production between 2002 and 2011



Source: USGS (2013)

Figure 5.3 Lime trade balance for the EU-27 between 2000 and 2012



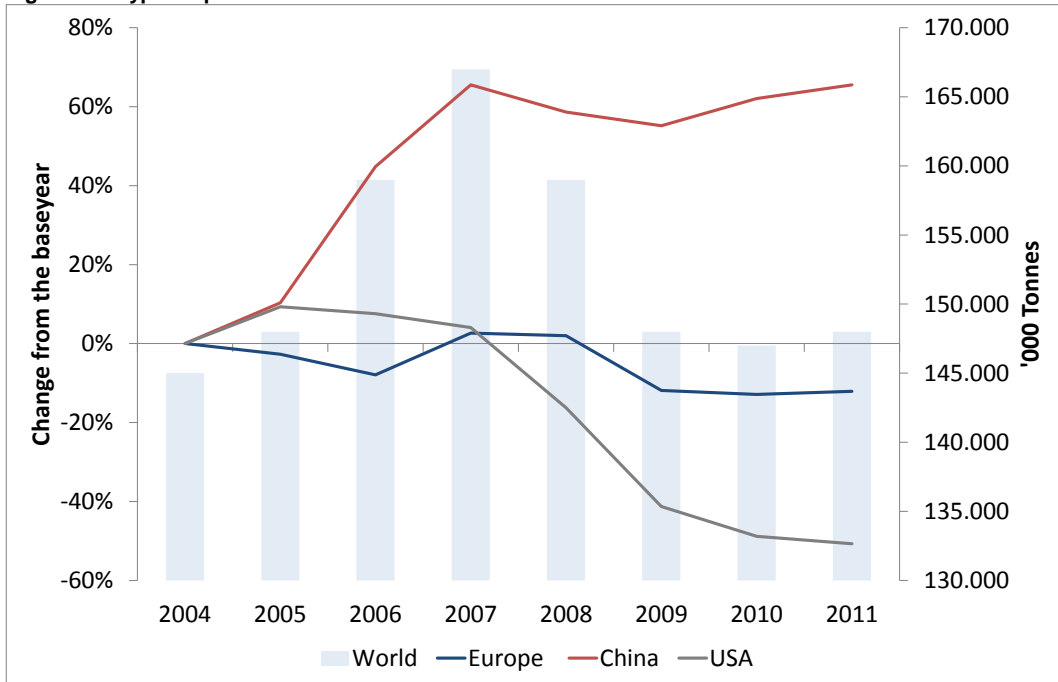
Source: COMTRADE (2013)

Global production of gypsum has increased from 145 Mt in 2004 to 148 Mt in 2011, which represents an increase of 2 % from annual production levels in 2004 (Figure 5.4). It is evident that the economic recession contributed to a considerable decline in production in 2008 and 2009 from a global peak output of 167 Mt in 2007. Figure 5.4 illustrates that China's production of gypsum has increased substantially from 29 Mt in 2004 to 48 Mt in 2011 accounting for 32 % of the world's total production. In contrast, Europe⁷³ and the USA have both experienced a decline in output during the 2004 to 2011 period and this has seen their share of total gypsum production reduce to 18 % and 6

⁷³ Not all Member States have data published within the USGS dataset.

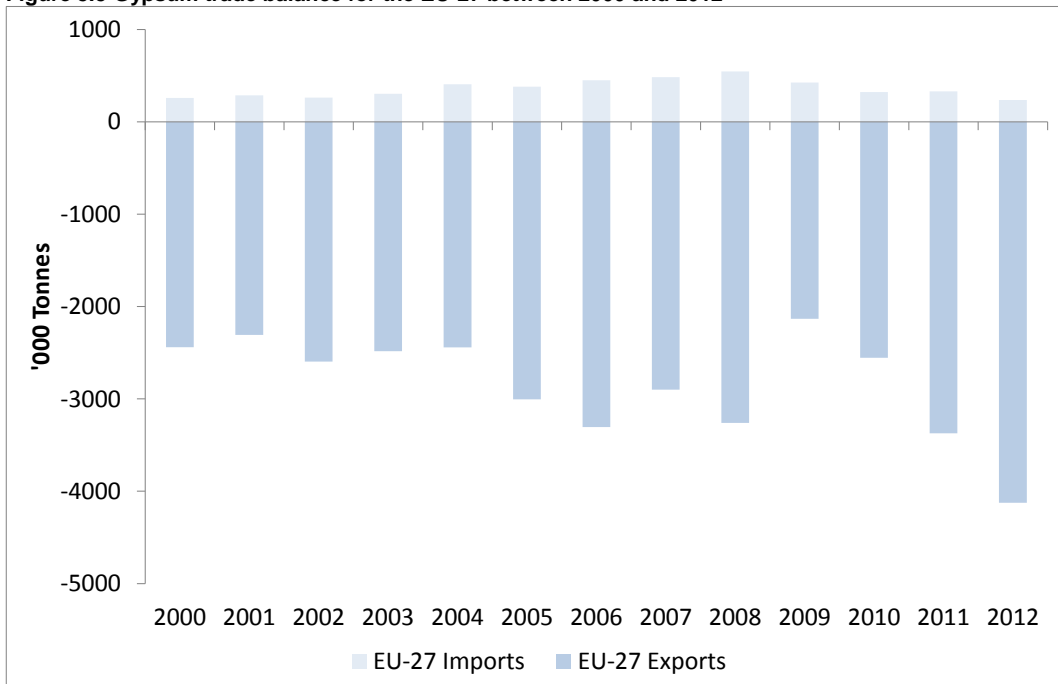
% respectively. Figure 5.5 shows that the EU-27 is a net exporter of gypsum throughout the 2000 to 2012 period and exports have increased. Again it is also important to acknowledge that traded volumes are very low compared to levels of production.

Figure 5.4 Gypsum production between 2004 and 2011



Source: USGS (2013)

Figure 5.5 Gypsum trade balance for the EU-27 between 2000 and 2012



Source: COMTRADE (2013)

5.3.2 Development of production capacity and investment

The level of investment as a proportion of turnover is calculated for the manufacture of lime and plaster based on data from the Structural Business Statistics (SBS) Database. **Table 5.6** shows that the rate of investment⁷⁴ as a proportion of turnover for the manufacture of lime and plaster has declined between 2000 and 2010. However, the level of investment for manufacturing as a whole is lower than for the manufacture of lime and plaster, which are both considered to be very capital intensive industries.

Table 5.6 Comparison of the Investment as a proportion of turnover for the manufacture of lime and plaster with total manufacturing in the EU-25

	2000	2002	2004	2006	2008	2010
Lime and Plaster	11 %	8 %	6 %	11 %	8 %	4 %
Total Manufacturing	4 %	4 %	3 %	3 %	3 %	2 %

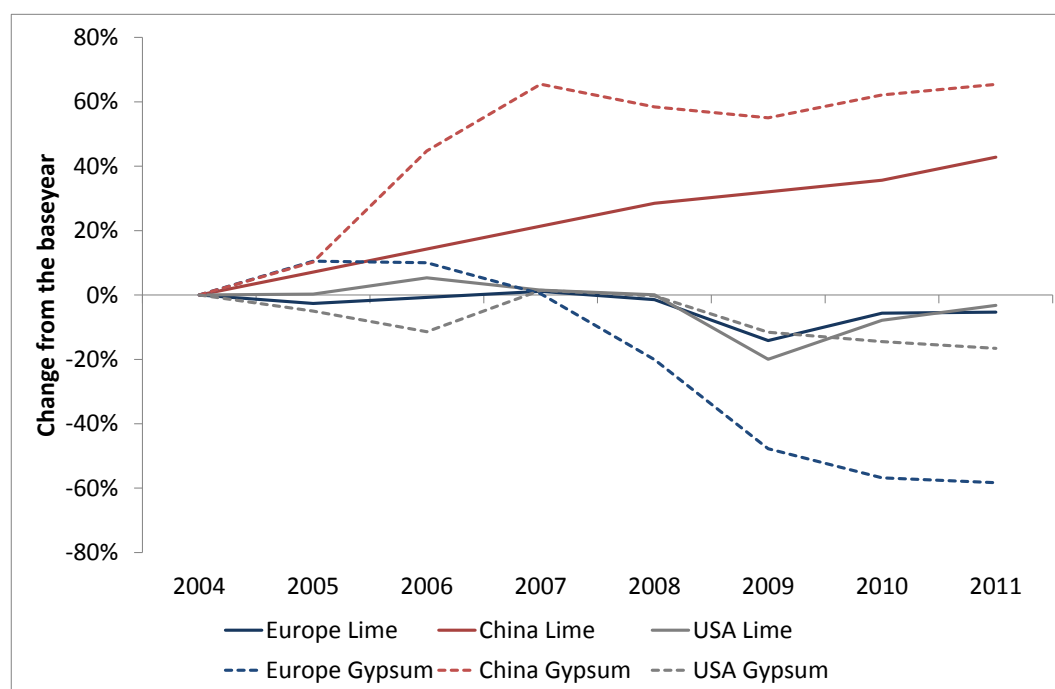
Source: Eurostat (2013)

5.4 Drivers for relocation

5.4.1 Development of demand

Figure 5.6 shows the rapid growth in the consumption⁷⁵ of lime and gypsum in China compared to the lower growth and in some cases the decline in consumption of lime and gypsum in Europe and the USA. In China, the consumption of gypsum in 2011 has increased by 65 % compared to levels in 2004. Lime consumption has increased by 43 % over the same time period (Figure 5.6). It is to be expected that levels of consumption in Europe will experience less growth than in China as the lime and plaster market is more established.

Figure 5.6 Comparison of consumption rates for different lime and gypsum products



Source: USGS (2013); COMTRADE (2013)

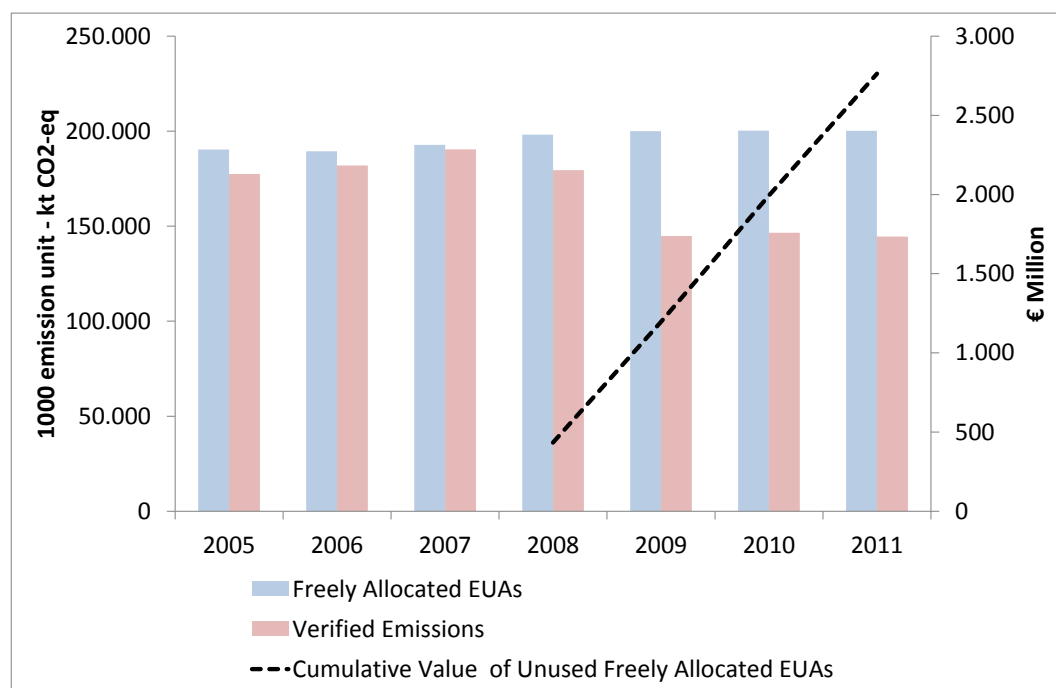
⁷⁴ 'Gross investment in tangible goods is defined as investment during the reference period in all tangible goods. Included are new and existing tangible capital goods, whether bought from third parties or produced for own use (i.e. Capitalised production of tangible capital goods), having a useful life of more than one year including non-produced tangible goods such as land. Investments in intangible and financial assets are excluded' (Eurostat, 2013).

⁷⁵ Consumption estimated by adding production data from USGS (2013) with import data from UN COMTRADE (2013) and subtracting the total from export data from UN COMTRADE (2013).

5.4.2 Compliance costs in relation to EU ETS

Figure 5.7 shows the direct carbon emissions resulting from the manufacture of cement, clinker or lime between 2005 and 2011. It is evident that for every year under the EU ETS, the verified emissions have been lower than the annual allocation of free EUAs. As a consequence the cement, clinker and lime producers participating in the EU ETS from 2008 onwards have received free EUAs beyond their verified emissions that are equivalent to a value of €2.8 billion.⁷⁶ Whether the profits from selling these EUAs were used to invest into abatement technology in order to reduce the specific emissions as claimed by the industry cannot be assessed with the given data. The indirect impacts of the EU ETS are more difficult to determine (i.e. the impact on raw material and electricity costs) as is the impact of the EU ETS on long term investment decisions.

Figure 5.7 Direct costs of EU ETS compliance for the manufacture of cement, clinker or lime in the EU-25



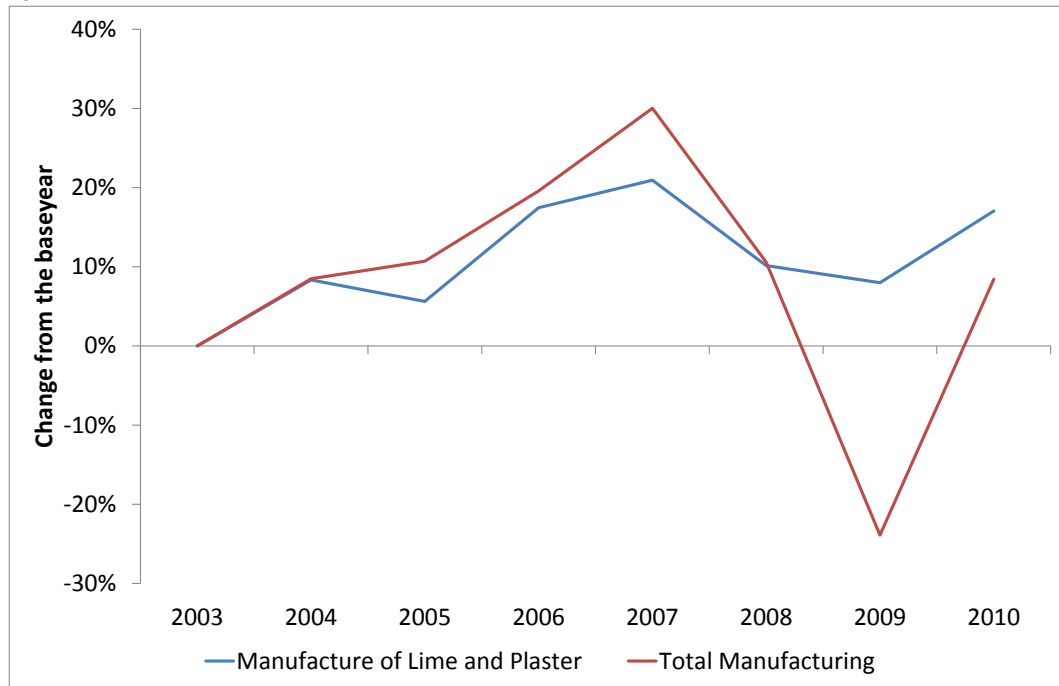
Source: EEA (2013); EEX (2013)

5.4.3 Development of gross operating surplus

Figure 5.8 shows the change in gross operating surplus for the manufacture of lime and plaster and total manufacturing in the EU-25. It is evident that the lime and plaster sector in the EU-25 outperformed manufacturing as a whole in terms of profitability in 2010. Although the manufacture of lime and plaster is associated with higher profitability than the average for manufacturing, lime and plaster production is one of the most capital intensive industries and therefore industry would argue that higher profits are necessary in order to upgrade and maintain processing equipment. However the increase in profits throughout the period as well as being a net exporter suggests that carbon costs could still potentially either be passed through to product prices or absorbed by the profit margin.

⁷⁶ Calculated by multiplying the unused allowances in a year by the average EUA y+1 price for the 2008-12 time period. Direct emissions from limet account for 17 % of the total direct emissions for both the manufacture of cement and lime (average between 2008-11).

Figure 5.8 Change in the gross operating surplus for lime and plaster and total manufacturing in the EU-25⁷⁷

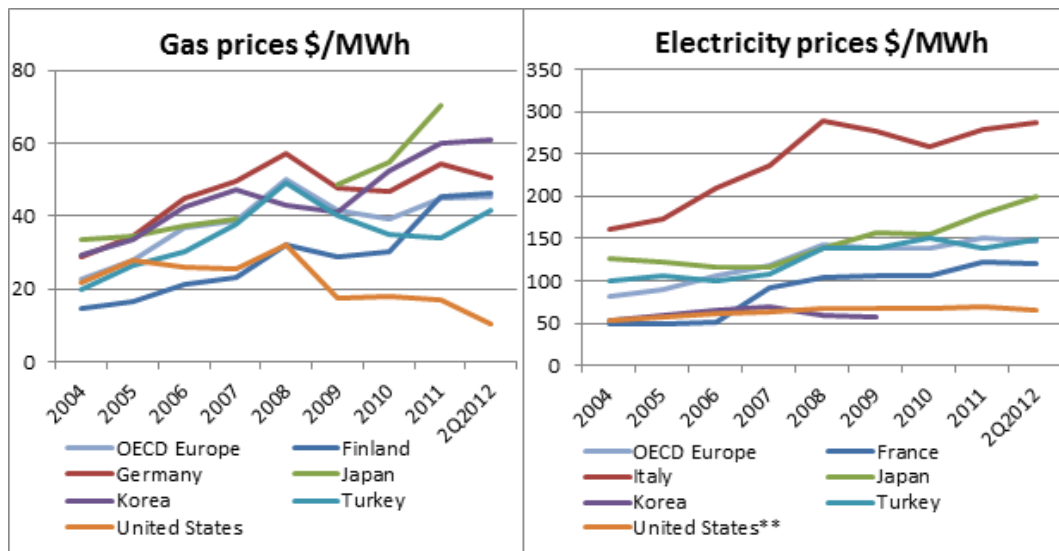


Source: Eurostat (2013)

5.4.4 Development of energy prices

An international comparison of energy products is possible for OECD countries based upon statistics published by the IEA (2012) as shown in Figure 5.9 below.

Figure 5.9 Energy prices for industry in selected world regions / countries, incl. taxes⁷⁸



Source: IEA Energy Prices & Taxes, 4th quarter (2012)

It is evident that the USA may have a competitive advantage. For example, the cost of natural gas for industry in the USA was considerably cheaper in 2011 compared to OECD Europe and other

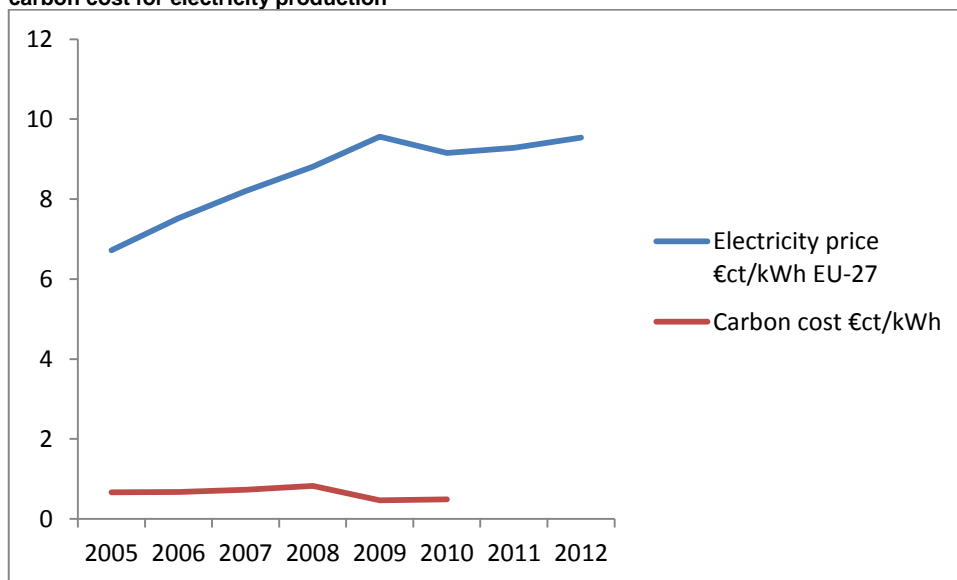
⁷⁷ In absolute terms the gross operating surplus for the lime and plaster sector increased from €625 million in 2000 to €751 million in 2007. Following the economic recession the gross operating sector fell sharply to €639 million in 2009 before recovering to pre-recession levels (Eurostat, 2013)

⁷⁸ Definition: Prices and taxes for the industry sector are the average of amounts paid for the industrial and manufacturing sectors. ** Electricity price data for the US excludes taxes. Note that there are data gaps for Japanese gas price data and Korean electricity price data. OECD Europe comprises Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

countries or regions. Of the countries considered, prices for natural gas were highest in Germany, Korea and Japan. Electricity costs also appear to be lower in the USA than in OECD Europe and other countries and regions, but it has to be noted that US electricity prices are shown without taxes in the graph. Both electricity and gas prices roughly doubled in most countries in the selected period, except for the US. It should be noted though that the dollar lost about 20% of its value against the Euro in the same time frame, so part of the cross-country differences can also be explained by currency fluctuations.

Although the extent to which electricity producers passed through CO₂ costs into electricity prices is uncertain, empirical analyses have shown that the EU ETS has increased electricity prices (Keppler et al., 2010; Fell, 2010; Fell et al., 2013). The order of magnitude compared to other electricity price drivers is low though, as can be seen in the picture below. It should be noted that the energy prices within Europe vary considerably as well.

Figure 5.10 Electricity prices for industrial consumers in the EU-27, excluding taxes; compared to carbon cost for electricity production



Source: Eurostat Energy Statistics, EEX, EEA, IEA.⁷⁹

5.4.5 Development of output prices

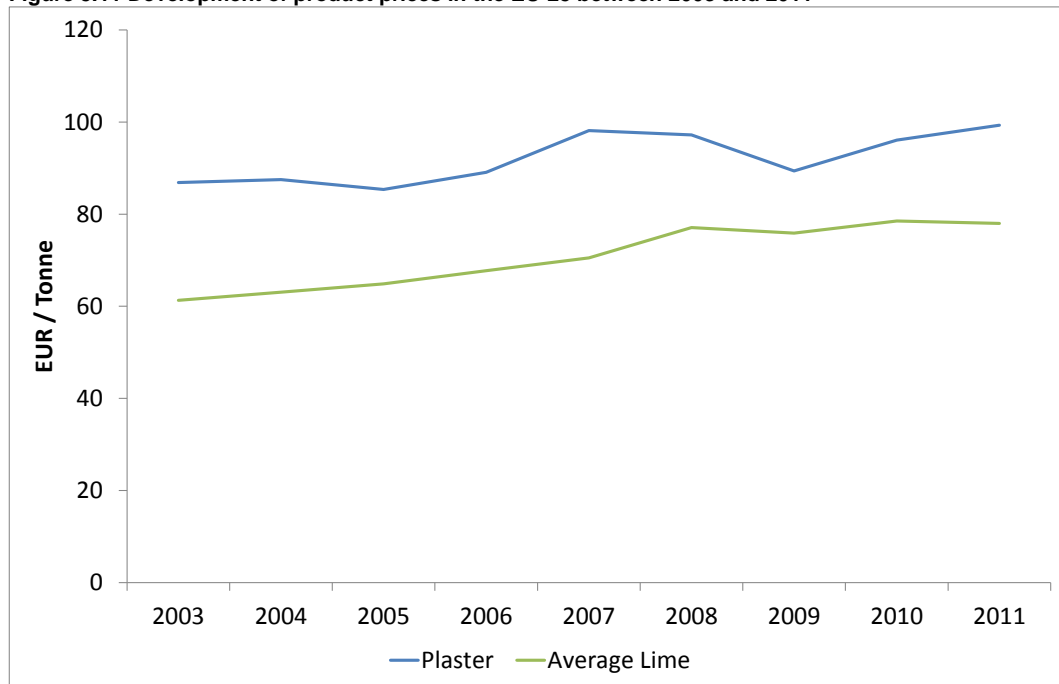
Figure 5.11 shows the development of the average EU-25 lime and plaster prices between 2003 and 2011 based upon a simple calculation using data publically available from Eurostat (2013).⁸⁰ It is evident that the average lime price has steadily increased from €61/ tonne in 2003 to €78/ tonne in 2011.⁸¹ The rate of growth in product prices slowed slightly after 2007 due to the economic recession. This suggests that lime producers have to a certain extent passed on costs to consumers during the time series. Although more volatile, product prices for plaster have also increased between 2003 and 2011 from €87 in 2003 to €99 in 2011.

⁷⁹ Electricity prices shown are the average prices in Euro per kWh without taxes applicable for the first semester of each year for medium size industrial consumers (Consumption Band Ic with annual consumption between 500 and 2000 MWh). Until 2007 the prices are referring to the status on 1st January of each year for medium size consumers (Standard Consumer Ie with annual consumption of 2 000 MWh). Note that prices can be expected to be lower for large size industrial consumers. Carbon cost is calculated by taking data from IEA on carbon emissions per kWh of electricity in OECD Europe; this quite precisely coincides with EU-27 data from the EEA, but has less data gaps. These values are multiplied by the EU allowance unit forward price (ETS emission forward price, used here because it is more stable than the spot price).

⁸⁰ Average lime and plaster price calculated by dividing production value by production quantity from the PRODCOM SOLD database. Average Lime consists of Quicklime, Slaked lime and Hydraulic lime.

⁸¹ A similar calculation in the NERA (2008) study estimates that the average price of lime in 2006 was €69/ tonne in 2006

Figure 5.11 Development of product prices in the EU-25 between 2003 and 2011



Source: Eurostat (2013)

Lime and plaster are characterised by having inelastic demand and an oligopolistic market structure – this suggests that pass-through rates are relatively high, and thus more able to pass costs into prices and maintain profit levels. This is especially the case for inland producers that are less vulnerable to competition due to high inland transportation costs⁸². For example, EuLA members have provided estimates of the costs of road transport ranging from €5 to €15 per tonne depending upon the distance lime is transported as well as other characteristics (NERA, 2008). In terms of rail transport costs EuLA lime members report the costs ranging from €15 to €20 per tonne for routes in excess of 500 km (NERA, 2008). Competition may be more of an issue for coastal producers as imports tend to set prices in coastal locations.⁸³ The role of geography is therefore an important consideration in the discussion on cost pass through in these sectors.

⁸² The cost of transporting lime is high relative to other production costs and relative to its overall value. Lime can be transported by three modes: road, rail and sea. Lime is typically transported by road over distances less than 300 km, although this varies by region, and in some regions the distances may be significantly greater. Transporting lime into the EU by rail is limited by the constraints imposed by the rail infrastructure between EU and non-EU countries (NERA, 2008).

⁸³ According to data collected from EuLA members the cost of sea transport in 2006 ranged from €12 to €20 for short distance routes (i.e. 500 to 1000 km), €23 to €26 for medium distance routes (i.e. 3,500 to 7,500 km) and €33 to €45 for long distance routes (i.e. greater than 7,500 km) (NERA, 2008). It is important to acknowledge that shipping transport costs have been volatile over the time period 2000 to 2012 and experienced a considerable downturn due to the recession.

5.5 Synthesis

Using all of the evidence from the previous sections, Table 5.7 and Table 5.8 provide a short overview of whether there has been evidence of carbon leakage due to the EU ETS.

Table 5.7 Evidence for (production) relocation

Indicator for (production) relocation	Trend	Additional information on trend
Net imports	EU-27 is a net exporter for lime and gypsum	Both lime and gypsum are to a very high extent consumed domestically. They are important inputs to other industries (construction, steel, agriculture) and domestic demand thus depends largely on the demand of those sectors.
Investment activity in EU compared to outside EU	Decrease in relative investment	China has built up significant production capacity in recent years to meet Chinese demand.
ETS installations	Slight increase in the number of lime installations	
Summary: evidence for (production) relocation	EU-27 is a net exporter and production goes along with domestic consumption. No evidence for a shift in production due to carbon cost.	

Table 5.8 Drivers for (production) relocation

Drivers for (production) relocation	Assessment	Justification of assessment
Carbon cost	The carbon cost does not appear to be the driving factor in any shift in production	Direct carbon costs have been high for lime production but free allocation has exceeded emissions.
Other costs: fossil fuels	Important	Natural gas prices have increased over time and been higher in the EU than in most other regions.
Pass through of costs	Should be possible due to domestic character of the market	Very low level of international competition
World demand	Important	EU demand has slightly decreased, while demand from China has increased
Summary: CO ₂ cost among the relevant drivers?	Over the 2005 to 2012 period CO ₂ cost is not among the relevant drivers	The main driver appears to be shift of world demand as cement and gypsum are predominantly produced and consumed domestically.

5.6 References

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6 Non Ferrous Metals

6.1 Scope and current leakage list position

Non Ferrous Metal (NFM) production is classified under the following NACE codes (Table 6.1).

Table 6.1 NACE classification of the NFM sector

NACE Rev 1.1. Classification	NACE Rev 2 Classification
27.41 Precious metals production	24.41
27.42 Aluminium production	24.42
27.43 Lead, zinc and tin production	24.43
27.44 Copper production	24.44
27.45 Other non-ferrous metal production	24.45

Source: Eurostat (2008)

'The NFM industry incorporates a range of productive activities along various stages of the value chain including mining, smelting recycling and refinery upstream and second processing and fabrication of intermediaries further downstream' (Ecorys, 2011). The various sub-sectors that make up the NFM industry include primarily:

- Base metals (aluminium, copper, zinc, lead, nickel, tin).
- Precious metals (silver, gold, palladium, other platinum group metals).
- Minor metals including refractory metals (e.g. tungsten, molybdenum, tantalum, niobium, chromium) and specialty metals (e.g. cobalt, germanium, indium, tellurium, antimony, gallium).

NFM are non-magnetic and are typically more resistant to corrosion than ferrous metals; many NFM conduct electricity well. Given these and various more specific characteristics of individual NFM, they are a strategic input for a wide variety of products and sectors, ranging from chemical processing, catalytic processes and engineering to transport equipment, automotive, electronics, packaging, construction and many more (Ecorys, 2011). In the current leakage list, NFM production is defined as being at a significant risk of carbon leakage for reasons of both induced carbon costs and trade intensity (Table 6.2).

Table 6.2 Status in current leakage list, values for carbon cost and trade intensity

NACE Code	Direct Cost	Indirect Cost	Total Cost	Trade Intensity
27.41	<5 %	< 5 %	< 5 %	73.9 %
27.42	1.7 %	10.3 %	14 %	35.9 %
27.43	1.3 %	6 %	7.4 %	26.8 %
27.44	2.1 %	3.4 %	5.5 %	34.6 %
27.45	<5 %	2 %	>5 % and <30 %	73.8 %

Source: COM (2009)

The number of installations of the non-ferrous metal sector that participate in the EU ETS is shown in Table 6.3. The number of installations of the sector covered by the EU ETS is significantly higher in the third trading period starting in 2013 as new gases and activities are covered.

Table 6.3 Number of installation of the non-ferrous metals sector participating in the EU-ETS

	Installations participating since 2005	Thereof: New installations during 2005-2012	Thereof: Closed installation during 2005-2012	New installations from 2013 on (scope extension)
Aluminium	25 ⁸⁴	2	4 ⁸⁵	52
Lead, zinc and tin	10 ⁸⁶	2	1	12
Copper	8 ⁸⁷	2	2	13

Based upon information from the EUTL database.

6.2 Characteristics of sector

6.2.1 Overview

The NFM industry plays an important role in adding value and creating jobs within a long value chain. Important characteristics of the NFM industry for the year 2010 include:

- Turnover: €99.9 billion (Eurostat, 2013)
- Added value: €16 billion (Eurostat, 2013)
- Number of companies: 3,477 / Employees: 156,480 (Eurostat, 2013)
- Global output of primary refined base NFM in 2009: about 76 million tonnes.
- Aluminium, copper and zinc represent more than 85% of annual global NFM production (Ecorys, 2011).
- Key characteristics for the main subsectors (aluminium, copper and zinc) described below.

The structure of the industry varies by metal. No company produces all, or even a majority of, non-ferrous metals. However, there are a few pan European companies producing several metals, e.g. copper, lead, zinc, cadmium etc. (Ecorys, 2011). The capital-intensive nature of metals refining is reflected in the greater importance of large firms in the NFM sector than in manufacturing as a whole. Even so, the NFM sector has many small firms. The NFM sector in the EU is mostly made up of micro and small enterprises, with 56% of the enterprises operating in this sector having fewer than ten employees and around 25% having between ten and 49 employees' (Ecorys, 2011). As can be seen in Table 6.4, the share of EU-27 production in global production also varies by metal, though, with the exception of Nickel production it ranges from 10 to 16%. The share of EU-27 use in global use is around 15% for all metals.

Table 6.4 EU-27 Shares of Global Use and Production of Refined Base NFM, 2009

	Global share (%) of	
	Use	Production
Aluminium	15	10
Copper	17	15
Lead	16	13
Nickel	18	6
Zinc	14	16

Source: Ecorys (2011)

⁸⁴ thereof 4 located in Bulgaria/Romania participating since 2007

⁸⁵ thereof 3 with applications for free allocation from 2013 on

⁸⁶ thereof 2 located in Bulgaria participating since 2007

⁸⁷ thereof 3 located in Bulgaria/Romania participating since 2007

6.2.2 Production processes

Each of the processes and value chains of the non-ferrous metals studied here has their peculiarities; however, in general, all share the following general characteristics (Ecorys, 2011):

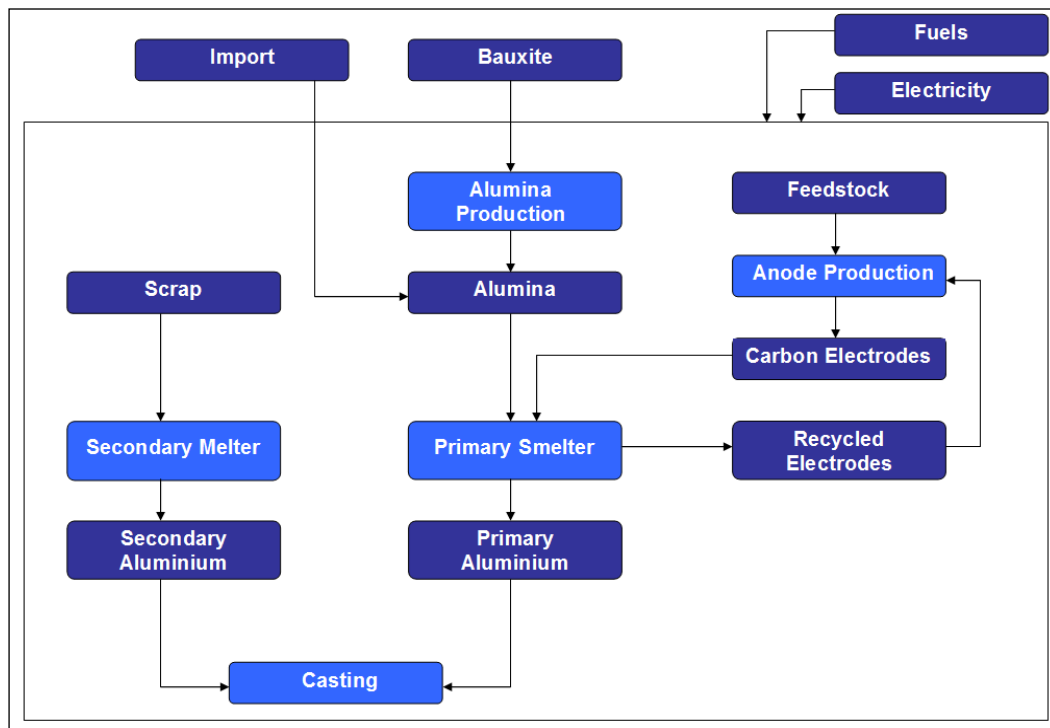
- “The mining and beneficiation of ore into concentrates or intermediate raw materials for refining;
- The refining of the latter and/or refining of scrap into unwrought metal (unalloyed or alloyed);
- The processing of unwrought metal into semi-manufactured products (plate, sheet, strip, foil, bar, rod, profile, tube), or processing into pure chemical compounds for use by the manufacturing industry.” (Ecorys, 2011)

Non-ferrous metals can be produced via a primary or a secondary production route. Primary metal production is based on a variety of primary raw materials that are derived from ores that are mined and then further treated before they are metallurgically processed to produce crude metal. The treatment of ores is carried out close to the mines as, increasingly, is metal production. Secondary metal production is based on scrap and residues. “Process scrap and residues, and old scrap from end-of-life products, enter the value chain at the refining and processing stages. This is a source of significant energy and resource savings, environmental benefits and increased competitiveness.” (Ecorys, 2011)

6.2.3 Aluminium

A simplified illustration of the production processes of aluminium (primary, secondary) along with the initial extraction of bauxite and the production of anodes is provided in Figure 6.1.

Figure 6.1 A simplified flow chart of the aluminium production process



Source: Healy, Schumacher (2011)

Following the extraction of bauxite, which is considered to be a process outside of the system boundary in aluminium production, the raw material is converted to alumina via the Bayer process. The Bayer process is very energy intensive consuming on average 13% and 85% of total electricity

and fuel use for the production of primary aluminium respectively (Table 6.5). Subsequently, the Hall-Heroult process is used to electrolytically reduce the alumina product to aluminium in a primary smelter (aluminium smelting). The Hall-Heroult process is electricity intensive and accounts for the majority of electricity consumption in the production of primary aluminium (Table 6.5).

Table 6.5 World best practice final energy intensity values for aluminium production (values are per metric tonne aluminium)

Process	Input	Primary Aluminium	Secondary Aluminium
Alumina Production	Fuel [Digesting]	12.1 GJ / t	
	Fuel [Calcining Kiln]	6.5 GJ / t	
	Electricity	1.4 GJ / t	
Anode Manufacture	Fuel	GJ / t	
	Electricity	0.2 GJ / t	
Aluminium Smelting	Electricity	49.0 GJ / t	
Ingot Casting	Electricity	0.4 GJ / t	
Total		70.6 GJ / t	2.5 GJ / t

Source: Worrell et al (2007)

The production of secondary aluminium relies upon the use of recycled aluminium scrap that is either generated at the smelter and fabrication plants (i.e. new scrap) or collected post consumption (i.e. old scrap). Depending upon the source of the scrap material it may be necessary to pre-treat the metal (i.e. sorting, shredding and cleaning) in order to promote more efficient melting in the smelting and refining steps of the process (Figure 6.1). Secondary smelting of aluminium using scrap only requires about 5% of the energy of primary smelting due to the relatively low melting temperature of 700-800 °C, the exact energy consumption depending on the type and quality of scrap and the process.

World aluminium production is concentrated in certain parts of the globe and within a small number of different producers. From 2007 to 2009 China, the EU and the US were collectively responsible for just over half of global primary and secondary production. In terms of producers, in 2009 the seven largest companies (with head offices in Russia, Canada, US, China, Norway, UK-Australia, Dubai) accounted for half of total global production of primary aluminium (Ecorys, 2011).

With respect to secondary aluminium production, the US and the EU were the largest secondary producers up to 2009. Secondary production in China has picked up in recent years and has reached US and EU levels in 2009 (Healy, Schumacher 2011).

6.2.4 Refined Copper

'Refined copper is produced from primary and secondary raw materials, including copper concentrates, blister, anodes, scrap. Copper refineries produce copper cathode from raw materials which is melted, alloyed and further processed to produce rods, profiles, wires, sheets, strips, tubes, etc. As copper mining and thus primary copper resources are rare in the EU, a large share of the raw materials is purchased on competitive international markets' (European Commission, 2001).

Primary copper cathodes production can be done either pyrometallurgically or hydrometallurgically. The traditional process is based on roasting, smelting in reverberatory furnaces (or electric furnaces for more complex ores), producing matte (copper-iron sulfide), and converting for production of blister copper, which is further refined to cathode copper. This route for production of cathode

copper requires large amounts of energy per ton of copper: 14-20 GJ per ton cathode copper (European Commission, 2001).

Secondary copper is produced through the same process, but using scrap as feed material. The process is substantially less energy-intensive compared to primary production (ca. 80% lower according to experts from the European Copper Institute). Recovery of copper metal and alloys from copper-bearing scrap metal and smelting residues requires preparation of the scrap (i.e., removal of insulation) prior to feeding into the process (World Bank Group, 1998). In the hydrometallurgical process, the ore is leached with ammonia or sulfuric acid to extract the copper. These processes can operate at atmospheric pressure or as pressure leach circuits. Copper is recovered from solution by electrowinning, a process similar to electrolytic refining. Recycling constitutes an important component of the raw material supplies to the copper refining and manufacturing facilities and holds a large share in the EU (European Commissions, 2001).

Around half of global refined copper is produced by only 11 companies, the three largest of which account for just over a quarter of global refined copper production (Ecorys, 2011). Production in the EU-27 accounted for about 15% in global production in 2009 (compare Table 6.4).

6.2.5 Zinc

'Zinc is produced from a range of zinc concentrates. Some concentrates contain high proportions of lead and these metals are also recovered. Zinc is also associated with cadmium and the concentrates are a source of this metal' (European Commission, 2001). 'Zinc is processed through either of two primary processing methods, electrolytic or pyrometallurgical. However, before either method, zinc concentrate is roasted to remove the sulfur from the concentrate and produce impure zinc oxide referred to as roasted concentrate or calcine' (BSC, 2002). 'In electrolytic zinc processing, calcine is digested with sulfuric acid to form a zinc sulfate solution, from which zinc is deposited through electrolytic refining' (BSC, 2002). Today over 90% of zinc is produced hydrometallurgically in electrolytic plants (International Zinc Association, 2013). Alternatively zinc is smelted in blast furnaces through the Imperial Smelting Furnace (ISF) process, which is capable of recovering both zinc and lead from mixed zinc-lead concentrates.

In 2009, the EU-27 accounted for 16% of global zinc production (compare Table 6.4). 'In 2010, thirteen zinc smelters were in operation in Europe, five of which were located in recent accession EU Member States' (Ecorys, 2011). No new smelters were built in the EU over the last two decades while large size new smelters are reported to be under construction in China (Ecorys, 2011).

6.2.6 Cost structure

Table 6.6 provides data on the structure of conversion costs for the basic NFM subsectors. Raw material costs⁸⁸ are not included even though they represent a high share of the total production cost. This is due to the fact that raw material prices are set on global markets and are therefore not a source of competitive advantage or disadvantage. Energy costs account for the majority of the conversion cost in the production of primary aluminium (i.e. 68.6 %), far greater than for secondary aluminium production. The range in energy costs for copper production also reflects the differences between primary and secondary production routes (Ecorys, 2011).

⁸⁸ Raw material costs can range from 49% to 85% of total production costs. The EU is not heavily endowed with the necessary ores for NFM production. Use of these ores in the EU exceeds domestic production and so the EU is heavily reliant on imported raw materials.

Table 6.6 Cost structure for Non-Ferrous Metals

	Cost category			
	Energy Costs (%)	Labour Costs (%)	Other Costs (%)	Capital Costs (%)
Aluminium Primary	68.6	19.6	11.8	
Aluminium Secondary	22	78		
Copper	25-34	23-36	15-21	20-27
Zinc	36	24	27	13
Lead	18	27	41	14
Nickel	19	30	7	44

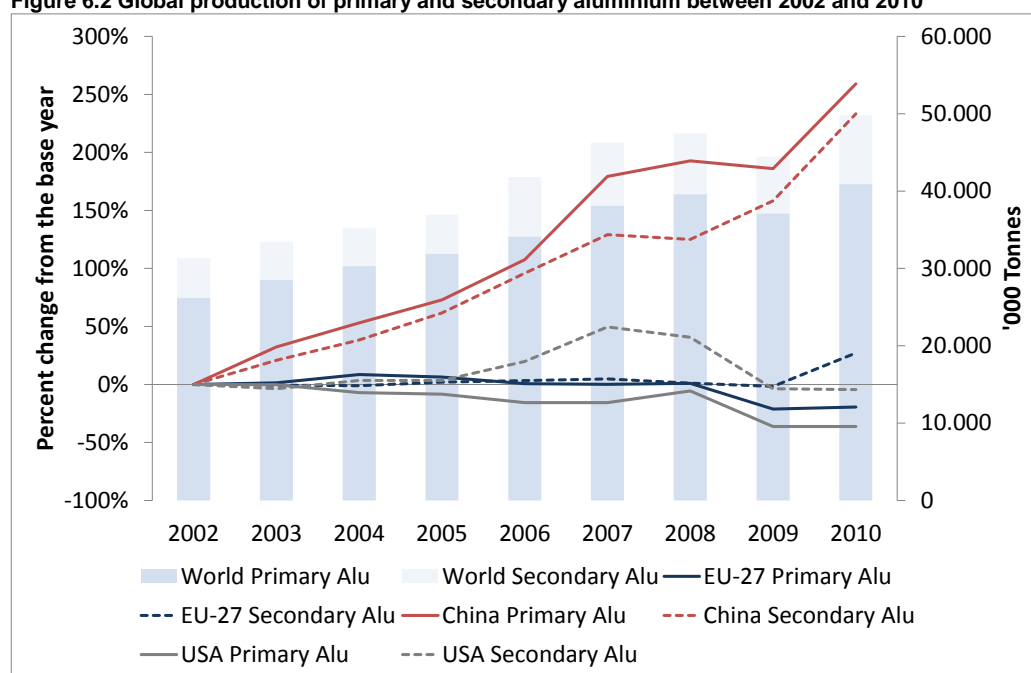
Source: Ecorys (2011)

6.3 Evidence of production shift / relocation

6.3.1 Aluminium

Global primary aluminium production has increased from 26.2 Mt in 2002 to 40.9 Mt in 2010, which represents an increase of 56 % from annual production levels in 2002. It is evident that the economic recession contributed to a decline in production in 2009, however the abrupt fall in production in 2009 has been followed by a return to growth in 2010⁸⁹. Figure 6.2 illustrates that China's production of primary aluminium has increased substantially from 4.5 Mt in 2002 to 16.2 Mt in 2010⁹⁰ accounting for 40 % of the world's total production. In contrast, the EU-27 and the USA have not experienced any growth throughout the 2002 to 2010 period with the economic recession leading to a decline in production. This has seen their share of total primary aluminium decline to 6 % and 4 % respectively.⁹¹

Figure 6.2 Global production of primary and secondary aluminium between 2002 and 2010



Source: USGS (2013)

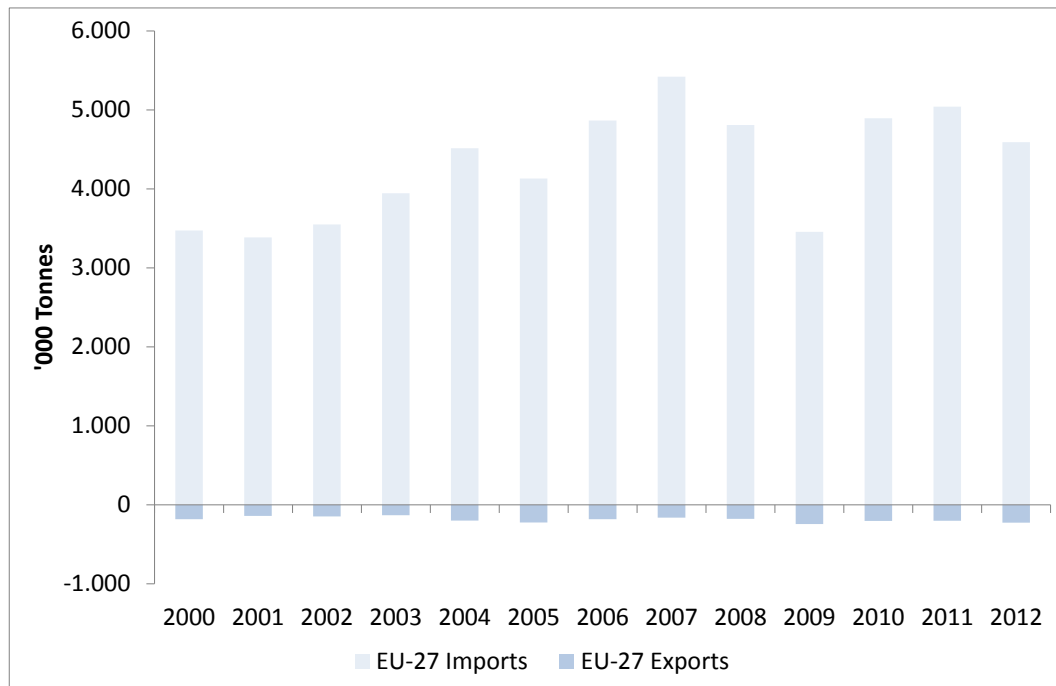
⁸⁹ World Aluminium (2013) report that global production of primary aluminium has increased to 45.2 mt in 2012

⁹⁰ World Aluminium (2013) report that Chinese production of primary aluminium has increased to 19.8 mt in 2012

⁹¹ The production of primary aluminium in Norway declined from 1.1 Mt in 2002 to 0.8 Mt in 2010. Therefore primary aluminium production has declined during the time period for the combined production of the EU27 and Norway.

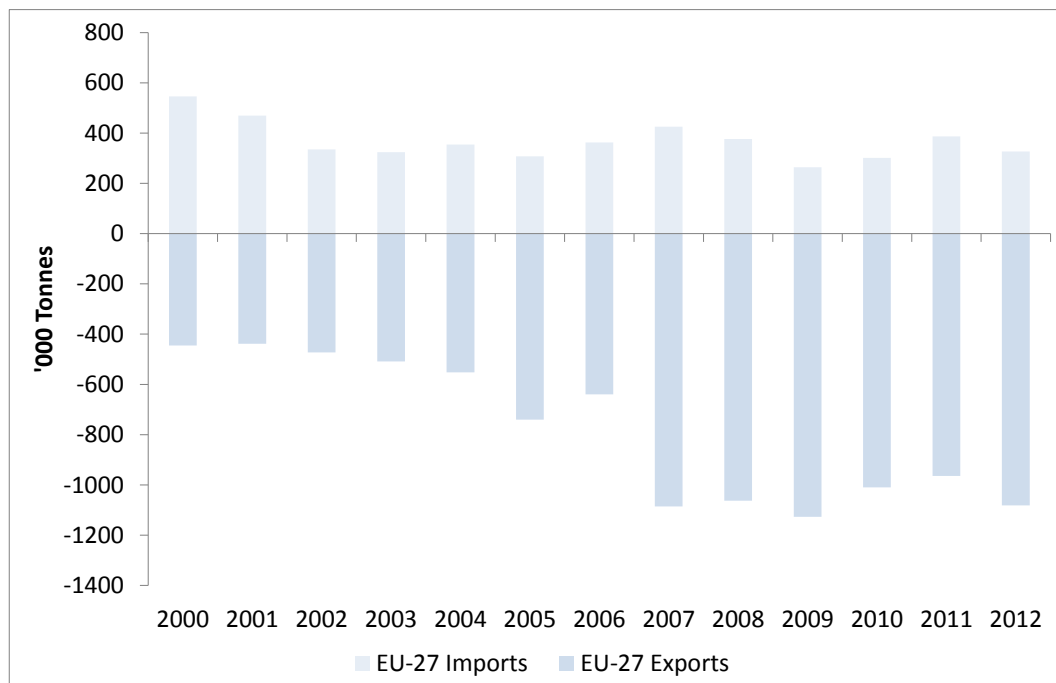
Given the competitive advantage of certain third countries that benefit from low energy costs and given the fact that transport costs are relatively low⁹², the EU-27 is increasingly importing primary aluminium products from these regions (i.e. Figure 6.3 shows that the EU-27 is a net importer of unwrought aluminium).

Figure 6.3 Trade balance in unwrought aluminium for the EU-27 between 2000 and 2012



Source: COMTRADE (2013)

Figure 6.4 Trade balance in waste scrap aluminium for the EU-27 between 2000 and 2012



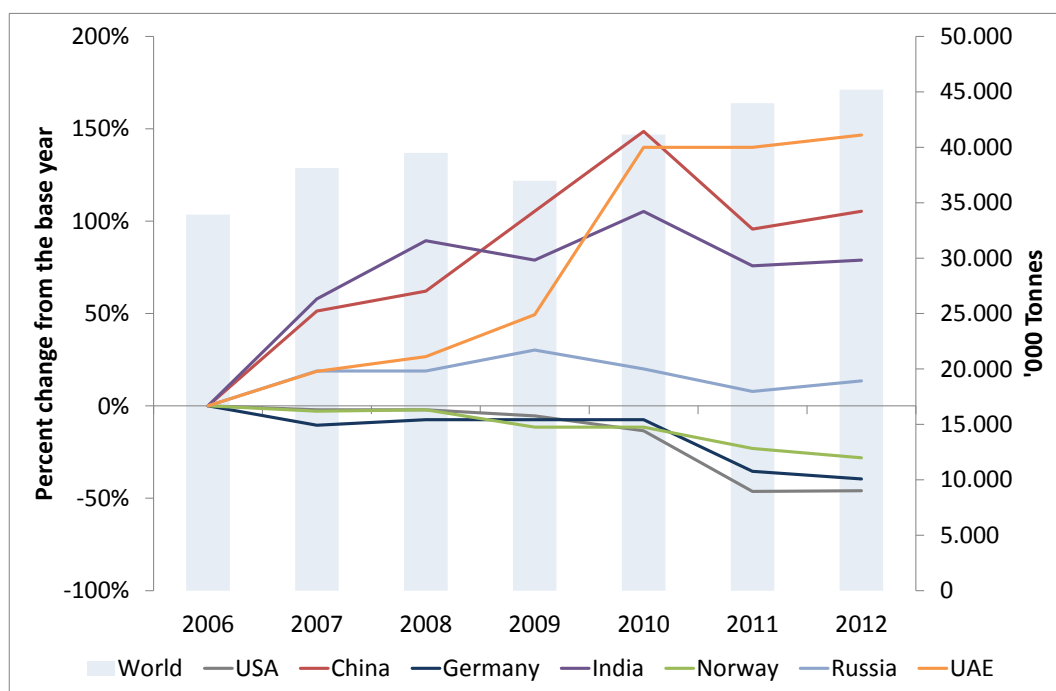
Source: COMTRADE (2013)

⁹² Eurometaux estimate those to be at around 2%.

The EU-27 has improved the capacity to recycle aluminium and is now considered one of the most advanced regions for recycling in the world and in 2010 accounted for 35 % of total secondary aluminium production (USGS, 2013). However, despite the high recycling rate and demand for aluminium scrap in the EU-27, Figure 6.4 shows that the region continues to export aluminium scrap, most is exported to China. The price of aluminium scrap has increased in response to the high demand from China and the export restriction on raw materials by supplying countries (i.e. Russia) incentivising the export of aluminium scrap from the EU27 to China (Ecorys, 2011).

Figure 6.5 illustrates the rate of increase in world capacity in aluminium production between 2006 and 2012. It is evident that the majority of investments in new capacity have taken place in China, UAE and India, whereas capacity levels have declined in both Germany and the USA over the same time period (USGS, 2013).⁹³ Data provided by the sector association Eurometaux shows that capacity in the EU-27 during the period only declined by 6%, probably driven by a plant closure in Germany.

Figure 6.5 World capacity trends in primary aluminium production between 2006 and 2012



Source: USGS (2013)

6.3.2 Copper

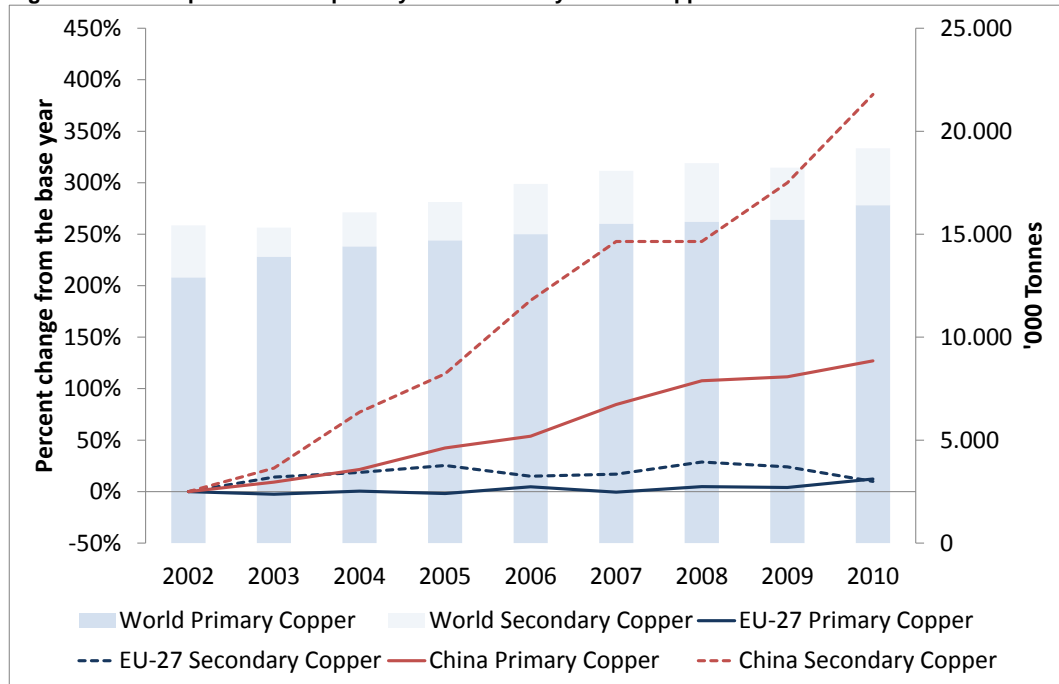
Total global refined copper production increased by 24 % between 2002 and 2010.⁹⁴ In 2010, the EU-27 produced 2.6 Mt of refined copper⁹⁵, around 12 % higher than levels in 2002 (Figure 6.6). In 2010, the EU-27 accounted for 14 % of global total refined copper production. Figure 6.7 shows that the EU-27 remained a net importer of refined copper in 2010, however the level of imports have declined from 2000 levels while exports have increased.

⁹³ Investment in aluminium refining is flowing to locations that can offer long-term energy contracts (from hydrocarbon and other, non-hydrocarbon power sources). In this context, isolated power (without transmission links) generation facilities are attractive because they provide a dedicated power source. The policy emphasis in the Middle East to diversify economic activity by attracting energy-intensive industrial activity is a related driver' (Ecorys, 2011).

⁹⁴ In absolute terms, global production of refined copper increased from 15.4 Mt in 2002 to 19.2 Mt in 2010 (USGS, 2013)

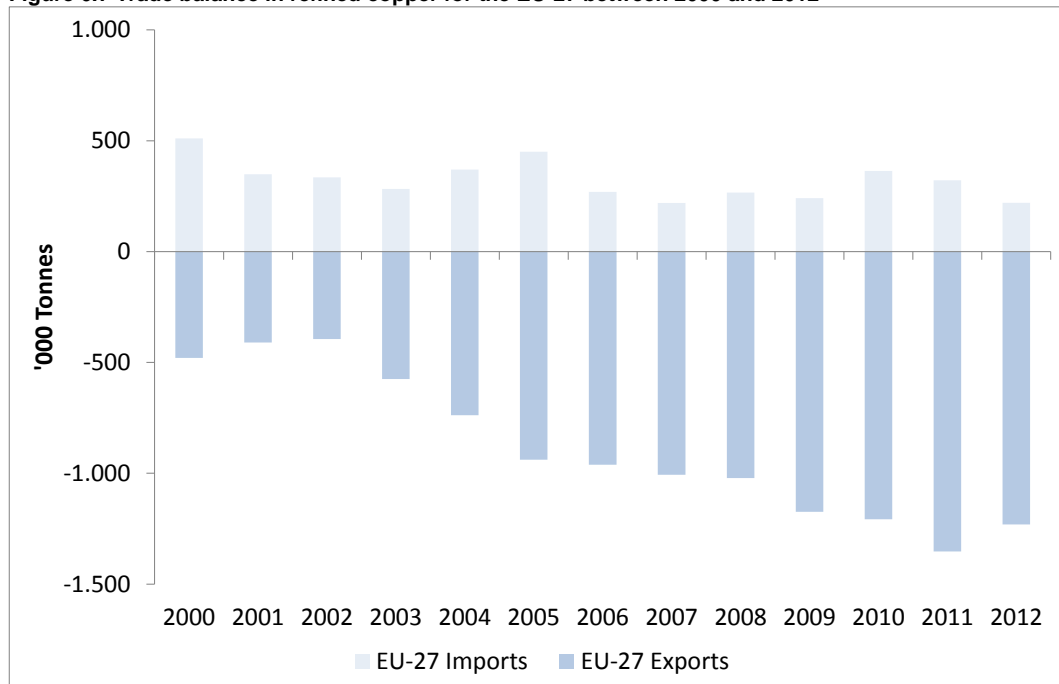
⁹⁵ Primary refined copper accounted for 81 % of total refined copper production in the EU-27 in 2010 (USGS, 2013)

Figure 6.6 Global production of primary and secondary refined copper



Source: USGS (2013)

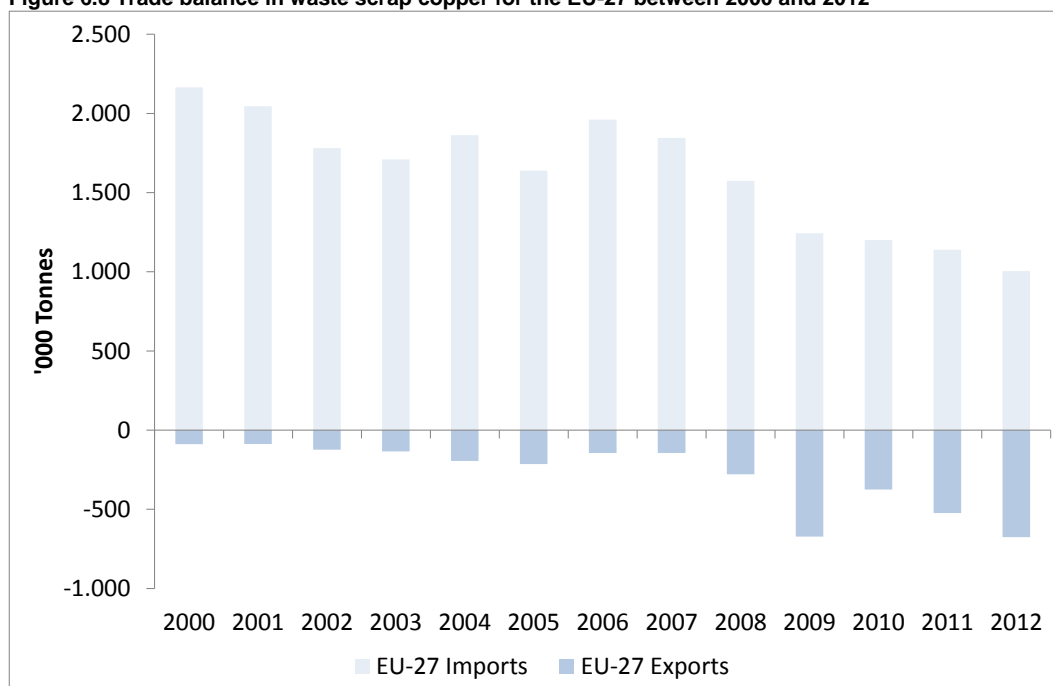
Figure 6.7 Trade balance in refined copper for the EU-27 between 2000 and 2012



Source: COMTRADE (2013)

China has experienced considerable growth in the production of refined copper (see Figure 6.6) between 2002 and 2010 and has resulted in the country acquiring a 24 % share of total production in 2010 (USGS, 2013). Interestingly the country has increased its production of secondary refined copper at a faster rate than primary refined copper and depends upon the import of scrap metal from the EU-27 and the USA in particular to meet their demand. Figure 6.8 shows that the EU-27 export of scrap copper has increased significantly between 2000 and 2012, with demand from China a key driver in this trade pattern.

Figure 6.8 Trade balance in waste scrap copper for the EU-27 between 2000 and 2012



Source: COMTRADE (2013)

Table 6.7 provides an overview of the main global investments in refined copper production capacity that occurred in 2009. It is evident that new capacity of more energy intensive processes is locating outside of the EU-27. However, companies continue to invest in Europe especially with regards to secondary production routes. For example, ‘in 2008/2009 Aurubis invested mainly in two copper projects in the EU. Aurubis is investing some EUR 90 million to 2011 on the installation of a second furnace plant and modifications to its recycling system at its recycling plant in Lunen, Germany. This will allow the processing of complex materials to be substantially increased. The other project was in its smelter plant in Pirdop, Bulgaria, which targets markets in south-east Europe’ (Ecorys, 2011).

Table 6.7 2009 Investments in global capacity to produce refined copper

Location	Process	Capacity
Congo (Kinshasa)	Electrowinning	150 000 t/yr
Chile	Electrowinning	115 000 t/yr
Zambia	Electrowinning	50 000 t/yr
China	Electrolytic	340 000 t/yr
Zambia	Electrolytic	110 000 t/yr

Source: USGS (2009)

6.3.3 Zinc

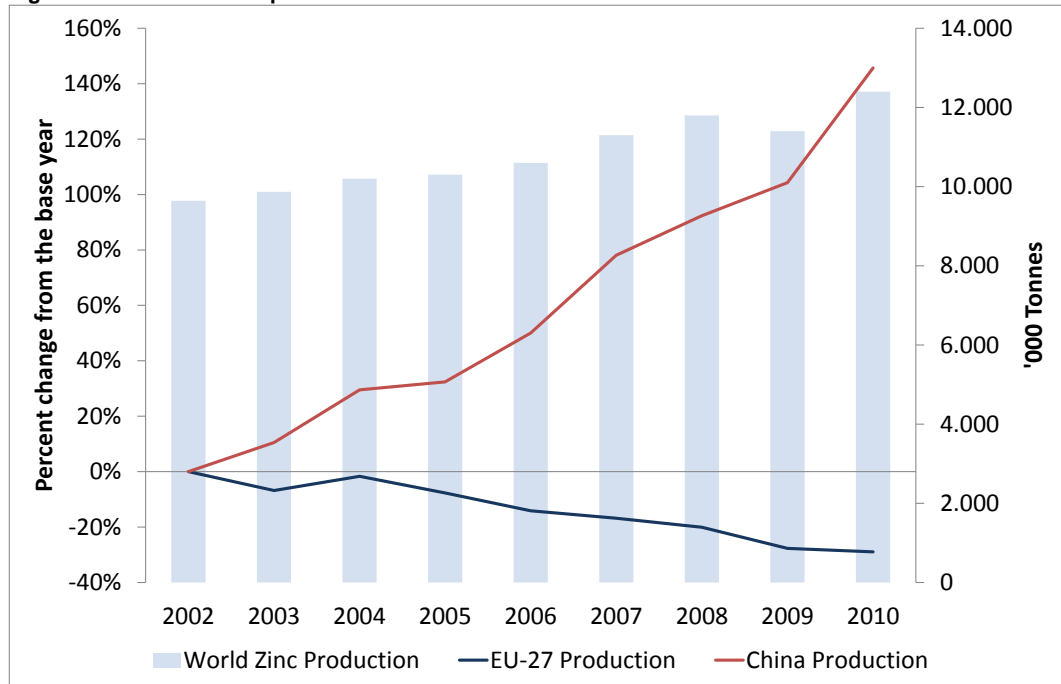
China and the EU-27 account for more than half of global zinc production in 2010. Zinc production in China accounts for 42 % of total production.⁹⁶ In comparison the EU-27 has a 14 % share of the global zinc market in 2010 (Figure 6.9).⁹⁷ In relative terms production of zinc in the EU-27 has declined compared to 2002 levels, whilst China has experienced significant growth since 2002. The

⁹⁶ In absolute terms, in 2010 China produced 5.2 Mt of Zinc (USGS, 2013)

⁹⁷ In absolute terms, in 2010 the EU-27 produced 1.8 Mt of Zinc (USGS, 2013)

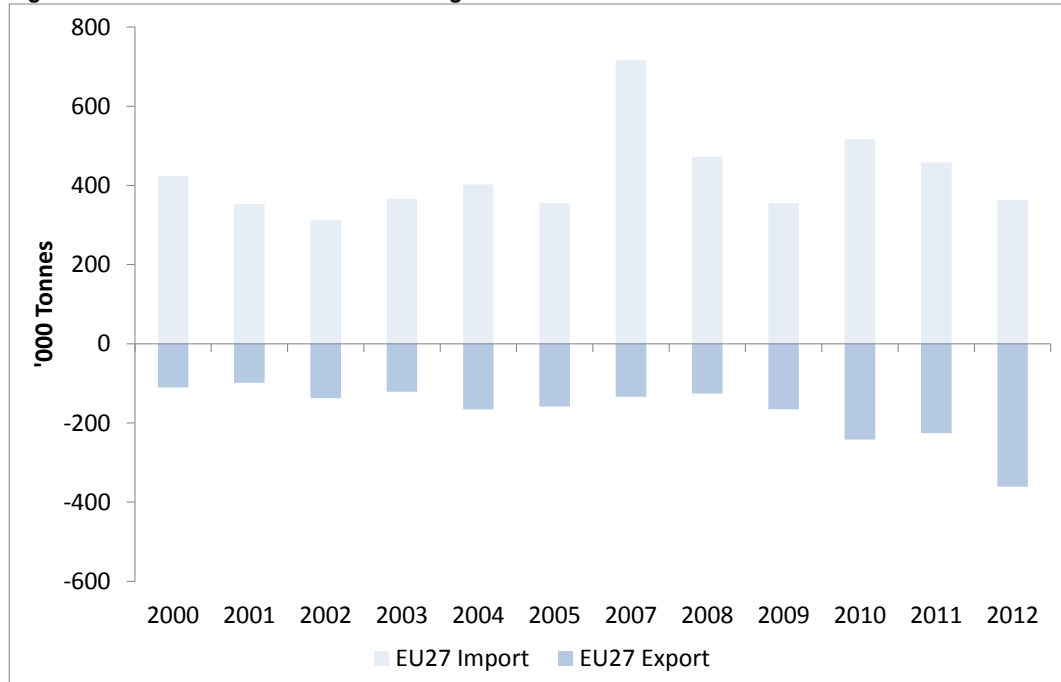
EU-27 is a net importer of unwrought zinc, with the majority of the zinc produced consumed internally (Figure 6.10). The EU-27 is also a net exporter of scrap metal zinc (Figure 6.11).

Figure 6.9 Global production of zinc between 2002 and 2010



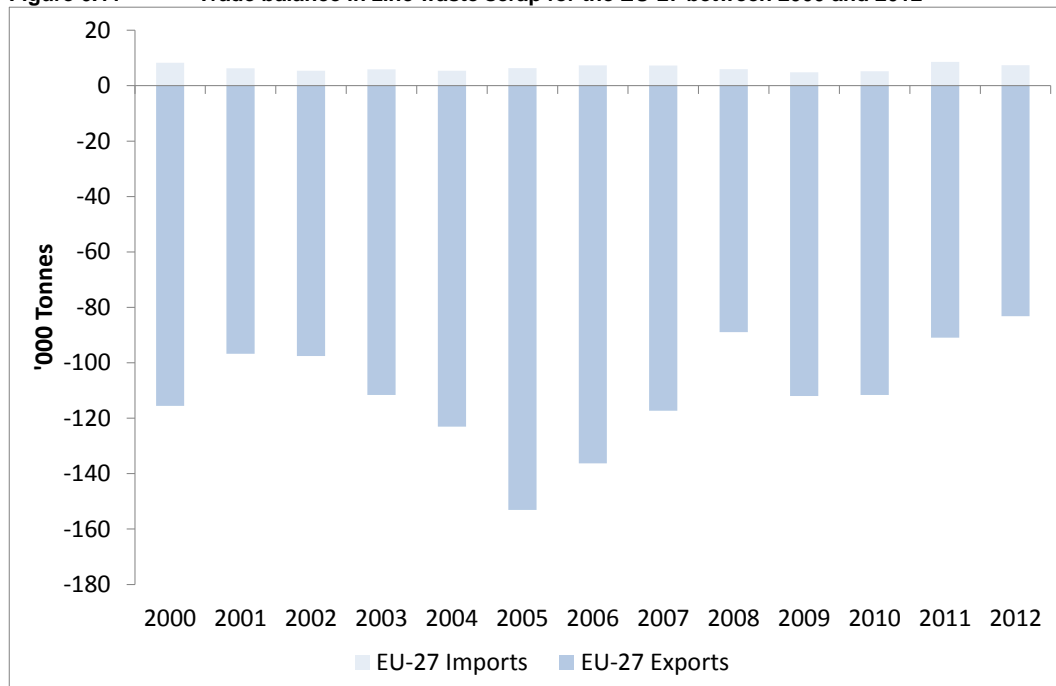
Source: USGS (2013)

Figure 6.10 Trade balance in unwrought zinc for the EU-27 between 2000 and 2012



Source: COMTRADE (2013)

Figure 6.11 Trade balance in zinc waste scrap for the EU-27 between 2000 and 2012



Source: COMTRADE (2013)

Table 6.8 provides an overview of the main global investments in zinc production capacity that occurred in 2011. According to the USGS (2011) ‘zinc smelter production capacity increased by 370,000 t/yr in 2011, of which, 350,000 t/yr was in China. Xstrata increased production capacity by 20,000 t/yr at the Nordenham smelter in Germany.’

Table 6.8 2011 Investments in global capacity to produce zinc

Location	Process	Capacity
China	Smelter production capacity increase	350 000 t/yr
Germany	Smelter production capacity increase	20 000 t/yr

Source: USGS (2011)

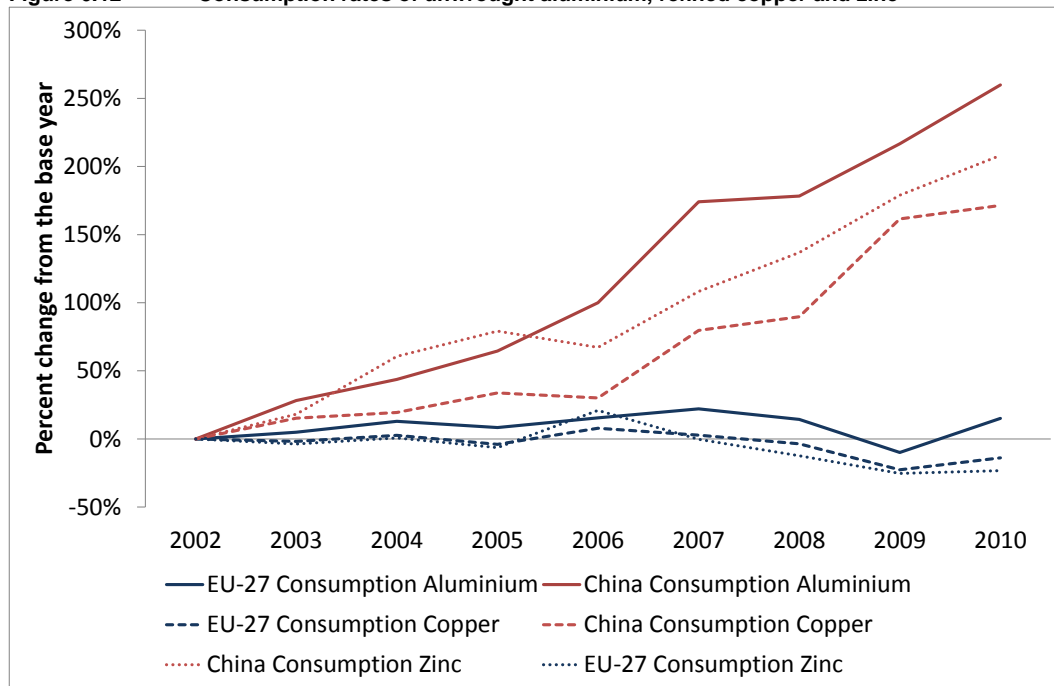
6.4 Drivers for relocation

6.4.1 Development of demand

Figure 6.12 shows the rapid growth in the consumption⁹⁸ of unwrought aluminium, refined copper and unwrought zinc in China compared to the lower growth and in some cases the decline in consumption of unwrought aluminium, refined copper and unwrought zinc in the EU-27. In China, the consumption of aluminium has increased by 260 % compared to levels in 2002. Zinc and copper have increased by 201 % and 171 % respectively over the same time period (Figure 6.12). It is to be expected that levels of consumption in the EU-27 will experience less growth than in China as the NFM market is more established. The slower economic growth in the EU-27 compared to developing countries and the different cost structures in those countries are likely to have contributed to production moving to regions where consumption rates are higher.

⁹⁸ Consumption estimated by adding production data from USGS (2013) with import data from UN COMTRADE (2013) and subtracting the total from export data from UN COMTRADE (2013).

Figure 6.12 Consumption rates of unwrought aluminium, refined copper and zinc



Source: COMTRADE (2013); USGS (2013)

Given that the prices of raw materials are set on the global market and offer neither a competitive advantage nor disadvantage to NFM producers, the development of energy prices over time is the most important production cost in determining international competitiveness.

6.4.2 Development in relation to EU ETS

Compared to other manufacturing sectors, non-ferrous metals (and particularly aluminium production) are exceptional for the electricity-intensive nature of production, high value per unit weight and high international trade intensity (Carbon Trust, 2007).

Only very few installations of the non-ferrous metals sector participated in the EU ETS during the first and second trading period. As indicated above most emissions in the sector are indirect through the use of electricity, in particular in the secondary production processes which hold a significant share in the EU. Indirect carbon costs ranged from 3.4% for copper to 10.3% for aluminium production in the carbon leakage list 2009; whereas direct carbon costs were assessed to be lower than 2% for most metal sectors. However, the actual indirect cost effect might be substantially lower because large electricity consumers such as smelters can negotiate favourable terms e.g. through long-term contracts with suppliers arranged independent of the ETS or the availability of low-cost electricity generation options such as hydropower in Norway.

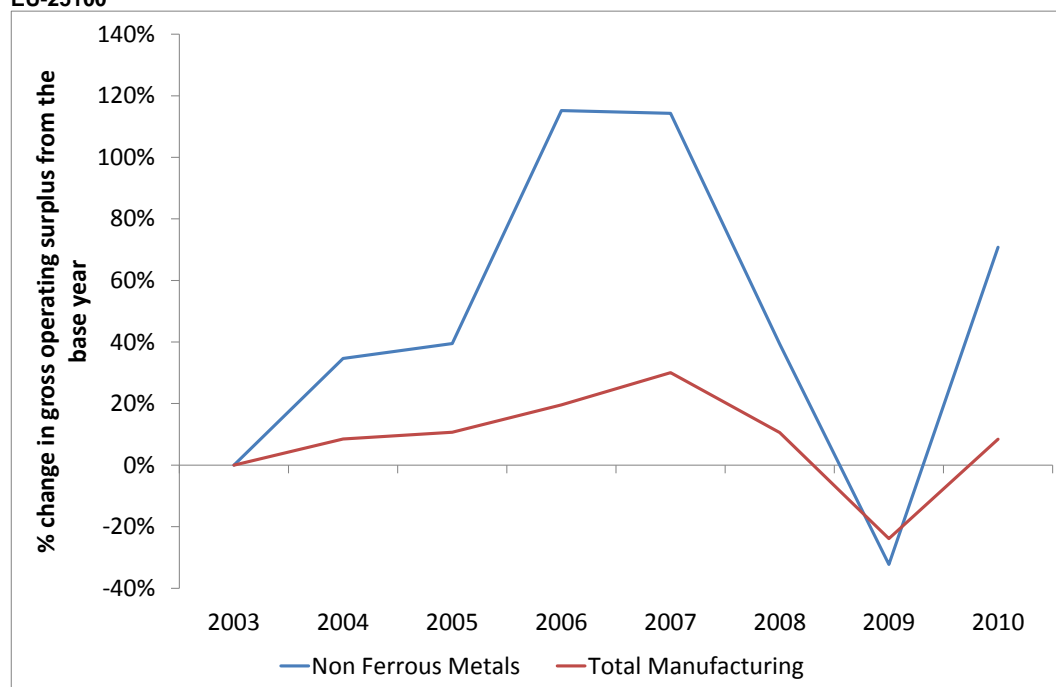
Applying an econometric approach, Sartor (2012) examined the effects of the EU ETS carbon price on net imports of primary aluminium in the EU. Using empirical data on trade, industrial production, exchange rates, CO₂ spot prices and EU coal and natural gas cost data, the econometric model was set up to investigate whether an increase in the cost of CO₂ in any given economic quarter (resulting in a higher electricity prices for EU smelters which are not on long-term contracts) would reduce production (either marginally or by shutting down) and hence lead to increased imports from non-EU ETS countries to meet domestic demand. The econometric analysis failed to identify a statistically significant effect of CO₂ pricing on the net imports of primary aluminium and therefore Sartor (2012) concluded that there is no evidence to suggest that the carbon price has caused a net

increase in imports of primary aluminium during the first 6 and a half years of the EU ETS. However Sartor (2012) points out that it is likely that the majority of aluminium producers have been on long-term electricity contracts and have therefore been insulated from electricity price rises due to CO₂ pricing. Secondly, Sartor (2012) suggests that for aluminium producers who are no longer on long-term electricity contracts, technical constraints make it too expensive to vary production levels in the short run unless the carbon price was significantly higher than historic levels. Thus, evidence for production or investment relocation up to now cannot be found in response to the EU ETS, even though transport costs are relatively low in relation to the high value per unit of weight.

6.4.3 Development of gross operating surplus

Figure 6.13 shows the development of gross operating surplus of the NFM sector in the EU-25 compared to total manufacturing between 2003 and 2010.⁹⁹ The NFM sector experienced a growth in profits from 2003 onwards and acquired profits above the average for manufacturing before an abrupt decline in profits following the economic recession which reversed to a positive growth again after 2009. Due to the fact that the prices of metals are determined in the global market, an erosion of profit margins (i.e. due to pressure on prices from oversupply) affects high-cost producers, generally located in more mature market economies, more severely than suppliers located in regions with abundant resources and energy (Ecorys, 2011).

Figure 6.13 Change in the gross operating surplus for non-ferrous metals and total manufacturing in the EU-25100



Source: Eurostat (2013)

⁹⁹ Gross operating surplus calculated for the EU-25 by subtracting values for Bulgaria and Romania from the EU-27 value provided by Eurostat (2013).

¹⁰⁰ In absolute terms the gross operating surplus for the NFM sector increased from €6 billion in 2000 to €8.1 billion in 2007. Following the economic recession the gross operating sector fell sharply to €2.6 billion in 2009 before recovering to €6.4 billion in 2010 (Eurostat, 2013)

6.4.4 Development of output and input prices

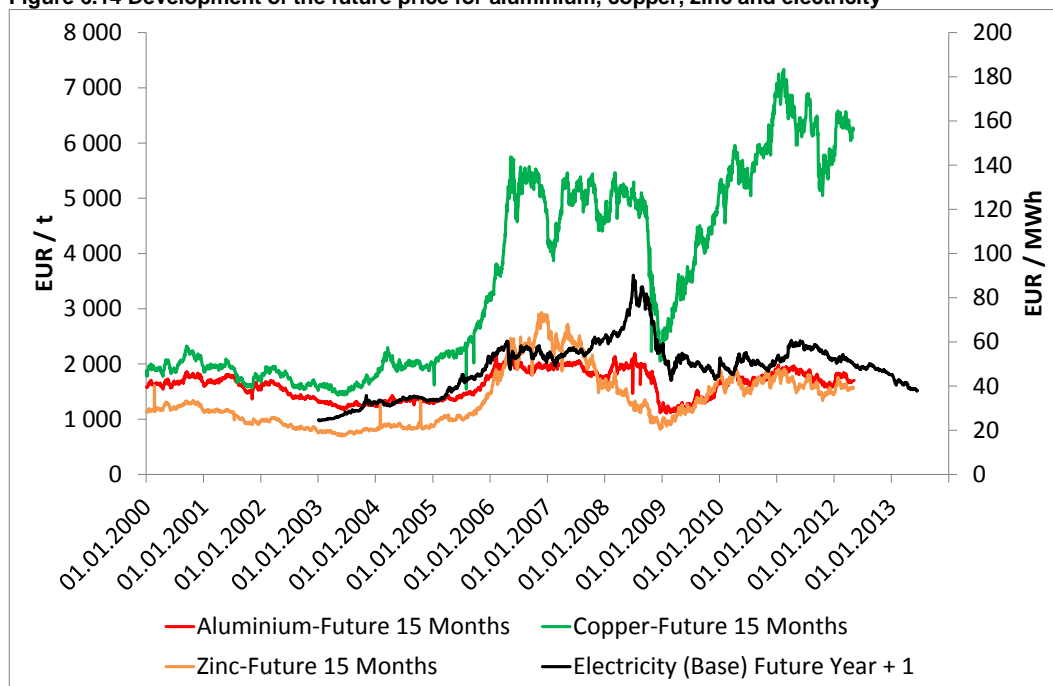
Base non-ferrous metal prices are determined by the supply of and demand for metals. Base metals are priced globally on international metal exchanges; primarily the London Metals Exchange (LME). The price paid for the finished base metal is composed of two parts:

- 1) The price determined on the metals exchange, say the LME;
- 2) A regional price premium that reflects the balance of supply and demand in the region.

The balance of supply and demand determines the price for the metal on the exchanges. The LME price for instance varies with the global supply of and demand for metal concentrate/primary metal, which is closely correlated to economic growth. For example, Figure 6.14 shows that the fluctuation in the price of aluminium follows the economic cycle with prices peaking at €2,300/ t in early 2007 (driven by high demand, especially in China and India) before crashing to below €1,000/ t in mid-2009 following the onset of the economic recession (Figure 6.14). Prices have recovered and are currently at around €1,400 /t in July 2013 (Metals Bulletin, 2013).

Figure 6.14 also shows that the price of aluminium rise and falls in a similar pattern to the price development of electricity between 2003 and 2012. However, the pattern between the electricity price and the price of copper and zinc is less pronounced, which implies that the electricity cost is not as important in the production (and thus in the supply curve) of these non-ferrous metals compared to aluminium. This is partly reflected by the fact that both copper and zinc are less electricity-intensive than aluminium and are assessed to have lower indirect costs in the previous carbon leakage assessment (compare Table 3.2). It appears that the price of these metals is more likely to be driven by the supply of competitive and scarce raw materials and by global demand.

Figure 6.14 Development of the future price for aluminium, copper, zinc and electricity

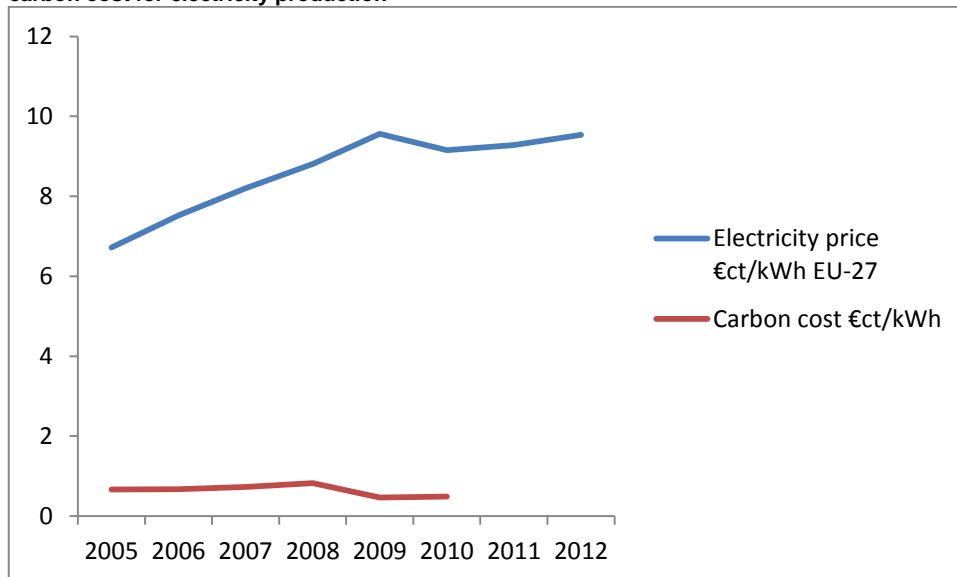


Source: Metals Bulletin (2013); EEX (2013)

Figure 6.15 shows the development of electricity prices in Europe. Electricity prices have increased up until 2008 and then dropped sharply during the economic recession with a slight increase since. Electricity prices are lowest in those countries that have substantial amounts of nuclear, hydro or renewable energy resources. Although the extent to which electricity producers passed through

CO₂ costs into electricity prices is uncertain, empirical analyses have shown that the EU ETS has increased electricity prices (Keppler et al., 2010; Fell, 2010; Fell et al., 2013). However, with EUA prices on a downward trend due to the oversupply of allowances the impact on electricity prices is currently lower than before the economic recession. The order of magnitude compared to other electricity price drivers is low, as can be seen in the picture below. It should be noted that the energy prices within Europe vary considerably as well.

Figure 6.15 Electricity prices for industrial consumers in the EU-27, excluding taxes; compared to carbon cost for electricity production



Source: Eurostat Energy Statistics, EEX, EEA, IEA.101

In order to further assess the relationship of the electricity price with the aluminium price an aluminium spread is calculated and presented in Figure 6.16. The aluminium spread is defined as the theoretical gross margin of an aluminium smelter from selling a unit of aluminium, having bought the electricity required to produce this aluminium. All other costs (operation, maintenance, raw materials, capital and other financial costs) must be covered from the aluminium spread. It is assumed that the aluminium smelter needs 14 MWh of electricity per ton of aluminium.

Figure 6.16 shows this aluminium spread as well as the aluminium spot price, the difference between the two indicating the electricity related costs. With rising electricity prices between 2003 and 2012 this gap widens significantly, by 2012 it is almost double the size compared to 2003. Nonetheless the overall aluminium spread remains relatively constant and lies in a range between 800 €/t and 1000 €/t. This implies that the development of electricity prices did not compromise the possibility for cost recovery for other inputs.

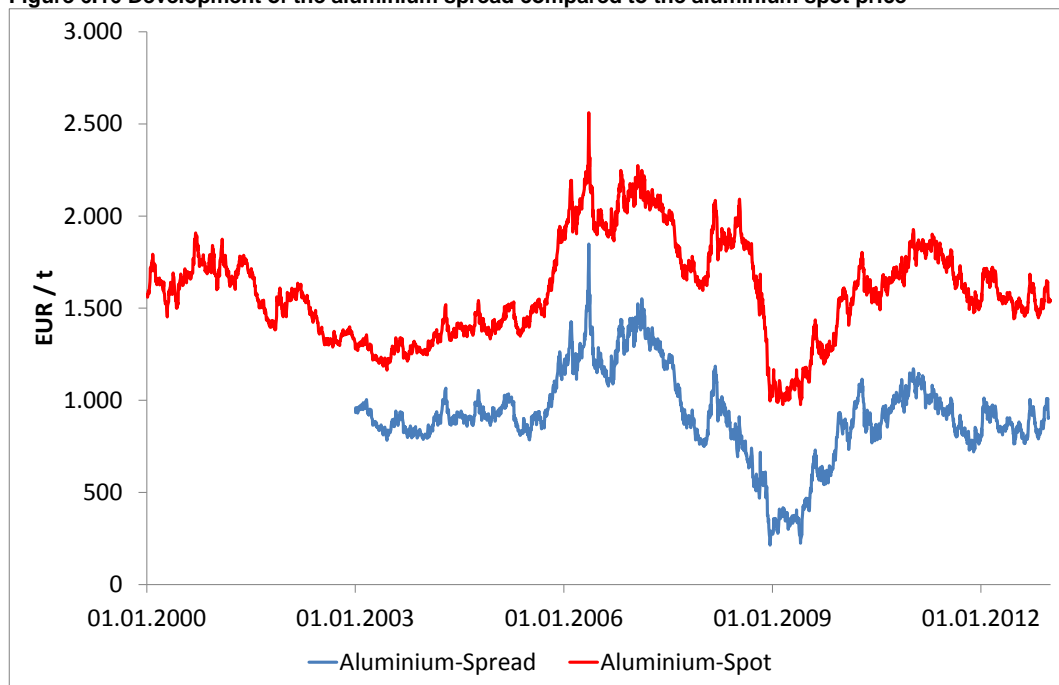
Exceptions to a spread within the 800 €/t to 1000€/t range can be observed for the year 2006/2007 which saw a boom in several commodity markets and also a considerably higher aluminium spread and the economic recession in 2009, which brought the aluminium spread down to only 250 €/t.

¹⁰¹ Electricity prices shown are the average prices in Euro per kWh without taxes applicable for the first semester of each year for medium size industrial consumers (Consumption Band Ic with annual consumption between 500 and 2000 MWh). Until 2007 the prices are referring to the status on 1st January of each year for medium size consumers (Standard Consumer Ic with annual consumption of 2 000 MWh). Note that prices can be expected to be lower for large size industrial consumers. Carbon cost is calculated by taking data from IEA on carbon emissions per kWh of electricity in OECD Europe; this quite precisely coincides with EU-27 data from the EEA, but has less data gaps. These values are multiplied by the EU allowance unit forward price (ETS emission forward price, used here because it is more stable than the spot price).

This very low aluminium spread is mirrored by a decline in primary aluminium production in the EU-27 (see Section 6.3.1). Since 2010 the aluminium spread again reaches pre-crisis levels of 800 €/t to 1000 €/t.

Overall, it can be noted that in comparison to the increasing price of electricity between 2003 and 2012 the aluminium spread remains level over the time period. This suggests that the profitability, i.e. the possibility for cost recovery, in the EU remained level over time.¹⁰² However, this would need to be compared to price and cost development and resulting profitability in other regions to fully understand the situation of EU producers in comparison to competitors. Likewise, the prices of raw materials would need to be taken into account. As the prices of most raw-materials have increased in the last decade the inclusion of the cost for the raw-material alumina could lead to a slightly decreasing trend of the EU aluminium spread. All in all, however Figure 6.16 clearly illustrates that profitability of aluminium production in Europe was highly influenced by the economic crisis in 2009 in the last decade. It also shows that volatile EU electricity (and CO₂ prices) had a rather small impact on the aluminium spread.

Figure 6.16 Development of the aluminium spread compared to the aluminium spot price



Source: Metals Bulletin (2013); EEX (2013)

6.5 Synthesis

Using the evidence from the previous sections Table 6.9 and Table 5.8 provide a short overview of the main important sector characteristics and potential drivers of relocation.

¹⁰² Given the high bargaining power that aluminium smelters normally have to negotiate electricity contracts it is conceivable that many plants have negotiated electricity contracts at discounted rates.

Table 6.9 Evidence for (production) relocation

Indicator for (production) relocation	Trend	Additional information on trend
Net imports	Increase in unwrought aluminium net imports / Decrease in imports of refined copper and unwrought zinc	Production of unwrought aluminium has been relatively stable, except for a drop in the crisis year 2009 when EU-27 consumption dropped considerably, too. The production of copper in the EU-27 has slightly increased while the demand has declined as exports have increased. The production of zinc in the EU-27 has decreased as well as the domestic consumption.
Investment activity in EU compared to outside EU	Decrease in relative investment	China has built up significant production capacity in recent years
Summary: evidence for (production) relocation	Whereas the EU-27 production has been rather stable for aluminium (with the exception of the crisis year 2009) and slightly increased for copper, the production of zinc has declined. Only zinc shows strong evidence of a shift in production. All three metals show a decrease in relative investments which is in line with a decrease in the share of global consumption.	

Table 6.10 Drivers for (production) relocation

Drivers for (production) relocation	Assessment	Justification of assessment
Carbon cost	Effect through indirect carbon costs from electricity consumption. In general, indirect carbon costs might play an important role. However, so far, low to very small effect due to long-term electricity contracts and/or low carbon price impact on electricity.	Long-term contracts on electricity supply arranged prior to (or independent of) ETS. Studies show that CO ₂ prices have to some extent been passed-through into electricity prices. There are direct costs but direct emissions play a less important role compared to indirect ones.
Other costs: Electricity	Important	Isolated electricity generation (e.g. in remote locations) providing long-term supply at low costs is among the main drivers for relocation
Other costs: Labour	Some influence	Labour costs represent a smaller share of the cost structure, however labour cost are high compared to third countries
Other costs: Intermediate inputs	Some influence	Price of scrap metal increasing due to demand from China. EU-27 is a net exporter of scrap metal.
Pass through of costs	Limited for zinc and copper, more pronounced for aluminium.	High level of international competition.
World demand	Important	Overall, demand has increased over time with high growth in China. EU demand for aluminium has also

Drivers for (production) relocation	Assessment	Justification of assessment
		increased while zinc and copper show a slightly decreasing trend
Summary: Was CO ₂ cost among the relevant drivers?	No	Electricity is a major input, but significant changes in EU production or net imports have only been observed in reaction to the economic crisis and induced reduction in demand.

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7 Manufacture of Pulp, Paper and Paperboard

7.1 Scope and current leakage list position

The manufacture of pulp, paper and paperboard is classified under two NACE codes (Table 7.1).

Table 7.1 NACE classification of the pulp, paper and paperboard sector

NACE Rev 1.1. Classification	NACE Rev 2 Classification
21.11 Manufacture of pulp	17.11 Manufacture of pulp
21.12 Manufacture of paper and paperboard	17.12 Manufacture of paper and paperboard

Source: Eurostat (2008)

Paper and paperboard products are frequently used on a daily basis in a range of applications varying from the manufacture of fine coated paper for writing to kraft paperboard for packaging requirements. The sector is characterised by a high number of products that are easily tradable and whereby producers compete on price, quality and product characteristics. Since the EU ETS started in 2005, the number of pulp and paper and paperboard installations that have participated in the scheme is 81 and 717 respectively (Table 7.2). Installations producing both pulp and paper (i.e. integrated paper mills) are attributed fully to the sector of their main product.

Table 7.2 Number of installation of the pulp and paper sector participating in the EU-ETS

	Installations participating since 2005 ¹⁰³	Thereof: New installations during 2005-2012	Thereof: Closed installation during 2005-2012	New installations from 2013 on (scope extension)
Pulp	81	3	5	1
Paper	717	42	165	25

Source: Based upon information from the EUTL database.

In the current leakage list, the manufacture of pulp and the manufacture of paper and paperboard are both defined as being at a significant risk of carbon leakage (Table 7.3), for reasons of high trade intensity only for the manufacture of pulp and for the combined indicators of carbon costs and trade intensity for the manufacture of paper and paperboard.

Table 7.3 Status in current leakage list, values for carbon cost and trade intensity

NACE Code	Direct Cost	Indirect Cost	Total Cost	Trade Intensity
21.11	2.9 %	< 5 %	< 5 %	46.1 %
21.12	5.3 %	4.8 %	10.2 %	25.7 %

Source: COM (2009)

¹⁰³ The number of installations were calculated as part of a NACE matching exercise, which was completed for the European Commission.

7.2 Characteristics of sector

7.2.1 Overview

The pulp, paper and paperboard industry plays an important role in adding value and creating jobs within a long value chain. According to the CEPI (2011a), important characteristics of the manufacture of pulp, paper and paperboard in Europe¹⁰⁴ for the year 2010 include:

- Turnover: €80.6 billion
- Production: Paper and board (96.5 million tonnes) / Market pulp (12.7 million tonnes). Share of global production: 24.5 %
- Number of companies: 683 / Number of mills: 998
- Employees: 224,129
- Added value: €16 billion

Manufacturers of pulp, paper and paperboard have been going through a process of consolidation and globalisation: The concentration process leads to a reduction of companies. Within Europe¹⁰⁵, the top 5 companies account for 30.1 %¹⁰⁶ of the total pulp and paper production capacity.¹⁰⁷

However, the industry is also characterised by a high proportion of SMEs (i.e. about two thirds of all companies within the pulp and paper industry) mainly higher up the value chain.¹⁰⁸

7.2.2 Production process and energy consumption

The manufacture of pulp, paper and paperboard produces energy as a by-product and thus the majority of mills produce much of their electricity and heat on site and in some cases export electricity to the national grid. The CEPI claim that the pulp, paper and paperboard sector produces about half of their electricity needs on site. In addition, more than half of the total primary energy consumption for the manufacture of pulp, paper and paperboard in Europe is based on biomass (CEPI, 2011a). The production input for paper and paperboard products is pulp, which is sourced from wood and non-wood fibres and manufactured using several processes:

- Mechanical pulping is an energy intensive process, however given that only a fraction of the energy is used to separate the fibres (i.e. by pressing logs against wet grind stones), the heat generated can be recovered. In 2010, the EU-25 produced 33 % of the world's total mechanical pulp output, which accounted for 27 % of EU-25 pulp production (FAO, 2013)
- Chemical pulping involves cooking wood chips in an aqueous solution at high temperature and pressure. The Kraft process is more common and produces excess electricity that can be exported. The export is the result of balancing the energy used in the pulping process and the energy recovered from the black liquor recovery process¹⁰⁹ (combusting the lignin).
- The EU-25 produced 19 % of the world's chemical pulp output in 2010, representing 66 % of EU-25 pulp production (FAO, 2013). A major source of fibres for the future will be in Brazil, which already accounted for 11 % of the world's chemical pulp output in 2010 (FAO, 2013).
- Recovered pulp based on recycled paper represents an important option for reducing pulping energy use. European firms therefore have a high paper recycling rate of 71.7 % in 2012 (CEPI, 2013), although a high proportion of recovered paper is currently exported to China where fibres are in limited supply to match the country's growing demand.

¹⁰⁴ Europe refers to CEPI countries which accounts for 19 Member States of the EU and Norway and Switzerland

¹⁰⁵ Europe refers to the EU-27 + 3

¹⁰⁶ Data provided by the CEPI (2013)

¹⁰⁷ Sweden and Finland accounted for 31 % and 28 % respectively of the pulp for paper produced within the EU-25 in 2011 (FAO, 2013) Germany and Finland accounted for 28 % and 14 % respectively of the paper and paperboard produced within the EU-25 in 2011 (FAO, 2013)

¹⁰⁸ Information provided by CEPI & RISI (2013)

¹⁰⁹ Black liquor, a by-product of the papermaking process, is an important liquid fuel in the pulp and paper industry. It consists of the remaining substances after the digestive process where the cellulose fibres have been cooked out from the wood.

Table 7.4 World best practice final energy intensity values for stand-alone pulp mills (values are per air dried metric tons)¹¹⁰

Raw material / Product	Process	Fuel Use Steam [GJ/Adt]	Steam Exported [GJ/Adt]	Electricity use [kWh/Adt]	Electricity produced [kWh/Adt]	Total [GJ / Adt]
Non-wood / Market Pulp	Pulping	10.5	-4.2	400		7.7
Wood / Market Pulp	Kraft	11.2		640	-655	11.1
	Sulfite	16.0		700		18.5
	Thermo-mechanical		-1.3	2190		6.6
Paper/ Recovered Pulp		0.3		330		1.5

Source: Worrell et al. (2007)

Mechanical, chemical and recovered pulps are the main inputs for paper and paperboard production. The energy intensity of paper and paperboard products reflects the extent to which additional processing is necessary (i.e. grade of paper to be produced) and the fibre quality (i.e. water retention) in the pulp. It is important to acknowledge that integrated mills can be more efficient than stand-alone mills due to the fact that no drying energy is needed for the intermediate drying of the pulp. In addition, the integration of different processes may result in further optimisation of the steam use on site.

Table 7.5 World best practice final energy intensity values for stand-alone paper mills (values are per air dried metric tons)

Raw Material	Product	Process	Fuel Use for Stream [GJ / Adt]	Electricity Use [kWh / Adt]	Total [GJ / Adt]
Pulp	Uncoated fine	Paper machine	6.7	640	9.0
	Coated fine		7.5	810	10.4
	Newsprint		5.1	570	7.2
	Board		6.7	800	9.6
	Kraftliner		5.9	535	7.8
	Tissue		6.9	1000	10.5

Source: Worrell et al. (2007)

7.2.3 Cost structure

The purchase of fibres (i.e. wood, market pulp and recovered paper) represents the largest share of the total cash manufacturing cost, which accounted for 48.6 % in 2010 (Table 7.6). Chemicals are another important intermediate input in the manufacture of paper and paperboard accounting for 15.2 % of the total cash manufacturing cost in 2010. The manufacture of paper and paperboard is an energy intensive process, thus expenses for fuels and electricity are relatively high.

¹¹⁰ There are 11 benchmarks for different grades in EU ETS and many installations covered by the heat benchmark.

Table 7.6 Cash manufacturing cost structure in 2010 for the manufacture of pulp, paper and paperboard

Wood ¹¹¹	15.7 %	Fuels	10.9 %
Maintenance	8.0 %	Chemicals	15.2 %
Labour	10.4 %	Market pulp	23.4 %
Electricity	6.9 %	Recovered paper	9.5 %

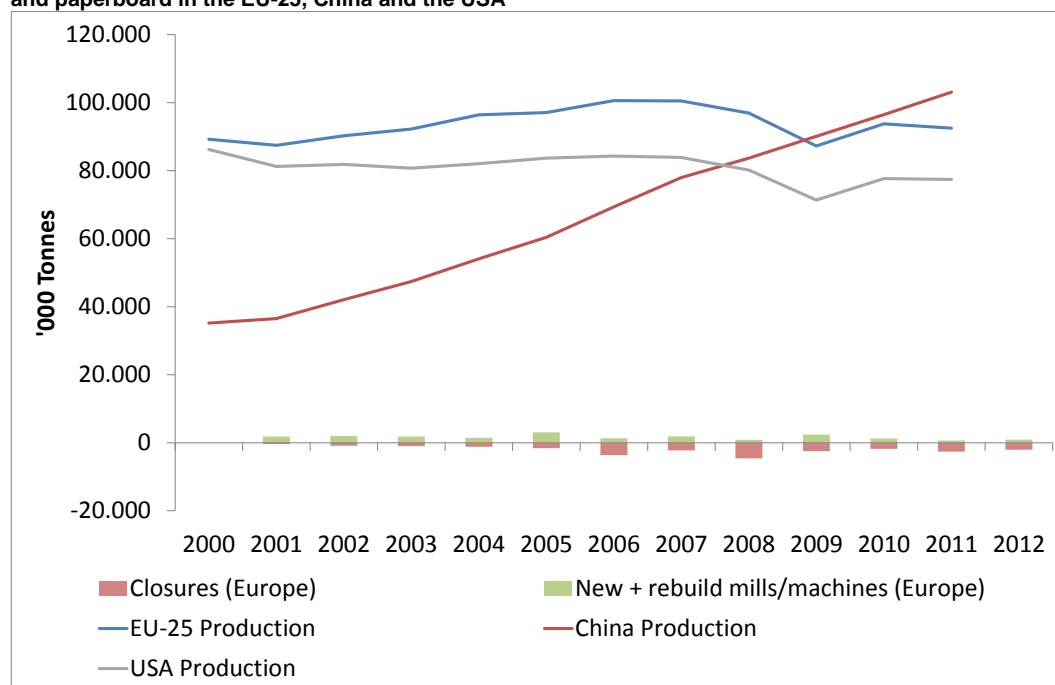
Source: CEPI (2011a)

7.3 Evidence of production shift / relocation

7.3.1 Development of production and import/export

Figure 7.1 illustrates the development of paper and paperboard production over time for the EU-25 (i.e. blue line), the USA (i.e. grey line) and China (i.e. red line). It is evident that the rapid growth in paper and paperboard production experienced in China occurred prior to the implementation of the EU ETS. The production trends for the EU-25 and the USA are more similar, both showing a decline in production following the economic recession. Given that the USA does not currently implement an emission trading scheme at the federal level, the comparability with the production trend of the EU-25 implies that factors other than carbon cost may have been more influential. Figure 7.1 also shows the trend of new additions (i.e. in green bars) and reductions (i.e. in red bars) in production capacity in Europe. Every year during the time period there have been additions and closures and, as one would expect, the rate of closures increased with the onset of the economic recession. In 2011, over 2.5 million tonnes of production capacity was closed down, which was equivalent to 2.8 % of the total EU-25 production in the same year.

Figure 7.1 Additions and closures to production capacity in Europe compared to production of paper and paperboard in the EU-25, China and the USA

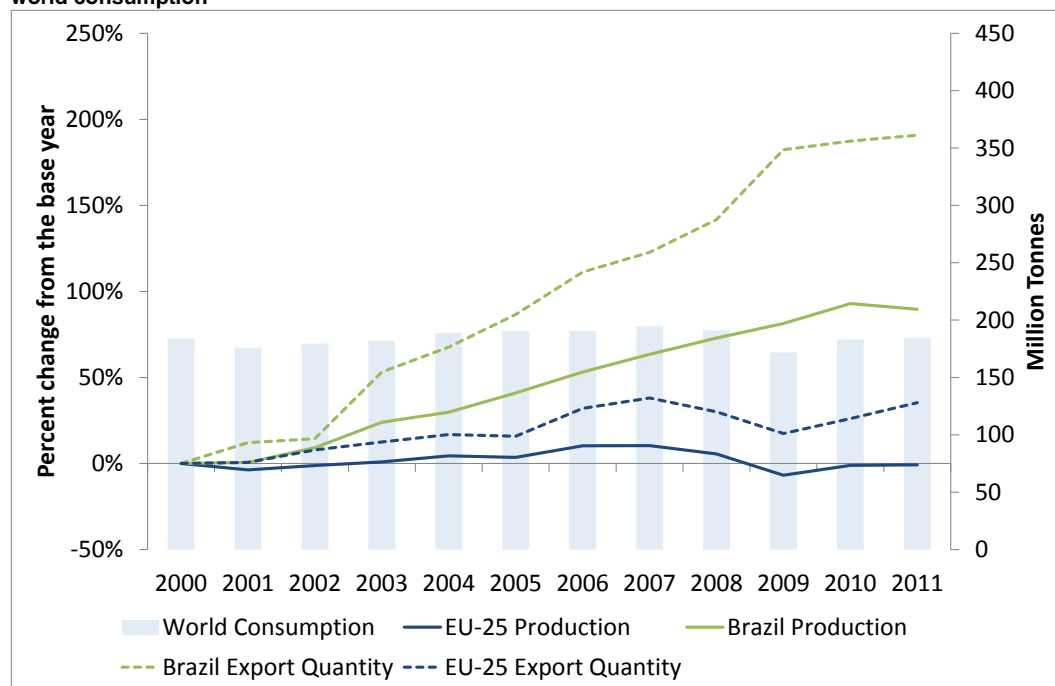


Source: CEPI & RISI (2013), FAO (2013)

¹¹¹ CEPI (2013) stress that wood costs also form part of the energy costs as 50% of their energy needs comes from biomass

Figure 7.2 provides a comparison between the EU-25¹¹² and Brazil¹¹³ with regards to their production and export levels between 2000 and 2011. While the change in exports of pulp products in the EU-25 (i.e. blue dotted line) closely mirrors the trend in world consumption (i.e. blue bars), the rate of growth in pulp exports from Brazil (i.e. green dotted line) since 2002 has been very high and is part of a longer term trend whereby the country has successfully capitalised on the availability of low cost fibre. In 2011, Brazil accounted for 18% of global exports in chemical pulp compared to a 25% share for the EU-25 (FAO; 2013).¹¹⁴

Figure 7.2 Comparison of the production and export of pulp by the EU-25 and Brazil in the context of world consumption



Source: FAO (2013)

Figure 7.3 provides a comparison between the production and exports of paper and paperboard products for the EU-25¹¹⁵ and China¹¹⁶. Production of paper and paperboard products in the EU-25 (i.e. blue line) follows the trend of world consumption (i.e. blue bars). Whereas the growth in Chinese production (i.e. red line) has increased considerably between 2000 and 2011 and China now accounts for 26 % of global production (compared to 23 % for the EU-25). The majority of the paper and paperboard produced in China is however consumed domestically with only 5 % of paper and paperboard products produced exported in 2011 (FAO 2013).¹¹⁷

¹¹² In absolute terms the EU-25 produced 37.5 million tonnes of pulp for paper in 2011, which has remained stable compared to production levels in 2000 (i.e. 37.8 million tonnes) (FAO, 2013)

¹¹³ In absolute terms Brazil produced 13.9 million tonnes of pulp for paper in 2011, the majority of which was chemical pulp (i.e. 13.4 million tonnes). Pulp for paper production has increased considerably in Brazil compared to 2000 levels (i.e. 7.3 million tonnes) (FAO 2013).

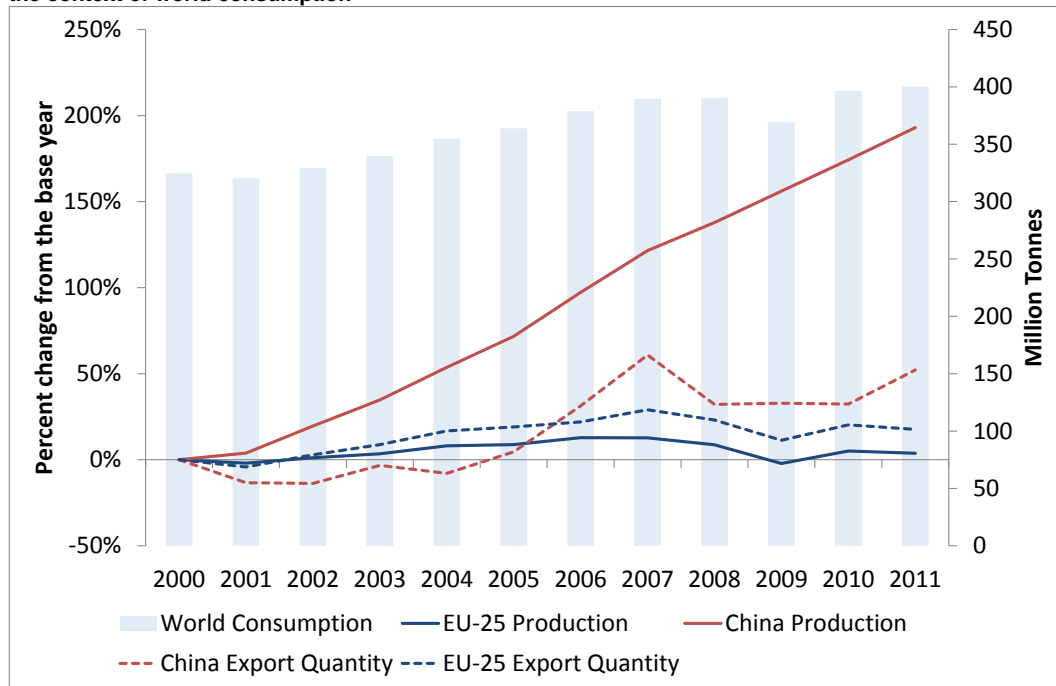
¹¹⁴ According to data provided by the FAO (2013), imports of pulp for paper into the EU-25 increased from 15.9 million tonnes in 2000 to 17.2 million tonnes in 2010.

¹¹⁵ In absolute terms the EU-25 produced 92.5 million tonnes of paper and paperboard in 2011, which has increased slightly from levels in 2000 (i.e. 89.2 million tonnes) (FAO, 2013)

¹¹⁶ In absolute terms China produced 103 million tonnes of paper and paperboard in 2011, which has increased considerably from levels in 2000 (i.e. 35.2 million tonnes) (FAO, 2013)

¹¹⁷ According to data provided by the FAO (2013), imports of paper and paperboard products into the EU-25 increased from 45.5 million tonnes in 2000 to 50.1 million tonnes in 2010.

Figure 7.3 Comparison of the production and export of paper and paperboard by the EU-25 and China in the context of world consumption



Source: FAO (2013)

7.3.2 Development of production capacity and investment

The rise in emerging markets accompanied by the development of integrated plantation/ pulp production has resulted in the creation of local, modern and successful paper industries (i.e. Aracruz in Brazil and Nine Dragons in China) that are growing fast. The shift in production capacity that is currently underway is characterised by a more ‘disintegrated’ business model, whereby pulp production is located where there is low cost fibre (i.e. Brazil¹¹⁸) and paper production where there is demand (i.e. China¹¹⁹). The result of a recent survey published by PwC (2012) provides further evidence for a shift in production as China recorded in 2011 the highest re-investment ratio¹²⁰ of 4.6, which was followed by Latin America at 1.5 and Europe were below the industry average re-investment ratio of 0.98.

The level of investment as a proportion of turnover is calculated for the manufacture of lime and plaster based on data from the Structural Business Statistics (SBS) Database. Table 7.7 shows that the rate of investment as a proportion of turnover for the manufacture of lime and plaster has declined between 2000 and 2010. However, the level of investment for manufacturing as a whole is lower than for the manufacture of lime and plaster, which are both considered to be very capital intensive industries.

shows that levels of investment in the EU have declined between 2001 and 2011 and planned investments for 2013 and 2016 are relatively low in Europe compared to other regions in the world (Figure 7.4).

¹¹⁸ ‘Since pulp and timber from sawmills take up less than half the volume of round wood, and since shipping costs are highly dependent on volume, it is more economical for countries such as Brazil to export pulp and timber rather than wood’ (NEP, 2009).

¹¹⁹ ‘Even though sea transport costs are low per km, local production is an advantage. For instance, it is very difficult for Nordic pulp and paper companies to compete on the Chinese market with products produced in the Nordic region. Instead the Nordic forest industry builds production plants in China’ (NEP, 2009).

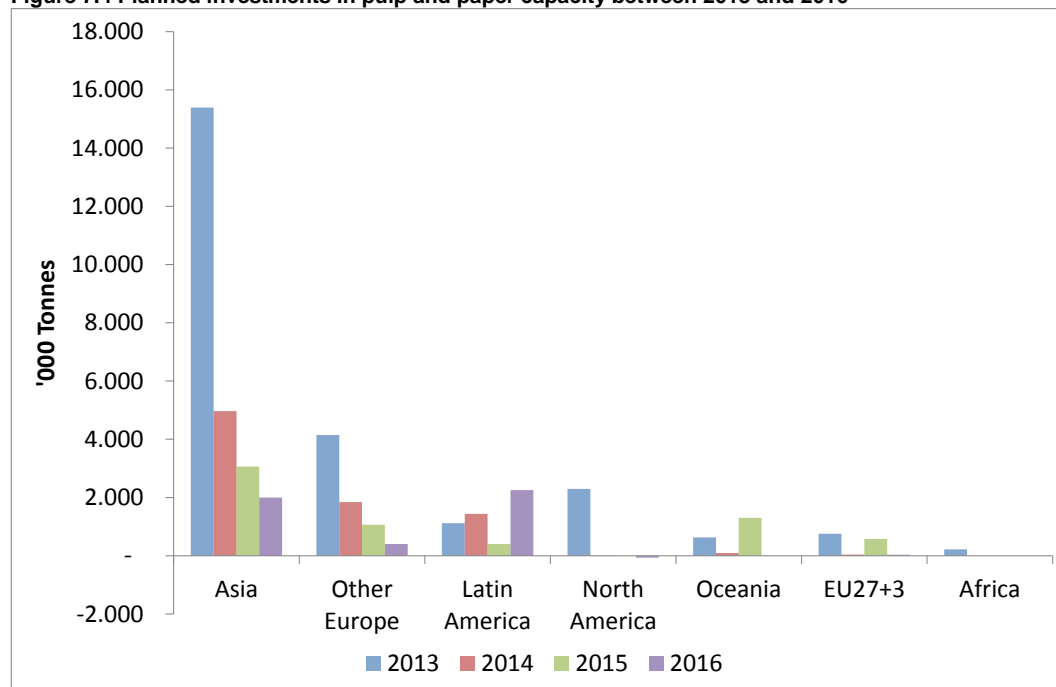
¹²⁰ Reinvestment ratio, calculated as capital investment as a percentage of depreciation, measures the extent that capital investment is replacing aging assets. A ratio in excess of 1.0 indicates an expansion of capacity. A ratio of less than 1.0 indicates capacity shrinkage and suggests that assets are being depreciated faster than they are being replaced.

Table 7.7 Comparison of the investment as a proportion of turnover for the manufacture of pulp, paper and paperboard with total manufacturing in the EU-25

	2001	2003	2005	2007	2009	2011
Pulp, Paper and Paperboard	8 %	7 %	6 %	5 %	4 %	3 %
Total Manufacturing	4 %	4 %	3 %	3 %	3 %	2 %

Source: Eurostat (2013)

Figure 7.4 Planned investments in pulp and paper capacity between 2013 and 2016



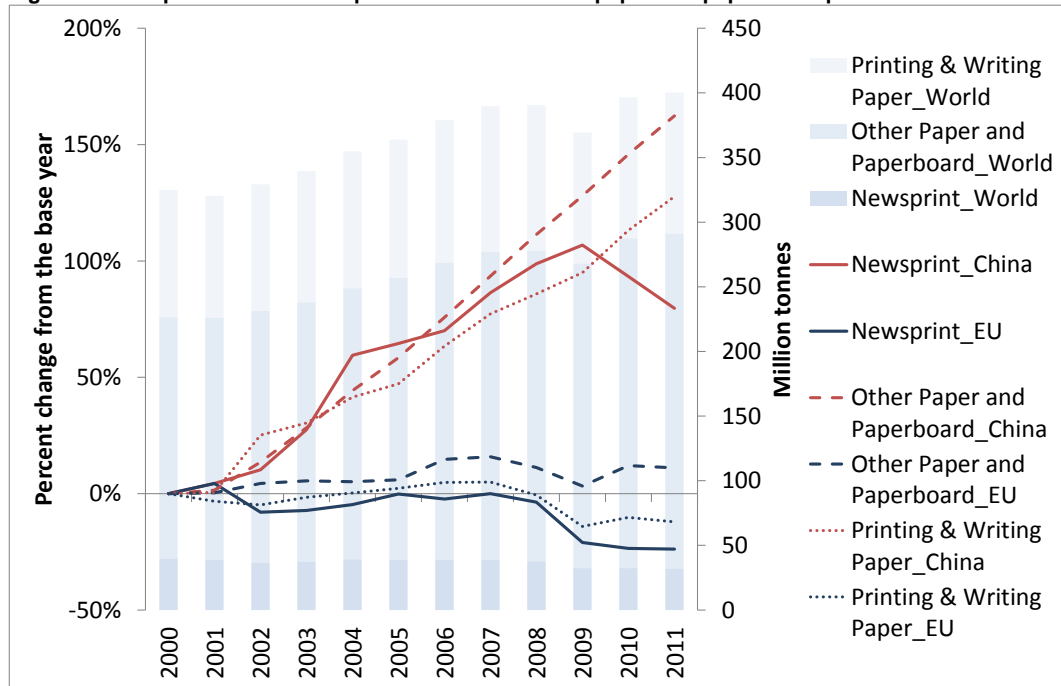
Source: RISI (2013)

7.4 Drivers for relocation

7.4.1 Development of demand

Figure 7.5 shows the rapid growth in the consumption of paper and paperboard products in China compared to the lower growth and in some cases the decline in consumption of some paper and paperboard products in the EU-25.

Figure 7.5 Comparison of consumption rates for different paper and paperboard products



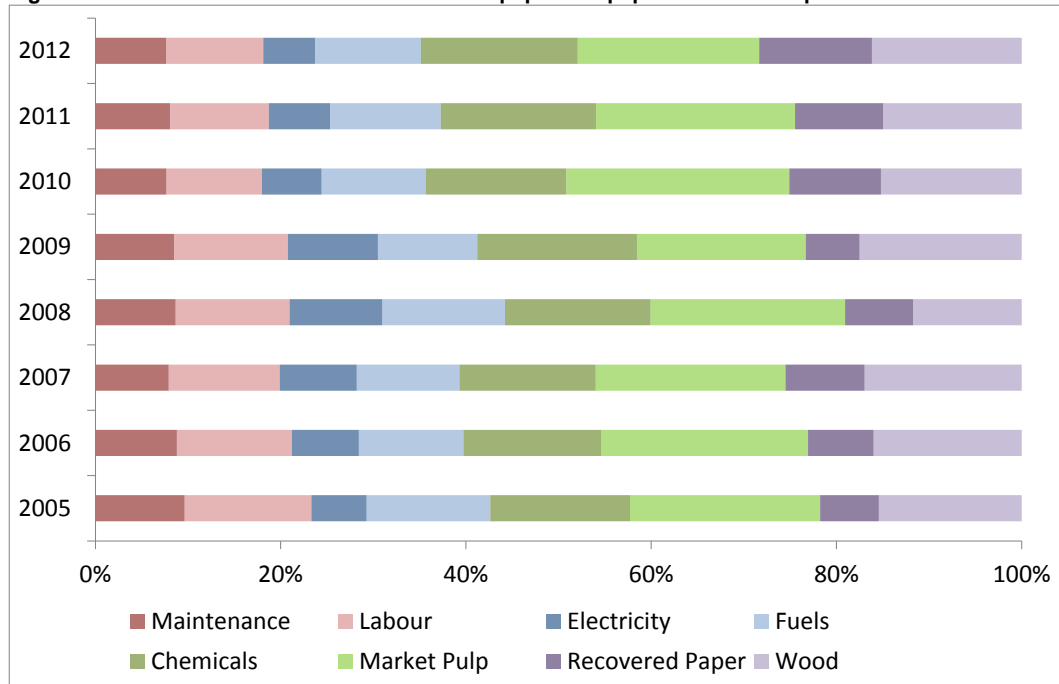
Source: FAO (2013)

It is to be expected that levels of consumption in the EU-25 experience less growth than in China as the market is more established. However, there is evidence that in contrast to the growing world pattern of consumption the EU-25 has experienced declining levels of consumption in newsprint and printing & writing paper – in part due to the rise in electronic media and the economic recession.

7.4.2 Development of the cost structure

The evolution in the cost structure associated with the manufacture of paper and paperboard is illustrated in Figure 7.6. The purchase of fibres represents the largest share of costs and this has risen from 42 % in 2005 to 48 % in 2012. Demand for fibres to support China's growing production of paper and paperboard products has increased input prices for recycled paper in particular (i.e. rising from 6 % in 2005 to 12 % in 2010). Labour costs have also declined as the European industry has improved the levels of productivity in order to compete with the lower labour costs abroad. Fuel costs have reduced slightly over the time period, which may indicate improvements in energy efficiency within the manufacturing process. Electricity use represented 6 % of the total manufacturing costs in 2012; however this value peaked at 10 % in 2009 and according to the CEPI electricity costs account for a larger share of total costs than that experienced by third countries (with the exception of Japan).

Figure 7.6 Cost structure for the manufacture of paper and paperboard in Europe



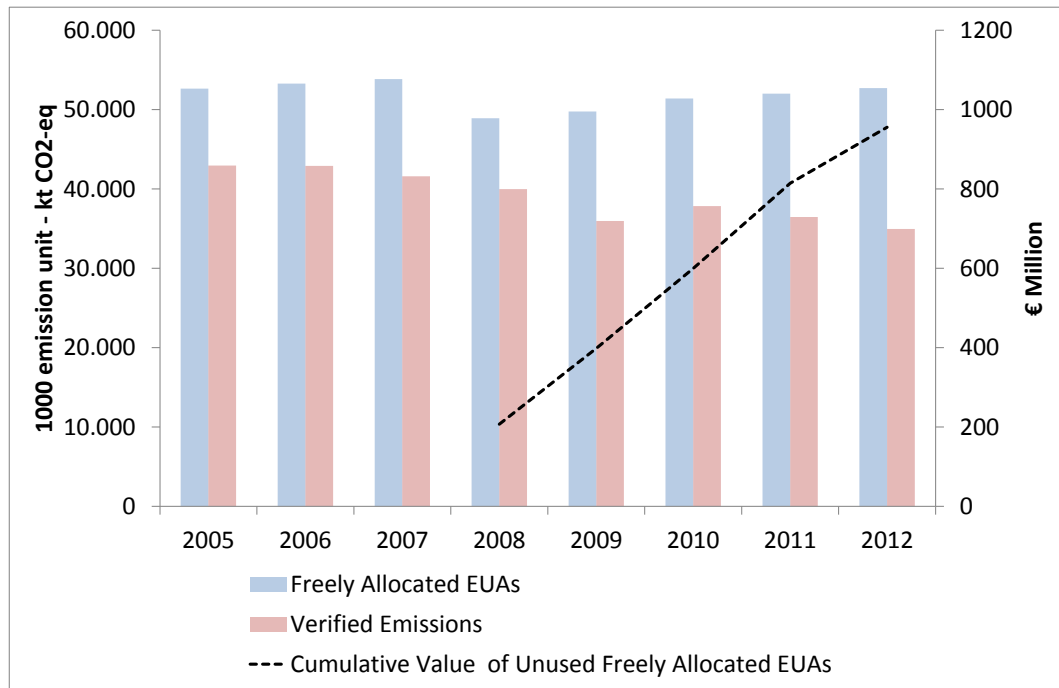
Source: CEPI & RISI (2013)

7.4.3 Compliance costs in relation to EU ETS

Figure 7.7 shows the direct emissions resulting from the manufacture of pulp, paper and paperboard between 2005 and 2012. It is evident that for every year under the EU ETS, the verified emissions have been lower than the annual allocation of free EUAs. As a consequence the pulp, paper and paperboard producers participating in the EU ETS from 2008 onwards have received free EUAs beyond their verified emissions that are equivalent to a value of €956 million.¹²¹ Whether the profits from selling these allowances were used to invest into abatement technology in order to reduce the specific emissions of pulp, paper and paperboard production as claimed by the industry cannot be assessed with the given data. Although the CEPI state that specific emissions have declined by 14 % between 2005 and 2012, it is not possible to fully attribute the impact of investments in abatement technology to this trend without further information from industry.

¹²¹ Calculated by multiplying the unused allowances in a year by the average EUA y+1 price for the 2008-12 time period.

Figure 7.7 Direct costs of ETS compliance for the manufacture of pulp, paper and paperboard



Source: CITL (2013) - all PPI installations identified

The indirect impacts of the EU ETS on the sector are more difficult to determine (i.e. the impact on input costs for fibres, chemicals and electricity¹²²) as is the impact of the EU ETS on long term investment decisions.

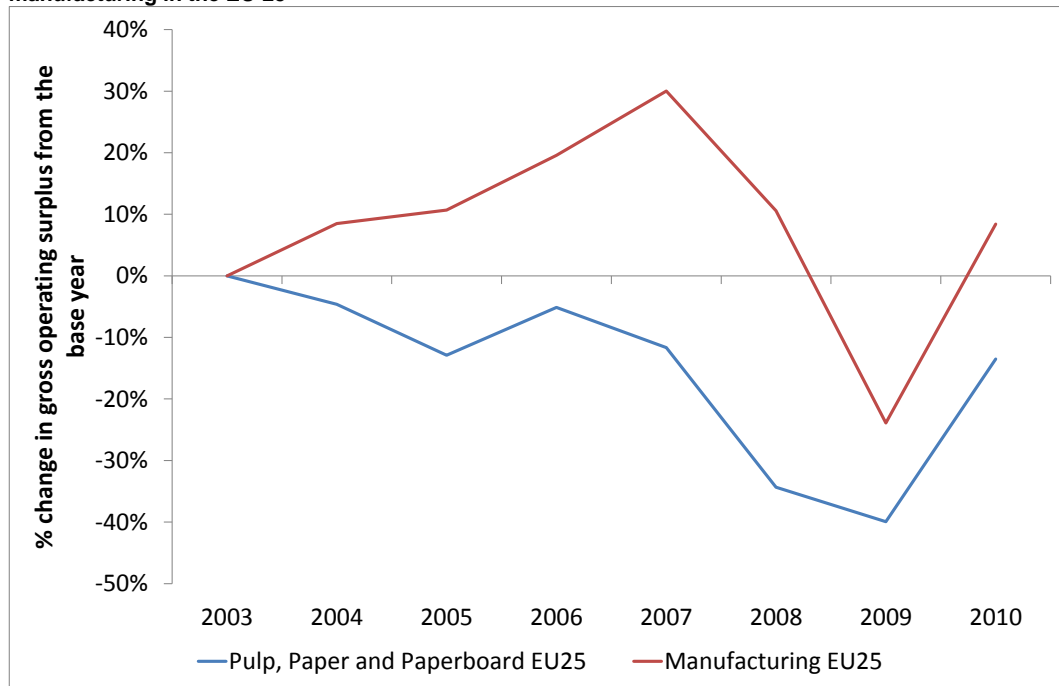
7.4.4 Development of gross operating surplus

Figure 7.8 shows the change in gross operating surplus for the manufacture of pulp, paper and paperboard products and total manufacturing in the EU-25.¹²³ To reverse the negative trend in profitability, the CEPI recently launched its '2050 Roadmap' which explores how the sector could reduce emissions by 80 % and increase the added value of products by 50% (CEPI, 2011b). New technologies (i.e. energy conversion technologies, fuel mix changes, biomass and waste/ residue gasification) could lead to cost reductions, lower emissions per tonne produced, increased production of bioenergy and the creation of high value-added products. The key conclusion from the CEPI roadmap is that breakthrough technologies need to be developed in order to decarbonise the pulp, paper and paperboard sector.

¹²² COM (2012) defines both mechanical pulp and paper and paperboard as being exposed to a significant risk of carbon leakage due to indirect emission costs in the state aid guidelines (refer to OJ C158, 5.6.2012, p.4)

¹²³ In absolute terms the gross operating surplus for the pulp, paper and paperboard sector declined from €14 billion in 2000 to €7.6 billion in 2007. Following the economic recession the gross operating sector fell sharply to €5.2 billion in 2009 before recovering to pre recession levels (Eurostat, 2013)

Figure 7.8 Change in the gross operating surplus for the pulp, paper and paper board and total manufacturing in the EU-25

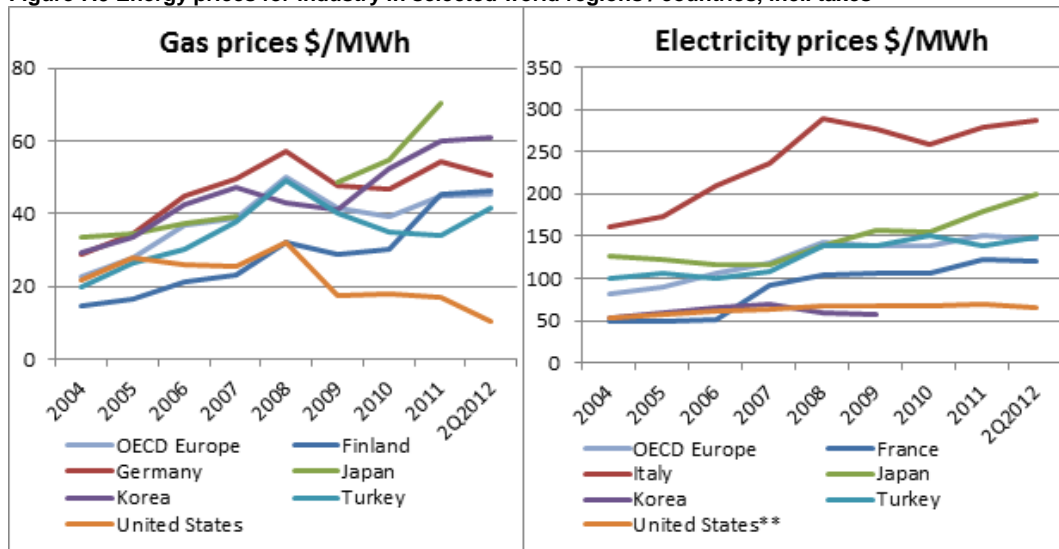


Source: Eurostat (2013)

7.4.5 Development of energy prices

An international comparison of energy products is possible for OECD countries based upon statistics published by the IEA (2012) as shown in Figure 7.9 below.

Figure 7.9 Energy prices for industry in selected world regions / countries, incl. taxes¹²⁴



Source: IEA Energy Prices & Taxes, 4th quarter (2012)

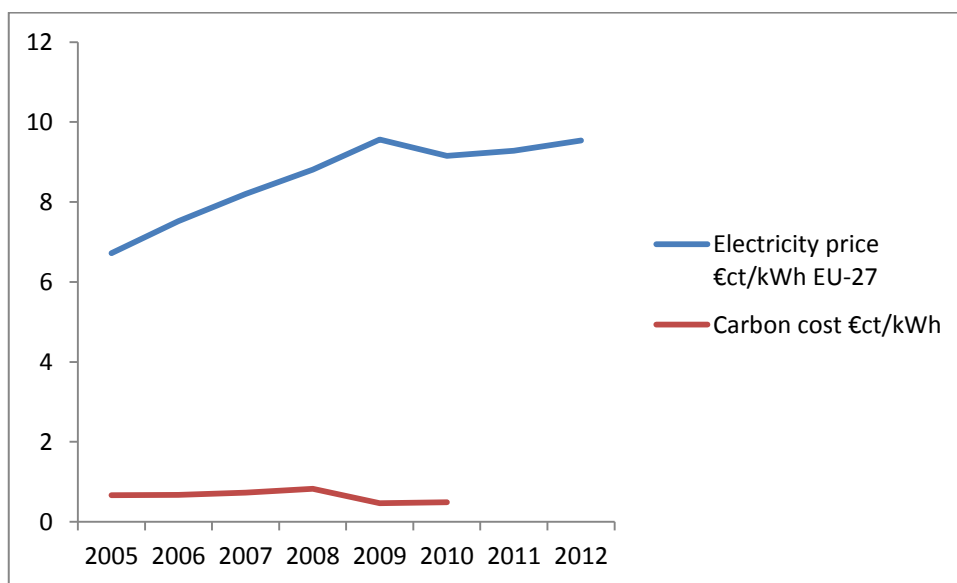
It is evident that the USA may have a competitive advantage. For example, the cost of natural gas for industry in the USA was considerably cheaper in 2011 compared to OECD Europe and other

¹²⁴ Definition: Prices and taxes for the industry sector are the average of amounts paid for the industrial and manufacturing sectors. ** Electricity price data for the US excludes taxes. Note that there are data gaps for Japanese gas price data and Korean electricity price data. OECD Europe comprises Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

countries or regions. Of the countries considered, prices for natural gas were highest in Germany, Korea and Japan. Electricity costs also appear to be lower in the USA than in OECD Europe and other countries and regions, but it has to be noted that US electricity prices are shown without taxes in the graph. Both electricity and gas prices roughly doubled in most countries in the selected period, except for the US. It should be noted though that the dollar lost about 20% of its value against the Euro in the same time frame, so part of the cross-country differences can also be explained by currency fluctuations.

Although the extent to which electricity producers passed through CO₂ costs into electricity prices is uncertain, empirical analyses have shown that the EU ETS has increased electricity prices (Keppler et al., 2010; Fell, 2010; Fell et al., 2013). The order of magnitude compared to other electricity price drivers is low though, as can be seen in the picture below. It should be noted that the energy prices within Europe vary considerably as well.

Figure 7.10 Electricity prices for industrial consumers in the EU-27, excluding taxes; compared to carbon cost for electricity production



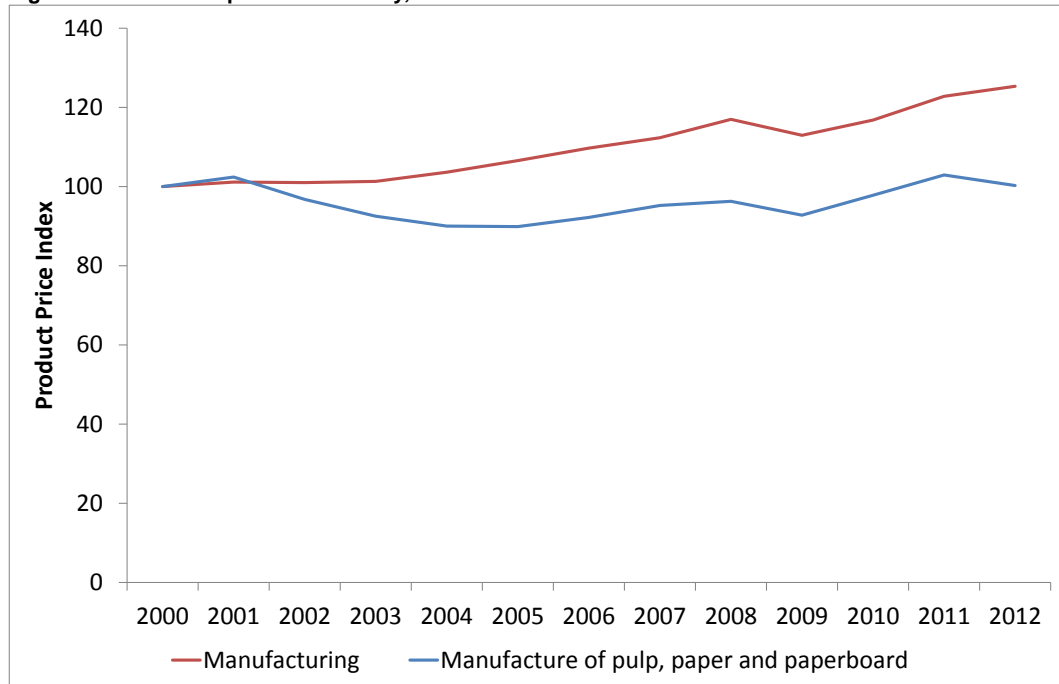
Source: Eurostat Energy Statistics, EEX, EEA, IEA.125

7.4.6 Development of output prices

Producer prices for manufacture of pulp, paper and paperboard in the EU-27 are shown for the years 2000 to 2012, indexed to 2000, in Figure 7.11. Prices have steadily fallen since 2001, but show an increase from 2005 onwards with the exception of a small kink in 2009, the year of the economic recession.

¹²⁵ Electricity prices shown are the average prices in Euro per kWh without taxes applicable for the first semester of each year for medium size industrial consumers (Consumption Band 1c with annual consumption between 500 and 2000 MWh). Until 2007 the prices are referring to the status on 1st January of each year for medium size consumers (Standard Consumer 1e with annual consumption of 2 000 MWh). Note that prices can be expected to be lower for large size industrial consumers. Carbon cost is calculated by taking data from IEA on carbon emissions per kWh of electricity in OECD Europe; this quite precisely coincides with EU-27 data from the EEA, but has less data gaps. These values are multiplied by the EU allowance unit forward price (ETS emission forward price, used here because it is more stable than the spot price).

Figure 7.11 Producer prices in industry, annual data



Source: Eurostat (2013), CEPI (2013)

The declining profitability of European producers has resulted in a contraction in production and employment in the pulp and paper sector. A decline in product prices has restricted the ability of producers to absorb any additional costs or pass them through to the final consumer. The situation will most likely not improve given international competition.¹²⁶ 'There are no obvious substitutes for pulp and paper for end users but to save costs (including energy costs and potential CO₂ costs) there is some opportunity to substitute products and processes within the sector e.g. in terms of quality, wood type, and whether or not the material is from recycled sources. These factors will impact on production costs and product prices' (Dröge, 2012).

It is important to acknowledge that other policies and trade agreements influence the competitiveness of the pulp and paper industry in Europe. For example, variations in the price of wood have been caused by increased competition for wood from energy producers, supported by public subsidies for the production of renewable energy. There has also been a sharp increase of payments for customs established in Russia for exported wood in 2008. 'This measure has directly affected Finland but has also led, on a smaller scale, to an increase in prices for pulp wood in the rest of Europe' (IPCC, 2010).

7.5 Synthesis

Using all of the evidence from the previous sections, Table 7.8 and Table 7.9 provide a short overview of the main important sector characteristics and potential drivers of relocation.

Table 7.8 Evidence for (production) relocation

¹²⁶ CEPI (2013) refer to the anti-dumping and anti-subsidy measures that are currently in place with China for paper imports to Europe as an example of their trade exposure.

Indicator for (production) relocation	Trend	Additional information on trend
Net imports	Slight increase	Imports of paper and paperboard to the EU-25 have increased by 10 % between 2000 and 2012 (FAO, 2013)
Investment activity in EU compared to outside EU	Decrease in relative investment	China and Brazil have built up significant production capacity in recent years
ETS Installations	Several pulp and paper and paperboard installations have closed during the time period.	
Summary: evidence for (production) relocation	Limited evidence of a shift in EU production	

Table 7.9 Drivers for (production) relocation

Drivers for (production) relocation	Assessment	Justification of assessment
Carbon cost	Carbon cost are not the driving factor in relocations between 2005 and 2012	Allowances were allocated for free and exceeded verified emissions in the period considered.
Other costs: fossil fuels	Important	Gas prices play a major role for input costs. The high gas price in Europe has likely influenced industry's competitiveness.
Other costs: Labour	Some influence	Labour costs represent a minor share of the cost structure, however labour cost are high compared to third countries
Other costs: Intermediate inputs	Important	The price of fibre has risen due, in part, to an increase in global demand and this represents a large share of the cost structure
Pass through of costs	Limited	High level of international competition
World demand	Important	EU demand has slightly decreased, while demand from other states (e.g. China) has increased
Summary: CO ₂ cost among the relevant drivers?	Over the 2005 to 2012 period CO ₂ cost is not among the relevant drivers. The industry has received free allowances during this period.	The main driver appears to be shift of world demand and cost pressure on raw materials.

7.6 References

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8 Manufacture of Cement

8.1 Scope and current leakage list position

8.1.1 Sector definition

The manufacture of cement is classified under the following NACE code¹²⁷ (Table 8.1).

Table 8.1 NACE classification of the manufacture of cement sector

NACE Rev 1.1. Classification	NACE Rev 2 Classification
26.51 Manufacture of Cement	23.51 Manufacture of Cement

Source: Eurostat (2008)

8.1.2 Type and homogeneity of products

Cement is a relatively homogenous product and producers of cement essentially compete on price alone due to the lack of product specialisation. However, to date, high transportation costs relative to product value have led to the creation of regional markets largely protected from international competition; despite large regional variations in production costs.¹²⁸ Since the EU ETS started in 2005, the number of cement installations that have participated in the scheme is 247.¹²⁹ Out of these 40 cement installations have closed after the year 2005; however 5 new installations have opened up until the year 2012. Another 5 installations will enter the scheme from 2013 onwards. In the current leakage list, the manufacture of cement is defined as being at a significant risk of carbon leakage for reasons of induced carbon costs (Table 8.2).

Table 8.2 Status in current leakage list, values for carbon cost and trade intensity

NACE 1.1 Code	Direct Cost	Indirect Cost	Total Cost	Trade Intensity
26.51	41.1 %	4.4 %	45.5 %	6.8 %

Source: COM (2009)

8.2 Characteristics of sector

8.2.1 Overview

The following statistics below summarises the performance of the cement sector in the EU-25 in 2010:

- Production value: €16.2 billion (Eurostat, 2013)
- Production: 182.7 million tonnes (Cembureau, 2013a)
- Number of enterprises: 386 (Eurostat, 2013)
- Number of employees: 40, 696 (direct jobs) (Eurostat, 2013)
- Added value: €6.1 billion (Eurostat, 2013)

Manufacturers of cement have been going through a process of consolidation and globalisation: The largest five cement producers (i.e. Lafarge, Holcim, CNMB, Anhui Conch and Heidelberg

¹²⁷ The PRODCOM code for cement clinker is 23511100

¹²⁸ High transport costs relative to product value are a barrier to carbon leakage, however it is important to compare this cost with production costs outside of the EU.

¹²⁹ The number of installations was calculated as part of a NACE matching exercise, which was completed for the European Commission. Included within this figure are 11 installations from Bulgaria/Romania since 2007 and 6 from the UK since 2007 (opt-out).

Cement) account for a large share of global production. For example, the cement production capacity of Lafarge alone was 223 million tonnes in 2011 (Lafarge, 2012). Given the growth in demand in developing countries, cement producers are increasing their presence in non-EU markets. These firms typically operate multiple plants across different countries, which allows for internal balancing of supply and demand and optimised decision making based on relative production costs, inland transportation costs and, crucially, capacity availability (Cook, 2011).

8.2.2 Production process

Cement is produced in two steps: first, clinker is produced from raw materials. In the second step cement is produced from clinker. The first step can be a dry, wet, semi-dry or semi-wet process according to the state of the raw material.¹³⁰

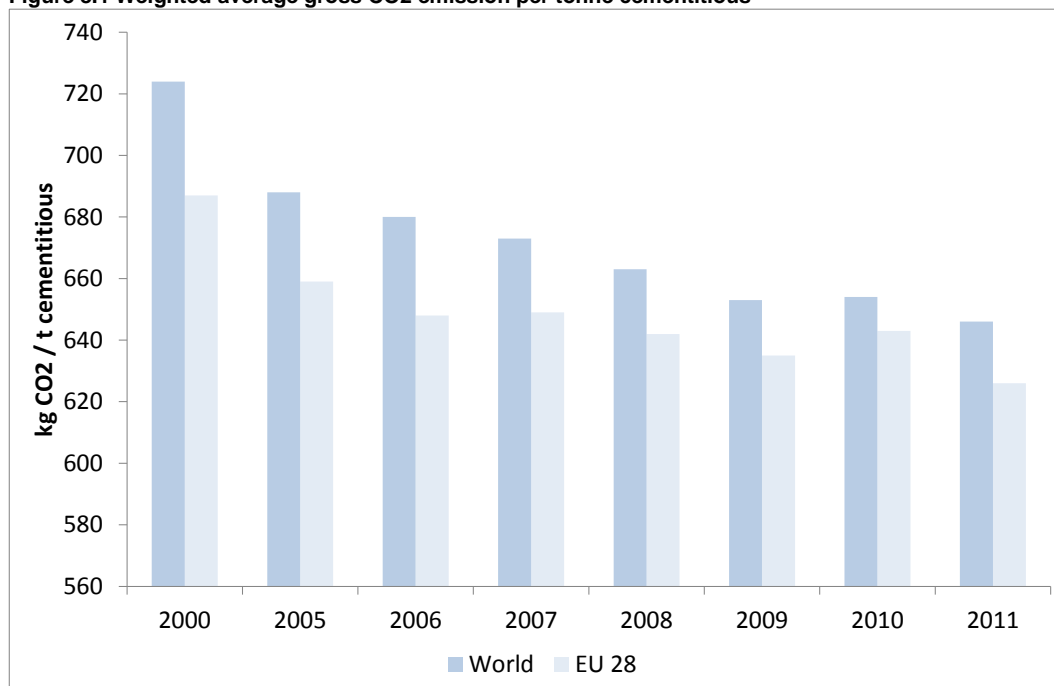
1. Clinker production: 'The raw materials are delivered in bulk, crushed and homogenized into a mixture which is fed into a rotary kiln. Four basic oxides make cement clinker: calcium oxide (65%), silicon oxide (20%), alumina oxide (10%) and iron oxide (5%). These elements mixed homogeneously will combine when heated by the kiln at a temperature of approximately 1450°C' (Cembureau, 2013b). The final product is called clinker.
2. Cement production: 'Gypsum (calcium sulphates) and possibly additional cementitious (such as blast furnace slag, coal fly ash etc.) or inert materials (limestone) are added to the clinker in a cement grinding mill. All constituents are ground leading to a fine and homogenous powder' (Cembureau, 2013b).

8.2.3 Carbon dioxide emissions

Given that clinker production is responsible for about 90 % of the energy consumed in the making of cement, reducing the ratio of clinker to final cement produced by mixing clinker with additives can considerably lower the amount of energy used in the manufacturing process. Figure 8.1 illustrates a declining trend in the specific emissions associated with cementitious production between 2000 and 2011 for both the EU-28 and the world average.

¹³⁰ According to Boston Consulting Group (2013) 'Over the past decades, the cement industry in Europe has heavily invested in kiln technology with now more than 90 percent of the kilns being highly efficient dry kilns, and less than 10 percent semi-wet and wet kilns'

Figure 8.1 Weighted average gross CO2 emission per tonne cementitious¹³¹



Source: WBCSD (2013)

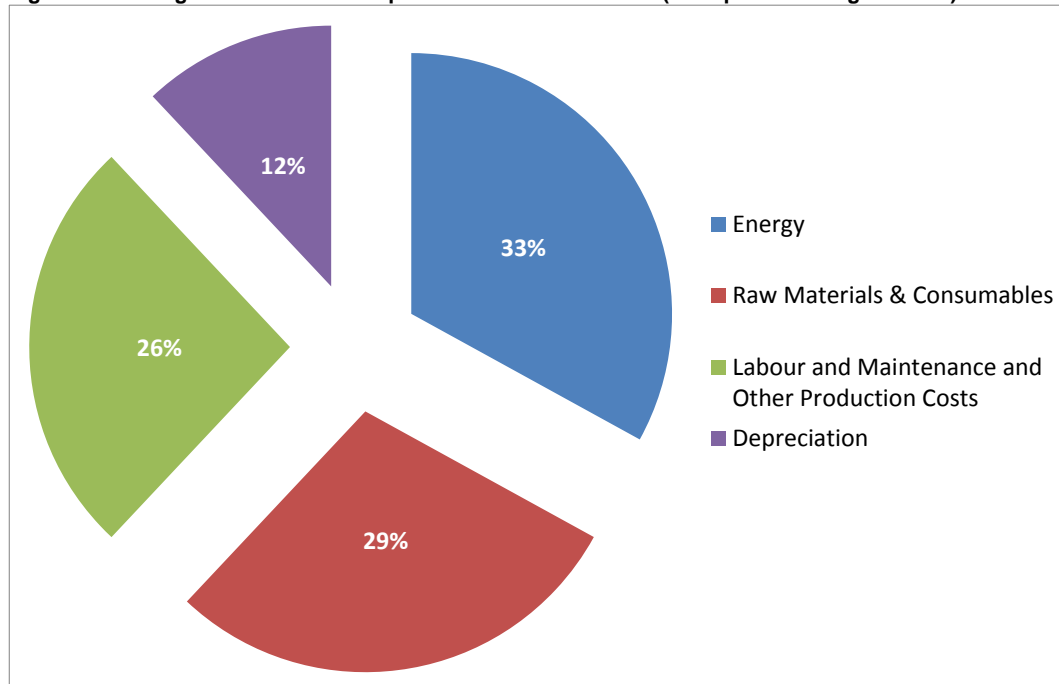
8.2.4 Cost structure

Figure 8.2 shows the average breakdown of cement production costs (before distribution and administrative costs) for Lafarge in 2012. It is evident that energy costs represent the highest share of production costs (i.e. 33 %) and reflects the very energy intensive nature of the industry. Fuels and electricity are the two main types of energy used in cement manufacture. Electricity represents up to 20% of the overall energy use. Traditionally, the primary solid fossil fuels used are coal and petroleum coke (about 40% of heat generation) (JRC IPTS, 2013). A wide range of other solid, liquid or gaseous fossil fuels are used, such as lignite, natural gas and oil (heavy, medium or light fuel oil). Moreover, the cement industry has been using large quantities of waste fuels or biomass fuels (JRC IPTS, 2013). The extraction from quarries of raw materials necessary for cement making (i.e. calcium, carbonate, silica alumina and iron ore) represent 29 % of the average breakdown of production costs for Lafarge in 2012. This cost can vary depending upon land usage, rate of consumption of raw materials and the method required for extraction.¹³²

¹³¹ Cementitious products are all clinker volumes produced by a company for cement making or direct clinker sale, plus gypsum, limestone, CKD, and all clinker substitutes consumed for blending, plus all cement substitutes produced. Clinker bought from third parties for the production of cement is excluded.

¹³² According to the Boston Consulting Group (2013), production costs for the cement sector between 2007 and 2011 have increased in terms of labour (6 %), electricity (12 %) and other intermediates (10 %). The report also suggests that operating costs in Europe are higher than in Asia but lower than in North America.

Figure 8.2 Average breakdown of the production cost of cement (example for Lafarge in 2012)



Source: Lafarge (2012)¹³³

8.3 Evidence of production shift / relocation

8.3.1 Development of production and import/export

Figure 8.3 illustrates the trend in global cement production, which has increased year on year from 1.7 billion tonnes of cement in 2001 to 3.3 billion tonnes in 2010 (Cembureau, 2013a). In comparison to this growing trend in global production, the EU-25 production remains relatively flat between the 2001 and 2010 – with production levels declining slightly from the peak in 2007 due to the economic recession. Asia¹³⁴ accounted for the highest share of global cement production in 2010 (78 %) followed by Europe¹³⁵ (8 %), America¹³⁶ (7 %) and Africa (4 %). It is important to acknowledge that world exports of cement only accounted for approximately 5 % of total production in 2010, reflecting both the homogenous nature of cement products and the difficulty with transporting the heavy product over long distances. However, given the fluctuations in supply and demand within local markets traded cement is still essential to balance demand.

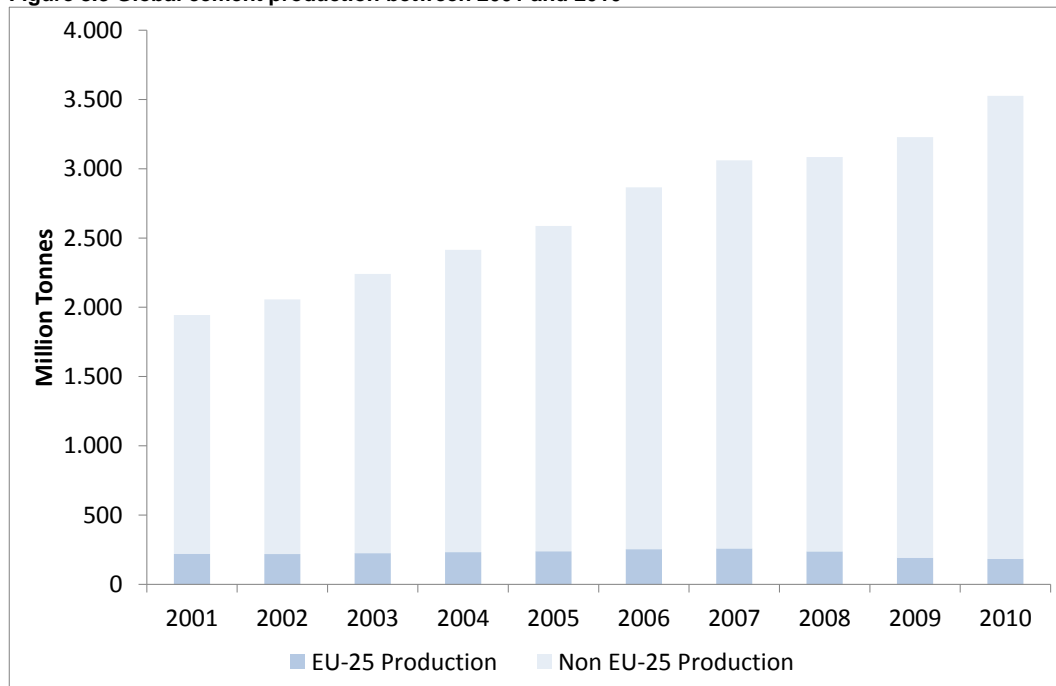
¹³³ The cost structure of cement production is only representative of Lafarge in 2012, which operates in 58 countries 116 cement plants, 39 clinker grinding plants and 6 slag grinding plants. Cost structures will vary from one company to another.

¹³⁴ China and India accounted for 56 % and 7 % of global cement production respectively in 2010.

¹³⁵ In the Cembureau (2013a) statistics Europe includes non-EU countries. When the region is disaggregated further the EU-25 accounts for 5 % of global cement production in 2010. Turkey alone represented 2 % of global production in 2010.

¹³⁶ The USA and Brazil both accounted for 2 % of global cement production in 2010.

Figure 8.3 Global cement production between 2001 and 2010



Source: Cembureau (2013a)

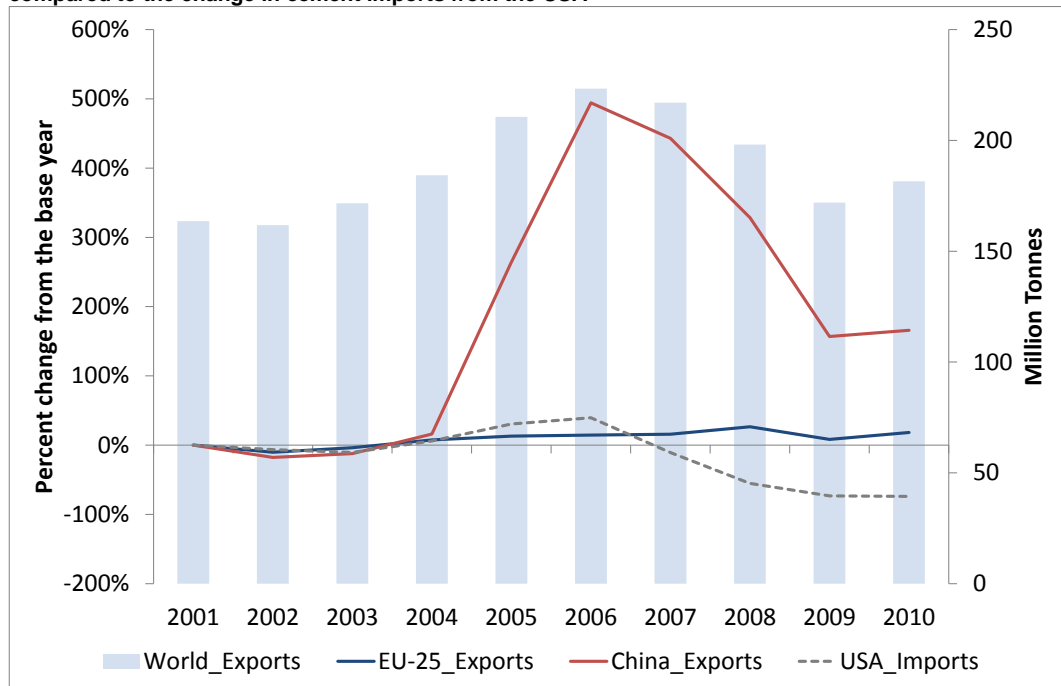
In contrast to the year on year growth in global cement production, Figure 8.4 shows an abrupt decline in world exports (i.e. the blue bars) after reaching a peak of 223 million tonnes in 2006. The USA is a net importer of cement, however following the collapse of the housing market in the country the demand for cement and therefore imports (i.e. dotted grey line) declined and in 2010 cement imports in terms of quantity were 74 % less than levels in 2001.¹³⁷ China is a net exporter of cement products and it is evident from Figure 8.4 that exports (i.e. red line) have increased considerably since 2001, however it is important to acknowledge that China's growth started from a low base (i.e. China only exported approximately 6 million tonnes of cement in 2001) and has more recently been affected by the reduced demand in the USA. As a consequence, China's share of the world export market has reduced from 15 % in 2007 to 9 % in 2010. A further explanatory factor for the recent decline in China involves the government's decision to phase out small, inefficient plants and remove subsidies on exported cement thus impacting on export levels (China Daily, 2012). Although exports in the EU-25 (i.e. blue line) have declined since 2008, in relative terms European exports have not decreased as sharply as in China.¹³⁸

Figure 8.5 shows the growth in clinker capacity for key countries in the context of rising global exports in clinker products. China has increased clinker capacity by 191 % between 2000 and 2011 and the country can now produce over 160 million tonnes of clinker product annually (USGS, 2013). In absolute terms clinker capacity in China has increased from 550 million tonnes in 2000 to over 1.6 billion tonnes in 2010. India and Turkey have also experienced high rates of growth in clinker capacity between 2000 and 2010. A decline in clinker capacity in Germany is primarily due to a plant closure in 2002 before the implementation of the EU ETS – after which capacity remained stable throughout the time series in Figure 8.5.

¹³⁷ In comparison, imports of cement for the EU-25 initially increased from 28.3 million tonnes in 2001 to 38.8 million tonnes in 2007 – however this declined to 20.1 million tonnes in 2010 (Cembureau, 2013).

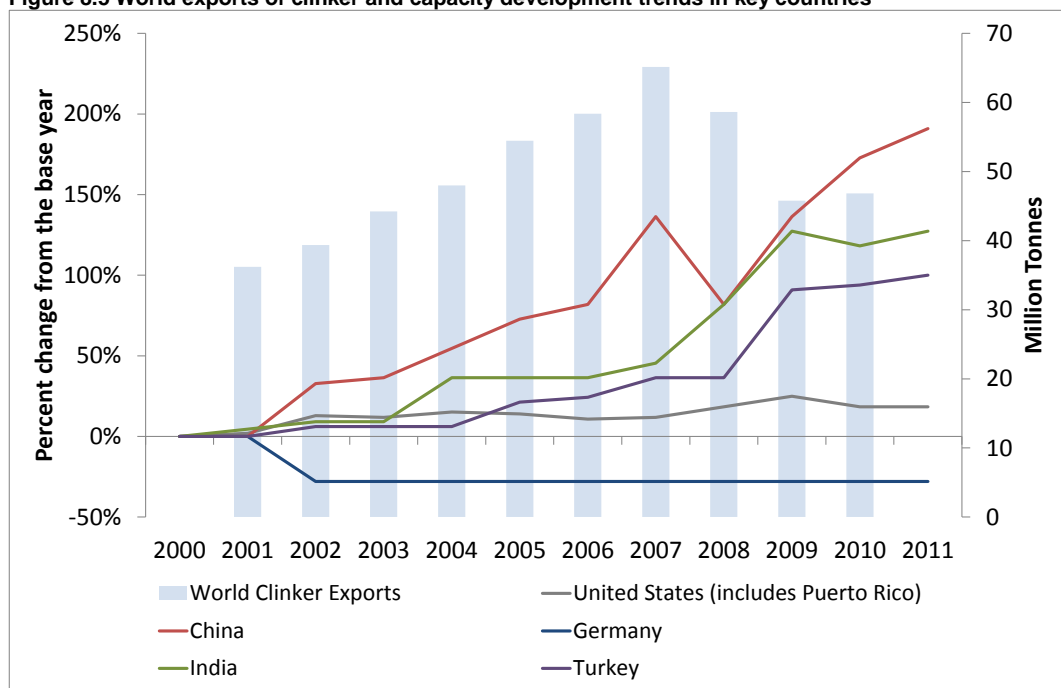
¹³⁸ In absolute terms the EU-25 exported 32.5 million tonnes cement in 2010, compared to 16.2 million tonnes in China (Cembureau, 2013a)

Figure 8.4 Change in cement exports of the World , China and the EU-25 between 2001 to 2010 compared to the change in cement imports from the USA¹³⁹



Source: Cembureau (2013a)

Figure 8.5 World exports of clinker and capacity development trends in key countries¹⁴⁰



Source: USGS (2013), Cembureau (2013a)

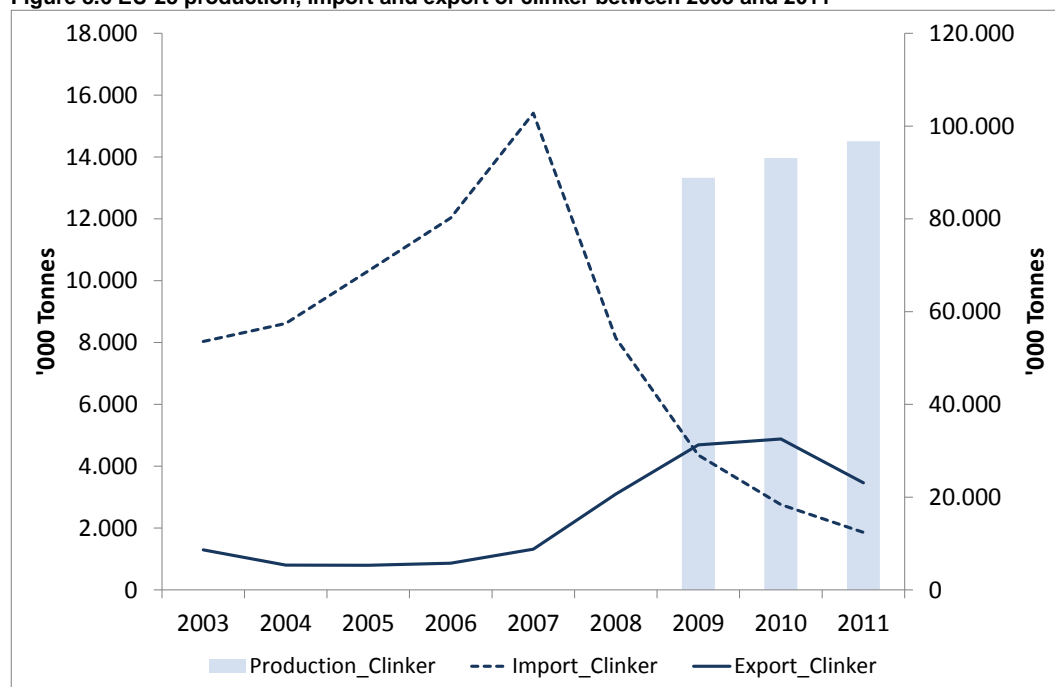
There is a growing concern that clinker production is increasingly re-locating outside of the EU-25 to benefit from lower electricity costs and less stringent environmental legislation. The Boston Consulting Group (2013) suggests that approximately 60 % of the total European clinker and

¹³⁹ World exports of cement is on the secondary y-axis with exports from the EU-25 and China and imports from the USA on the primary y-axis.

¹⁴⁰ World clinker exports on the secondary y-axis and capacity development trends are on the primary y-axis.

cement production may be vulnerable to competition from imports as the plants are located less than 150-200 km from coast or inland ports – which would be an economically viable distance to transport clinker product. Before the recession it is evident that EU-25 imports of clinker were increasing year on year, however this trend reversed abruptly after the economic recession and up until 2011 the EU-25 was actually net exporting clinker (Figure 8.6).¹⁴¹

Figure 8.6 EU-25 production, import and export of clinker between 2003 and 2011¹⁴²



Source: Eurostat (2013)

8.3.2 Development of investment

Table 8.3 shows how investment as a proportion of turnover has remained stable in the EU-25 between 2000 and 2008 before declining slightly in 2010 due to the economic recession. Given the slower growth rates in home markets, the largest cement firms are increasingly buying firms in developing countries to enter new markets with faster growth rates.¹⁴³ This appears to be the key factor in the investment decisions of cement producers.

Table 8.3 Comparison of investment as a proportion of turnover for the manufacture of cement with total manufacturing in the EU-25

	2000	2002	2004	2006	2008	2010
Manufacture of Cement	9 %	9 %	8 %	7 %	9 %	6 %
Total Manufacturing	4 %	3 %	4 %	3 %	3 %	3 %

Source: Eurostat (2013)

¹⁴¹ However, Cembureau argue strongly that the decrease in imports (from its peak in 2007) and the increase in exports are purely a consequence of the dramatic fall in clinker demand in the EU-25 countries in recent years. It is important to acknowledge that the economic recession has considerably changed the normal import and export trends in the industry.

¹⁴² EU-25 production data for clinker is not available from Eurostat (2013) prior to the year 2009. The primary y-axis shows imports and exports of clinker for the EU-25 whilst the secondary y-axis shows clinker production data for the EU-25.

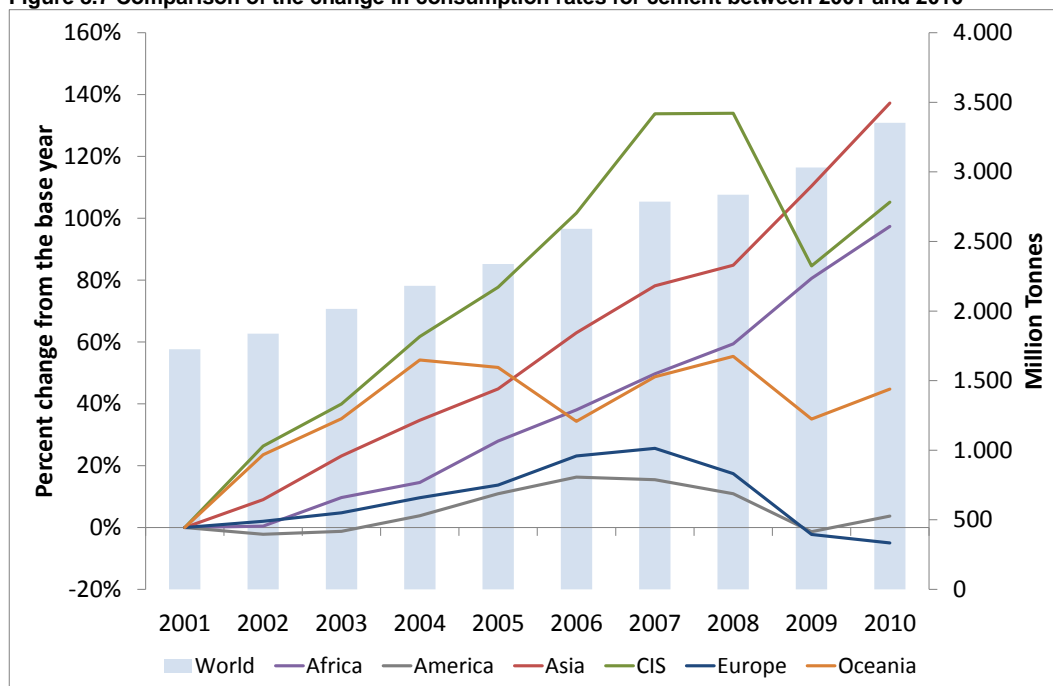
¹⁴³ 'Holcim, based in Switzerland, now rakes in around 70% of profits from the developing world; Lafarge, of France, is not far behind' (The Economist, 2013).

8.4 Drivers for relocation

8.4.1 Development of demand

Figure 8.7 shows the rapid growth in the consumption of cement in China (i.e. red line) and India (i.e. purple line) compared to the lower growth in the EU-25 (i.e. blue line) and the USA (i.e. grey line) until 2007/2008 and the subsequent decline in consumption in the latter two. In 2010, the consumption of cement in the EU-25 was approximately 19 % lower than in the year 2001. However, between 2009 and 2010 demand has again steadied out. Overall, world demand for cement has continuously increased between 2001 and 2010.

Figure 8.7 Comparison of the change in consumption rates for cement between 2001 and 2010



Source: Cembureau (2013a)

8.4.2 Development in relation to EU ETS

Figure 8.8 shows the direct emissions resulting from the manufacture of cement, clinker or lime between 2005 and 2011 and so covers a wider scope of activities than just cement production.¹⁴⁴ It is evident that for every year under the EU ETS, the verified emissions have been lower than the annual allocation of free EUAs. As a consequence the cement, clinker or lime producers participating in the EU ETS from 2008 onwards received allowances equivalent to a value of €2.8 billion that were not required given the actual emissions levels.¹⁴⁵ Whether the revenues from selling these allowances were used to invest into abatement technology in order to reduce the specific emissions of cement production as claimed by the cement industry¹⁴⁶ can not be assessed with the given data. Although it is evident from Figure 8.8 that specific emissions of cement production have declined in Europe (at a faster rate than the world average) it is not possible to fully attribute the impact of investments in abatement technology to this trend without further information from industry. The indirect impacts of the EU ETS are more difficult to determine (i.e. the impact on

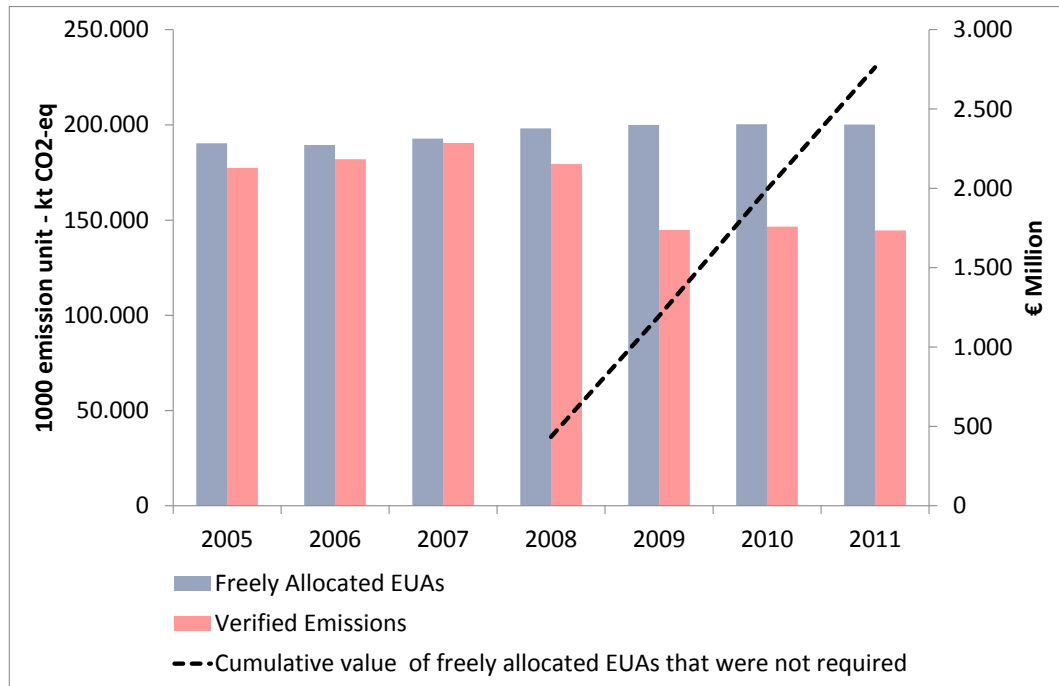
¹⁴⁴ Direct emissions from cement account for 83 % of the total direct emissions for both the manufacture of cement and lime (average between 2008-11).

¹⁴⁵ Calculated by multiplying the unused allowances in a year by the average EUA y+1 price for the 2008-11 time period

¹⁴⁶ Cembureau have calculated a proxy for 'investment in reduction of CO₂ emissions' as a proportion of total investment for the cement sector. Cembureau collected this data from their members (accounting for 70 % of cement production in the EU) and calculated an aggregate figure of 16.7 % (equal to €1.1 billion) for the period between 2007 and 2012.

raw material and electricity costs) as is the impact of the EU ETS on long term investment decisions.

Figure 8.8 Direct costs of EU ETS compliance for the manufacture of cement, clinker or lime in the EU-25



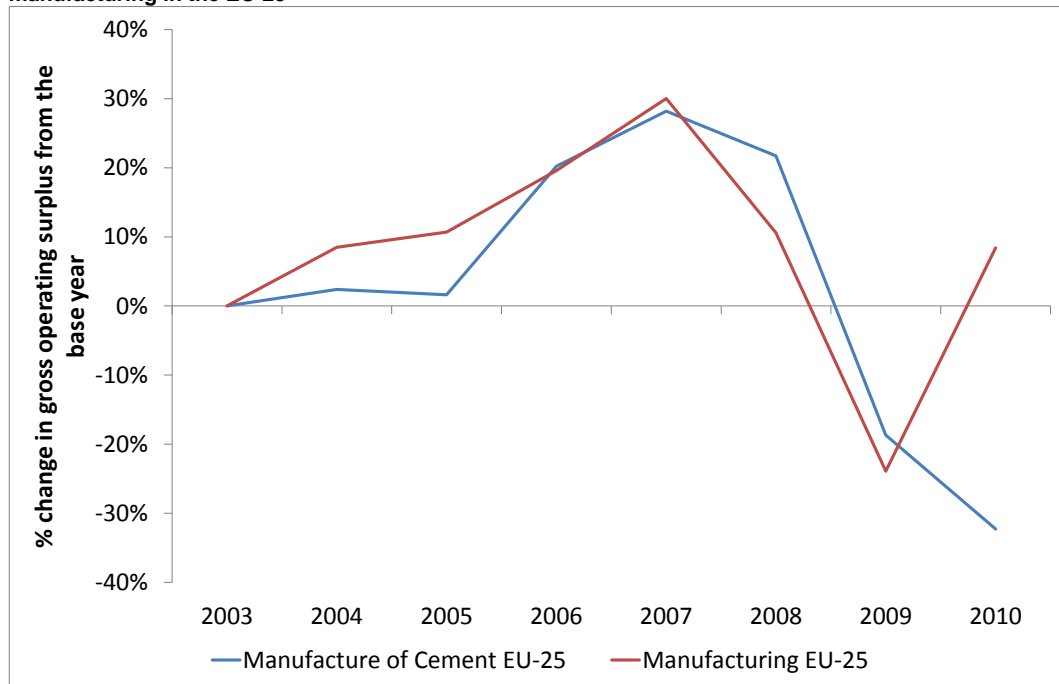
Source: EEA (2013), EEX (2013)

8.4.3 Development of gross operating surplus

Figure 8.9 shows the change in the gross operating surplus for the manufacture of cement and total manufacturing in the EU-25.¹⁴⁷

¹⁴⁷ In absolute terms the gross operating surplus for the cement sector increased from €4.9 billion in 2003 to €6.3 billion in 2007. Following the economic recession the gross operating sector fell to €4.0 billion in 2009 before declining further in 2010 (Eurostat, 2013).

Figure 8.9 Change in the gross operating surplus for the manufacture of cement and total manufacturing in the EU-25



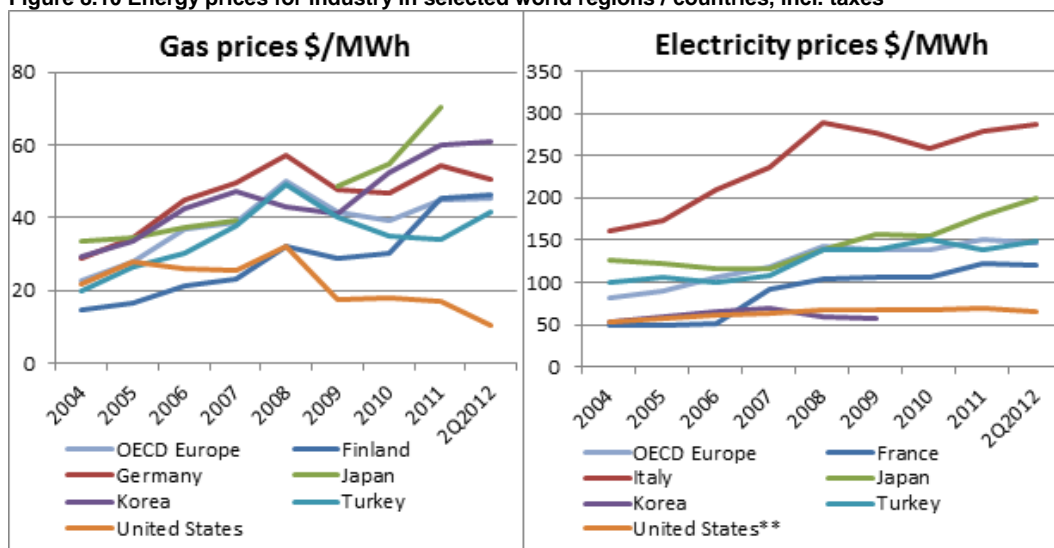
Source: Eurostat (2013)

Until the economic recession it is evident that the cement sector in the EU-25 performed strongly in terms of the gross operating surplus. The steep decline in the profits of the cement sector in the EU-25 after 2008 demonstrates the importance of economic growth (and thus demand) as a key driver of demand for cement. As the cement sector is highly capital intensive, returns to capital (or profits/operating surplus) play a key role for new investment.

8.4.4 Development of energy prices

An international comparison of energy products is possible for OECD countries based upon statistics published by the IEA (2012) as shown in Figure 8.10 below. It is evident that the USA may have a competitive advantage. For example, the cost of natural gas for industry in the USA was considerably cheaper in 2011 compared to OECD Europe and other countries or regions. Of the countries considered, prices for natural gas were highest in Germany, Korea and Japan. Electricity costs were also lower in the USA than in OECD Europe and other countries and regions. Unlocking the potential of shale gas in the USA is the main driver for this price differential. Both electricity and gas prices roughly doubled in most countries in the selected period, except for the US. It should be noted though that the dollar lost about 20% of its value against the Euro in the same time frame, so part of the cross-country differences can also be explained by currency fluctuations.

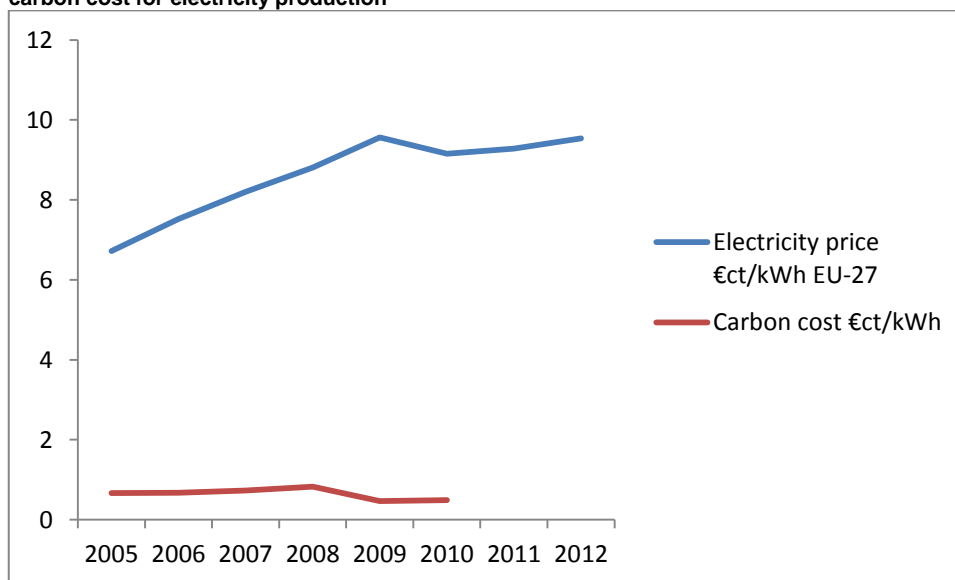
Figure 8.10 Energy prices for industry in selected world regions / countries, incl. taxes¹⁴⁸



Source: IEA Energy Prices & Taxes, 4th quarter (2012)

Although the extent to which electricity producers passed through CO₂ costs into electricity prices is uncertain empirical analyses have shown that the EU ETS has increased electricity prices (Keppler et al., 2010; Fell, 2010). However, with EUA prices on a downward trend due to the oversupply of allowances the impact on electricity prices is currently lower than before the economic recession. The order of magnitude compared to other electricity price drivers is low, as can be seen in the picture below. It should be noted that the energy prices within Europe vary considerably as well.

Figure 8.11 Electricity prices for industrial consumers in the EU-27, excluding taxes; compared to carbon cost for electricity production



Source: Eurostat Energy Statistics, EEX, EEA, IEA.¹⁴⁹

¹⁴⁸ Definition: Prices and taxes for the industry sector are the average of amounts paid for the industrial and manufacturing sectors. ** Electricity price data for the US excludes taxes. Note that there are data gaps for Japanese gas price data and Korean electricity price data. OECD Europe comprises Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

¹⁴⁹ Electricity prices shown are the average prices in Euro per kWh without taxes applicable for the first semester of each year for medium size industrial consumers (Consumption Band Ic with annual consumption between 500 and 2000 MWh). Until

8.4.5 Econometric analysis to test for the presence of carbon leakage

Econometric analysis of the relationship between net imports of the cement industry and the price of carbon was carried out to test for evidence of carbon leakage. The analysis controlled for other factors that influence net imports (notably the level of activity in the EU market). The hypothesis is that carbon leakage would be evident from a statistically significant positive relationship between our measure of carbon leakage, net imports, and the price of carbon. If this was the case then a high carbon price would displace production outside of the EU through a loss of competitiveness.

The econometric analysis did not find a statistically significant relationship between the price of carbon measured by the EU ETS price and net imports. An examination of the developments of net imports in the cement industry over time reveals that net imports have been falling over time since the recession while the price of carbon has experienced some increases over the same period as well as some falls. As an alternative, one and two year ahead prices for the price of carbon were used as forward- looking measures of carbon prices, but this did not change the results of the analysis.

8.4.6 Development of output prices

Figure 8.12 shows the development of the average EU-25 cement price between 2005 and 2010 based upon a simple calculation using data publically available from Eurostat (2013).¹⁵⁰ Until 2007 the average cement price in the EU-25 steadily increased peaking at €87 / tonne before declining to a value of €84 / tonne in 2010. Cement demand is relatively inelastic to variations in price, but more responsive to trends in the construction sector of a country (Deutsche Bank, 2011). Given that for several years global cement production capacity increased at a faster rate than sales in cement (based upon ambitious forecasts for construction growth), the sharp drop in demand as a consequence of the economic recession exacerbated the issue resulting in surplus capacity globally. In such circumstances, competition amongst cement producers should increase and product prices should decline along with rates of capacity utilisation¹⁵¹. However, Figure 8.12 shows that prices have decreased much less than production.¹⁵² Due to the limiting factor of transport costs and the oligopolistic market structure, certain competitors from third countries are not in a position to take advantage of their cheaper production costs in order to increase market share.¹⁵³

2007 the prices are referring to the status on 1st January of each year for medium size consumers (Standard Consumer Ie with annual consumption of 2 000 MWh). Note that prices can be expected to be lower for large size industrial consumers. Carbon cost is calculated by taking data from IEA on carbon emissions per kWh of electricity in OECD Europe; this quite precisely coincides with EU-27 data from the EEA, but has less data gaps. These values are multiplied by the EU allowance unit forward price (ETS emission forward price, used here because it is more stable than the spot price).

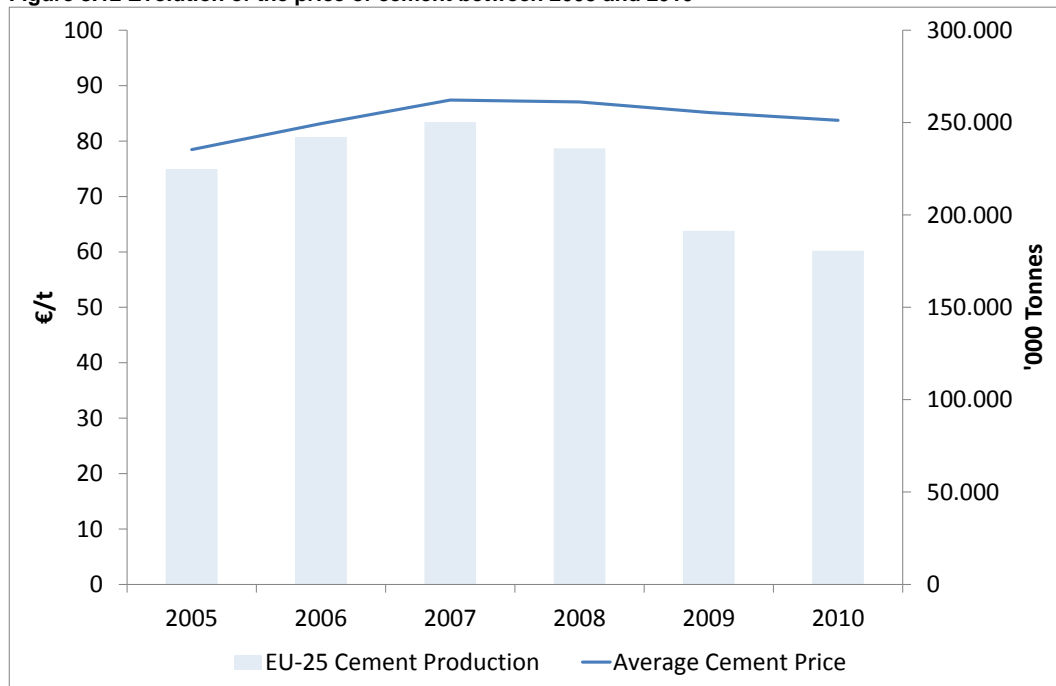
¹⁵⁰ Average cement price as a simple average of EU-25 value in Euro for turnover (less intra EU-25 imports of cement including clinker), divided by EU-25 cement production in tonnes.

¹⁵¹ According to the Boston Consulting Group (2010) capacity utilisation in the European cement industry across the main European countries was less than 60 % in 2010.

¹⁵² Cembureau argue that the price of cement in the EU-25 drops more considerably after 2010, however at the time of publishing this could not be confirmed as data after 2010 was not available from Eurostat.

¹⁵³ In December 2010, the price of Chinese cement was \$56 / t compared to €75 / t for the Average Western European price (Dixon, 2011)

Figure 8.12 Evolution of the price of cement between 2005 and 2010



Source: Eurostat (2013)

Given that the cement sector is characterised by having inelastic demand and an oligopolistic market structure it is likely that pass-through rates are relatively high, and thus more able to pass costs into prices and maintain profit levels. This is especially the case for inland producers that are less vulnerable to competition due to high inland transportation costs. Competition may be more of an issue for coastal producers or producers on the periphery of the EU as imports tend to set prices in these locations. The role of geography is therefore an important consideration in the discussion on cost pass through in the cement sector.

8.5 Synthesis

Using all of the evidence from the previous sections, Table 8.4 and Table 8.5 provide a short overview of the main important sector characteristics and potential drivers of relocation.

Table 8.4 Evidence for (production) relocation

Indicator for (production) relocation	Trend	Additional information on trend
Net imports	High up to 2007, decreased, especially in clinker products in the since the economic recession.	Before the economic recession imports were rising for cement products, however the economic recession has completely reversed this trend up to 2011. Information on recent years would be needed to assess whether trends persist.
Investment activity in EU compared		China and India have built up

Indicator for (production) relocation	Trend	Additional information on trend
to outside EU		significant production capacity in recent years
ETS Installations	Cement plants have closed since 2005 – however hard to attribute this to the EU ETS.	
Summary: evidence for (production) relocation	Limited evidence of a shift in production between 2000 and 2012 with imports of clinker into the EU-25 declining over the period.	

Table 8.5 Drivers for (production) relocation

Drivers for (production) relocation	Assessment	Justification of assessment
Carbon cost	The carbon cost does not appear to have had a significant influence on cement exports.	Direct carbon costs have been low. Due to the energy input structure indirect costs are of lower importance.
Other costs: energy	Some influence	Coal and coke use takes a large share of energy consumption. Price differs across regions.
Pass-through of costs	Possible in certain circumstances	Depends on geographical location, where transport costs acts as a barrier to international competition
World demand	Important	EU demand has decreased in recent years (during the economic recession), while world demand has continued to increase in particular, in India and China.
Summary: CO ₂ cost among the relevant drivers?	Over the 2005 to 2012 period CO ₂ cost is not among the relevant drivers. The cement industry has received free allowances during this time period.	The main drivers appear to be shift of world demand and economic growth

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9 Clay building materials

9.1 Scope and current leakage list position

9.1.1 Sector definition

The definition of the clay building materials sector, based on the NACE classification, is presented in the table below.

Table 9.1 Definition of the sector on NACE Rev.2 and NACE Rev. 1.1

NACE Rev. 2 Classification	NACE Rev. 1.1 Classification
23.3 Manufacture of clay building materials	No corresponding sector at 3-digit level
<i>incorporating</i>	<i>incorporating</i>
23.31 - Manufacture of ceramic tiles and flags	26.3 - Manufacture of ceramic tiles and flags
23.32 – Manufacture of bricks, tiles and construction products in baked clay	26.4 – Manufacture of bricks, tiles and construction products in baked clay

Sources:

Eurostat (2008), *NACE Rev.2 Statistical classification of economic activities in the European Community*, Luxembourg: Office for Official Publications of the European Communities;

Eurostat, Correspondence table NACE Rev. 2 - NACE Rev. 1.1 at:

http://epp.eurostat.ec.europa.eu/portal/page/portal/nace_rev2/documents/52249E90762B69F8E0440003BA9322F9.xls.

9.1.2 Type and homogeneity of products

Ceramics are a very diverse group of products broadly defined as ‘non-metallic inorganic materials that lend themselves to permanent hardening by high temperatures’ (Peterson, 2003). Within the industry for ceramics products the two largest sub-sectors are those concerned with the production of wall and floor tiles (23.31), and with the production of bricks and roof tiles (23.32); these accounted for 32% and 21% of EU27 production by value in 2011. Production within the sector for clay building materials relies heavily on demand derived from the construction sector

The ceramic tiles and flags subsector comprises the manufacture of the various types of wall and floor tile, which can be shaped, sized, styled and finished (glazed) in a variety of ways to enhance the final product. Additionally, the subsector for the manufacture of bricks, tiles and construction products in baked clay is similarly varied in its product output due to particular regional traditions of manufacture and the range of end uses. Differing cultures and climates mean the specifications of bricks, blocks and tiles produced in the EU vary across the Member States. These different techniques of manufacture have led some brickyards to specialise in various groups of products.

Clay based ceramics may be made up of a single clay or several, mixed with mineral modifiers such as powdered quartz and feldspar. Common clay minerals are hydrated aluminium silicates that have resulted from the weathering of rocks. Clays such as sedimentary clays, shale clay, loamy clay and marl are mostly used for the manufacture of bricks roof tiles and clay pipes. Organic or inorganic auxiliary agents can be added to obtain a greater pore volume. Metallic oxides may also be added to obtain the desired colour for the finished product.

9.1.3 EU ETS coverage

Annex I category of activities, with clarification	NACE code (Rev. 2)	Description (NACE Rev. 2)
Installations for the manufacture of ceramic products by firing, in particular roofing tiles, bricks, refractory bricks, tiles, stoneware or porcelain, with a production capacity exceeding 75 tonnes per day, and/or with a kiln capacity exceeding 4 m3 and with a setting density per kiln exceeding 300 kg/m3	23.31 23.32	Manufacture of ceramic tiles and flags Manufacture of bricks, tiles and construction products in baked clay

For the relevant subsectors for the clay industry, government interpretation of the ETS schema established the following arrangements in Member States responsible for large shares of European production. In Italy, all producers in the wall and floor tiles sub-sector and the large majority of those in the bricks and roof tiles sub-sector were out of the ETS during phase 1 and phase 2. In Spain, the majority of brick and roof tile producers were in during both phase 1 and phase 2 but around 20% of their production was outside of the ETS. For Germany, the majority of brick producers were in for phase 1 and 2 while roof tile producers were out and for the UK and the Netherlands, the majority of brick and roof tile producers were out during phase 1 but in during the second phase of the ETS¹⁵⁴.

9.1.4 Status in the current leakage list

The future-oriented carbon leakage assessment for the third phase, valid at the moment, was carried out at the 4-digit NACE level, using the NACE 1.1 revision. This is presented in the table below.

Table 9.2 Quantitative assessment for original carbon leakage list (2009)

NACE Rev. 1.1 sector	Direct Cost	Indirect Cost	Total Cost	Trade Intensity
26.3 (Ceramic tiles and flags)	>5%	1.5 %	>5% and <30%	28.6%
26.4 (Bricks, roof tiles etc.)	8%	1.7 %	9.8%	2.7%
Article 10a(15) threshold			≥5%	AND >10%
Article 10a(16) threshold			≥30%	OR >30%

Notes: A sector or sub-sector is deemed to be at a significant risk of carbon leakage if either the additional costs induced by the implementation of the Directive would lead to a cost increase exceeding 5% of its gross value added and trade intensity of the (sub-)sector concerned exceeds 10%, or if one of the two criteria exceeds 30%. Data indicated in the Community Independent Transaction Log was considered the most accurate, reliable and transparent source for estimations of GHG emissions used in calculation of the direct cost. Data provided from Member States on electricity consumption was used to calculate indirect costs from higher electricity prices. The trade intensity refers to the total value of a sector's exports and imports divided by the total value of its turnover and imports.

Sources: COM (2009), Impact assessment of Commission Decision determining a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage pursuant to Article 10a (13) of Directive 2003/87/EC (2010/2/EU), SEC(2009) 1710¹⁵⁵.

Based on the quantitative criteria set out in Article 10a(15) of Directive 2003/87/EC, the ceramic tiles and flags sector was included on the currently valid carbon leakage list¹⁵⁶ because the trade

¹⁵⁴ Cerame Unie

¹⁵⁵ Available at: http://ec.europa.eu/clima/policies/ets/cap/leakage/docs/sec_2009_1710_en.pdf

¹⁵⁶ Available at: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:001:0010:0018:EN:PDF>

intensity and total CO₂ cost (as a proportion of GVA) exceed the assessment thresholds. Meanwhile, the brick and roof tile sector did not qualify for the carbon leakage list based on the mentioned quantitative criteria, as the trade intensity was lower than 10% and total CO₂ cost (as a proportion of GVA) was less than 30%. In 2011, however, based on an assessment of the qualitative criteria referred to in Article 10a(17) of the Directive¹⁵⁷, the brick and roof tile sector was deemed to be exposed to a significant risk of carbon leakage and was included in the list.

9.2 Characteristics of sector

9.2.1 Production value and employment

The EU sector for clay building materials is diverse with regard to the range of products manufactured and the technologies relied on for the production process, serving a range of markets within and outside the EU. In 2010, the sector was responsible for €16.7bn of production and employed 115,000 people in the EU25 a marked reduction on the peak of 156,000 in 2008. This amounts to 0.3% of total manufacturing production in the EU25 (€5,755bn in 2010) and 0.43% of all manufacturing employees (26.6m in 2010). There were approximately 4,000 enterprises in operation concerned with the manufacture of clay building materials in 2010; around one third were in the ceramic tiles and flags sub-sector. One important feature of the sector is the importance of small and medium-sized enterprises. Around 97% were SMEs (1-249 employees) and roughly 64% were micro-enterprises (less than 10 employees). SMEs have been responsible for the majority of production and have provided the majority of employment for the sector. In 2010 SMEs were responsible for production valued at €7.8bn compared to €7bn from large firms (those with more than 250 employees). In the same year SMEs employed 64,000 workers, significantly more than the 41,000 positions of employment maintained by large firms¹⁵⁸. The available data do not provide detail on the composition of the individual sub-sectors. The qualitative assessment for the bricks and tiles sub-sector for the current carbon leakage list¹⁵⁹ reported that, 'at the EU level SMEs account for around 40% of the market for bricks and roof tiles'. It also noted also that some regional differences exist: in northern Europe production is more concentrated among some multi-national producers, whereas in southern Europe, producers tend to be SMEs.

Today the major producing regions for the sector overall are Germany, the UK, Spain and Italy with Germany a major producer across most of the sub-sectors. Europe had previously been the global leader in producing ceramic wall and floor tiles but has been overtaken in recent years due to a massive expansion in Chinese production capacity. Ceramic tiles production in Europe is geographically concentrated, with the largest centres of production located in Spain and Italy. There is also significant production in Germany, France, the United Kingdom, the Netherlands and Portugal. With regard to production of bricks and roof tiles, the weight and associated transport costs of the products have tended to limit imports and exports and manufacturing is therefore widely distributed across Member States. The number of factories and intensity of production does, however, vary across countries. Spain and Italy had the highest number of enterprises within this subsector in 2010, with 420 and 398 firms respectively compared to Germany, where the corresponding figure was 152, but also where the number of employees per factory tends to be significantly higher. The levels of production for these Member States were broadly comparable and in 2010 Germany in fact led production for the subsector. Production in the new Member States is strongest in the Czech Republic, Poland and Hungary.

¹⁵⁷ The criteria are: (a) the extent to which it is possible for individual installations in the sector to reduce emission levels or electricity consumption; (b) current and projected market characteristics; (c) profit margins (and impact on investment or relocation).

¹⁵⁸ *Structural Business Statistics* database, Industry by employment size class

¹⁵⁹ Available at: http://ec.europa.eu/clima/policies/ets/cap/leakage/docs/qualitative_assessment_en.pdf

9.2.2 Market concentration and general cost structure

The largest companies operating in the clay building materials sector are listed in the table below.

Table 9.3 Largest companies in clay sector (2008)

Wall and floor tiles	Bricks and roof tiles
Atlas Concord (Italy)	CRH (Ireland)
Cooperative Ceramica d'Imola (Italy)	Hanson (UK) ; part of Heidelberg Cement
Marazzi (Italy)	Wienerberger (Austria)
Pamesa Ceramica (Spain)	Imerys (France)
Porcelanosa (Spain)	Terreal (France)
	Monier (Germany)

Sources:

Cerame Unie, Financial Times FT 500 2013;

Ecorys (2008), *Competitiveness of the Ceramics Sector*, available at:

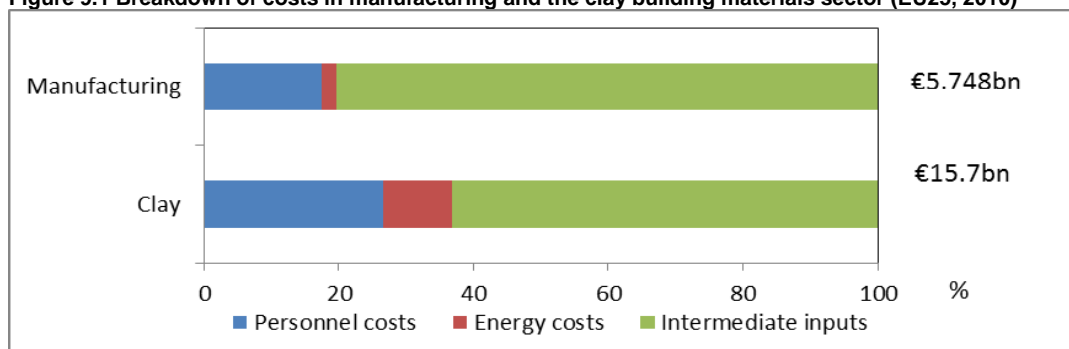
http://ec.europa.eu/enterprise/newsroom/ctrl_getdocument.cfm?doc_id=4043;

EC (2007), Reference Document on Best Available Techniques (BAT) in the Ceramic Manufacturing Industry, available at:

http://eippcb.jrc.ec.europa.eu/reference/BREF/cer_bref_0807.pdf.

In both manufacturing and the clay building materials sector, intermediate inputs are the largest cost item and energy costs are the smallest cost item (see Figure 9.1). But compared to manufacturing, personnel and energy costs in the clay building materials sector account for larger shares of the cost base and intermediate inputs make up a smaller share. The larger share of energy costs in the clay sector, compared to manufacturing makes the structure more exposed to uncertainty and sharp rises in energy prices. Across the two clay sub-sectors, the share of energy costs tends to be a little higher in the brick and roof tile sector. The higher share of personnel costs reflects the fact that, even with increased automation, the sector is still more labour intensive than other manufacturing industries. There remains considerable variation in energy intensity by ceramics sub-sector or product and across Member States, in some cases it can account for over 30% of production costs. In Spain and Germany for example energy costs as a percentage of total costs were around 15% in 2010, significantly higher in comparison to the shares for the UK and Italy, which were 10% and 6% respectively. The share of costs was higher still for Greece and Portugal, at 23% and 25% respectively.

Figure 9.1 Breakdown of costs in manufacturing and the clay building materials sector (EU25, 2010)



Sources:

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2.

9.2.3 Technology and main technical processes

The manufacture of these products takes place in different types of kilns with a general process that is rather uniform, although a multiple stage firing process is often used for the manufacture of wall and floor tiles and for household ceramics. Raw materials are mixed, then pressed or extruded into

shape. The products are then placed into kilns either by hand or placed onto carriages that are transferred through continuously operated kilns. Kilns are mostly powered by natural gas but fuel oil, coal, petroleum coke or electricity may also be used. An irreversible ceramic structure for the product is achieved in the kiln. The temperature gradient needs to be accurate to ensure products are treated correctly and controlled cooling is also necessary to ensure the structure is preserved.

Table 9.4 Main stages in production of clay building materials

Stage	Ceramic tiles and flags	Bricks, tiles and construction products in baked clay
<i>Raw materials</i>		
	Mostly sedimentary clays. Vast diversity in composition depending on location. Calcium oxide	Sedimentary clays and primary kaolin are typical plastic raw materials. Calcite, dolomite and talc, quartz, feldspar are non-plastics. Combined with glaze frits, metal oxides and colourants for glazes. Electrolytes such as deflocculant to reduce energy consumption.
<i>Preparation of raw materials</i>		
	Dry preparation (high grade products; engineering or facing bricks) Semi-wet preparation	Fine grinding or wet preparation (ie ball milling) followed by spray drying into granules. Tiles are predominantly manufactured by use of 'dust pressing powder'. This can be produced through a wet or dry process. 'Extrusion paste' and semi-wet preparation are also possible.
<i>Shaping</i>		
	Pressing, extrusion or soft-mud moulding depending on kind of mass, water content and desired product.	'Extrusion paste' is shaped in an extruder to the right geometry and cut into pieces. 'Dust pressing powders' are shaped in hydraulic presses.
<i>Drying</i>		
	Chamber or tunnel drying	Tunnel dryers, roller dryers or vertical dryers.
<i>Firing and glazing</i>		
	Tunnel kiln mainly in an oxidising atmosphere (Reduction period in final firing sector if special colour effects are needed)	Tiles are made as glazed or unglazed single fired products or as glazed double or even triple fired products.
<i>Subsequent treatment</i>		
	Sometimes treatment with hydrophilic or hydrophobic agents is applied	After the final firing, some types of tiles can be ground or polished.

9.2.4 Supply Chains

The raw materials for clay are widely distributed throughout Europe and so for products such as bricks, which are relatively inexpensive but which incur high transport costs, manufacturing takes place in virtually every Member State. Supply chains thus tend to remain regional in their breadth and in the past geographical clusters of ceramics manufacturing operations have developed due to the need for close proximity to raw materials, fuel and labour supplies. In northern Europe many manufacturers are vertically integrated so that the brick producers are also responsible for the extraction of clay, eliminating an aspect of the supply chain. For both sub-sectors the main

customers operate in the construction sector, and so demand for clay products is heavily influenced by dynamics in this sector.

The products of both clay sub-sectors are finished goods. For the brick and roof tile sub-sector there are four core distribution channels linking producers to consumers; retailers, developers, builders' merchants and specialist brick factors. Prices are reached through negotiation and each distributor tends to source brick supplies from a range of suppliers leading to a high degree of competition.

For the ceramic tiles and flags sub-sector, evidence seems to show that manufacturers have moved to new locations that are closer to markets¹⁶⁰. This helps to reduce the costs associated with distribution as transport can account for up to 10% of total costs. As the sources of some raw materials within the boundaries of the EU become scarcer, some manufacturers have been forced to import more. They can thus be more flexible in their choice of manufacturing location as it is less necessary to be located close to traditional sources of input materials.

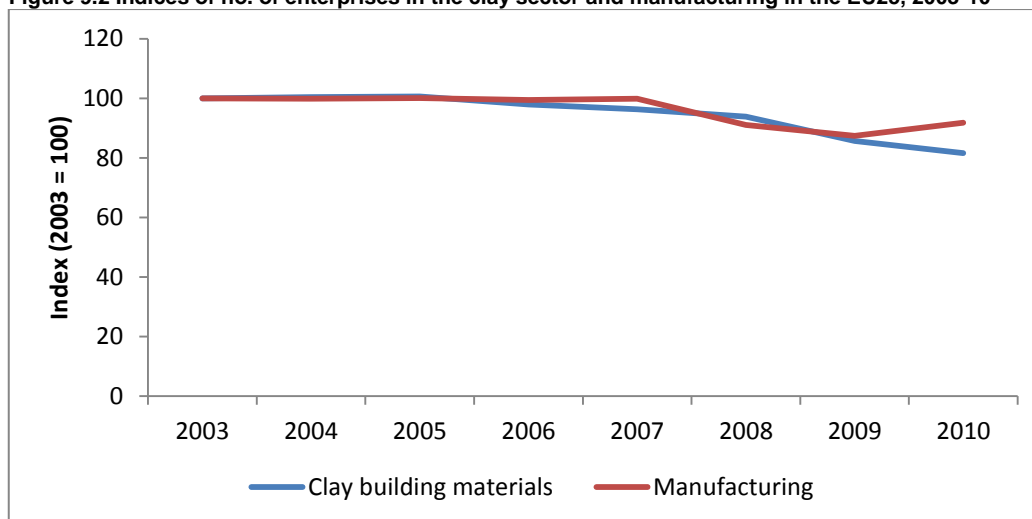
Ceramics with lower value added such as bricks and roof tiles are generally not exported over long distances due to the high transport costs and so exports consist predominantly of fine ceramics, typically of higher quality and added value and of lower weight. The majority of EU ceramics exports are wall and floor tiles, primarily originating in Spain and Italy with much of these products destined for sale in the US.

9.3 Evidence of production shift / relocation

9.3.1 Number of enterprises

Figure 9.2 shows that although the number of enterprises in the manufacture of clay building materials stayed relatively stable between 2003 and 2005, it has declined since then (from 4,930 in 2005 to around 4000 in 2010) with the decline quickening during the recession.

Figure 9.2 Indices of no. of enterprises in the clay sector and manufacturing in the EU25, 2003-10



Notes: Data for 2000-07 are based on the NACE 1.1 classification; data for 2008-10 are based on NACE 2 classification.

Sources:

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2;

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics on manufacturing subsections DA-DE and total manufacturing (NACE Rev. 1.1, D), database: sbs_na_2a_dade.

¹⁶⁰ Ecorys et al 2008, p97

This decline in enterprises was split quite equally between the two sub-sectors, with the number of firms manufacturing bricks, tiles and construction products falling from 3230 to 2587 and the number of firms producing ceramic tiles falling from 1700 to 1323 over the same period. Employment in the sector was also falling substantially during this period. While some merger activity has been evident, this is not the main explanation for the fall in the number of firms operating witnessed. The sharp fall in construction activity has been severe for the sector and has pushed enterprises throughout the EU to cease trading. The number of enterprises in the clay sector continued to fall in 2010, from 4200 to 4000, while in manufacturing the number picked up, rising from 2 million to 2.1 million¹⁶¹, reflecting the continued weakness of construction demand.

9.3.2 EU-25 production, imports and exports trends

Production within the ceramic tiles and flags subsector was broadly stable up to 2007, before the decline seen during the economic crisis. A similar picture applied in bricks, roof tiles and other construction products, aside from a sharp fall in 2005. The impact of the recession in Europe and subsequent eurozone crisis on demand (particularly its impact on the construction sector) are key drivers behind the decline in production. Additionally, for the ceramic tiles and flags subsector, the growth of competition from regions outside of Europe has some explanatory power. Total production in 2010 stood at 47% of the production level in 2003 and neither sector has shown signs of recovery in 2010 or 2011 (see **Error! Reference source not found.**).

In recent years there have been important developments in patterns of trade in clay building materials, which tend to be dominated by wall and floor tiles, given their relatively higher added value and lower weight. The trend has been for deterioration in the trade balance reflecting growth in competition associated with the appreciation of the euro against most currencies since 2000.

In 2003 the quantity of imports as a percentage of total European production was 4.64% for the manufacture of ceramic tiles and flags and 0.28% for bricks, tiles and construction products in baked clay. In 2010 these percentages had risen to 9.93% for tiles and flags and 0.52% for bricks, tiles and construction products. There has also been evidence of counterfeiting of EU origin tiles¹⁶². Imports from India to the EU in 2012 were almost 7 times their value in 1999 and for Turkey the value had risen to more than 21 times its 1999 figure. In 2012 India's share of EU total imports had risen to 2.5% whereas for Turkey it has reached a level of 4.5%¹⁶³.

There has been a decline in the total volume of exports over 2003-10, driven by a fall in demand after 2007 caused by the global economic crisis. The volume of exports of ceramic tiles and flags was nearly 20% lower in 2010 than in 2003. The share of exports in total quantity of production remained fairly stable and even rose slightly during this time, reflecting the decline in production for the domestic market.

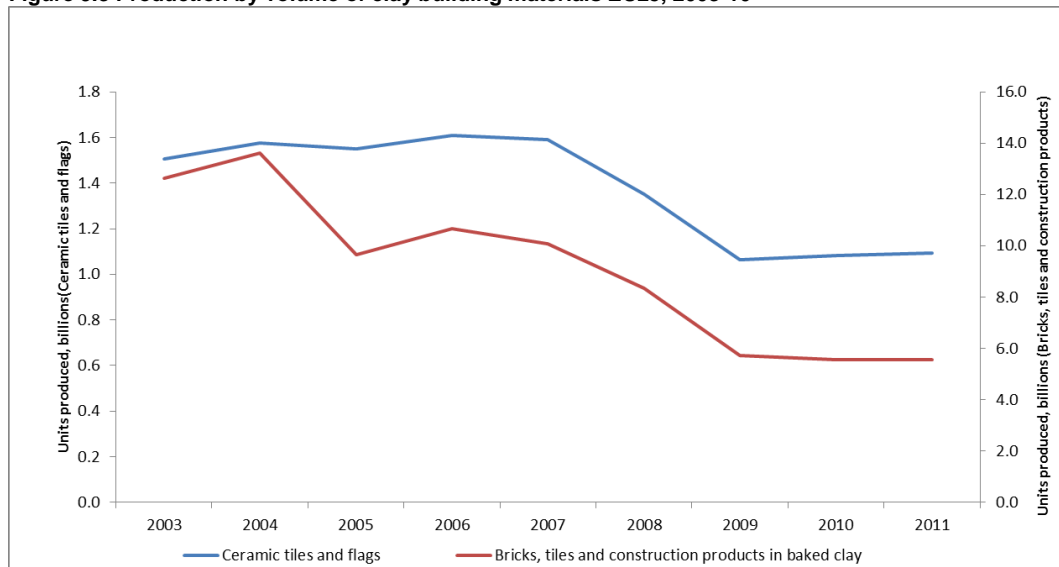
With regard to developments in the value of exports and imports the total value of imports increased by around 75% between 2003 and 2010, from €333m to €584m (see Figure 9.4). The value of exports, which is much higher than for imports has recovered a little from the trough in 2009 and by 2011 was slightly higher than the 2003 level.

¹⁶¹ Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry

¹⁶² Ibid, p32

¹⁶³ Comext

Figure 9.3 Production by volume of clay building materials EU25, 2003-10

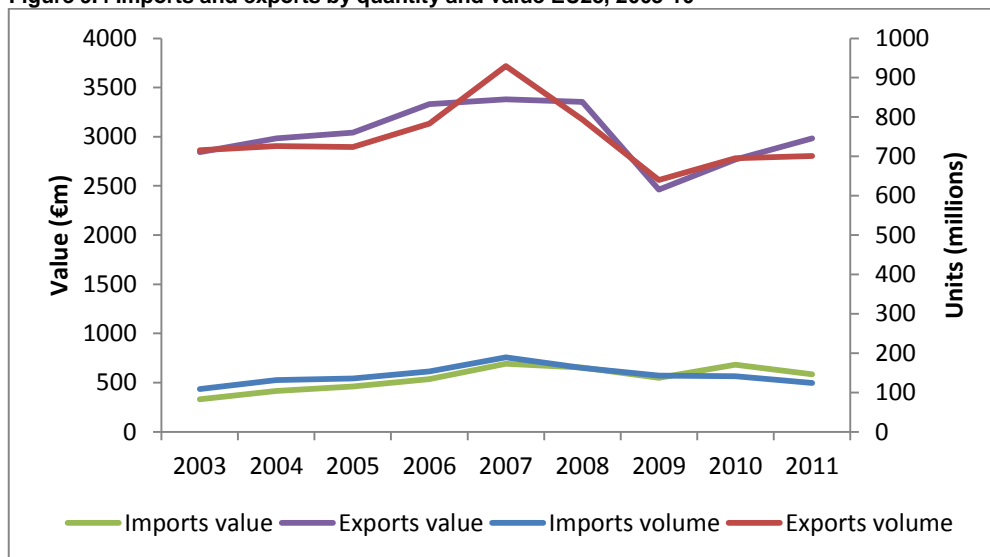


Notes: Data for 2000-07 are based on the NACE 1.1 classification; data for 2008-10 are based on NACE 2 classification.

Sources:

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2.

Figure 9.4 Imports and exports by quantity and value EU25, 2003-10



Sources:

Eurostat, *Prodcom* database and *Comext* database.

9.3.3 Investment trends

Table 9.5 details the trends in investment within both clay subsectors and provides a comparison with trends in manufacturing as a whole. It is clear that the clay sector had been an investment intensive sector, with investment amounting to 8% of turnover for the ceramic tiles and flags sub-sector in 2000 and 9.2% for bricks, tiles and construction products, in comparison to a figure of 4.4% for total manufacturing. By 2010, there had been a substantial decline in the investment share with the two sub-sectors reporting investment shares of turnover as little as 4.6% for tiles and flags and 3.6% for bricks, tiles and construction products, levels more in line with manufacturing as a whole. In explaining this decline one important factor has been the trend of growing discrepancy

between the return on capital employed and the weighted average cost of capital in the sector, reducing

Table 9.5 Investment in the clay sector in the EU25, 2000-10

Ceramic tiles and flags											
Investment (€ /m)	897	1,008	805	2,743	668	751	813	777	867	350	471
Investment/turnover (%)	8.0	8.6	6.7	22.5	5.2	5.8	6.3	5.5	6.8	3.5	4.6
Brick, tiles, etc.											
Investment (€ /m)	827	773	712	607	870	1,018	846	1,082	775	262	254
Investment/turnover (%)	9.2	8.9	8.5	6.7	9.2	10.6	8.1	9.8	3.6	3.6	
Manufacturing											
Investment (€ /m)	248,252	250,369	227,438	213,291	215,287	214,359	229,610	250,702	228,753	200,845	195,441
Investment/turnover (%)	4.4	4.3	3.9	3.7	3.6	3.4	3.4	3.5	3.2	3.5	3.1

Sources:

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2;

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics on manufacturing subsections DA-DE and total manufacturing (NACE Rev. 1.1, D), database: sbs_na_2a_dade.

incentives to invest in the long run.¹⁶⁴ Commentators within the industry have also pointed to the lack of available financial capital and regulatory uncertainty in addition to the long asset lifetimes and investment cycles as further explanation of this fall in investment share.

Although the EU remains a world leader in the production of wall and floor tiles there has been an increase in competition, from India and Turkey, and especially from China, where there has been growth in production capacity, from 300 million m² pa during the 1990s to 3 billion m² by 2006¹⁶⁵.

9.4 Drivers for relocation

Approximately 20% of EU output by value in the clay building materials sector is exported each year. Even for the finer ceramics that are more easily transported over long distances (and as such, more susceptible to competition) a majority of wall and floor tile ceramics purchased by consumers living in the EU originate within the EU (93% in 2010¹⁶⁶) a sign of the continuing competitiveness of the region's producers.

Nevertheless there have been substantial changes in the international structure and dynamics of the industry for clay building products and evidence of the pressure for relocation is clearly apparent. The drivers for relocation most frequently cited and evidenced centre around considerations of labour cost, lower burdens of compliance to regulatory regimes and, crucially,

¹⁶⁴ Results of the assessments of sectors and sub-sectors on the qualitative criteria set out Article 10a(17) of Directive 2003/87/EC, p3

¹⁶⁵ Ecorys et al 2008, p26

¹⁶⁶ Eurostat, *Structural Business Statistics* database and Eurostat Comext database

access to energy markets. Imports have demonstrated an increasing trend as importers from third countries have benefited from relatively low costs for sea transport. Although still modest, the total extra-EU27 imports more than doubled between 2005 and 2008 and available data suggests that trade exposure, although still relatively low, has increased further over 2008-12 and is higher still in Member States most vulnerable to competition from non-EU neighbours.

Imports from China have risen rapidly in recent years and in one year, from 2005 to 2006, imports of ceramic tiles increased by 150%¹⁶⁷. While further increases of that magnitude would present a strong argument for relocation, it is not clear if such increases will be repeated. In March 2011 and September 2012 anti-dumping penalties were imposed on Chinese imports. This has led to sharp falls in imports from China, (to around 35m m² pa), thereby reducing this pressure somewhat. The fact that EU consumers purchase the majority of wall and floor tile products from EU firms does however give support to confidence in European competitiveness for now. It can be understood that the EU maintains a competitive advantage over China and other world ceramics by competing on quality and not on price. The large number of SMEs still operating in the sector have specialised in high quality ceramic tiles, differentiated from cheaper alternatives and with the emphasis on value-added. As third countries increasingly utilise the same production technology as EU manufacturers we can expect this competitive advantage relating to quality to weaken with time.

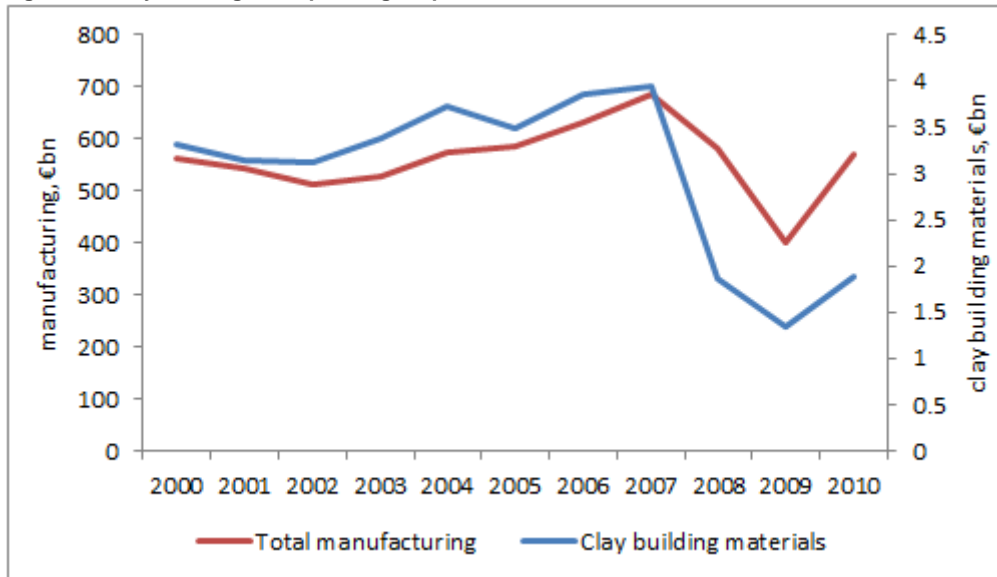
9.4.1 *Development of profits*

As a sector heavily influenced by demand in the construction sector, the recent economic crisis in Europe has had an enormous impact on profits. The impact of the crisis on industry profits, as demonstrated by Figure 9.5, was considerable with profits contracting more sharply than for manufacturing in general, and recovering more slowly. This decline in profits puts pressure on costs for European firms, giving an additional reason to consider relocation. Producers aim to minimise the costs of personnel and intermediate goods whilst also seeking relief from the continuing uncertainty felt over prospects for development in environmental regulations. The precise and permanent impact of these pressures is difficult to determine before a broader economic recovery has been secured.

While the pathway for European demand may not appear to be conducive to great expansion in the near future, demand for the products of the sector continues to grow in a number of expanding economies. While the potential for export growth and the recovery of profits this offers to European centres of production is clear, the historically regional and localised division of production activity means it is likely that the share of world production taken by Europe may decline further.

¹⁶⁷ Ecorys et al 2008, p26

Figure 9.5 Clay sector gross operating surplus, 2000-10



Sources:

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2;

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics on manufacturing subsections DA-DE and total manufacturing (NACE Rev. 1.1, D), database: sbs_na_2a_dade.

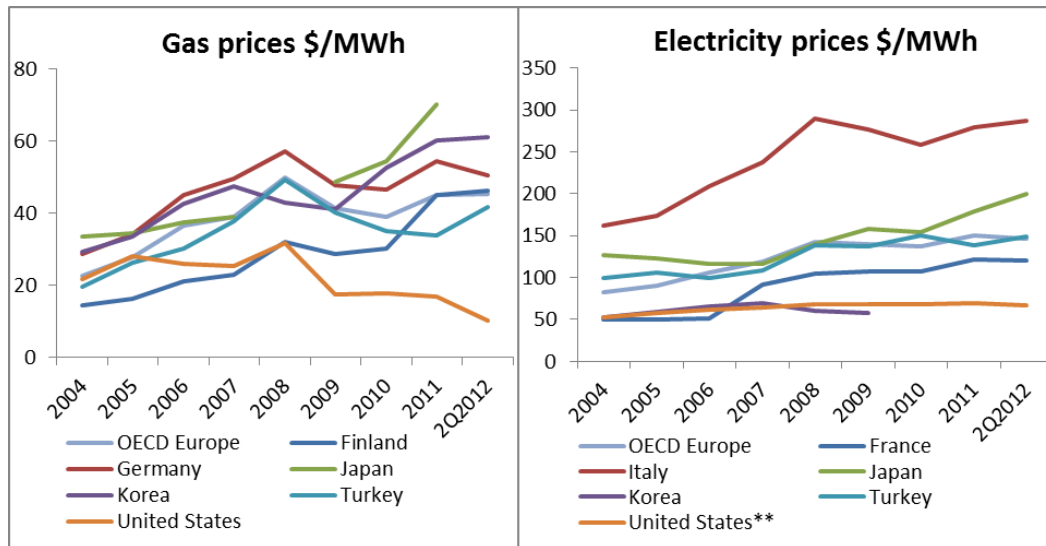
9.4.2 Development of cost structure

The developments in the cost structure for the sector can be considered through its main components; energy, regulation including ETS costs, labour and raw materials. The evidence for the structure and development of costs for firms operating within the sector seems to indicate an increasing share of costs as a percentage of turnover, rising from 85% in 2004 to a peak of 92% in 2008 (see Figure 1-7). There has been little change in the balance of costs, which have remained broadly similar, and the growth and decline of absolute costs in line with fluctuations in industry turnover demonstrate the continuing high and growing levels of competition within the sector and the shrinking profit margins associated with this.

Energy cost

The primary source of energy supply for manufacturers is natural gas and the cost of energy has increased significantly in recent years, posing challenges for the sector. Both electricity and gas prices roughly doubled in most countries in the selected period, except for the US (see Figure 9.6). It should be noted though that the dollar lost about 20% of its value against the Euro in the same time frame, so part of the cross-country differences can also be explained by currency fluctuations and the actual prices paid by very large industrial consumers can be lower due to their large-volume contracts with discounts.

Figure 9.6 Energy prices for industry in selected world regions / countries, incl. Taxes



Source: IEA Energy Prices & Taxes, 4th quarter 2012.¹⁶⁸

In 2011 energy prices in EU tended to compare unfavourably against prices in the US and against prices in other major ceramic manufacturing countries such as China, Russia, Brazil and North Africa, but were cheaper than those in Japan.

Although the extent to which electricity producers passed through CO₂ costs into electricity prices is uncertain, empirical analyses have shown that the EU ETS has increased electricity prices (Keppler et al., 2010; Fell, 2010; Fell et al., 2013). The order of magnitude compared to other electricity price drivers is low though, as can be seen in the picture below. It should be noted that the energy prices within Europe vary considerably as well.

¹⁶⁸ Definition: Prices and taxes for the industry sector are the average of amounts paid for the industrial and manufacturing sectors.

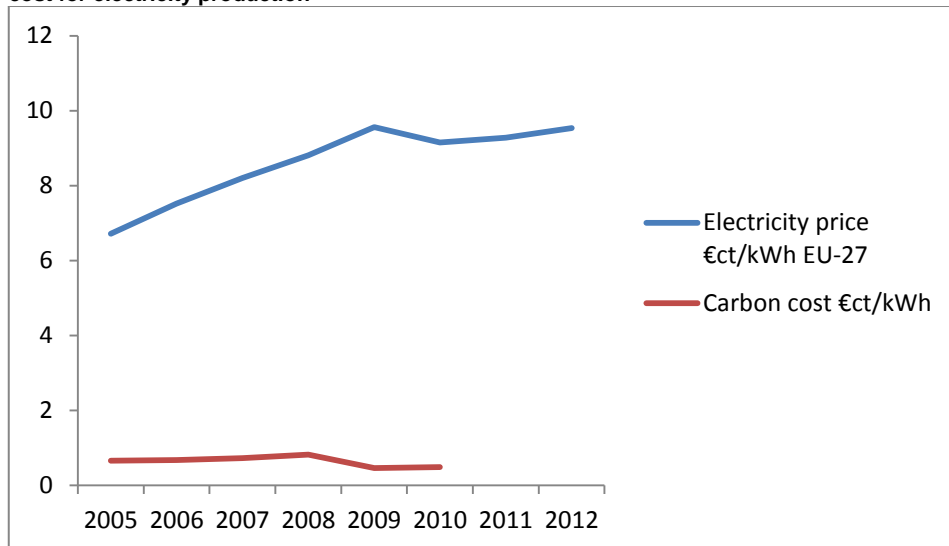
** Electricity price data for the US excludes taxes.

Note that there are data gaps for Japanese gas price data and Korean electricity price data.

OECD Europe comprises Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

In order to show the range within the EU, data for the EU countries with the highest and lowest prices are shown in both graphs.

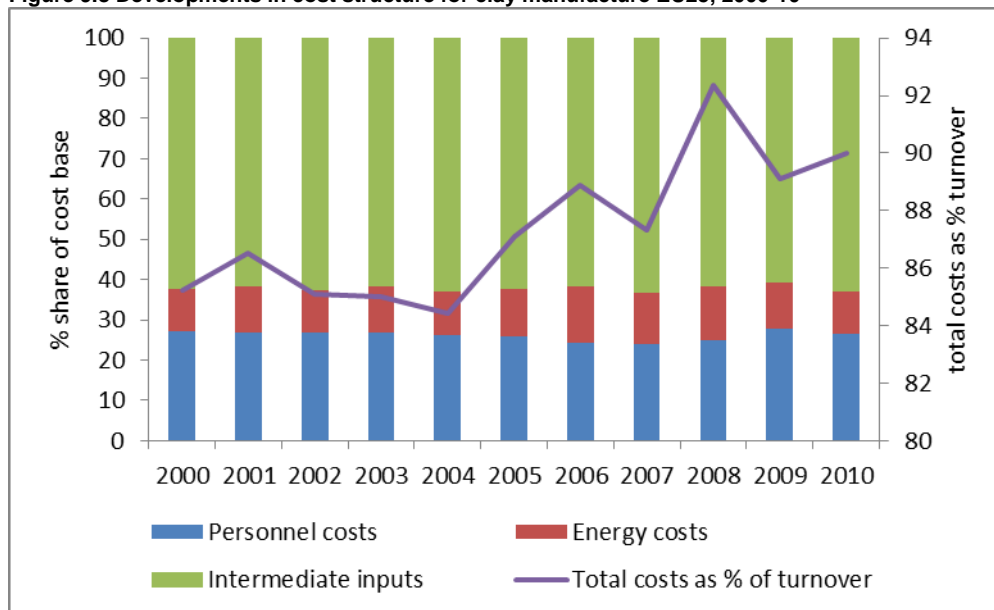
Figure 9.7 Electricity prices for industrial consumers in the EU-27, excluding taxes; compared to carbon cost for electricity production



Source: Eurostat Energy Statistics, EEX, EEA, IEA.¹⁶⁹

While there was some evidence of an increasing burden on firms in the years leading up to 2007 from the costs of energy, this has since eased. It is important to see that while there may have been upward pressure on energy costs in particular, a combination of effective management of energy sources and supplies by firms in addition to investment in cleaner and more efficient technologies has seen the share of turnover devoted to meeting energy needs remain fairly constant.

Figure 9.8 Developments in cost structure for clay manufacture EU25, 2000-10

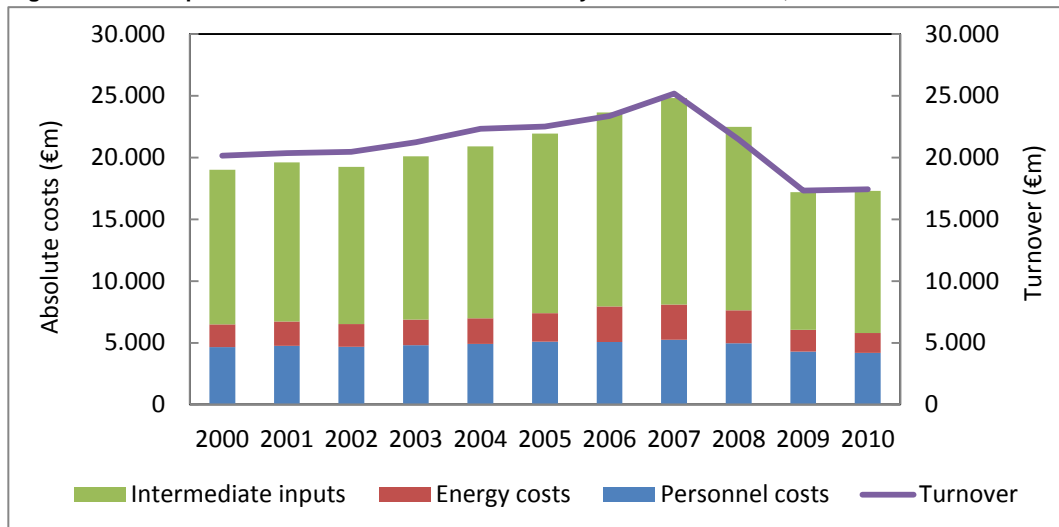


Sources:

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2;

¹⁶⁹ Electricity prices shown are the average prices in Euro per kWh without taxes applicable for the first semester of each year for medium size industrial consumers (Consumption Band Ic with annual consumption between 500 and 2000 MWh). Until 2007 the prices are referring to the status on 1st January of each year for medium size consumers (Standard Consumer Ic with annual consumption of 2 000 MWh). Note that prices can be expected to be lower for large size industrial consumers. Carbon cost is calculated by taking data from IEA on carbon emissions per kWh of electricity in OECD Europe; this quite precisely coincides with EU-27 data from the EEA, but has less data gaps. These values are multiplied by the EU allowance unit forward price (ETS emission forward price, used here because it is more stable than the spot price).

Figure 9.9 Developments in the absolute costs of the clay sector in the EU25, 2000-10



Sources:

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E), database: sbs_na_ind_r2;

Eurostat, *Structural Business Statistics* database, Annual detailed enterprise statistics on manufacturing subsections DA-DE and total manufacturing (NACE Rev. 1.1, D), database: sbs_na_2a_dade.

Regulation and investment

Environmental regulations are a prominent concern in the minds of operators in the manufacture of clay building materials. Notable examples include European initiatives such as the Emissions Trading System, Industrial Emissions Directive and the Energy Efficiency Directive. The EU-ETS has potential effects on the production costs for firms, particularly for SMEs, for whom there is a greater challenge to meet the workload and time frames set by regulation. These regulations do however serve to provide an incentive to invest in research and development aimed at better energy efficiency. The returns from such investments are spread over a number of years while the investment costs are felt immediately, and European manufacturers remain concerned about any competitive disadvantage vis-a-vis producers facing a less demanding regulatory regime. There have been notable examples of firms operating within the sector which are large and robust enough to commit to investments in their production process to reduce their costs whether through reducing their energy consumptions and costs directly or through reducing the costs of compliance with any taxes or charges associated with polluting behaviour. One of the most important companies in the sector recently committed to two such initiatives recently, installing a new spray drier and heat recovery system in a plant in Czech Republic, an important region of production for the sector.

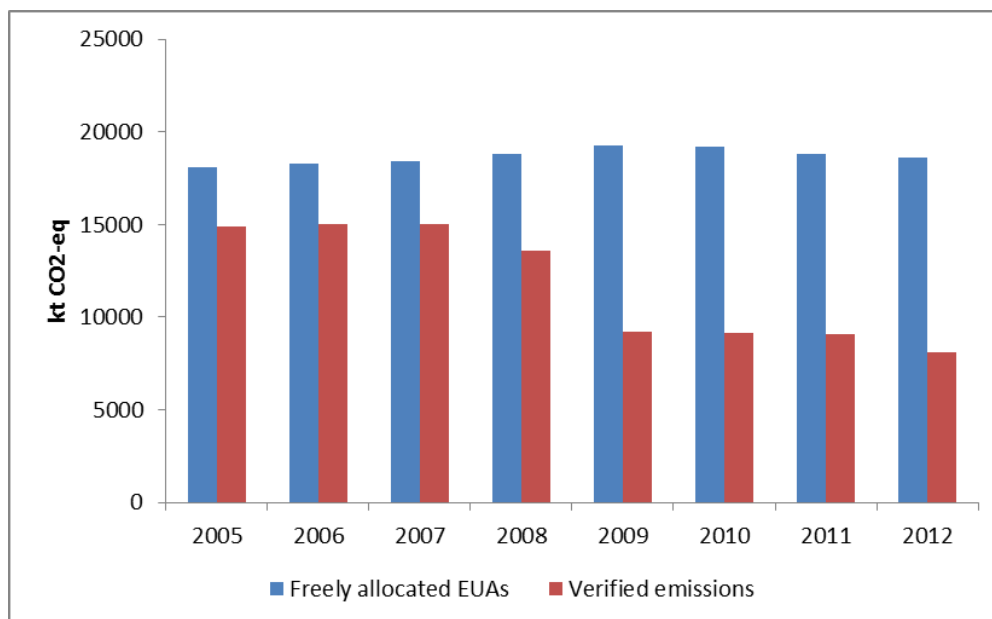
ETS cost

An important concern for the ceramics sector has been the impact of the Emissions Trading Scheme, both through direct costs (due to emissions from the combustion of fuels such as natural gas) and indirectly through higher electricity prices.

It is clear from Figure 9.10 that, given the verified emissions levels, the ceramics sector as a whole has received more allowances than required in every year under the EU ETS thus far. Between 2008 and 2012, a cumulative total of almost 44,000 kt CO₂-eq of allowances were not required to offset emissions. The introduction of auctioning with Phase III of the Emissions Trading Scheme

may add to future compliance costs, but at present the EUA price remains low because across most sectors more allowances have been allocated than are required.

Figure 9.10 Free EUAs and Verified Emissions for Ceramic products by firing, 2005-12



Sources: EU Emissions Trading System (ETS) data viewer

The recent trend in the direct cost of compliance with the ETS is presented in Table 9.6. This shows the cumulative benefits or costs from EU ETS compliance for the ceramics sector. The price for EUAs has fallen substantially from €23.20 in 2008 to €7.95 in 2012 while the consistency of freed-up allowances during this period led to a consistent accumulation of benefits to a level of €602m in 2012.

However, this data is not representative of the entire clay building sector as almost the entirety of sub-sector 23.31 covering ceramic tiles and flags was not included in the EU ETS. Additionally, for sub-sector 23.32, production or parts of production in some Member States were not covered for either Phase I or for both Phase I and Phase II. These installations that were not covered will not have received any free allocation in Phase I and Phase II but have entered the ETS in 2013 under the new scope for ceramic installations with the associated rules on free allocation.

Table 9.6 Developments in direct cost of EU ETS compliance in the ceramic products sector, 2008-2012

	2008	2009	2010	2011	2012
Freed-up allowances (kt CO2-eq)	5,143	9,529	9,646	9,228	10,025
Cum. Freed-up allowances (kt CO2-eq)	5,143	14,672	24,318	33,546	43,572
EUA Y+1 price (€)	23.20	13.82	14.85	13.83	7.95
Benefit/cost of ETS (€m)	119.3	131.7	143.3	127.7	79.7
Cum. Benefit/cost of ETS (€m)	119.3	251.0	394.3	521.9	601.6

Sources: EEX, EEA.

With regard to the indirect costs associated with the ETS most empirical studies seem to indicate that even during the early days of the ETS a major part of the carbon costs induced by the scheme was passed through to power prices¹⁷⁰. However, most studies focused on the more competitive power markets in West-European countries, not on the more regulated or less competitive markets

¹⁷⁰ Sijm et al., 2008, p68

in other parts of the EU ETS. The potential implications of these differences in structure of power markets need to be considered before general conclusions can be drawn on the importance of indirect-costs associated with the scheme.

Labour cost

Labour costs have shown little movement over the period as a proportion of total costs although the continued discrepancies between labour costs in Member States and some non-EU countries mean this factor continues to provide some drive for relocation, although the degree of specialisation and concentration of skills associated with historical production centres serves to offset this force. While there is evidence of a growing burden from raw materials and other intermediate inputs in the period to 2007, this was limited in magnitude and has since dissipated.

9.5 Synthesis

Using all of the evidence from the previous sections, Table 9.7 and Table 9.8 provide a short overview as to whether there has been evidence of carbon leakage due to the EU ETS.

Table 9.7 Evidence for (production) relocation

Indicator for (production) relocation	Trend	Additional information on trend
Net imports	Slight increase in the sub-sector for bricks and roof tiles with a more pronounced rise for wall and floor tiles.	Some evidence of growing trend towards imports. Value of imports doubled from €333m to €682m between 2003 and 2010.
Investment activity in EU compared to outside EU	Decrease in relative investment, significant fall in investment levels in EU since crisis.	China has built up significant production capacity in recent years, for ceramic tiles capacity increased from 300 million m ² pa to 3 billion m ² pa in the decade to 2006 making China the world leader. Russia and North African states have also expanded their capacity.
Number of ETS installations	Gradual decline although due to the change in the definition of an ETS installation, their number will actually increase.	Recent years have seen substantial falls in the total number of sector workers and in enterprise numbers. The number of enterprises fell by more than 10% EU wide in 2009.
Summary: evidence for (production) relocation	Mixed. There has been huge expansion in capacity in certain extra-EU regions but Europe remains a hub of production and specialisation.	

Table 9.8 Drivers for (production) relocation

Drivers for (production) relocation	Assessment	Justification of assessment
Carbon cost	No clear influence	Free allocation meant negative direct carbon costs. Indirect costs (through electricity) hard to quantify, efficiency measures have worked to balance this pressure.
Other costs: fossil fuels	Some influence	Increasing energy prices compared to other ceramic manufacturing nations and rapidly increasing electricity prices. Additionally the high gas price in Europe would threaten industry competitiveness but efficiency measures and technological investment seem to have curbed costs in some cases.
Other costs: Labour	Some influence	While labour costs apply a certain pressure for relocation, the degree of expertise and specialisation offered in parts of the European industry offsets this.
World demand	Important	EU demand has decreased, while demand from developing nations has grown
Summary: CO ₂ cost among the relevant drivers?	No clear impact observed	Free allocation of allowances has led to the accumulation of a net benefit over 2008-12. The main drivers appear to be shift of world demand and labour costs associated with a higher burden of regulation. In addition rising energy prices, due in some part to indirect ETS costs have played a role and there has been a decline in the level of profitability, although the main driver here is no doubt the recession.

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10 Manufacture of refined petroleum products

10.1 Scope and current leakage position

10.1.1 Scope of the industry

The European refinery industry covers the manufacturing of finished oil products from crude oil into some twenty different finished product types. According to the NACE (Rev.2) definitions, this includes the manufacture of liquid or gaseous fuels or other products from crude petroleum, bituminous minerals or their fractionation products, for example (i) the production of motor fuel (gasoline, kerosene, etc.), (ii) the production of other fuels (light, medium and heavy fuel oil, refinery gases such as ethane, propane, butane etc.), (iii) manufacture of feedstock for the petrochemical industry and for the manufacture of road coverings and (iv) blending of biofuels. Directive 2010/75/EU on industrial emissions refers to this industry as the 'refining of mineral oil and gas' (Annex I, under 1.2).

10.1.2 Type and homogeneity of products

In essence, refineries separate and convert crude oils into a number of various components which are then used to make finished products. The main subsequent process steps are (i) the **separation** of crude oil components via distillation into common 'boiling-point fractions'; (ii) the **conversion** of these raw components into other more suitable components (e.g. via cracking, coking or visbreaking); and (iii) the **treating** process to stabilise or upgrade the products. The main categories of products are summarised in the table below. In principle, these products are homogeneous products which have to fulfil certain (chemical and/or physical) specifications and quality standards.

Table 10.1 Overview of main refinery products

Category	Products	Remarks about use
Light distillates (20-50%wt)	Liquefied petroleum gas (LPG), naphtha, gasoline,	LPG and naphtha is used as feedstock for the chemical industry. Other products are mainly used for transportation (diesel, gasoline) or heating. The crude oil characteristics determine the 'output' in different products.
Middle distillates (30-55%wt)	Diesel, heating oil for domestic and commercial applications, marine diesel, kerosene/jet fuel	
Heavy distillates and residuum (10-50%wt)	Heavy fuel oil, bunker fuels, speciality products (coke and lubricants, bitumen, wax, asphalt)	

Source: EUROPIA, 'How an oil refinery works'; and 'White paper on EU refining (2010, p. 19) and IEA, oil product definitions.

10.1.3 Status of sector in the current carbon leakage list

The manufacturing of refined petroleum products is deemed to be at risk of carbon leakage. Under the double threshold carbon leakage criteria assessment, the additional costs to refining induced by the implementation of the Directive were assessed to be 11.7% of its gross value added (direct costs: 10.5%, indirect costs: 1.2%), which is above the threshold level of 5%. At the same time the trade intensity was assessed to be 16.1%, which is above the 10% threshold.¹⁷¹

¹⁷¹ European Commission, 'Draft commission staff working document - Impact assessment accompanying document to the Commission Decision determining a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage pursuant to Article 10a (13) of Directive 2003/87/EC', SEC(2009) 1710 final, December 2009, p. 42.

10.1.4 EU ETS Emissions

The overall level of EU ETS emissions for the refinery industry in 2012 was 132 Mt CO₂ for 160 EU ETS installations (EU-25), which corresponds to 92 mainstream refinery sites. In 2005 this figure was 151 Mt CO₂¹⁷². During 2005-2012, the refinery industry was on average responsible for 7.5% of total EU-25 ETS emissions.¹⁷³ The level of emissions per product depends on the refinery configuration (see also the section on technology), which means that the emissions per product are very difficult to determine. Some average figures (for some types of refinery configuration) are shown in the next table. More complex products (due to demand or regulation) require more energy and more hydrogen, which results in higher CO₂ emission.¹⁷⁴

Table 10.2 Average CO₂ emissions from various refinery configurations

Refinery configuration ¹⁷⁵	Overall refinery (mt CO ₂ / mt crude)	Remarks
HSK	0.205	The EU average figures estimated by the JEC for EU refineries are 7.0 gCO ₂ /MJ for gasoline and 8.6 gCO ₂ /MJ for diesel. This equates to 0.30 tCO ₂ /t gasoline and 0.37 tCO ₂ /t diesel. ¹⁷⁶
HSK + VB + FCC	0.337	
HSK + VB + HCU	0.325	
HSK + DC + HCU	0.329	
HSK + VB + FCC + HCU	0.362	

Sources: (i) for the first two columns: Reinaud, 'The European refinery industry under the EU emissions trading scheme', study for the IEA, November 2005, p. 39 and (ii) for the third column: JRC, 'Well-to-wheels Analysis of Future Automotive Fuels and Powertrains in the European Context' (WELL-to-TANK Report Version 3c), July 2011, p. 25 (main report) and p. 16 (annex).

10.2 Characteristics of the sector

10.2.1 Production value and employment

The total production value of the EU refinery industry in 2010 was € 517 billion, which is approximately 5-6% of the production value of total EU manufacturing industry. In 2003 the total production value for refining was approximately € 290 billion.¹⁷⁷ According to the Commission, the EU refining industry directly employed in 2010 approximately 140,000 people. At the same time it is considered that 400-600,000 jobs are directly dependent on the EU refining industry (excluding logistics and marketing).¹⁷⁸ SBS data reports a direct employment of 95,000 people in 2011, with Germany, Italy, France and Poland as the biggest 'employers' together approximately 70% of the total employment).¹⁷⁹

¹⁷² Community Independent Transaction Log (CITL)

¹⁷³ EEA, EU Emissions Trading System (ETS) data viewer, see: <http://www.eea.europa.eu/data-and-maps/data/data-viewers/emissions-trading-viewer>. The indicators used are: (i) the verified emissions for all stationary sectors (1000 emission unit - kt CO₂-eq) and (ii) Verified emissions for the mineral oil refineries. Period: 2005-2012.

¹⁷⁴ Concawe, 'The EU oil refining industry perspective on the EU--ETS phase III', presentation, 24 September 2012, slide 8.

¹⁷⁵ These refinery configurations are described in more detail in section XX. The abbreviations stand for: hydroskimming (HSK), visbreaking (VB), delayed cooking (DC), Fluid Catalytic Cracking (FCC), Hydrocracking (HCU). More information regarding these technologies is also described in the EC Best Available Technologies Report (2012).

¹⁷⁶ The JRC used Lower Heating Values (LHV) of 43.2 MJ/kg for gasoline and 43.1 MJ/kg for diesel.

¹⁷⁷ Eurostat SBS data (Structural business statistics), under 'Annual detailed enterprise statistics - industry and construction'. The production value covers "the amount actually produced by the unit, based on sales, including changes in stocks and the resale of goods and services". The data shows a large 'jump' in the production value when the transfer from NACE rev 1.1. to NACE rev 2 was made, which may be related to definition and measuring issues.

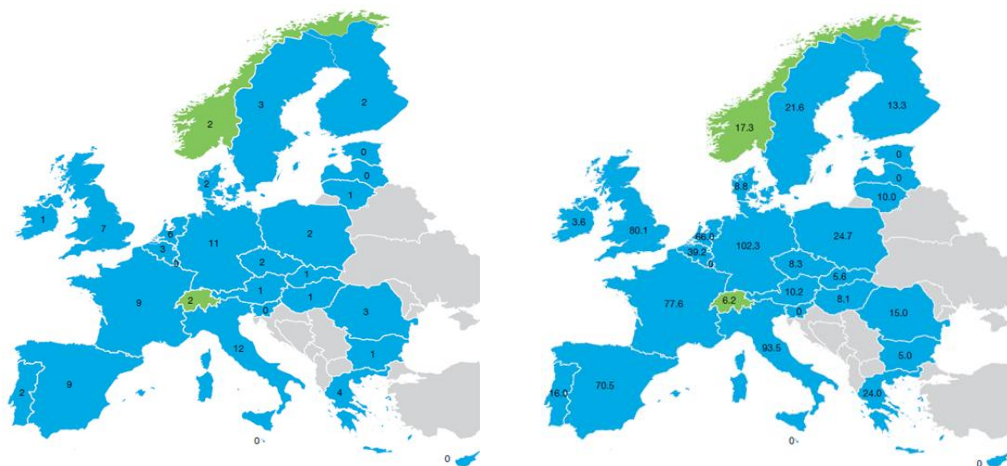
¹⁷⁸ Commission working paper on refining and the supply of petroleum products in the EU, SEC(2010) 1398 final, November 2010, p. 19.

¹⁷⁹ SBS data (NACE rev. 2). The data shows a large 'jump' in the employment level when the transfer from NACE rev 1.1. to NACE rev 2 was made, which may be related to definition and measuring issues. The industry also indicates an employment of approximately 100.000 people (see: Fuelling Europe's Future, see: <http://www.fuellingeuropesfuture.eu/en/refining-in-europe/fuelling-the-eu/jobs>).

10.2.2 Industry structure

The European refinery industry is characterised by the presence of a large number of ‘mainstream’ refineries¹⁸⁰, although this number is decreasing. In 2012 there were 87 mainstream refineries operating within the EU-27, while previously in 2007 there were 98 mainstream refineries¹⁸¹. The total primary refining capacity in the EU-27 in the period 2007-2012 decreased from 767.0 to 703.5 million tonnes per year (-8%). The geographical spread of the number of large refineries and the primary refining capacity is shown in Figure 10.1. Approximately 60% of the capacity is located in north-west Europe.

Figure 10.1 – Number of refineries (left) and primary refining capacity (in million tonnes per year), in 2012



Source: EUROPIA, annual report 2012, p. 98 and 99.

Eurostat data reports the presence of 1,049 installations manufacturing refined petroleum products in 2010 (the peak in 2007 was 1,161 refineries).¹⁸² Most of these small(er) installations are located in France (328), UK (170) and Poland (165). The breakdown in terms of employment is shown in the table below. These smaller installations have little in common with large mainstream refineries. Only the latter use both crude oil as a feedstock and produce a large range of finished oil products. Therefore, the Eurostat data cannot be used without further differentiation to represent the mainstream oil refining sector.

Table 10.3 Break-down in terms of employment (as % of total number of enterprises) in 2008

Amount of employees	0 – 9 persons	10 – 19 persons	20 – 49 persons	50 – 249 persons	250 or more persons
Share of total	59.37 %	11.9 %	10.3 %	10.85 %	7.5 %

Source: SBS data, under ‘SMEs - annual enterprise statistics by size class - industry and construction’.

The level of concentration of the EU refinery market is moderate. The four biggest enterprises (C4) cover approximately 38% of the total EU capacity (2012).¹⁸³ A 2008 study indicated that for 2003

¹⁸⁰ The threshold used by EUROPIA is: >50 kbb/d (kilobarrel per day) or 2.5 million ton per annum.

¹⁸¹ EUROPIA, annual report 2012 (p. 98) and CONCAWE, report no.9/12 (p. 16). The reduction in the number of mainstream refineries corresponds to permanent closures. For the period 2007-2012 the closures were in France (-4 refineries), Italy (-2), Germany (-2), UK (-2), Romania (-1). Please note that the EUROPIA annual report for 2007 also included small lube and bitumen refineries that can not be classified as ‘mainstream refineries’ (especially relevant for Romania). The presented figures for 2007 are corrected for this.

¹⁸² Eurostat SBS data, under ‘Annual detailed enterprise statistics - industry and construction’ (number of enterprises).

¹⁸³ EUROPIA.

the concentration level according to the Herfindahl–Hirschman Index (HHI-index) of ‘manufacture of coke, refined petroleum products and nuclear fuel’ was ‘moderate’.^{184,185} The biggest refining companies in (Western) Europe in 2010 were (i) Total SA (FR, 15 refineries, capacity of 2.1 million barrels per day), (ii) ExxonMobil (US, 9 refineries, 1.7 million b/d), (iii) Shell (NL/UK, 11 refineries, 1.6 million b/d), and (iv) Agip Petroli (IT, 10 refineries, 0.9 million b/d).¹⁸⁶ For 2012 the capacity ranking is (i) Total, (ii) Exxon Mobil, (iii) Shell and (iv) BP.¹⁸⁷ EUROPIA-CONCAWE indicates that their 42 members cover nearly 100% of the European capacity.¹⁸⁸

10.2.3 Value chain

The refining of crude oil is the third main stage (out of five) of the total value chain, after (i) exploration/ production and (ii) transportation of crude oil, and before (iv) distribution of petroleum products and (v) sales and marketing. Most of the large international oil companies (e.g. Total, Shell, BP, ExxonMobil, etc.) are vertically integrated companies with activities covering the whole value chain. Other competitors in the chain are ‘regional oil companies’ (e.g. Eni in Italy, PKN in Poland, etc.; these prevalently retain an historically strong national position), independent refiners (e.g. Ineos and Petroplus; with Petroplus becoming insolvent in January 2012) and refineries which serve specific niche markets (e.g. lubricants, bitumen, etc.).¹⁸⁹ The main client industries are: suppliers of transport fuels (gasoline, kerosene, diesel, etc.) which account for about 64% of refined products, heating and power (about 22%) and other industry (about 15%, e.g. feedstock for the production of plastics, fibres, industrial gases, etc).¹⁹⁰

10.2.4 Technology

The mainstream refining industry uses various materials and equipment in processing crude oil to refined products. As mentioned before, the three basic steps of the refinery process are separation, treating and conversion. Obviously there are different refinery processes, as the techniques are very specific to the characteristics of the specific crude oil which is used. In order to obtain lighter and cleaner products more process steps have to be taken. In general one can distinguish, based on the configuration of the process units, three main types of refineries:¹⁹¹ (i) the **hydroskimming refinery** is a relatively simple configuration which separates oil in different distillation streams for further treatment towards commercial products; (ii) the ‘semi-complex’ **conversion refinery** has the configuration of a hydroskimming refinery, but additional conversion units are added. Specific conversion techniques are visbreaking, coking and cracking (e.g. hydrocracking and fluid catalytic cracking); (iii) in the ‘complex’ **deep conversion refinery** even more processing units are added (e.g. coking) in order to increase the yield of lighter, more valuable products.

The majority of the European refineries are ‘conversion refineries’, although there is a clear trend towards more deep conversion refineries and more complex processes. These complex processes

¹⁸⁴ Peneder, ‘Sectoral Growth Drivers and Competitiveness in the European Union’, study for the European Commission, 2009, p. 57-58.

¹⁸⁵ The HHI-index was assessed to be 1,137, which corresponds to a ‘moderate’ level of concentration (between 1,000 and 1,800). See: European Commission, ‘Glossary of terms used in EU competition policy’, 2002, p. 24.

¹⁸⁶ Oil and Gas Journal, Top 10 Largest Refining Companies In Western Europe as per 2010-11, December 2010.

¹⁸⁷ Information received from EUROPIA/CONCAWE (confidential statistics).

¹⁸⁸ ConcaWE, ‘The EU oil refining industry perspective on the EU-ETS phase III’, presentation, 24 September 2012.

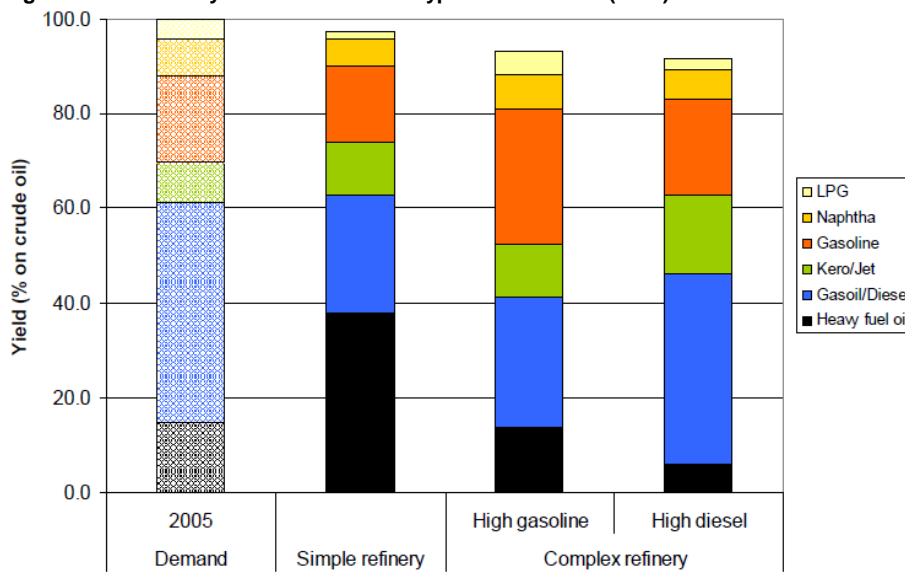
¹⁸⁹ Commission working paper on refining and the supply of petroleum products in the EU, SEC(2010) 1398 final, November 2010, p. 35-36.

¹⁹⁰ EUROPIA, ‘White paper on EU refining’, May 2010, p. 19.

¹⁹¹ Reinaud, ‘The European refinery industry under the EU emissions trading scheme’, study for the IEA, November 2005, p. 20-21; EUROPIA, ‘How an oil refinery works’ publication data unknown, p. 3-4. The basic techniques are also described in the Commission working paper on refining and the supply of petroleum products in the EU, SEC(2010) 1398 final, November 2010, p. 30-31.

are more energy and CO₂ intensive and have a lower, but more valuable, total final product yield than the hydroskimming refineries. These differences in product yield are illustrated in Figure 10.2.

Figure 10.2 Product yield of the different types of refineries (2005)



Source: Concaawe, 'European Refining Outlook to 2030: Technical & Economic Challenges', presentation October 2012.

10.2.5 Cost structure

Industry figures indicate that in 2010 the energy costs¹⁹² were approximately 60% of the total operating costs.¹⁹³ This estimate is supported by other data, which indicates that for central and southern European refineries, the energy costs are 64% of the operating costs, followed by personnel and maintenance costs (both approximately 15%).¹⁹⁴ The minority of the energy used is purchased, as refineries produce their own energy (mainly by using gas).¹⁹⁵ The energy costs in the above-mentioned cost calculations are based on market prices ('opportunity costs'). Public Eurostat SBS data on this specific topic is of a low and unreliable quality.¹⁹⁶ Given these high energy costs the refining industry is constantly looking for opportunities to increase energy efficiency. The relevance of the ETS will be discussed later in this report. Transportation costs are not very relevant, as the transportation of refined products is relatively cheap. This is illustrated by the large trade flows from and towards the EU (see section on import/export).

10.3 Evidence of production shift / relocation

10.3.1 Development of capacity and number of refineries

In terms of refinery capacity, Europe (including the EU) still covers approximately 17% of the global capacity.¹⁹⁷ The BP Statistical Review of World Energy¹⁹⁸ shows that the global refinery capacity

¹⁹² These costs cover all costs related to the energy used for refining processes including electricity, gas and auto-consumed energy from raw materials. Please note this does not include crude oil as a feedstock.

¹⁹³ CONCAWE, report no.3/12 'EU refinery energy systems and efficiency', p. 21.

¹⁹⁴ Solomon Associates' Benchmarking, 'An Insight into Energy Performance and Gaps', October 2011, slide 2, see: http://core.theenergyexchange.co.uk/agile_assets/1535/10.45_Lawrence_Anness.pdf

¹⁹⁵ Reinaud, Julia, The European Refinery Industry under the EU Emissions Trading Scheme. Competitiveness, trade flows and investment implications. IEA Information Paper, November 2005, p. 36.

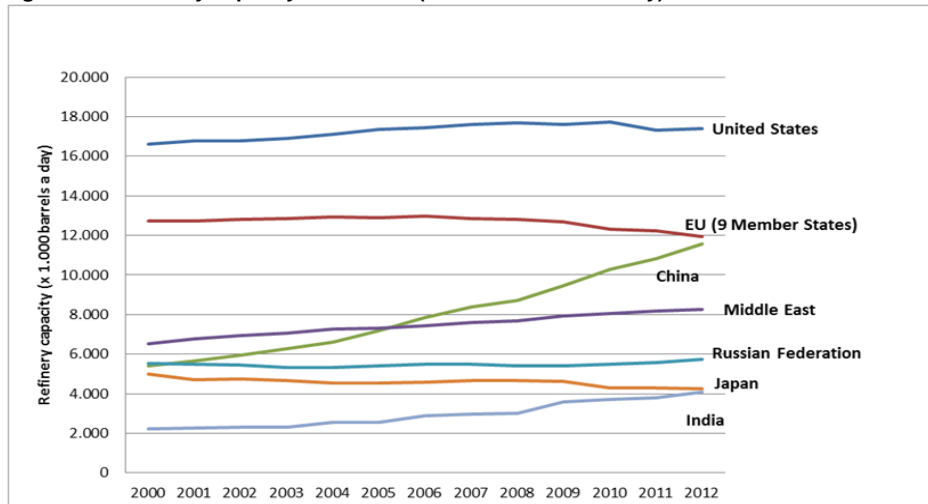
¹⁹⁶ According to SBS data the purchase of goods would cover 97% of the total operating costs, followed by personnel costs (2%) and energy costs (1%).

¹⁹⁷ EUROPIA, annual report 2012, p. 96..

¹⁹⁸ BP Statistical Review of World Energy, June 2013; see: http://www.bp.com/content/dam/bp/pdf/statistical-review/statistical_review_of_world_energy_2013.pdf.

increased from 82.2 million barrels a day (mb/d) in 2000 to 92.2 mb/d in 2012, an increase of approximately 12%. The largest capacity increases were in the Asia-Pacific region (+40%, especially China and India) and the Middle East region (+27%, especially the United Arab Emirates). The Africa (+16%) and North America (+5%) regions also show a surplus, while the Europe/Eurasia (-5%) and South & Central America regions (-5%) show refining capacity decreases. These trends in capacity are illustrated for a number of regions/countries in the next graph below (Figure 10.3).

Figure 10.3 Refinery capacity 2000 -2012 (thousand barrels a day)



Source: BP Statistical Review of World Energy (June 2013). Note: for the EU, national data is only available for nine Member States (NL, BE, FR, ES, IT, GR, DE, SE and the UK). Other Member States fall under the category 'Other Europe & Eurasia'.

As is clear from refining capacity developments, the European refinery industry is facing turbulent times. As mentioned before, the total number of refineries in the EU is decreasing. According to the SBS statistics the refining industry reached a peak (in terms of enterprises) in 2007 with an amount of 1,161 enterprises. (including the “smaller” refineries whose feedstock is not crude oil). During the three years after 2007, the refining industry shrank by almost 9% to 1 056 enterprises in 2010. This trend is in line with total EU manufacturing industry, which also saw a decrease in enterprise numbers of 8.3% in the period 2008-2010. More importantly, the number of large refineries decreased in the period 2007-2012 from 98 to 83 refineries (-15%), which is a much higher ratio than the decrease in the total primary refining capacity in the same period (-5%, from 767 to 727 million tonnes per year)¹⁹⁹.

The Commission has stated that in the period 2008-2010 a number of refineries were sold /on sale or were shut down for extended maintenance or conversion (including waiting for better market conditions)²⁰⁰. Another source (ENI) indicates that in the period 2009-2012 9 refineries were actually closed (4 in France, 2 in Germany, 1 each in Italy, UK and Romania; total capacity 30 million tonnes per year), while at the same time 9 refineries were sold (from international oil companies to independent refiners and to national oil companies), with another 11 refineries at 'risk of closure' (in 8-9 different countries).²⁰¹ EUROPIA indicates that since 2009, 11 refineries were shut down, 17 refineries changed ownership and the Petropus Group bankruptcy has resulted in 1 closure, 1 refinery still under threat and 3 refineries for sale.

¹⁹⁹ EUROPIA, annual report 2012 (p. 98) and 2007 (p. 49).

²⁰⁰ Commission working paper on refining and the supply of petroleum products, SEC(2010) 1398, November 2010, p. 18.

²⁰¹ ENI, 'The future of refining in Europe', presentation, probably dated in 2012, slide 11; see also: Boncourt de M., 'The European Refining crisis: what is at stake for Europe', Ifri Centre for energy, March 2013.

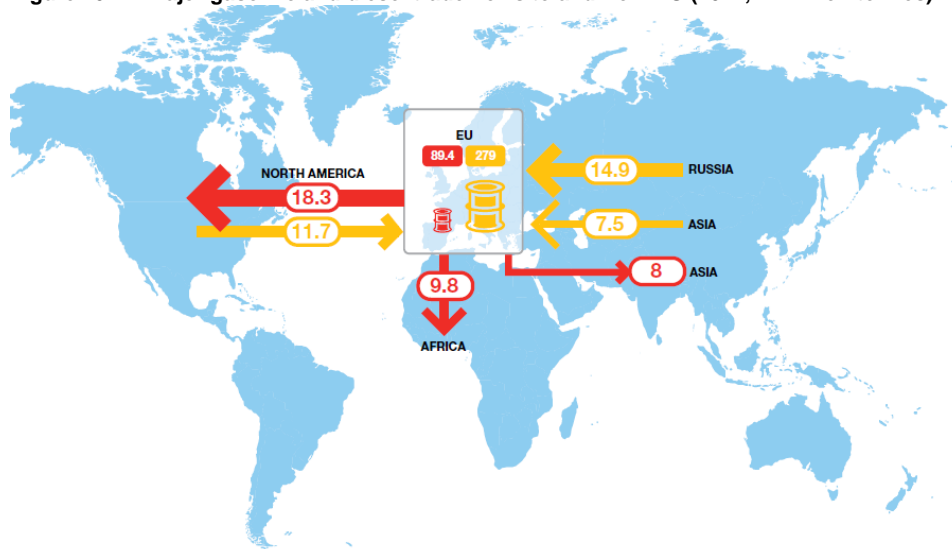
10.3.2 Demand / production imbalance

One of the main problems for the European refinery industry is that during the last six decades an imbalance has developed between European refinery output and actual demand in Europe. The majority of European refineries were built shortly after World War II with a gasoline-oriented configuration, while since the early 1990s, actual demand has changed towards diesel. In fact, Europe now has an overproduction of gasoline and an underproduction of diesel. In the last decades European overproduction of gasoline was exported to the US, but these trade opportunities are decreasing as the US demand for gasoline shrinks and the US has also become a net exporter of gasoline.²⁰²

10.3.3 Development of production and import / export

The imbalance between exports and imports is illustrated in the next figure from EUROPIA. This shows that in 2011 net imports of gasoil/diesel to the EU were 34 Mt. Also in 2011, net exports of gasoline from the EU were 36 Mt, of which 18.3 Mt were exported to North America. Gasoil/diesel imports into the EU are mainly from Russia (14.9 Mt) and North America (11.7 Mt).²⁰³

Figure 10.4 – Major gasoline and diesel trade flows to and from EU (2011, in million tonnes)



Source: EUROPIA, Annual report 2012, p. 78; the data is based on Eurostat. Note: the red arrows represent the net export of gasoline and the yellow arrows the net import of gasoil/diesel. The barrels in the middle represent the total EU demand.

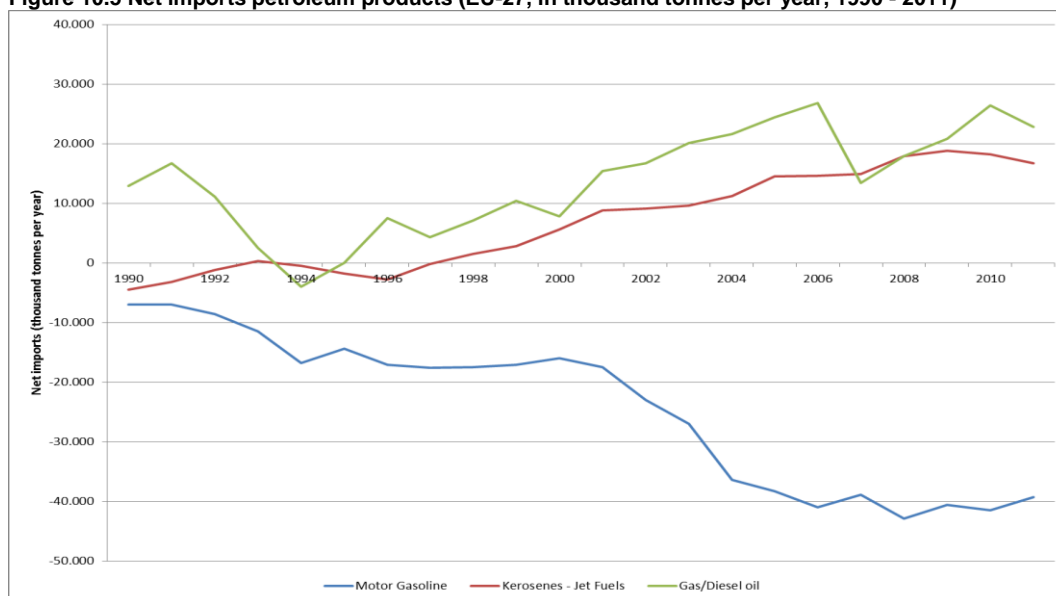
The imbalance between exports and imports has existed for a long period of time and is illustrated for the period 1990-2011 in the figure below. The net imports for gasoline doubled in the last decade to -40.000 Mt per year, while also the net imports of gasoil/diesel doubled. The Commission expects that up to 2030 the export of gasoline will be reduced due to reduced utilisation or closure of gasoline-producing process units).²⁰⁴

²⁰² IEA: 2013 EIA Energy Conference "Energy in the Americas" May 17, 2013. See also: ATKearney, 'Refining 2021: who will be in the game?', 2012, p. 3.

²⁰³ See also: EUROPIA, annual report 2012, p. 79-81

²⁰⁴ Commission working paper on refining and the supply of petroleum products, SEC(2010) 1398, November 2010, p. 9-12.

Figure 10.5 Net imports petroleum products (EU-27, in thousand tonnes per year, 1990 - 2011)



Source: Eurostat.

10.3.4 Development of gross investments

Investments in new global refinery capacity are being mainly made in advanced developing countries, such as India, China and Saudi Arabia. The total expenditure in refineries at global level is estimated to be some € 54 billion (\$ 69 billion) in 2012 - slightly higher than the preceding years (2009: € 51 billion; 2010: € 51 billion; 2011: € 53 billion). Approximately 41% of 2012 expenditure is related to maintenance, 36% to new capacity ('capital investment spending') and 23% for catalysts and chemicals.

Despite the decline in total EU capacity, the industry was still investing heavily. Between 2003 and 2010, investments averaged € 6.5 billion per year (SBS data, see **Error! Reference source not found.**) and concentrated in some significant projects in Spain, Greece, Central Europe and Netherlands. The investment as a percentage of the turnover was relatively stable throughout the period, but lower than that of total manufacturing industry. SBS figures differ to some extent from EUROPIA data; EUROPIA estimated that investments in 2006 were approximately € 8.5 billion (\$ 11 billion) and in 2007 approximately € 6.2 billion (\$ 8 billion).²⁰⁵ Continuing investment is necessary to keep the installations operational, e.g. to ensure competitiveness particularly to adapt to changing product demand.

Table 10.4 Development of gross investments in tangible goods: EU – refining industry

	2003	2004	2005	2006	2007	2008	2009	2010
Gross investment ²⁰⁶	5,058	5,312	5,862	5,672	7,511	7,880	7,239	6,334
Investments/ turnover (%)	1.6 %	1.5 %	1.4 %	1.2 %	1.6 %	1.4 %	1.9 %	1.3 %
Manufacturing - Investments/ turnover (%)	3.8 %	3.6 %	3.5 %	3.5 %	3.6 %	n/a	n/a	n/a

Source: SBS, 2013.

²⁰⁵ EUROPIA, Annual report 2010, p. 15.

²⁰⁶ Years 2003 to 2008 are compiled from NACE Rev.1.1 codes, whereas the years 2009 and 2010 are compiled from the NACE Rev.2 statistics.

10.4 Drivers for relocation

10.4.1 World demand shifting eastwards

Apart from the demand/production imbalance mainly between Europe and the US, we can attribute most of observed production and investment location decisions to an increase in demand for refined products in the economically fast developing countries and shift of production to countries with abundant raw materials. The following table shows development of demand in different regions until 2006.

Table 10.5 Total refined product consumption (millions of tonnes per year) in selected regions

	1995	2000	2001	2002	2003	2004	2005	2006
EU	679	702	713	704	712	718	727	728
USA	809	897	884	889	897	936	942	926
China	152	206	211	226	248	287	316	332
India	79	108	106	112	116	120	121	124
Middle East	187	209	218	226	234	246	254	264
North Africa	50	57	57	59	59	64	68	65
Russia	136	129	130	126	126	127	133	144
Total	2,092	2,308	2,319	2,342	2,393	2,499	2,561	2,582

Source: Purvin & Gertz Inc. (2008), Study on Oil Refining and Oil Markets. Prepared for the European Commission.

This data unfortunately stops in 2006. According to IEA data, European refined product demand fell by 14% between 2006 and 2013, which means an 11% decline between 2002 and 2013.²⁰⁷

10.4.2 Development of capacity in oil extracting countries

In addition to investments in India, South Korea and China, investments in new refinery capacity are mainly in the Middle East (Saudi Arabia is building three refineries with a total capacity of 1.2 million barrels a day).²⁰⁸

10.4.3 Development of refining margins

There has been strong pressure on refining margins²⁰⁹, which is reflected in the recent closures of refineries and by capacity reductions within the EU (see above). The main reasons for this pressure are: the declining demand for refined products in the EU (but also the USA), the increasing refining capacity outside the EU, the current energy tax regime favourable to diesel production coupled with a gasoline-oriented refining infrastructure (which does not meet the EU demand and makes the industry vulnerable to declining gasoline demand) and, finally, costs related to compliance with existing EU and national legislation.²¹⁰ The pressure on margins is reflected in the following graph which shows for two product types the net refinery margin per barrel for the period 1995-2012. Note for 'hydro skimming' refineries, the margin is often at or below zero, while for 'cracking' refineries

²⁰⁷ Fielden, 'Where the crudes have no margins – European refinery woes', in: Oil & Gas Financial Journal, July 2013, <http://www.ogfi.com/articles/2013/07/where-the-crudes-have-no-margins-european-refinery-woes.html>.

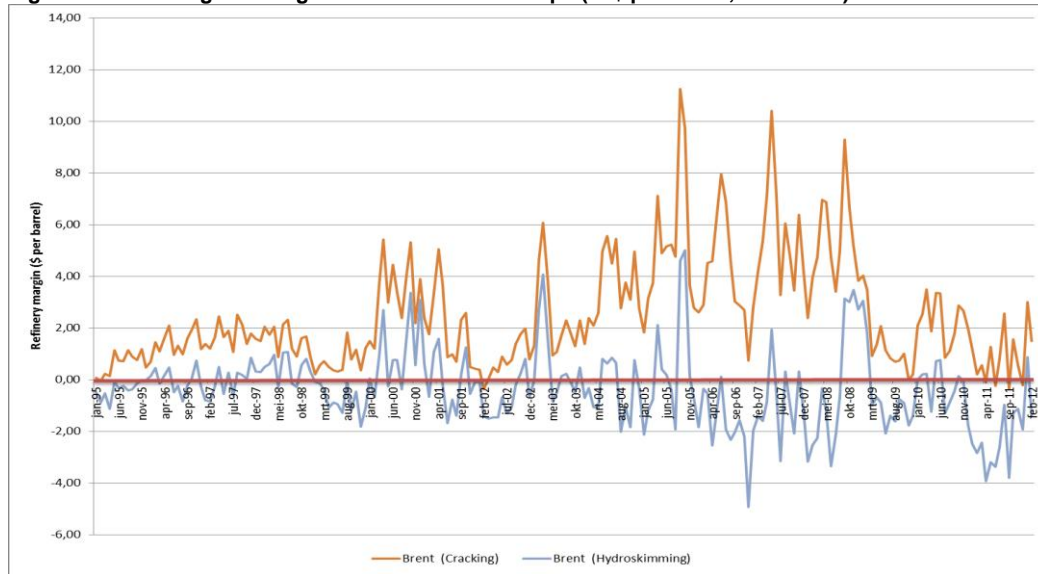
²⁰⁸ Bloomberg, 'Europe to shut 10 refineries as profits tumbles', April 2013; Boncourt de M., 'The European Refining crisis: what is at stake for Europe', Ifri Centre for energy, March 2013.

²⁰⁹ See also: Fielden, 'Where the crudes have no margins – European refinery woes', in: Oil & Gas Financial Journal, July 2013, <http://www.ogfi.com/articles/2013/07/where-the-crudes-have-no-margins-european-refinery-woes.html>.

²¹⁰ AT Kearney, 'Refining 2021: who will be in the game?', 2012, p. 3.

(which cover the majority of EU mainstream refineries) there has been a substantial decrease in margins since the end of 2008.²¹¹

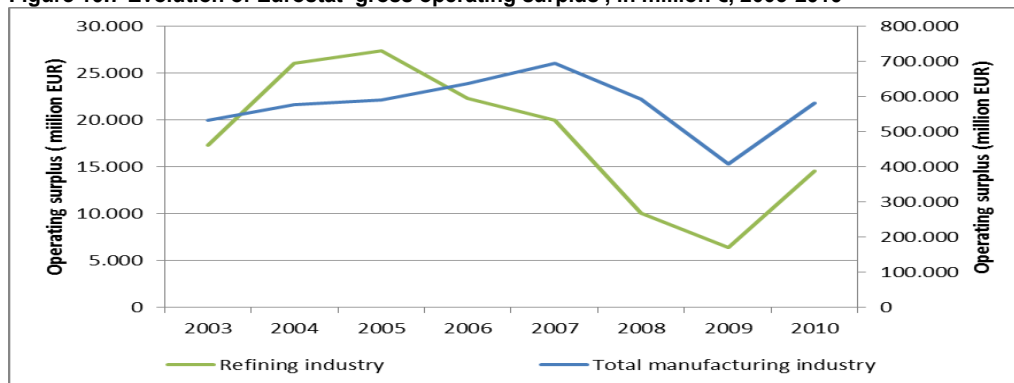
Figure 10.6 Refining net margins for North-West Europe (in \$ per barrel, 1995-2012)



Source: IEA, statistics oil market report, see <http://omrpublic.iea.org/refinery.asp>

This pressure on the margins is also illustrated in the profitability of the EU refining industry. The next figure shows that the gross operating surplus recorded by Eurostat for both refining (68% reduction between 2007-2009) and total EU manufacturing industry (41% reduction between 2007-2009) heavily declined between 2007 and 2009, but the downward trend did not continue thereafter.

Figure 10.7 Evolution of Eurostat 'gross operating surplus', in million €, 2003-2010



Source: SBS. Note: the left axis reflects the refinery industry, the right axis the total manufacturing industry.

10.4.4 Developments in utilisation

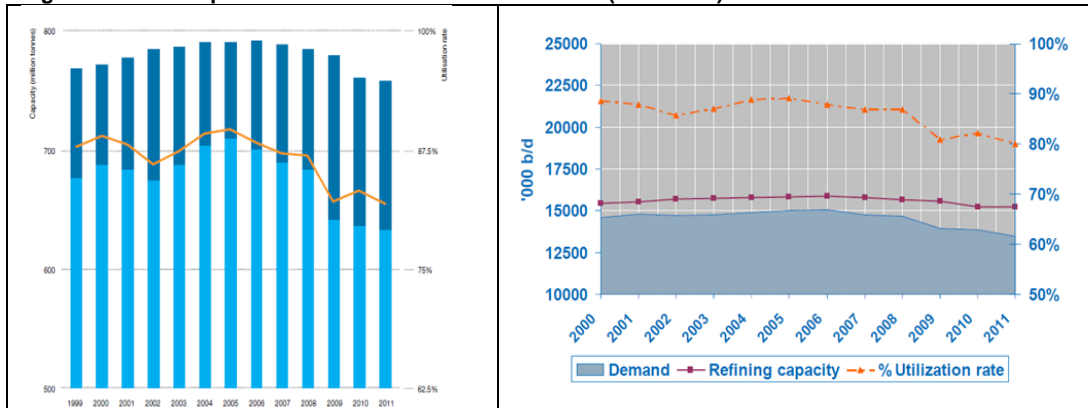
The different developments (lower demand/throughput, overcapacity, lower margins) are also reflected in the utilisation rates of the European refineries. EUROPIA²¹² indicates that in 2011, the utilisation rate had dropped to approximately 80%, which is consistent with other sources.²¹³ The development of the EU utilisation rate is shown in the next figure below (Figure 10.8).

²¹¹ See also the IEA, Oil market report, June 2013, p.43-44. The IEA defines net refinery margins as the gross product worth less the feedstock costs less the cash running expenses (variable and fixed costs).

²¹² EUROPIA, Annual report 2010, p. 100.

²¹³ IFPEN, 'Investment in exploration-production and refining 2012', October 2012, p. 45.

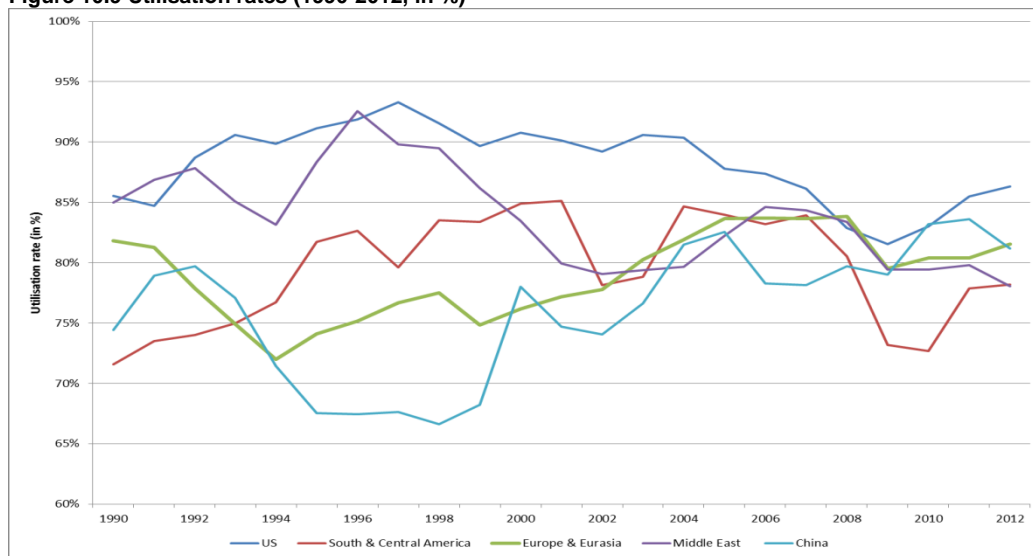
Figure 10.8 Development of utilisation rates EU refineries (2000-2011)



Sources: EUROPIA, Annual report 2012, p. 100 (left chart) and IFPEN, 'Investment in exploration-production and refining 2012', October 2012, p. 45 (right chart).

The global utilisation rate in 2012 was approximately 82% (down from 86% in 2005). For the Europe/Eurasia region, the utilisation rate dropped from 84% (in the period 2005-2008) to 80% (2009-2011) and then rose again to 82% in 2012. In the US the utilisation rate showed a decline for the period 2003-2010 (from 91% to 83%), but then rose again (to 86% in 2012). In China, the utilisation rate for 2012 was around 81% while in the Middle-East it was 81% (down from 85% in 2006). These utilisation rates are shown in the next figure (Figure 10.9).

Figure 10.9 Utilisation rates (1990-2012, in %)



Source: BP Statistical Review of World Energy, June 2013 (refinery throughput divided by the refinery capacity).

10.4.5 Development of costs in relation to the EU ETS

As indicated in the previous section, the margins in the EU refining industry are under pressure. There are several reasons for these low margins, but one of the main determinants is the relatively high cost of energy in the production process (approximately 60% of the operating cost is related to energy consumption). For the limited number of refineries that need to purchase electricity from the grid, the EU Emission Trading Scheme (EU ETS) might not only affect the sector via the direct CO₂ cost, but also indirectly via the carbon cost pass-through from the electricity sector. As foreign producers might subsequently have a relative price advantage and transportation of refined products is relatively cheap, the attractiveness to import products from outside the EU would increase.

The first (2005-2007) and second (2008-2012) ETS trading periods were characterised by free allocation of allowances to industry sectors. This process was administered by the individual Member States. Table 1.4 shows that since 2005, the refining industry received free allowances for 106% of its verified emissions (on average). This means that the EU ETS did not impose any direct costs on the industry and thus no risk of carbon leakage would be expected. The allowances which were not needed to cover the emissions could be sold on the market, so instead of creating additional cost, the high level of allocation has on average been a potential source for additional revenues.

Table 10.6 Emissions for the refinery sector (EU-25, 2005-2012)

	2005	2006	2007	2008	2009	2010	2011	2012
Verified emissions (Mt CO ₂)	151,1	149,6	149,5	149,5	141,5	139,4	137,8	132,2
Freely allocated EUAs (MtCO ₂)	159,4	158,6	158,1	146,1	146,2	150,7	150,1	152,4
% (free EUA/verified emissions)	105%	106%	106%	98%	103%	108%	109%	115%

Source: EEA, EU Emissions Trading System (ETS) data viewer

Given the current price of EUAs and level of free allocation, the impact of the EU ETS on the refining industry is small.

10.5 Synthesis

From this sector analysis it has become clear that the EU refinery industry has been facing turbulent times. This industry is affected by a number of trends and market characteristics. First of all, the industry has a gasoline-oriented refining infrastructure while current energy taxation supports the use of diesel fuels. As a result the EU is importing diesel and exporting gasoline, mainly to the US. A second trend is the decline in overall demand for fuels in the EU, as well as in the US (gasoline). This impacts the export potential for EU gasoline. As a result utilisation rates are going down, leading to pressure on the profitability of the industry and a number of closures of refineries. Overall, this creates an EU competitive disadvantage towards other countries/regions which are investing in new state of the art refineries with their economies of scale (e.g. in China, India, Middle-East). At the same time, this creates overcapacity in the (global) market. While these (negative) market conditions have had and will have a rather large impact on the competitiveness of the refining industry, the effect of the introduction of the EU ETS has been limited. Until 2012, the EU ETS refining sector received more than 100% of allowances required for free.

The main findings are summarised in Table 10.7 and Table 10.8.

Table 10.7 Evidence for (production) relocation

Indicator for (production) relocation	Trend	Additional information on trend
Net imports	Diesel: doubled net imports (2000 – 2011) Gasoline: doubled exports (2001-2011)	Due to Europe's gasoline-oriented refining infrastructure and increasing diesel demand, more diesel fuels are imported and gasoline exported.
Investment activity in EU compared to outside EU	Investments are relatively stable.	Still significant investments in the EU but more investments needed to comply with changing market demand. Majority of investments in capacity take place outside the EU (Middle-East, China, India).
Number of ETS installations	Declining	Number of large refineries is decreasing (11 closures since 2007, which is 12% of total; these were the smaller refineries within the sector of large ones)
Demand	EU refined products demand is declining	Overall EU refined products demand has declined by 14% between 2006 and 2013, or by 11% between 2002 and 2013. Diesel remains the primary fuel of choice and its demand is increasing.
Summary: evidence for (production) relocation	Strong evidence of production relocation from the EU. EU refineries are under constant pressure (low margins, increasing global competition, global overcapacity, decreasing EU/US demand, regulatory compliance).	

Table 10.8 Drivers for (production) relocation

Drivers for (production) relocation	Assessment	Justification of assessment
Carbon cost	No influence	Both indirect and direct carbon costs have been very low. Until 2012 the industry received more than the needed allowances for free (on average 106% of the total needs since 2005). Only a small fraction of electricity is purchased from the grid. With auctioning of emissions allowances and higher carbon prices, carbon costs would have an impact on operating costs and refining margin.
Other costs: fossil fuels	Some influence	The availability of affordable fossil fuel – both as feedstock and energy carrier – plays a role in determining the choice for production location, as can be observed in increased capacity investments in the Middle East
Pass through of costs	Limited	The industry is active on a global market, so the pass through of additional costs (due to EU-ETS) is only possible in a limited way.
World demand	Very important	Until today, EU demand is decreasing (14% decrease between 2006 and 2013), while demand in emerging countries is growing.
Trade & investment agreements	Not assessed	Refined products are exchanged on global and open markets. However, existing trade agreements

Drivers for (production) relocation	Assessment	Justification of assessment
		and non-tariff barriers such as EU-only regulatory proposals (FQD Art 7a) could influence this.
Margins	Very important	Constant pressure on the margins in the EU. Operating surplus declined between 2005 and 2009, but started to increase again in 2010.
Summary: CO ₂ cost among the relevant drivers?	No	The main drivers for relocation appear to be the shift in global demand patterns and the current EU refining industry operating conditions (refinery configuration, demand imbalance, etc.). No ETS related cost increase due to free allocation under Phase I and Phase II. However, under current circumstances industry is generally sensitive to cost pressure.

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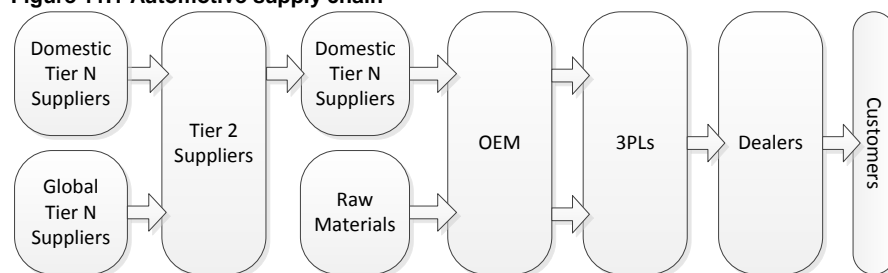
11 Manufacture of Motor Vehicles

This fact sheet is a part of a series providing a brief overview of sectors that have been or may be affected by the European Trading Scheme (ETS). The automotive industry was singled out as a sector with concerns, though data limitations prevented a quantitative breakdown of carbon leakage. As such, the text below is meant to discuss various elements of the value chain and provide a qualitative look at ETS and how it could influence the automotive industry.

11.1 Introduction to the sector and its value chains

Called the industry of industries, automotive products are highly complex, consisting of approximately 20,000 detailed parts with around 1,000 key components (Thomas 2012), a figure that continues to rise. As a consequence, supply chains are highly complex, including the (1) production raw materials, such as steel, aluminium, plastics, and glass; (2) formation and fabrication of parts, components, and subsystems; (3) assembly of the hundreds of elements; and, (4) distribution and sales.

Figure 11.1 Automotive supply chain



Source: O’Ryan David, Presentation: Clean and Sustainable Automotive Supply Chain

According to Thomas (2012), 56 percent of the vehicle cost structure lies in major systems and structures such as the powertrain and body; 31 percent lies in OEM assembly, administration, design, engineering, sales and marketing and margin; seven percent in warranty, transportation and advertising, and six percent in the dealers’ gross margin.

Generalising about emissions generated in the manufacturing process can be difficult for two reasons, both related to the complexity of the supply chain. First, particular components of the supply chain generate a disproportionate amount of emissions, most particularly raw materials. Second, even within the discrete categories of the value chain illustrated above, the problem of emissions can vary from plant to plant.

At the same time, digging into any of these components of the value chain reveals an ever-changing set of manufacturers. The rise of electric hybrid engines and “connected” vehicles which are wirelessly connected to the Internet has brought new components into the mix. Carbon fibres, lightweight materials, and new types of plastics have begun to change the dynamic for the raw materials that need to be placed into a vehicle, and new information systems mean that new types of suppliers are required.

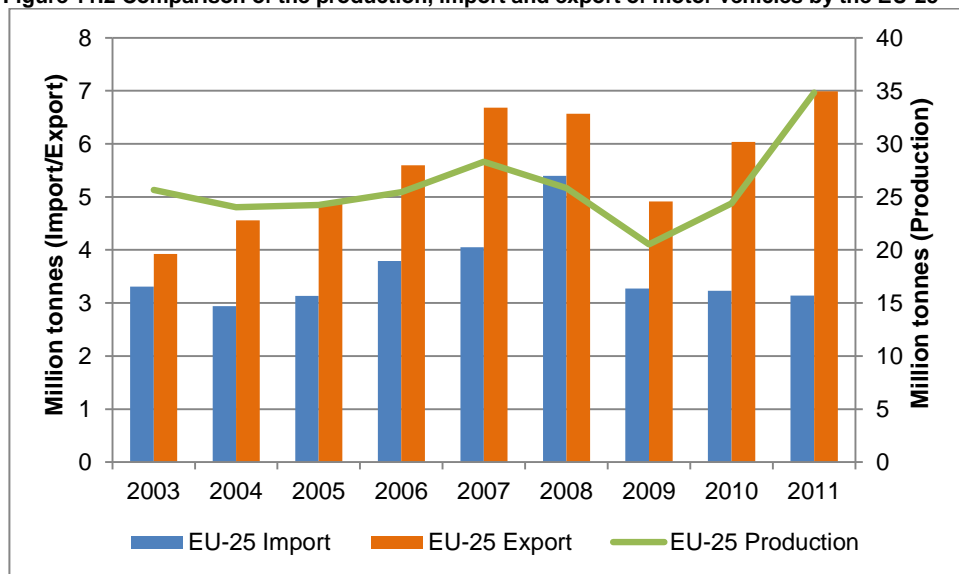
Generalising about emissions from the OEMs perspective is also difficult because the level of vertical integration differs by player. For example, for historical reasons, Daimler (with thirteen plants that fall under the ETS) has a higher level of vertical integration, owning foundries in Europe that supply the raw materials for the vehicles that they assemble. Other OEMs, such as the Volvo Group, focus more on assembly.

11.2 Global value chains and production

11.2.1 Production and sales

The global economic recession and the rise of China as the largest consumer of motor vehicles are two major trends that have led to shifts in the structure of the automotive sector. Figure 11.2 below shows a clear drop in production, imports and exports after 2008.

Figure 11.2 Comparison of the production, import and export of motor vehicles by the EU-25



Source: Prodcorn

These figures, however, must be approached with caution. First, some of the reported changes in levels of production have taken place because NACE codes definitions changed in 2008. The figures before 2008 correspond with the NACE Code 34.1 (Table 11.1), while the figures after 2008 correspond to NACE code 29.1.

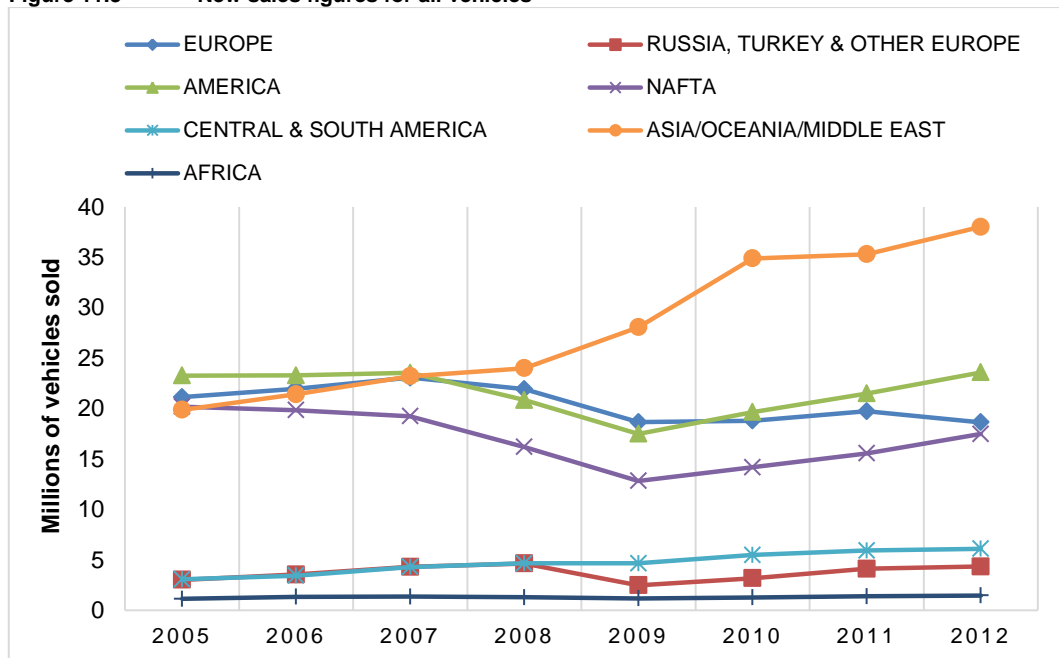
Table 11.1 Changes in NACE Codes after 2008

NACE Code, Rev 1.1		NACE Code, Rev 2		
34.1	Manufacture of motor vehicles	28.92	Manufacture of machinery for mining, quarrying and construction	Off-road dumping trucks
34.1	Manufacture of motor vehicles	29.1	Manufacture of motor vehicles	Except: - off-road dumping trucks - motor cycle engines
34.1	Manufacture of motor vehicles	30.91	Manufacture of motorcycles	Manufacture of motor cycle engines

Source: Eurostat

Second, the way these figures are interpreted need to be contextualised within the recent economic crisis and longer-term shifts in (new) demand. As will be addressed later in this document, one key location determinant for suppliers and OEMs in the automotive industry is to produce product closer to customers. And demand in Europe has clearly stagnated, a trend that preceded the financial crisis, with sales figures starting to fall already in 2007 with little sign of recovery, as shown in Figure 11.3 below.²¹⁴

Figure 11.3 New sales figures for all vehicles

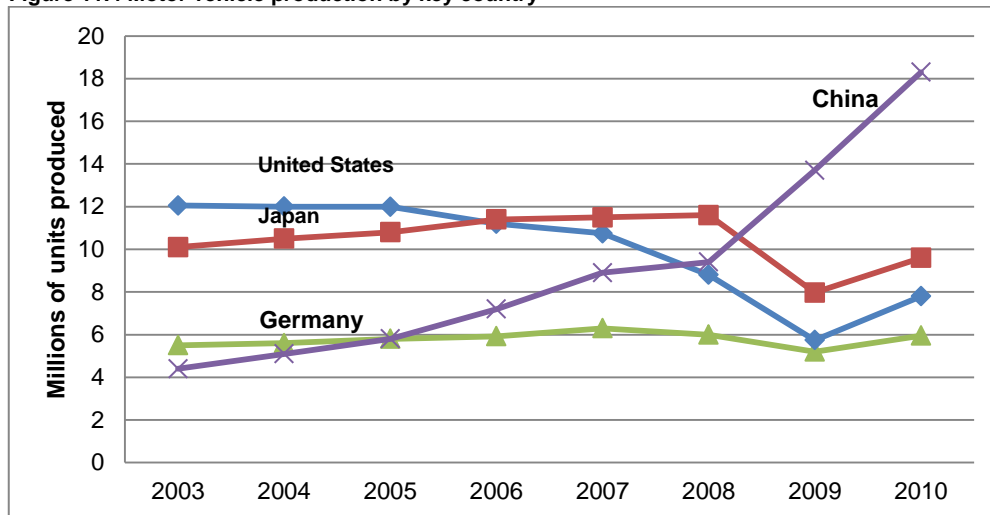


Source: OICA.

Currently, production is increasing in Europe, which largely comes out of increased demand for products abroad rather than internal demand. Starting from 2009, EU 25 exports and production have increased, reaching their highest value in 2011 (Figure 11.2). This trend reflects the global trend, with global motor vehicle production declining by 15.7 percent in 2009 and then rebounding by 26 percent to 2011, reaching around 78 million vehicles produced in 2011 against 74 million vehicles produced in 2007 (Thomas 2012). The only market to buck the trend of declining production over this period was China, as shown in Figure 4 below.

²¹⁴ Decreasing sales, it should be noted, cannot only be attributed to economic conditions. Europe is the only region in the world where distances traveled per year in vehicles are expected to decrease in the next ten years. (Berger, 2011) A trend towards “demotorisation” in crowded urban centres and stagnant population trends, while they should not be overly exaggerated, also suggests demand for new vehicles will remain relatively soft into the future.

Figure 11.4 Motor vehicle production by key country



Source: International Organization of Motor Vehicle Manufacturers

Despite increased imports, European production is still characterised by overcapacity, with 58 percent of the top 100 European assembly plants operating below the 70-80 percent plant utilisation break-even levels in 2013. (AlixPartners, 2013) This figure was even worse in 2012 at 40 percent. However, globally, sales growth of three percent in 2013 is expected, with China, Russia, Brazil, India and the United States accounting for 75 percent of global growth of the automotive industry through 2018.

11.2.2 Product innovations

In general, innovation in the automobile industry can be seen in a shift from traditional to connected cars and more innovative mobility systems. To support the competitiveness of the European car sector and stress their importance, the European Commission initiated a smart car development program called the Intelligent Car Flagship Initiative. It was launched in February 2006 as part of the i2010 policy framework to boost Europe's digital economy and to improve the absorption of ICT in road transport.

Several working groups and a task force were established to foster new ideas and push innovation, such as the EC-METI (promoting international harmonisation and standardisation). The group focuses on materials technology, recycling, energy and fuels, drive-train development, aerodynamics and ergonomics. According to Cap Gemini, 80 percent of industry executives agreed that the future of their industry lies in e-mobility, and they expect this change to occur over the coming five to 20 years.

Most R&D in this field takes place in cooperation between several OEMs to save costs. The 2013 Global Automotive Study underlines that a high degree of collaboration and integration has been reached in the automotive industry. As a result from cost pressures and the need for investments in new technologies, sourcing technologies or entire platforms from competitors are no longer uncommon. There are currently more than 15 joint ventures and 25 alliances among automotive companies.

These consortia of different companies have led many European (especially German) automakers to seek out local Chinese state-owned companies to secure a long-term presence in overseas development. Examples of joint ventures that have been formed by European car makers, focussed

on hybrid vehicles, include BMW and Brilliance Automotive; Daimler AG and BYD; as well as Renault and Dongfeng. Apart from a common R&D department, as mentioned earlier, production has also been shifting to emerging markets to deal with regional requirements and to reduce costs.

While longer-term trends in innovation revolve around ICT, more immediate trends in the industry involve improving the fuel efficiency of the fleets of manufacturers, a move pushed both by the European Commission and California legislation as well as various CSR policies of the car manufacturers themselves. Within the industry, manufacturers have tied themselves to different technologies to meet these requirements. Toyota, for example, is generally seen as a world leader in gasoline/electric hybrids, and purely electric vehicles are coming to market. European carmakers, however, have tended to look at making highly efficient diesel engines to meet the same ends.

These innovations are important because they brings shifts to the value chain, which have potential implications for where firms will locate in future.

11.2.3 *Supply chain innovations*

The automotive supply chain represents a global supply infrastructure both for technology development and manufacturing. Platform consolidation, modular assembly, and focused management of supply chains have been widely adopted as a means of increasing production efficiencies.

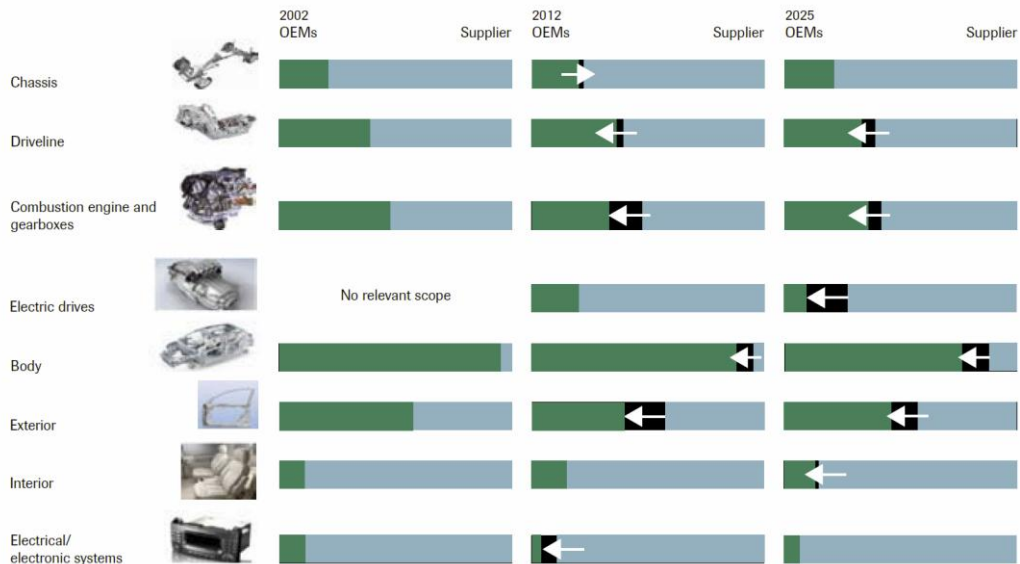
A new trend in the automotive supply chain is the introduction of so called 'e-exchange' of business documentation. Suppliers are incorporated into production lines irrespective of their location and thus are more closely involved in the entire planning process.

A second trend is the increasing importance of global modular mega-platforms in development. Several models can be built on the same platform and therefore help to increase flexibility and save costs. According to the 2013 Global Automotive Study, production volumes from such a platform could save costs 10-20 percent in non-recurring costs and 4-8 percent in recurring costs. It is expected that the use of global platforms for vehicle production will rise by 63 percent over the next five years and will account for more than 88 percent of the automotive industry growth through to 2018.

These trends open the possibility to make the segments of the supply chain more mobile, though currently, the need to locate production close to customers remains an equally important location factor. Both cases would seem to point to production shifting outside of Europe, though only in the former case could this potentially be related to the effects of ETS.

While changes to the way suppliers interact creates shifts in the value chain, new technologies also create changes. One minor trend to note, for example, is the possible inclusion of more composite materials in vehicles to make them lighter. But currently, the more important shift comes from the inclusion of e-technology and battery suppliers. Figure 11.5 below provides some illustration of changes in the value chain and projected further changes, showing shifting shares in value added.

Figure 11.5 Shifts in the value chain



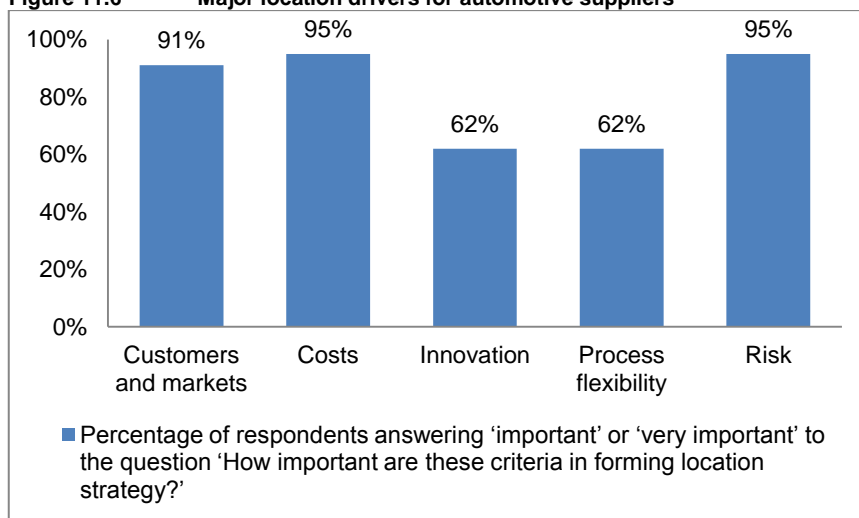
Source: FAST 2025

11.3 Location drivers

A study from KPMG (2009) identified major location drivers for automotive suppliers including growth, cost, and innovation (Figure 11.6). Among the companies that reported cost as the most important factor, the study underlines that they would first focus on optimizing production facilities before relocation. For those who are looking in new markets, material cost would be the first criteria, before labour or capital costs. However quality of the material as well as logistics cost and complexity are factors constraining relocation.

The companies interviewed in the KPMG study cited other cost relocation drivers such as government incentives, landed cost, regional interest rates, wages and trade agreements, but energy costs did not appear as a major driver.

Figure 11.6 Major location drivers for automotive suppliers



Source: KPMG, Global Location Strategy For Automotive Suppliers, 2009.

Raw material used in the supply chain are mainly steel, aluminium and plastic. Production and processing of steel and aluminium represent the biggest share of energy consumption for the transmission system with respectively 49 percent and 38 percent of the energy consumed during the production of the transmission system. (Energetics Incorporated, 2009) The cost for the raw material depends on the extraction costs and the energy to produce it: “A new smelter in Iceland or China could deliver aluminium to Europe or the US at a cost 10% lower than for European production, including the transport costs, even before an EU ETS driven increase in electricity prices”. (McKinsey & Ecofys, 2006)

The automotive industry tends to be characterised by a dual structure. The innovation, engineering and technology centres stay close to the headquarters, whereas design centres and production are tailored to the specific market. Hence, the automotive industry is neither fully global, consisting of a set of linked, specialized clusters, nor is it tied to the narrow geography of nation states. In recent years, platform consolidation, modular assembly, and the focused management of supply chains and networks have been widely adopted as a means of increasing production efficiencies. However companies seem to be conservative on R&D location with reluctance to relocate R&D to emerging economies. (KPMG, 2009)

11.4 ETS and the potential for carbon leakage

The automotive sector has experience in generating energy efficiencies by both adopting energy efficient production techniques and using different materials in the production of their vehicles. Toyota, for example, has adopted “ecological plastics” for the interiors of their vehicles, which they claim reduce CO₂ emissions by 20 percent over the life of the vehicle.

Car manufacturers are attempting to respond to government regulation to reduce the overall impact of their vehicles on the environment, while also remaining profitable entities. Arguably, legislation has provided a positive stimulus to these efforts. Nonetheless, the need to remain profitable means that manufacturers are continuously re-evaluating costs, and where they locate their facilities is an important element in that.

11.4.1 Costs

Any change in input price is going to cause an industry to re-evaluate how they produce a product. If energy prices increase, the question is whether those costs are low enough to either make relocation more economically attractive or whether—on higher margin products—those extra costs can be passed along to the consumer. Alternatively, the question becomes whether energy efficient techniques can be adopted to mitigate those increased costs or whether a move to a lower-cost location is in order. Energy efficiency can be introduced in two ways—by producing the same product though with greater efficiency or by producing a product with other materials that require less energy.

Table 11.2 CO₂ emission during Lifetime of a car

Part	t CO ₂	Percentage of total
Raw material	2.6	10.12
Production of supplier	1.6	6.23
Production OEM	1.2	4.67
Logistic	0.3	1.17
Emission during use	19.3	75.10
Reparation/Maintenance	0.6	2.33

Part	t CO ₂	Percentage of total
Destruction	0.1	0.39
Total	25.7	100

Source: Management engineers – Climate Cost and Competition

The EU ETS can mainly impact the automotive industry indirectly through raw material and energy costs. Estimates are that a price of 40€/tCO₂ would lead to a 26 percent increase in costs for an OEM, a 28 percent increase in costs for suppliers, and a 46 percent increase in the costs for raw materials. (Management Engineers, 2010) The main inputs through which the ETS potentially affects the automotive industry are steel, aluminium, and plastics. For both inputs from suppliers and raw materials the OEMs source, their bargaining power (and thus exposure to increased costs) depends on the type of input they source. Interchangeable commodities are sourced based on world market prices and thus can be assumed to be roughly the same worldwide; their price increases are thus not causing competitive (dis-)advantages.

For specialized aluminium, steel and plastics products, which are potentially developed in collaboration with the OEM or supplier, world markets play less of a role, and the OEM's demand is less elastic, so that a partial cost pass-through is more likely. In the case of an OEM with little vertical integration, the ETS therefore affects first the suppliers whose products contain niche products of aluminium, plastic and steel. If their input prices increase due to the ETS, the suppliers have limited room to pass costs through to the OEMs.²¹⁵

The ability of the OEM to pass potential costs along to consumers depends on the segment of the market to which the auto industry is aiming. For manufacturers aiming largely at the lower value segment of the market, where margins are very thin (lying in the single digits), even a small increase in input costs can have an impact.

11.4.2 Potential production shifts

Given that the main impacts of EU ETS will be felt at the raw material level, the risks of production relocation *caused by ETS* will generally be at this level. The shift of production and mining of input materials for the automotive industry outside Europe already happened before the introduction of the EU ETS, and procurement of raw material from outside Europe is a viable option given that much of the material inputs are commodities traded worldwide. However this development of international sourcing is hardly related to ETS, and it alone creates little incentive to relocate production of the automotive sector.

If an automotive manufacturer has a preference for a geographically close supplier of raw or intermediate input materials – especially in the case of specialized products – the competitive environment is a bit different. In this case, regional price differences may occur, and shifts of production to regions with lower prices is a theoretical option – but this option disregards the advantages of the often long-term relationships between OEMs and their historically grown base of suppliers.

²¹⁵ The suppliers' negotiating power in general seems to increase due to decreasing numbers of suppliers in the market and increasing collaboration with OEMs in R&D, which increases the cost of switching suppliers. See <http://www.pwc.de/de/automobilindustrie/krisenmanagement-bei-oems-und-automobilzulieferern.jhtml>.

11.5 Qualitative final assessment

One of the tools that has been used to assess the potential for carbon leakage has been to examine overall levels of production worldwide, and then examining whether the European share of that production has been decreasing after ETS was implemented. However, for a number of reasons, evaluating the automotive industry in this way, with its complicated and variable supply chains, is problematic.

First, looking exclusively at production figures in this way would show potential “leakage” in the technical sense. Production figures in Europe lag behind other major jurisdictions in the rest of the world. However, given lower demand in Europe, rising demand in the rest of the world, and the desire to locate close to customers, this trend cannot be attributed to ETS. Costs are an important location factor, but not the only one (and ETS costs are not the only costs that are changing). A proper assessment of the level of leakage would require breaking down shifts caused by increasing costs and those caused by shifting demand (and the need to follow that demand).

Second, the potential of the ETS to affect the automotive industry lies mainly in automotive manufacturers’ material inputs, and the complex nature of supply chains makes an overall assessment problematic. Certain elements of the value chain are potentially much harder hit than others, given that a large component of CO₂ emissions that derives from the metals and other materials being made for vehicles. As mentioned by both the association and several interviewees, the effects of ETS are very much plant specific. Costs of ETS for those companies that are not vertically integrated are indirect and relatively low.

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12 The lighting industry

This fact sheet is a part of a series providing a brief overview of sectors that have been or may be affected by the European Trading Scheme (ETS). The lighting industry was singled out as a sector of interest, though data limitations prevented a quantitative breakdown of carbon leakage. As such, the text below is meant to discuss various elements of the value chain and provide a qualitative look at ETS and how it could influence the lighting industry.

12.1 Introduction to the sector and its value chains

Traditionally, people's homes have been lit by standard incandescent lamps, a simple form of lighting that passes current through a tungsten filament suspended in an inert gas to produce light. New products like Compact Fluorescent Lamps (CFL), advanced halogen lamps and Light Emitting Diodes (LED) have been replacing this century's old technology. While there has been some consumer resistance, governments worldwide have been banning their sale in favour of higher efficiency technologies. In 2012, the European Union instituted a full ban on their sale in 2012. The ban of incandescent bulbs saw a massive increase in sales of halogen and LED lighting, with these two types making up 63 percent of sales in the UK at the end of 2012. (GFK 2013)

Currently, each of these new technologies is seen to have their disadvantages. CFLs, for instance, contain trace levels of mercury, which cause a large problem with waste. Halogen lamps produce a lot of heat as a by-product, and their average lifespan, while much better than incandescent bulbs, is still far lower than other technologies.

LEDs and other forms of solid-state lighting (SSL) would appear to have the longest-term appeal. The bulbs last, on average, 10 times longer than equivalent halogen bulbs, and produce far less heat. Moreover, they contain no mercury, making disposal less problematic to CFLs. Compared to traditional incandescent bulbs, SSL bulbs allow a reduction of 80 percent in energy consumption (McKinsey, 2010). Some factors do inhibit wider take-up of the technology, with retail price being one of the largest issue, but prices continue to decrease as the technology matures.

Table 12.1 Characteristics of incandescent, CFL and LED bulbs

	Incandescent	Halogen	CFL	SSL (LED)
Purchase Price (USD)	0.41		4.00	15.00
Electricity Usage	60W	20 W	13W	9W
Lumens (Light Intensity)	860	278	660	900
Lumens/Watt of Energy	14.3	14	51	100
Lifespan (Hours)	2,000	2,000 - 6,000	8,000	25,000
Bulb cost over 10 years (USD) Assumes 6 hours/day	4.40		10.95	17.52
Energy cost over 10 years (USD)	198		43	30
Total Cost over 10 years (USD)	202		54	47

Source: George (2012) and Paget et al. (2008)

Emissions from production and sale of lighting products tend to be very low, and both the European Engineering Industries Association representing the industry and some players in the industry itself

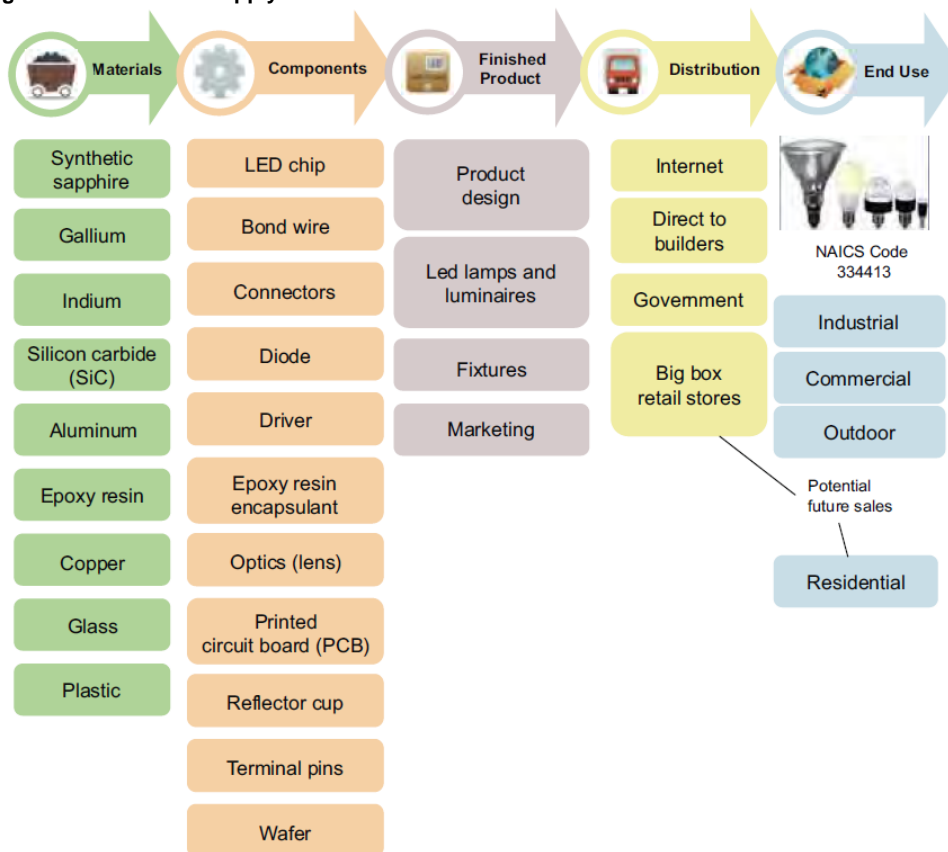
acknowledge that EU ETS will not have much effect on the sector. Some, such as Philips, see potential indirect benefits of EU ETS and other carbon market mechanisms, as they drive demand for products that the industry sells.

12.2 Global value chains and production

12.2.1 Value chain

Value chains in the lighting industry tend to be global, with Asian firms designing and manufacturing product for original equipment manufacturer (OEM) that market and sell the product under their own brand. North American and European companies in SSL tend to do product design, marketing and selling, but many of them outsource the manufacturing to Asian subcontractors. A few exceptions exist, like Cree, Philips Lumileds and a number of smaller firms (Globalization, 2008). A further singularity of the LED market is its distribution through internet sales and direct sales to businesses and builders.

Figure 12.1: Overview supply chain LED

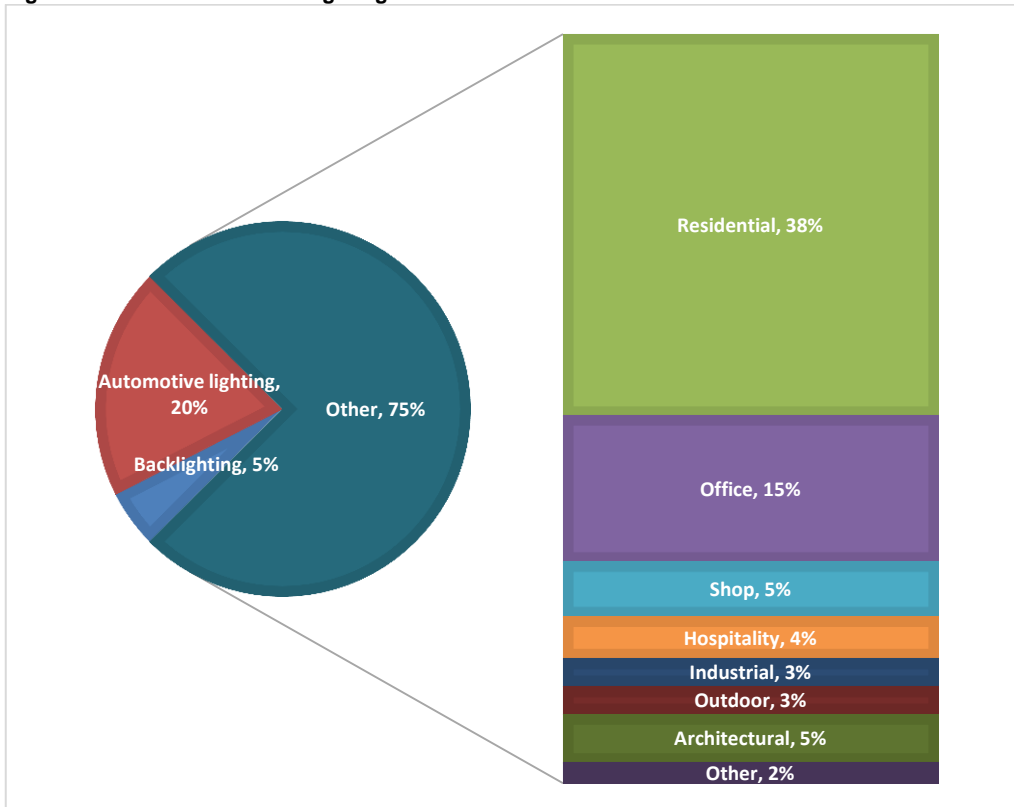


Source: Globalization (2008)

12.2.2 Production and sales

The global economic recession and Europe's debt crisis have had an impact on global and regional growth, which has also affecting the lighting sector. The slowdown in sales has been caused largely by a drop in new construction, which affects the sale of new lighting installations.

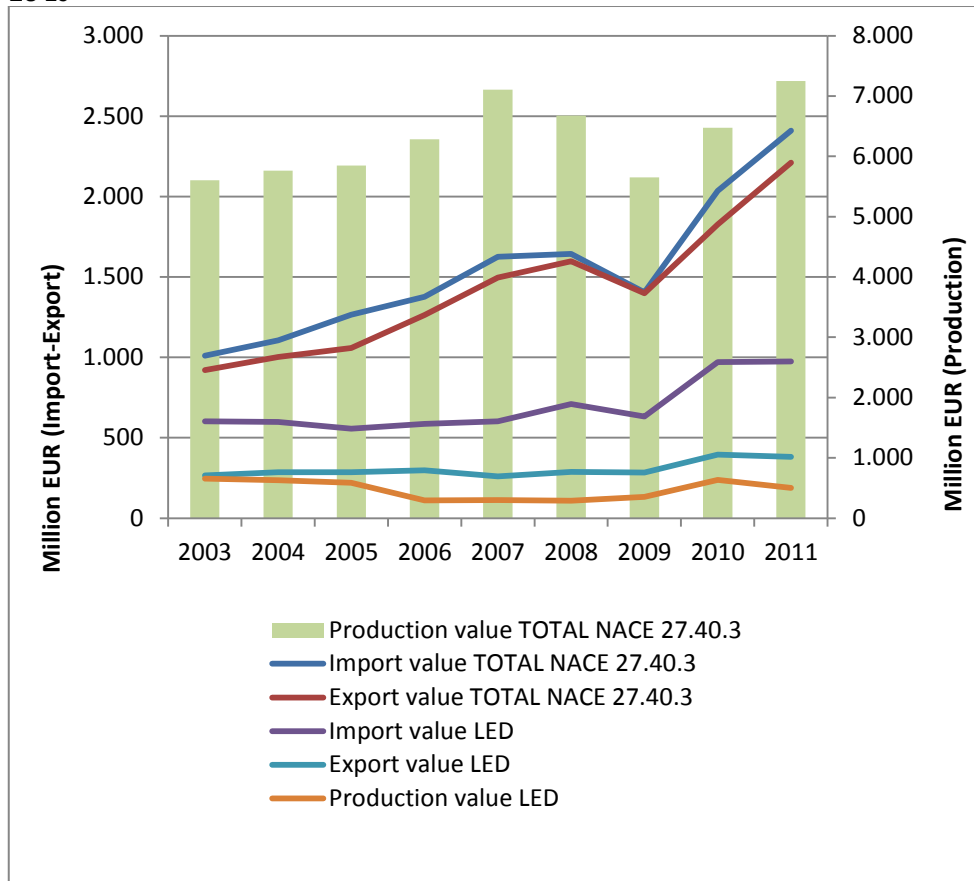
Figure 12.2: Breakdown of the lighting sector



Source: McKinsey & Company (2012)

The phase-out of incandescent bulbs has also had a significant effect on the types of lighting being produced, with sales of halogen and SSL increasing markedly in Europe after the ban instituted in 2012. Demand for energy efficient lighting will continue to gain pace as other countries also institute bans, with China upcoming in 2016. According to the “Global LED Industrial Lighting Market 2012-2016” (2013), the LED industrial lighting market is expected to grow around 49 percent globally over the period 2012-2013, with demand for more energy-efficient lighting as one of the most important drivers.

Figure 12.3 Comparison of the production, import and export of lighting devices and LED by the EU-25

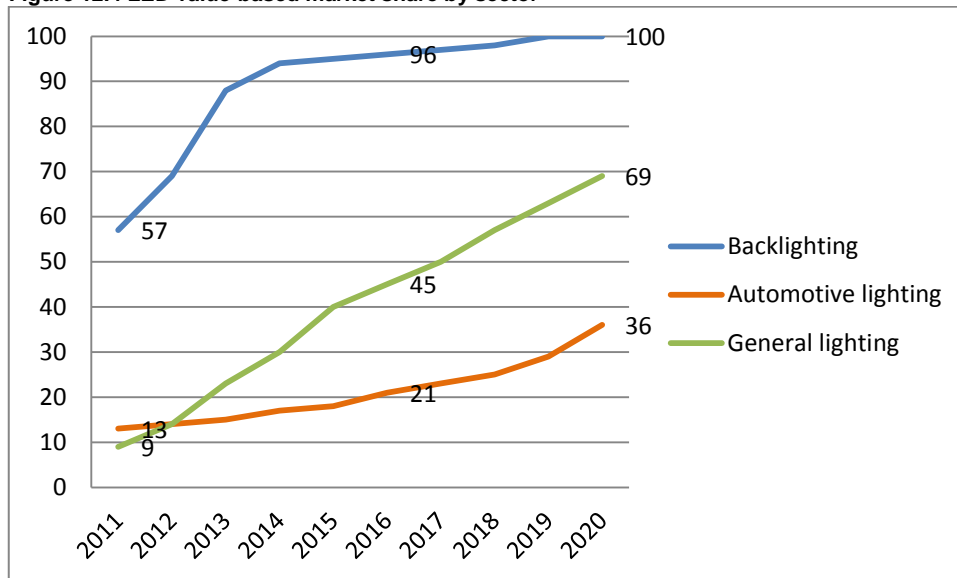


Source: PRODCOM

While lighting is generally associated with providing light to an environment (an office or the street), lighting is also used in modern devices with displays. Known as backlighting, high demand for smartphones, tablets, and other devices have driven demand for SSL, with a 12-fold expansion of the manufacturing capacity for this purpose over the last decade (Doe, 2012).

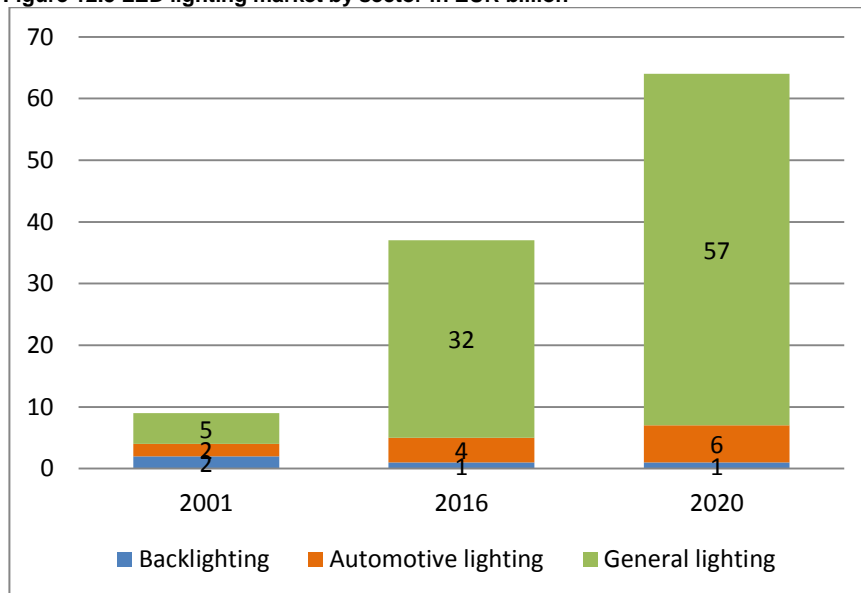
Over the coming years, demand for backlighting is expected to remain stable as some markets reach saturation (particularly for televisions), but demand for general lighting is expected to take over and expand significantly (Figure 12.4, Figure 12.5). Demand from industry and the public sector is expected to continue to rise. For example, cities and regions are looking to lower their environmental footprint and reduce the costs of outdoor lighting by moving to new energy-efficient designs. According to a recent McKinsey report (2012), recent retail price decreases will lead SSL's share in general lighting to increase to 45 percent in 2016 and up to almost 70 percent in 2020. According to the same report, the total market for SSL is expecting to grow by 5 percent through to 2016 and then by 3 percent to 2020, with revenues of around EUR 100 billion in 2020 worldwide.

Figure 12.4 LED value-based market share by sector²¹⁶



Source: McKinsey's 2012 Global Lighting Market Model in McKinsey (2012)

Figure 12.5 LED lighting market by sector in EUR billion²¹⁷



CAGR in %	2011-16	2016-20
Total	33	15
Backlighting	-9	-13
General lighting	45	15
Automotive lighting	15	15

Source: McKinsey's 2012 Global Lighting Market Model in McKinsey (2012)

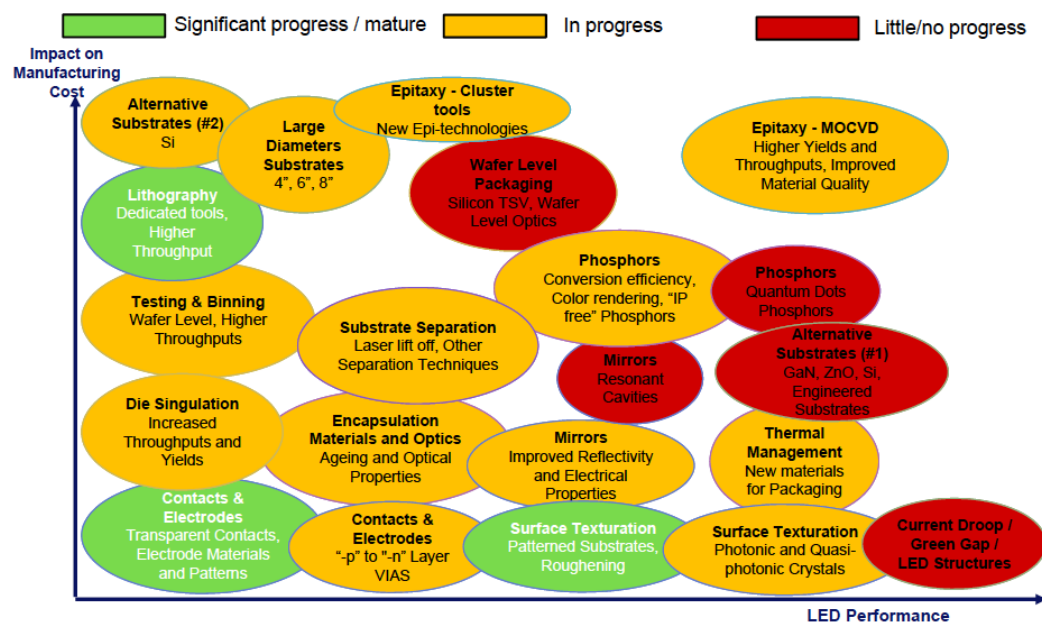
²¹⁶ Total general lighting market (new fixture installations including full value chain, including lighting system control components and light sources replacements) automotive lighting (new fixture installations and light sources replacement), and backlighting (light source only: CCFL and LEC package)

²¹⁷ Total general lighting market (new fixture installations including full value chain, including lighting system control components and light sources replacements) automotive lighting (new fixture installations and light sources replacement), and backlighting (light source only: CCFL and LEC package)

12.2.3 Key innovations

Innovations to increase lighting product performance and to bring costs down are needed to increase market penetration of LEDs. Figure 12.6 shows the status of the main innovations in 2013. Forecasts predict SSLs with 150 lm/W converting more than 50 percent of input watts to light (Yole Développement, 2009). Disruptive manufacturing technologies include GaN-on-GaN, GaN-on-Si, and semiconductor industry process control (Doe, 2012). Another increasing trend is to look for new functionalities for LEDs both at the component and system level. One example at the system level is the recent development of software for light bulbs with Philips creating a software development kit for third-party applications. This will allow more interaction with users through apps for smartphones, for instance, and will open new features such as the possibility to control the brightness of the bulbs in the house according to outside daylight or to flash colours in synchronisation with music. (Doe, 2013).

Figure 12.6 Status of innovation in 2013



Source: Yole Développement, 2013

To cut down production costs, improved supply chain management is also being examined by companies. Costs can be saved with simplifying and optimizing the supply chain, for instance by moving from the current approach where chip, package, module, and luminaire are separated to a modular approach with more integration and hybrid modules for instance (Doe, 2013). The trend is strengthened by the move of the LED manufacturing industry to a volume manufacturing industry, with more automated production and more cooperation and integration between stakeholders (Doe, 2012).

12.3 Location drivers

The world's top three leading firms in producing SSL, namely Cree, Philips Lumileds and Osram, also supply other forms of lighting. SSL has opened the door to other producers that are not traditionally associated with lighting, such as large suppliers of semiconductor products, including Vishay (U.S.), Toyoda Gosei (Japan), and Avago (U.S.). Other firms in the SSL market include those that focus solely on LEDs, such as the world leader, Nichia (Japan). However, these three big

players face more on more competition from growing companies in Japan, Taiwan, South Korea, and other Asian countries.

Table 12.2 Facilities location of CREE, LUMILEDS, OSRAM

CREE	LUMILEDS	OSRAM
Santa Barbara CA (CA, USA) – technology Centre	San Jose (CA, USA) - manufacturing	Regensburg (Germany) - Headquarters and manufacturing main site
Research Triangle Park (NC, USA) – technology Centre	Best (Netherlands) - R&D	Penang (Malaysia) - manufacturing
Cotco (China) – production and packaging	Yishun (Singapore) - production	
	Penang (Malaysia) - packaging	
	Tokyo – Sales and Marketing	

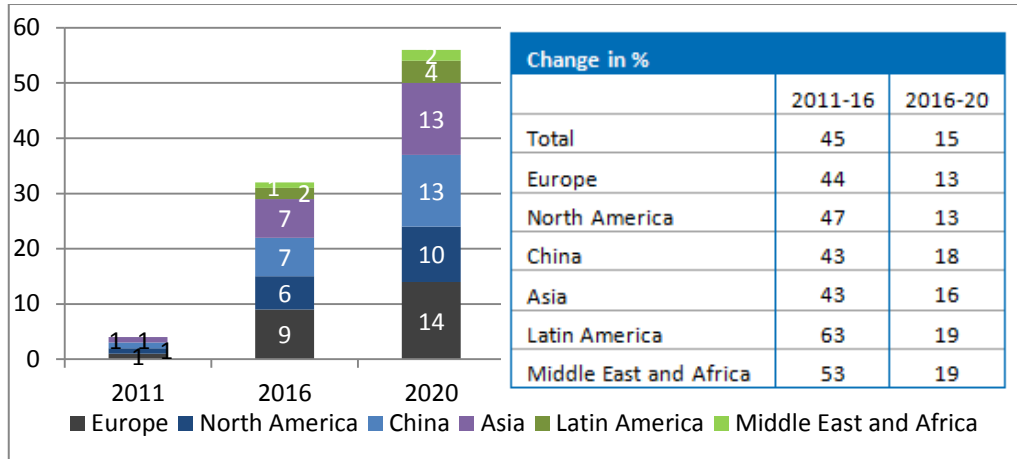
Source: Yole Développement, 2009

Notwithstanding the high costs in Europe and the United States, several companies continue to manufacture products domestically. On the one hand, companies appreciate the better protection of intellectual property, and on the other hand, quality standards still tend to be higher—two major factors in its success.

Havells Sylvania is one company that has actually “relocalized” part of its production from China to Europe as they encountered inconsistent quality, which led to higher verification and fixing costs. Delivery times from Asian subcontractors were averaging six weeks, which were considered too long by the company. As a consequence from moving from China to Europe, automatization of production increased. In China, labour costs represented 30 percent of production against 5 to 10 percent in Europe (Les Echos, 2013).

Regarding LED manufacturing, Taiwan is the leader. In 2012 Taiwan concentrated over 21 percent of the world’s capacity (SEMI Taiwan, 2012). Currently, Asia is leading the market transition to LED in general lighting, and by 2020, Asia is expected to account for approximately 45 percent of the global market (Figure 12.7).

Figure 12.7 LED lighting market size by country/region, including lighting system control components in EUR billion²¹⁸



Source: McKinsey's 2012 Global Lighting Market Model in McKinsey (2012)

According to McKinsey report (2012), unlike typical electronic products, the general lighting fixtures market is regionally fragmented because of local product requirements and the importance of being close to the local decision makers such as the architects or electrical installers for instance.

12.4 EU ETS and the potential for carbon leakage in the sector

The lighting industry is not carbon intensive and the EU ETS appears to a very minor factor for the main stakeholders in their location decisions. As described earlier, some companies have found reason to even move production back to Europe. Quality standards and protection of intellectual property rights (IPRs) work as pull factors against push factors such as increased production costs.

For the industry, EU ETS (and other carbon market mechanisms) are arguably more important and a motivator for industries to seek out additional efficiencies, encouraging them to seek out high-efficiency lighting solutions. For example, in Mexico, Philips teamed with the Dutch energy provider Eneco and ING Bank to deliver 20 million high-efficient light bulbs to Mexico City. Those energy savings were monetised through carbon credits, which helped to pay for the bulbs. The aim was to save 33,000 gigawatt hours of electricity, which was the equivalent of about one-third of road transport emissions in Mexico City.²¹⁹

A study from McKinsey (2010) demonstrates that a switch from incandescent lights to LED ones can yield a profit of 140€/tCO₂ abated whereas it would cost 190€ to reach the same result by reducing CO₂ outputs in cars, and 80€/tCO₂ abated if done through solar subsidies.

²¹⁸ Total general lighting market: new fixture installations including full value chain, including lighting system control components and light sources replacements.

²¹⁹ <http://www.reuters.com/article/2011/11/07/mexico-carbon-idAFL4E7M71AE20111107>

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