CEPS SPECIAL REPORT

Thinking ahead for Europe

Composition and Drivers of Energy Prices and Costs in Energy Intensive Industries:

The Case of Ceramics, Flat Glass and Chemical Industries

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Prepared for the Directorate General for Enterprise and Industry

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OVERVIEW*

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The European Union has taken the lead globally in tackling the climate change challenge, with more stringent regulations and ambitious objectives. The European Commission published in 2011 a 'Roadmap for moving to a competitive low carbon economy in 2050', including challenging long-term targets. As part of its efforts to accelerate progress towards meeting these targets, the Commission adopted in March 2013 a Green Paper intended to stimulate debate and launch a public consultation on a new energy and climate framework for the period until 2030. This Green Paper addressed, among others, the challenge to secure the competitiveness of the EU economy under the new energy framework. The Council recently[1] welcomed this paper and also called on the Commission to '*present by the end of 2013 an analysis of the composition and drivers or energy prices and costs*'. The analysis should cover households, SMEs and energy intensive industries, and also look at the question of European competitiveness in the global context.

Drawing on the above call for action, this study has focused on energy prices for a selection of energy-intensive industries. More specifically, it has covered three types of energy-intensive industries: ceramics, float glass[2] and chemicals. In order to address a variety of different production technologies and processes as well as energy inputs, the study covers the following sub-sectors:

- Bricks and roof tiles (ceramics)
- Wall and floor tiles (ceramics)
- Ammonia (chemicals)
- Chlorine (chemicals)

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[1] In May 2013.

[2] Float glass and flat glass are often used as synonyms in the literature, and also throughout this study. However, float glass is defined as flat glass produced with the float process. Hence, the term float glass refers both to a type of glass and to the process by which it is made. The term flat glass refers to flat glass regardless of the technology used to produce it (i.e. it could be produced with the float glass process or rolled glass process).

- Ethylene (chemicals)
- Float glass

The main focus of the study has been:

- An overview of energy prices developments with particular attention to i) energy price levels, and ii) the structure of energy prices, i.e. the components of energy bills;
- Energy intensity/efficiency and changes thereof;
- An assessment of the impact of energy prices and of their components on the unit production costs and other key performance indicators, such as price-cost margin, EBIT and EBITDA for a selection of producers in the various sectors mentioned above;
- A comparison with non-EU production sites in the selected sectors.

To undertake this study, information/data were collected at plant level for each sector and covered energy prices and costs, their drivers and recent developments. Specifically, data were collected on energy consumption and energy prices paid by the plant, the structure of energy bills (energy component, grid fees, RES levies and other non-recoverable taxes) as well as information on energy efficiency/energy intensity. Some respondents from the two ceramics sectors also provided data on plants located outside the European Union, thus allowing an international comparison. Separately, the sampled plants were asked about financial data to allow analysis of the production costs and margins of the sampled producers.

Plant specific data were obtained via questionnaires, which were sent to and filled in by industrial sites. Altogether 78 questionnaires[3] were received, of which 58 were used for the analysis of the energy intensive industries covered by the sector chapters. In total, 65 questionnaires contained plausible data and were used in the cross-sectoral analysis (see Table 1).[4] The remaining questionnaires were excluded from the analysis, because there were plausibility issues that could not be resolved. The questionnaires contained 19 questions, covering the issues explained above.

The analysis has been conducted between 24 July 2013 and 31st October 2013. The project, including data collection, did not involve any fieldwork neither in the EU nor in third countries. However, received questionnaires have been followed up by telephone calls to plant managers to discuss the findings and address issues that were unclear. In spite of the short available time frame to complete the study, CEPS remained in close contact with each plant for the entire duration of the study both by

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[3] This figure refers to the total number of questionnaires received for float glass, ceramics (bricks and roof tiles as well as wall and floor tiles) and chemicals (ammonia and chlorine).

[4] As described below, the cross-sectoral analysis uses data not only from the 5 sectors analyzed in this study (ammonia, chlorine, float glass, bricks and roof tiles as well as wall and floor tiles) but also from the separate cumulative cost assessment studies for the sectors of steel and aluminium.

telephone and e-mail to continuously clarify open issues and increase understanding of plant specifics.

Table 1. Total number of questionnaires received and used in the study

Industry Sector	**Number of questionnaires received**	**Number included in the sample**[5]
Ammonia	10	10
Chlorine	11	9
Float glass	10	10
Wall and floor tiles	24	12
Bricks and roof tiles	23	13
Total	78[6]	58
Number used in the cross-sectoral (excluding aluminum and steel)	65[7]	
Number used in the cross-sectoral (including aluminum and steel)	89[8]	

The period for which the assessment has been undertaken are the years 2010 to 2012.

The establishment of the different sectoral samples was made on the basis of *five* criteria:

5 Please note that in some cases there is a divergence between the total number of questionnaires included in the sample and the number used for the analysis of the different sections of the sector reports (energy prices trends, energy intensity, production costs, etc.). More info is presented in the sector reports.

6 Of which, 65 included plausible data.

7 This figure refers to the total number of questionnaires from the 5 energy-intensive industry sectors that was used in the cross-sectoral analysis; section 1.2 of the cross-sectoral analysis further differentiates between the number of questionnaires used for analysing electricity and natural gas costs.

8 This figure refers to the total number of questionnaires used in the cross-sectoral analysis; however, please note that for natural gas this figure was reduced to 69; see section 1.2 of the cross-sectoral analysis for more details.

- The *geographical criterion* has been used with a dual objective. First to reflect as much as possible the different contribution of member states to overall EU capacity in each sector. In addition, it aimed at creating a sample that included as many member states as possible;
- The *plant capacity* criterion was applied to ensure that the sample resembles as much as possible the actual composition of the plant (capacity) sizes across the EU and its regions;
- The production *technology* criterion was chosen to reflect the shares of different production technologies. This criterion was relevant only for the chemical sector;
- Finally, the *size criterion* was used to represent the sampled population in terms of company size, i.e. to denote the sector in terms of SMEs and large companies.

Whilst both the geographical and capacity criteria were employed for all sectors, the remaining ones were applied selectively to some sectors, depending on their relevance.

Finally, it is worth adding that although the analysis is principally EU-wide, the research team devoted particular attention to the member states with the relatively largest share of industry output when establishing the various samples.

This study was carried out in strict compliance with confidentiality and anti-trust rules. All presented information and data are anonymised, aggregated and/or indexed to ensure that no data can be attributed to any particular plant. This has meant that the sector-specific analysis is presented for regions (e.g. Central Northern Europe, Southern Europe, etc.) rather than for member states. Whilst general trends can be depicted and explained, there can be shortcomings in presenting the situation in member states. In some cases, trends in member states have been cancelling themselves out, e.g. an increase of energy prices in one member state was 'matched' with a decrease in another, thereby concealing member state trends.

This shortcoming could be addressed for four member states: Germany, Italy, Poland and Spain. For these four countries, a sufficient number of plants accepted to participate in the study across all covered sectors so as to allow country-specific analysis whilst ensuring the anonymity of plants. The results of this cross-sectoral analysis are presented in chapter 1. As mentioned above, the cross-sectoral analysis also covers the sectors steel and aluminium, which were not part of this study. However, as similar data was gathered through questionnaires, the results were included in the cross-sectoral analysis (see section 1.1 for more details).

A major issue has been the validation of the data received via the questionnaires, which was addressed by a mixture of measures. First, CEPS conducted a plausibility test, e.g. by comparing 'comparable' plants across member states. In several cases, plants have been taken out of the sample due to inconsistent data with comparable plants and which could not be explained by desk analysis or subsequent interviews with the plant managers. A second validation source has been the cross-sectoral analysis, which allowed comparing plant data from different sectors for the same member states. A third type of validation relied on data sources from third parties. The level of detail of this comparative exercise and robustness depends upon the availability of information from secondary sources and/or information provided by sectoral experts. Further details on validation, sample and response rate are provided in the relevant sections of the sector chapters.

Detailed findings for all sectors can be found in the sector chapters. However and despite several attempts by the research team, CEPS did not receive a sufficient number of questionnaires to enable an authoritative analysis for the ethylene sector. As a result, the development of a report illustrating energy prices trends for ethylene was not possible.

All 5 sector chapters are generally structured as follows:

- Sector description including production processes, value chain, capacities per member states etc.
- Sample selection
- Methodology including validation
- Energy prices trends for EU and regional differences
- Energy bill components for EU and regional differences
- Energy intensity developments for EU and regional differences
- Indirect ETS costs
- General impressions on the current state of energy policy and markets

Depending on the amount and quality of the information received as well as on the specific characteristics of each industry, some sectors also include the following sections:

- International comparison (bricks and roof tiles as well as wall and floor tiles - ceramics)
- Production costs (float glass, ammonia, chlorine as well as a case study for wall and floor tiles)
- Margins (float glass and a case study for wall and floor tiles)

CHAPTER 1.
CROSS-SECTORAL ANALYSIS

FABIO GENOESE

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1. CROSS-SECTORAL ANALYSIS

FABIO GENOESE

1.1 Introduction

This section presents a cross-sector analysis of the total energy costs and the structure of energy prices. While the analyses in the Sector Reports were presented for regions (e.g. North-western Europe, Southern Europe, etc.) rather than for member states in order to ensure that no data can be attributed to any particular plant, this cross-sector analysis presents national data for a selected number of member states, namely Italy, Spain, German and Poland. For electricity, the analysis comprises the sectors bricks & roof tiles ("bricks"), wall & floor tiles ("tiles"), float glass, ammonia ("amm."), chlorine, steel and aluminium ("alum."). For natural gas, data from the chlorine and aluminium sectors was not available, as these industries hardly consume any natural gas in their production processes. It has to be noted that the assessment of cost data for the sectors steel and aluminium was not part of this study. Data for these two sectors have extracted from existing studies[9], although with a consistent methodology.

1.2 Sample size and methodology

Table shows on the number of questionnaires that were evaluated for this cross-sector analysis. In total, electricity cost and consumption data from 89 plants was available. In the case of natural gas, the sample size is constituted of 69 plants.

Table 1. Sample size of the various sectors

	Bricks	Tiles	Glass	Amm.	Chlorine	Steel	Alum.
Electricity	16	20	10	10	9	15	9
Nat. gas	16	20	10	10	0	13	0

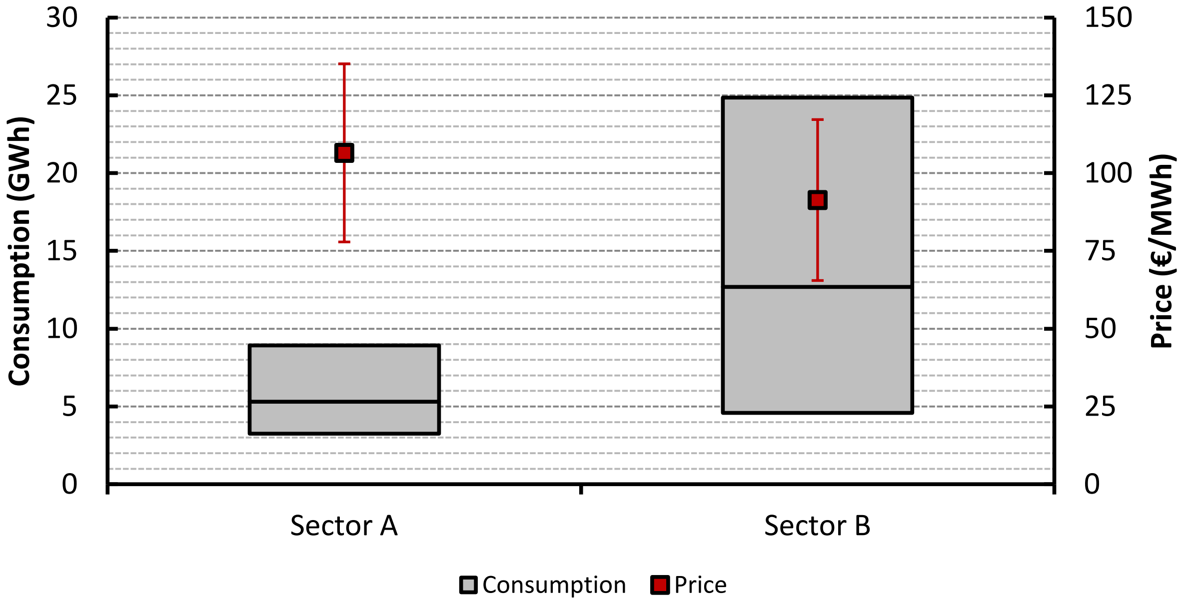
In order to give an impression of the consumption and price ranges in the various sectors, graphs resembling Figure 1 were prepared. The consumption range is illustrated by a so-called box plot: the upper and lower boundary line of the grey box

[9] Renda et al. (2013): "Assessment of Cumulative Cost Impact for the Steel and the Aluminium Industry", Report for DG ENTR (http://tinyurl.com/ktswbn5).

in the graph represent the first and third quartile of the data set. This means that 25% of the plants consume less than the value indicated by the lower line, while 25% of the plants consume more than the value indicated by the upper line. Put differently, the box comprises the middle half of the data sample. Moreover, the middle line that divides the box in two parts represents the median value.

The average prices are represented by the red squares in the graphs. The vertical lines below and above the square illustrate the standard deviation of the price distribution. Roughly 68% of the values lie within one standard deviation of the mean.

Figure 1. Exemplary plot



Source: Own illustration.

1.3 Electricity

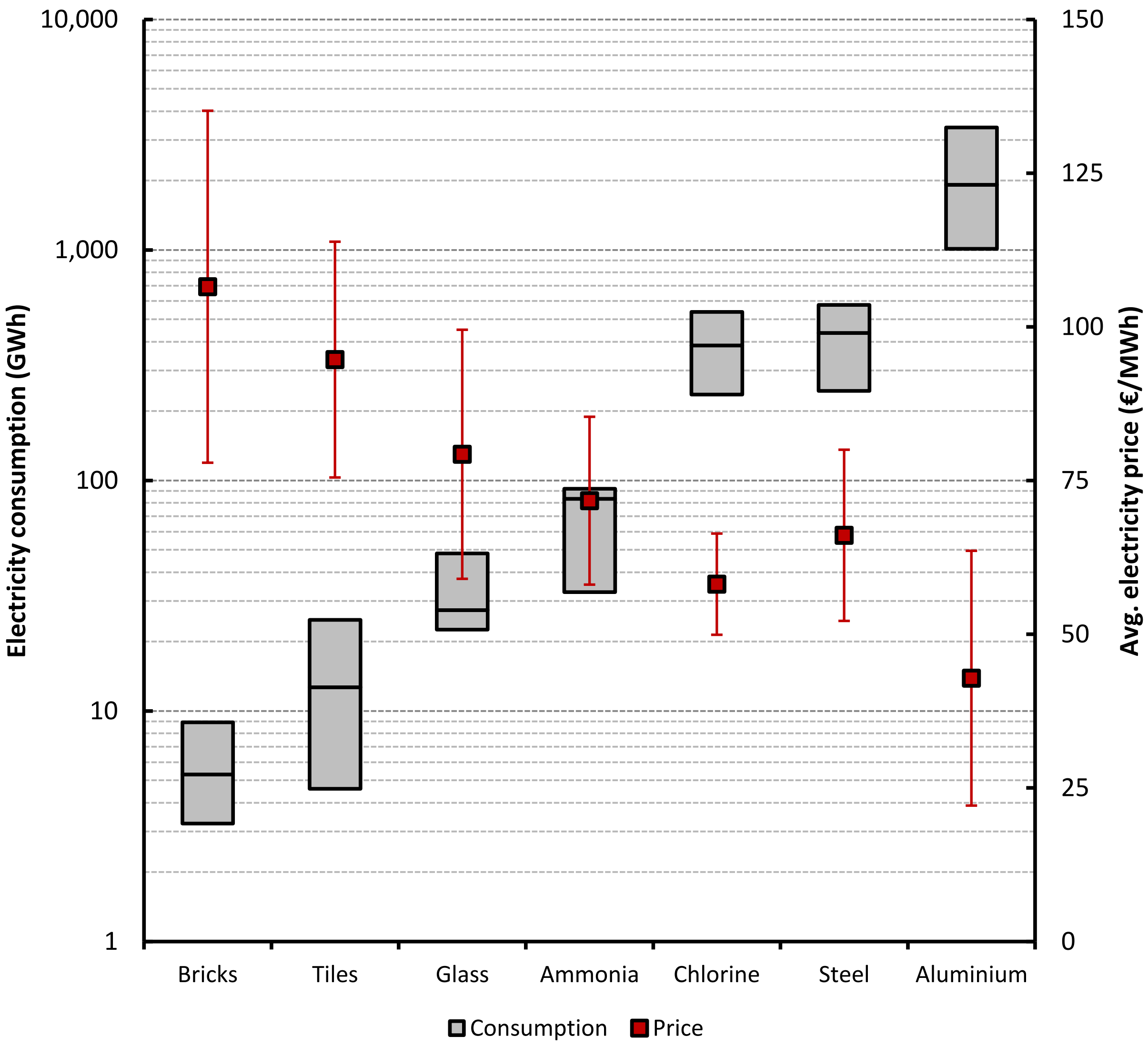
Figure 2 illustrates the variation of the data for each of the 7 sectors[10]. Generally, the consumption level increases when moving from the sector of bricks to the sector of aluminium. Increasing consumption levels are accompanied by decreasing power prices: The median electricity consumption in the latter sector is 361 times higher than in the bricks sector, whereas an average aluminium producer pays 42.9 €/MWh,[11] i.e. 63.7 €/MWh less an average bricks producer (see Table 3). Among

[10] Because of the differences in electricity consumption, a logarithmic scale is used for the axis displaying the consumption.

[11] In the aluminium report, an average value of 44.7 €/MWh was reported (p. 158). The average was weighted by 2012 production. For the cross-sectoral analysis, a different weighting factor has been applied, because production data was not available for all plants and all sectors. In order to apply the same methodology for all sectors, the research team used consumption data as a weighting factor.

the possible reasons for the decreasing price levels are: (i) more favourable supply contracts (e.g. long-term contracts that had been negotiated when the level of prices was much lower), (ii) discounts for large-scale consumers, or (iii) different level of levies and taxes (incl. exemptions for large-scale consumers). It is worth noting that these average prices represent the values aggregating multiple countries with different price levels and a different legislative framework. Therefore, national analyses of the cost structure were also conducted. In the following, this national assessment is presented and discussed.

Figure 2. Electricity consumption and price variations grouped by sector (89 facilities)



Source: Own illustration.

Therefore, the average value reported for aluminium in the cross-sectoral analysis slightly differs from the value reported in the dedicated aluminium report.

Table 2. Mean electricity prices and median electricity consumption in the various sectors (89 facilities)

	Bricks	Tiles	Glass	Amm.	Chlorine	Steel	Alum.
Price[12] (€/MWh)	106.5	94.7	79.3	71.7	58.2	66.1	42.9
Cons.[13] (GWh)	5.3	12.7	27.4	83.2	384.8	436.0	1,915.0

Figure 3 shows the structure of electricity costs in 4 member states: Italy (5 plants, Ø consumption: 23 GWh/a), Spain (10 plants, Ø consumption: 14 GWh/a), Germany (8 plants, Ø consumption: 313 GWh/a) and Poland (5 plants, Ø consumption: 242 GWh/a). The total costs are grouped into the following four components: (i) the energy component, (ii) grid fees, (iii) other levies and taxes (excluding VAT) and (iv) RES levies.

In general, the figures indicate a rising level of costs with some exceptions. For the 8 analysed plants in Germany, the average price decreased from 2011 to 2012 because three out of four components were in decline: Grid fees, RES levies and the energy component. Decreasing grid fees in relation to the amount of electricity consumed do not necessarily imply decreasing figures in absolute terms. A certain share of grid fees is charged in relation to the connection power of a production plant (i.e. euro per watt peak) and is not related to annual consumption. Therefore, increasing the annual consumption would decrease the grid fees when expressed in euro per watt hours, as it is the case in this graph. Admittedly, it is still possible that one or more plants has been exempted from paying grid fees starting in 2012. Decreasing RES levies, however, unquestionably point out that new exemptions have been granted in that year, since the RES levy in Germany is charged in terms of Euro per watt hours and since it has constantly been on the rise for the period under study. The reasons behind the slightly decreasing energy component are ambiguous. It is possible that producers have benefitted from falling wholesale market prices in Germany.

The figures also show that producers pay different prices depending in which member state the plant is located. Among the selected countries and the selected facilities, plants located in Italy face the highest electricity prices. Despite the fact that the selected plants in Italy have a similar average consumption as the selected plants in Spain (23 vs. 14 GWh/a), Italian producers paid up to 21.3 €/MWh more than Spanish producers. A major part of this difference is due to higher costs for the energy component in Italy. The costs for the energy component are linked to the

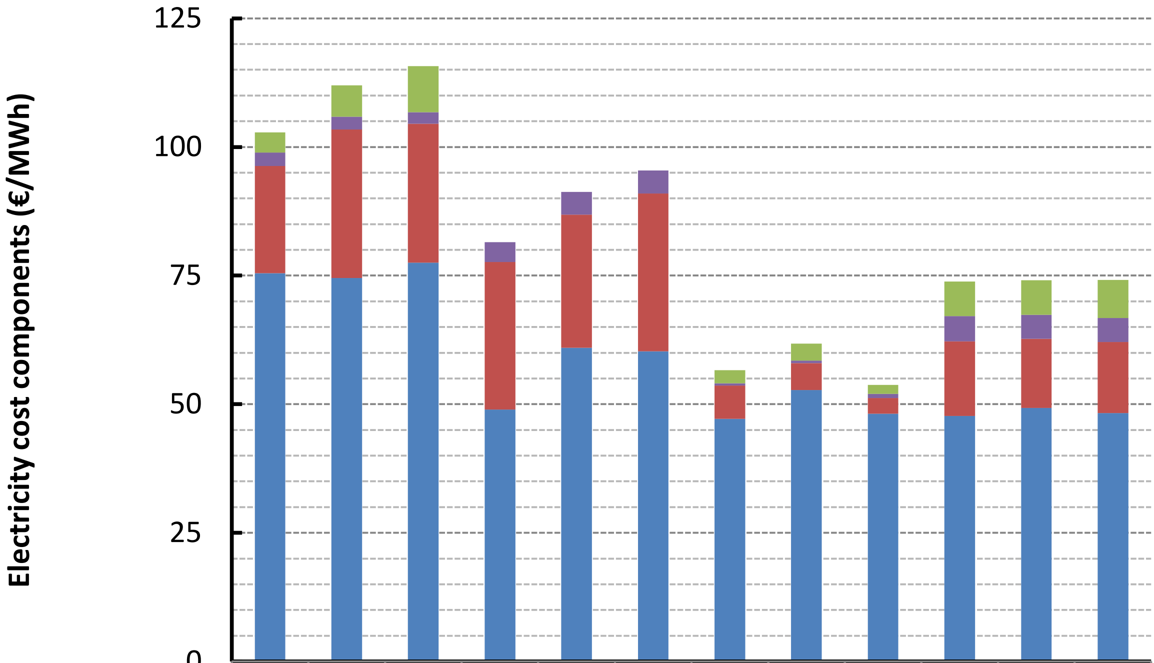
12 Mean value of sampled plants.

13 Median value of sampled price.

wholesale market price for electricity, which in Italy is higher than in Spain. A functioning and completed internal market would reduce this wholesale price differential.

To a lesser extent, the price difference between Italy and Spain is also due to higher costs for levies and taxes (incl. RES levies). In contrast to the other countries analysed, Spanish electricity consumers do not directly pay the costs for RES support through levies. Therefore, the RES levy figures equal zero. Instead, the Spanish government sets a so-called access fee ("peaje de acceso") to cover all costs that are not related to (conventional) production and commercialisation. Costs for RES support are therefore supposed to be included in the other components but may also partly be covered by the public budget.

Figure 3. Structure of electricity costs in Italy, Spain, Germany and Poland in absolute terms (€/MWh)



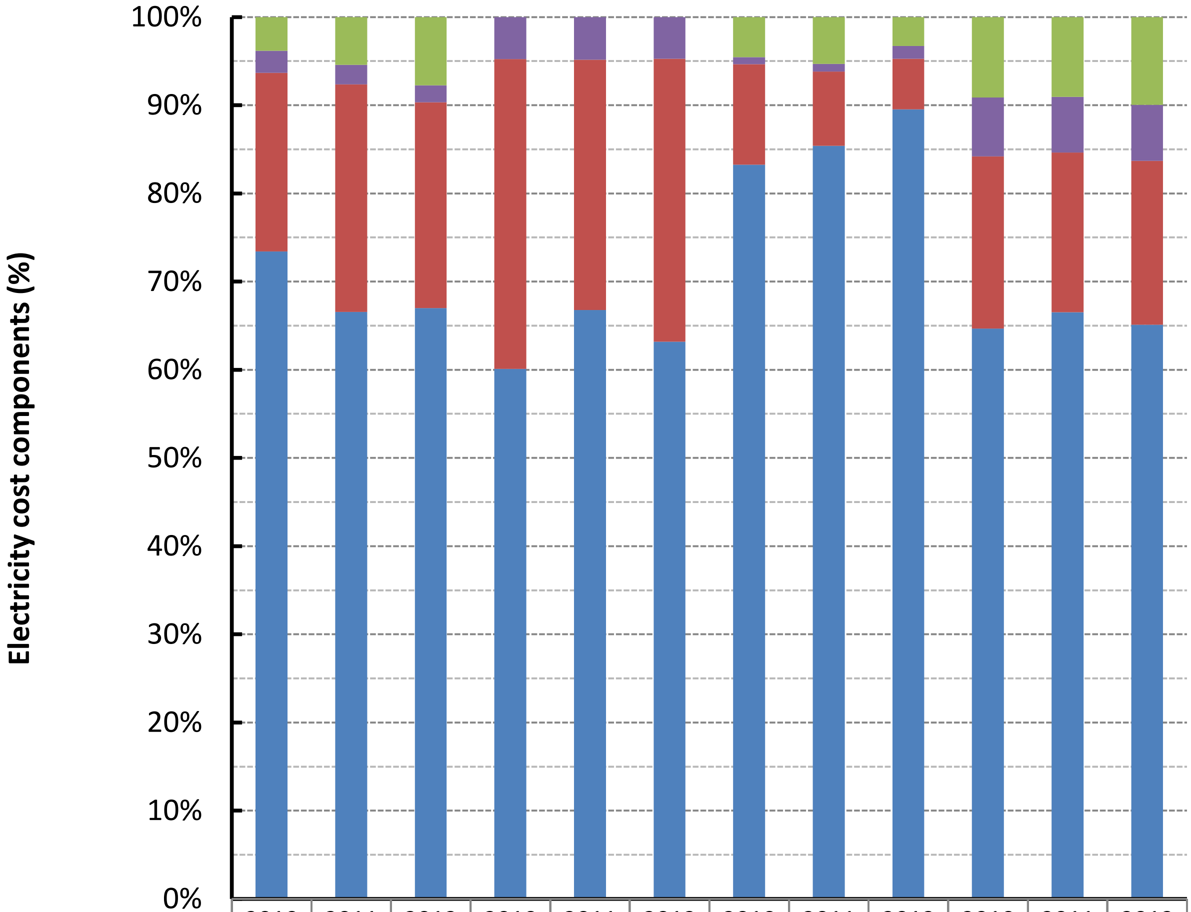
	IT (5 plants)			ES (10 plants)			DE (8 plants)			PL (5 plants)		
	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
RES levy	3.9	6.1	9.0	0.0	0.0	0.0	2.6	3.3	1.8	6.7	6.7	7.4
Other (excl. VAT)	2.6	2.5	2.2	3.9	4.4	4.5	0.5	0.5	0.8	4.9	4.7	4.7
Grid fees	20.8	28.9	27.0	28.6	25.9	30.6	6.5	5.2	3.1	14.4	13.4	13.8
Energy comp.	75.5	74.5	77.5	49.0	60.9	60.3	47.1	52.8	48.1	47.7	49.3	48.3

Note that grid fees are flat fees (mainly). Expressing them in €/MWh may be misleading but was chosen for consistency reasons.

Source: Own illustration.

Compared to Polish and German producers, Italian and Spanish producers face higher grid fees. Among the possible explanations are: (i) exemptions from paying a certain share of grid fees, (ii) generally lower grid costs in Germany and Poland and (iii) avoidance of a certain share of grid fees, as some of the Polish and German plants are possibly connected to the high-voltage grid due to a higher level of electricity consumption.

Figure 4. Structure of electricity costs in Italy, Spain, Germany and Poland in relative terms (%)



	IT (5 plants)			ES (10 plants)			DE (8 plants)			PL (5 plants)		
	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
RES levy	4%	5%	8%	0%	0%	0%	5%	5%	3%	9%	9%	10%
Other (excl. VAT)	3%	2%	2%	5%	5%	5%	1%	1%	1%	7%	6%	6%
Grid fees	20%	26%	23%	35%	28%	32%	11%	8%	6%	20%	18%	19%
Energy comp.	73%	67%	67%	60%	67%	63%	83%	85%	90%	65%	67%	65%

Energy comp. Grid fees Other (excl. VAT) RES levy

Source: Own illustration.

It is worth noting that all figures presented include possible exemptions from taxes, levies or transmission costs. The research team asked the producers to communicate the electricity and natural gas costs they effectively had paid between 2010 and 2012. Therefore, their answers include exemptions/reductions if these are applicable. This is particularly evident for the German plants in the sample. In Table 3, the regular, non-discounted RES levies are confronted with the average values paid by the sampled plants. The figures show that the sampled German plants received – on average – a 93% reduction in the year 2012.

Table 3. RES levies in Germany – regular vs. average values paid by the sampled plants (in €/MWh)

	2010	2011	2012
RES levy (regular, non-discounted)	20.47	35.30	35.92
RES levy (Ø for sampled plants)	2.6	3.3	1.8

1.3.1 Natural gas

Figure 5 illustrates the variation of natural gas cost and consumption data for each of the 5 sectors. Generally, the consumption level increases when moving from the sector of bricks to the sector of ammonia. Increasing consumption levels are accompanied with decreasing gas prices. However, it is worth to note that this trend is less clear than in the case of power prices. The difference in the price of natural gas paid by an average producer of bricks and an average producer of ammonia is of 7.0 €/MWh (-26%, see Table 5). As gas prices are mainly determined by the energy component, electricity contracts offer more flexibility for eventual discounts/exemptions. Contrary to power prices, no clear trend can be observed in relation to price variations.

Figure 5. Natural gas consumption and price variations grouped by sector (69 facilities)

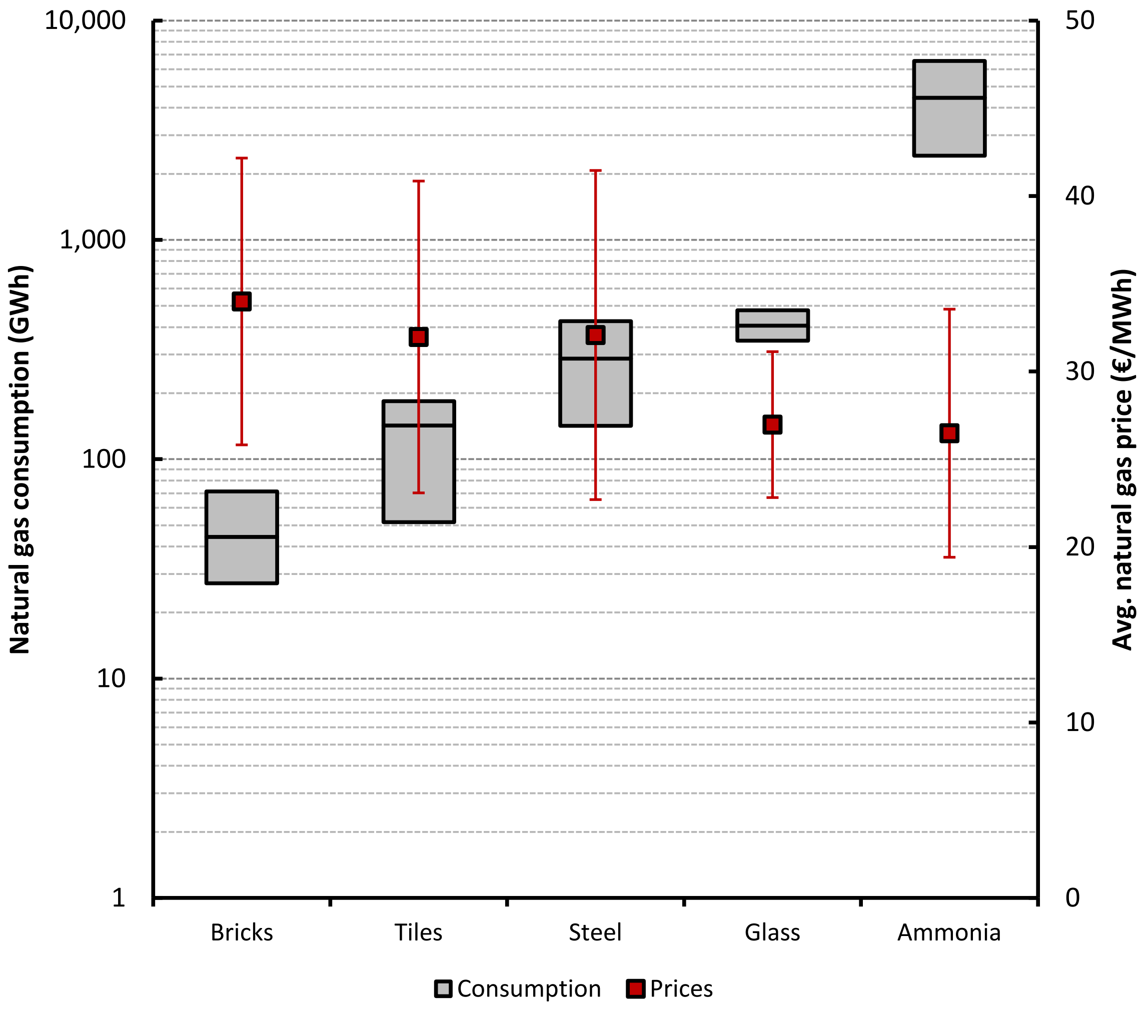


Table 4. Mean natural gas prices and median natural gas consumption in the various sectors (69 facilities)

	Bricks	Tiles	Steel	Glass	Ammonia
Mean price (€/MWh)	34.0	32.0	32.1	27.0	26.5
Median cons. (GWh)	44.3	142.5	288.0	406.2	4,446.3

CHAPTER 2.
THE CASE OF THE CHEMICAL INDUSTRY – AMMONIA

VASILEIOS RIZOS, FEDERICO INFELISE, GIACOMO LUCHETTA FELICE SIMONELLI, WIJNAND STOEFS, JACOPO TIMINI AND LORENZO COLANTONI

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2. THE CASE OF THE CHEMICAL INDUSTRY – AMMONIA

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2.1 Chemical description and uses

Ammonia (NH3) is a compound composed of one nitrogen (N) and three hydrogen (H) atoms. It is usually found as a gas.

In the environment, ammonia is produced naturally through the breakdown of organic waste matter. Although intensive agricultural practices may increase the local production of ammonia (e.g. from large amounts of animal waste), this substance occurs naturally at very low levels (Health Protection Agency, 2007). Ammonia is also one of the most commonly produced industrial chemicals and is used in a diversified set of industrial sectors (see Table 1). About 80% of the global ammonia production is consumed by the fertiliser industry; specifically, 48% of the ammonia produced is deployed in the production of urea (the most commonly used nitrogen fertiliser and basic feedstock for industrial products like plastics, resins and adhesive), 11% is employed in the production of ammonium nitrate, 20% for the production of other fertilisers like ammonium sulfate, ammonium phosphate, diammonium phosphate and monoammonium phosphate and 3% is directly used as fertiliser (Potashcorp, 2013).

Table 1. Uses of Ammonia

Industry	Use
Fertiliser	production of: • urea, $(NH_2)_2CO$ • ammonium nitrate, NH_4NO_3 • other fertilisers; ammonium sulfate, ammonium phosphate, diammonium phosphate, monoammonium phosphate • direct application
Chemicals	synthesis of: • nitric acid, HNO_3, which is used in making explosives such as TNT (2,4,6-trinitrotoluene), nitroglycerine which is also used as a vasodilator (a substance that dilates blood vessels) and PETN (pentaerythritol nitrate). • sodium hydrogen carbonate (sodium bicarbonate), $NaHCO_3$ • sodium carbonate, Na_2CO_3

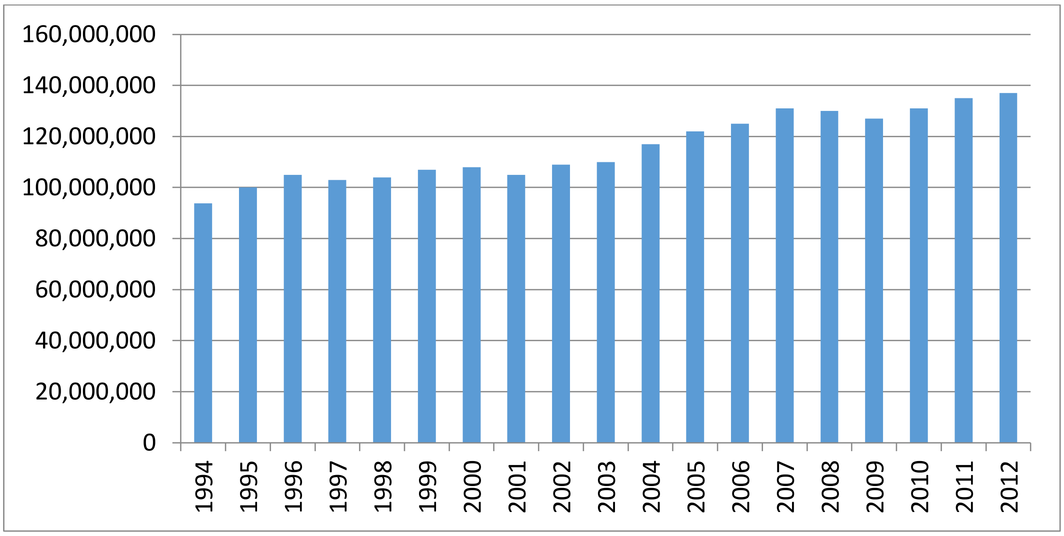
	• hydrogen cyanide (hydrocyanic acid), HCN • hydrazine, N_2H_4 (used in rocket propulsion systems)
Explosives	ammonium nitrate, NH_4NO_3
Fibres and Plastics	nylon, -[$(CH_2)_4$-CO-NH-$(CH_2)_6$-NH-CO]-,and other polyamides
Refrigeration	used for making ice, large scale refrigeration plants, air-conditioning units in buildings and plants
Pharmaceuticals	used in the manufacture of drugs such as sulfonamide which inhibit the growth and multiplication of bacteria that require *p*-aminobenzoic acid (PABA) for the biosynthesis of folic acids, anti-malarials and vitamins such as the B vitamins nicotinamide (niacinamide) and thiamine.
Pulp and Paper	ammonium hydrogen sulfite, NH_4HSO_3, enables some hardwoods to be used
Mining and Metallurgy	used in nitriding (bright annealing) steel, used in zinc and nickel extraction
Cleaning	ammonia in solution is used as a cleaning agent such as in 'cloudy ammonia'

Source: Potashcorp (2013).

2.2 Ammonia market features

Global ammonia production has been constantly growing in the last decades, peaking at 137 million tonnes in 2012 (see Figure 1).

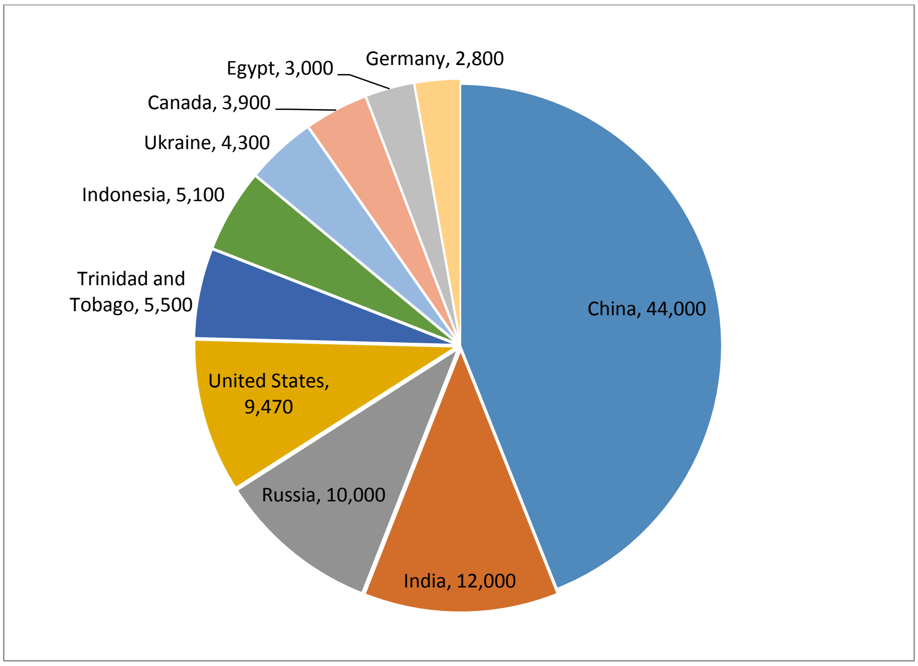
Figure 1. Global ammonia production (tonnes)



Source: Authors' elaboration on USGS (2013).

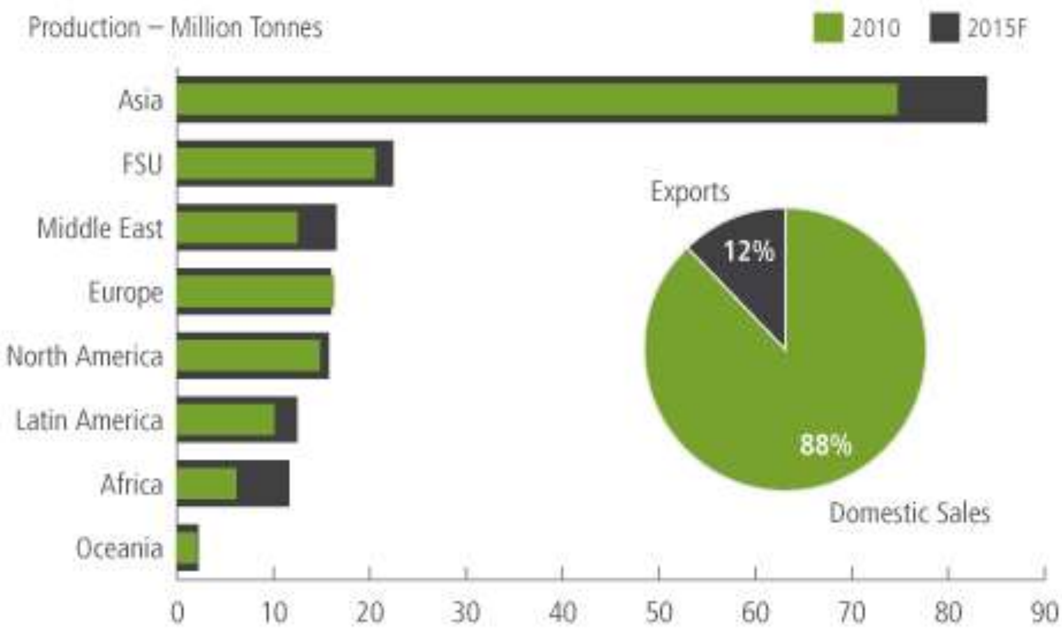
The global production of ammonia is dominated by China which was responsible for 32% of the total global production in 2012; the other major producers are India (9%), US (7%) and Russia (7%) (USGS, 2013). Figure 2 illustrates the ammonia production of the top ten global producers.

Figure 2. Top ten global ammonia producers, 2012 (k tonnes)



Source: Authors' elaboration on USGS (2013).

Figure 3. Ammonia sales profile

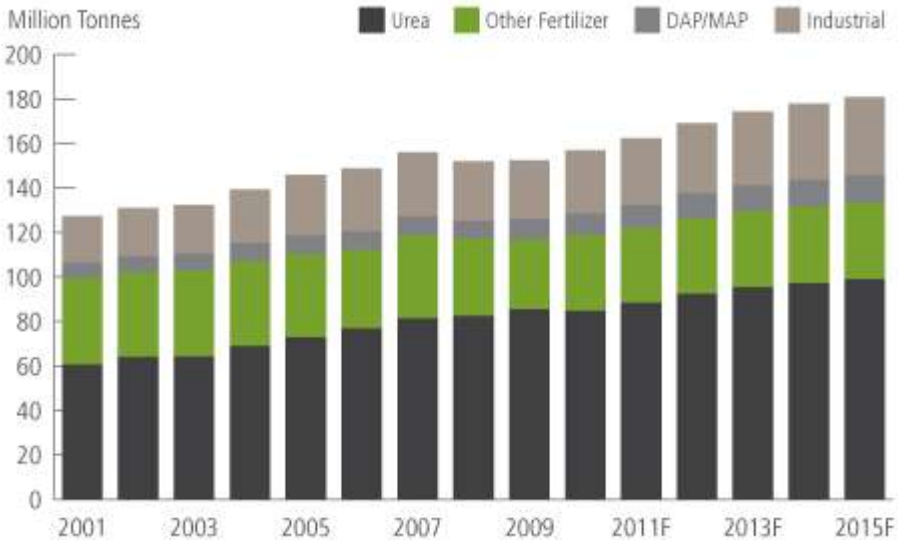


Source: Potashcorp (2013).

The two main drivers of ammonia consumption are the use in the agricultural sector and the development of applications for industrial purposes; both have determined the increase of consumption of ammonia in the last decade. Interestingly, as shown in Figure 4, the moderate drop in consumption during the recent global economic downturn (2008-2009) has been mostly triggered by a decline in the demand for industrial applications;

this can be explained by the strong agricultural fundamentals in developing countries that managed to limit the fall in consumption.

Figure 4. Global ammonia consumption (mln tonnes)



Source: Potashcorp (2013).

In the EU virtually all ammonia is produced by using natural gas as a feedstock; however this is not the case in some major producers of ammonia. In particular, in China coal is still the most commonly used feedstock, while in India a mix of natural gas and naphtha is used (IEA, 2009). Natural gas is generally favoured over other feedstocks for different reasons: its availability and ease of delivery as an inexpensive feedstock, its high hydrogen content and the relative simplicity and relative low operating costs of plants designed for natural gas (ChemSystems, 2007). Table 2 below compares the efficiency of different types of feedstock used for ammonia production.

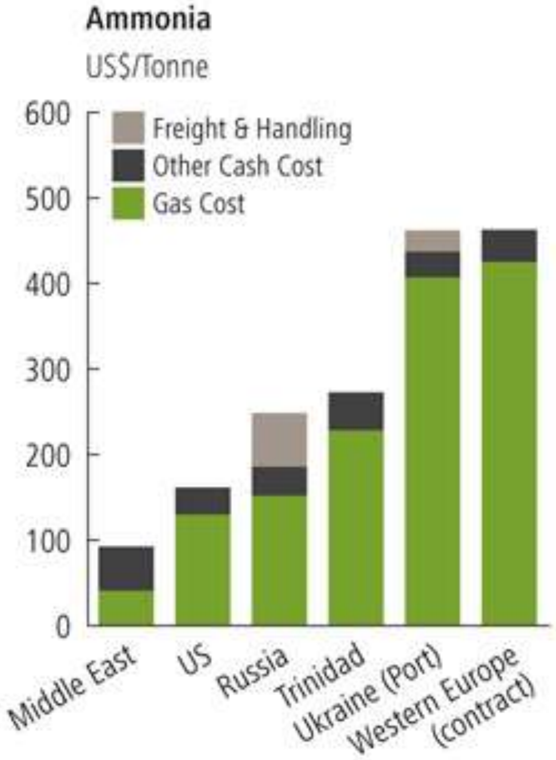
Natural gas is usually employed both as feedstock, in order to obtain the necessary hydrogen to form the chemical compound NH_3 (non-energy use of natural gas), and as fuel to provide the required energy. According to gross estimations, approximately 2/3 of consumed natural gas is used as a feedstock, while around 1/3 is used for energy purposes. Natural gas is the key cost driver for the ammonia industry as, depending on its price, it makes up approximately 70-85% of the ammonia production costs (see Figure 5).

Table 2. Feedstock comparison in ammonia production

	Natural Gas	Heavy Oil	Coal
Energy Consumption	1	1.3	1.7
Investment Cost	1	1.4	2.4
Production Cost	1	1.2	1.7

Source: EFMA (2000).

Figure 5. Ammonia production costs by geographical region



Source: Potashcorp (2013).

2.3 The ammonia production process

Large scale industrial production of ammonia has been performed since the beginning of the 20th century. The industrial process through which nitrogen gas and hydrogen gas are reacted together is called the Haber-Bosch process[14].

The industrial production of ammonia can be divided into two major stages: the manufacture of hydrogen and the synthesis of ammonia. The whole process requires the use of a feed stock, mainly natural gas, coal or naphtha. When coal or naphtha is used, it is first converted into methane, hydrogen and oxides of carbon.

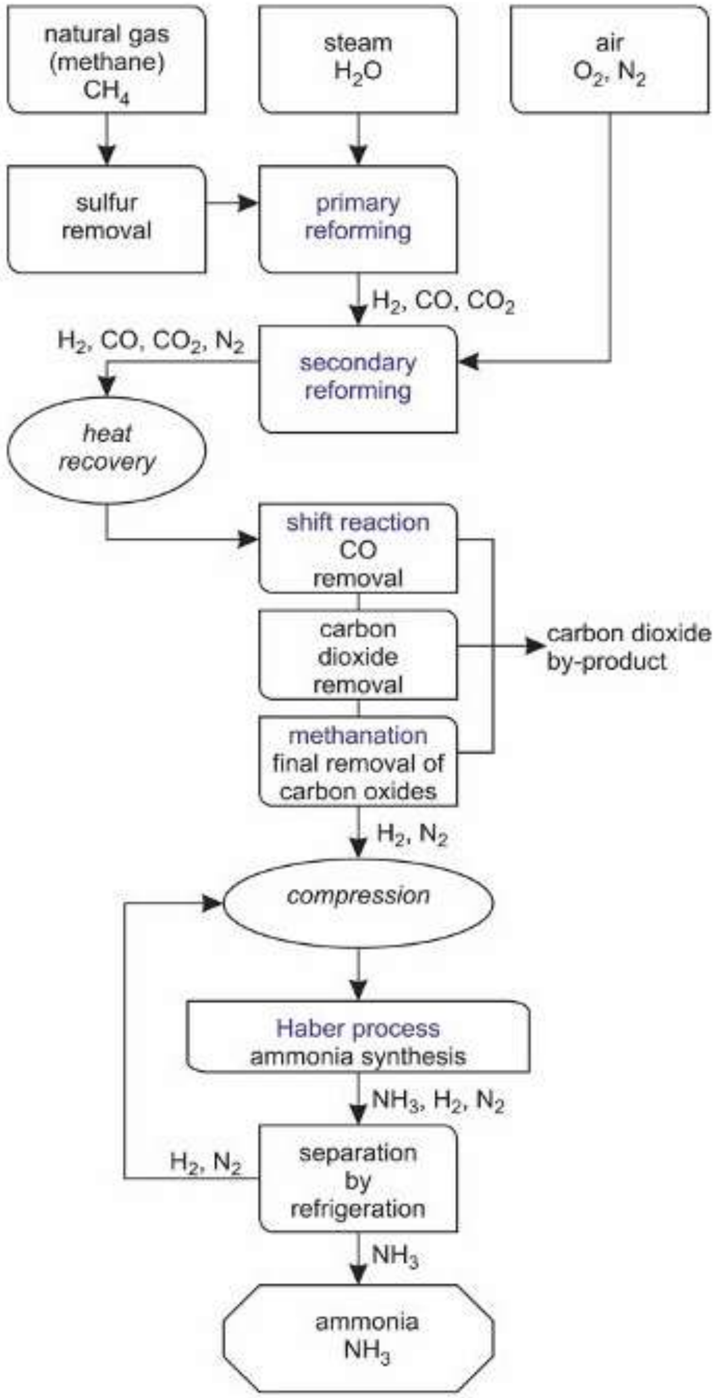
The first stage involves the manufacture of synthesis gas as well as the removal of the carbon monoxide and production of a mixture of hydrogen and nitrogen. The latter is called *the shift reaction* and involves the release of carbon monoxide which is often liquefied and sold as coolant for nuclear power stations or for carbonated drinks (University of York, 2013).

During the second stage, the synthesis gas[15] is introduced in a so-called fixed bed reactor, at certain conditions of pressure and temperature which vary from reactor to reactor.

[14] The origin of the name comes from the German chemists Fritz Haber who discovered the process and Carl Bocsh who scaled-up the process for industrial applications. Ammonia was synthesised on an industrial scale with the Haber-Bosch process for the first time in 1913 in the BASF's Oppau plant located in Germany.

Temperatures range from 600 to 700k, while pressures can reach up to 100 atmospheres. The reactant passes through several layers or beds of catalyst, usually potassium hydroxide, undergoing the fundamental chemical reaction of the process: $N_2 + 3H_2 \Longleftrightarrow 2NH_3 + \text{Heat}$. Part of the synthesis gas is then converted into ammonia (NH_3) and stored, while the remaining mix of hydrogen and nitrogen is returned again into the reactor (New Zealand Institute of Chemistry, 2008).

Figure 6. The Ammonia production process

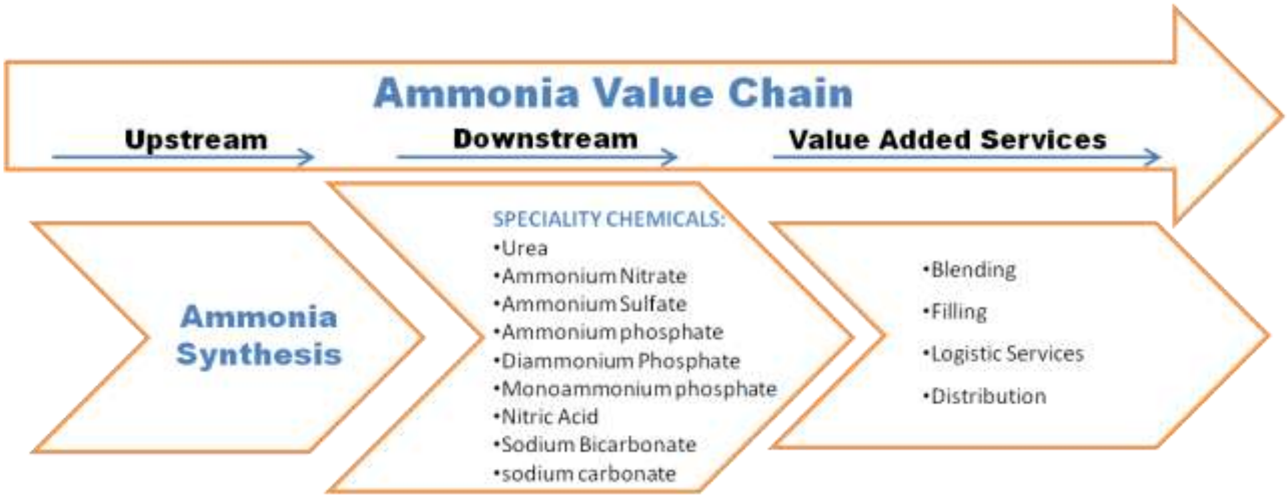


Source: University of York (2013).

[15] This is a mixture of nitrogen and hydrogen.

2.4 The ammonia value chain

Figure 7. Ammonia value chain



Source: Authors elaboration.

The ammonia value chain is highly vertically integrated. The possibility to exploit substantial economies of *scale* and *scope* determines that the largest majority of fertilisers producers synthesise "in-house" the ammonia they use as input for the following stages of production. The option of sharing production facilities for the synthesis of different types of fertilisers creates the incentive for the industry to integrate horizontally.

2.5 The EU ammonia market

The EU-27 has a total capacity for the industrial production of ammonia equal to about 21 million tonnes. The EU production is spread over 17 different member states and over a total number of 42 plants (see Table 3). Note that different ammonia production lines operating at the same site are considered to be part of the same facility[16]. The member state with the highest capacity is Germany with a total capacity of around 3.4 million tonnes per year (5 plants, 17% of EU capacity) followed by Poland with about 3.2 million tonnes (5 plants, 16 % of EU capacity), the Netherlands with 2.7 million tonnes (2 plants 13% of EU capacity), Romania with 2.1 million tonnes (6 plants, 11% of EU capacity) and France with 1.5 million tonnes (4 plants, 7% of EU capacity). The remaining ammonia production facilities are located in Lithuania, Bulgaria, UK, Belgium, Spain, Italy, Austria, Slovakia, Hungary, Czech Republic, Estonia and Greece.

[16] See section 2.6.1 for more details.

Table 3. EU-27 capacity and number of plants per country, 2013

COUNTRIES	CAPACITY (k tonnes)	NUMBER OF PLANTS PER COUNTRY	% EU-27
Germany	3,438	5	17%
Poland	3,210	5	16%
Netherlands	2,717	2	13%
Romania	2,176	6	11%
France	1,495	4	7%
Lithuania	1,118	1	5%
Bulgaria	1,118	3	5%
Uk	1,100	3	5%
Belgium	1,020	2	5%
Spain	609	3	3%
Italy	600	1	3%
Austria	485	1	2%
Slovakia	429	1	2%
Hungary	383	2	2%
Czech Rep.	350	1	2%
Estonia	200	1	1%
Greece	165	1	1%
TOTAL EU-27	20,613	42	100.00%

Source: Authors' elaboration on list of plants provided by Fertilizers Europe.

Table 4. EU-27 statistics on plants capacity, 2013

EU-27 statistics	
Average plants capacity (kt)	490
Median capacity (kt)	405
Highest (kt)	1700
Lowest(kt)	9
Standard deviation	326

Source: Authors' elaboration on list of plants provided by Fertilizers Europe.

2.6 Sample selection

2.6.1 Sample selection criteria

Considering that about 80% of the global ammonia production is used for the production of fertilisers (see section 2.1), this study focuses on ammonia plants that in the vast majority of cases are integrated in large installations that subsequently produce fertilisers.

During the early stages of the project the consultant acquired from the European Fertilizer Manufacturers Association (Fertilizers Europe) a list[17] including all ammonia production lines across the EU, displayed by country, location, capacity and type of feedstock. The list was compiled through data from public sources such as company websites and trade magazines. To double-check the validity of this information, plants included in the final sample were asked to provide data on exact location, capacity and production[18]. Different ammonia production lines located at the same site are treated in this study as part of the same plant. This decision was taken following consultations with the industry.

The criteria for establishing the final sample are presented below. It should be noted that before selecting the sample, a number of European ammonia producers expressed their interest in participating in the study, in collaboration with Fertilizers Europe. The research team duly took into account these expressions of interest when selecting the final sample so as to enable both an authoritative analysis and limit the risk of receiving too few questionnaires.

Geographical coverage

The geographical criterion was chosen to ensure that different EU regions are represented in the analysis and to reflect the relative weight of the member states' ammonia capacity.

Capacity of plants

To reflect different capacities, the consultant divided the total set of EU-27 plants into 3 sub-groups: those plants with a capacity equal or higher than 600.000 tonnes per year were defined as *large size*; those with a capacity higher than 400.000 t/y but strictly lower than 600.000 t/y were included in the *medium size* set; those with a capacity lower than 400.000 t/y were included in the *small size* set. According to these criteria, in the EU there are 10 large plants, 15 medium-size plants and 17 small plants.

2.6.2 Sample statistics

Based on the above criteria, out of the 42 plants located at 17 different member states, the final sample includes 10 plants from 10 different member states[19]. Concerning the size of the selected plants, 4 are defined in this study as large-size plants, 4 as medium and 2 as small. The plants selected in the sample represent altogether around 27% of the total EU-27 capacity (Table 6).

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[17] The list is not publicly available.

[18] Production data were provided for the period between 2010 and 2012 (three years).

[19] Please note that two companies which initially committed to participate in the study decided to withdraw their participation. This happened before the final version of the sample was established and has thus no impact on the validity of the results presented in this study. One of the two companies claimed that it encountered technical difficulties in completing the questionnaire due to the integration of the ammonia plant with other facilities, while the other did not provide any justification for its withdrawal.

Table 5. EU-27 statistics on plant size, 2013

EU-27 plants size	N plants	% total
Large (>600 kt)	10	24%
Medium (>=400<=600 kt)	15	36%
Small (<400 kt)	17	40%
Total	42	100%
Number of member states	17	63%

Source: Authors' elaboration on the list of plants provided by Fertilizers Europe.

Table 6. Sample statistics

		% EU-27 total
Total Capacity (kt)	5,500	27%
Sample average capacity (kt)	554	
Sample standard deviation	307	

Source: Authors' elaboration on the list of plants provided by Fertilizers Europe.

2.7 Methodology

2.7.1 Data collection

The analysis of the energy prices and costs for the ammonia sector was based on questionnaires sent to all plants included in the sample. The content of the questionnaire was discussed with ammonia industry experts to ensure that the technical specifications of the ammonia sector are properly reflected. In addition and with the help of the Chemical Industry Association (Cefic), the questionnaire was tested by one pilot plant. Strict confidentiality agreements were also signed with the companies participating in the study.

All 10 participants provided detailed figures on the level and structure of energy prices as well as on energy consumption. The data underwent a validation process e.g. through a plausibility check, and then evaluated (see section 2.7.4 below). Additionally, 7 out of the 10 sampled plants provided further data on production costs. Table 7 below presents an overview of the number of questionnaires received and used in the analysis of each section.

Table 7. Number of questionnaires received and used in each section

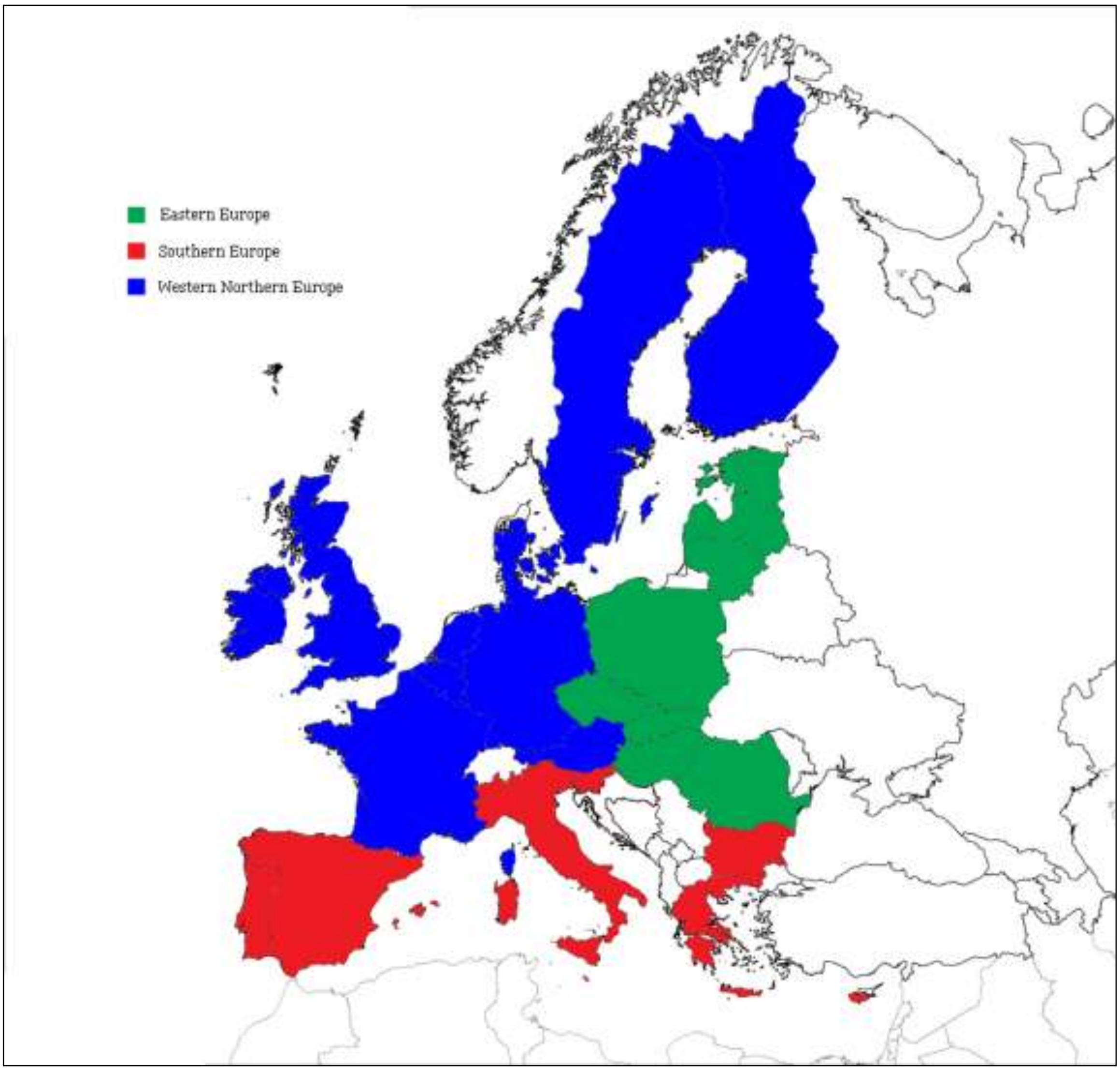
Number included in the sample	10
Energy prices trends	10
Energy bill components	10
Energy intensity	10
Indirect ETS costs	10
Production costs	7

2.7.2 Data analysis and presentation

To ensure that no information can be attributed to any specific plant, data have been aggregated together per three major EU geographical regions. As already recalled, the sample covers 10 different member states; however, the number of ammonia plants per region/country is not included in the report for confidentiality reasons and in order to avoid any risk of identifying the plants included in the study:

a. **Southern Europe** (Italy, Malta, Portugal, Greece, Slovenia, Cyprus, Spain and Bulgaria) is responsible for 12% of total EU ammonia production capacity.
b. **Western Northern Europe** (UK, France, Belgium, Ireland, Luxemburg, Sweden, Germany, the Netherlands, Finland, Denmark and Austria) is responsible 65% of total EU ammonia production capacity.
c. **Eastern Europe** (Lithuania, Romania, Czech Republic, Hungary, Estonia, Latvia, Slovakia and Poland) is responsible for 23% of total EU ammonia production capacity.

Figure 8. EU division in major geographical regions



Source: Own illustration.

Based on the geographical division explained above, section 2.8 presents the average energy prices paid by EU ammonia producers as well as the differences among the major EU regions. Importantly, prices represent average values of the price paid by each plant included in the sample within the region considered (Southern Europe, Eastern Europe, Western Northern Europe or EU-27). Each plant price has been weighted by a coefficient representing the specific year contribution of that plant to the total actual production of the region considered (Western Northern Europe, Southern Europe, Eastern Europe or EU-27). Section 2.9 focuses on the analysis of the energy bill components, while section 2.10 addresses the energy intensity of ammonia producers. The indirect ETS costs for ammonia producers are presented in section 2.11, while section 2.12 analyses the production costs for 7 sampled plants. Finally, section 2.13 reflects the general impressions of the participants on the current state of energy policy and markets.

2.7.3 Calculation of indirect ETS costs

The objective of the ETS cost calculations per sector in this study is to provide an estimation of the indirect ETS cost for the sub-sector between 2010 and 2012. The level of information is aggregated on a regional level, although the definition of those regions differs between cases studies.

The model for the indirect cost of EU ETS, per plant, is defined as:

Indirect costs

Indirect cost (€/Tonne of product) = Electricity intensity (kWh/Tonne of product)

** Carbon intensity of electricity (Tonne of CO_2/kWh)*

** CO_2 Price (€/Tonne of CO_2) * Pass-on rate*

Where:

- Electricity intensity of production: the amount of electricity used to produce one tonne of product. This amount is sector, plant and process specific;
- Carbon intensity of electricity generation indicates the amount of tonnes of CO2 emitted by utilities to generate one kWh;
- CO2 Price: is the average yearly market-price of CO2.
- Pass-on rate: the proportion of direct costs faced by utilities (disregarding any mitigating effects from free allocation) that they pass on to electricity consumers.

Sources:

- Electricity intensity of production; this was acquired from interviews with and questionnaires answered by industry members.
- Carbon intensity of electricity generation: the maximum regional carbon intensity of electricity is utilised, provided by the Commission's Guidelines on State aid

measures[20]. Note that these figures are not national. Member States who are highly interconnected or have electricity prices with very low divergences are regarded as being part of a wider electricity market and are deemed to have the same maximum intensity of generation (for example, Spain and Portugal).

- CO2 Price: Yearly averages of the daily settlement prices for Dec Future contracts for delivery in that year. The daily settlement prices were reported by the European Energy Exchange.

Table 8. Average yearly prices per tonne of CO2 (€)

Year	2010	2011	2012
CO_2 Price	14.48	13.77	7.56

2.7.4 Validation of information

The research team has used a combination of an internal cross-sectoral comparison of energy prices reported by all participant sectors and sub-sectors[21] and a validation through EU energy statistics publications[22]. To test consistency, the research team conducted targeted interviews with ammonia producers included in the sample. No secondary sources could be retrieved on plant-specific energy costs of ammonia producers.

The validation of the production costs for the EU ammonia industry is a complex task. Ammonia is an intermediate product which companies usually use as an input for their downstream activities. As a result, it is not possible to retrieve meaningful information from companies' balance sheet data as regards this specific product line. Nonetheless, data consistency for production costs was ensured by comparing data submitted by different producers and data submitted by the same producer for different years and asking for clarification and integrations whenever inconsistency was detected. This verification process improved the quality of the analysis and led to the exclusion of data submitted by one of the sampled companies for 2010, taking into account that the observed plant was undergoing a restructuring process and cost figures were not representative for the business as usual.

[20] Communication from the Commission: Guidelines on certain State aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012 (2012/C 158/04).

[21] This refers to all 5 sub-sectors included in the study i.e. the float glass sector, the wall and floor tiles/bricks and roof tiles (ceramics sector) and the two chemicals sub-sectors (ammonia and chlorine).

[22] Validation was conducted through the EU Statistical Pocketbook for 2012 (European Commission, 2013; available at: http://tinyurl.com/latgngh, accessed: 27 October 2013) and the EU Market observatory & Statistics, (http://ec.europa.eu/energy/observatory/gas/gas_en.htm), accessed: 15 September 2013.

2.8 Energy prices trends

2.8.1 Introduction

This section will focus on the energy prices for the ammonia industry, namely natural gas and electricity prices. Table 9 below summarises the share of natural gas and electricity costs in total energy costs and total production costs, respectively. As shown in the table, natural gas dominates the total production costs and is thus a key cost driver for the sampled ammonia producers. Natural gas and electricity collectively account for the vast majority of total energy costs. Note that the energy prices presented in this section are delivered at plant excluding VAT; hence include possible exemptions[23] from taxes, levies or transmission costs. All values presented in this section are weighted averages that have been calculated on the basis of actual production.

Table 9. Share of natural gas and electricity in total energy costs and total production costs[24]

	Share in total energy costs, %	Share in total production costs, %
Natural gas	90-94%	80-88%
Electricity	4-8%	3-6%

Source: Author's elaboration based on data from questionnaires.

2.8.2 Natural gas

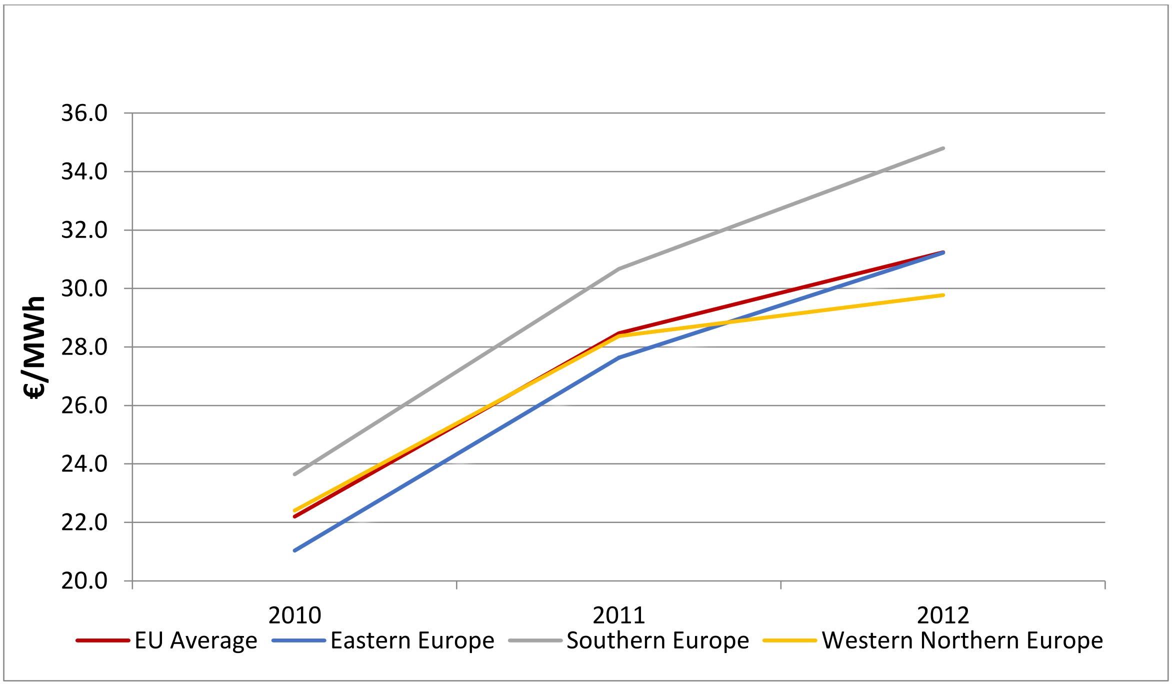
2.8.2.1 General trends

There is an upward trend in the prices of natural gas paid by EU ammonia producers (Figure 9). The EU average price rose by about 28% between 2010 and 2011 and by 9.5% between 2011 and 2012. Between 2010 and 2012, the average EU price for the ammonia industry rose by 40.5%, i.e. from 22.2 €/MWh to 31.2 €/MWh. Table 10 provides an overview of the natural gas prices for the sampled EU producers.

[23] Notably, five out of 10 participants mentioned that they are entitled to reductions/exemptions from network tariffs, taxes or levies.

[24] The figures on the share of natural gas and electricity costs in total energy costs represent averages for the full sample (ten plants). The figures on the share of natural gas and electricity costs in total production costs represent averages for the seven plants (see section 2.12 for more details) that provided data on production costs and thus have a lower representativeness.

Figure 9. Natural gas prices paid by EU ammonia producers, (€/MWh)



Source: Author's elaboration based on data from questionnaires.

Table 10. Descriptive statistics for natural gas prices paid by sampled EU ammonia producers (€/MWh)

	2010	**2011**	**2012**
EU (average)	22.2	28.5	31.2
Eastern Europe (average)	21	27.6	31.2
Southern Europe (average)	23.6	30.7	34.8
Western Northern Europe (average)	22.4	28.4	29.8

Source: Author's calculation based on data from questionnaires.

2.8.2.2Regional differences

Southern Europe

For the whole period - 2010 to 2012 - ammonia plants in Southern Europe were exposed to the highest average natural gas price among the three addressed regions. The average price rose by 47%, i.e. from 23.6 €/MWh in 2010 to 34.8 €/MWh in 2012.

Eastern Europe

From 2010 to 2012, natural gas prices rose from 21 €/MWh in 2010 to 31.2 €/MWh representing an increase of around 49%, the sharpest increase across the three sub-regions considered in this study. In the period 2010-2011, they rose by 31% and between 2011-2012 by 13%.

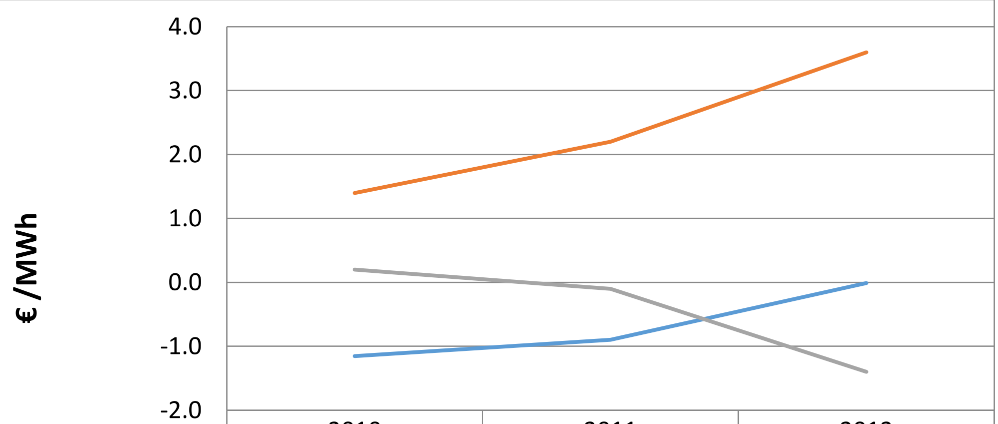
Western Northern Europe

In 2012, the average natural gas price in Western Northern Europe was lower than the EU average and the two other regional average prices. During the whole period - 2010 to 2012 - the average price increased by 33% with an increase of approximately 27% from 2010 to 2011 and 5% during the following year.

Regional gaps

Figure 10 below provides a graphical representation of the evolution of the gaps between the EU average price and the three regional average prices. The gap between the EU average and Southern Europe has consistently been the largest, while ammonia producers in Southern Europe have constantly paid a higher average price than the EU average: in 2010, producers were paying on average 1.4 €/MWh more than the EU average price; in 2012 this gap more than doubled reaching the value of 3.6 €/MWh. This is different when comparing the EU average with Western Northern Europe: while in 2010 the gap between the average natural gas price in this region and the EU average was +0.2 €/MWh, in 2012 this value reached -1.4 €/MWh. As for Eastern Europe, the gap between the average natural gas price in this region and the EU average steadily diminished between 2010 and 2012.

Figure 10. Regional gaps of natural gas price with EU average, (€/MWh)



	2010	2011	2012
Eastern Europe	-1.2	-0.9	0.0
Southern Europe	1.4	2.2	3.6
Western Northern Europe	0.2	-0.1	-1.4

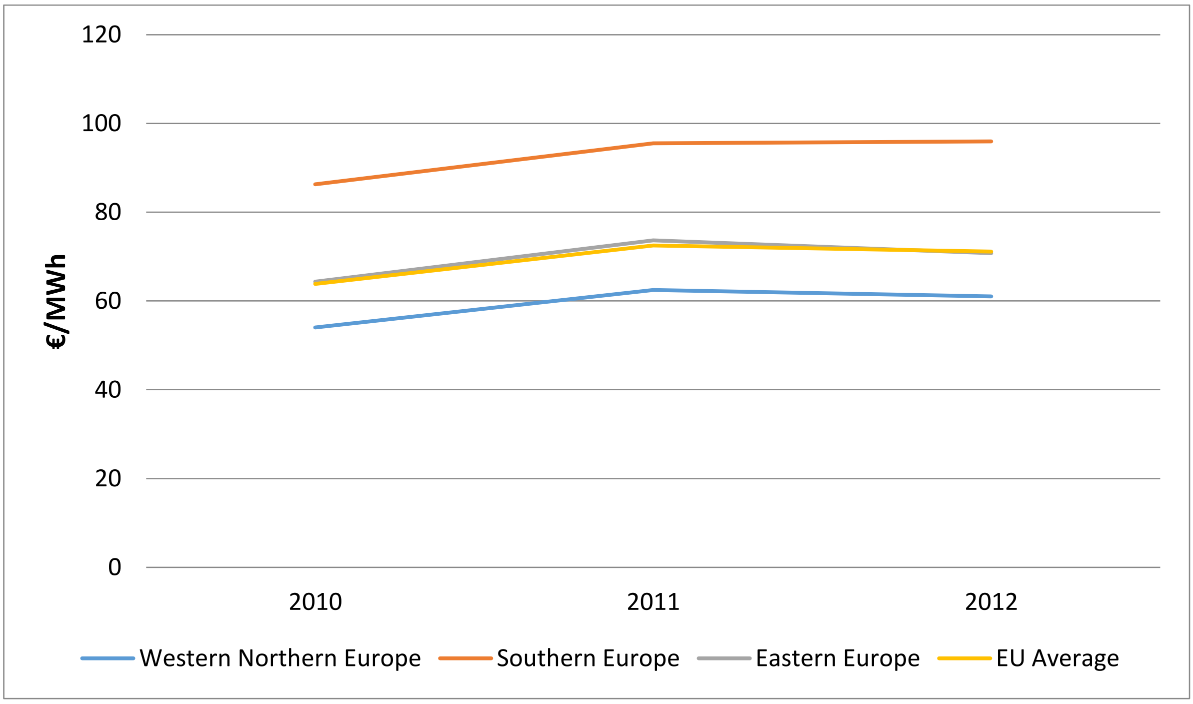
Source: Author's elaboration based on data from questionnaires.

2.8.3 Electricity

2.8.3.1 General trends

Between 2010 and 2012 prices increased from 63.9 €/MWh to 71.1€/MWh; this represents an increase of approximately 11%. In more detail, the EU average electricity price paid by ammonia producers increased by about 13.5% between 2010 and 2011, while it decreased by 1.9% during the following year. Table 11 provides an overview of the electricity prices for the sampled EU ammonia producers[25].

Figure 11. Electricity prices paid by EU ammonia producers, (€/MWh)



Source: Author's elaboration based on data from questionnaires.

Table 11. Descriptive statistics for electricity prices paid by sampled EU ammonia producers (€/MWh)

	2010	**2011**	**2012**
EU (average)	63.9	72.5	71.1
Eastern Europe (average)	64.3	73.6	70.7
Southern Europe (average)	86.3	95.5	96
Western Northern Europe (average)	54	62.4	61

Source: Author's calculation based on data from questionnaires.

[25] Please note that for 2012 the sample has been reduced to 9 plants, after the validation of all data points.

2.8.3.2 Regional differences

Southern Europe

Similar to natural gas, ammonia plants in Southern Europe were exposed to the highest average electricity price among the three regions during the whole period of observation. Between 2010 and 2012 the prices increased from 86.3 €/MWh to 96 €/MWh (+11%).

Eastern Europe

Electricity prices in Eastern Europe are almost coincident with average EU prices. For the whole period - 2010 to 2012 - they rose by around 10%, i.e. from 64.3 €/MWh to 70.7 €/MWh. Between 2010 and 2011 they increased by 14.5%, while from 2011 to 2012 they decreased by 3.9%.

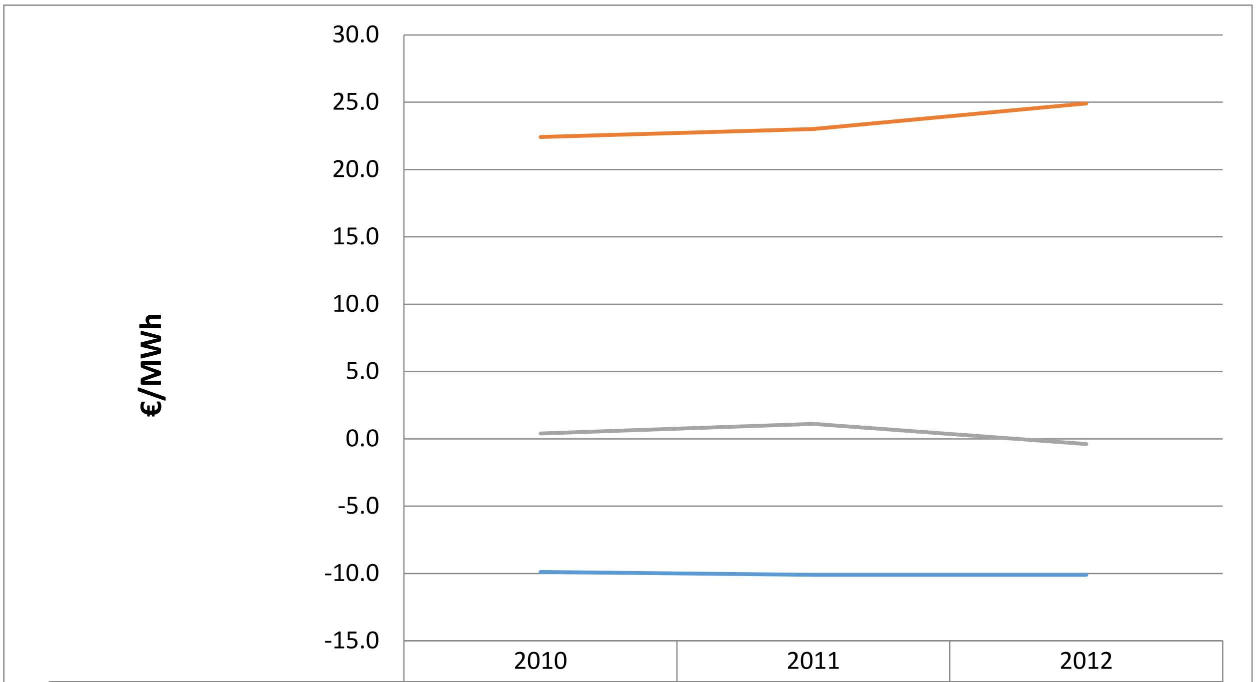
Western Northern Europe

Ammonia producers in Western Northern Europe paid lower electricity prices than the EU average during all the three years covered by this study. Prices in this region increased by about 13% between 2010 and 2012, from 54 €/MWh to 61 €/MWh; specifically, they increased by 15.5% between 2010 to 2011, while during the following year they decreased by 2.2%.

Regional gaps

Figure 12 below provides a graphical representation of the evolution of the gaps between the EU average electricity price paid by ammonia producers and the three regional average prices. Similar to natural gas, the difference between the EU average and Southern Europe has consistently been the largest: in 2010, Southern European producers were paying on average 22.4 €/MWh more than the EU average price; in 2012 this gap reached the value of 24.9 €/MWh. In contrast, ammonia producers from Western Northern Europe paid in 2010 9.9 €/MWh less than the EU average, and this value remained almost stable between 2010 and 2012. As for the Eastern European producers, they paid prices that were very close to the EU average, except for the year 2011 when the prices were slightly higher (+1.1 €/MWh).

Figure 12. Regional gaps of electricity price with EU average, (€/MWh)



	2010	2011	2012
Eastern Europe	0.4	1.1	-0.4
Southern Europe	22.4	23.0	24.9
Western Northern Europe	-9.9	-10.1	-10.1

Source: Author's elaboration based on data from questionnaires.

2.9 Analysis of energy bills components

2.9.1 Introduction

In order to better understand the price developments, sections 2.9.2 and 2.9.3 present the breakdown (in €/MWh and percentages, respectively) of the different components of the natural gas and electricity bills for the sampled EU ammonia producers: i) energy component, ii) grid fees, iii) RES levy and iv) other non-recoverable taxes.

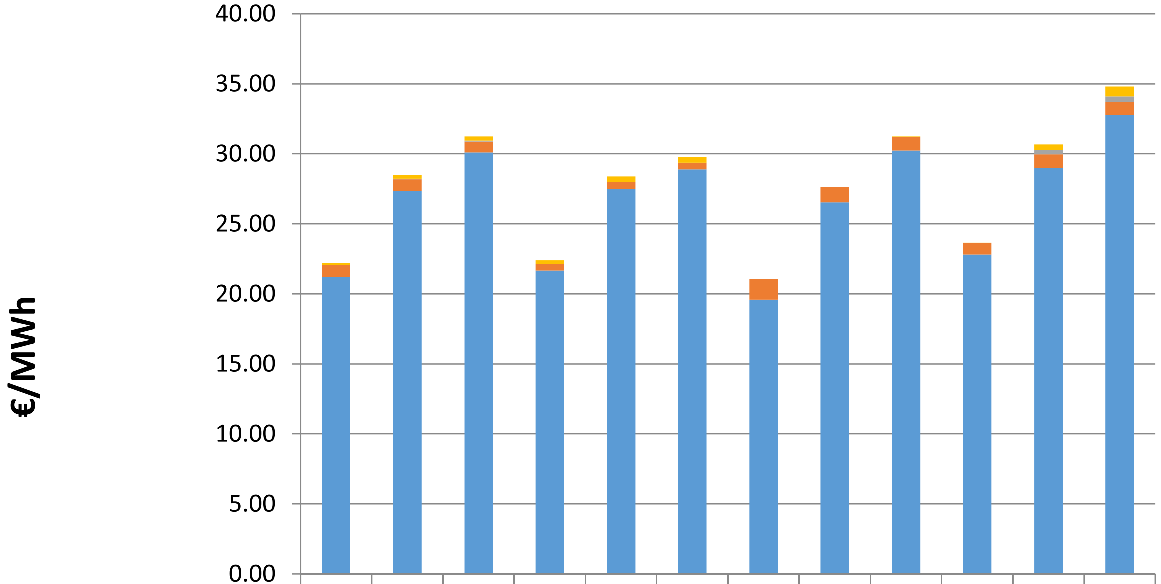
2.9.2 Natural gas

2.9.2.1 General trends

As shown in Figure 13, the natural gas bill[26] is dominated by far by the energy component, which makes up more than 90% of the total bill. In 2010, the energy component accounted for 95.5% of natural gas bill; this figure increased to 96.1% in 2011 and to 96.4% in 2012. Note that between 2010 and 2012, the absolute value of the energy component increased by about 42% (from 21.2 to 30.1 €/MWh).

[26] Please note that in some of the legal systems covered by the sample, gas consumption is subject to a RES levy.

Figure 13. Components of the natural gas bill paid by EU ammonia producers (€/MWh)

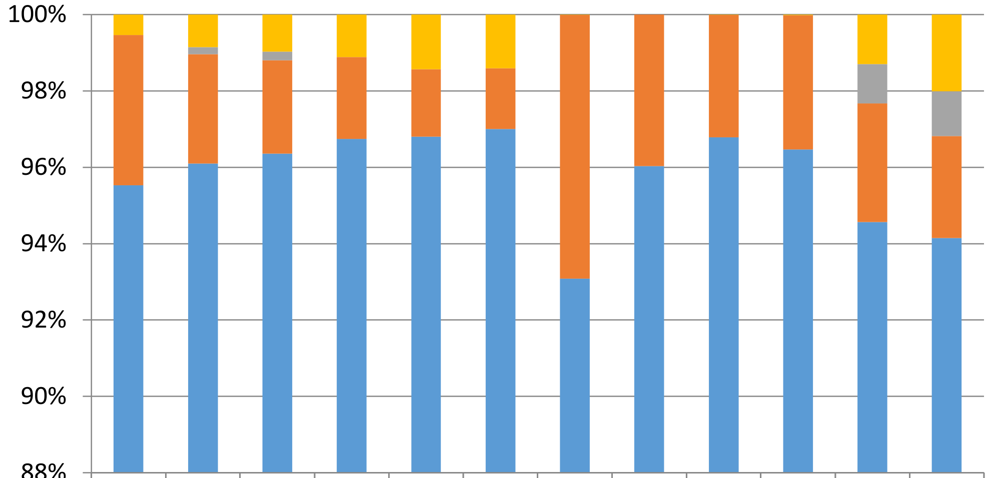


	EU average			Western Northen Europe			Eastern Europe			Southern Europe		
	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
Other non-recoverable taxes	0.12	0.24	0.30	0.25	0.41	0.42	0.00	0.00	0.00	0.00	0.40	0.70
RES levy	0.00	0.05	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.41
Grid fees	0.87	0.82	0.76	0.48	0.50	0.47	1.45	1.10	1.00	0.83	0.95	0.93
Energy component	21.20	27.36	30.10	21.67	27.47	28.89	19.58	26.54	30.23	22.81	29.00	32.76

Source: Data from questionnaires.

Other price components accordingly represent a small part of the overall bill. Starting with the category of other non-recoverable taxes, their share in the total natural gas bill increased from 0.5% in 2010 to 0.9% in 2011 and to 1% in 2012. This represents an increase in absolute values between 2010 and 2012 from 0.12 to 0.3 €/MWh. On the contrary, the impact of grid fees on the total bill decreased from 3.9% in 2010 to 2.9% in 2010 and to 2.4% in 2012. This represents a decrease in absolute values from 0.87 €/MWh in 2010 to 0.76 €/MWh in 2012. RES levies were introduced in 2011; however, their share in the total bill is small (0.2% in both 2011 and 2012).

Figure 14. Components of the natural gas bill paid by EU ammonia producers (in %)



	EU average			Western Northen Europe			Eastern Europe			Southern Europe		
	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
Other non-recoverable taxes	0.5%	0.9%	1.0%	1.1%	1.4%	1.4%	0.0%	0.0%	0.0%	0.0%	1.3%	2.0%
RES levy	0.0%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	1.2%
Grid fees	3.9%	2.9%	2.4%	2.1%	1.8%	1.6%	6.9%	4.0%	3.2%	3.5%	3.1%	2.7%
Energy component	95.5%	96.1%	96.4%	96.7%	96.8%	97.0%	93.1%	96.0%	96.8%	96.5%	94.6%	94.1%

Source: Data from questionnaires.

2.9.2.2 Regional differences

Southern Europe

In Southern Europe the energy component increased in absolute terms from 22.81 €/MWh in 2010 to 29 €/MWh in 2011 and to 32.76 €/MWh in 2012. However, the share of the energy component in the total bill decreased somewhat from 96.5% in 2010 to 94.6% in 2011 and to 94.1% in 2012. This small decrease in the share of energy component and grid fees in the total bill is owed to the introduction of non-recoverable taxes and RES levies. In 2011, other non-recoverable taxes for ammonia producers were introduced and rose from 1.3% in 2011 to 2%[27] in 2012. RES levies were also introduced in this region in 2011; however, compared to non-recoverable taxes, their contribution in the total bill remains small (1% in 2011 and 1.2% in 2012). Southern Europe is the only region where ammonia producers pay RES levies in the gas bill.

The share of grid fees in the total natural gas prices decreased from 3.5% in 2010 to 3.1% in 2011 and to 2.75% in 2012. In absolute terms their value however increased by around 12% between 2010 and 2012 (from 0.83 to 0.93 €/MWh).

[27] The absolute value on other non-recoverable taxes increased from 0.4 to 0.7 €/MWh between 2011 and 2012.

Eastern Europe

Compared to the other two regions, Eastern Europe has seen the most significant increase in the cost level of energy component. Specifically, the energy component increased from 19.58 €/MWh (93.1% of total bill) in 2010 to 26.54 €/MWh (96% of total bill) in 2011 and to 30.23 €/MWh (96.8% of total bill) in 2012. In parallel, the grid fees decreased from 1.45 €/MWh (6.9% of total bill) in 2010 to 1.1 €/MWh (4% of total bill) in 2011 and to 1 €/MWh (3.2% of total bill) in 2012. Ammonia producers in this region pay neither non-recoverable taxes nor RES levies.

Western Northern Europe

Ranging from 96.7% in 2010 to 97% in 2012, the share of the energy component in the total natural gas bill remained almost stable in Western Northern Europe. Although in absolute terms grid fees were rather stable[28], the contribution of grid fees in the total bill decreased from 2.1% in 2010 to 1.8% in 2011 and to 1.6% in 2012. The share of non-recoverable taxes increased from 1.1% in 2010 to 1.4% in 2011 and remained stable between 2011 and 2012. There were no RES levies.

2.9.3 Electricity

2.9.3.1 General trends

Although the energy component represents the dominant component of the electricity bill, its share in the total electricity price is less significant compared to natural gas. In 2010, the energy component amounted for 74.8% of the electricity price; this figure increased to about 75.8% in 2011 and then decreased to 74.1% in 2012. However, in absolute terms the energy component has steadily increased: from 47.1 €/MWh in 2010 to 51.36 €/MWh in 2011 and to 52.91 €/MWh in 2012[29].

Regarding the other price components, the share of other non-recoverable taxes in the total bill remained stable between 2010 and 2012. Their value was also rather stable in absolute terms, as it moved between 1.58 €/MWh and 1.75 €/MWh. The contribution of RES levies in the total bill has steadily increased: from 5.6% in 2010 to 6.1% in 2011 and to 8% in 2012. In absolute terms, their value also increased from 3.53 €/MWh in 2010 to 4.13 €/MWh in 2011 and to 5.7 €/MWh in 2012. As for the grid fees, their impact on the total bill decreased from 17.1% in 2010 to 15.5% in 2012. Their absolute value remained almost stable between 2010 and 2012.

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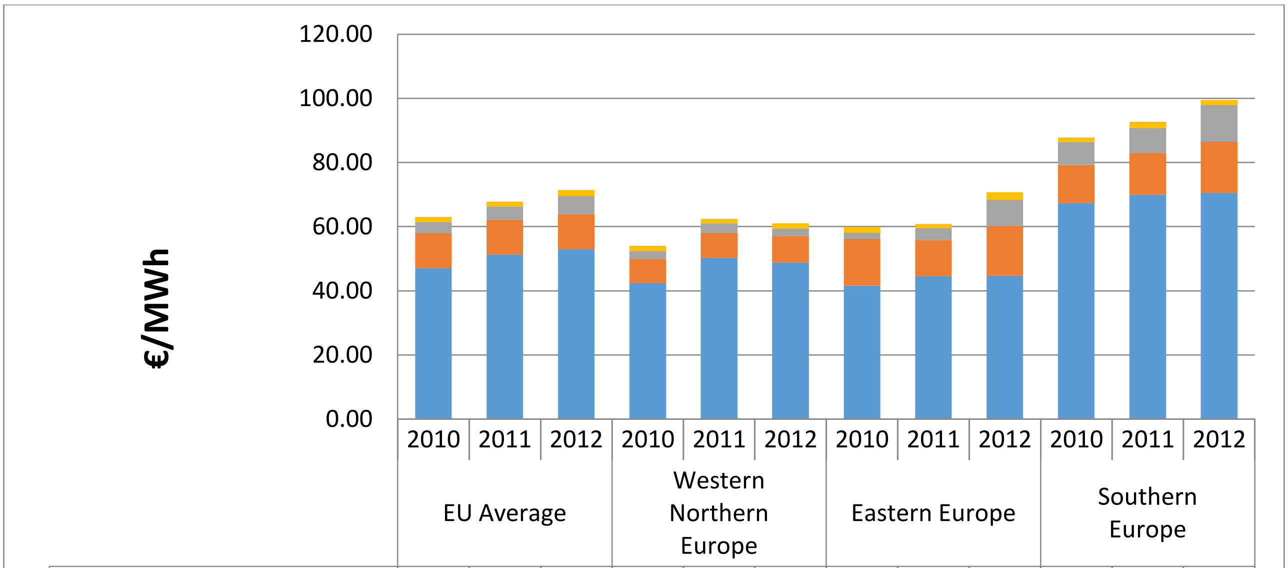
[28] Specifically, their value was 0.48 €/MWh in 2010, 0.5 €/MWh in 2011 and 0.47 €/MWh in 2012.

[29] Please note that for one plant the energy component also includes network costs; however, this has a negligible impact on the various averages herein reported. Please also note that for one plant the electricity price (thus also the various components) for 2012 as well as the values of RES levy for 2010-2012 are missing. For another plant, the RES levy could be disentangled from network costs based on public sources. In view of the aforementioned, there are some divergences between the average electricity prices reported in section 2.8.3.1 and the total values of all components of the electricity bill presented in this section.

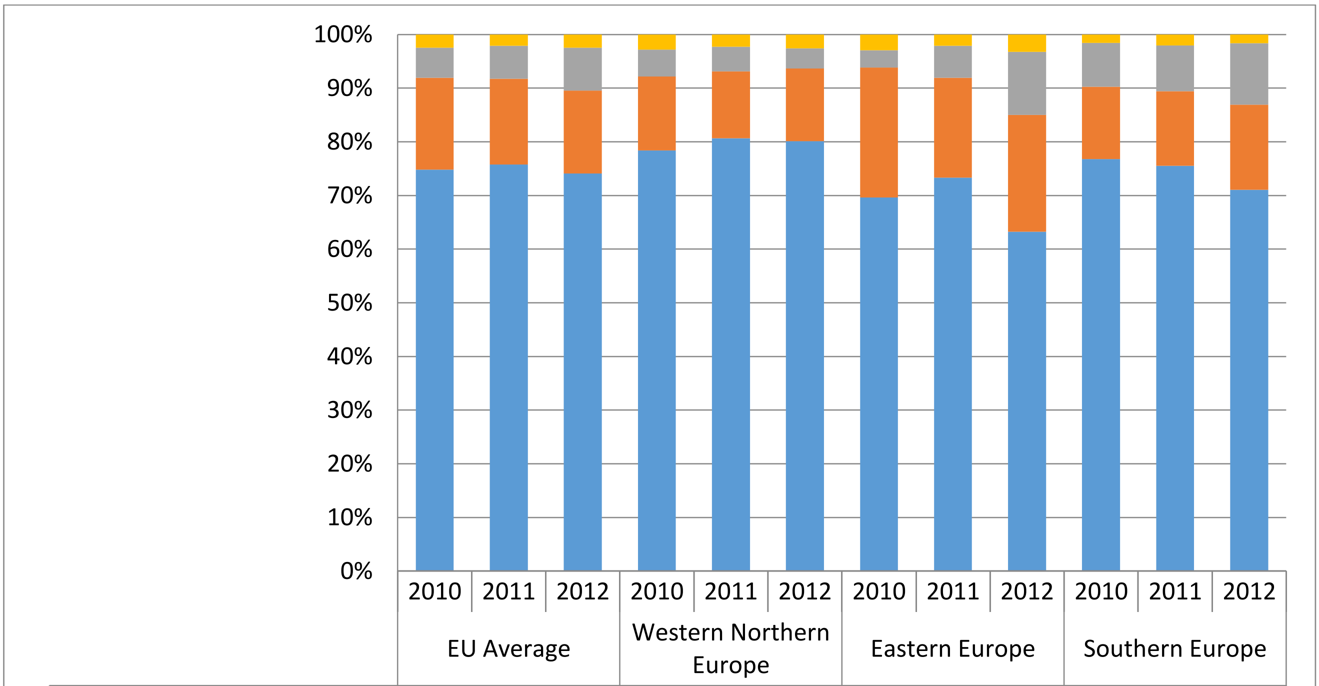
Figure 15. Components of the electricity bill paid by EU ammonia producers (€/MWh)



	EU Average 2010	EU Average 2011	EU Average 2012	Western Northern Europe 2010	Western Northern Europe 2011	Western Northern Europe 2012	Eastern Europe 2010	Eastern Europe 2011	Eastern Europe 2012	Southern Europe 2010	Southern Europe 2011	Southern Europe 2012
Other non-recoverable taxes	1.58	1.45	1.75	1.54	1.43	1.57	1.75	1.28	2.30	1.37	1.92	1.64
RES Levy	3.53	4.13	5.70	2.68	2.87	2.29	1.95	3.63	8.33	7.17	7.91	11.37
Grid Fees	10.78	10.84	11.05	7.44	7.80	8.29	14.51	11.32	15.38	11.83	12.87	15.82
Energy component	47.10	51.36	52.91	42.37	50.36	48.86	41.69	44.56	44.73	67.40	70.01	70.65

Source: Data from questionnaires.

Figure 16. Components of the electricity bill paid by EU ammonia producers (in %)



	EU Average 2010	EU Average 2011	EU Average 2012	Western Northern Europe 2010	Western Northern Europe 2011	Western Northern Europe 2012	Eastern Europe 2010	Eastern Europe 2011	Eastern Europe 2012	Southern Europe 2010	Southern Europe 2011	Southern Europe 2012
Other non-recoverable taxes	2.5%	2.1%	2.5%	2.9%	2.3%	2.6%	2.9%	2.1%	3.2%	1.6%	2.1%	1.7%
RES Levy	5.6%	6.1%	8.0%	5.0%	4.6%	3.8%	3.2%	6.0%	11.8%	8.2%	8.5%	11.4%
Grid Fees	17.1%	16.0%	15.5%	13.8%	12.5%	13.6%	24.2%	18.6%	21.7%	13.5%	13.9%	15.9%
Energy component	74.8%	75.8%	74.1%	78.4%	80.6%	80.1%	69.6%	73.3%	63.2%	76.8%	75.5%	71.0%

Source: Own calculation based on questionnaires.

2.9.3.2 Regional differences

Southern Europe

Southern Europe is the region with the highest impact of RES levies on the total energy bill, except for the year 2012 when the share of RES levies in the total bill in Eastern Europe was slightly higher (11.8% vs 11.4%). The absolute value of RES levies in Southern Europe increased from 7.17 €/MWh in 2010 to 11.37 €/MWh in 2012. The level of the energy component also increased from 67.4 €/MWh in 2010 to 70.65 €/MWh in 2012; however, during the same period its impact on the bill decreased from 76.8% to 71%. As for the grid fees, their value increased from 11.83 €/MWh to 15.82 €/MWh, while their contribution to the bill also rose from 13.5% in 2010 to 15.9% in 2012. The contribution of other non-recoverable taxes to the total bill remained rather stable from 2010 to 2012.

Eastern Europe

As shown in Figures 15 and 16, the impact of the energy component on the total bill in Eastern Europe is the lowest among the three addressed regions during the three year-period studied, while its value increased from 41.69 €/MWh in 2010 to 44.73 €/MWh (+7.3%) in 2012. In contrast, the share of the grid fees in the total bill in Eastern Europe is the highest among the three regions. The value of RES levies in this region has increased substantially from 1.95 €/MWh in 2010 to 8.33 €/MWh in 2012, while their contribution to the bill also increased from 3.2% in 2010 to 11.8% in 2012. The absolute value of other non-recoverable taxes increased from 1.75 €/MWh in 2010 to 2.3 €/MWh in 2012, while their impact on the bill increased from 2.9% to 3.2%.

Western Northern Europe

Augmenting from 78.4% in 2010 to 80.1% in 2012, the share of the energy component in the total bill in Western Northern Europe is the highest among all three regions during the three-year period covered by this study. Although in absolute terms grid fees increased from 7.44 €/MWh in 2010 to 8.29 €/MWh in 2012, their impact on the total bill remained almost stable. The contribution of RES levies to the total bill decreased from 5% in 2010 to 3.8% in 2012; in absolute terms they also decreased from 2.68 €/MWh to 2.29 €/MWh. The absolute value of non-recoverable taxes increased from 1.54 €/MWh in 2010 to 1.57 €/MWh in 2012, while their contribution to the electricity price decreased from 2.9% to 2.6%.

2.10 Energy intensity

This section addresses the energy intensity of sampled ammonia plants in terms of physical output (unit: MWh/tonne). The analysis focuses on natural gas which dominates the energy consumption of the sampled producers; specifically, the average share of natural gas consumption in total energy consumption was about 94%[30] during all three

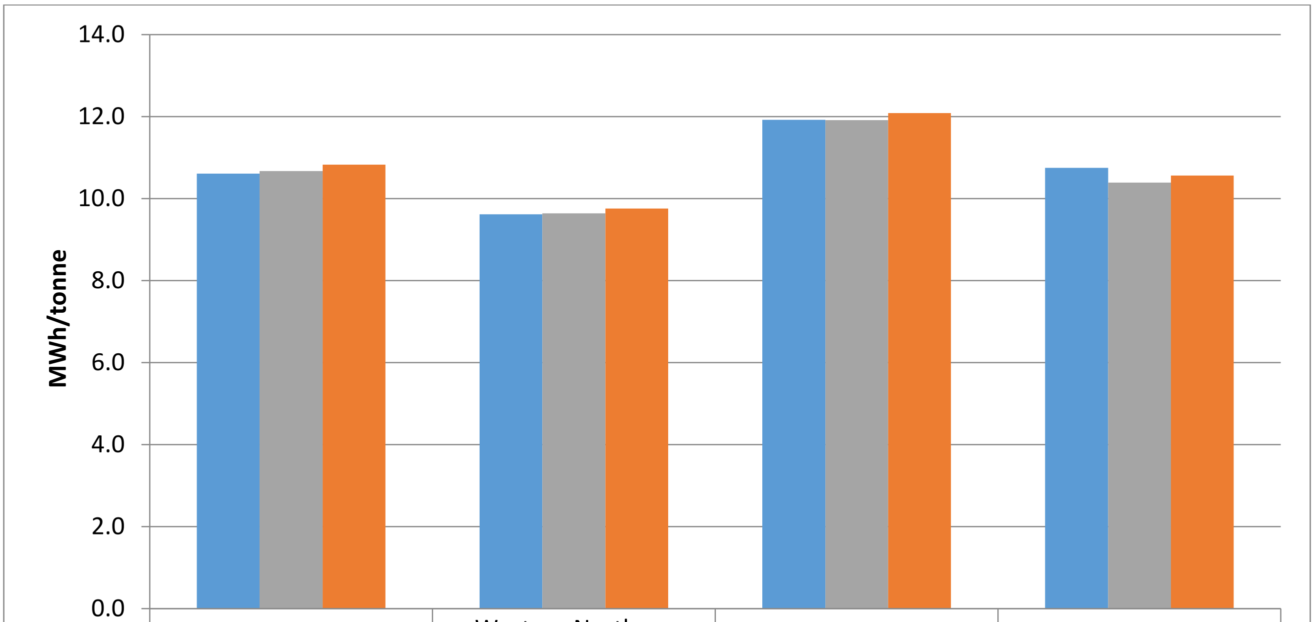
[30] Ranging from 94.1% in 2010 to 94.2% in 2012. Regarding the remaining energy sources, all participants used electricity in addition to natural gas, while four producers also used steam.

years considered in the study. The figures presented below are based on the natural gas consumption data and ammonia production levels provided by all 10 sampled ammonia producers.

2.10.1 General trends

Figure 17 below illustrates the energy intensity per tonne of ammonia product of the sampled EU ammonia plants. All presented figures are weighted averages that have been calculated on the basis of actual production. Ranging from 10.6 MWh/tonne in 2010 to 10.8 MWh/tonne in 2012, the average intensity of EU natural gas consumption has increased moderately (+1.9%). It should be noted that 6 out of 10 participants reported that they have made energy efficiency investments in recent years, mainly triggered by energy cost savings considerations; however, this is not reflected in the energy efficiency data for the addressed period (2010-2012).

Figure 17. Natural gas intensity of EU ammonia producers (MWh/tonne)



	EU average	Western Northern Europe	Eastern Europe	Southern Europe
2010	10.6	9.61	11.92	10.74
2011	10.7	9.64	11.91	10.39
2012	10.8	9.75	12.08	10.56

Source: Author's elaboration based on data from questionnaire

2.10.2 Regional differences

Eastern Europe

Eastern Europe has the highest average natural gas intensity (i.e. lowest average energy efficiency) among all three regions considered in this study. This is the only region where average natural gas intensity is higher than the EU average. The average natural gas intensity increased from 11.92 MWh/tonne in 2010 to 12.08 MWh/tonne in 2012 (+1.3%). For the whole period - 2010 to 2012 - the average natural gas prices in Eastern Europe were close to the EU average.

Western Northern Europe

Western Northern Europe had the lowest average natural gas intensity (i.e. highest average energy efficiency) during the three-year period covered by this study; however the average intensity increased from 9.61 MWh/tonne tonne in 2011 to 9.75 MWh/tonne in 2012 (+1.5%). As described in section 2.8.2, the average natural gas price paid by ammonia producers in this region was lower than the EU average.

Southern Europe

Compared to the other two regions, the average energy intensity in Southern Europe is closest to the EU average. Between 2010 and 2012, the average intensity decreased from 10.74 MWh/tonne to 10.56 MWh/tonne (-1.7%). Notably, ammonia producers in Southern Europe faced the highest natural gas price among the three addressed regions.

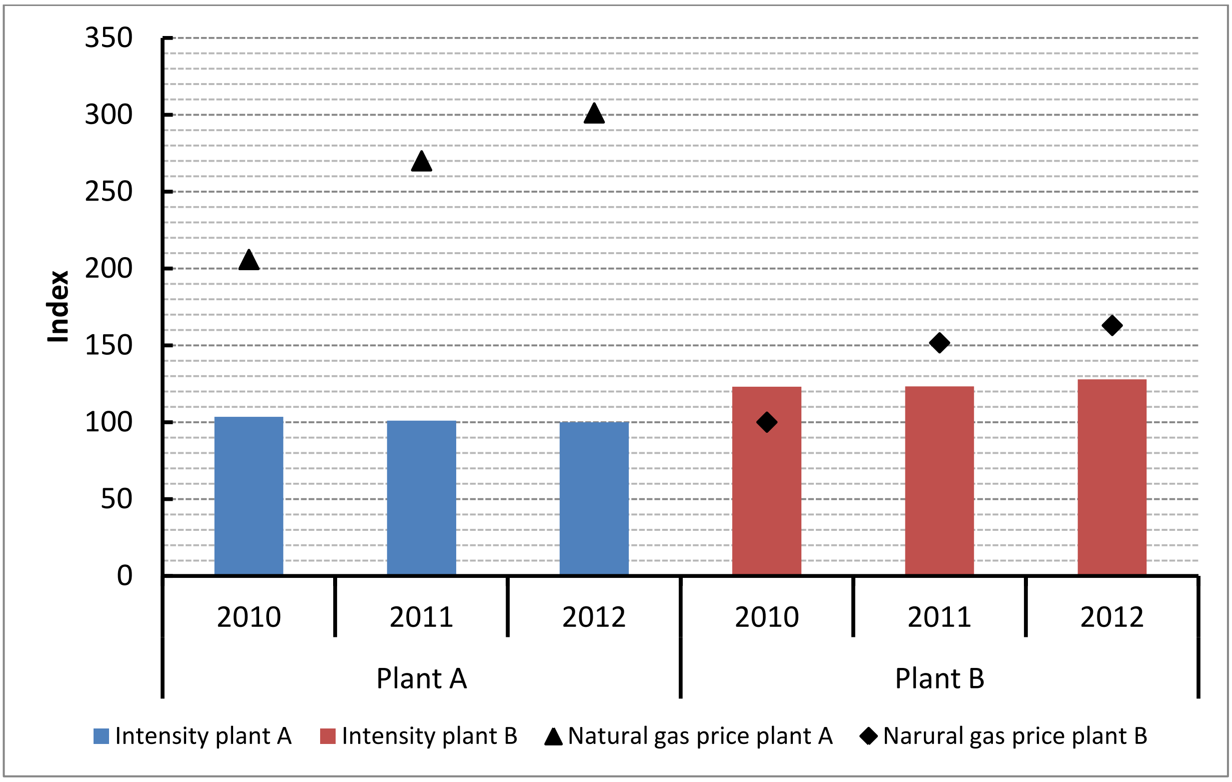
2.10.3 Plant case study

Figure 18 below illustrates the different natural gas intensities of two sampled plants of comparable capacity. Plant A has a lower natural gas intensity (i.e. higher energy efficiency) which decreased by approximately 3.3% between 2010 and 2012. Plant B has a higher natural gas intensity (i.e. lower energy efficiency), which increased by 4% between 2010 and 2012. As shown in the figure, Plant A, which has a higher energy efficiency, pays significantly higher natural gas prices[31] during all three years addressed in this study than Plant B, which has a lower energy efficiency[32].

[31] Figure 18 presents the natural gas intensity and natural gas prices of the two plants in relative (indexed) terms.

[32] Please note that no general conclusions can be drawn from this comparison of two individual plants.

Figure 18. Natural gas intensity and natural gas prices of two EU plants (indexed values, lowest value = 100)



Source: Author's elaboration based on data from questionnaire

2.11 Indirect ETS costs

2.11.1 Results

The calculation of indirect ETS costs for the ammonia industry was based on the electricity consumption and total production figures provided by the sampled EU ammonia producers as well as on the maximum regional CO2 emission factors of electricity generation and price of emission allowances (see also 2.7.3). Tables 12, 13 and 14 summarise the indirect costs borne by EU ammonia producers, using different pass-on rates.

Table 12. Ammonia indirect costs, averages per region (Euro/tonne of ammonia)

	Western Northern Europe	Eastern Europe	Southern Europe
2010	1.46	1.58	0.77
2011	1.59	1.61	0.72
2012	0.70	0.85	0.39

Pass-on rate: 0.6

Table 13. Ammonia indirect costs, averages per region (Euro/tonne of ammonia)

	Western Northern Europe	Eastern Europe	Southern Europe
2010	1.94	2.11	1.02
2011	2.12	2.15	0.97
2012	0.94	1.13	0.52

Pass-on rate: 0.8

Table 14. Ammonia indirect costs, averages per region (Euro/tonne of ammonia)

	Western Northern Europe	Eastern Europe	Southern Europe
2010	2.43	2.64	1.28
2011	2.66	2.68	1.21
2012	1.17	1.41	0.65

Pass-on rate: 1

Three plants in this sample used long term electricity contracts to acquire electricity; one from Eastern Europe and one from Southern Europe acquired 100% of their electricity via a long term contract, while one Western Northern European plant still relied on the wholesale market for 25% of its electricity. In addition one Eastern European plant covered around 10% of their electricity consumption with self-generated power.

Electricity that is acquired via a contract pre-dating the establishment of the EU ETS or is self-generated is not taken into account for the calculation of indirect ETS costs.

The drop in indirect-ETS costs across all regions between 2011 and 2012 can be largely attributed to a sharp decrease in EUA prices (from a yearly average of 13.77 Euros per EUA in 2011 to a yearly average of 7.56 Euros per EUA in 2012).

There are large inter-regional differences in indirect costs, caused by two distinct factors:

- the maximum regional CO_2 emissions factor[33], which is lowest in Southern Europe and highest in Eastern Europe and

[33] As defined and listed in Annex IV of the 'Guidelines on certain State aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012' (2012/C 158/04).

- differences in electricity intensities between plants. Ammonia plants in Eastern Europe consume on average circa 0.33 MWh/tonne of ammonia, compared with circa 0.20 in Western Northern Europe and circa 0.18 in Southern Europe.

2.11.2 Key findings

1) The inter-regional differences are relatively large.

- Indirect ETS costs in Eastern Europe are higher than those in the other regions, caused largely by significantly higher electricity intensity of production for two out of three plants in the Eastern European region.
- The difference between Eastern Europe and Western Northern Europe is relatively limited because the number of plants shielded from indirect costs differs while the sample-size is limited. Two out of three Eastern European plants face partial or no indirect ETS costs, while only one out of four Western Northern European plants is partially shielded from indirect costs.
- In Southern Europe these costs are lower than the other regions due to a combination of lower electricity intensity of production and lower maximum regional CO2 emissions factors.

2) Electricity intensity of production differs significantly between plants within the same region.

3) The ETS indirect cost was significantly lower in 2012 compared to the previous years, because the price of EUAs was significantly lower in 2012.

2.12 Production costs

This section presents an analysis of the production costs for EU producers of ammonia. Due to the intermediate nature of the good, it is not possible to retrieve meaningful data from publicly available sources – including companies' balance sheets. Therefore, to estimate production costs of ammonia it is necessary to rely on information provided directly by companies that can extract relevant data from their analytical accounting. The research team ensured the consistency of those cost figures by comparing data submitted by different producers and data submitted by the same producer for different years and asking for clarification and integrations whenever inconsistency was detected.

As explained in section 2.7.1, a questionnaire to collect data on production costs was sent to all the companies included in the sample. Data over the period 2010-2012 were provided by only seven out of ten plants. Thus, due to the lower response rate, the representativeness of the following figures is lower than of the figures presented in the other sections of this report. Furthermore, one of these plants underwent a restructuring process in 2010 so that information for that year is not representative for the business as usual and is not included in the analysis presented in this section.

All figures presented in this section are indexed for confidentiality reasons. For the responding plants, the following elements are estimated for the years 2010, 2011, and 2012:

- Total production costs, whose estimate has been provided by companies and includes all production costs, *i.e.* cost of finished ammonia, other operating expenses, depreciation, amortization, and financial expenses referred to the product line[34]; for confidentiality reasons, production costs have been indexed, with 2010 as the base year;
- Natural gas costs, provided by companies in terms of €/MWh and converted into €/tonne using the corresponding energy intensities of the production process; for confidentiality reasons, natural gas costs have been indexed, with 2010 as the base year;
- Electricity costs, computed adopting the same methodology as natural gas costs.

Table 15. Production costs of EU ammonia producers

	2010	**2011**	**2012**
Number of plants	6	7	7
Total production costs, Index 2010=100	100	120.2	134.0
Natural gas costs, Index 2010=100	100	127.3	144.0
Electricity costs, Index 2010=100	100	99.1	101.2

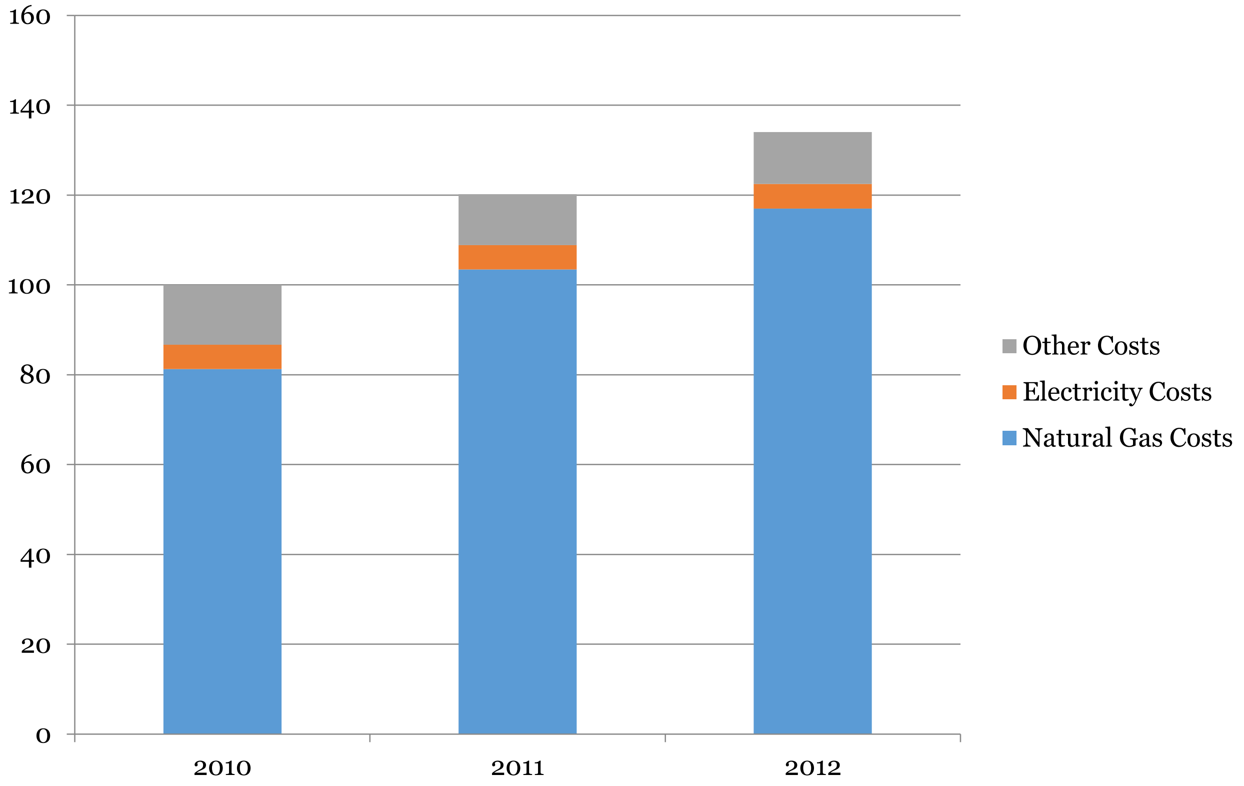
Source: Author's calculation based on companies' data.

Total production costs experienced a steep increase over the observation period (+34%). This trend reflects the parallel growth of natural gas costs, that increased by 44% between 2010 and 2012. As for electricity costs, they remained almost stable over the entire period (+1%), with a cost reduction between 2010 and 2011 (-1%) and a growth between 2011 and 2012 (+2%).

As shown in Figure 19, natural gas costs were responsible for the lion's share of total production costs, i.e. about 80-88%. Electricity costs accounted for around 3-6% of total production costs.

34 Although the research team provided this explicit definition of total production costs to the participants, it is possible that due to the intermediate nature of the good in some cases depreciation and amortization were not included in the calculation of total production costs.

Figure 19. Total production costs of EU ammonia producers (indexed)



Source: Authors' elaboration on companies' data.

2.13 General impressions

The consultant used the questionnaires to (*inter alia*) ask EU ammonia producers about their impressions of the effects of liberalisation. The respondents had divergent views on the impact of liberalisation on the energy markets. Some participants, mainly from Western Northern Europe, emphasised the benefits of liberalisation and claimed that it has opened the door to more suppliers and has helped them to move away from oil-indexed contracts. However, one producer also noted that oil-related gas prices are still the long term proxy. On the contrary, producers from Southern and Eastern Europe generally claimed that the market is still not liberised or partially liberised in their countries with a negative impact on their energy costs. Some participants also mentioned that they face monopoly situations. Finally, one producer from this region claimed that oil remains the underlying driver of the market.

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CHAPTER 3.
THE CASE OF THE CHEMICAL INDUSTRY – CHLORINE

VASILEIOS RIZOS, FEDERICO INFELISE, GIACOMO LUCHETTA FELICE SIMONELLI, WIJNAND STOEFS, JACOPO TIMINI AND LORENZO COLANTONI

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3.1 Chemical description and uses

Chlorine (Cl) is a chemical element that, under standard conditions, appears as a greenish-yellow gas formed by diatomic molecules (Cl_2).

Chlorine is one of the most common elements in nature but, due to its high reactivity, it practically does not exist by itself and is usually found bound with other elements. Common kitchen salt (sodium chloride) is probably the best example of inorganic chlorinated substances while the oceans, forest fires and fungal activity are examples of organic chlorinated substances.

The production of chlorine is one of the major sectors within the global chemical industry. According to the World Chlorine Council (2012), the annual global production capacity of chlorine is estimated at around 60 million metric tonnes.

Chlorine was discovered in 1774 by the Swedish chemist Karl Wilhelm Scheele; until the beginning of the 21st century it had been used mainly for its sanitation properties in different scientific health-related fields ranging from the disinfection of household water supply to the development of improved medications. The invention of polyvinyl chloride (PVC) in 1912 was a major breakthrough for the large-scale industrial production of chlorine. Nowadays, chlorine plays a key role in many industries, as illustrated in the table below.

Table 1. Uses of Chlorine[35]

Industry	Application
Pulp and paper industry	Chlorine and its compounds are used to bleach wood pulp during the paper production process.
Manufacture of organic chemicals	Chlorine is used for making ethylene dichloride, glycerine, glycols, chlorinated solvents and chlorinated methanes.
Plastic industry	Chlorine is used for making plastics, most notably polyvinyl chloride (PVC), which is being used extensively in building and construction, packaging, and

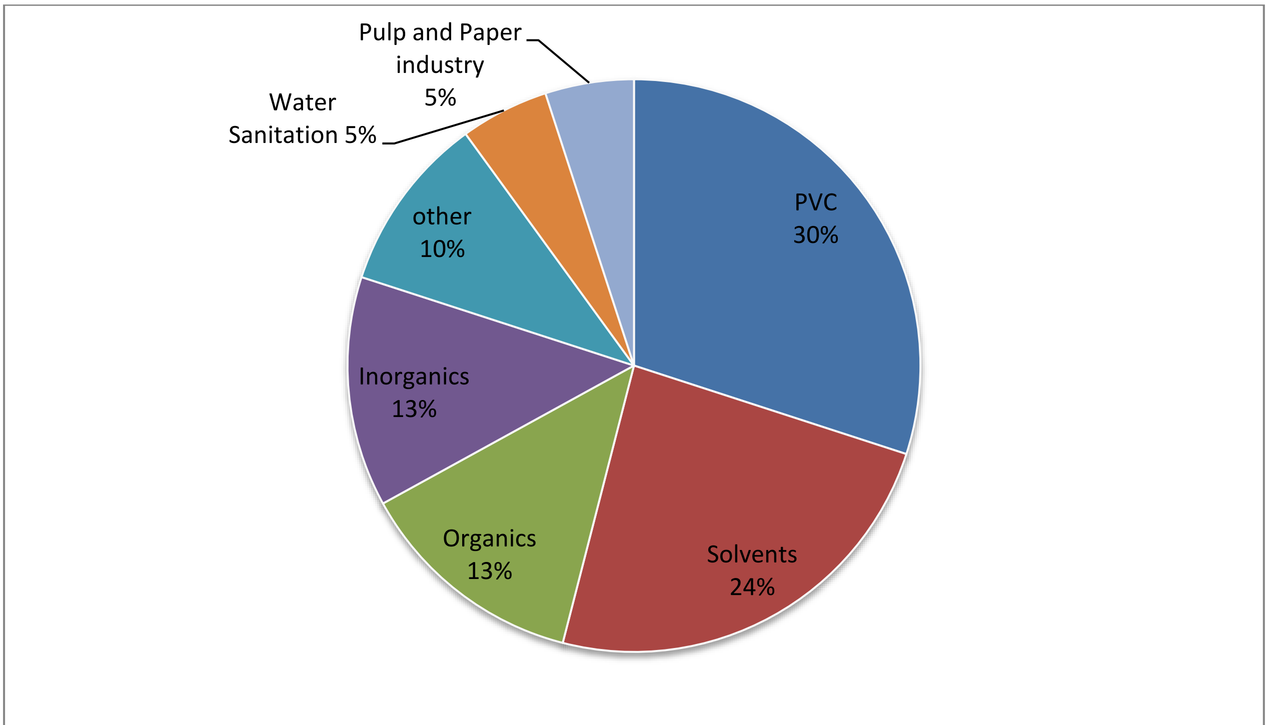
35 The source of the major uses of chlorine is the website of the Centre for Science and Environment, (http://www.cseindia.org/node/283), accessed: 30 October 2013.

	many other items.
Pesticides	96 % of all pesticides are produced using chlorine.
Industrial solvents	A variety of chlorinated compounds are used as industrial solvents, including the main ingredient used in dry cleaning.
Water treatment	Chlorine is used in 98 % of the water treatment plants in the world.
Pharmaceuticals	85 % of all pharmaceuticals use chlorine at some point in the production process.
Other relevant applications	Domestic bleaches, flame-retardants, food additives, refrigerants, insulation, computer chip manufacturing and hospital disinfectants among others.

3.2 Chlorine market features

As shown in Figure 1, chlorine has a very broad set of applications. The PVC industry accounts for 30% of the total chlorine demand and, due to its multiple different uses within cornerstone sectors such as construction, automotive, IT and packaging, it is often seen as the key driver of the global demand for chlorine.

Figure 1. Uses of chlorine by sector, 2012



Source: Authors' elaboration on Greener-industry (2012).

The exposure of the chlorine industry to sectors whose expansion is highly correlated to the level of the general economic activity makes the demand for chlorine highly pro-cyclical. Since 1990, despite some low-demand periods around the major episodes of strong global economic downturn (notably in early 2000 and between 2007-2009), global demand for chlorine has been steadily growing (see Figure 2) and, in the period 1990-2012, it experienced an annual average growth rate of 2.4%.

Producing chlorine is an energy-intensive activity. The key input for the production process, irrespective of the specific technology applied in each plant, is electricity[36]. As a result, electricity is a key cost driver for the chlorine industry as it accounts for approximately 50%[37] of the total cash production cost[38] (Eurochlor, 2010). Both physically and chemically, the electric current is essential to the chlor-alkali reaction and there are virtually no viable options to produce chlorine on an industrial scale without recurring to electricity. Figure 3 highlights the key role of electricity costs in driving the total cost of chlorine production and ultimately in shaping the international competitiveness of different geographical areas. According to IHS (2013), the electricity price differential between North America and Western Europe, which is in the range of 4.5 USD cents per kW/h, is the key factor in determining a price differential among the two regions of roughly 161 USD per ton of electrochemical unit (ECU)[39].

Figure 2. Chlorine world demand and construction spending, 1990-2013

Source: IHS (2013).

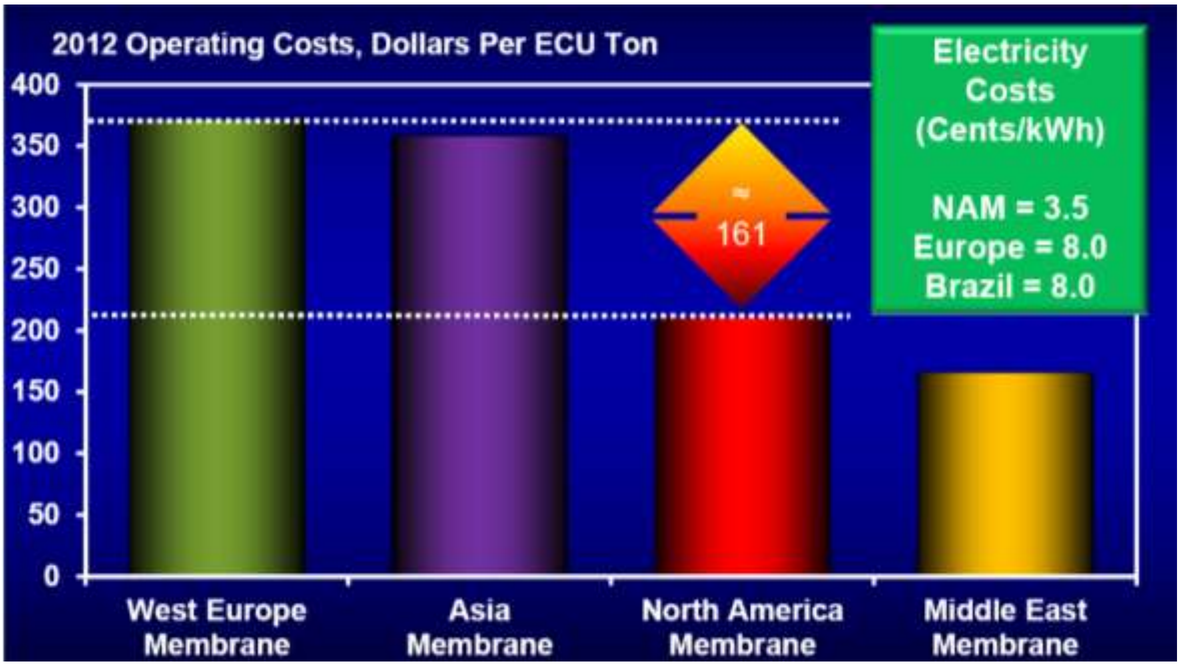
[36] Around 90% of the total electricity used for chlorine electrolysis is used as raw material, while the remaining 10% is used for lighting and operating pumps, compressors and other necessary equipment (Eurochlor, 2010).

[37] It should be emphasised that this figure presents a broad estimate for the chlorine industry, as there are large variations in the capacities of EU plants as well as in the technologies used for chlorine production.

[38] The total production cost refers to the sum of the cost of raw materials, labour cost, maintenance costs, overhead costs and taxes.

[39] The electrolysis of brine produces a fixed ratio of 1 tonne of chlorine, 1.1 tonne of caustic soda and 0.03 tonne of hydrogen; this product combination is called Electrochemical Unit (ECU).

Figure 3. Chlorine world production cost (membrane technology) by geographical area, 2012



Source: IHS (2013).

3.3 Chlorine production technologies

At industrial level, virtually all chlorine is produced by passing electricity through a solution of brine, which is common salt dissolved in water. This process is called electrolysis. The chemical reaction generated by the electrolysis of the three raw materials at the base of this process (namely salt, water and electricity) generates chlorine and also two other co-products: *caustic soda* (sodium hydroxide or NaOH) and *hydrogen* (H_2) Both caustic soda and hydrogen have important applications in other industrial sectors[40] since, despite their high reactivity, the development of efficient technologies has enabled the separation of these three substances allowing their use in further industrial processing.

There are three major technologies for the industrial production of chlorine[41] :

- the mercury cell process: in this case, brine passes through a chamber which has a carbon electrode (the anode) suspended from the top. Mercury flows along the floor of this chamber and acts as the cathode. When an electric current is applied to the circuit, chloride ions in the electrolyte are oxidised to form chlorine gas.

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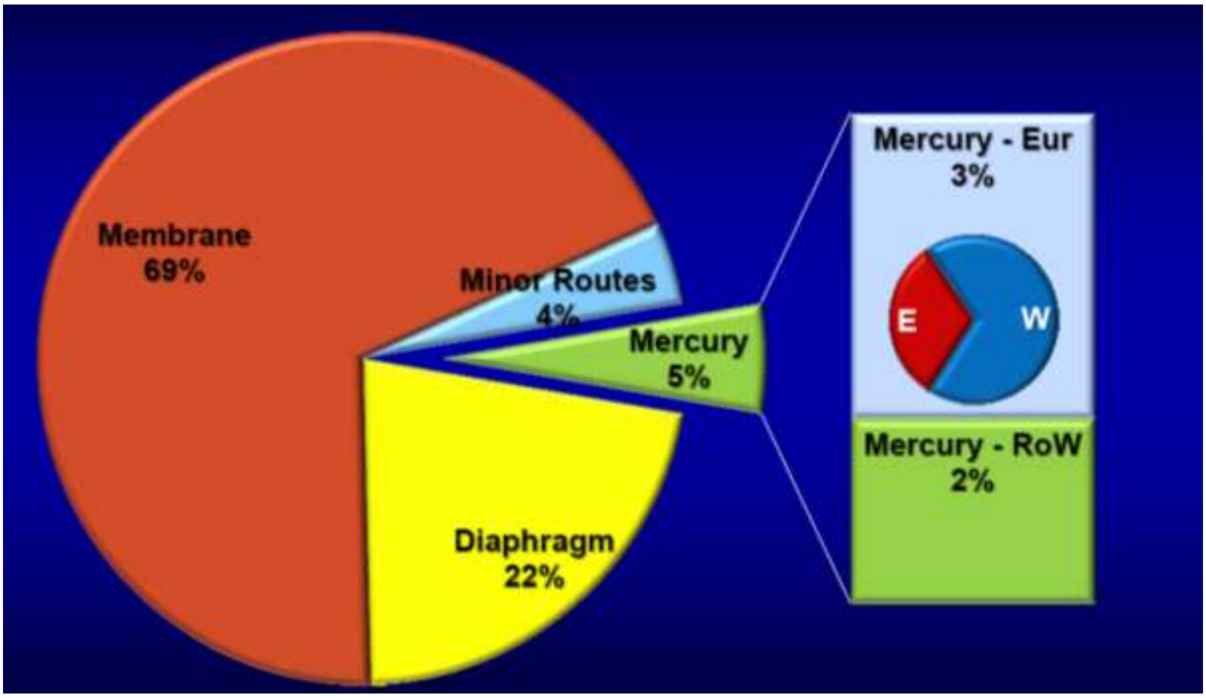
[40] Caustic soda is an alkali which is widely-used in many industries, including the food industry, textile production, soap and other cleaning agents, water treatment and effluent control. Hydrogen is a combustible gas used in various processes including the production of hydrogen peroxide and ammonia as well as the removal of sulphur from petroleum derivatives. Depending on their sustainability programmes, more and more companies also use the excess hydrogen in fuel cells to generate electric power (Eurochlor, 2011).

[41] The source of the description of the three major technologies for chlorine production is the Everything Science website, (http://tinyurl.com/q9ntv86), accessed: 30 October 2013.

- the diaphragm cell process: a porous diaphragm divides the electrolytic cell, which contains brine, into an anode compartment and a cathode compartment. The brine is introduced into the anode compartment and flows through the diaphragm into the cathode compartment. When an electric current passes through the brine, the salt's chlorine ions and sodium ions move to the electrodes and chlorine gas is produced at the anode.

- the membrane cell process: the membrane cell is very similar to the diaphragm cell, and the same reactions occur. The main difference with the previous process is that the two electrodes are separated by an ion-selective membrane, rather than by a diaphragm. Among the three available technologies, this is the most energy-efficient and the one with the lowest operating-costs.

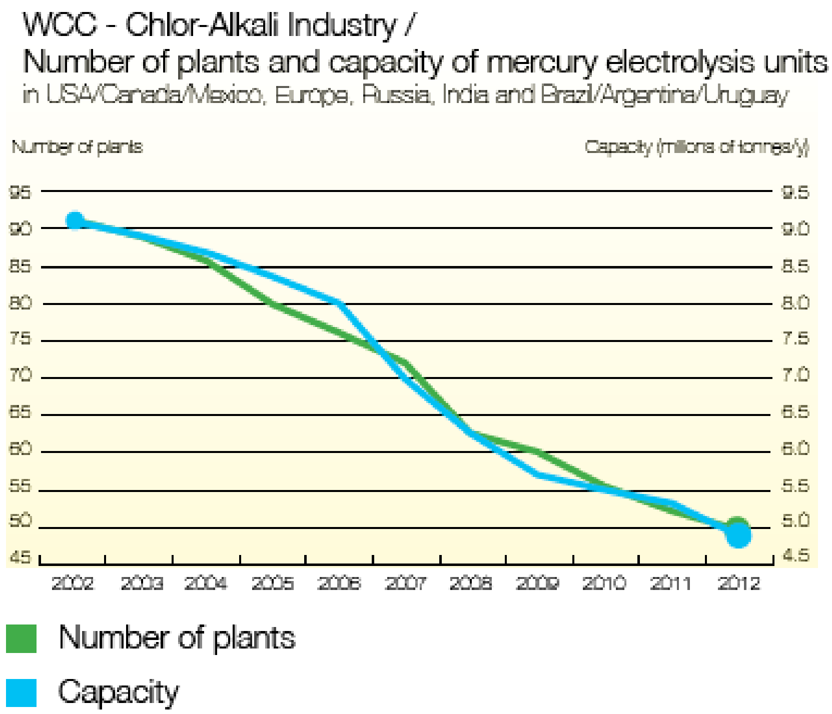
Figure 4. World chlorine capacity by production technology, 2012



Source: IHS (2013).

The mercury cell is the oldest technology and accounts for just about 5% of the world capacity (see Figure 4). Of the three processes, the mercury process uses the largest amount of electricity and is therefore the least-efficient available technology for chlorine production. The use of mercury technology also requires measures to prevent the harmful release of mercury into the environment. Chlorine producers are increasingly moving towards membrane technology (see Figure 5), which has much less impact on the environment and is the most cost-efficient in the long run (UNEP, 2012).

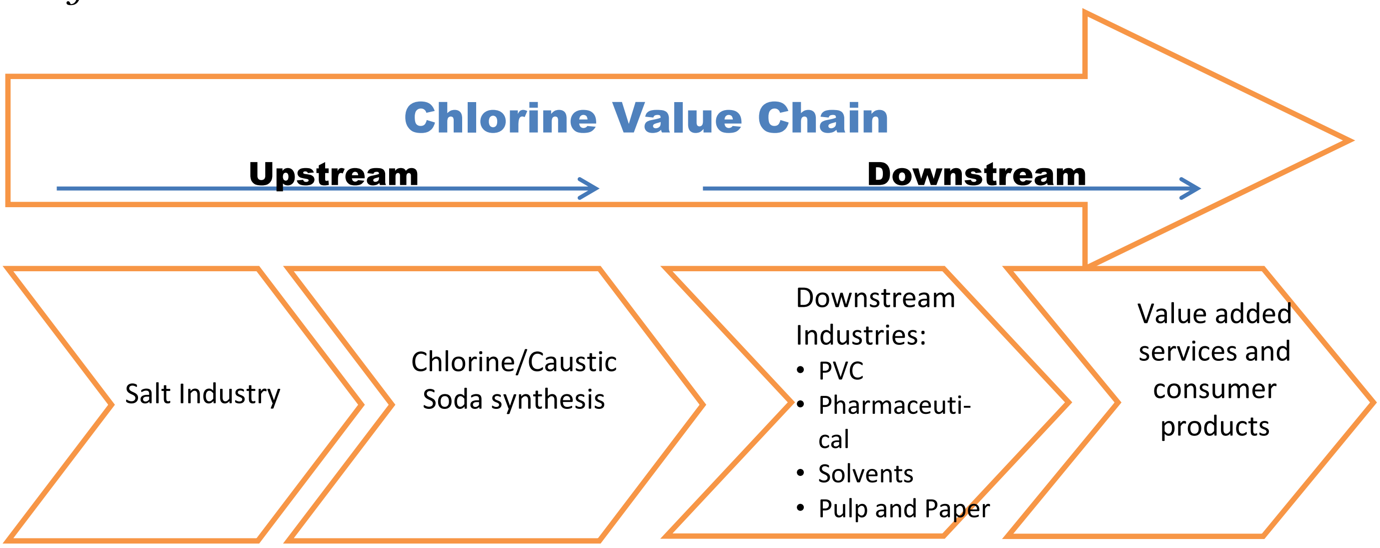
Figure 5. World number of plants and capacity using mercury cell technologies



Source: Eurochlor (2013).

3.4 The Chlorine value chain

Figure 6. Chlorine value chain



Source: Author.

The chlorine value chain presents a high degree of vertical integration among upstream and downstream players. The key factors determining the degree of vertical integration are the high transportation costs and the absence of a proper market for chlorine as such. Indeed, chlorine is used almost exclusively as an intermediate product since downstream industries in the value chain (e.g. PVC producers) produce themselves most of the chlorine required as an input in the production process. The value added across the value chain is therefore determined by the downstream industries, which process chlorine and use it as raw material for the production of different consumer products.

3.5 The EU chlorine market

The EU-27 has a total capacity for the industrial production of chlorine equal to around 12.2 million tonnes (see Table 2). The EU production is spread across 19 different member states and 72 production plants. The member state with the highest production capacity is by far Germany with a capacity of 5.2 million tonnes (19 plants, 42,5% of EU capacity), followed by France with a capacity of 1.4 million tonnes spread over 10 plants (11.6% of total EU capacity), Belgium (3 plants, 8.5% of EU capacity), the Netherlands (3 plants, 6.9% of EU capacity), Spain (9 plants, 6,1% of EU capacity) and the UK (2 plants, 6%). The remaining member states are responsible all together for about 18% of the total EU capacity.

Table 2. EU-27 capacity and number of plants per country, 2013[42]

Country	Capacity (k tonnes)	Plants	% EU capacity
Germany	5,187	19	42.49%
France	1,419	10	11.62%
Belgium	1,034	3	8.47%
The Netherlands	847	3	6.94%
Spain	744	9	6.09%
Uk	729	2	5.97%
Poland	339	3	2.78%
Italy	426	6	3.49%
Romania	384	2	3.15%
Hungary	291	1	2.38%
Czech Republic	196	2	1.61%
Portugal	142	2	1.16%
Sweden	120	1	0.98%
Finland	115	2	0.94%
Slovak Republic	76	1	0.62%
Austria	70	1	0.57%
Greece	64	3	0.52%
Slovenia	16	1	0.13%
Ireland	9	1	0.07%
TOTAL EU-27	**12,208**	**72**	100.00%

Source: Authors' elaboration on Eurochlor (2013).

[42] As of January 2013.

Table 3 illustrates the share of the total European installed chlorine capacity between the three different chlorine production technologies. In particular, approximately 55% of the EU-27 capacity is based on the most efficient “membrane” technology, about 13% is based on the “diaphragm technology” and around 29% is still based on the “mercury technology”.

Table 3. EU-27 capacity of chlorine per technology, 2013

Process	Capacity (k tonnes)	% EU total
Diaphragm "D"	1,635	13%
Mercury "Hg"	3,484	29%
Membrane "M"	6,788	55%
others	376	3%
Total[43]	12,283	100%

Source: Authors’ elaboration on Eurochlor (2013).

3.6 Sample selection

3.6.1 Sample selection criteria

To establish the sample for this study, the research team took as a starting point the complete list of chlorine plants published by Eurochlor[44] (2013)[45]. The criteria to establish the final sample of EU plants covered in the analysis are presented below. It should be noted that before selecting the sample, a number of European chlorine producers expressed their interest in participating in the study, in collaboration with Eurochlor. The research team duly took into account these expressions of interest when establishing the final sample, so as to enable both an authoritative analysis and limit the risk of receiving too few questionnaires.

Geographical coverage

The geographical criterion was chosen to ensure that different EU regions are represented in the analysis and to reflect the relative weight of the member states’ chlorine capacity.

Capacity of plants

To reflect different capacities, the research team divided the total set of EU-27 plants into 3 sub-groups: those plants with a capacity higher than 300.000 tonnes per year have been identified as *large size*; those with a capacity higher than 100.000 t/y but lower than

[43] There is a small divergence between the sum of the capacities of all technologies (12,283) and the total EU capacity figure reported in Table 2 (12,208) since, according to the information provided by Eurochlor (2013), the combined production capacity of one EU plant is smaller than the sum of the two technologies used (mercury and membrane) by this plant for chlorine production.

[44] Eurochlor is the association of European chlorine producers.

[45] To double check the validity of this information, plants included in the final sample were asked to provide data on exact location, capacity and production. Production data were provided for the period between 2010 and 2012 (three years).

300.000 t/y have been included in the *medium size* set; those with a capacity lower than 100.000 t/y have been included in the *small size* set. According to this classification, in the EU there are 10 large plants, 27 medium-size plants and 35 small plants.

Technology

The research team applied the technology criterion to reflect, to the extent possible, the shares of the three major production technologies (i.e. membrane technology, diaphragm technology and mercury technology) in the total EU installed chlorine capacity.

3.6.2 Sample statistics

The final sample consists of 9 plants[46], covering altogether around 12% of the total EU chlorine capacity. Concerning the size of the selected plants, 1 plant is defined in this study as large-size plant, 6 as are defined as medium and 2 as small (see Table 5). The membrane manufacturing technology represents 62% of the sample's total capacity, the mercury technology 32% and others 5%. The diaphragm technology is not represented in the sample (see Table 6).

Table 4. EU-27 chlorine plants statistics, 2013

	EU-27	%
Large	10	14%
Medium	27	37%
Small	35	49%
Highest (k tonnes)	1,585	
Lowest (k tonnes)	4	
Average Capacity (k tonnes)	170	
Median Capacity (k tonnes)	120	

Source: Authors' elaboration on Eurochlor (2013).

Table 5. Chlorine plants sample statistics

		% of sample
Total capacity (k tonnes, % EU-27)	1,500	12%
Average Capacity (k tonnes)	165	
Large	1	11%
Medium	6	67%
Small	2	22%

Source: Authors' elaboration.

[46] Notably, the research team received questionnaires for 11 plants; however, as also described in the following section, two questionnaires were excluded from the final sample after a plausibility check.

Table 6. Chlorine plants sample statistics on production technologies

	% of sample
Diaphragm "D"	0%
Mercury "Hg"	32%
Membrane "M"	62%
Others	6%

Source: Authors' elaboration.

3.7 Methodology

3.7.1 Data collection

The analysis of the energy prices and costs for the chlorine sector was based on questionnaires sent to all plants included in the sample. The content of the questionnaire was discussed with chlorine industry experts to ensure that the technical specifications of the chlorine sector are properly reflected. In addition and with the help of the Chemical Industry Association (Cefic), the questionnaire was tested by one pilot plant. Strict confidentiality agreements were also signed with the companies participating in the study.

The research team received in total 11 questionnaires; however, two questionnaires were excluded from the final sample as provided data were not fully usable. All 9 participants provided detailed figures on the level and structure of energy prices as well as on energy consumption. Additionally, 5 out of the 9 sampled plants provided further data on production costs. Table 7 below provides an overview of the number of questionnaires received and used in the analysis of each section.

Table 7. Number of questionnaires received and used in each section

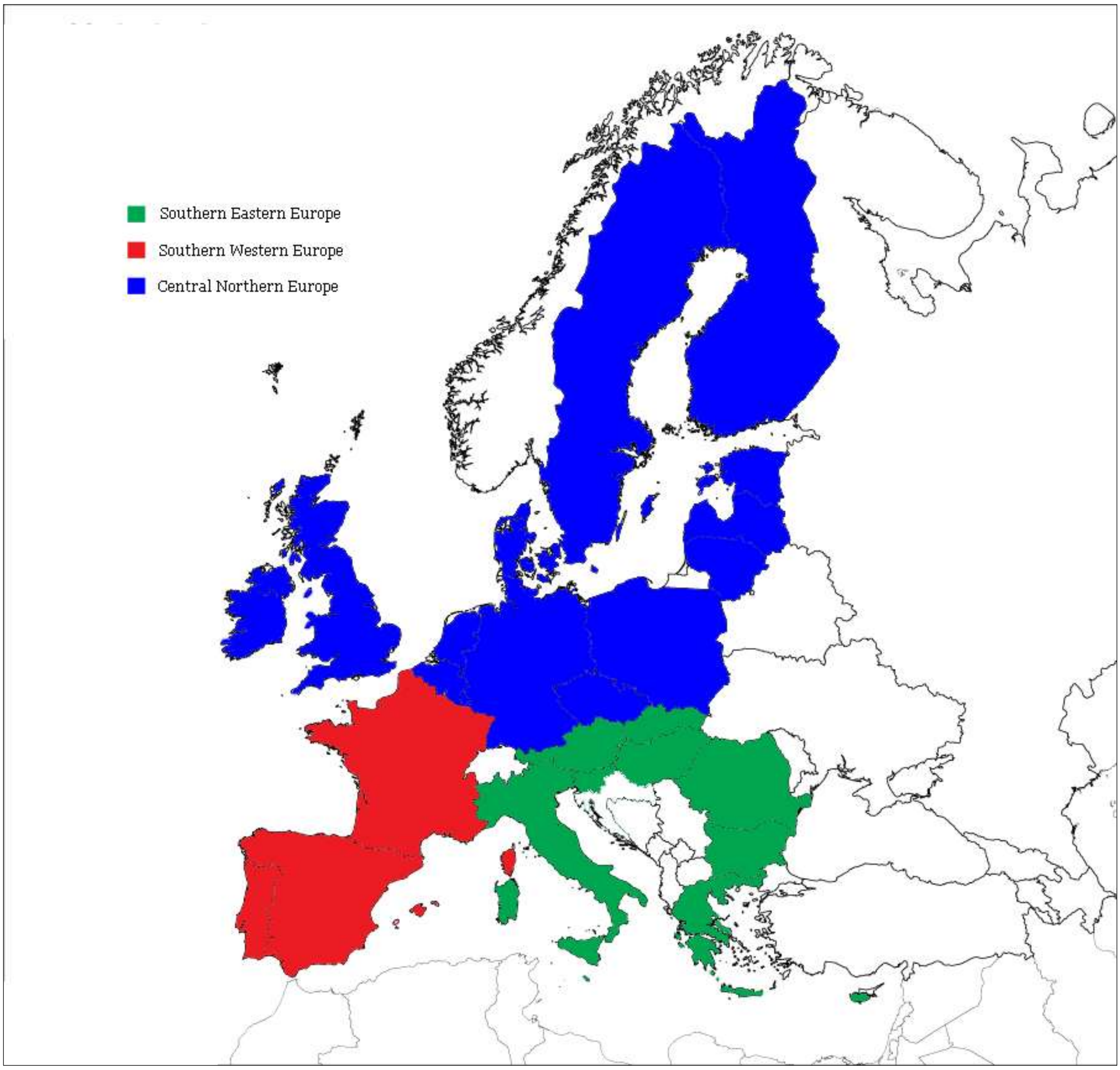
Total number received	11
Number included in the sample	9
Energy prices trends	9
Energy bill components	9
Energy intensity	9
Indirect ETS costs	9
Production costs	5

3.7.2 Data analysis and presentation

To ensure that no information can be attributed to any specific plant, the research team has applied the following geographical division for data aggregation. Notably, the research team did not receive any data from chlorine producers operating in the region defined below as Southern Eastern Europe:

a. **Southern Western Europe** (Spain, Portugal and France) is responsible for 19% of total EU chlorine production capacity and includes 3 of the sampled facilities.
b. **Central Northern Europe** (UK, Ireland, Belgium, the Netherlands, Luxembourg, Denmark, Germany, Poland, the Czech Republic, Latvia, Lithuania, Estonia, Sweden and Finland) is responsible for 70% of total EU chlorine production capacity and includes 6 of the sampled facilities.
c. **Southern Eastern Europe** (Italy, Slovenia, Austria, Hungary, Slovakia, Bulgaria, Romania, Greece, Malta and Cyprus) is responsible for 11% of total EU chlorine production capacity. The research team did not receive any questionnaires for facilities located in this region.

Figure 7. EU division in major geographical regions



Source: Own illustration.

Based on the geographical division explained above, section 3.8 presents the average energy prices paid by EU chlorine producers as well as the differences among the major EU regions. Importantly, prices represent average values of the price paid by each plant included in the sample within the region considered (Southern Western Europe, Central Northern Europe or EU-27). Each plant price has been weighted by a coefficient representing the specific year contribution of that plant to the total actual production of the region considered (Southern Western Europe, Central Northern Europe or EU-27). Section 3.9 focuses on the analysis of the energy bill components, while section 3.10 addresses the energy intensity of chlorine producers. The indirect ETS costs for chlorine producers are presented in section 3.11, while section 3.12 analyses the production costs for 5 sampled plants. Finally, section 3.13 reflects the general impressions of the participants on the current state of energy policy and markets.

3.7.3 Calculation of indirect ETS costs

The objective of the ETS cost calculations per sector in this study is to provide an estimation of the indirect ETS cost for the sub-sector between 2010 and 2012. The level of information is aggregated on a regional level, although the definition of those regions differs between cases studies.

The model for the indirect cost of EU ETS, per plant, is defined as:

Indirect costs

Indirect cost (€/Tonne of product) = Electricity intensity (kWh/Tonne of product)

** Carbon intensity of electricity (Tonne of CO_2/kWh)*

** CO_2 Price (€/Tonne of CO_2) * Pass-on rate*

Where:

- Electricity intensity of production: the amount of electricity used to produce one tonne of product. This amount is sector, plant and process specific;
- Carbon intensity of electricity generation indicates the amount of tonnes of CO2 emitted by utilities to generate one kWh;
- CO2 Price: is the average yearly market-price of CO2.
- Pass-on rate: the proportion of direct costs faced by utilities (disregarding any mitigating effects from free allocation) that they pass on to electricity consumers.

Sources:

- Electricity intensity of production; this was acquired from interviews with and questionnaires answered by industry members.

- Carbon intensity of electricity generation: the maximum regional carbon intensity of electricity is utilised, provided by the Commission's Guidelines on State aid measures[47]. Note that these figures are not national. Member States who are highly interconnected or have electricity prices with very low divergences are regarded as being part of a wider electricity market and are deemed to have the same maximum intensity of generation (for example, Spain and Portugal).

- CO2 Price: Yearly averages of the daily settlement prices for Dec Future contracts for delivery in that year. The daily settlement prices were reported by the European Energy Exchange.

Table 8. Average yearly prices per tonne of CO2 (€)

Year	2010	2011	2012
CO_2 Price	14.48	13.77	7.56

3.7.4 Validation of information

The research team has used a combination of an internal cross-sectoral comparison of energy prices reported by all participant sectors and sub-sectors[48] and a validation through EU energy statistics publications[49]. To test consistency, the research team conducted targeted interviews with chlorine producers included in the sample. No secondary sources could be retrieved on plant-specific energy costs of chlorine producers.

The validation of the production costs for the EU chlorine industry is a complex task. Chlorine is an intermediate product which companies usually use as an input for their downstream activities. As a result, it is not possible to retrieve meaningful information from companies' balance sheet data as regards this specific product line. Nonetheless, data consistency for production costs was ensured by comparing data submitted by different producers and data submitted by the same producer for different years and asking for clarification and integrations whenever inconsistency was detected.

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[47] Communication from the Commission: Guidelines on certain State aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012 (2012/C 158/04).

[48] This refers to all 5 sub-sectors included in the study i.e. the float glass sector, the wall and floor tiles/bricks and roof tiles (ceramics sector) and the two chemicals sub-sectors (ammonia and chlorine).

[49] Validation was conducted through Eurostat statistics, (http://tinyurl.com/mt2p27d), accessed: 28 October 2013.

3.8 Energy prices trends

3.8.1 Introduction

This section will present the energy prices for the chlorine industry. All sampled chlorine producers use electricity as a primary source of energy, while a number of them[50] also use steam as a secondary energy carrier; however the number of data points is too low to allow for an analysis of steam as a secondary energy carrier. At the same time, natural gas is used by only one plant in the sample. For these reasons, the analysis is limited to electricity costs. As shown in Table 9 below, electricity is responsible for the lion's share of total energy costs and also accounts for 43-45% of total production costs. Note that the energy prices presented in this section are delivered at plant excluding VAT; hence include possible exemptions[51] from taxes, levies or transmission costs but exclude any interruptibility discounts[52].

Table 9. Share of electricity in total energy costs and total production costs[53]

	Share in total energy costs, %	**Share in total production costs, %**
Electricity	91%[54]	43-45%

Source: Author's elaboration based on data from questionnaires.

3.8.2 General trends

Between 2010 and 2011 average electricity prices increased marginally from 59.4 €/MWh to 59.8 €/MWh, or +0.7% (Table 10). This trend reversed from 2011 to 2012 as electricity prices decreased by 5.7% i.e. from 59.8 €/MWh to 56.4 €/MWh. This means that for the whole period – 2010 to 2012 – electricity prices paid by sampled EU chlorine producers decreased by around 5%, i.e. from 59.4 €/MWh to 56.4 €/MWh. It should be noted that the trends in the EU average are largely driven by the trends in the prices in Central Northern Europe, as this region's weight in the sample is higher than that of Southern

[50] See section 3.10.

[51] Notably, the majority of producers mentioned that they are entitled to reductions/exemptions from network tariffs, taxes or levies.

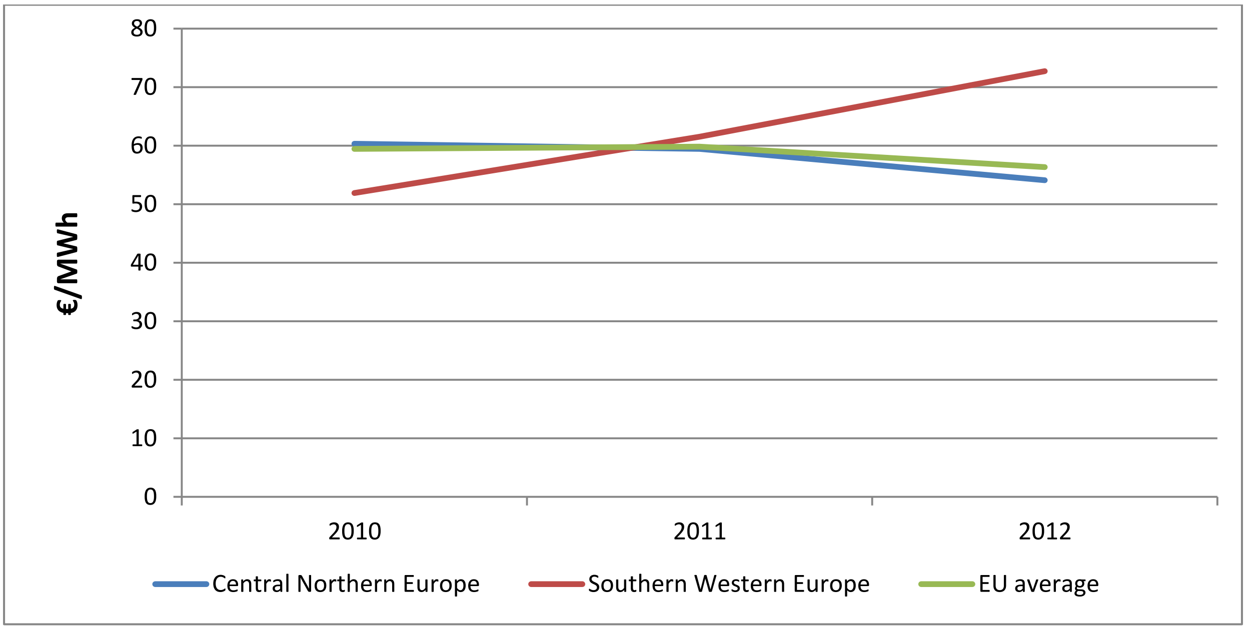
[52] This refers to various forms of remuneration provided to companies which accept cuts in their electricity supply at the request of the transmission system operator. Two participants in the study reported that they provide interruptibility services and thus in practice they face lower energy costs than the ones reported in this section.

[53] The figure on the share of electricity costs in total energy costs is an average for the full sample (nine plants) and the three-year period studied. The figures on the share of electricity costs in total production costs are averages for the five plants (see section 3.12 for more details) that provided data on production costs and thus have a lower representativeness.

[54] Ranging from 91.84% in 2010 to 91.18% in 2012.

Western Europe, thus affecting considerably the weighted average[55]. Section 3.8.3 below focuses in greater detail on the decrease in electricity prices in Central Northern Europe.

Figure 8. Electricity prices paid by EU chlorine producers, (€/MWh)



Source: Author's elaboration based on data from questionnaires.

Table 10. Descriptive statistics for electricity prices paid by sampled EU chlorine producers (€/MWh)

	2010	2011	2012
EU (average)	59.4	59.8	56.4
Southern Western Europe (average)	51.9	61.5	72.7
Central Northern Europe (average)	60.3	59.5	54.1

Source: Author's calculation based on data from questionnaires.

3.8.3 Regional differences

Central Northern Europe

For the period covered by the study – 2010 to 2012 – the average price decreased by 10.3% (from 60.3 to 54.1 €/MWh) with a decrease of about 1.3% from 2010 to 2011 and 9% during the following year. As explained in section 3.8.2, the downward trend in the EU average electricity price between 2011 and 2012 was driven by the decrease in the prices paid in Central Northern Europe. Figure 11 illustrates that in this region the share of the energy component in the total energy bill is very high and also increased from 84% in 2010

55 All presented figures are weighted averages that have been calculated on the basis of the actual annual production of the sampled plants. See also section 3.7.2.

to 89% in 2012. This should be considered in conjunction with the fact that the majority of respondents from this region reported that they buy electricity either on spot basis or on the basis of spot and future prices. Thus, an explanation that could be given for the decrease of electricity prices is that producers in this region benefited from decreasing wholesale market prices, also due to the increasing share of renewables.

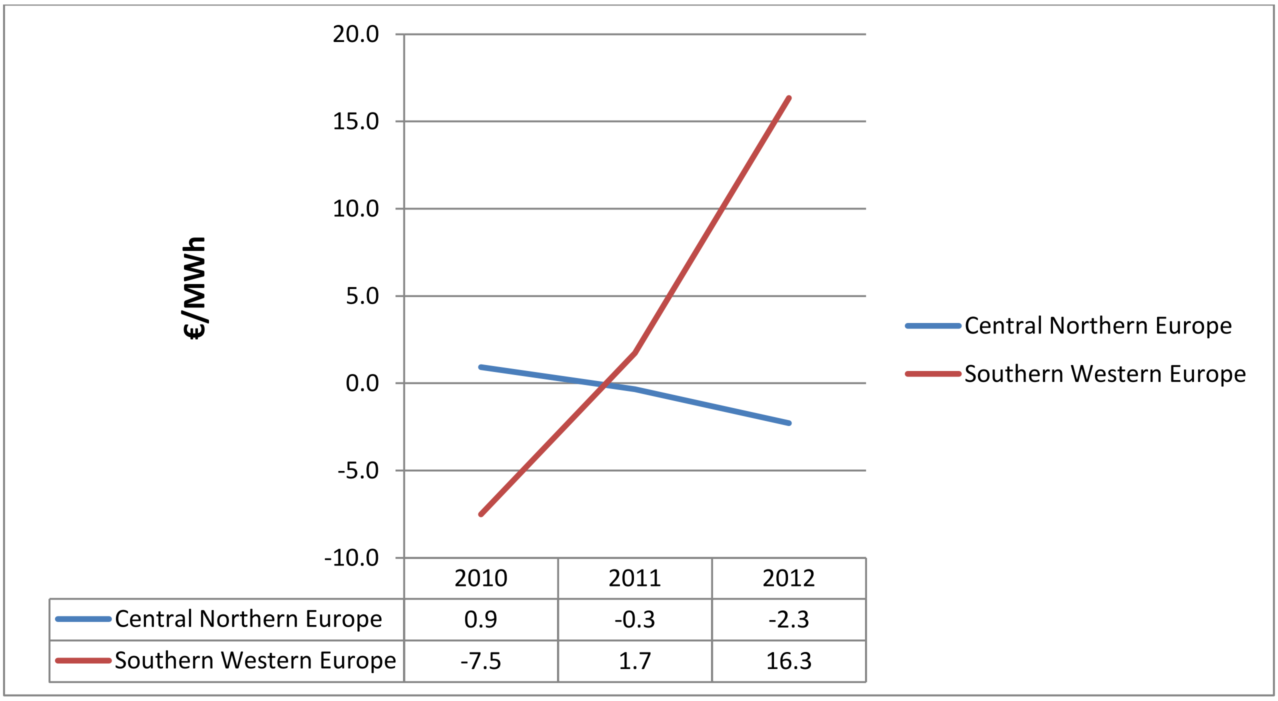
Southern Western Europe

There is a steep upward trend in the electricity prices paid by chlorine producers in Southern Western Europe. In particular, between 2010 and 2012 electricity prices rose sharply by some 40% from 51.9 €/MWh to 72.7 €/MWh. From 2010 to 2011 they increased by about 18.5% and from 2011 to 2012 by 18.2%. As a result, chlorine producers in this region faced higher electricity prices compared to producers in Central Northern Europe, except for the year 2010, when the average electricity price was lower in this region (51.9 versus 60.3 €/MWh).

Regional gaps

Figure 9 below provides a graphical presentation of the divergent trends and the gap between the EU average price and the two regional average prices. In 2010, producers in Southern Western Europe were paying on average 7.5 €/MWh less than the EU average. In just two years however, this trend reversed, as in 2012 producers were paying 16.3 €/MWh more. On the contrary, while in 2010 the average electricity price in Central Northern Europe was 0.9 €/MWh higher than the EU average, in 2012 this value reached minus 2.3 €/MWh.

Figure 9. Regional gaps of electricity price with EU average, (€/MWh)



Source: Author's elaboration based on data from questionnaires.

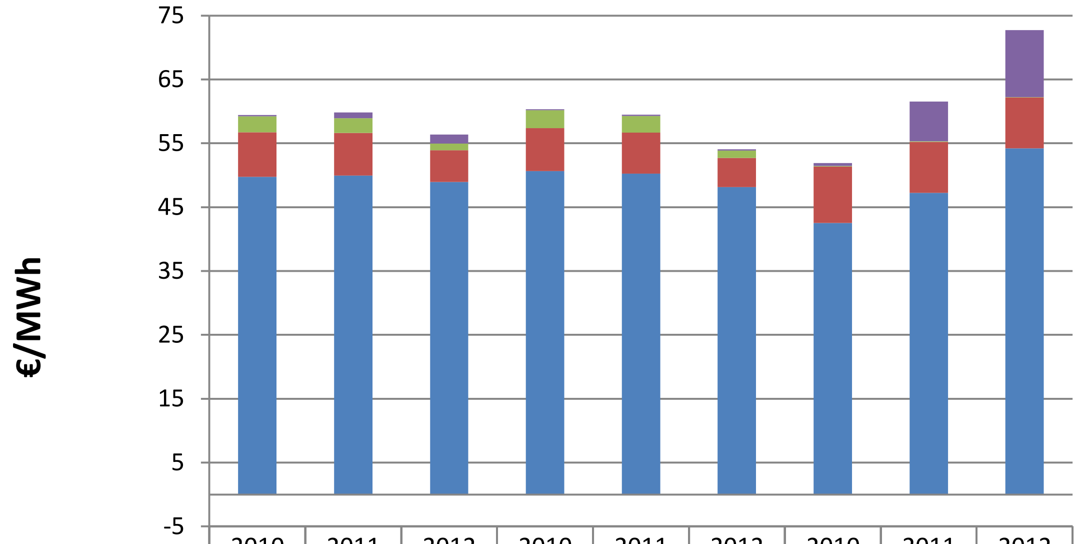
3.9 Analysis of energy bills components

3.9.1 General trends

This section illustrates the various components of the electricity bill: i) energy component, ii) grid fees, iii) RES levy and iv) other non-recoverable taxes. As shown in Figure 10, the energy component accounts for the lion's share of the electricity price, while its contribution to the total electricity bill increased from 83.7% in 2010 to 86.8% in 2012. However, in absolute terms the energy component decreased somewhat from 49.76 €/MWh in 2010 to 48.94 €/MWh in 2012 (-1.6%).

Concerning the other price components, the share of grid fees in the total electricity bill decreased from 11.7% in 2010 to 8.8% in 2012; this represents a decrease in absolute values from 6.97 €/MWh in 2010 to 4.98 €/MWh in 2012 (-28.6%). The contribution of RES levies in the total bill decreased substantially from 4.2% in 2010 to 1.8% in 2012. In absolute terms, RES levies decreased from 2.49 €/MWh in 2010 to 1.02 €/MWh in 2012 (-59%). On the contrary, the impact of other non-recoverable fees in the total bill increased from 0.3% in 2010 to 2.5% 2012. This represents an increase in absolute values between 2010 and 2012 from 0.2 to 1.41 €/MWh.

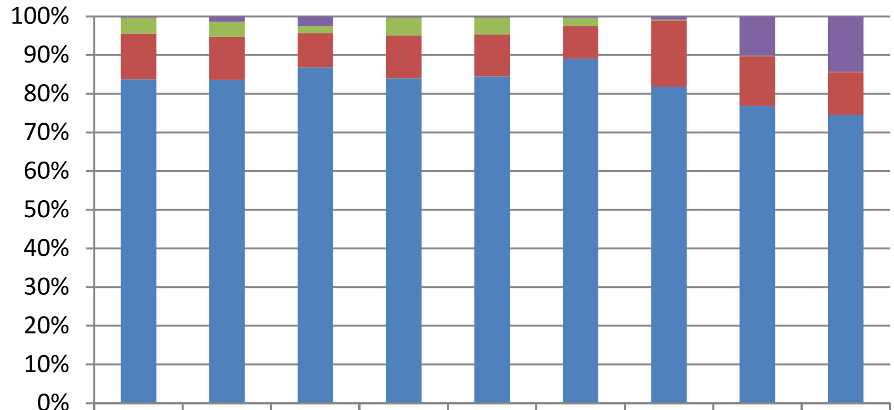
Figure 10. Components of the electricity bill paid by EU chlorine producers (€/MWh)



	EU average 2010	EU average 2011	EU average 2012	Central Northern Europe 2010	Central Northern Europe 2011	Central Northern Europe 2012	Southern Western Europe 2010	Southern Western Europe 2011	Southern Western Europe 2012
Other non-recoverable taxes	0.20	0.87	1.41	0.17	0.17	0.20	0.44	6.24	10.47
RES levy	2.49	2.34	1.02	2.81	2.63	1.15	0.12	0.10	0.07
Grid fees	6.97	6.63	4.98	6.69	6.45	4.58	8.86	7.98	7.97
Energy component	49.76	49.96	48.94	50.66	50.22	48.14	42.49	47.22	54.20

Source: Own calculation based on questionnaires.

Figure 11. Components of the electricity bill paid by EU chlorine producers (in %)



	EU average			Central Northern Europe			Southern Western Europe		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
Other non-recoverable taxes	0.3%	1.4%	2.5%	0.3%	0.3%	0.4%	0.9%	10.1%	14.4%
RES levy	4.2%	3.9%	1.8%	4.7%	4.4%	2.1%	0.2%	0.2%	0.1%
Grid fees	11.7%	11.1%	8.8%	11.1%	10.8%	8.5%	17.1%	13.0%	11.0%
Energy component	83.7%	83.5%	86.8%	84.0%	84.4%	89.0%	81.9%	76.7%	74.5%

Source: Own calculation based on questionnaires.

3.9.2 Regional differences

Southern Western Europe

Although in absolute terms the energy component increased significantly[56] between 2010 and 2012, its contribution to the total electricity bill decreased from 81.9% to 74.5%. The contribution of grid fees also decreased[57] from 17.1% in 2010 to 11% in 2012. At the same time, the impact of non-recoverable taxes on the bill rose from 0.9% in 2010 to 14.4% in 2012; this represents an increase in absolute values from 0.44 €/MWh in 2010 to 10.47 €/MWh in 2012 (+2279%). RES levies in this region have a very small share in the total energy bill, which decreased from 0.2% in 2010 to 0.1% in 2012.

Central Northern Europe

In Central Northern Europe, the energy component has an even higher impact on the total electricity prices than in Southern Western Europe. In 2010, its share in the total bill accounted for 84%, while in 2012 it increased to 89%. However, the absolute value of the energy component decreased from 50.66 €/MWh to 48.14 €/MWh (-5%). In 2010, the contribution of RES levies to the total electricity bill was 4.7%; however, in 2012 this figure decreased to 2.1%. Compared to Southern Western Europe, the impact of other non-recoverable taxes in this region is almost marginal, and increased from 0.3% in 2010 to 0.4% in 2012.

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56 Specifically, its absolute value increased from 42.49 €/MWh in 2010 to 54.2 €/MWh in 2012.

57 In absolute terms, grid fees deceased from 8.86 €/MWh in 2010 to 7.97 €/MWh in 2012.

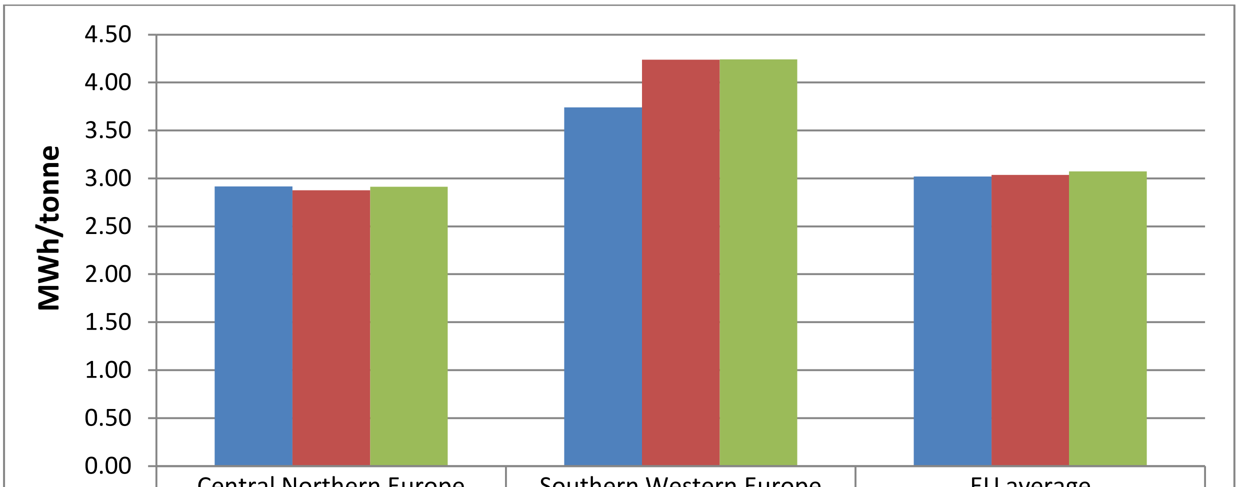
3.10 Energy intensity

This section assesses the energy intensity of sampled chlorine plants in terms of physical output (unit: MWh/tonne). It focuses on electricity, which dominates the energy consumption of the sampled producers. Specifically, the average share of electricity consumption in total energy consumption was about 87%[58] during all three years considered in the study. The figures presented below are based on the electricity consumption data and chlorine production levels provided by all 9 sampled chlorine producers.

3.10.1 General trends

Figure 12 below presents the energy intensity per tonne of chlorine product of the sampled EU chlorine plants. Augmenting from 3.02 MWh/tonne in 2010 to 3.07 MWh/tonne in 2012, the average intensity of EU electricity consumption has increased by 1.7%. This increase has been mainly driven by the increase in Southern Western Europe, as in Central Northern Europe the electricity intensity has remained rather stable (see next section 3.10.2). It should be noted that 4 out of 9 interviewees reported that they have made energy efficiency investments in recent years[59], primarily triggered by energy cost savings considerations but also by public policy[60].

Figure 12. Electricity intensity of EU chlorine producers (MWh/tonne)



	Central Northern Europe	Southern Western Europe	EU average
2010	2.92	3.74	3.02
2011	2.88	4.24	3.04
2012	2.91	4.24	3.07

Source: Author's elaboration based on data from questionnaire.

[58] This figure represents an average for 8 out of 9 plants, as one participant could not provide full energy consumption data for other energy sources apart from electricity. Notably, 5 out of 9 producers also used steam/hot water and one natural gas.

[59] This refers to the three-year period addressed by the study or earlier.

[60] It is noteworthy that another participant reported that large-scale energy efficiency investments are not made on a very regular basis and are mainly driven by public policy, while a further one mentioned that energy efficiency investments are generally triggered by both cost savings and public policy.

3.10.2 Regional differences

Southern Western Europe

Southern Western Europe exhibits a higher average electricity intensity (or lower energy efficiency) compared to Central Northern Europe during the three-year period covered by this study. The average electricity intensity increased from 3.74 MWh/tonne in 2010 to 4.24 MWh/tonne (+13.4%) in 2011 and remained stable between 2011 and 2012.

Central Northern Europe

In contrast, in Central Northern Europe the average electricity intensity remained rather stable during the analysed period; it decreased by approximately 1.4% between 2010 and 2011 and then increased by around 1% between 2011 and 2012. In 2010 it was 2.92 MWh/tonne and in 2012 2.91 MWh/tonne.

3.11 Indirect ETS costs

3.11.1 Results

The calculation of indirect ETS costs for the chlorine industry was based on the electricity consumption and total production figures provided by the sampled EU chlorine producers as well as on the maximum regional CO_2 emission factors of electricity generation and price of emission allowances (see also 3.7.3). Tables 11, 12 and 13 summarise the indirect costs borne by EU chlorine producers, using different pass-on rates.

Table 11. Chlorine indirect costs, averages per region (Euro/tonne of chlorine)

	Central Northern Europe	Southern Western Europe	EU average
2010	19.27	24.71	21.08
2011	18.02	26.18	20.74
2012	10.07	15.98	12.04

Pass-on rate: 0.6

Table 12. Chlorine indirect costs, averages per region (Euro/tonne of chlorine)

	Central Northern Europe	Southern Western Europe	EU average
2010	25.69	32.95	28.11
2011	24.02	34.91	27.65
2012	13.42	21.30	16.05

Pass-on rate: 0.8

Table 13. Chlorine indirect costs, averages per region (Euro/tonne of chlorine)

	Central Northern Europe	Southern Western Europe	EU average
2010	32.11	41.19	35.14
2011	30.03	43.64	34.56
2012	16.78	26.63	20.06

Pass-on rate: 1

None of the plants included in the sample rely on long-term contracts or self-generation to cover their electricity consumption. They all acquired electricity through wholesale markets or short-term contracts with one supplier.

The drop in indirect-ETS costs across all regions between 2011 and 2012 can be largely attributed to a sharp decrease in EUA prices (from a yearly average of 13.77 Euros per EUA in 2011 to a yearly average of 7.56 Euros per EUA in 2012).

There are large inter-regional differences in indirect costs. Indirect costs are significantly higher in the Southern Western European region when compared with the Central Northern European region. There are two specific differences between these two regions that influence the inter-regional differences:

- the maximum regional CO_2 emissions factor[61], which is lowest in Southern Western Europe (around 0.60 tonnes of CO2 per MWh) and highest in Central Northern Europe (around 0.75 tonnes of CO2 per MWh) and
- differences in electricity intensities between plants. Chlorine plants in Southern Western Europe consume on average circa 4.7 MWh/tonne of chlorine, compared with circa 3 in Central Northern Europe.

3.11.2 Key findings

4) The inter-regional differences are relatively large.

5) Indirect ETS costs in Southern Western Europe are far higher than in the Central Northern European region, caused largely by the significantly higher electricity intensity of production in Southern Western Europe.

6) Although the average CO2 intensity of electricity generation is higher in Central Northern Europe, a lower average of electricity intensity of production results in lower indirect costs compared to Southern Western Europe.

7) Electricity intensity of production differs significantly between plants within the same region.

[61] As defined and listed in Annex IV of the 'Guidelines on certain State aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012' (2012/C 158/04).

8) The ETS indirect cost was significantly lower in 2012 compared to the previous years, mainly because the price of EUAs was significantly lower in 2012.

3.12 Production costs

This section presents an analysis of the production costs for EU producers of chlorine. Due to the intermediate nature of the good, it is not possible to retrieve meaningful data from publicly available sources – including companies' balance sheets. Therefore, to estimate production costs of chlorine it is necessary to rely on information provided directly by companies that can extract relevant data from their analytical accounting. The research team ensured the consistency of those cost figures by comparing data submitted by different producers and data submitted by the same producer for different years and asking for clarification and integrations whenever inconsistency was detected.

As explained in section 3.7.1, a questionnaire to collect data on production costs was sent to all the companies included in the sample. Data over the period 2010-2012 were provided by only five out of nine plants. Thus, due to the lower response rate, the representativeness of the following figures is lower than of the figures presented in the other sections of this report. Furthermore, one of these plants did not provide figures for 2010.

All figures are expressed in Euro per tonne of product at current prices. For the responding plants, the following elements are estimated for the years 2010, 2011, and 2012:

- Total production costs, whose estimate has been provided by companies and includes all production costs, *i.e.* cost of finished chlorine, other operating expenses, depreciation, amortization, and financial expenses referred to the product line;

- Electricity costs, provided by companies in terms of €/MWh and converted into €/tonne using the corresponding energy intensities of the production process.

The figures reported in Table 14 are weighted averages for the respondent plants, based on individual plant production for each year.

Table 14. Production costs of EU chlorine producers

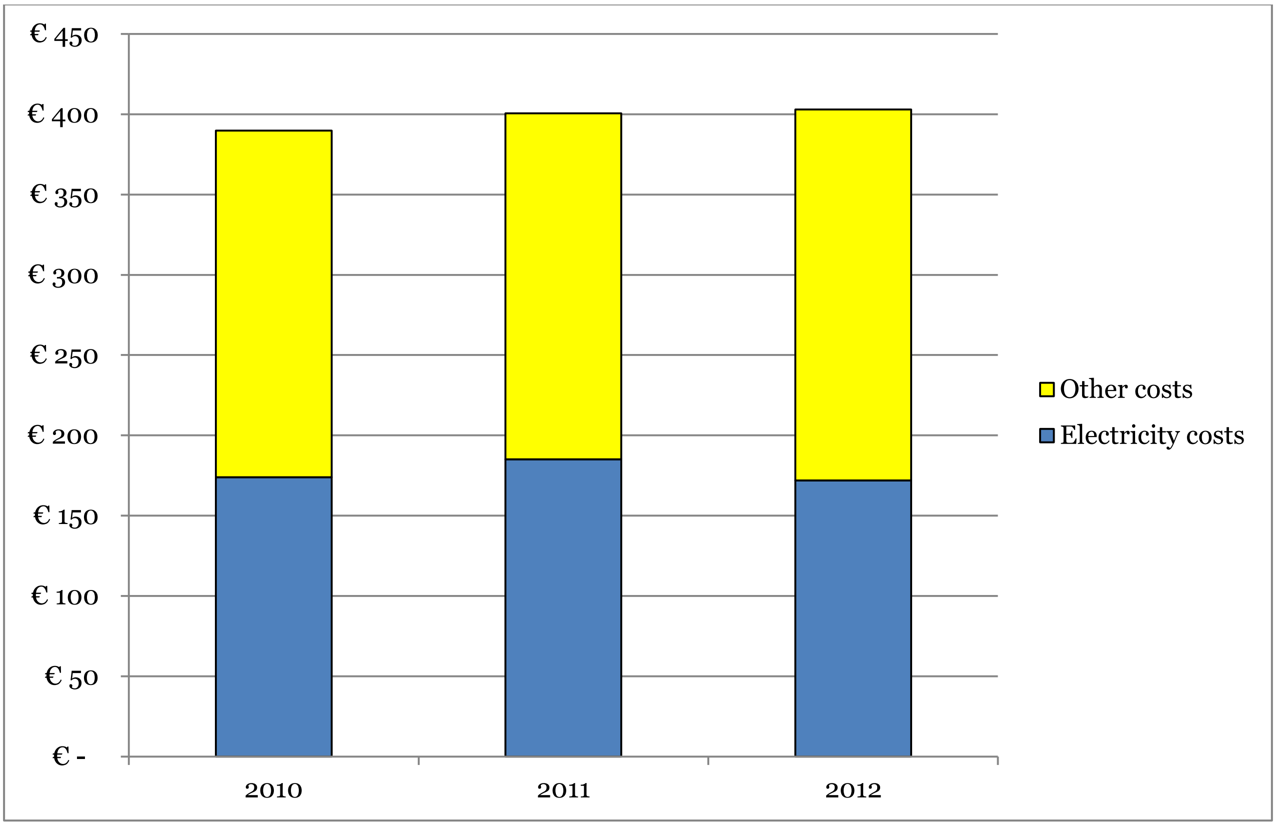
	2010	2011	2012
Number of plants	4	5	5
Total production costs (€/tonne)	€ 389.70	€ 400.51	€ 402.92
Electricity costs (€/tonne)	€ 173.96	€ 185.17	€ 171.94

Source: Authors' elaboration on companies' data.

Total production costs experienced a slight and constant increase over the period 2010-2012 (+3%; +13 €/tonne). As for electricity costs, the growth registered between 2010 and

2011 (+6%) was followed by a comparable decrease between 2011 and 2012 (-7%), thus leading to an overall cost reduction over the observation period (-1%). All in all, electricity costs represent a significant share of total production costs, going from about 45% in 2010 to some 43% in 2012 (see Figure 13).

Figure 13. Total production costs of EU chlorine producers (€/tonne)



Source: Authors' elaboration on companies' data.

3.13 General impressions

The research team used the questionnaires to (*inter alia*) ask EU chlorine producers about their impressions of the effects of liberalisation. The respondents had divergent views on the impact of liberalisation on the energy markets. Some argued that liberalised markets have contributed to lower energy prices, while others claimed that liberalisation has resulted in higher prices. Two participants also mentioned that an integrated EU market would have a positive impact on energy prices.

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CHAPTER 4.
THE CASE OF THE FLAT GLASS INDUSTRY

ANDREI MARCU, SUSANNA ROTH AND WIJNAND STOEFS

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4. THE CASE OF THE FLAT GLASS INDUSTRY

ANDREI MARCU, SUSANNA ROTH AND WIJNAND STOEFS

4.1 Flat glass description and production

4.1.1 Flat glass description and uses

There are four main sub-sectors within the glass sector: container, flat, fibre (mineral wool, textile and optical) and specialty glass. The term 'flat glass' includes all glass produced in flat form, regardless of the type of manufacturing process involved. Flat glass is the second largest glass sub-sector in the EU, after container glass.

There are two types of flat glass production processes in the EU: float glass and rolled glass. Float glass dominates the sector's output (around 95% of total production in Europe). The end-products in the float process, float glass, are large 'jumbo' sheets of glass (typically 6 per 3.1 m, or in sizes specific to customer orders)[62]. The float process is a standardised production process used by all European float glass manufactures. The end-product, float glass, is therefore a rather homogenous product with low variation.

Float glass is often further processed to give the glass certain qualities and characteristics. Table 1 describes both basic float glass; that is, the direct result of the float process, as well as different types of processed float glass (from downstream processes).

Rolled glass is not produced with the float process and is mainly patterned or wired glass. Rolled glass accounts for around 3.5% of total sector output, but its share is diminishing (GLS-BREF, 2013). Patterned glass is used for horticultural greenhouses, for decorative purposes, in applications where light is dispersed, and for photovoltaic panels. Rolled glass and float glass are produced in different installations and do not use the same processes or tools, for instance, rolled glass installations have smaller furnaces than float glass.

The most important markets for float glass are the building and automotive sectors. The building sector accounts for around 80-85% of the output and the majority of the

[62] Float glass and flat glass are often used as synonyms in the literature, and also throughout this study. However, float glass is defined as flat glass produced with the float process. Hence, the term float glass refers both to a type of glass and to the process by which it is made. The term flat glass refers to flat glass regardless of the technology used to produce it (i.e. it could be produced with the float glass process or rolled glass process).

remaining output (15-20%) goes into the automotive industry, including buses and coaches, trucks and off-road mobile machinery.

Table 1. Main types of flat glass

Glass type	Description
Annealed glass	Annealed glass is the first result of the float process. Annealed glass is used in some end-products, often in double-glazed windows, but mostly as the starting material for more advanced products.
Toughened glass	Toughened glass is a type of safety glass that is more resistant to breakage than annealed glass. It breaks in more regular, square fragments than annealed glass and is made from annealed glass with a thermal tempering process. Toughened glass is produced through heating annealed glass to 600°C and then rapidly cooling the surface. The inside remains hot, which creates compressive stresses in the surface due to different physical properties. Toughened glass is used in buildings (e.g. facades, sliding doors); cars (windshields) and other applications (e.g. interior design and furniture).
Laminated glass	Laminated glass is a type of safety glass made of different layers of glass with one or more interlayer(s) of polymeric material between the layers. In the event of breakage, the glass is partly held together by the interlayer, which reduces the risk of shattered glass. The interlayer also allows for colouring, sound dampening, ultraviolet filtering and other technologies. Laminated glass can either be produced with a thin layer of PVB (Poly Vinyl Butyral) using heat and pressure or with Cast In Place, where a resin is poured into the space between two sheets. Laminated glass is often used in building facades and in the automotive industry.
Coated	Coatings are applied to glass to give it characteristics such as special reflections, scratch and corrosion resistance. The exposure of the glass surface to vapours forms a permanent coating. Coating can either be applied when the glass is still in the float process – so-called hard-coated glass, or as a vacuum-coating process where the vapour is applied onto the cold glass surface in a vacuum.
Mirrored glass	Mirrored glass is produced through applying a metal coating on one side of the glass. As well as for mirrors, mirrored glass is being used increasingly in the building sector.
Patterned	Patterned glass can be produced using different methods, the most common of which is to pass the heated glass between rollers with surfaces of the pattern, once it comes out of the furnace. It is mostly used for decoration and internal architecture.
Extra clear glass	Extra clear glass differs from other types of glass by its raw material mix and is not the result of processed annealed glass. It is made with a very low iron content to minimise sun reflection and is used for solar energy purposes, in particular.

Source: Glass for Europe, 2013a.

The market for solar applications is growing and now accounts for around 5% of flat glass volume in Europe. Flat glass is an integral component of many solar energy technologies such as thermal collectors, photovoltaics and concentrated solar power systems. Extra clear glass, float or patterned, is especially designed to be used in solar applications (see Table 1). Some projections state that solar energy glass could represent over 10% of flat glass volume in a couple of years (Glass for Europe, 2013b).

Flat glass is also used in smaller applications for interior fittings and decoration, greenhouses and for industrial appliances and electronics.

4.1.2 The float glass production process

This section will describe raw materials for the float process, energy use in the float process and conclude with an illustration of the process itself.

4.1.2.1 Raw materials

There are different types of glass, for instance soda-lime glass, lead glass and borosilicate glass. Float glass is primarily soda-lime glass (Schmitz et al, 2011). The materials that go into soda-lime glass consist of sand (69-74%), soda ash (10-16%) and lime 5-14% (Ecorys, 2008). In general, there is less variation in the raw material composition in the float glass sub-sector than in other glass sub-sectors, but some differences do exist. A typical soda-lime silica flat glass composition is described in Table 2.

Table 2. Composition of typical soda-lime silica flat glass

Component	Mass percentage
Sand, Silicon dioxide (SiO_2)	72.6
Soda ash, Sodium dioxide (Na_2O)	13.6
Lime, Calcium oxide (CaO)	8.6
Magnesium oxide (MgO)	4.1
Aluminium oxide (Al_2O_3)	0.7
Potassium oxide (K_2O)	0.3
Sulphur trioxide (SO_3)	0.17
Minor materials (colour modifiers and incidental impurities from raw materials)	Traces

Source: GLS-BREF, (2013).

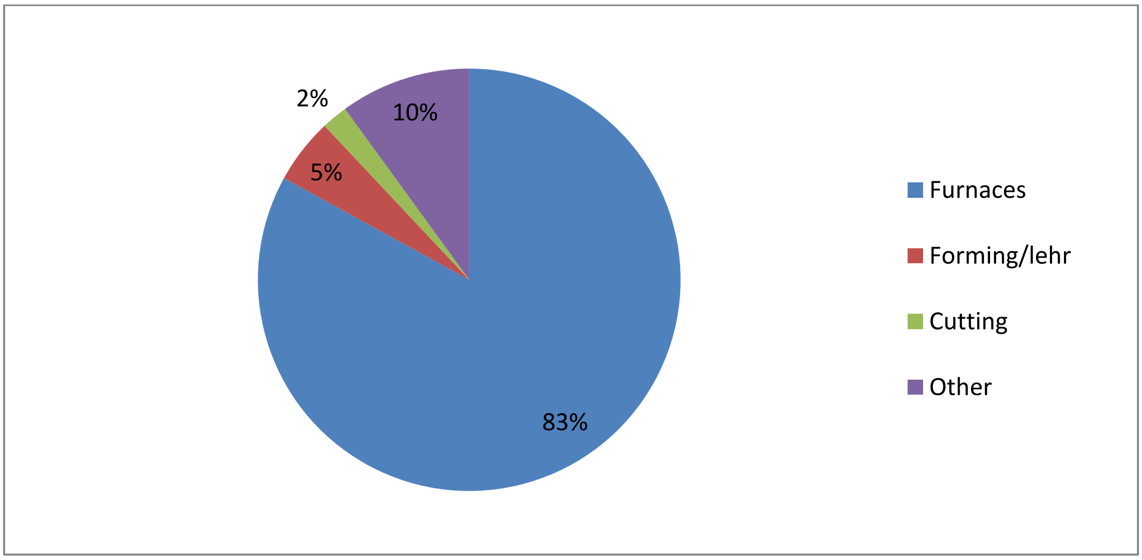
Cullet glass, i.e. recycled glass, is also used in the production process. When cullet glass is mixed with raw materials, CO_2 emissions are reduced, both because of reduced process emissions (due to lower use of raw materials), and from less energy consumption in the melting process (Ecofys, 2009). Increasing the use of cullet by 10% in the melting mass decreases energy consumption by about 2-3% (IEA, 2007). In almost all cases, float glass plants recycle internal cullet directly to the furnace.

The amount of cullet is limited by the availability of cullet of the right quality and right chemical compatibility. For this reason, external cullet is not extensively used in the float process, since the manufacturing process is highly sensitive to even low levels of contamination, with problems involving colour variation, bubbles and ream knots, among others (Glass for Europe, 2010). For different installations, it is unclear what the percentage of cullet used is. An average estimate is that it is usually around 20%, but it can vary from 10 to 40% (GLS-BREF, 2013).

4.1.2.2 Energy Use

Natural gas is the predominant fuel for glass production, followed by oil products63. Both fuels are interchangeable in the melting process. Over three-quarters of the energy used in the float sector come from furnace activities (i.e. melting the glass), as shown in Figure 1. Forming and annealing takes 5% of total energy and cutting 2%. The remaining energy is used for service, control systems, lighting, factory heating and other activities, such as inspection and packaging.

Figure 1. Energy use distribution in the float process



Source: GLS-BREF, (2013).

To date, there is no technology available to operate large-scale float furnaces using only electricity. The best performing installations are powered by a mix of fossil fuel and electric boosting. Electric boosting is common to increase the melting capacity of the furnaces, if it is needed. Electric boosting is, in general, installed for supplying 2-20% of total energy input. The percentage of energy provided by electricity is, however, very limited in float glass furnaces (<5%), due to high electricity costs, according to Schmitz et al (2011).

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[63] There is one experimental oxy-fuel fired furnace in France for the production of float glass that started at the end of 2008. Oxy-fuel furnaces generally have better energy efficiency. Potential drawbacks are high costs for specialist refractory design and the cost of oxygen related to the price of electricity (GLS-BREF, 2013).

The variation in energy consumption, compared with other glass sub-sectors, is relatively narrow in the float glass sector, due to low variations in the type of furnace used (GLS-BREF, 2013). However, energy use varies for different plants, for instance with the age of the installation, its size, the proportion of cullet used and the technology of the furnace. A furnace with a capacity of more than 800 tonnes/day of melted glass requires around 10-12% less energy than a furnace with the capacity of 500 tonnes/day. Moreover, older furnaces lead to increased energy consumption that is equivalent to 1-1.3% per year (GLS-BREF, 2013).

The average energy intensity in the flat glass sector is difficult to assess and varies according to installation size, technology used and the proportion of cullet used. Energy intensities can either be calculated as energy per production of basic float glass or energy use per saleable output. The saleable output has been processed further than the basic float glass and therefore demands more energy. This study focuses on energy intensities for basic float glass, but some studies that looked at energy intensities for saleable output are also presented below.

Schmitz et al (2011) assessed the energy consumption and CO2 emissions of European flat glass industries and arrived at an average energy intensity of around 9.2 GJ/tonne of saleable output. The corresponding figure in the US is around 10.7 GJ/tonne of output. These data, however, are for the year 2002 (Worell et al, 2008). Energy consumption in the EU deviates somewhat among Member States (see Table 3). In the study by Schmitz et al (2011), Italy had the highest energy intensity and Germany the lowest.

Table 3. Fuel consumption for flat glass in 2007, GJ/t Volumes refer to tonnes of saleable product

Region/Member State	Fuel Consumption
EU-25	9.2 ± 15%
France	9.4 ± 11%
Germany	8.5 ± 16%
Italy	9.7 ± 11%
Spain	8.6 ± 16%
UK	Not available
Poland	8.8 ± 11%

Source: Schmitz et al, (2011).

Another assessment by Beerkens et al. (2004) reports the energy intensity for basic float glass as being 5.3 – 8.3 GJ/t per production, depending on the size and technology of the furnace, and the proportion of cullet used. GLS-BREF (2013) reports the average value of 7.5 GJ/tonne of production within the EU-27.

From 1960 to 1995, energy consumption in the EU flat glass sector was reduced by about 60%, associated with a corresponding reduction of CO2 emissions. The glass sector believes it is possible to reduce CO2 emissions by 5-10% per output unit by 2030 (Glass for Europe, 2013c). Beyond this, further reductions will require major technological breakthroughs in thermo-dynamics, raw material use and/or carbon capture and storage. Decarbonisation of the flat glass sector is expected to follow a slow path in the next 20 to 30 years as technologies and infrastructure are put in place and rolled out to installations (Glass for Europe, 2013c).

4.1.2.3 CO_2 Emissions

Around 75% of the CO2 emissions from the float glass process originate from the fossil fuel used to fire the furnaces, while around 25% originate from process emissions. The latter source of CO2 is not a function of efficiency but of the chemical process and therefore some emissions will always remain, unless new processes are developed. Nevertheless, the use of recycled glass (meaning fewer raw materials) is being increased, leading to a reduction in process emissions.

There are also indirect emissions from electricity use (electricity boosting in the melting process and downstream activities). The overall indirect emissions in the flat glass sector accounted, according to Schmitz et al (2011), for around 16% of overall CO2 emissions for the saleable product.

4.1.2.4 The float glass process

About 90% of the world's flat glass is produced by the float glass process. In the EU, the figure is 95%. The float glass process, invented by Sir Alastair Pilkington in 1959, consists of molten glass flowing in a controlled way onto a bath of molten tin.

Before the invention of the float glass process, there were two main types of un-patterned glass: sheet glass and plate glass. The most common method of producing glass was the Pittsburgh process whereby glass was drawn vertically from a tank. Plate glass was the highest quality glass available, prior to float glass.

When it comes to economy, product range, low waste and quality, the advantages of the float process are leading to the gradual replacement of sheet glass and plate glass (GLS-BREF, 2013) by float glass. Diminishing amounts of sheet glass and plate glass are still being produced in some parts of the world, but not within the EU.

Figure 2 shows the float glass process. The float glass process can be divided into five steps: mixing raw materials in the batch plant, melting the raw material in furnace, tin bath, annealing lehr and cutting the glass.

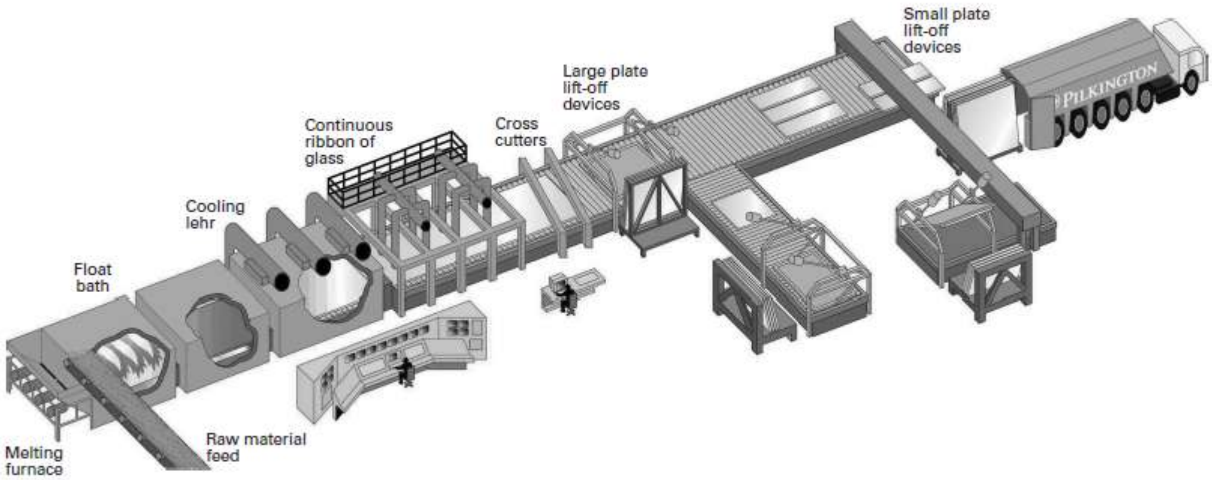
i. *Mixing raw materials in the batch plant*

Raw materials such as sand, limestone, soda ash, dolomite (a carbonate mineral composed of calcium magnesium carbonate), iron oxide and salt cake are mixed together with cullet in the batch plant.

ii. Melting of raw material in furnace

The raw materials are charged into a large furnace and melted at around 1600°C to form molten glass.

Figure 2. The Float glass process



Source: Pilkington, (2009).

i. Tin bath

The molten glass flows from the furnace along a canal, heated to maintain the correct glass temperature. At the end of the canal the molten glass is fed onto the surface of an enclosed bath of molten tin at 1100°C, through a refractory lip that ensures the correct spreading of the glass. When the glass passes over the bath, it develops a uniform thickness and flatness. Inside the float tank are rollers that are adjustable in direction, penetration and angle. The rate of glass flow and the rotation speed of the rollers help to govern the thickness of the glass. Today, the float glass process can make glass as thin as 0.4 mm and as thick as 25 mm.

ii. Annealing lehr

At the exit of the float bath, the glass ribbon is taken out by lift-out rollers and passed through a temperature-controlled tunnel, the lehr, to be annealed. During this stage, internal stresses are released to ensure perfect flatness. The glass is gradually cooled from 600°C to 60°C. This operation takes time and space. From the pouring of the glass onto the float bath and to the cutting line, there is a continuous 200 m ribbon of glass.

iii. Cutting the glass

When the glass has cooled, it goes into the cutting area. The glass is cut to 'jumbo size' (6 per 3.1 m) or in sizes specific to customers' orders. The edges of the ribbon are cut off and recycled to the furnace as cullet. The sheets are then packed and stored, either for direct sale or for secondary processing.

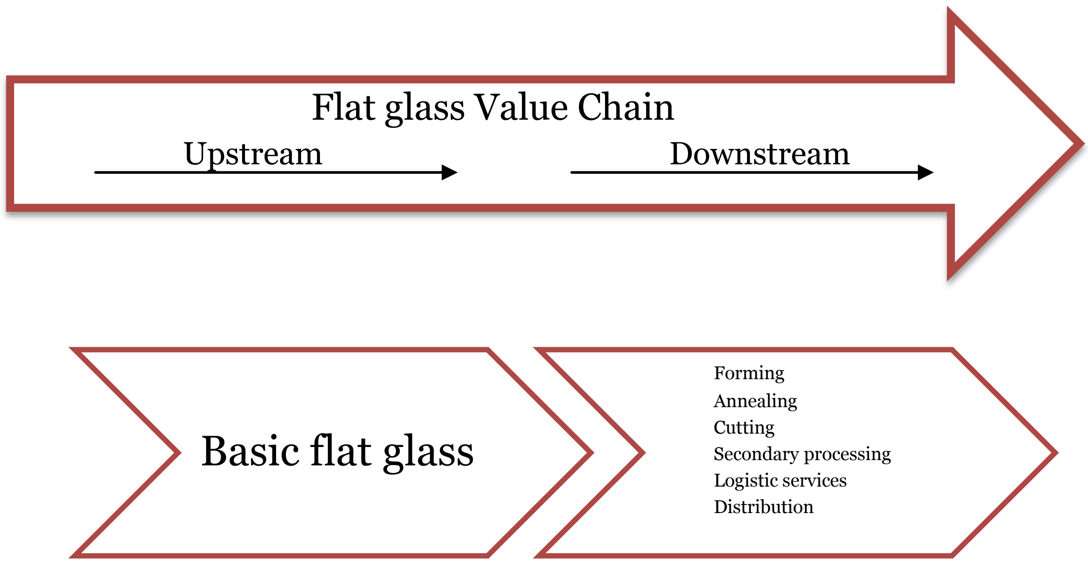
Diversification in glass composition and thickness can reduce nominal output. Production is lost when float production changes from one specification to another. For most complex changes, this can amount to as much as seven days of lost production.

4.1.3 The industry value chain

The float glass sector value chain includes all the processes required to transform raw material into finished processed flat glass. We consider that the process of producing flat glass can be divided into an upstream and downstream process.

The upstream process includes producing basic float glass, as described above in steps 1-5 of the float glass process. Downstream activities describe all activities following this, for example further cutting, forming, annealing and secondary processing (such as coating, insulating and laminating). Downstream processes are generally located close to the actual floating process. Customers are to a large degree processing companies and can either be the same companies producing the float glass or other companies specialised in secondary processing.

Almost all direct CO2 emissions come from the upstream process. As a result, downstream processes are not included in the EU ETS.



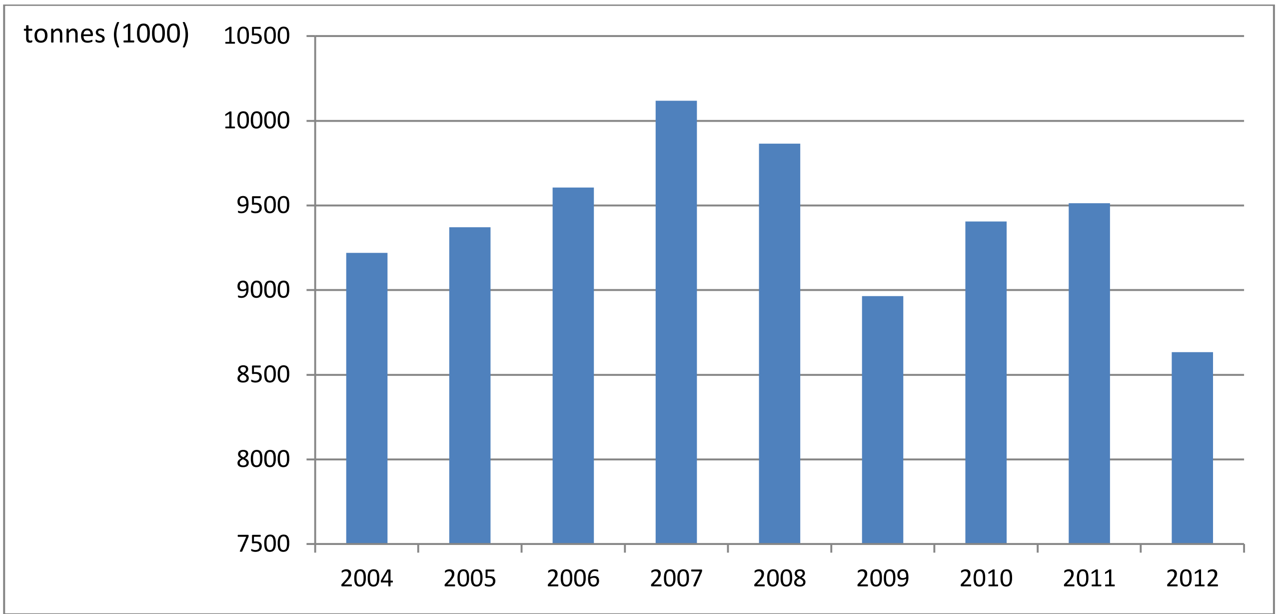
Note: Secondary processing includes e.g. coating, insulating glass, laminated glass and vacuum glass production.

4.2 The European flat glass market

4.2.1 EU flat glass production and players

Flat glass production in the EU peaked in 2007 with around 10 million tons of annual production. At that time 58 float tanks were operating in the EU. Recently, however, several float plants have been closed because of the economic crisis in Europe. In 2012, total production of flat glass was around 8.6 million tons (Figure 3). Demand for flat glass is sensitive to economic cycles and highly dependent on the building and automotive industries.

Figure 3. EU-27 Flat glass production (only for member companies of Glass Alliance Europe), in thousand tonnes



Source: Authors elaboration on data from Glass Alliance Europe (2013).

At the last count, the number of float tanks in the EU is 46 operating tanks[64]. Seven companies have running float installations in the EU today and four major groups dominate the European market: Saint Gobain, AGC, NSG Group (Pilkington) and Guardian (Table 4). Together, these four operate almost 90% of the European float tanks. All four companies are members of the European flat glass Association, Glass for Europe (henceforth the Association), together with Sisecam[65].

64 Personal communication with Mr. Bertrand Cazes, CEO at Glass for Europe, based on publicly available information, to the best of Glass for Europe's knowledge, referring to the situation in 2013.

65 Guardian is not a full member but works in association with Glass for Europe.

Table 4. Float glass companies and number of tanks in EU, 2013

Company	**Country1**	**Nr. of float tanks**
Saint Gobain	France	12
AGC	Japan	11
NSG Group	Japan	9
Guardian	US	8
Euroglass	New Zealand	4
Sisecam	Turkey	1
Sangalli	Italy	1
Total		46

[1] The country in which the parent company is located.
Source: Glass for Europe[66].

The production of float glass is spread over 12 EU member states. The Member State with the most float tanks is Germany (10 float lines), followed by Italy (6 float lines), Spain (5 float lines), France (5 float lines) and Poland (5 float lines). Belgium and the UK both have 4 float lines each, and the Czech Republic and Luxembourg have 2 operating float lines each. In Bulgaria, Hungary and Romania there is currently one running float plant. Table 5 depicts the geographical distribution of float tanks in the EU-27 in 2013 and provides figures on total capacity for 2011.

Table 5. EU number of plants per country, 2013 and total capacity per country, 2011

Country	Nr. of float lines, 2013*	Total capacity, 2011 (metric tonnes per day)**
Germany	10	6 400
Italy	6	4 000
Spain	5	3 000
France	5	3 600
Poland	5	2 850
Belgium	4	2 400
UK	4	3 050
Czech Republic	2	1 600
Luxembourg	2	1 100
Bulgaria	1	650
Hungary	1	500
Romania	1	600
Finland	0	250
Netherlands	0	550
Portugal	0	550
Sweden	0	700
Total	46	31 570

Source: *Glass for Europe67, **World flat glass, Freedonia (2013).

[66] Personal communication with Mr. Bertrand Cazes, CEO at Glass for Europe, based on publicly available information, to the best of Glass for Europe's knowledge, referring to the situation in 2013.

The geographical spread of the float installations is described in Figure 4. Clusters of plants can be observed in Western Europe (mainly the Be-Ne-Lux countries, UK, northern France and West Germany) as well as in Eastern Europe and Southern Europe.

Figure 4. Location of float installations in Europe

Note: Red stars represent plants that recently closed; yellow are float lines still running.
Source: Glass for Europe (2013d).

The capacity of float plants in the EU lies at around 500 tonnes/day, but deviations exist, and capacity can be as great as 1100 tonnes/day. Table 6 illustrates the percentage of float capacity in the EU-27 within different capacity ranges, in 2007. Almost half of the float tanks have a capacity of between 550-700 tonnes/day and around a third of the plants have a capacity of between 400-550 tonnes/day. In general, the plants that recently closed in the EU are, however, smaller plants,

[67] Personal communication with Mr. Bertrand Cazes, CEO at Glass for Europe, based on publicly available information, to the best of Glass for Europe's knowledge, referring to the situation in 2013.

meaning that a larger proportion of running plants is probably found within the higher capacity ranges today.

Table 6. Percentage of float capacity in specified ranges (2007)

Capacity range (tons/day)	% capacity in EU-27
<400	1
400-550	37
550-700	48
>700	14

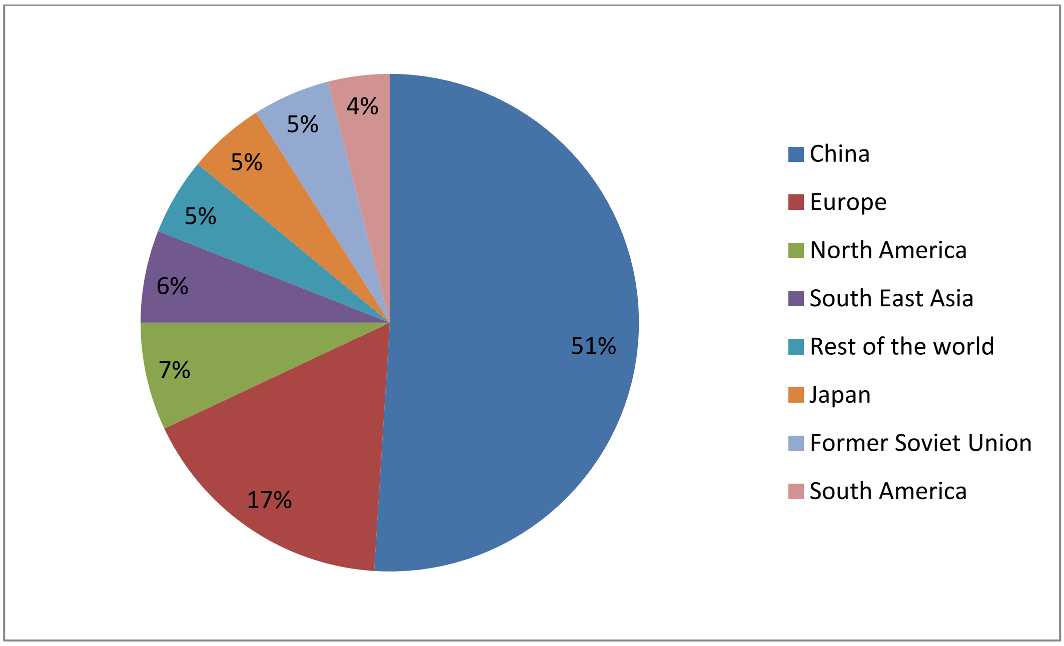
Source: GLS-BREF (2013).

4.3 International flat glass market

4.3.1 Global flat glass production and consumption

The global demand for flat glass in 2009 was approximately 50 million tonnes. Demand is dominated by China (51%)[68], Europe (17%) and North America (7%), as shown in Figure 5.

Figure 5. Regional float and sheet glass demand by region in 2011



Source: Pilkington, (2011).

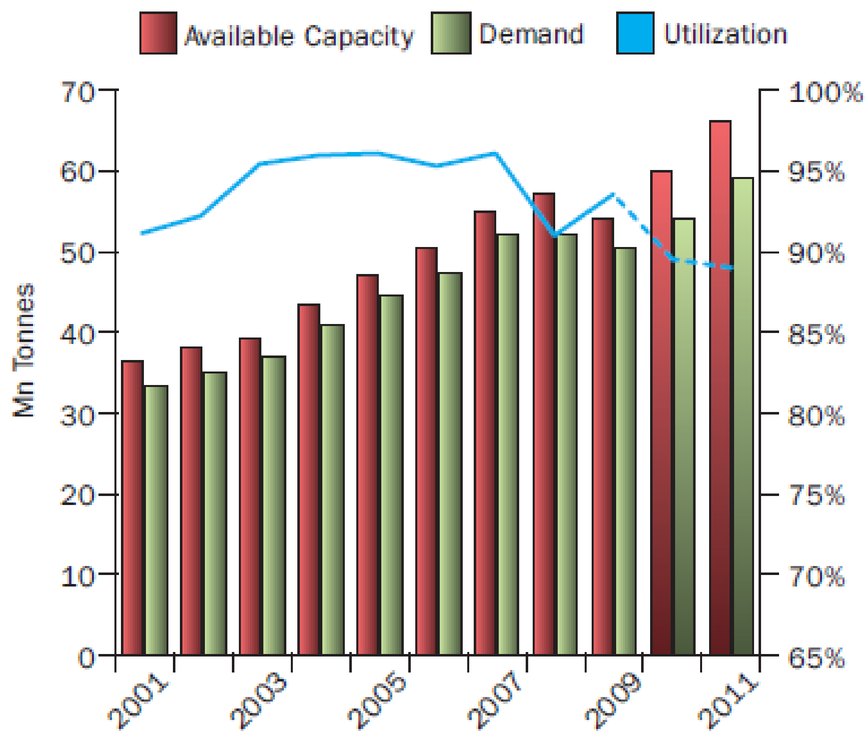
Over the past 20 years, global float glass demand has grown more quickly than GDP and demand continues to grow (Pilkington, 2011). World demand for flat glass is expected to grow by 7.1% annually through 2016 according to World Flat Glass

[68] In 1990, China accounted for about one-fifth of global demand, but demand has increased rapidly since then.

(2013). In 2009, demand contracted by 3.6% due to the economic crisis. In 2010, however, demand increased again by 9.1% (Pilkington, 2011).

Moreover, global capacity utilisation has increased the last ten years but was hit by the recession in 2009, as shown in Figure 6. Until 2009, global utilisation ranged between 90-95%. Utilisation dropped, however, in 2008 during the economic crisis and was expected to dip again in 2010 due to new capacity brought into the system, especially in China (Pilkington, 2010). In general, long-term profitability requires capacity utilisation in excess of 90% (GLS-BREF, 2013).

Figure 6. Global capacity utilisation



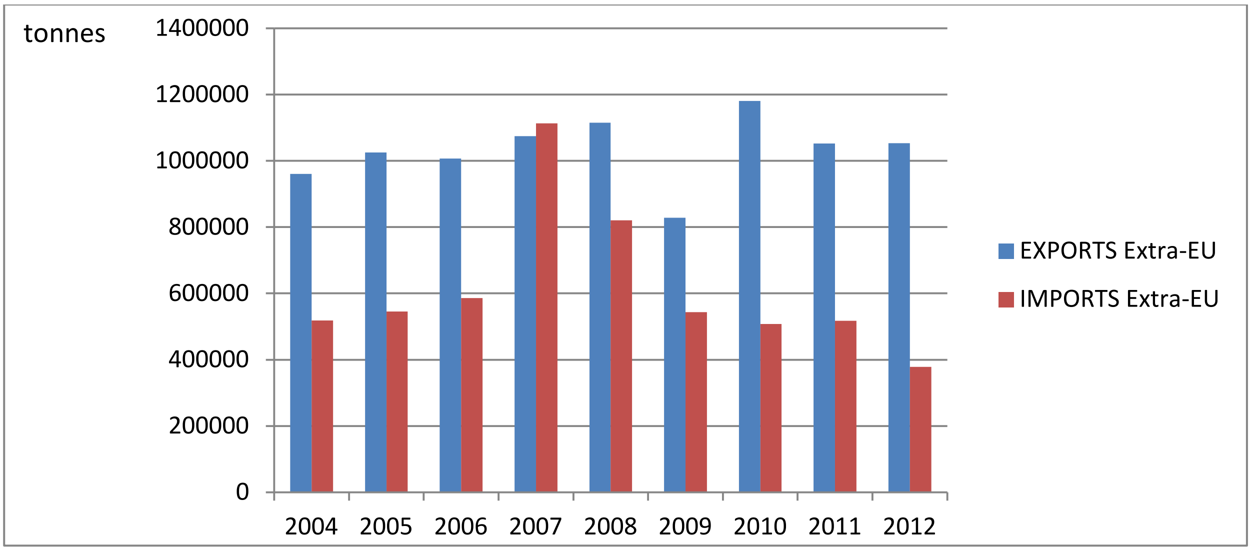
Source: Pilkington, (2010).

4.3.2 World and EU trade flows

Extra-EU Trade

A large majority of the float glass produced in the EU is sold in Western Europe (GLS-BREF, 2013). Imports from non-EU-27 countries increased up to 2007, when it peaked at approximately 11% of total EU production, predominately from China (GLS-BREF, 2013). Since then, however, the import rate has decreased (see Figure 7). According to the industry, the European float glass industry has to face increasing competition from producers from, for example, the Middle East, North Africa and China. There is a positive balance of trade in EU.

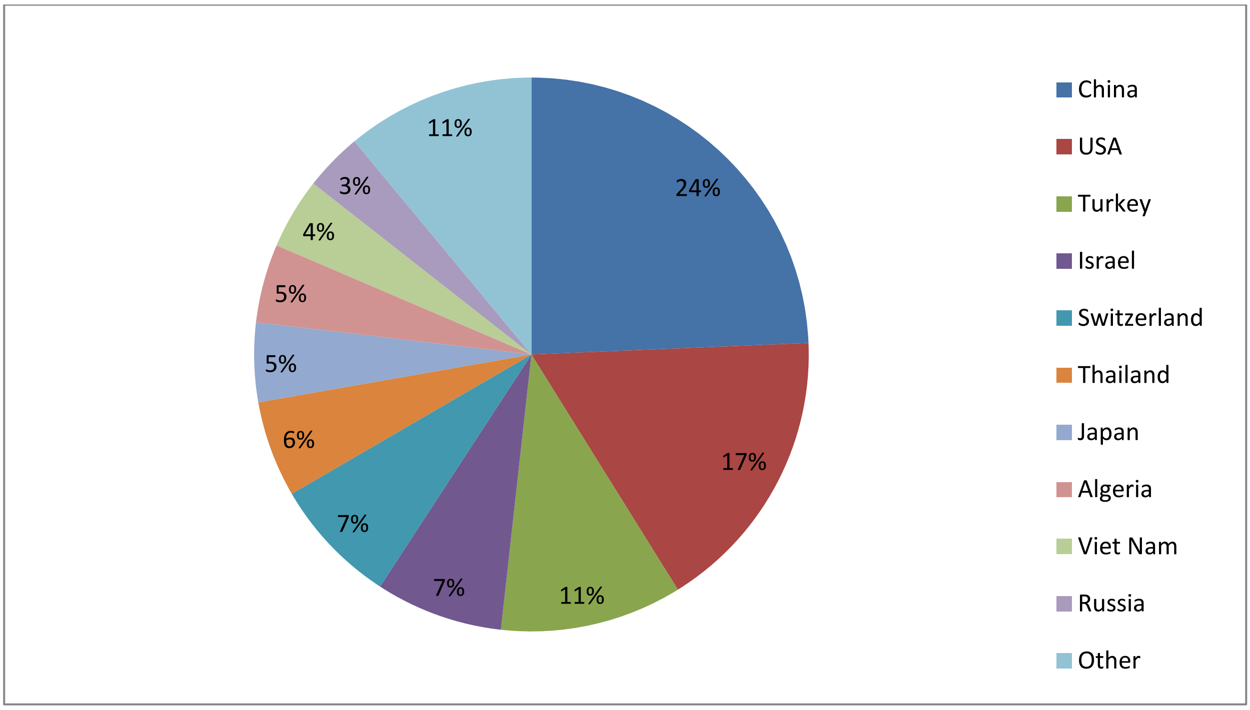
Figure 7. Flat glass (unworked), Extra-EU exports and imports, tonnes



Source: Authors elaboration on data from Glass Alliance Europe (2013).

The EU's ten largest import partners in 2012 are illustrated in Figure 8. China dominates, followed by the US, Turkey and Israel.

Figure 8. EU-27 main importing countries in 2012



Source: UN comtrade (2013).

4.3.3 Cost structure

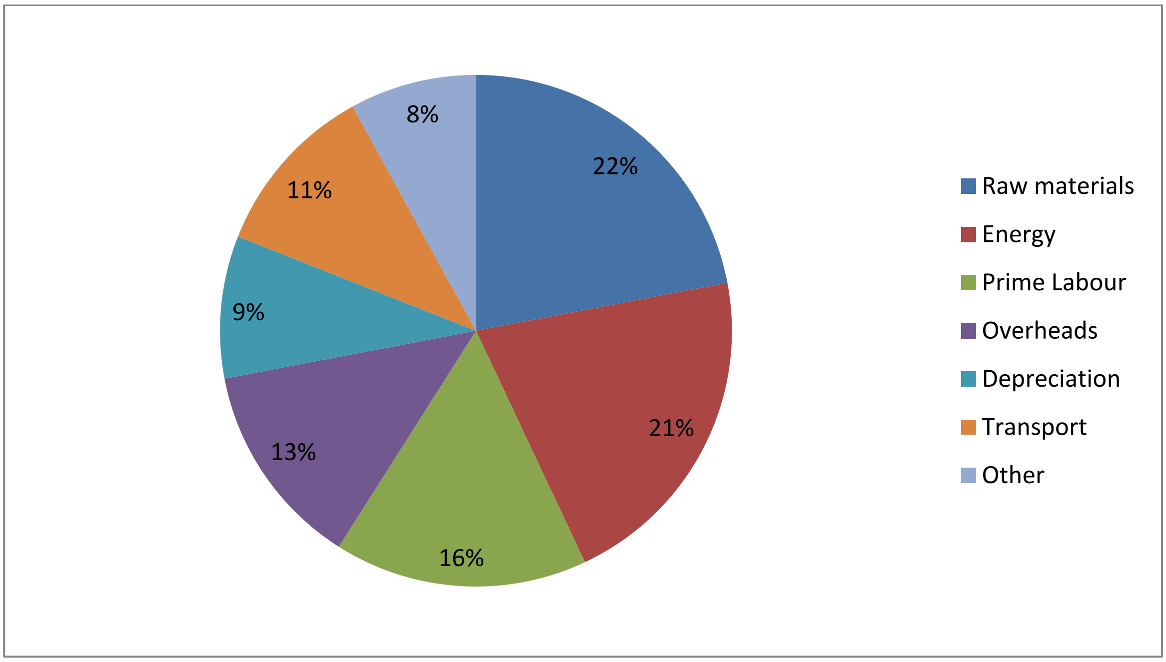
4.3.3.1 Cost of installations

A float plant is highly capital intensive and designed to operate for between 16 and 18 years, 365 days a year. The cost of a float plant is between euro 70 to 200 million, depending on size, location and production complexity (Pilkington, 2009). It is therefore not the type of installation that will generally be associated with an SME. After its operation time, installations are either rebuilt through partial or total replacement, depending on their condition. A major rebuild would cost around euro 30-50 million (Ecorys, 2008).

4.3.3.2 Cost structure

In terms of costs, raw material and energy are the two largest elements, followed by labour costs and overheads (Figure 9). Soda ash is one of the most expensive raw materials used and accounts for around 60% of batch costs (Pilkington, 2010). Since natural gas is the dominating fuel in the production process, the price of natural gas is a main cost driver for the float glass industry.

Figure 9. Cost structure Float Glass Nominal Cost



Source: Pilkington, (2010).

4.3.3.3 Transportation

Transportation costs differ for transportation by land and sea. By land, flat glass is expensive to transport, which is why it is generally supplied on a local or regional basis. Distribution costs typically represent around 10-15% of total production costs (Pilkington, 2006). However, intense competition between companies has led to glass being transported over longer distances, ultimately limited by cost (Ecorys, 2008).

For transportation by land, 200 km is seen as the norm and 600 km as the economic limit (Glass for Europe, 2013e).

Transportation by sea, however, opens up for longer transportation. Float lines with local port access are therefore favoured. As an example, float glass manufacturers in the EU and the Association have seen increased competitiveness from North Africa. A new Algerian company started operating in 2007 and exports a large share of its production with weekly sea transport to platforms in Italy and Spain (Glass for Europe, 2013c).

4.4 Selection of sample and sample statistics

4.4.1 Sample criteria

This study will only cover float installations and production. We have also limited the study to include only float installations that have float glass as an end-product, i.e. installations that involve downstream processes are excluded.

During the early stages of this project, the research team acquired from the Association a list including all float glass lines in EU, displayed by country and company.

Data on capacity for float glass installations has proved difficult to obtain, mainly for confidentiality reasons. Collecting data on capacity is complicated further by the fact that several float installations have stopped production recently. Therefore, all the individual companies involved in this study were asked for capacity data for all their plants. In parallel, capacity data was also obtained from an independent provider69 on country and company level.

To define the sample of float glass installations in the EU for the purpose of the study, the following criteria have been considered:

- Geographical location
- Capacity of plants
- Big and small players (ensuring a mix between multinational companies and SMEs)
- Production technology

They are based on the general criteria applied by CEPS in all sectoral studies, however with some modifications where relevant for this specific case.

[69] World Flat Glass, Freedonia.

4.4.1.1 Geographical location

This criterion has been developed as follows:

- Regional grouping. A mapping of the float plants in the EU shows that they are clustered in a number of areas. The biggest cluster of plants is found in Western Europe in the Be-Ne-Lux countries together with northern France, the UK and Germany, mainly in the West. Southern Europe is another cluster, as is Eastern Europe. We have aimed for a sample that represents all these three clusters.

- Number of float installations per member state. As the total number of Member States with operating float lines is 12 countries, we strived for comparable shares in these countries and tried to include at least one plant from the countries with more than one float installation.

4.4.1.2 Capacity of plants

Plant capacity is another important element of plant selection. Ideally, plants that represent the spectrum of production would allow a better assessment of the impact that size can have on the economics of production.

The research team classified float glass installations in three sub-groups: low-capacity (less than 550 tonnes/day), medium-capacity (550-699 tonnes/day) and high-capacity (equal to or higher than 700 tonnes/day). The sample was chosen to reflect the same pattern as the float glass producers in EU.

4.4.1.3 Big and small companies

The EU market is highly concentrated around a number of large multinational companies. All companies in the sample thus represent big European firms. With the total investment cost for a float plant being between € 70 to 200 million, there are no SMEs that own float plants and produce flat glass.

4.4.1.4 Technology

Technology is standard and will have little bearing as a criterion for the sample selection. There is no difference in the technology for float glass production.

4.4.2 Sample statistics

Based on the above discussed criteria, the sample consists of 10 float installations in EU, out of a total number of 46 (this is the most updated number of float lines in EU). However, in practice the research team had to select the sample from a list of 33 plants since some companies did not want to participate in this study.

As explained further in section 4.5.2, the plants were divided in three geographical regions: Western Europe, Eastern Europe and Southern Europe. The sample broadly reflects the situation in the EU with Western European Member States dominating with more than half of the installations. Southern and Western Europe, respectively, represent around one quarter each.

The sample with ten plants is spread in eight Member States. Due to confidentiality reasons, the Member States included in the sample cannot be exposed.

Table 7 describes different ranges of installation capacity for all companies in the study and the capacities in our sample. Note that the table only presents nominal capacity (i.e. not actual output) and only represents the companies participating in this study, not the whole EU. For reasons of confidentiality it is not possible to present capacities for individual companies in the sample, but only ranges.

Table 7. Percentage of float capacity in specified ranges, total population for companies in the study (N=33) and sample (N=10)

Capacity range (tons/day)	% capacity companies in study	% capacity in sample
<550	9.7	10
550-699	51.6	50
≥700	38.7	40

Source: Authors' own calculations with data from flat glass companies.

4.5 Methodology

4.5.1 Data collection

The questionnaires for the flat glass sector have the same structure and include the same questions as the other sectors in this study, to ensure conformity. Ahead of the actual data collection, a draft questionnaire was provided to all companies participating in the study, as well as the Association, to ensure that the questions were applicable, relevant and that plant staff actually understood them. In addition, telephone conferences were carried out with all the individual companies in the study to discuss the questionnaire and to ensure company input.

For some companies, confidentiality agreements were signed before any data exchange took place. Once the data was collected, questions for clarification were addressed to the companies, by telephone interviews.

Out of the ten plants in the sample, all returned the questionnaires, however with varying quality. All companies provided data on energy price paid, total energy consumption, production and energy intensity. Out of the ten plants, seven provided information on the structure of the energy bill. As a result the sample is too small to do an analysis on the structure of the energy bills for all geographical regions. Hence, no results for Southern Europe on the structure of the energy bill are presented.

Additionally, seven plants out of ten provided further data on production costs and four plants provided data on margins. To ensure comparability, only the four plants that both provided data on total production cost and margins were included in the analyses. These four plants cover all three geographical regions in the sample. Table 8 describes number of questionnaires used in each section of the analysis.

Table 8. Number of questionnaires used in each section

Total number received	10
Number selected in the sample	10
Energy prices trends	10
Energy bill components	7
Energy intensity	10
Production costs	7
Margins	4
Indirect ETS costs	10

4.5.2 Data analysis and presentation

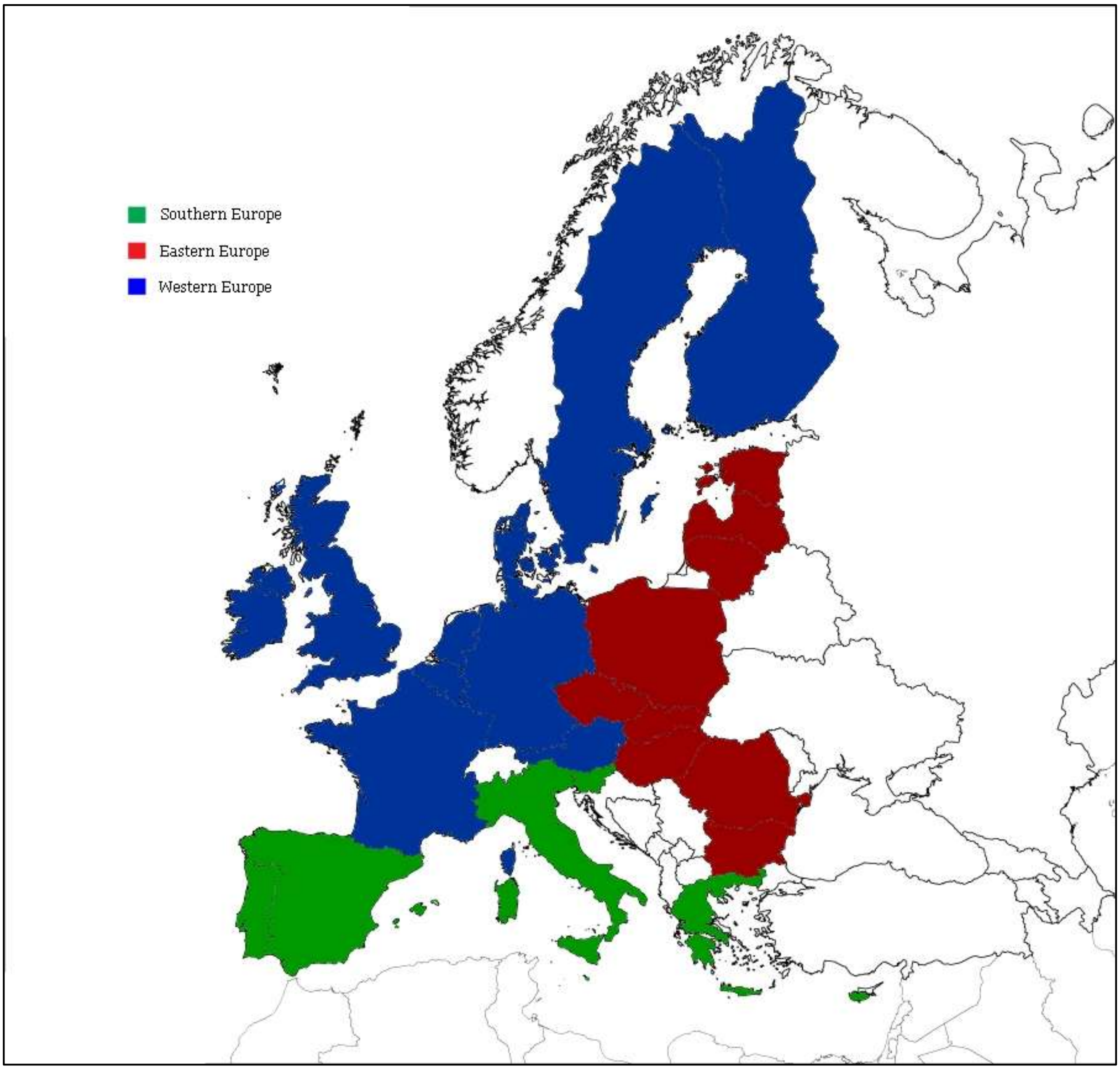
For reasons of confidentiality, we have aggregated the data into different geographical regions: Western Europe, Southern Europe and Eastern Europe. The countries in the different geographical regions are the following (see also Figure 10):

a. Western Europe - UK, France, Belgium, Ireland, Luxembourg, Sweden, Germany, the Netherlands, Finland, Denmark and Austria. This represents 54% of total EU float glass plants in 2013 and 60% of the sample (6 plants in the sample).

b. Eastern Europe - Lithuania, Romania, Bulgaria, Czech Republic, Hungary, Estonia, Latvia, Slovakia and Poland. This represents 22% of total EU float glass plants in 2013 and 20% of the sample (2 plants in the sample).

c. Southern Europe - Italy, Malta, Portugal, Greece, Slovenia, Cyprus and Spain. This represents 24% of total EU float glass plants in 2013 and 20% of the sample (2 plants in the sample).

Figure 10. EU division in major geographical regions

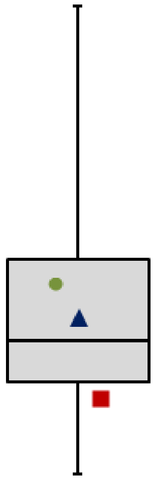


Source: Own illustration.

Throughout the whole study, weighted averages are calculated on the basis of actual production.

Box plots are furthermore presented in section 4.6 in order to display the cost ranges and to give an indication of the distribution among the units in the sample. An exemplary box plot is illustrated in Figure 11. The box itself is divided in two parts by a horizontal line. This line indicates the median of the sample, i.e. the numerical value separating the higher half of the data sample from the lower half. The lower border of the box represents the first (lower) quartile of the sample. It splits off the lowest 25% of the data sample from the highest 75%. Correspondingly, the upper border of the box indicates the third (upper) quartile of the sample, thus separating the highest 25% of data from the lowest 75%. Put differently, the box contains exactly the middle half of the data. The height of the box is also referred to as inter-quartile range (IQR). It is a robust way of showing the variability of a data sample without having to make an assumption on the underlying statistical distribution. The whiskers below and above the box represent the minimum and maximum value of the sample.

Figure 11. Exemplary box plot



Source: own illustration.

4.5.3 Calculation of indirect ETS costs

The objective of the ETS cost calculations per sector in this study is to provide an estimation of the indirect ETS cost for the sub-sector between 2010 and 2012. The level of information is aggregated on a regional level, although the definition of those regions differs between cases studies.

The model for the indirect cost of EU ETS, per plant, is defined as:

Indirect costs

Indirect cost (€/Tonne of product) = Electricity intensity (kWh/Tonne of product)

** Carbon intensity of electricity (Tonne of CO2/kWh)*

** CO2 Price (€/Tonne of CO2) * Pass-on rate*

Where:

- Electricity intensity of production: the amount of electricity used to produce one tonne of product. This amount is sector, plant and process specific;
- Carbon intensity of electricity generation indicates the amount of tonnes of CO_2 emitted by utilities to generate one kWh;
- CO2 Price: is the average yearly market-price of CO_2.

- Pass-on rate: the proportion of direct costs faced by utilities (disregarding any mitigating effects from free allocation) that they pass on to electricity consumers.

Sources:

- Electricity intensity of production; this was acquired from interviews with and questionnaires answered by industry members.

- Carbon intensity of electricity generation: the maximum regional carbon intensity of electricity is utilised, provided by the Commission's Guidelines on State aid measures.[70] Note that these figures are not national. Member States who are highly interconnected or have electricity prices with very low divergences are regarded as being part of a wider electricity market and are deemed to have the same maximum intensity of generation (for example, Spain and Portugal).

- CO2 Price: Yearly averages of the daily settlement prices for Dec Future contracts for delivery in that year. The daily settlement prices were reported by the European Energy Exchange.

Table 9. Average yearly prices per tonne of CO2 (€)

Year	**2010**	**2011**	**2012**
CO2 Price	14.48	13.77	7.56

4.5.4 Validation of information

Data on capacity for float glass installations has proved difficult to obtain. All the individual companies involved in this study were asked for capacity data for all their plants. In parallel, capacity data was also obtained from an independent provider[71] on country and company level. This allowed validating the data on capacities for some of the individual companies that had one installation per country.

To our knowledge, and according to the Association, there are no independent data providers in the flat glass sector on energy costs[72]. This has made data validation difficult. Therefore, all the data on energy prices and energy consumption presented in the report was collected through the questionnaires to the individual installations in the sample.

[70] Communication from the Commission: Guidelines on certain State aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012 (2012/C 158/04)

[71] World Flat Glass, Freedonia.

[72] Existing data focus on market and product trends.

Given this situation, the research team has tried to validate the data from the questionnaires by comparison of the different installations. This allowed indentifying outliers. When this was the case, follow-up interviews were carried out. Numbers were also compared with the other sub-sectors in this study (chemical sub-sectors and ceramics sub-sectors). Further checks were done with the help from other external sources[73].

For some of the companies, energy costs and structure of energy bills was validated with the help of actual monthly energy invoices. We have received monthly bills from four installations. For three of the plants we received monthly energy bills for all the years covered in this study. For the other plant we received one monthly bill.

The validation of production costs and margins for the float glass is complex. It is not possible to retrieve data from publicly available sources. Both production cost and margins of the EU float glass industry were validated through comparing the data submitted by the producers and verifying the plausibility of key indicators' evolution during the addressed period[74].

Please note that all the figures presented in section 4.6 and 4.7 include possible exemptions from taxes, levies or transmissions costs. The researchers asked the producers to communicate the prices they pay for energy carriers between 2010 and 2012. Therefore, their answers include exemptions/reductions if these are applicable. Note also that all the replies were submitted on a plant level.

4.6 Energy price trends

4.6.1 Introduction

The most energy intensive stage of the production process of float glass is furnace activities, where heating is typically provided by natural gas. Some of the plants in the sample use fuel oil instead of natural gas. Natural gas makes up the largest share of the total cost for the plants in the sample; on average 71% of total energy cost, while electricity on average makes up 15% and fuel oil 14% (see Table 10). This is reflected by the ratio of natural gas and electricity costs, which is in the range of 2.8 and 3.3. On average, the energy cost share of total production cost for the plants in the sample was estimated to 37% (see Table 10).

All figures on energy costs in this section include possible exemptions from taxes, levies or transmissions costs.

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73 Validation of price levels and price trends were done with the help of the European Commission, Statistical Pocketbock 2013.

74 Verification was conducted through both data analysis and telephone interviews with the companies.

Table 10. Energy sources' cost share of total energy cost and total production cost. Averages for the sample and time period studied, 2010-2012[75]

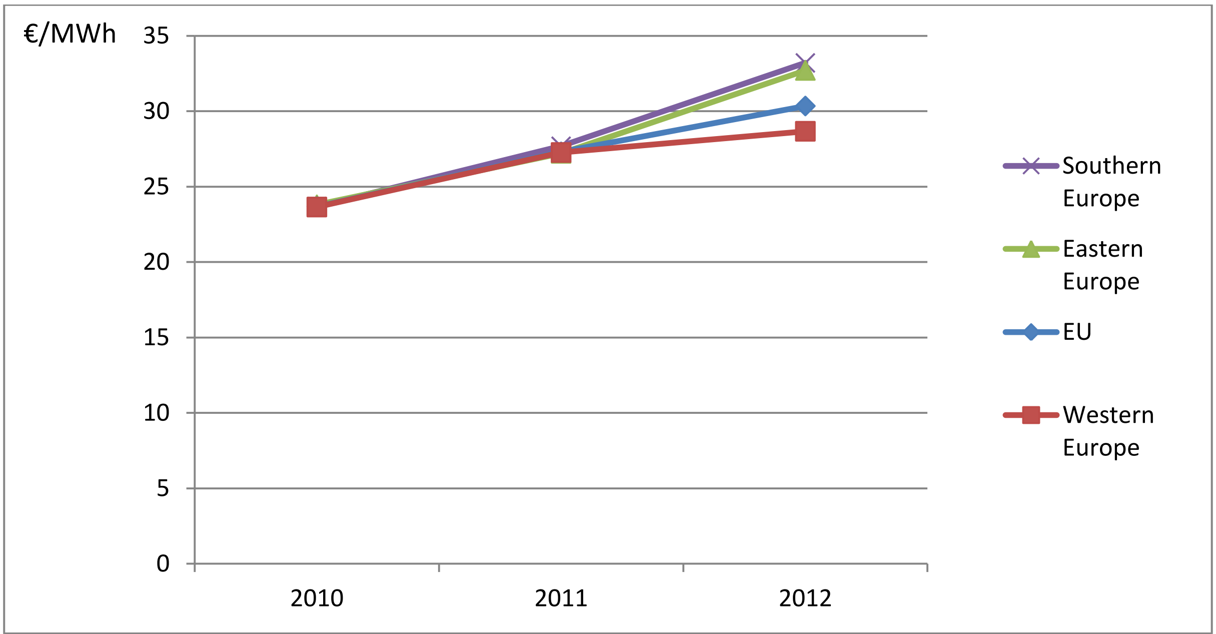
	Share in total energy cost, %	**Share in total production cost, %**
Natural gas	66.7 - 76.6%	21.0 - 28.1%
Electricity	14.6 - 15.5%	3.6 - 4.0%
Fuel oil	8.8 - 17.8%	6.0 - 10.9%
Energy Total	100%	35.1 - 39.1%

4.6.2 Natural gas

4.6.2.1 General trends

The prices of natural gas, paid by EU float glass producers in this sample, are on the rise. Figure 12 and Table 11 describe the trend in natural gas prices for the sample average, Western Europe, Eastern Europe and Southern Europe. Between 2010-2012, the sample average price increased by 28% (from 23.7 €/MWh to 30.3 €/MWh).

Figure 12. EU natural gas prices, weighted averages, €/Mwh



Source: Authors' own calculations based on questionnaires.

[75] The figures on the share of energy sources of total energy cost are averages for the full sample (ten plants) and the three-year period studied. The figures on the share of energy sources in total production cost present averages for the time period studied for the four plants that provided data on production cost and margins, such as EBITDA, to be consistent with section 4.10.

Table 11. Descriptive statistics for natural gas prices paid by sampled EU float glass producers (€/MWh)

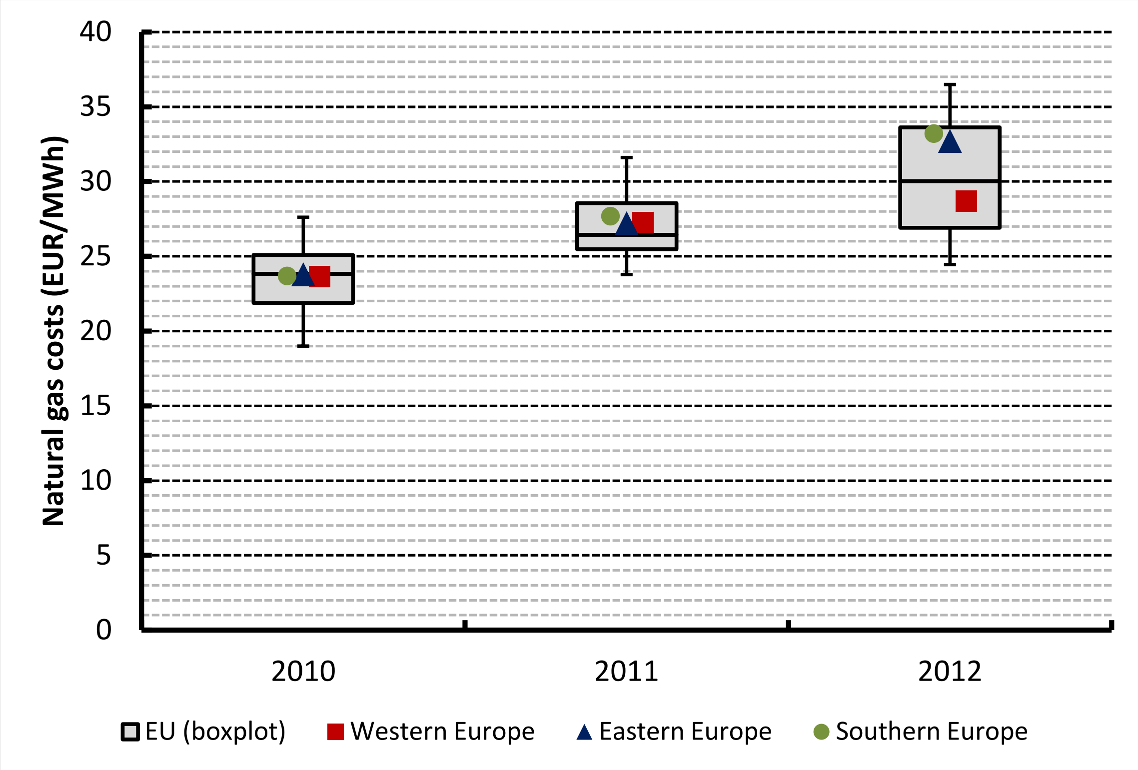
	2010	2011	2012
EU (average)	23.7	27.3	30.3
EU (median)	23.8	26.4	30.0
EU (IQR)	3.2	3.1	6.7
Western Europe (average)	23.6	27.3	28.7
Southern Europe (average)	23.7	27.7	33.2
Eastern Europe (average)	23.8	27.2	32.7
EU (max)	27.6	31.6	36.5
EU (min)	19.0	23.8	24.4

Source: Authors' own calculations based on questionnaires.

The trends in natural gas prices paid by EU float glass producers are also reflected in the box plots presented in Figure 13. The median price is increasing, and confirms that EU prices of natural gas are on the rise. In 2010 the median price was 23.8 €/MWh, while in 2012 it rose to 30.0 €/MWh (+26%). Additionally, the increasing inter-quartile range[76] (IQR) illustrates that the gap of prices paid by EU float glass producers is also growing. Figure 13 also describes maximum and minimum prices paid for different producers in the sample 2010-2012. The price gap between the maximum and minimum price has increased during the period from 9 €/MWh in 2010 to 12 €/MWh in 2012.

[76] This refers to the difference between the lower and upper quartile which represents the middle half of data.

Figure 13. Natural gas prices paid by EU float glass producers, €/Mwh



Source: Authors' own calculations based on questionnaires.

4.6.2.2 Regional differences

In 2010 and 2011, prices in the geographical regions were at a comparable level. However, in 2012, prices started to diverge. While prices in Southern Europe and Eastern Europe increased at almost the same pace, the price increase in Western Europe slowed down, although still positive. The following trends can be observed in the geographical regions:

Western Europe

The average price in Western Europe for natural gas increased from 23.6 €/MWh to 28.7 €/MWh during the period (+21%). Prices increased substantially between 2010-2011 (+15%) but only moderately afterwards (+5%). Relative to the other regions, Western European plants had the lowest percentage price increase. Moreover, in 2012, the average Western European price on natural gas was the lowest, compared to the other geographical regions.

With respect to the full sample, the price gap between different producers in Western Europe increased over time. In 2012, both the highest and lowest price was in the Western Europe.

Southern Europe

The average price paid in Southern Europe in 2012 was marginally higher than the price paid in Western Europe and Eastern Europe. On average, ranging from 23.7 €/MWh in 2010 to 33.2 €/MWh in 2012 (+40%), Southern Europe experienced the highest percentage increase among the three regions. Prices increased 17% 2010-2011 and 20% 2011-2012.

Eastern Europe

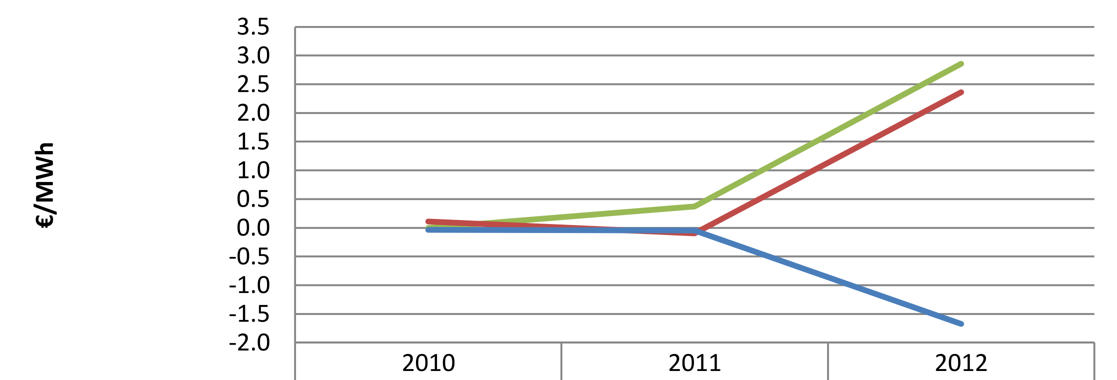
The average price on natural gas for Eastern European plants on average increased from 23.8 €/MWh in 2010 to 32.7 €/MWh in 2012 (+37%). The development is similar to the one in Southern Europe, with a fairly stable rate of increase, from 14% in 2010-2011 to 20% 2011-2012.

The average price paid in Eastern Europe in 2012 was higher than in Western Europe and slightly lower than in Southern Europe.

Regional gaps

Figure 14 provides a graphical presentation of the evolution of natural gas price gaps between the EU average price paid by float glass producers and the three regional average prices. Since 2010, the spread of prices paid by the EU float glass producers has increased steadily. In 2010 and 2011 prices in the three geographical regions were in line with the EU average. In 2012, however, Western European producers, on average, paid 1.7 €/MWh less than the EU average price. Prices in Eastern Europe and Southern Europe in 2012, on the other hand, were higher than the EU average price. In 2012, Eastern European producers paid 2.4 €/MWh more than the EU average price, while the corresponding figure for Southern European producers was 2.9 €/MWh.

Figure 14. Regional gap of natural gas prices compared with EU averages, (€/MWh)



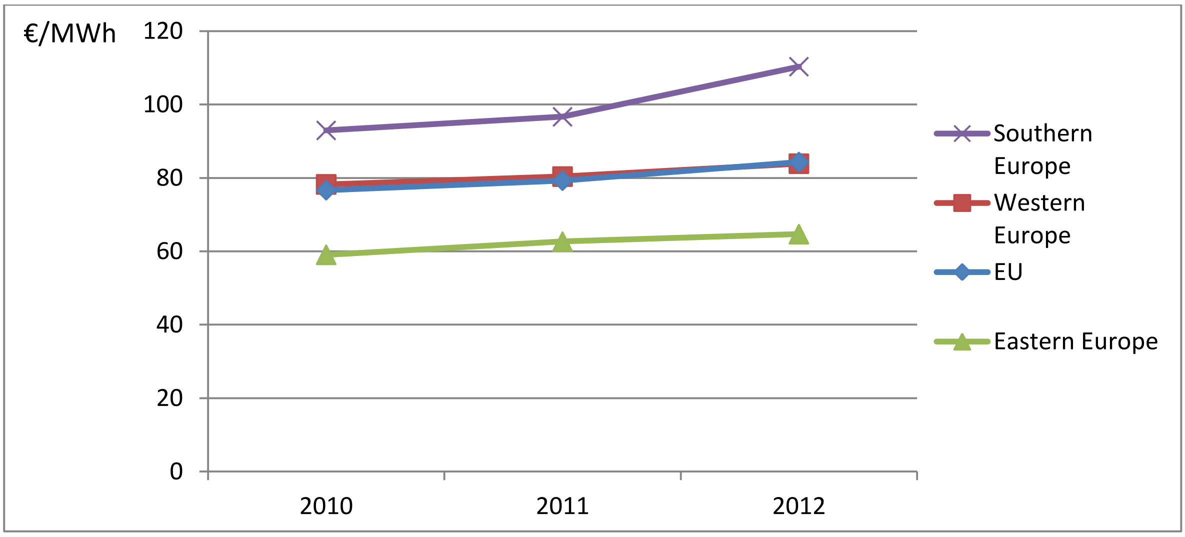
	2010	2011	2012
Southern Europe	0.0	0.4	2.9
Eastern Europe	0.1	-0.1	2.4
Western Europe	0.0	0.0	-1.7

4.6.3 Electricity

4.6.3.1 General trends

Similar to natural gas prices, electricity prices are on the rise. Figure 15 and Table 12 describe the electricity price trend for the full sample, Western Europe, Eastern Europe and Southern Europe. Overall, i.e. for all plants in the sample, the average price on electricity increased from 76.7 €/MWh to 84.3 €/MWh (+10%). Compared to the price of natural gas, the electricity prices, however, had a lower percentage increase.

Figure 15. Weighted average price electricity, €/Mwh



Source: Authors' own calculations based on questionnaires.

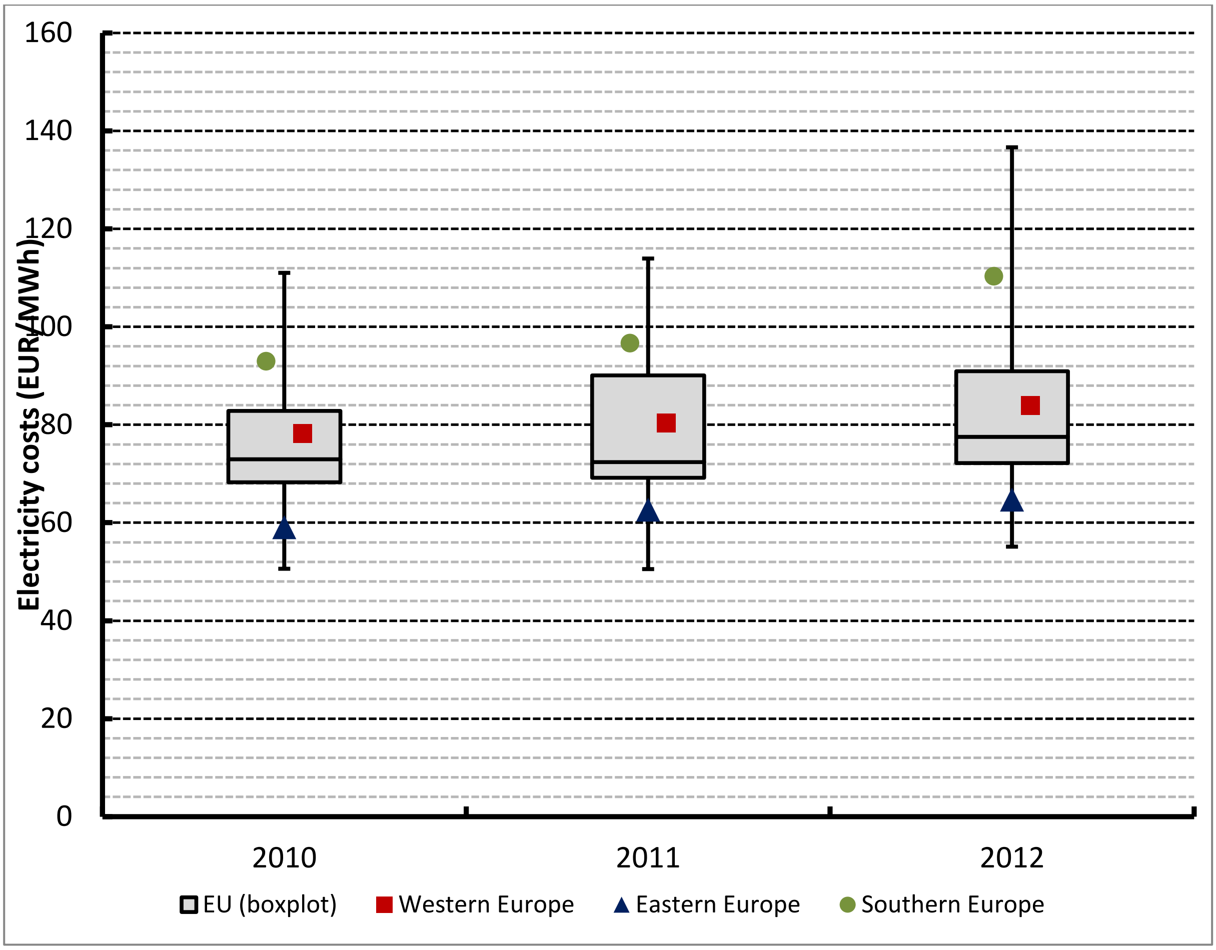
Table 12. Descriptive statistics for electricity prices paid by sampled EU float glass producers (€/MWh)

	2010	2011	2012
EU (average)	76.7	79.3	84.3
EU (median)	73.0	72.4	77.6
EU (IQR)	14.6	20.9	18.7
Western Europe (average)	78.3	80.4	83.9
Southern Europe (average)	93.0	96.7	110.3
Eastern Europe (average)	59.1	62.6	64.7
EU (max)	110.0	113.9	136.6
EU (min)	50.6	50.5	55.1

Source: Authors' own calculations based on questionnaires.

The trends in electricity prices paid by EU float glass producers are also reflected in the box plots presented in Figure 16. The median price is slightly increasing. In 2010 the median price was 73.0 €/MWh, while in 2012 it was 77.6 €/MWh (+6%). Additionally, the increasing inter-quartile range[77] (IQR) illustrates that the gap of prices paid by EU float glass producers is also growing, even though there was a decrease from 2011 to 2012. The price gap between the maximum and minimum price was about 60 €/MWh in 2010 while the corresponding figure in 2012 was 82 €/MWh. For each year during the period covered, the plant with the maximum price had a cost per MWh twice as high as the plant with the minimum price.

Figure 16. Electricity prices paid by EU float glass producers, €/Mwh



Source: Authors' own calculations based on questionnaires.

4.6.3.2Regional differences

Regional differences are also explained in Figure 15, where weighted average prices for different regions are illustrated. In general, the graph shows a prevalent difference between the geographical regions for all years, where prices are highest in Southern

77 This refers to the difference between the lower and upper quartile which represents the middle half of data.

Europe, lowest in Eastern Europe. Western Europe is in the middle. The following trends can be observed in the geographical regions:

Western Europe

In Western Europe, prices have had an upward trend. The average price increased from 78.2 €/MWh to 83.9 €/MWh (+7%), which is lower than for the full sample. The prices in Western Europe are above the EU average and in Eastern Europe, but lower than those in Southern Europe.

While the average price has shown an increase, there is no clear pattern. In some cases there has been an increase in prices, while for some others, prices decreased. The gap between the highest and lowest price has, hence, increased. The gap was 37.7 €/MWh in 2010, while the corresponding figure in 2012 was 47.2 €/MWh.

Southern Europe

Southern Europe shows the strongest rise of prices. The average price in Southern Europe increased from 93.0 €/MWh to 110.3 €/MWh (+19%). Prices especially increased in 2011-2012 (+14%) (in Eastern Europe the corresponding figure was 3% and in Western Europe 7%). For all years considered in the analysis, the price in Southern Europe is the highest of all geographical regions.

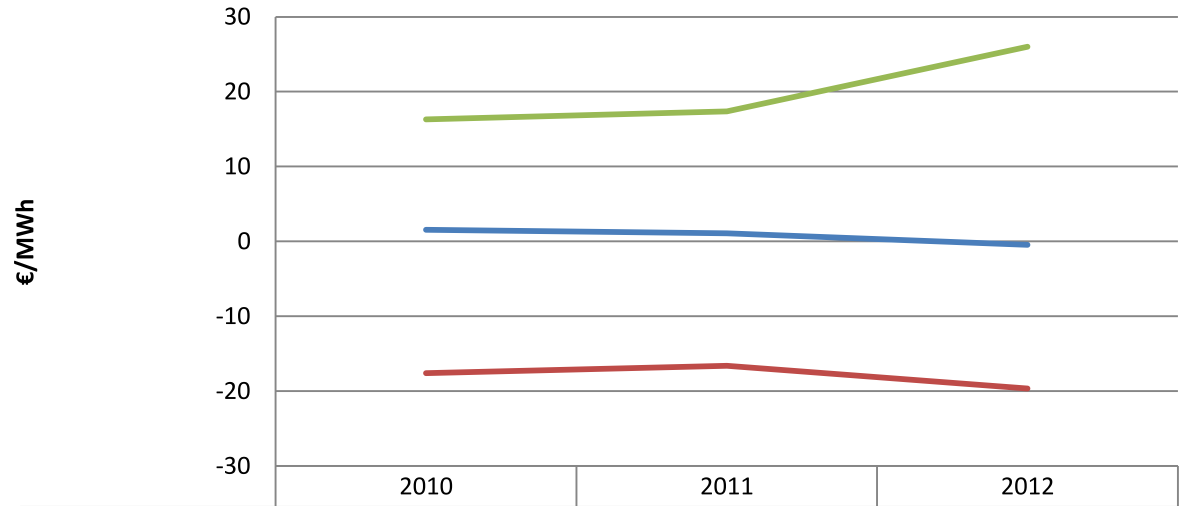
Eastern Europe

In Eastern Europe there is also an upward tendency in prices. The average price increased from 59.0 €/MWh to 64.7 €/MWh during the period (+10%). The electricity price levels in Eastern Europe are the lowest in all geographical regions in this study and all plants in the sample have prices below the EU average.

Regional gap

The gap of electricity prices across the regions is rather high, and has increased somewhat during the period. Figure 17 provides a graphical presentation of the evolution of the electricity price gap between the EU average price paid by float glass producers and the three regional average prices. Prices for Western European producers were in line with EU average during the studied time period. In Eastern Europe, average prices were lower than the EU average; in 2010 this gap was 17.6 €/MWh which increased to 19.6 €/MWh in 2012. In Southern Europe on the other hand, the average prices were higher than the EU average; in 2010 the gap was 16.3 €/MWh which increased to 26.0 €/MWh in 2012.

Figure 17. Regional gaps of electricity prices compared with EU averages, (€/MWh)



	2010	2011	2012
Southern Europe	16.3	17.4	26.0
Western Europe	1.6	1.1	-0.5
Eastern Europe	-17.6	-16.6	-19.6

Source: Authors' own calculations based on questionnaires.

4.7 Analysis of the energy bills components

To better understand the price developments, the total costs for natural gas and electricity are broken into their components. For natural gas the components are grouped into: the energy component, grid fees and other levies and taxes (excluding VAT). For electricity, we include one additional component, the RES levy. Please note that the data presented in this section do not include all geographical regions. The sample in Southern Europe was too small to perform an analysis for this geographical region (see section 4.5.1).

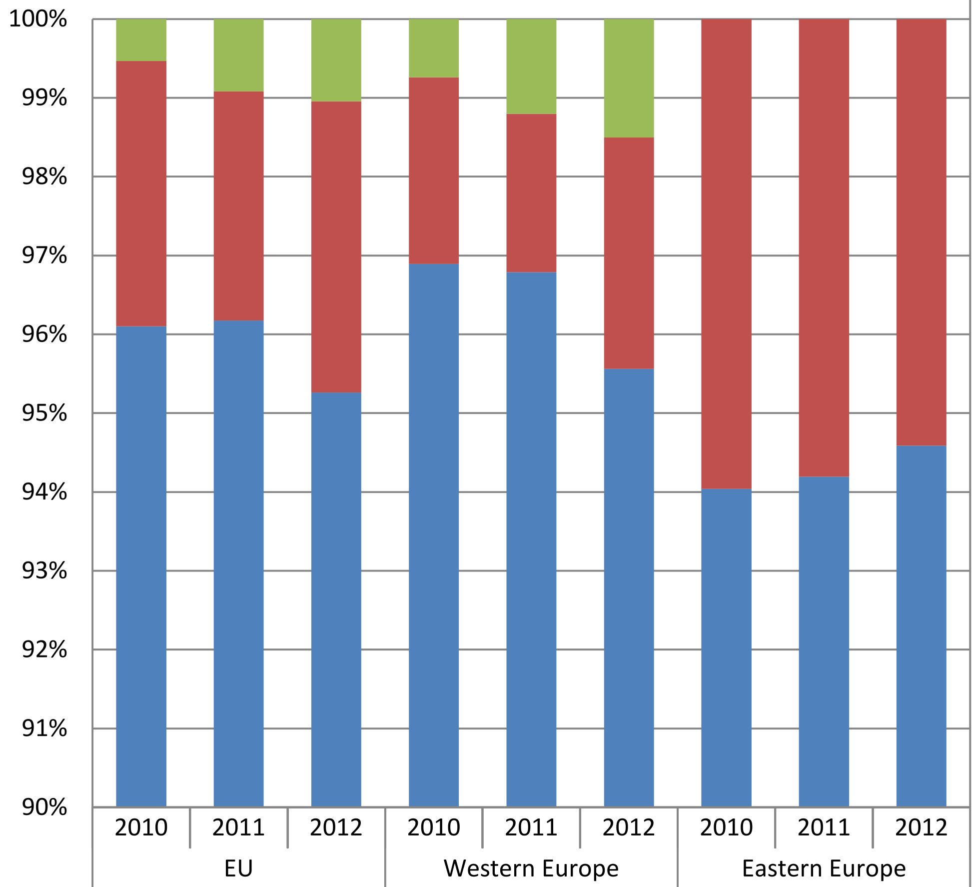
Moreover, all figures on energy costs in this section include possible exemptions from taxes, levies or transmissions costs.

4.7.1 Natural gas

4.7.1.1 General trends

In each year, the energy component dominates natural gas bills. Several plants in this study also stated that the major price driver in their gas contract was the rise in oil price, as natural gas prices are linked to the price of oil. The energy component made up around 95-96% of the total bill for the period examined (see Figure 18). In 2010, it amounted to roughly 23.3 €/MWh, which increased to 28.9 €/MWh in 2012 (Figure 19). In 2012, the energy component dropped slightly (from 96% to 95%) and was replaced with a growing share of the grid fee and other levies and taxes.

Figure 18. Natural gas bill components, EU weighted average



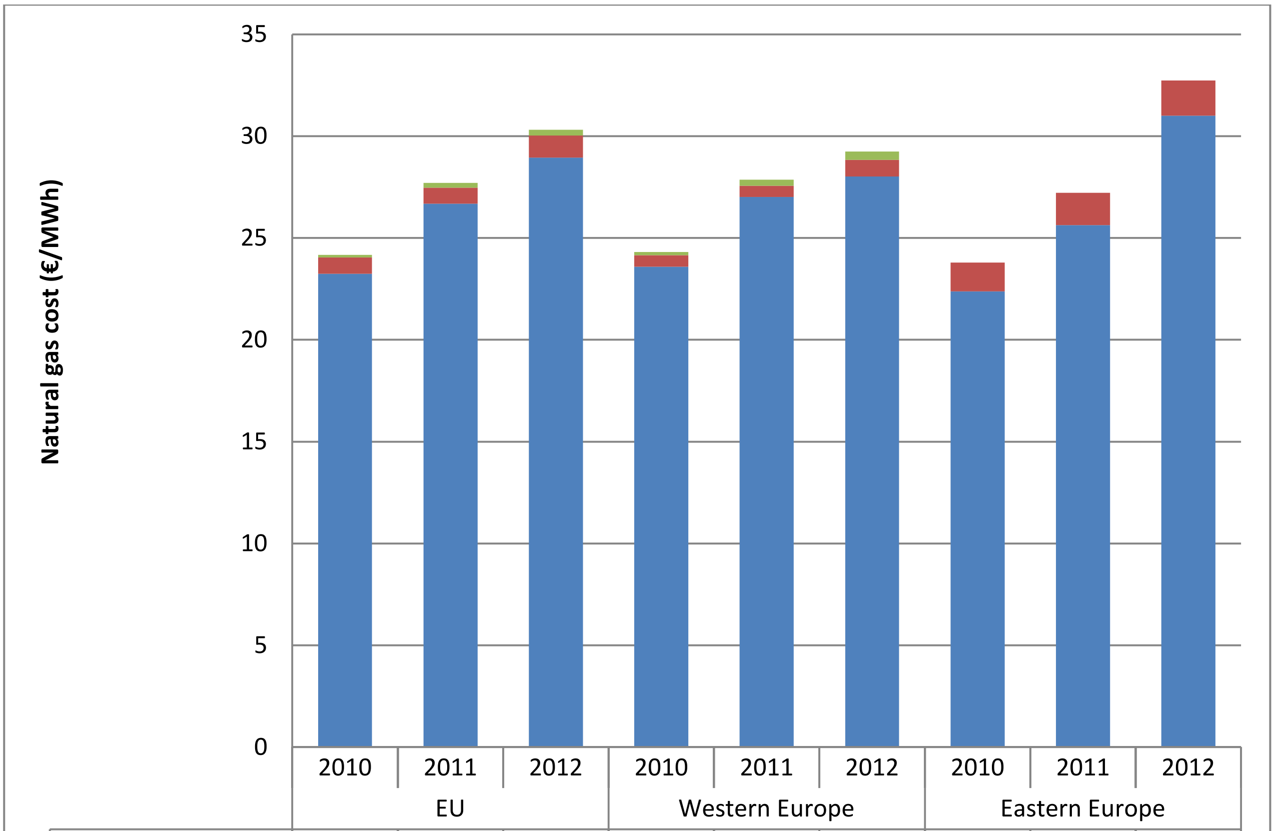
	EU 2010	EU 2011	EU 2012	Western Europe 2010	Western Europe 2011	Western Europe 2012	Eastern Europe 2010	Eastern Europe 2011	Eastern Europe 2012
Other (excl. VAT)	0.5%	0.9%	1.0%	0.7%	1.2%	1.5%	0.0%	0.0%	0.0%
Network cost	3.4%	2.9%	3.7%	2.4%	2.0%	2.9%	6.0%	5.8%	5.4%
Energy component	96.1%	96.2%	95.3%	96.9%	96.8%	95.6%	94.0%	94.2%	94.6%

Note: The scale starts at 90%.
Source: Authors' own calculations based on questionnaires.

The impact of grid fees and taxes and other levies, while marginal, has increased during this period. The average EU grid fee increased from 0.8 €/MWh to 1.1 €/MWh in 2012 (+36%). Other taxes and levies also increased, during the same period, from 0.1 €/MWh to 0.3 €/MWh (+154%).

The marginal effect of grid fees and taxes on the prices of natural gas is limited, however, this result points to an upward trend in grid fees and other taxes and levies in the EU.

Figure 19. Components of the natural gas bills paid by the sampled float glass producers in EU, weighted average, €/MWh



	EU			Western Europe			Eastern Europe		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
Other (excl. VAT)	0.1	0.2	0.3	0.2	0.3	0.4	0.0	0.0	0.0
Grid fees	0.8	0.8	1.1	0.6	0.5	0.8	1.4	1.6	1.7
Energy component	23.2	26.7	28.9	23.6	27.0	28.0	22.4	25.6	31.0

Source: Authors' own calculations based on questionnaires.

4.7.1.2 Regional differences

Figure 18 and Figure 19 also show the breakdown of costs for Western Europe and Eastern Europe. The data presented in this section do not include Southern Europe since the data availability in this geographical region on the breakdown of costs was too limited (see section 4.5.1). On regional level, the following trends can be observed:

Western Europe

Similarly to the EU average, the energy component dominates natural gas costs in Western Europe. The energy component's share is, however, slightly diminishing. Its share decreased from 97% in 2010 to 96% in 2012, see Figure 18. The grid fee increased during the period and made up around 3% of the total cost in 2012. Other taxes and levies also increased, from 0.2 €/MWh in 2010 to 0.4 €/MWh in 2012 (+155%). The influence of taxes and levies in Western Europe remains rather small but is increasingly important. In 2012, they accounted for around 1.5% for the Western European plants in this sample.

Eastern Europe

While the average price of natural gas has increased, the weight of the different components remained stable (see Figure 18). The energy component was stable, at around 94% of the price of gas, while the grid fee made up around 6%. All the plants in Eastern Europe stated that they are not exposed to any other levies and taxes when it comes to natural gas.

4.7.2 Electricity

4.7.2.1 General trends

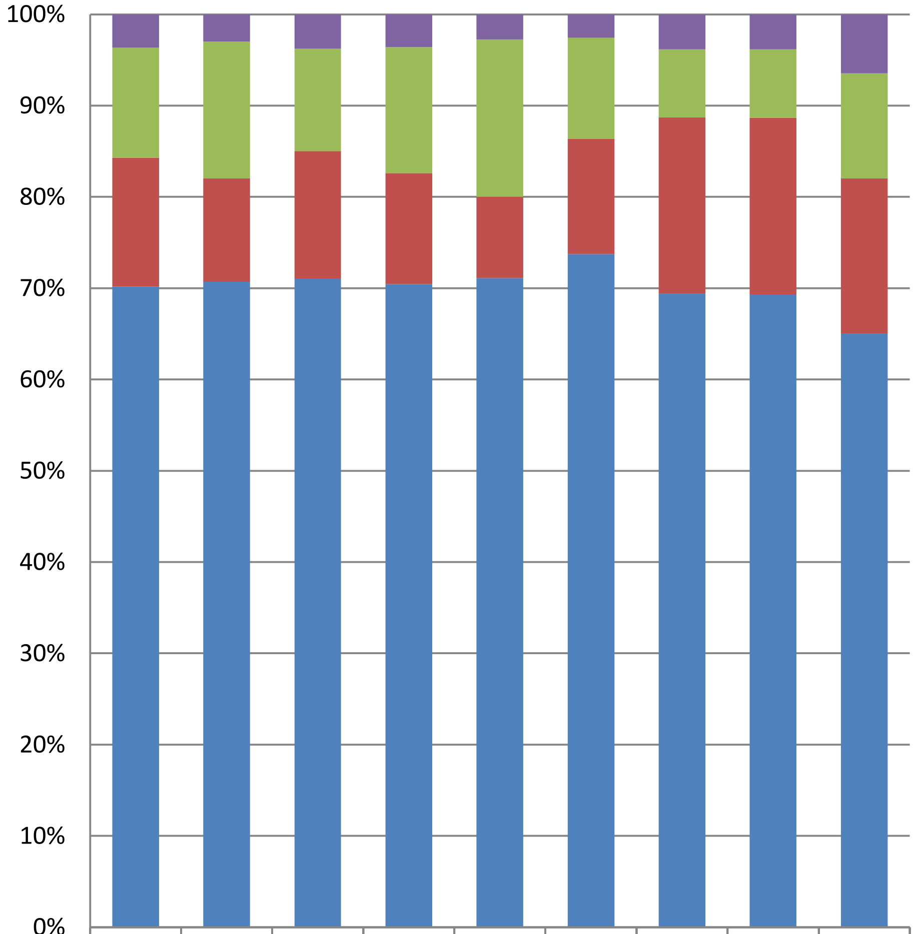
Similarly to natural gas, the energy component is the most significant component of the electricity prices paid by EU float glass plants (see Figure 20). In comparison to natural gas, however, this component is less dominant. In absolute terms, the energy component increased from around 50.5 €/MWh to 52.7 €/MWh (Figure 21). The energy component's share of the total cost is, however, rather stable at around 70-71% for the years included in this study.

While the grid fee's share of the electricity bill decreased during 2010-2011, mainly due to increased importance of the RES levy, it increased again between 2011-2012, and represented around 14% of total costs in 2012 (again, since the RES levy decreased in importance). In absolute terms, the cost of grid fees increased somewhat from 2010 to 2012. In 2010 the EU average grid fee cost was 10.3 €/MWh while in 2012 it was 11.0 €/MWh (+7%).

From 2010 to 2011 the RES levy increased from 10.1 €/MWh to 13.8 €/MWh while in 2012 it decreased to 9.9 €/MWh. The RES levy's share of the electricity bill also peaked in 2011 when it represented around 15%. For the whole time period, the RES levy's share of the total electricity bill decreased from 12% in 2010 to 11% in 2012. One explanation for the decrease in 2012 from 2011 probably lies in increased refunds on the RES-levy for some of the plants in 2012.

The share of other taxes and levies (excl. VAT) was rather stable during the period, around 3-4%. Adding the levy for RES and other taxes and levies, also their total share of the electricity price appears stable when comparing 2010 with 2012. There is no clear tendency for additional cost burdens to plants from taxes and levies during the time period studied.

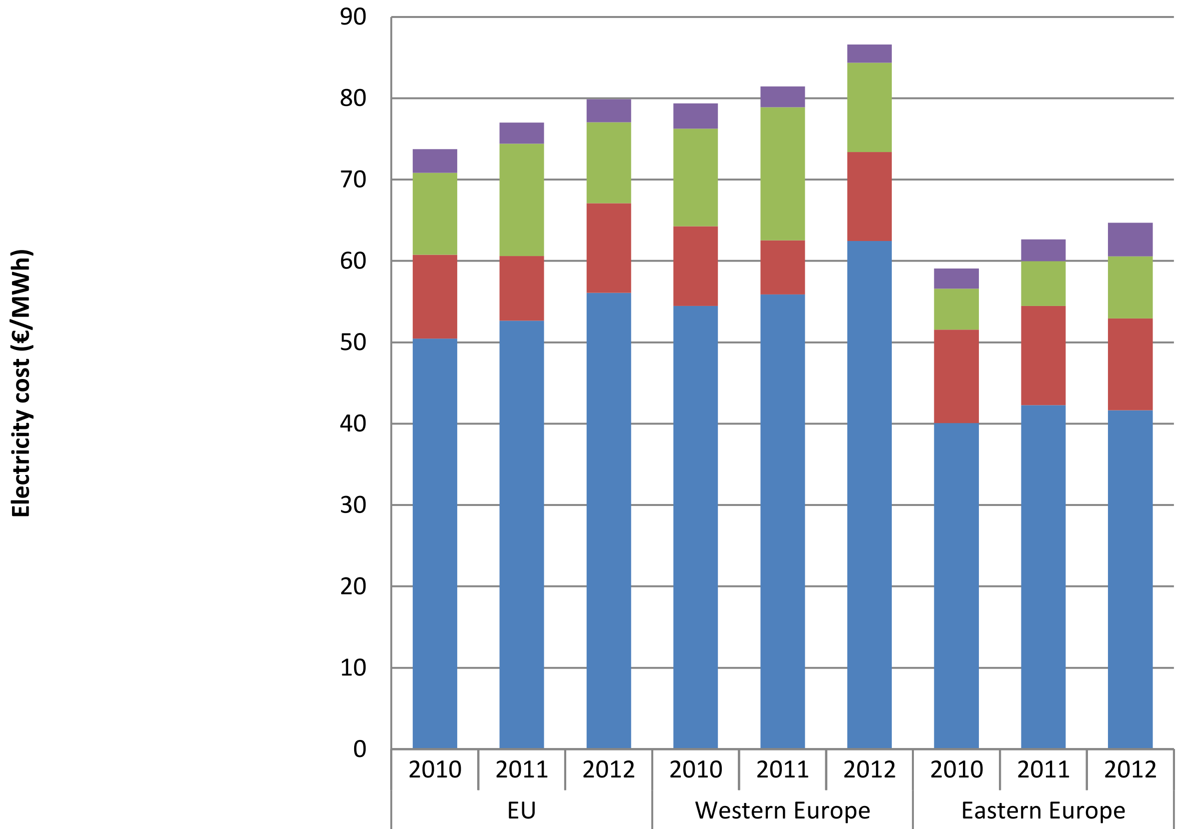
Figure 20. Electricity bill components, EU weighted average



	EU			Western Europe			Eastern Europe		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
Other taxes and levies	3.7%	3.0%	3.8%	3.6%	2.7%	2.6%	3.8%	3.8%	6.5%
Levy for RES and other non-recoverable taxes	12.0%	14.9%	11.2%	13.8%	17.2%	11.1%	7.5%	7.5%	11.5%
Network cost	14.1%	11.4%	14.0%	12.2%	8.9%	12.6%	19.3%	19.3%	17.0%
Energy component	70.2%	70.7%	71.1%	70.4%	71.1%	73.7%	69.4%	69.3%	65.0%

Source: Authors' own calculations based on questionnaires.

Figure 21. Components of the electricity bills paid by the sampled float glass producers in EU, weighted average, €/MWh



	EU 2010	EU 2011	EU 2012	Western Europe 2010	Western Europe 2011	Western Europe 2012	Eastern Europe 2010	Eastern Europe 2011	Eastern Europe 2012
Other levies & taxes (excl. VAT)	2.9	2.6	2.8	3.1	2.6	2.3	2.5	2.7	4.1
RES levy	10.1	13.8	9.9	12.0	16.4	11.0	5.0	5.5	7.6
Grid fees	10.3	8.0	11.0	9.8	6.6	10.9	11.5	12.2	11.3
Energy component	50.5	52.7	56.1	54.5	55.9	62.4	40.1	42.3	41.6

Source: Authors' own calculations based on questionnaires.

4.7.2.2 Regional differences

Figure 20 and Figure 21 also show the breakdown of costs for Western Europe and Eastern Europe. The data presented in this section do not include Southern Europe since the data availability in this geographical region on the breakdown of costs was too limited (see section 4.5.1). On regional level, the following trends can be observed:

Western Europe

For Western Europe, the energy component has increased somewhat in importance (from 70% to 74%), which is above the EU average in 2012 (see Figure 20). It is also worth noting that some plants in Western Europe stand out with a share of the energy component above 80%, while one Western European plant had a share just under 60%. The grid fee was lower than the EU average and stable at around 12-13%

as a share of the electricity bill when comparing 2010 and 2012. The large drop in the grid fee's share of the electricity bill in 2011 was mainly due to an increased share of the RES levies for that year.

The RES levy, on average for Western Europe, decreased from 12.0 €/MWh in 2010 to 11.0 €/MWh in 2012 (-9%). The RES levy in Western Europe is higher in absolute terms when compared to Eastern Europe. The RES levy peaked in 2011 mainly as a result of increased level in one Western European country when it, on average, made up 17% of the electricity bill. The decline in 2012 could probably partly be attributed to increased exemptions for some plants in the sample. For the time period studied, the levy for RES in total expressed as a share of the electricity bill decreased from 14% in 2010 to 11% in 2012. It is also worth noting that for one of the plants in Western Europe, this share was reported to be above 30% for all years.

During the same time period, there was a decrease of the cost for other tax and levies in Western Europe. In 2010 the cost of other taxes and levies was on average 3.1 €/MWh while the corresponding figure in 2012 was 2.3 €/MWh (-27%). The share of taxes and levies also reached its minimum in 2012 when it made up around 3% of the total electricity bill.

Eastern Europe

When comparing 2012 to 2010 the share of the energy component in the total bill has decreased somewhat in Eastern Europe, from 69% to 65%. In absolute terms, the grid fee was stable during the period, while in relative terms its share decreased from 19% in 2010 to 17% in 2012 (see Figure 20). This development is related to the stronger increase of other components, especially the levy for RES.

In 2010 the share of the average RES levy was 7% in Eastern Europe, but increased to 12% in 2012. When compared to the average for Western Europe, the RES levy's share of the total electricity bill was lower in 2010 and 2011 but comparable in 2012. In absolute terms, however, the RES levy is lower than in Western Europe. The RES levy increased from 5.0 €/MWh in 2010 to 7.6 €/MWh in 2012 (+52%).

Compared to Western Europe, where the cost from other levies and taxes decreased during the period, Eastern European plants had an increasing trend. Other taxes and levies increased from 2.5 €/MWh to 4.1 €/MWh (+64%). For the plants in the sample in Eastern Europe it appears that the additional burden due to RES and other levies and taxes is on the rise for producers, adding up to almost 20% of the total electricity bill in 2012.

4.8 Energy efficiency

Energy efficiency is often measured in terms of value added (MWh/€) or in terms of physical output (MWh/tonne). To analyse the energy efficiency in the float glass sector, the research team asked producers to provide information about annual energy use, value added and quantity produced. The completeness and quality of the data provided varied, especially when it comes to value added. We therefore provide energy intensity data in terms of physical output.

4.8.1 General trends

Several energy carriers are used in the production process: electricity, natural gas and fuel oil. Natural gas and fuel oil are used for heating the furnace and are interchangeable for this purpose. According to the industry, using natural gas instead of fuel oil demands approximately 8% more energy. Three plants in our sample switched to natural gas from fuel oil during the time period studied. However, the research team did not find any correlation between increased share of natural gas and energy intensity.

Natural gas as energy source dominates for the plants in the sample. On average, natural gas consumption made up 82% of total energy consumption, while fuel oil made up 12% and electricity 6%.

In order to compare outputs, the research team aggregated energy use from fuel oil and natural gas when presenting energy intensities for the three plants that use fuel oil. Fuel oil was converted from tonnes to MWh with conversion factors provided by the industries. Electricity intensities are presented separately.

4.8.1.1 Energy intensity (natural gas and fuel oil)

Energy intensities for EU and the geographical regions are presented in Figure 22. Four of the plants indicated in the questionnaire that investments in energy efficiency had been made during the time period studied.

The data on energy intensity does not, however, show a clear trend; the average intensity decreased from 2010 to 2011 (-9%) and then increased from 2011-2012 (+3%). For the whole period, 2010-2012, energy intensity decreased by 3%.

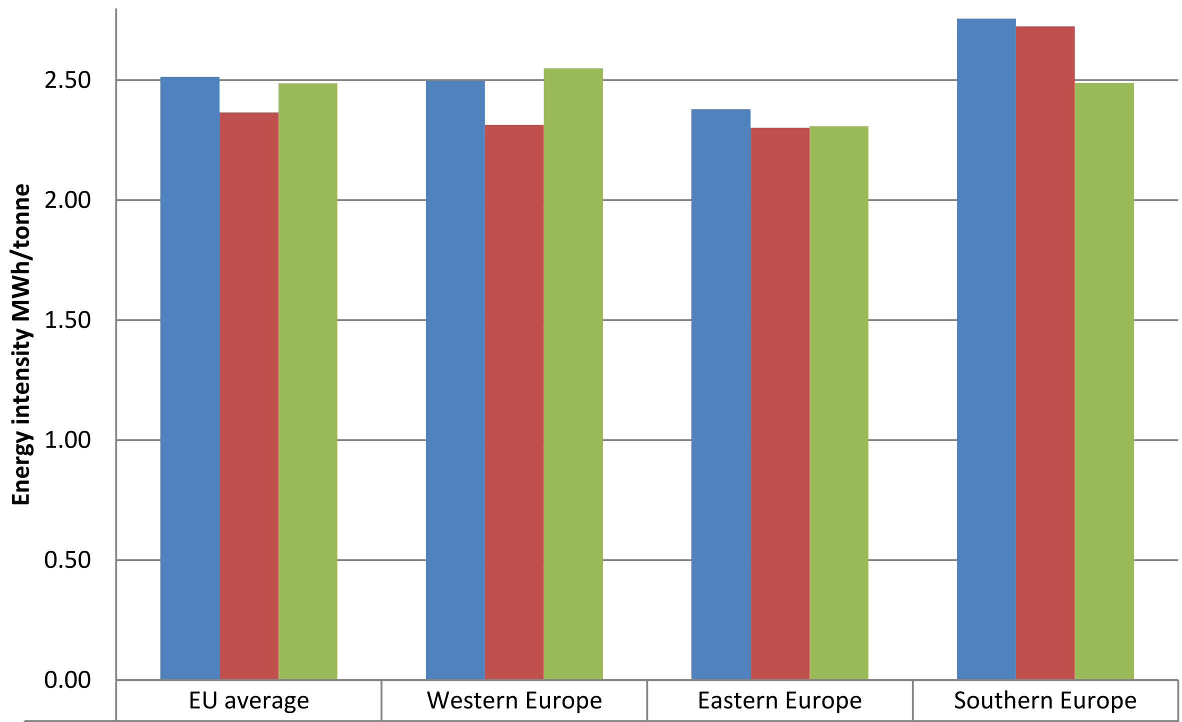
Figure 22 also illustrates regional differences in energy intensity.

Western European plants had a similar trend as the EU average. While the energy intensity decreased from 2010 to 2011 (-7%), it increased again from 2011 to 2012 (+6%).

Eastern Europe reported a somewhat lower energy intensity compared to the other geographical regions. For the period studied the energy intensity slightly decreased, from 2.4 Mwh/tonne to 2.3 Mwh/tonne (-3%).

The plants in Southern Europe had the highest energy intensity on average. Energy intensity in Southern Europe decreased during the period from 2.8 MWh/tonne to 2.5 MWh/tonne (-10%).

Figure 22. Energy intensities (natural gas and fuel oil) in terms of physical output, weighted average, MWh/tonne



	EU average	Western Europe	Eastern Europe	Southern Europe
2010	2.51	2.50	2.38	2.76
2011	2.37	2.31	2.30	2.73
2012	2.49	2.55	2.31	2.49

4.8.1.2 Electricity intensity

Electricity, as an energy source, varies between 3-11% for the plants in this sample. The average electricity consumption for the sample was 6%. No clear trends can be observed from Figure 23, which illustrates electricity intensity in the EU and the geographical regions. For the whole sample, electricity intensity was rather stable during the period studied. Electricity intensity decreased from 2010 to 2011 (-9%) but increased again from 2011 to 2012 (+10%).

Figure 23 also illustrates geographical differences in electricity intensity.

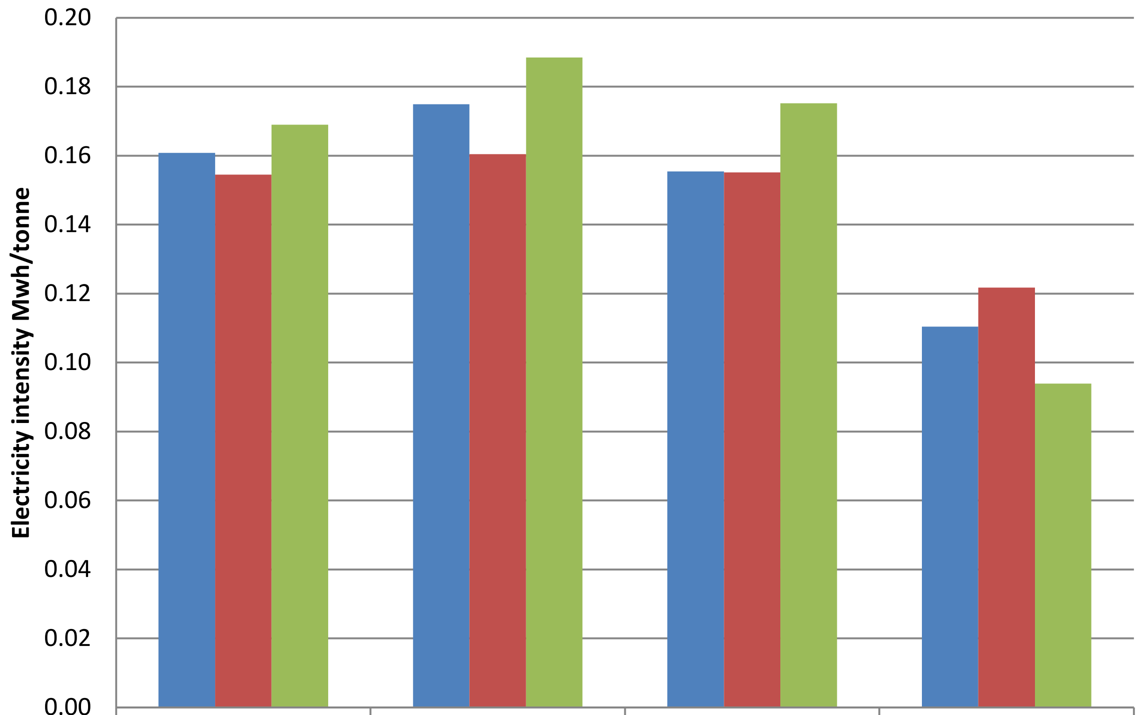
The average electricity intensity in Western Europe was the highest among all regions in the sample, and follows the same pattern as the EU average. Electricity intensity decreased from 2010 to 2011 (-8%), followed by an increase from 2011 to 2012 (+17%).

In Eastern Europe, electricity intensity increased during the period studied, in particular between 2011-2012 (+13%). The electricity intensity in 2012 was higher than the EU average and in Southern Europe, but lower than in Western Europe.

Southern Europe had the lowest electricity intensity compared to the other regions. On average, electricity consumption during the time period decreased from 0.11

MWh/tonne in 2010 to 0.09 MWh/tonne in 2012 (-15%). It is also worth mentioning that this is the region with the highest electricity price (see Figure 15).

Figure 23. Electricity intensities in terms of physical output, weighted average, MWh/tonne



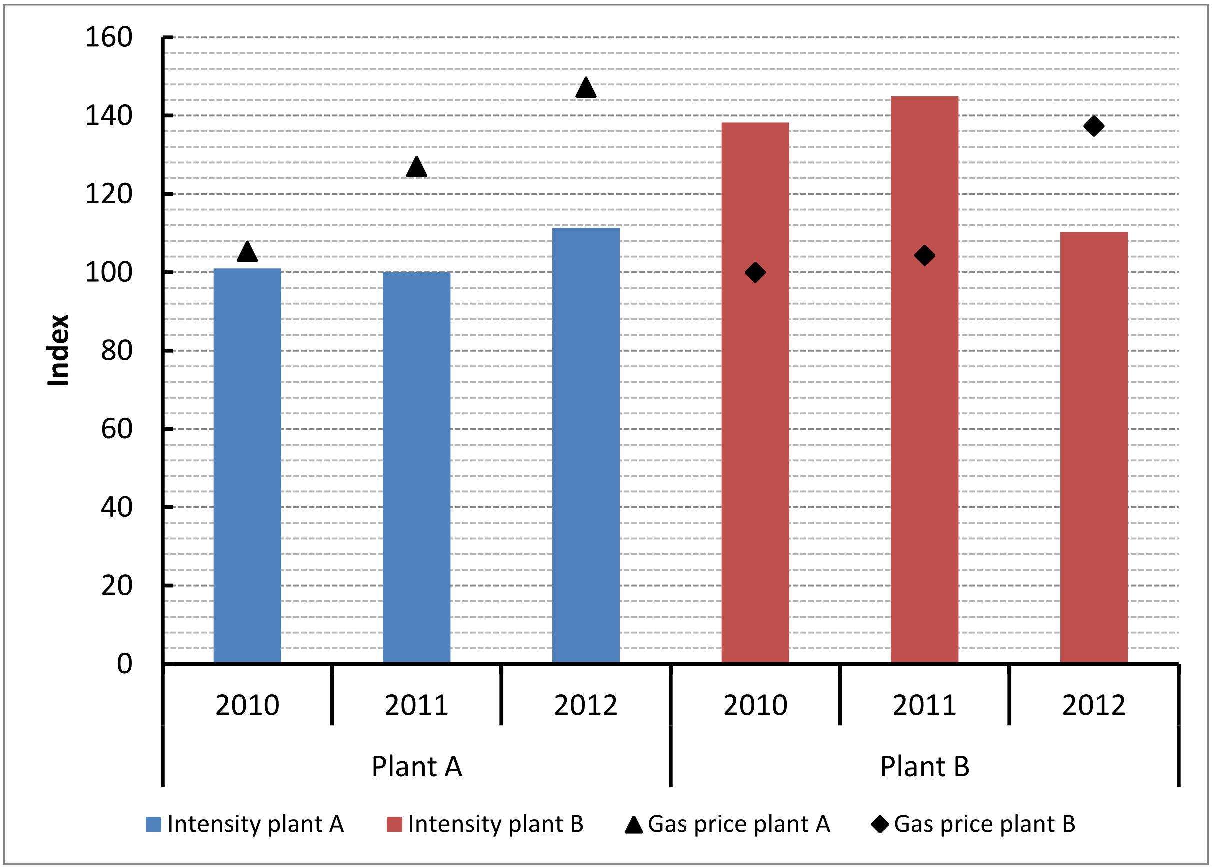
	EU average	Western Europe	Eastern Europe	Southern Europe
2010	0.16	0.17	0.16	0.11
2011	0.15	0.16	0.16	0.12
2012	0.17	0.19	0.18	0.09

4.8.2 Case studies

Figure 24 illustrates the natural gas intensity of two sampled plants in relative terms. Indexed values have to be used in order not to disclose confidential information. The corresponding gas prices paid by the producers were also indexed and are included in the graph. Both of the plants in the sample use only natural gas as energy source (and electricity, but this is not covered in the graph) and have comparable capacities.

In the case of Plant A, natural gas intensity increased by 10% during the period, while natural gas prices were on the rise the entire period observed (+40% during the whole period). Plant B had in 2010 and 2011 much higher natural gas intensity compared to Plant A. However, in 2012 Plant B was as efficient as Plant A. At the same time, natural gas prices for Plant B increased substantially from 2011 to 2012 (+31%). Based on this limited data and sample as well as the limited time horizon considered, it is difficult to draw any clear conclusions from this case study.

Figure 24. Natural gas intensity and natural gas prices of two plants (indexed values, lowest value = 100)



4.9 Indirect ETS costs for the Glass Sector

4.9.1 Sample

Information on the indirect costs of ETS was obtained from the industry via questionnaires. As mentioned above, float glass producers are grouped in 3 different regions: Western Europe, Eastern Europe and Southern Europe (see Figure 10).

As described in section 4.5.3, the calculation of indirect ETS costs for the float glass industry was based on the electricity consumption figures provided by the sampled EU float glass producers as well as on the regional emission intensity of electricity generation and price of emission allowances. Tables 13, 14 and 15 summarise the indirect costs borne by EU float glass producers with different pass-on rates (0.6, 0.8 and 1.0).

4.9.2 Results

Table 13. Glass indirect costs, averages per region (Euro/tonne of glass)

	Western Europe	Eastern Europe	Southern Europe
2010	0.95	1.42	0.57
2011	0.89	1.32	0.60
2012	0.60	0.81	0.25

Pass-on rate: 0.6

Table 14. Glass indirect costs, averages per region (€/tonne of glass)

	Western Europe	Eastern Europe	Southern Europe
2010	1.26	1.90	0.76
2011	1.18	1.76	0.81
2012	0.81	1.09	0.33

Pass-on rate: 0.8

Table 15. Glass indirect costs, averages per region (Euro/tonne of glass)

	Western Europe	Eastern Europe	Southern Europe
2010	1.58	2.37	0.95
2011	1.48	2.20	1.01
2012	1.01	1.36	0.41

Pass-on rate: 1

The Western European sample consists of six float lines, two of which deserve attention. One plant indicated that they acquired electricity via a long-term contract; they did not face any indirect costs because the contract pre-dated the ETS. A second Western European plant used self-generated power to cover a small part of its electricity consumption and only incurred indirect costs for the proportion of its electricity bought in the market.

There are large inter-regional differences in indirect costs, caused by two distinct factors. First the maximum regional CO2 emissions factor[78], which is lowest in Southern Europe and highest in Eastern Europe.

Secondly, differences in electricity intensities between plants. The float lines in Southern Europe consume on average circa 0.10 MWh/tonne of glass, compared with circa 0.17 in Eastern Europe and circa 0.18 in Western Europe.

[78] As defined and listed in Annex IV of the 'Guidelines on certain State aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012' (2012/C 158/04).

The drop in indirect ETS costs across all regions between 2011 and 2012 can be largely attributed to a sharp decrease in EUA prices (from a yearly average of 13.77 €/EUA in 2011 to a yearly average of 7.56 €/EUA in 2012).

4.9.3 Key findings

1) The inter-regional differences are relatively large. Indirect ETS costs in Eastern Europe are more than twice as high as the indirect costs faced by Southern European glass plants (see Tables 13, 14 and 15). Eastern Europe has both a higher average of emission intensity for electricity generation, and glass plants in that region also use, on average, more electricity per unit of output than Southern-European plants.

2) The average indirect costs for the plants in Southern Europe are significantly lower than for other regions. Two factors contributed to this: lower electricity intensity of production at Southern European plants, but also lower maximum regional carbon intensity of electricity generation.

3) The ETS indirect cost was significantly lower in 2012 compared to the previous years, because the price of EUAs was significantly lower in 2012. This decrease in carbon prices was partly compensated in the Western European sample by increased electricity consumption per tonne of output in two plants.

4.10 Production costs and margins

4.10.1 General figures

This section presents an analysis of the production costs and margins for EU producers of saleable float glass[79]. As already pointed out, 7 plants provided complete data on production costs and 4 plants provided data on financial indicators (e.g. EBITDA). To allow for a comparison between the various indicators, the research team proceeded with a reduced sample size of 4 plants. Validating the data provided by the producers was not possible.

All figures are expressed in Euro per tonne of saleable product at current prices. For the plants included in the sample, the following elements are estimated for the years 2010, 2011 and 2012:

- Total production costs per tonne of product, whose estimate includes all production costs, inter alia cost of finished goods, other operating expenses, depreciation, amortization and financial expenses referred to the product line;

[79] Following consultation with the industry, financial indicators per tonne are based on saleable production and not melted production. The factor to be used to reduce melted capacity to saleable capacity varies between plants with size, age and production mix. To convert melted capacity to saleable capacity an average factor of 0.82 is used. This factor is based on Glass for Europe members' average production experience (Glass for Europe, 2011).

- EBITDA,[80] i.e. the difference between plant market price and production costs, excluding capital costs;
- EBITDA over turnover (unit: %).

The figures reported in Table 16 are weighted averages for the sample, based on individual plant production.

Table 16. Production costs and margins, (saleable float glass) 2010-2012

	2010	2011	2012
Production costs (€/tonne)	252.3	260.9	306.3
EBITDA (€/tonne)	76.5	96.1	16.3
EBITDA / turnover (%)	21.9	25.0	4.4

In 2010, the production costs amounted for 252.3 €/tonne. Costs increased to 260.9 €/tonne in 2011 and to 306.3 €/tonne in 2012 for the sampled facilities. This corresponds to an increase of 21% between 2010 and 2012.

The EBITDA does not show a clear trend. It increased between 2010 and 2011 and decreased again in 2012. It is worth noting that it is not possible to estimate a trend for profits from only three years of observation. Moreover, with only three years included in the sample, there is too little data to draw any conclusions about possible correlations between energy cost data and production cost.

4.10.2 Impact of energy costs on production costs

This section presents the impact of energy costs on production costs for melted and saleable production. Energy costs in terms of €/MWh have been converted into costs in terms of €/tonne using the corresponding energy intensities (electricity, natural gas). In addition, the ratio between these energy costs and production costs was calculated. The ratio between the various energy cost components and EBITDA was not calculated due to the low number of plants that provided data both on EBITDA and on the energy cost components. The figures reported in Table 17 are weighted averages for the sample, based on individual plant production.

[80] EBITDA stands for Earnings Before Interest, Taxes, Depreciation and Amortisation.

Table 17. Impact of energy costs on production costs (melted and saleable float glass), 2010-2012[81]

	Electricity			Natural gas		
	2010	2011	2012	2010	2011	2012
Energy costs / production costs (%), melted production	3.9	4.0	3.6	21.0	24.4	28.1
Energy costs / production costs (%), saleable production	3.2	3.3	3.0	17.2	20.0	23.0

Source: Authors' own elaboration.

For the four plants in the sample, and during the period of the study, the share of natural gas costs over total production cost shows an increasing trend. Natural gas costs over total production costs for melted production increased from 21% in 2010 to 28% in 2012 and natural gas costs over total production cost for saleable production increased from 17% to 23%. Electricity costs share of production cost seems steady and represent about 4% of production costs for melted production and 3% for saleable production. During the time period studied, the sum of electricity and natural gas costs varied between around 25% and 32% for melted production and between 20% to 26% for saleable production.[82]

4.11 General impressions

The research team used the questionnaire to ask EU producers about their impressions of the effect of liberalisation, investments in energy efficiency, energy exemptions, how they procure energy or the energy intensity of the sector.

Some of the respondents described that the impact from liberalisation on contractual arrangements and prices paid for electricity and gas had not delivered the expected results. A few respondents saw a limited impact from liberalisation, in the form of lower prices.

Several of the plants described RES-levies and other taxes as one of the major price drivers in their electricity contracts. It was also mentioned that the impact from RES levies was expected to increase in the future. Also, the evolution of the wholesale market was mentioned by many respondents as a major driver in the electricity contract. For natural gas prices, the evolution on the wholesale market of heavy fuel oil and gas oil was mentioned as a major driver.

A number of plants in the sample stated that they were not entitled to any exemptions/reductions from network tariffs, taxes or levies. Some of the respondents

[81] The figures on energy costs on production cost is an average for the four plants that provided data on production costs and margins, such as EBITDA, as described in section 4.10.1.

[82] Please note that some of the plants in the sample use both fuel oil and natural gas. Hence, the numbers in Table 17 should not be understood as share of energy costs in production costs for plants using only natural gas and electricity.

described that they were entitled to certain reductions, without providing extensive details. A limited number of plants, however, gave a detailed description of the energy exemptions and reductions they were entitled to, for every year in the studied time period.

None of the respondents had the price of CO_2 explicitly expressed in the electricity contract.

Many of the respondents described that they recently changed the way they procure electricity and gas. For example, one plant changed from purchasing electricity from the forward market only to include spot market elements in the procurement strategy. Some plants described that they switched supplier of natural gas and changed to hub-based pricing.

One of the plants had a long term supply contract for electricity (20 years), while most of the respondents described that they had contracts ranging between 1 to 3 years.

To summarize, plants differed in the way they procure electricity and gas but most plants have contracts ranging between 1 to 3 years. In general, plants saw the RES levy, or the future RES levy, and the market evolution as main energy price drivers. Since data is scarce on energy exemptions for the industry, no detailed analysis can be made on this point.

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CHAPTER 5.
THE CASE OF THE CERAMICS INDUSTRY - BRICKS AND ROOF TILES

FABIO GENOESE, JULIAN WIECZORKIEWICZ, LORENZO COLANTONI, WIJNAND STOEFS AND JACOPO TIMINI

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5.1 Description and production

5.1.1 Introduction

The bricks and roof tiles sub-sector is constituted of four main categories of products, divided on the basis of their intended usage: (i) building bricks, (ii) roof tiles, (iii) paving bricks and (iv) chimney and other clay constructional products such as cowls, flue-blocks and chimney liners. These products are all made of the same raw material: clay. Usually, bricks and roof tiles are water and electricity resistant and fireproof. They are also characterized by a long functional life (Cerame-Unie, 2012).

The sub-sector of bricks and roof tiles is marked by seasonality. Winter is the season with the least activity which, together with the dependence on the building sector, leads to a widespread variability in demand.

5.1.2 Production process

The production of bricks and roof tiles consist of four main stages: (i) the preparation of the raw materials[83], (ii) shaping, (iii) drying and (iv) firing.

The first stage of the production process is the preparation of raw materials for shaping. Shaped products are dried in special chambers or tunnel dryers. Drying can last from 8 to 72 hours, at temperatures ranging from 75° to 90°. Drying is the most energy intensive stage of the production process (Cerame-Unie, 2013b). Dried products are then fired to acquire their main characteristics, i.e. water-resistance, fire-resistance and hardiness. The majority of the kilns employed by the producers are heated by natural gas (85% of cases). Coal and oil are usually employed when the latter is not available. Finally, products are exposed for cooling and later shipped to the distribution sites (EC, 2007).

[83] The raw material employed by the industry is clay, together with a few other argilliferous materials (bentonite, fire clay, etc.); minerals such as manganese dioxide, titanium dioxide, calcium carbonate. Other materials could be added to obtain different colors or porosity.

Environmental and climate concerns related to the production of bricks and roof tiles are mainly related to the degradation of the extraction sites and CO2 emissions.

In 2011, under the implementation of the ETS Directive, bricks and roof tiles were added to the list of products at risk of carbon leakage. As a result of the transposition of the Directive 2004/08/EC, cogeneration has developed widely in countries which promoted combined heat and power (CHP) generation through incentives, particularly in Spain, Italy and Portugal. However, any new investments in CHP are being withheld in Spain following the removal of such incentives in 2012 (Cerame-Unie, 2012).

5.1.3 Value chain

The production costs of bricks and roof tiles are driven by the costs of energy and transport. The energy-intensity of the sector is reflected by the share of energy in the total costs of production. Due to high transportation costs (reaching up to 10% of the total costs of production), extraction sites are usually located in the vicinity of production sites. As the sector of bricks and roof tiles is directly linked to the building industry, distribution channels are shaped in accordance (EC, 2007).

Table 1 illustrates the breakdown of productions costs for the bricks and roof tiles sub-sector. Note that the figures presented in Table 1 are referring to average EU values. According to the information provided by Cerame-Unie, the costs of energy are the most important cost-driver for the EU producers of bricks and roof tiles; Energy accounts for 30% to 35% of total production costs. Representing roughly 25%-30% of total production costs, labour costs also have a major impact on the costs of production of bricks and roof tiles.

Table 1. Breakdown of production costs (bricks and roof tiles)

Share in production costs	
Energy	30%-35%
Labour	25%-30%
Raw materials	20-25%
Other production costs	15%-20%
Total	100%

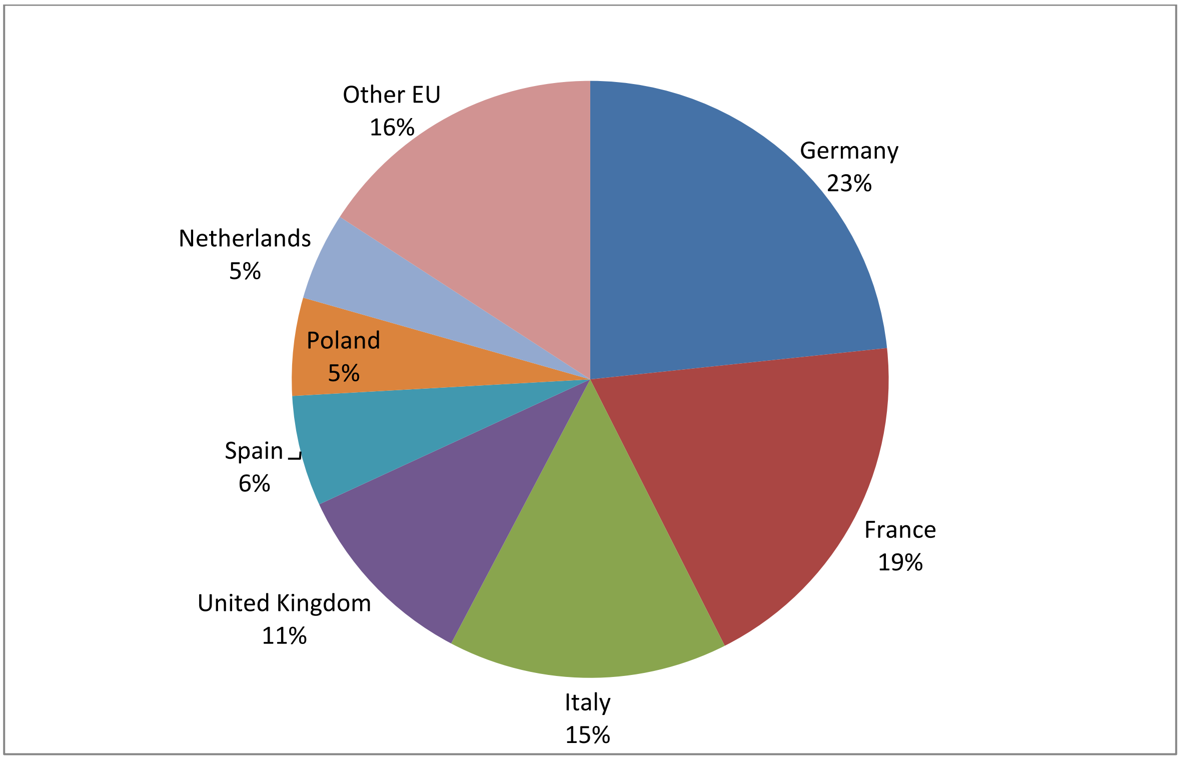
Source: Cerame-Unie (2013a)

5.2 Global and European markets

As a result of high transportation costs and due to their low value-added, there is neither a global nor a European market for bricks and roof tiles. The sub-sector is regionalised. By way of example, the British Competition Commission reports that 80% of bricks and roof tiles produced in the UK are sold not farther than 125 miles away from their production sites. However, Eurostat shows a growing trend in trade both inside and outside the EU, with a trade intensity of roughly 4% (EU extra) and 23% (EU extra and intra) in 2012. A detailed assessment shows that trade exposure of the member states located at the external borders of the EU is significantly above the EU average (Cerame-Unie, 2013a).

Figure 1 illustrates the distribution of the production of bricks and roof tiles among EU member states. In 2012, the joint production of six member states (Germany, France, Italy, the UK, Portugal and Poland) accounted for 79% of total EU production. While other ceramic sub-sectors are dominated by small and medium enterprises (SMEs), the bricks and roof tiles industry is composed almost equally by a number of regionally settled SMEs and larger producers (Cerame-Unie, 2012).

Figure 1. Bricks and roof tiles production in the EU-27 (in 2012)

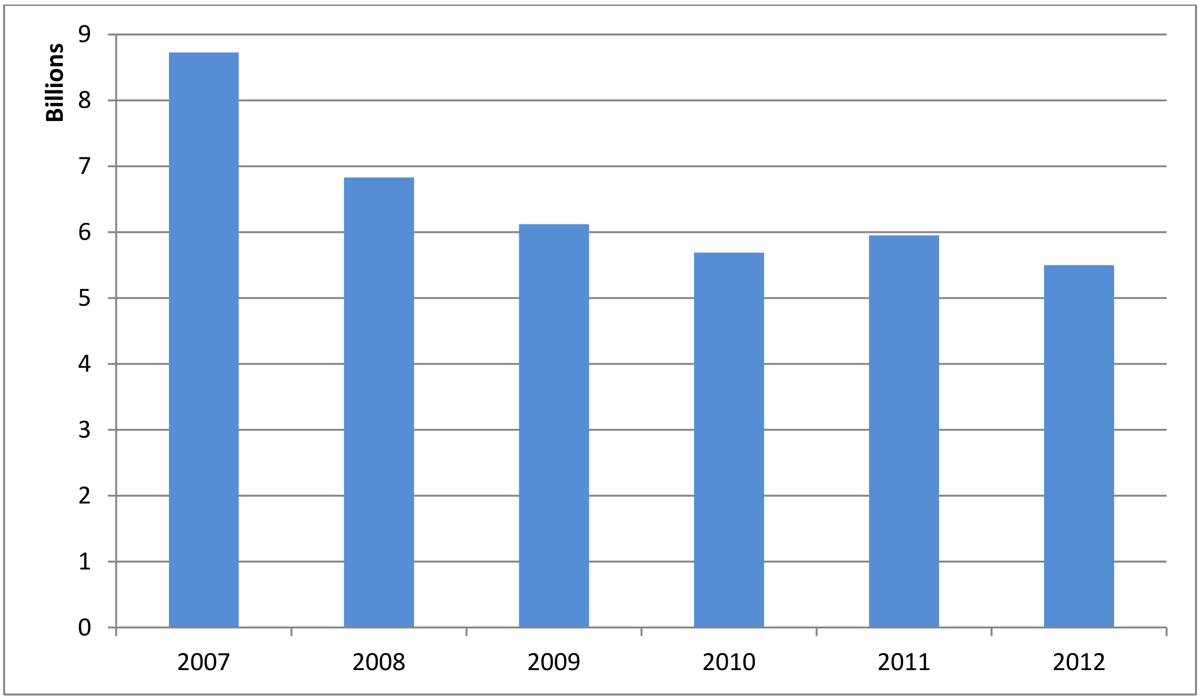


Source: Eurostat (2012).[84]

Figure 2 reports the production value of the EU's bricks and roof tiles industry which, between 2007 and 2012, decreased from a level of 8.7 billion euros to roughly of 5.5 billion euros (i.e. -36%).

[84] Eurostat database: http://tinyurl.com/p23sff

Figure 2. Production value of bricks and roof tiles in the EU (data expressed in billions of Euros)



Source: Eurostat (2012).[85]

5.3 Selection of the sample and sample statistics

5.3.1 The selection of typical facilities

The objective of this sub-chapter is to define and assess the composition and drivers of energy prices and costs in the case of bricks and roof tiles. A total of thirteen plants have been sampled for the purpose of this exercise[86]. To define the sample of typical facilities, the authors of this study tried to apply the following criteria:

- Geographical coverage
- Capacity of plants
- Ownership
- Production technology

Not all of these general criteria could eventually be applied. This issue is described hereunder.

[85] Eurostat database: http://tinyurl.com/p23sff

[86] For more information on the number of collected questionnaires please see Table 3.

5.3.1.1 Geographical coverage

In this case, the following criteria were applied:

Production per member state: four member states (Germany, France, Italy and the UK) covers 68% of the EU production of bricks and roof tiles. Therefore, a representative number of sampled plants are located therein.

Heterogeneity: to the extent possible and without undermining the representativeness of the sample, an element of geographical diversity among the selected plants has been taken into consideration. In short, the sampled facilities are located in member states differing in (i) geographical location, (ii) size and in (iii) the length of their membership in the EU.

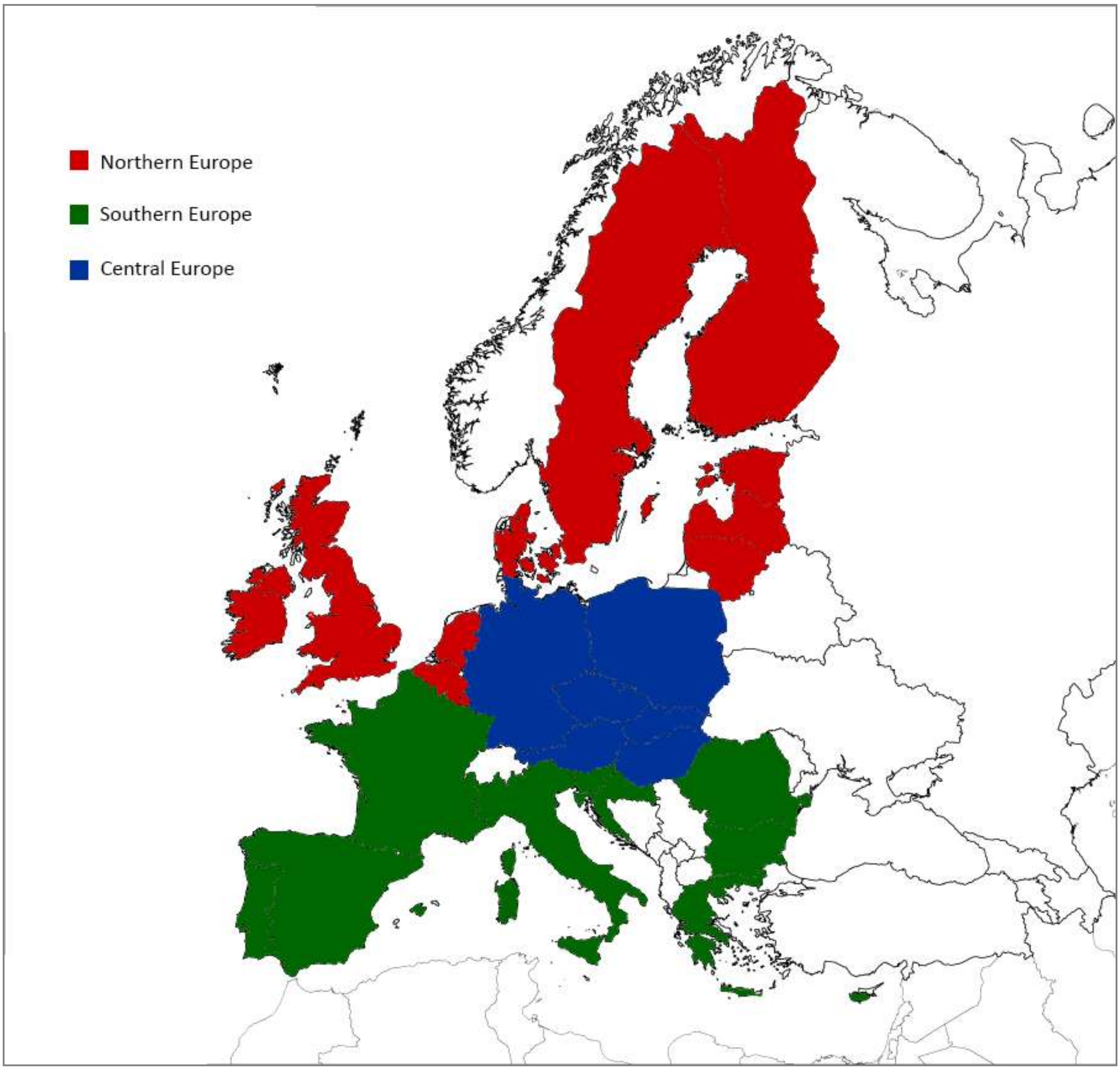
For the abovementioned reasons, thirteen sampled facilities have been allotted to three geographical areas (as illustrated by Figure 3)

a. **Northern Europe** (Ireland, the UK, Belgium, Luxembourg, the Netherlands, Denmark, Sweden, Norway, Lithuania, Latvia, Finland and Estonia), which covers approximately of 38% the EU production in 2012. Five of the sampled facilities are located in this geographical area.

b. **Central Europe** (Germany, Poland, the Czech Republic, Slovakia, Austria and Hungary), which represents approximately 35% of the EU production in 2012. Three of the sampled facilities are located in this geographical area.

c. **Southern Europe** (France, Portugal, Spain, Italy, Slovenia, Croatia, Bulgaria, Romania, Greece, Malta and Cyprus), which covers approximately 27% of the EU production in 2012. Five of the sampled facilities are located in this geographical area.

Figure 3. Bricks and roof tiles: division by regions



Source: Own illustration.

5.3.1.2 Capacity of plants

In general, plant capacity is an important element to establish a sample. Ideally, the sample should include plants that reflect the spectrum of production sizes across the EU. This would require detailed information on the capacity of all plants belonging to a sector. The authors of this study experienced difficulties in obtaining plant capacity data for the sub-sector of bricks and roof tiles as there is no external source of information. Due to the fragmentation of the sub-sector (according to the association, more than 700 companies are active in this sub-sector), the European Ceramic Industry Association was not in a position to provide this information. However, Cerame-Unie identified 21 plants producing bricks and roof tiles willing to participate in the exercise. Two additional questionnaires were submitted by producers operating in third countries. Having gained access to the information from these facilities, CEPS researchers adjusted the sample, including plants of varied production capacities (ranging from 25.000 to 250.000 t/year). This range is considered well representative of the sub-sector by the association.

5.3.1.3 Ownership

The sub-sector of bricks and roof tiles is composed almost equally by a number of SMEs and larger producers. The sample aims at reflecting the structure of the sub-sector. For this reason, out of thirteen plants, five are owned by SMEs and eight by large producers.

5.3.1.4 Production technology

The technology used by producers of bricks and roof tiles is standardised and had little bearing as a criterion for the sample.

5.4 Methodology

As previously described, the sample consists of 13 plants, which are located across three different regions.[87] For all 13 plants, cost and consumption data are available, i.e. annual and specific costs for the total amount of electricity and the natural gas consumed. One monthly energy bill is available for 6 out of 13 plants. Annual bills (i.e. 12 monthly bills) are available for 6 more plants. One of the sampled facilities was unable to submit an energy bill (neither monthly nor annual). This enabled CEPS researchers to perform a basic plausibility check of the information obtained via the questionnaires.

5.4.1 Data collection

The analysis of the energy prices and costs for the sector of bricks and roof tiles is based on questionnaires sent to all sampled plants. A confidentiality agreement was signed with Cerame-Unie. This agreement provided assurance that all collected data will be treated as strictly confidential.

All participants provided detailed data about their energy prices, structure of energy bills, and energy consumption. Having conducted a quality assessment of data received from all sampled participants, the research team eventually used 13 questionnaires for its analysis.

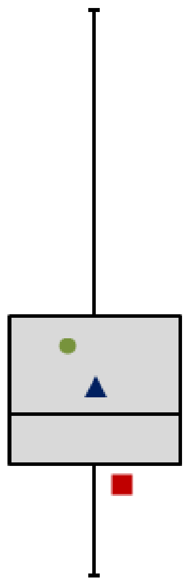
[87] Regions were developed by taking into account the need to reconcile the need for an adequate geographical coverage with confidentiality considerations.

5.4.2 Data analysis and presentation

Box plots are used to display the reported cost ranges and to give an indication of the distribution among the units in the sample. An exemplary box plot is illustrated in Figure 4.

The whiskers located below and above the box represent the minimum and maximum value of the sample. The box itself is divided in two parts by a horizontal line. This line indicates the median of the sample, i.e. the numerical value separating the higher half of the data sample from the lower half. The lower border of the box represents the first (lower) quartile of the sample. It splits off the lowest 25% of the data sample from the highest 75%. Correspondingly, the upper border of the box indicates the third (upper) quartile of the sample, thus separating the highest 25% of data from the lowest 75%. Put differently, the box contains exactly the middle half of the data. The height of the box is also referred to as inter-quartile range (IQR). It is a robust way of showing the variability of a data sample without having to make an assumption on the underlying statistical distribution.

Figure 4. Exemplary box plot



Source: Own illustration.

In order to ensure that no data are attributable to any specific plant, box plots are not created for the regional subsets of the sample, as these consist of only 3-5 plants. Instead, weighted average values are calculated and displayed next to or inside the box plots (see Figure 4). As weighting factors, the corresponding consumption data are applied, i.e. the annual consumption for electricity or natural gas, respectively.[88]

5.4.3 Calculation of indirect ETS costs

The objective of the ETS cost calculations per sector in this study to provide the indirect ETS cost for the sub-sector between 2010 and 2012. The level of information is aggregated on a regional level, though the definition of those regions differs from sector to sector.

The model for the indirect cost of EU ETS in is defined as:

Indirect cost (€/Tonne of product) = Electricity intensity (kWh/Tonne of product)

** Carbon intensity of electricity (Tonne of CO_2/kWh)*

** CO_2 Price (€/Tonne of CO_2) * Pass-on rate*

Where:

- <u>Electricity intensity of production</u>: the amount of electricity used to produce one tonne of product. This amount is sector, plant and process specific;
- <u>Carbon intensity</u> of electricity generation indicates the amount of tonnes of CO_2 emitted by utilities to generate one kWh;
- <u>CO_2 Price</u>: is the average yearly market price of CO_2.
- <u>Pass-on rate</u>: the proportion of direct costs faced by utilities (disregarding any mitigating effects from free allocation) that they pass on to electricity consumers.

Sources:

- <u>Electricity intensity of production</u>; this was acquired from interviews with and questionnaires answered by industry members.
- <u>Carbon intensity of electricity generation</u>: the maximum regional carbon intensity of electricity is utilised, provided by the Commission's Guidelines on State aid measures.[89] Note that these figures are not national. Member States who are highly interconnected or have electricity prices with very low divergences are regarded as being part of a wider electricity market and are deemed to have the same maximum intensity of generation (for example, Spain and Portugal).

[88] The same methodology has also been applied for the sub-sector of wall and floor tiles. Alternatively, annual production data can be used as a weighting factor. This was not possible, as the data on annual production provided in the questionnaires was incomplete. However, consumption and production values are typically correlated, i.e. the difference between the two approaches is expected to be minor.

[89] Communication from the Commission: Guidelines on certain State aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012 (2012/C 158/04).

- CO_2 Price: Yearly averages of the daily settlement prices for Dec Future contracts for delivery in that year. The daily settlement prices were reported by the European Energy Exchange.

Table 2. Average yearly prices per ton of CO2 (€)

Year	2010	2011	2012
CO_2 Price	14.48	13.77	7.56

5.4.4 Validation of information

All sampled plants provided detailed figures on the level and structure of energy prices as well as on energy consumption. The data was assessed, e.g. through a plausibility check and then evaluated. Table 3 presents the number of questionnaires received, selected in the sample and used in the analysis of each section.

CEPS conducted a validation of the collected data through EU energy statistics publications[90]. To further assess consistencies in the responses, the research team performed targeted interviews with sampled producers. The research team was not able to validate the energy prices data, for example, through external sources of information about the costs borne by EU producers at plant level.

Table 3. Number of questionnaires used in each section

Total number received	23
Number included in the sample	13
Energy prices trends	13
Energy bill components	13
Energy intensity	8
International comparison	6
Indirect ETS costs	11

Please note that all of the figures presented in chapters 5.5, 5.6 and 5.8 include possible exemptions from taxes, levies or transmission costs. The consultant asked

[90] Validation was conducted through the EU Statistical Pocketbook 2013 (European Commission, 2013; available at: http://ec.europa.eu/energy/publications/doc/2013_pocketbook.pdf) and the EU Market Observatory & Statistics.

the producers to communicate the prices they paid for energy carriers between 2010 and 2012. Therefore, their answers include exemptions/reductions if these are applicable. Note that all the replies were submitted on a plant level.

The consultant decided to use only 13 out of 23 collected questionnaires to (i) ensure the geographical representativeness of the sample and (ii) due to the poor quality of some of the received questionnaires. Note that all the questionnaires used by the consultant were submitted on a plant level[91].

5.5 Energy prices trends

5.5.1 Introduction

As mentioned, the most energy intensive stage of the production process is drying, where heating is typically provided by natural gas. This is reflected by the ratio of natural gas and electricity costs, which is in the range of 2.7 and 3.0. This means that electricity has a share of 25 to 27% on total energy costs, whereas natural gas holds a share of 73 to 75%[92].

5.5.2 Natural gas

5.5.2.1 General trends

As shown by the median in Figure 5, the prices of natural gas paid by the sampled producers of bricks and roof tiles are on the rise. In 2010, the median EU price of natural gas paid by those producers was of 30.4 €/MWh. In 2012, that price rose by 17.8% to a level of 35.8 €/MWh.

Furthermore, since 2010, the gap of prices paid by different EU producers kept growing steadily. The increasing inter-quartile range, i.e. the difference between the lower and upper quartile, which represents the middle half of the data, also reflects this trend. From 2011 to 2012, the range between the median and the upper quartile increased considerably, especially in comparison to the length separating the median from the lower quartile. Moreover, the total range of prices has also been increasing since 2010, as indicated by the whiskers of the box plot. According to the data collected, one or more producers are exposed to natural gas prices of up to 63.5 €/MWh.

5.5.2.2 Regional differences

Figure 5 also illustrates the average prices of natural gas paid by European producers operating in different geographical regions. The following trends can be observed at regional levels:

[91] In some cases, respondents provided information at company level, not at plant level, as they were not able to attribute costs and consumptions to different plants.

[92] Calculation based on the sample.

Northern Europe

Augmenting from 28.9 €/MWh in 2010, to 39.7 €/MWh in 2012, the average price of natural gas in Northern Europe increased by 37.4%. It is worth nothing that in 2012, the average north European price of natural gas was closest to the average European price (i.e. 39.5 €/MWh).

Central Europe

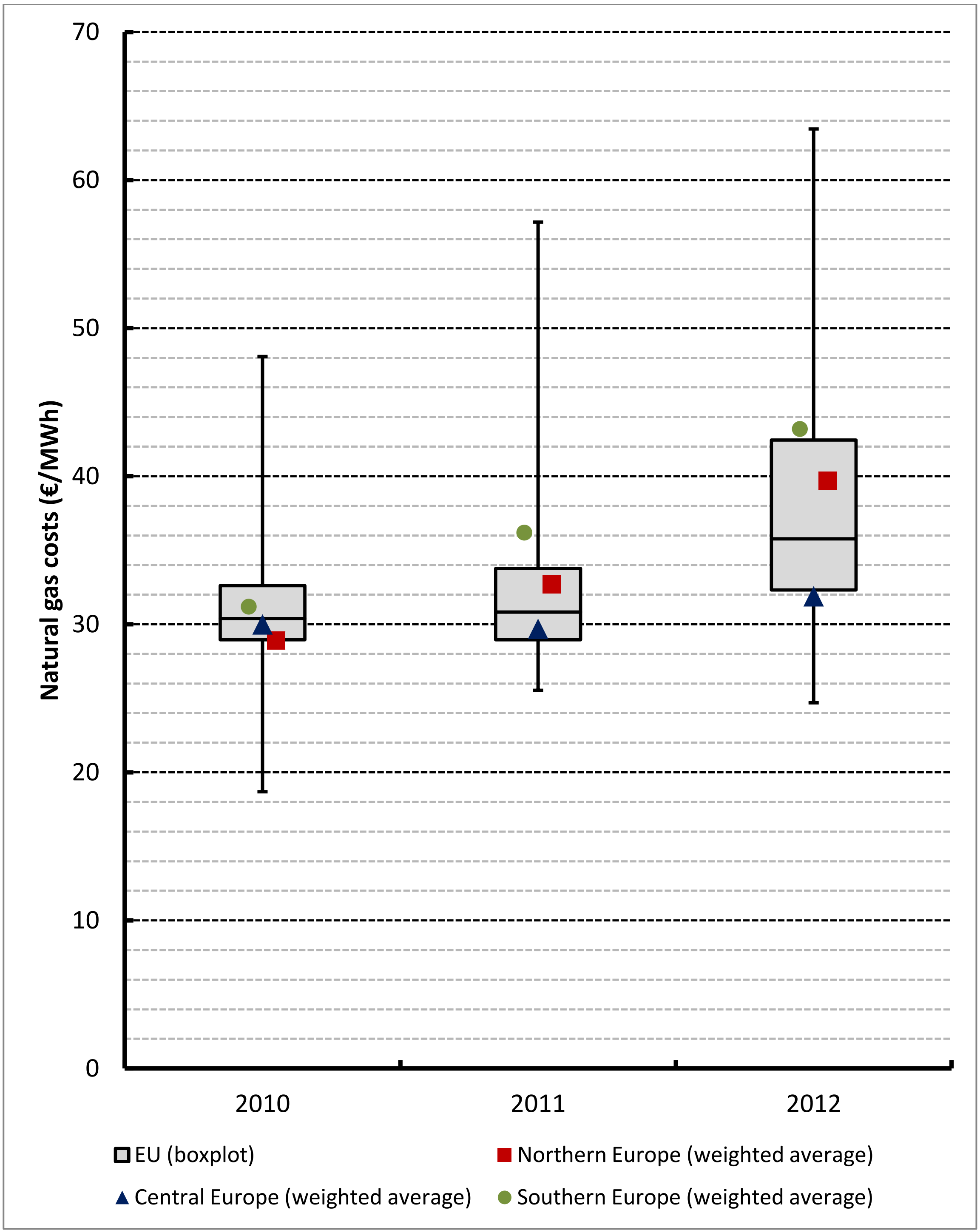
Ranging from 30.0 €/MWh in 2010 to 31.9 €/MWh in 2012, the average price of natural gas in Central Europe only increased moderately. It is noteworthy to mention that in 2012, the average price paid by Central European producers fell below the lower quartile of prices for the whole sample. This development is due to the soaring prices of gas in other regions, especially in Southern Europe. Therefore, in 2012:

- Central European producers paid lower prices than producers operating in Southern and Northern Europe;
- An average producer operating in Central Europe paid lower prices than 75% of the plants in the sample.

Southern Europe

Increasing from 31.2 €/MWh in 2010, to 43.2 €/MWh in 2012, the average price of natural gas in Southern Europe rose by 38.5% and was the highest among the three compared regions. The average price of natural gas paid by southern European producers exceeded the upper quartile of prices for all of Europe in 2011, remaining above this level in the following year. To summarise, the gap between the soaring prices in Southern and Northern Europe and the fairly stable prices in Central Europe grew rapidly.

Figure 5. Prices of natural gas paid by sampled EU producers (2010-2012)



Source: Own illustration.

Table 4. Descriptive statistics for natural gas prices paid by sampled EU producers (€/MWh)

	2010	2011	2012
Europe (average)	30.4	33.2	39.5
Europe (median)	30.4	30.8	35.8
Europe (IQR)[93]	3.7	4.8	10.1
Europe (minimum)	18.7	25.6	24.7
Europe (maximum)	48.1	57.2	63.5
Northern Europe (average)	28.9	32.7	39.7
Central Europe (average)	30.0	29.7	31.9
Southern Europe (average)	31.2	36.2	43.2

Source: Own calculation.

5.5.3 Electricity

5.5.3.1 General trends

Similar to natural gas, the median of electricity prices is on the rise (see Figure 6). For all plants in the sample, the median of costs has increased moderately from 93.8 €/MWh in 2010 to 100.9 €/MWh in 2012. This corresponds to an increase of 7.6%, which is 10.2 percentage points less than the value for natural gas. In 2012, electricity costs of 92.6 €/MWh or less occurred for 25% of the units (first quartile) in the sample. In the same year, 75% of the units (third quartile) had expenses for electricity of 120.7 €/MWh or less. In other words, 25% of the sampled units paid a price of 120.7 €/MWh or more.

The inter-quartile range has been thinning from 2010 to 2012. This means that - for the middle half of the plants in the data sample – the spread of electricity costs has decreased. According to the data provided by the plant owners in the sample, the lower quartile of electricity costs has been increasing faster than the upper quartile of electricity costs, thus reducing the inter-quartile range from 38.2 €/MWh (2010) to 28.1 €/MWh (2012). However, when also considering the whiskers of the box plot,

93 Inter Quartile Range.

which represent the outliers, it becomes evident that the spread between the minimum and maximum cost level does not follow the same trend but instead indicates an upward tendency. Augmenting from 91.4 €/MWh in 2010, to 128.0 €/MWh in 2012, the total range of electricity prices paid by the sampled facilities increased by 36.6 €/MWh with a limited number of plants exposed to electricity costs of up to 186.7 €/MWh.

5.5.3.2 Regional differences

In Figure 6, the weighted average prices of electricity paid by European producers in different geographical regions are illustrated.

In general, the differences between the regions considered in the sample were relatively low in 2010. In that year, expenses for electricity of plants located in Central Europe were about 8.4 €/MWh higher on average than the expenses for plants located in Southern Europe; the cost level in Northern Europe was in-between. This has changed recently (see Table 5). The following trends can be observed at regional level:

Northern Europe

The prices in Northern Europe show a slight upward tendency, increasing from 89.8 €/MWh to 95.0 €/MWh (+5.8%). For all years considered in the analysis, the price is below the median price of the sample, i.e. producers in Northern Europe have lower electricity costs than at least 50% of the plants in the sample.

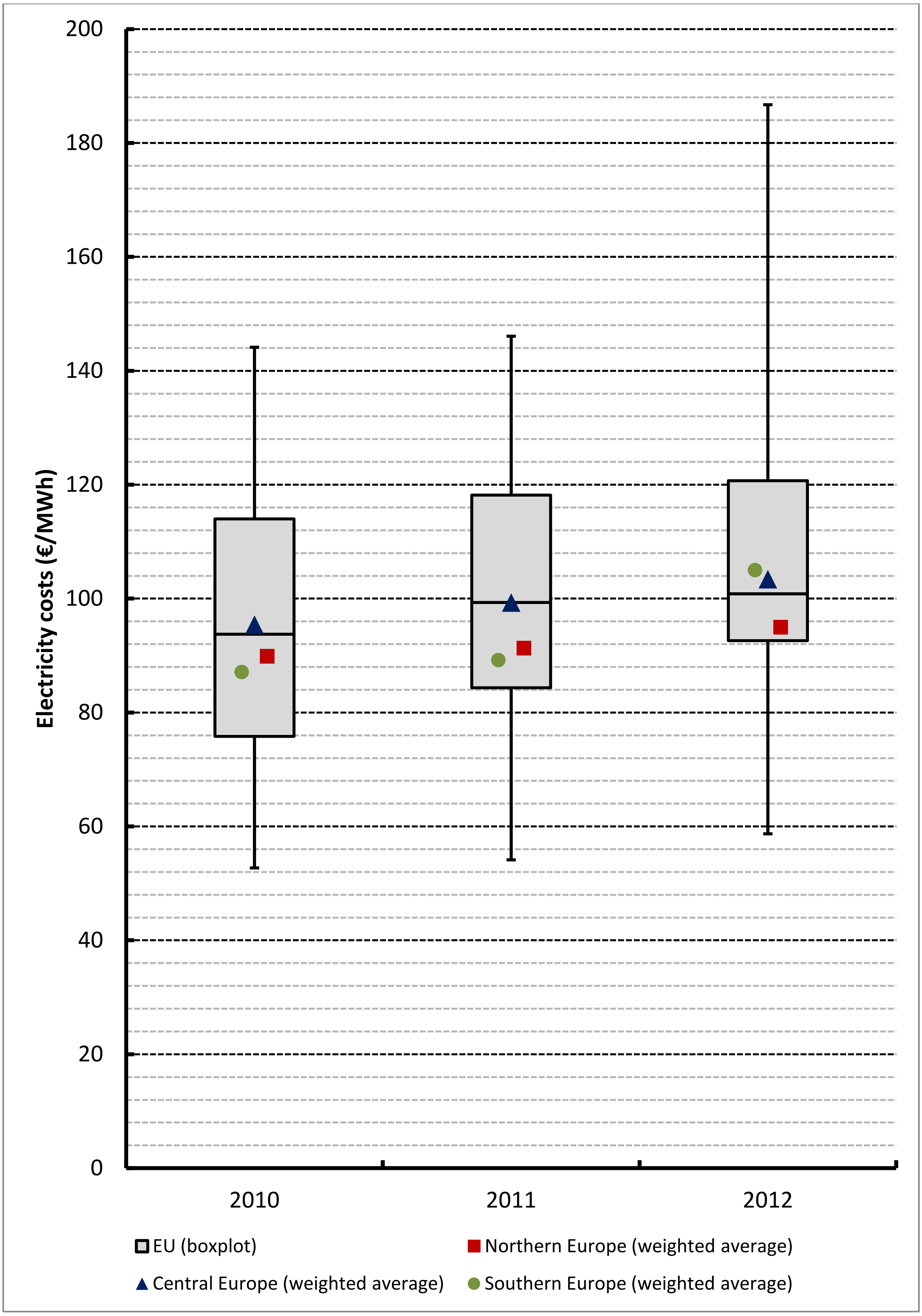
Central Europe

In Central Europe, the upward tendency is stronger, as prices augmented from 95.4 €/MWh in 2010 to 103.4 €/MWh in 2012 (+8.3%). In general, the average price paid by Central European producers is near to the median price of the sample.

Southern Europe

This region shows the strongest rise in prices. Increasing from 87.1 €/MWh in 2010, to 105.0 €/MWh in 2012, the average price of electricity in Southern Europe rose by 21% and is, as of 2012, the highest among the three compared regions. The average price of electricity paid by southern European producers exceeded the median price for the whole of Europe in 2012.

Figure 6. Prices of electricity paid by sampled EU producers (2010-2012)



Source: Own illustration based on questionnaires.

Table 5. Descriptive statistics for electricity prices paid by sampled EU producers (€/MWh)

	2010	**2011**	**2012**
Europe (average)	90.4	93.4	102.4
Europe (median)	93.8	99.3	100.9
Europe (IQR)	38.2	33.8	28.1
Europe (minimum)	52.7	54.1	58.7
Europe (maximum)	144.1	146.1	186.7
Northern Europe (average)	89.9	91.3	95.0
Central Europe (average)	95.4	99.3	103.4
Southern Europe (average)	87.1	89.2	105.0

Source: Own calculation.

5.6 Analysis of energy bills components

5.6.1 Introduction

In order to better understand the price developments, this section provides a breakdown of total costs into specific components. In particular, for natural gas, the total costs are grouped into the following three components: (i) the energy component, (ii) grid fees and (iii) other levies and taxes (excluding VAT). For electricity, there is one additional component, the RES levies.

It is worth noting that the CO2 cost component is not directly visible in this breakdown but is included in the energy component in the case of electricity. Given the relatively low CO2 prices between 2010 and 2012 and the limited share of electricity costs on total costs, the influence of CO2 prices on total costs for bricks and roof tiles was marginal for the period under study. For natural gas this depends on whether producers are getting free emission allowances. This was the case during the second phase of the ETS (2008-2012), i.e. there were no additional costs for CO2 certificates for the period under study. In the future, this cost component could become more important.

5.6.2 Natural gas

5.6.2.1 General trends

As shown by Figure 7 and Figure 8, the energy component is the major driver of natural gas prices for the sampled plants in Europe. In 2010, it amounted to roughly 26.4 €/MWh, reaching a share of 86.9% of the price of natural gas paid by an average European producer of bricks and roof tiles. The increase in natural gas prices was accompanied by a growing share of the energy component (92.7% in 2011 and 94.9%

in 2012). However, this development is also related to the diminishing share of the other two components, namely grid fees and other levies and taxes. Between 2010 and 2012, the costs of grid fees decreased from 3.0 €/MWh to approximately 1.7 €/MWh (-42%). As illustrated by Figure 7, the impact of taxes (excl. VAT) and other levies on the prices of natural gas is marginal. In 2010, they accounted for 3.2% of the cost of gas by the sampled producers. In 2012, this share decreased to 0.7%.

5.6.2.2 Regional differences

Figure 7 also illustrates the breakdown of costs for the 3 different regions. The following trends can be observed at regional level:

Northern Europe

The developments in Northern Europe are in line with the EU trends (i.e. increasing share of the energy components vs. decreasing shares of other components). However, it is worth mentioning that the impact of taxes and levies in Northern Europe is almost non-existent. In 2012, they accounted for less than 0.1% of the average price paid by producers in Northern Europe.

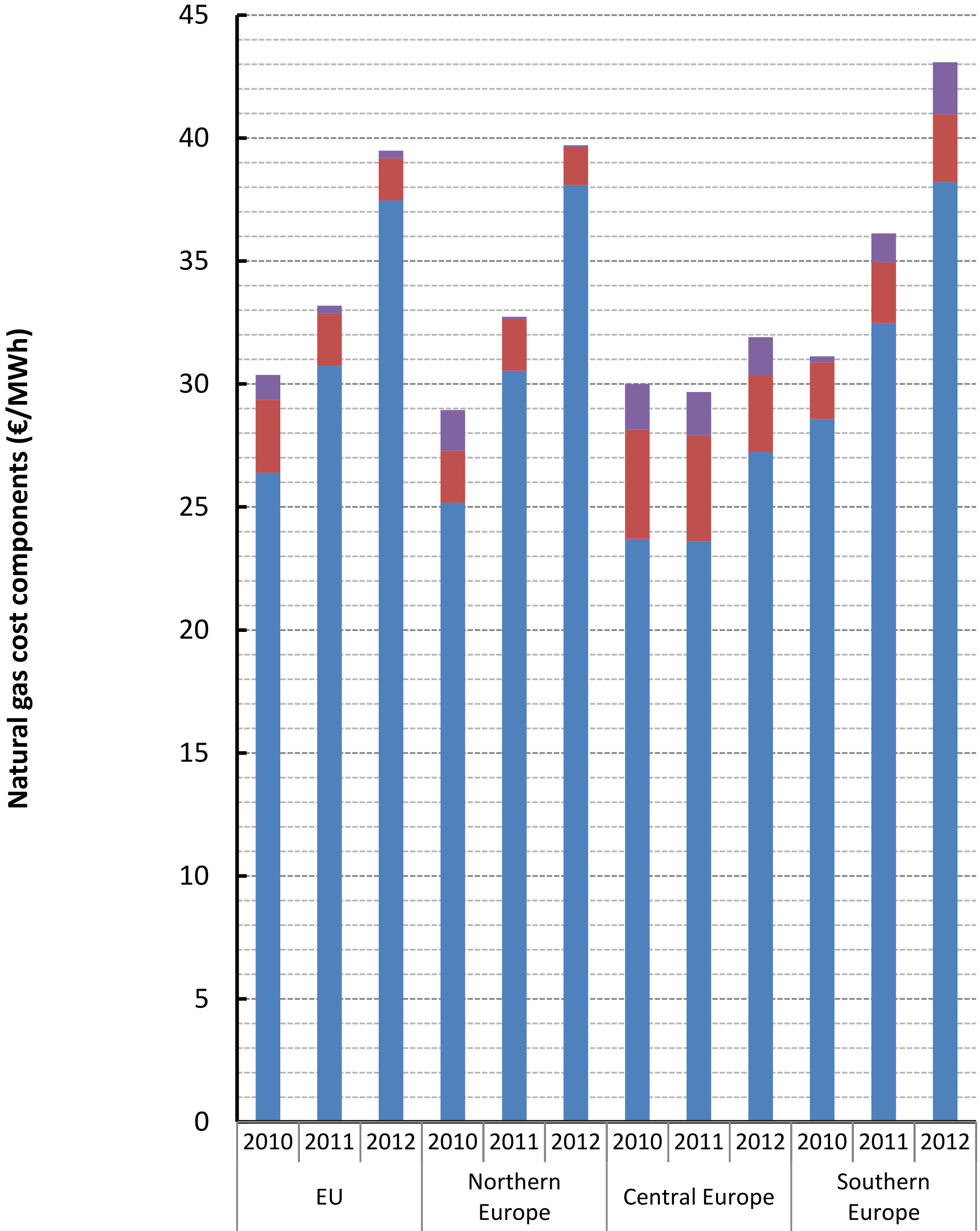
Central Europe

In comparison to the other regions, Central Europe is marked by a relatively strong influence of grid fees on the final price of natural gas (9.8% in 2012). As the share of taxes and other levies represented 4.8% of the price of gas, the impact of the energy component was the lowest among the three compared regions (85.3%, namely -9.6% in relation to the EU average). Such breakdown of the average gas price is particularly interesting. Indeed, among the three compared regions, producers operating in Central Europe benefit from the lowest prices for natural gas.

Southern Europe

The rising average price of gas paid by southern European producers was accompanied by a growing importance of taxes and levies. Ranging from 0.2 €/MWh in 2010, to 2.1 €/MWh in 2012 (+883%), the influence of this price driver remains limited, yet increasingly important. This can be illustrated by a comparison of the costs of the energy component in Northern and Southern Europe. In 2012, the costs of the latter were similar in the two regions, namely 38.1 €/MWh in Northern Europe vs. 38.2 €/MWh in Southern Europe. However, due to different taxation, the average price of natural gas paid by producers was higher in Southern Europe than in Northern Europe (by 3.4 €/MWh).

Figure 7. Components of the natural gas bills paid by the sampled producers in Europe (in €/MWh)

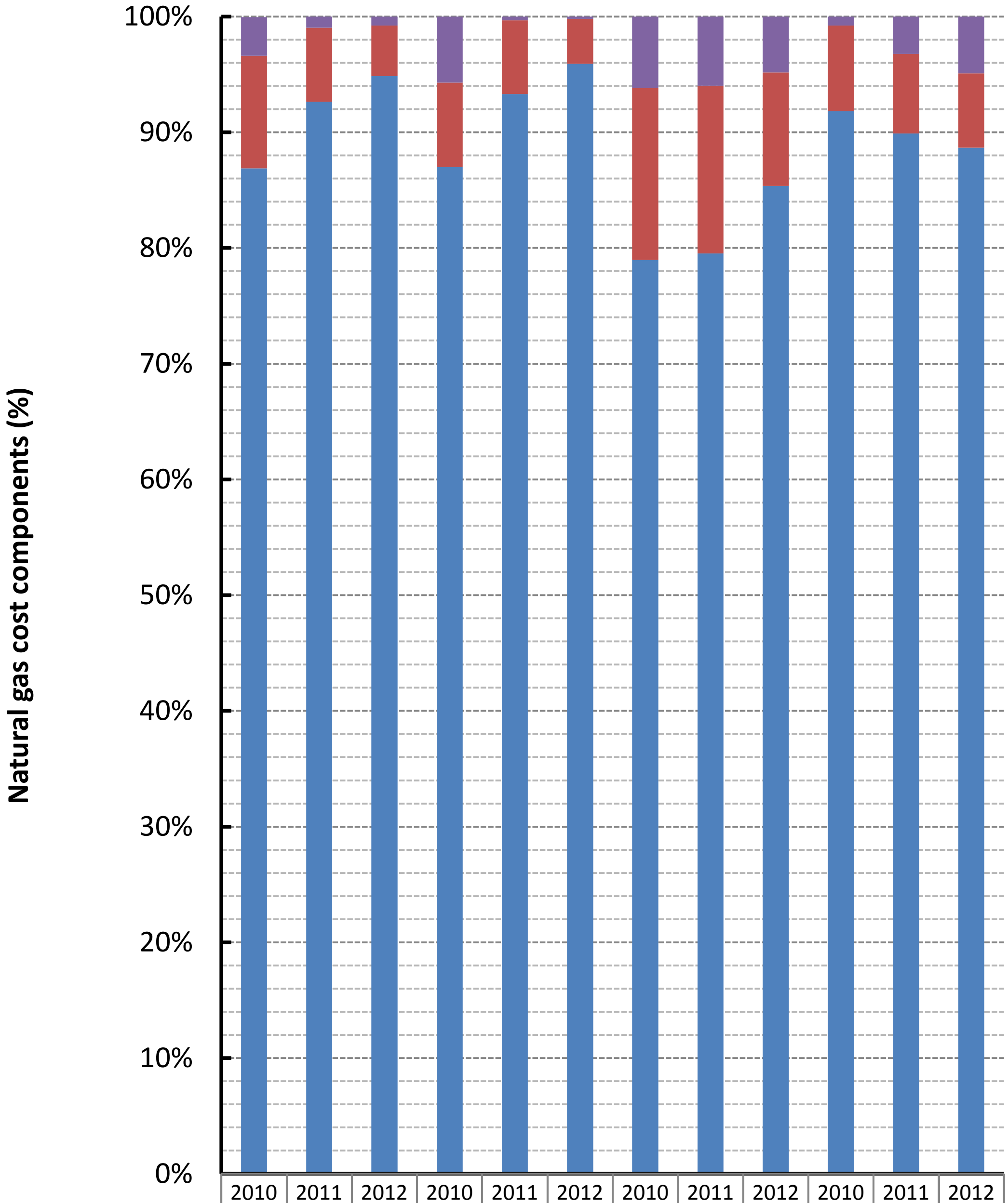


	EU 2010	EU 2011	EU 2012	Northern Europe 2010	Northern Europe 2011	Northern Europe 2012	Central Europe 2010	Central Europe 2011	Central Europe 2012	Southern Europe 2010	Southern Europe 2011	Southern Europe 2012
Other (excl. VAT)	1.0	0.3	0.3	1.7	0.1	0.1	1.9	1.8	1.5	0.2	1.2	2.1
Grid fees	3.0	2.1	1.7	2.1	2.1	1.5	4.4	4.3	3.1	2.3	2.5	2.8
Energy component	26.4	30.7	37.5	25.2	30.5	38.1	23.7	23.6	27.2	28.6	32.5	38.2

Energy component   Grid fees   Other (excl. VAT)

Source: Own calculation based on questionnaires.

Figure 8. Components of the natural gas bills paid by the sampled producers in Europe (in %)



	EU			Northern Europe			Central Europe			Southern Europe		
	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
Other (excl. VAT)	3%	1%	1%	6%	0%	0%	6%	6%	5%	1%	3%	5%
Grid fees	10%	6%	4%	7%	6%	4%	15%	15%	10%	7%	7%	6%
Energy component	87%	93%	95%	87%	93%	96%	79%	80%	85%	92%	90%	89%

Source: Own calculation based on questionnaires.

5.6.3 Electricity

5.6.3.1 General trends

In accordance with the structure of natural gas prices, the energy component is the most significant component of the electricity price paid by the sampled production facilities in Europe (see Figure 9 and Figure 10). However, in comparison to natural gas, this component is less dominant. In 2010, the energy component amounted for roughly 58.3 €/MWh, reaching a share of 64.5% of the electricity price paid by an average sampled European producer of bricks and roof tiles. In the same year, grid fees amounted to 17.6 €/MWh (19.5%), RES levies for 6.3 €/MWh (7.0%) and other levies & taxes (excl. VAT) for 8.1 €/MWh (9.0%).

Augmenting from 58.3 in 2010 to 59.9 €/MWh in 2012, the costs for the energy component have remained relatively stable in absolute terms. However, its share has been diminishing over the last two years, reaching a value of 58.4%. This development is related to the stronger increase of other components. From 2010 to 2012, average grid fees have increased by 3.7 €/MWh (+20.1%), RES levies by 4.6 €/MWh (+72.8%) and other levies & taxes (excl. VAT) by 2.3 (+27.9%). For the sampled facilities, the additional burden due to RES support schemes is clearly visible in the electricity bills.

5.6.3.2 Regional differences

On a regional level, the following trends can be observed:

Northern Europe

In comparison to the general situation, Northern Europe is marked by a stronger influence of grid fees on final electricity prices. In 2012, the share on total costs amounted to 29.5%. In contrast, the share of RES levies is significantly lower than in other parts of Europe (3.2% in 2012). The sum of all components has increased from 89.8 to 95.0 €/MWh (+5.8%) in the observation period.

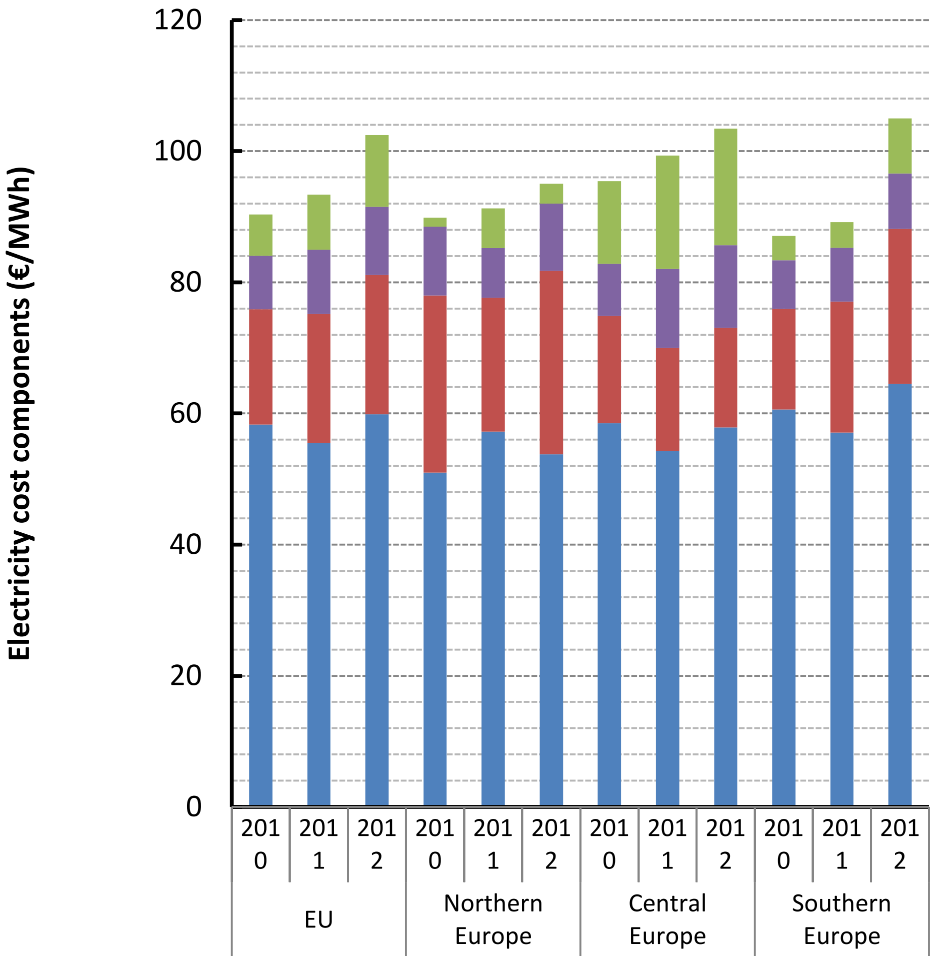
Central Europe

In Central Europe, RES levies have a higher impact on final electricity prices than they do in the other regions. In 2012, the share on total costs amounted to 17.2%. Other taxes & levies also have a greater influence compared to the European average of sampled producers (13.3% in 2012). As a result, grid fees are lower than in the other regions, both in absolute (15.2 €/MWh in 2012) and relative terms (16% in 2012). Augmenting from 95.4 to 103.5 €/MWh, the sum of all components has seen a 8.4% increase, i.e. a stronger increase than in Northern Europe.

Southern Europe

In comparison to the other regions, Southern Europe has shown the strongest increase of electricity in the observed period. Average electricity prices have increased from 87.1 to 105.0 €/MWh, which corresponds to a 20.6% increase. Augmenting from 3.7 €/MWh in 2010 to 8.4 €/MWh in 2012, the RES levy has seen a 129.0% increase. In the same period, grid fees have also been on the rise (+54.2%), while the trend of the energy component was not stable. From 2010 to 2011, the costs for this component fell by 3.5 €/MWh, but then regained 7.4 €/MWh from 2011 to 2012. As of 2012, the sampled plants of Southern Europe are exposed to the highest electricity prices among all the sampled facilities.

Figure 9. Components of the electricity bills paid by the sampled producers in Europe (in €/MWh)

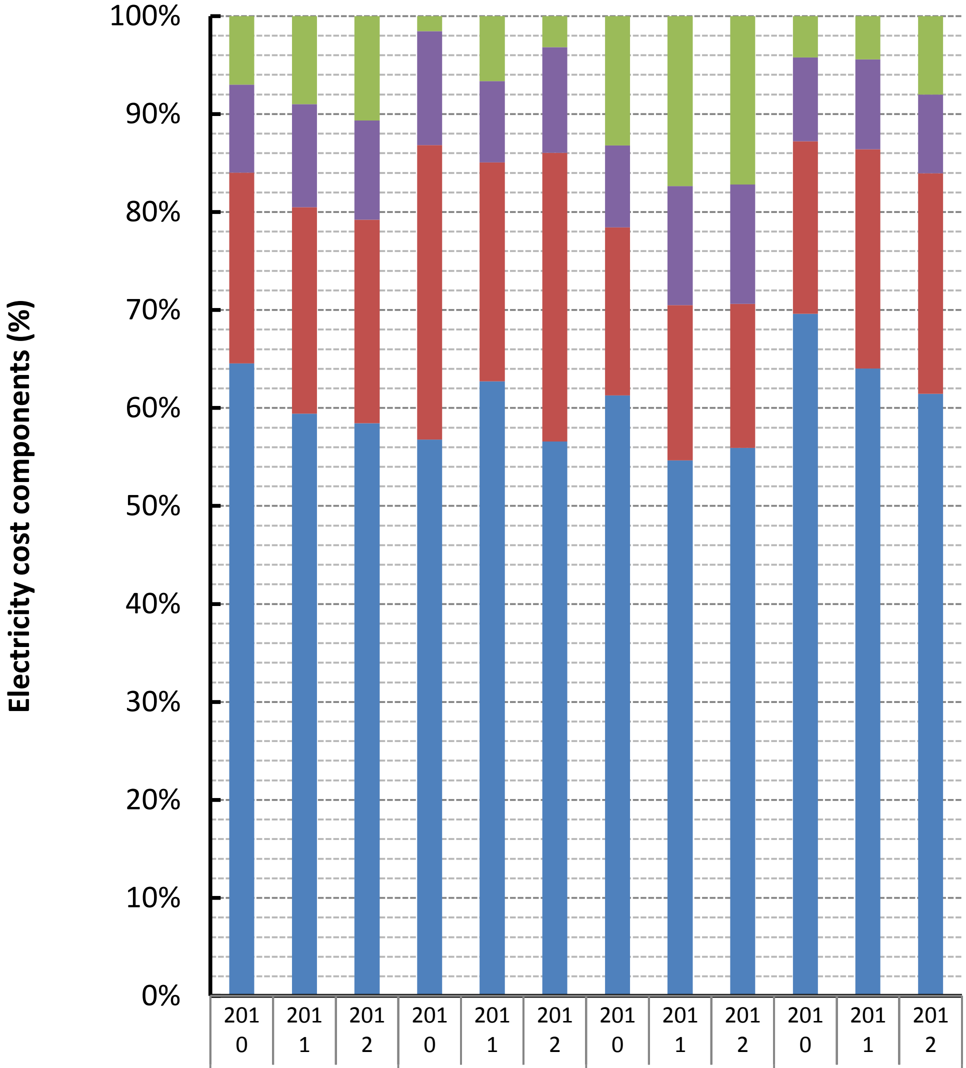


	EU 2010	EU 2011	EU 2012	Northern Europe 2010	Northern Europe 2011	Northern Europe 2012	Central Europe 2010	Central Europe 2011	Central Europe 2012	Southern Europe 2010	Southern Europe 2011	Southern Europe 2012
RES levy	6.3	8.4	10.9	1.4	6.1	3.0	12.6	17.2	17.8	3.7	3.9	8.4
Other (excl. VAT)	8.1	9.8	10.4	10.5	7.6	10.2	8.0	12.1	12.6	7.4	8.2	8.4
Grid fees	17.6	19.7	21.3	27.0	20.4	28.0	16.3	15.7	15.2	15.3	20.0	23.6
Energy comp.	58.3	55.5	59.9	51.0	57.2	53.8	58.5	54.3	57.9	60.6	57.1	64.5

Energy comp. Grid fees Other (excl. VAT) RES levy

Source: Own calculation based on questionnaires.

Figure 10. Components of the electricity bills paid by the sampled producers in Europe (in %)



	EU 2010	EU 2011	EU 2012	Northern Europe 2010	Northern Europe 2011	Northern Europe 2012	Central Europe 2010	Central Europe 2011	Central Europe 2012	Southern Europe 2010	Southern Europe 2011	Southern Europe 2012
RES levy	7%	9%	11%	2%	7%	3%	13%	17%	17%	4%	4%	8%
Other (excl. VAT)	9%	11%	10%	12%	8%	11%	8%	12%	12%	9%	9%	8%
Grid fees	19%	21%	21%	30%	22%	29%	17%	16%	15%	18%	22%	22%
Energy comp.	65%	59%	58%	57%	63%	57%	61%	55%	56%	70%	64%	61%

■ Energy comp. ■ Grid fees ■ Other (excl. VAT) ■ RES levy

Source: Own calculation based on questionnaires.

5.7 Energy intensity

5.7.1 General trends

The consultant asked the producers to provide information about the energy efficiency of their plants by disclosing figures on the energy intensity of their production processes[94]. Intensity is typically measured in terms of value added (unit: MWh/€) or in terms of physical output (unit: MWh/tonne). As several energy carriers are used in the production process, separate intensities should be calculated for each energy source (e.g. electricity, natural gas) to allow a correct interpretation of the data. Producers did not provide such a breakdown. However, it is possible to deduce these figures from the consumption values of each energy source given in the questionnaires.

The completeness of intensity data among respondents was varied. Out of the 13 sampled plants, only 10 provided intensity data in terms of physical output. In terms of value added, complete data was available for only 8 plants. The reduced size of the regional samples impedes the research team to disclose regional statistics due to confidentiality reasons. Instead, only EU-wide figures are given. The weighted average[95] and the median of both electricity and natural gas intensities in terms of physical output were calculated. To give an indication of the variability of the sample the inter-quartile range (IQR) is used. Minimum and maximum values cannot be disclosed due to confidentiality reasons.

Table 6. Descriptive statistics for the natural gas intensities for 10 out of 13 sample production plants in terms of physical output (MWh/tonne)

	2010	**2011**	**2012**
Europe (average)	0.52	0.54	0.56
Europe (median)	0.58	0.50	0.53
Europe (IQR)	0.24	0.22	0.29

The figures collected for natural gas are reported in Table 6. Although some plant owners have indicated that investments in energy efficiency have been made, the data does not show a clear trend. The median intensity decreased from 2010 to 2011 and then increased again from 2011 to 2012. Without further information, no

94 It is worth noting that energy intensity does not only depend on the physical features of machines and processes, but also on the capacity utilisation rate. Hence, difference in efficiency across multiple years may not only signal investments in energy efficiency, but also a better utilisation rate.

95 Weighting factor: consumption.

interpretation for this dip can be given. The weighted average intensity was on the rise during the entire observation period. As indicated by the IQR, the difference between the 25% of the plants with the highest intensity and the 25% with the lowest intensity increased from 2010 to 2012.

The figures for electricity are reported in Table 7. In this case, the trend is more visible. While the median decreased, the weighted average remained at the same level. This means that at least one smaller production plant (in terms of consumption) made progress and reduced its electricity intensity over the short time frame covered by this study, while for the rest of the sampled plants this was not evident. This development is also reflected by the increasing IQR. It is worth recalling that electricity has a share of 25 to 27% on total energy costs.

Table 7. Descriptive statistics for the electricity intensities for 10 out of 13 sampled production plants in terms of physical output (MWh/tonne)

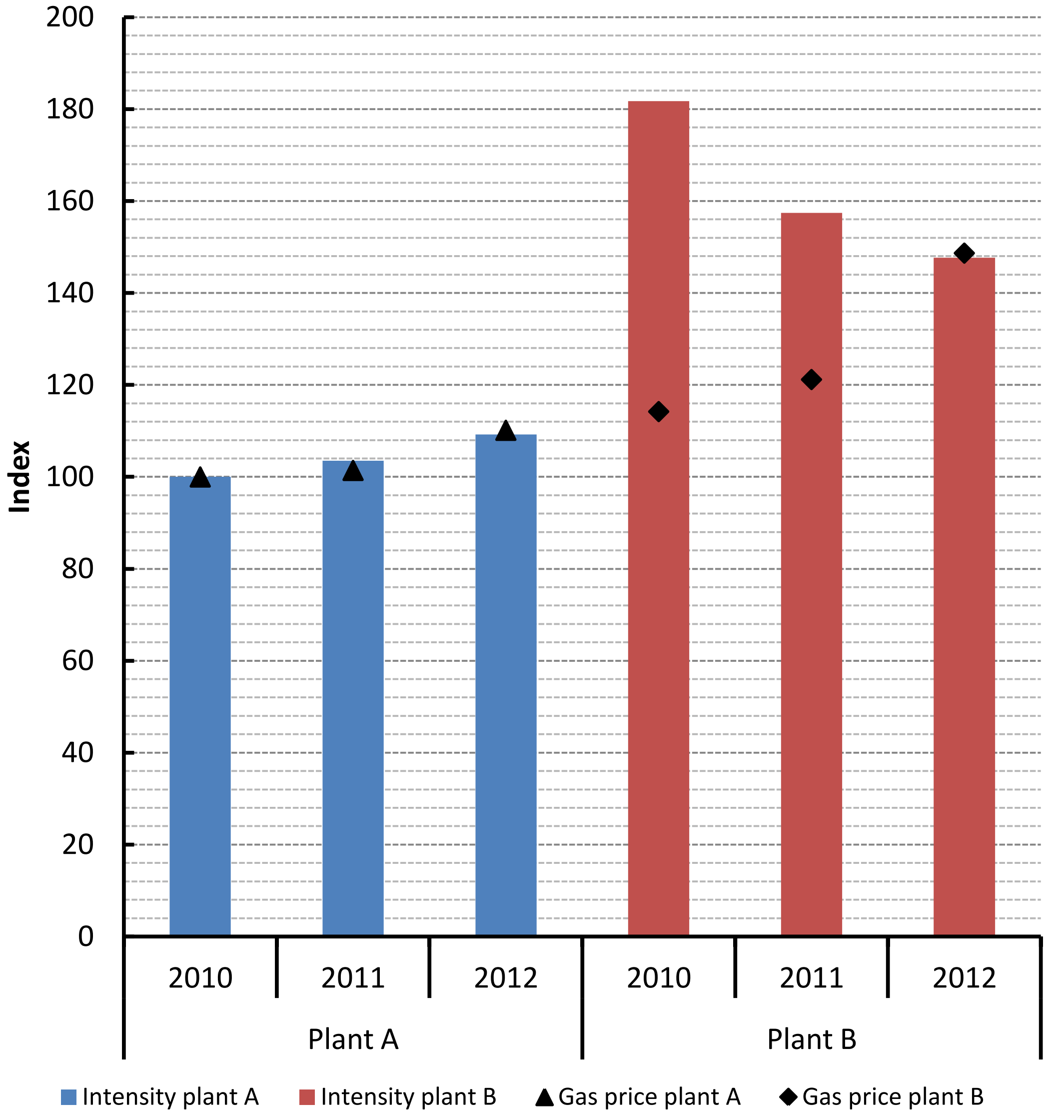
	2010	**2011**	**2012**
Europe (average)	0.07	0.07	0.07
Europe (median)	0.07	0.06	0.06
Europe (IQR)	0.03	0.03	0.04

5.7.2 Plant case study

Figure 11 shows the natural gas intensity of two sampled plants in relative terms[96]. Moreover, the corresponding gas prices paid by the producers were also indexed and have been included in the graph. In the case of plant B, energy efficiency improved over the years (i.e. natural gas intensity decreased), while gas prices were on the rise during the entire observation period (+35% since 2010). However, even after the improvements, plant B is not as efficient as plant A. As of 2012, the latter showed a 38% lower intensity when compared to plant B. In 2010, the difference between the two plants was of 82%. It is worth noting that the research team cannot exclude that drivers other than the rising gas price exist for the increase in energy efficiency.

[96] Indexed (relative) values have to be used in order not to disclose this highly confidential information.

Figure 11. Natural gas intensity and natural gas prices of two plants (indexed values, lowest value = 100)



Source: Own calculation.

5.8 International Comparison

The aim of this chapter is to compare the prices of energy carriers paid by producers based in the EU with the prices paid by manufacturers operating in third countries, namely Russia and the US. This section is based on a series of plant case studies. Data collected from two manufacturing sites located in Russia and the US has been confronted with figures collected through the questionnaires submitted by the sampled EU plants. Plants selected for this assessment are of comparable production capacities in order to avoid distortions that are due to different consumption levels of natural gas or electricity. In other words, the Russian plant and the EU plants “A” and

"B" have similar production capacities. Likewise, the US plant and the EU plants "C" and "D" have comparable production capacity.

As the research team received only monthly energy bills for the Russian and US plant, only plausibility checks could be performed. It is worth noting that the research team cannot assess the representativeness of the Russian or US plants in their respective markets.

5.8.1 Natural Gas

5.8.1.1 EU vs. Russia

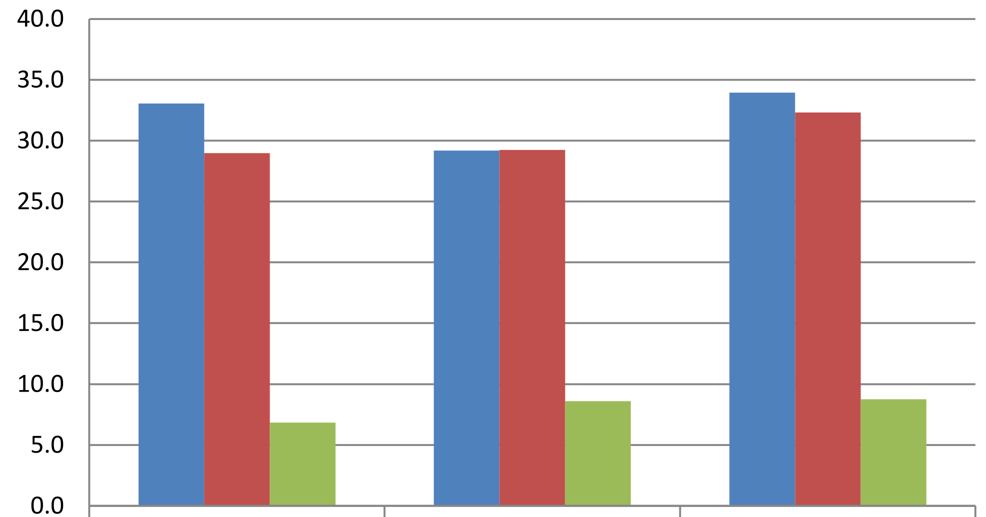
As shown by Figure 12, despite rising prices, the selected Russian facility benefited from the lowest prices of natural gas among the three compared plants during the entire observation period. Moreover, during the same timeframe, the prices paid by this specific Russian facility were lower than those of any EU plant included in the sample.

The prices of gas paid by EU plant "A" decreased from 2010 to 2011 (-12%) and then increased again to a level of 33.9€/MWh in 2012 (+16.1%). Without further information, no explanation for this dip can be given. EU Plant "B" experienced a similar trend; gas prices paid by that plant were augmenting throughout the observation period. Since 2010, they increased from 28.9 €/MWh to 32.3 €/MWh in 2012 (+11.7%). The differences between the two regions are probably due to the fact that prices are regulated in Russia.

5.8.1.2 EU vs. US

As illustrated by Figure 13, the prices of natural gas paid by the selected US facility were the lowest among the three compared plants. Decreasing from 25.2 €/MWh in 2010, to 14.1 €/MWh in 2012, prices diminished by 44.1%. In 2011 and 2012, the prices of natural gas paid by the US-based facility were lower than in any of the EU plants included in the sample. Contrary to the trend experienced by this specific US plant, the prices paid by the two EU facilities increased incessantly between 2010 and 2012. During the same period of time, the prices paid by EU plant "C" augmented from 32.6 €/MWh, to 42.45 €/MWh (+30%). In the case of EU plant "D", prices rose from 31.2 €/MWh in 2010, to 39.4 €/MWh in 2012 (+26.2%). The differences between the two regions are probably due to the fact that US consumers have access to abundant resources of unconventional fossil fuels driving natural gas prices down.

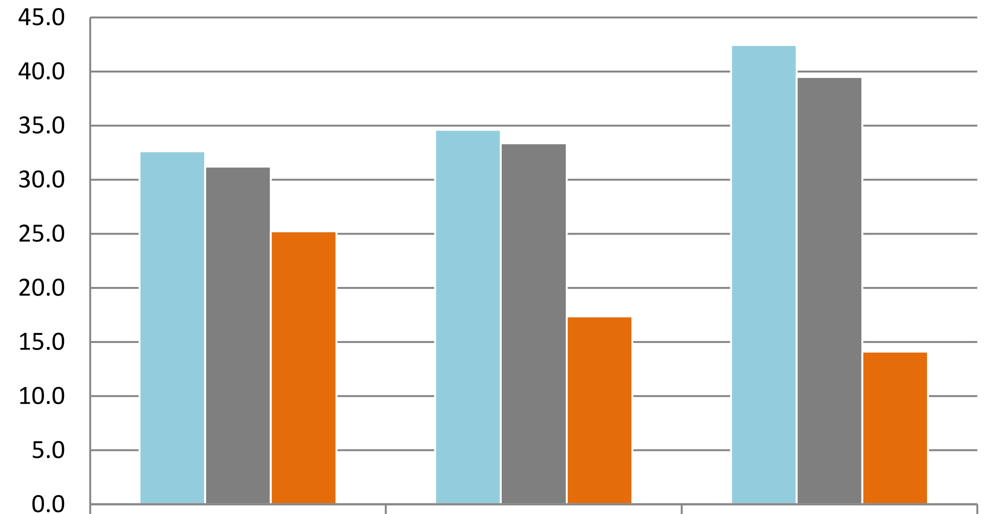
Figure 12. Prices of natural gas - EU vs. Russia (plant level data expressed in €/MWh)



	2010	2011	2012
EU Plant "A"	33.1	29.2	33.9
EU Plant "B"	29.0	29.2	32.3
RU Plant	6.8	8.6	8.7

Source: Own illustration.

Figure 13. Prices of natural gas - EU vs. US (plant level data expressed in €/MWh)



	2010	2011	2012
EU Plant "C"	32.6	34.6	42.5
EU Plant "D"	31.2	33.4	39.5
US Plant	25.2	17.4	14.1

Source: Own illustration.

5.8.2 Electricity

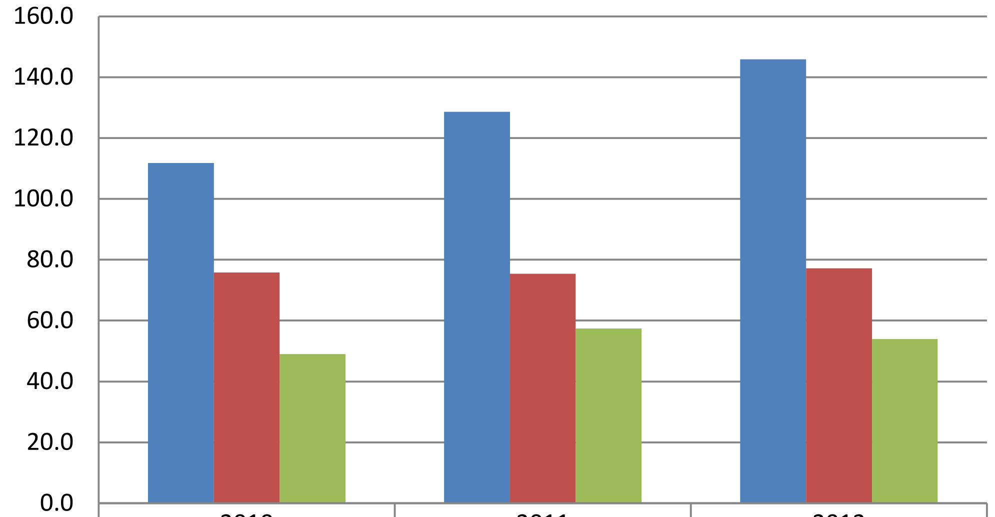
5.8.2.1 EU vs. Russia

As illustrated by Figure 14, the selected Russian plant benefited from the lowest electricity prices among the three production sites throughout the observation period (i.e. 53.9 €/MWh in 2012). As of 2012, the price paid by the Russian plant was lower than the price paid in any of the EU plants included in the sample (see Table 5). The prices of electricity paid by EU plant "B" increased almost unnoticeably. Between 2010 and 2012, power prices paid by the latter increased from 75.8 €/MWh, to 77.1 €/MWh (+1.7%). In the case of EU plant "A" the price increase was more important both in absolute and relative terms. Electricity prices augmented from 111.8 €/MWh in 2010, to 145.8 €/MWh in 2012 (+30.4%). The differences between the two regions are probably due to the fact that prices are regulated in Russia.

5.8.2.2EU vs. US

As shown by Figure 15, the electricity prices paid by the selected US facility were the lowest among the three compared facilities. However, it is worth noting that at least one of the EU plants included in the sample benefited from lower power prices than this specific US facility during the entire observation period. What is more, the prices of electricity paid by the latter increased from 2010 to 2011 (+7%) and then decreased (-5.9%) to a level of 69.1 €/MWh in 2012. Overall, since 2010, the power prices paid by this specific US plant decreased by 0.8% and were lower than for the two EU facilities assessed in Figure 15. The prices of electricity paid by EU plant "D" decreased between 2010 and 2011 (-2.5%) to rise to a level of 75.1 €/MWh in 2012 (+11.3%). Between 2010 and 2011, the power prices paid by plant "C" kept a fairly stable level (+1.4%) and were roughly twice as high as in the other two selected plants. However, from 2011 to 2012 they soared by 27.8% to a level of 186.7 €/MWh. As of 2012, the price paid by EU plant "C" was 2.7 times higher than the price paid by the US plant. The differences between the two regions are probably due to the fact that US consumers have access to abundant resources of unconventional fossil fuels driving natural gas prices down, which also affects electricity prices. As no information was provided on the US structure of the electricity bill, no further interpretation is possible.

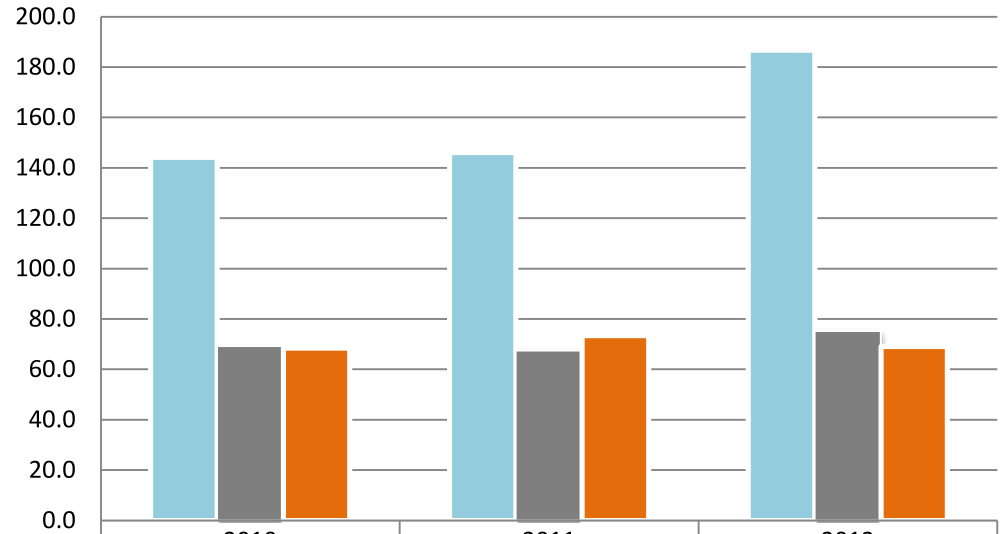
Figure 14. Prices of electricity - EU vs. Russia (plant level data expressed in €/MWh)



	2010	2011	2012
EU Plant "A"	111.8	128.7	145.9
EU Plant "B"	75.8	75.4	77.1
RU Plant	49.0	57.4	54.0

Source: Own illustration.

Figure 15. Prices of electricity - EU vs. US (plant level data expressed in €/MWh)



	2010	2011	2012
EU Plant "C"	144.1	146.1	186.7
EU Plant "D"	69.2	67.5	75.1
US Plant	68.5	73.4	69.1

Source: Own illustration.

5.9 Indirect ETS costs for the Bricks and Roof tiles Sector

5.9.1 Sample

Information on the indirect costs of ETS was obtained from the industry via questionnaires. As mentioned, bricks and roof tiles the research team has grouped producers in 3 different regions.

Two plants in the original sample were excluded from this part of the analysis; one from Central Europe and one from Northern Europe. Both were left out due to incomplete questionnaires: these two plants did not report yearly electricity intensity of production. Thus 11 plants were used for the analysis presented in this section.

5.9.2 Results

Table 8. Bricks and Roof tiles indirect costs, averages per region (€/tonne of bricks and roof tiles),

	Central Europe	Northern Europe	Southern Europe
2010	0.56	0.49	0.33
2011	0.50	0.41	0.31
2012	0.28	0.21	0.18

Pass-on rate: 0.6

Table 9. Bricks and Roof tiles indirect costs, averages per region (€/tonne of bricks and roof tiles),

	Central Europe	Northern Europe	Southern Europe
2010	0.74	0.65	0.44
2011	0.67	0.55	0.42
2012	0.37	0.29	0.24

Pass-on rate: 0.8

Table 10. Bricks and Roof tiles indirect costs, averages per region (€/tonne of bricks and roof tiles),

	Central Europe	Northern Europe	Southern Europe
2010	0.93	0.81	0.55
2011	0.84	0.69	0.52
2012	0.46	0.36	0.29

Pass-on rate: 1

In this sectoral analysis of indirect ETS costs, none of the plants in the sample have indicated that they either generate electricity themselves, or have a long term contract with a utility.

There are inter-regional differences in indirect costs, caused by two distinct factors. First the maximum regional CO2 emissions factor[97], which is lowest in Southern Europe and highest in Central Europe.

Second, differences in electricity intensities between plants. The plants in Southern Europe consume on average circa 0.05 MWh/tonne of bricks and roof tiles, compared with circa 0.07 in Central Europe and circa 0.08 in Northern-Europe.

The drop in indirect ETS costs across all regions between 2011 and 2012 can be largely attributed to a sharp decrease in EUA prices (from a yearly average of 13.77 Euros per EUA in 2011 to a yearly average of 7.56 Euros per EUA in 2012).

5.9.3 Key findings

Although the inter-regional differences are relatively low in comparison with other sectors covered by this study (most notably flat glass and ammonia), indirect costs in Central Europe are still significantly higher than indirect ETS costs in Southern Europe.

The inter-regional variations are caused by differences in the electricity intensity of production and differences in maximum regional CO2 emissions factors.

The average indirect costs for the plants in Southern Europe are significantly lower than for other regions. Several factors contributed to this: lower electricity intensity and lower maximum regional carbon intensity of electricity generation in the Southern European region.

The ETS indirect cost was significantly lower in 2012 compared to the previous years, because the price of EUAs was significantly lower in 2012.

5.10 General impressions

The research team used the questionnaires to (*inter alia*) ask EU producers about their impressions of the effects of liberalisation, investments in energy efficiency or the energy intensity of the sector.

Responders could not agree on the impacts of the liberalisation of the energy markets; while some manufacturers claimed that the liberalisation resulted in lower prices, others associated rising energy prices with the opening of the markets. Most of the respondents claimed that their facilities were not entitled to any

[97] As defined and listed in Annex IV of the 'Guidelines on certain State aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012' (2012/C 158/04).

reductions/exemptions from networks tariffs, taxes or levies. According to a large group of responders taxes and RES levies were the main cost drivers in their gas and power contracts. The majority of the interviewees admitted that the price of CO_2 was included in their electricity contracts. Most of the manufacturers did not switch their electricity suppliers. One of the producers invested in photovoltaic generation. Most of the respondents had yearly contracts with their energy utilities. Some of the contracts were concluded for a period of three years. One of the producers had a long term contract with its electricity provider. One of the producers (operating both inside and outside the EU) complained about the price volatility of natural gas in a member state located in Northern Europe.

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CHAPTER 6.
THE CASE OF THE CERAMICS INDUSTRY - WALL AND FLOOR TILES

FABIO GENOESE, JULIAN WIECZORKIEWICZ, LORENZO COLANTONI, WIJNAND STOEFS AND JACOPO TIMINI

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6.1 Description and production

6.1.1 Introduction

Wall and floor tiles (commonly known as ceramic tiles) are relatively thin plates made of ceramics. The forerunners of the ceramic tiles were invented in the times of the ancient Pharaohs. Tiles were shaped out of clay dug from the riverbanks; they were later burnt and exposed to the sun for drying (K. Radtke, 2010). Ancient civilisations upgraded these primitive materials, adding pigments and low-reliefs for decorative purposes. Greeks and Romans used ceramic tiles not only to cover the surfaces of their buildings; they also constituted an important element of their plumbing systems. As time passed, production techniques were improved and ceramic tiles became renowned for their usefulness and decorative values (G. Timellini et al., 2009).

Like any other ceramic materials, wall and floor tiles are long-lasting, fire-resistant and relatively easy to clean, yet fragile when exposed to shocks. Ceramic tiles can serve as a finishing material, but they also have an aesthetic function (EC, 2007). They can be used to cover and decorate internal facades (e.g. kitchens, bathrooms etc.) internal and external ground surfaces (e.g. garden alleys), swimming pools, and public areas (e.g. squares, fountains). Ceramic tiles are heterogeneous; they vary in dimensions (from few centimetres to 60 – 100 cm sided slabs), weight, shape (square, rectangular or other polygonal shapes), colour, surface (porous or vitrified, glazed or unglazed) etc. Nowadays, they are mainly used in the construction sector. Therefore, the performance of the construction industry has a direct impact on the production levels of ceramic tiles (G. Timellini et al., 2009).

6.1.2 Production process

The production of ceramic tiles consists of four main stages: (i) the preparation of the raw materials[98], (ii) shaping, (iii) drying and (iv) firing.

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98 The raw material employed by the industry is clay, together with a few other argilliferous materials (bentonite, fire clay, etc.); minerals such as manganese dioxide, titanium dioxide, calcium carbonate and others could be added to obtain different colors or porosity.

The raw materials are used to prepare of the extrusion paste. Thereafter, the paste is mechanically shaped by presses and dried in dryers. Firing is the most energy-consuming phase of the production process. Around 55-65%[99] of the total volume of energy used during the production process is consumed at this stage. The majority of the kilns employed by the producers are heated by natural gas (in roughly 85% of cases). Coal, oil and biomass gas are usually applied when the latter is not available (EC, 2007). During the firing process, ceramic tiles acquire their main characteristics, namely water-resistance, fire-resistance and hardiness. After the firing process, the products are exposed for cooling and shipped to distribution sites (Cerame-Unie, 2012).

Environmental concerns related to the production of wall and floor tiles are similar to those concerning bricks and roof tiles (i.e. CO_2 emissions, deforestation and degradation of the extraction sites etc.).

6.1.3 Value chain

The sub-sector partially relies on imported raw materials applied in the production process. Clays, kaolins, quartz, chamotte, calcium carbonate (calcite), talc and dolomite are used in production. These raw materials combined with glaze frits, metal oxides and colorants are also used for glazes production. In addition, ceramic tiles are high added value products compared to other ceramic products. Design, the choice of materials, applied techniques, innovativeness are all contributing factors (Cerame-Unie, 2009). Overall, the sub-sector is very energy intensive. In 2008, the production of one tonne of ceramic tiles required 6GJ of energy (G. Timellini, 2008). According to the information collected through the questionnaires, the share of energy in the total productions costs varies between 17 and 29%.

Table illustrates the breakdown of productions costs for the wall and floor tiles sub-sector. Note that the figures presented in Table are referring to average EU values. According to the information provided by Cerame-Unie, the costs of raw materials are the most important cost-driver for the EU producers of wall and floor tiles. The costs associated with raw materials procurement account for roughly 30%-35% of the total production costs. According to Cerame-Unie, energy related costs represent 25% to 30% of total production costs. Labour costs also accounts for approximately 25%-30% of total production costs.

Table 1. Breakdown of production costs (wall and roof tiles)

Share in production costs	
Energy	25%-30%
Labour	25%-30%
Raw materials	30-35%
Other production costs	10%-15%
Total	100%

Source: Cerame-Unie (2013).

[99] Depending of the characteristics of product, i.e. size, surface etc.

6.2 Global and European markets

Production

Table 2 illustrates the production levels of ceramic tiles by geographical regions. In 2011, the global production of ceramic tiles breached the level of 10.5 billion square meters (sq. m.). Concentrating more than two-thirds of the world's production, Asian producers largely dominated the global production. China itself amounts for 45.7% of the world production (i.e. 4.8 bn. sq. m.) and was the largest producing region. The EU-27 concentrated 11.2% of the global production and was the third largest producer in the world. It was followed by Central and Southern America, which concentrated roughly 10% of the global production. Other regions, namely "Other Europe", North America, Africa, and Oceania jointly produced 1,105 bn. sq m., which corresponds to 11% of the world's production.

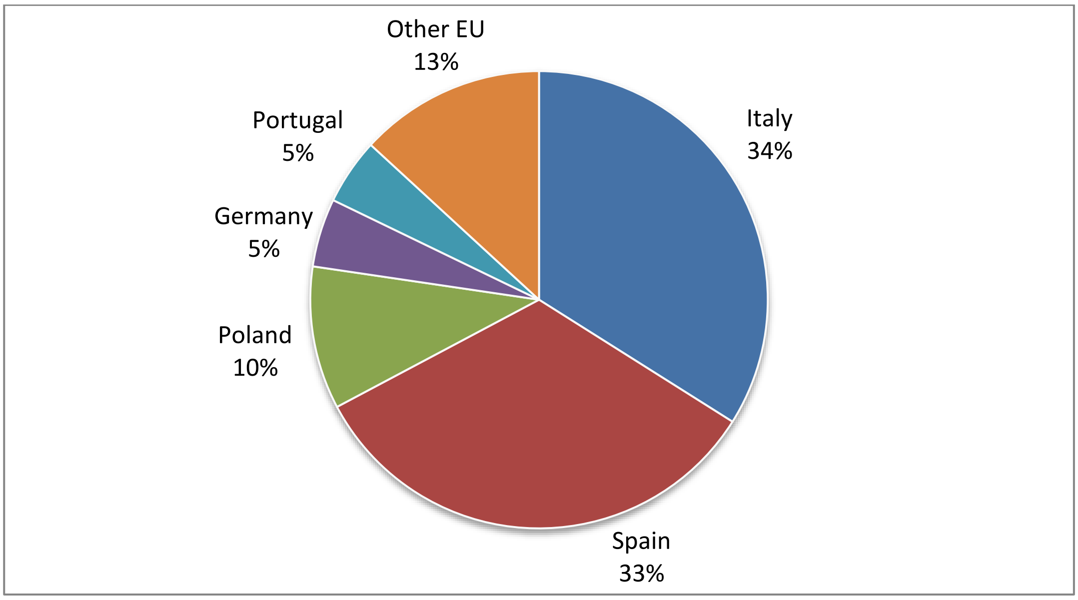
Table 2. Ceramic tiles production by geographical areas (in 2011)

Geographical areas	**2011 (sq. m MM.)**	**Percentage of world production**
China	4,800	45.7
Other Asia (excluding China)	2,379	24.2
European Union (EU-27)	1,178	11.2
Central and Southern America	1,051	10.0
Other Europe (including Turkey)	490	4.7
Africa	326	3.1
Other America (including Mexico)	284	2.7
Oceania	5	0.4
WORLD TOTAL	10,512	100

Source: D. Stock (2012).

Figure 1 illustrates the distribution of the EU production among its member states. In 2011, Italy was the biggest European producer of ceramic tiles (400 million sq. m.) followed by Spain (392 million sq. m.) and Poland (119 million sq. m.). These three member states concentrated 77% of the EU production (D. Stock, 2012). It is worth nothing that within the EU, the sub-sector of wall and floor tiles is heavily populated by SMEs. Small companies manufacture approximately 80% of ceramic tiles produced in Europe (Cerame-Unie, 2013).

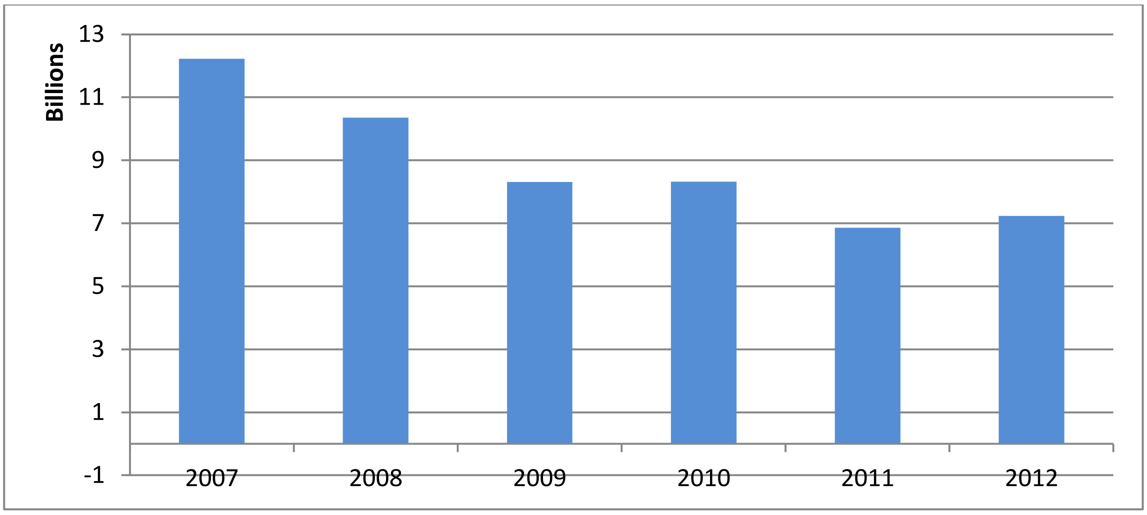
Figure 1. Ceramic tiles production in the EU-27 (2011 data)



Source: Source: D. Stock (2012).

Figure 2 shows the most recent trend in production value of the EU's wall and floor tiles industry which, between 2007 and 2012, decreased from 12,2 billion euros to a level of roughly of 7,2 billion euros (i.e. -40,9%).

Figure 2. Production value of ceramic tiles in the EU-27 (data expressed in billions of Euros)



Source: Eurostat (2012).[100]

Consumption

Table 3 shows the global consumption of ceramic tiles by geographical regions. In 2011, the world's consumption of wall and floor tiles reached the level of 10.4 bn. sq. m. Asian clients were absorbed roughly 66% of the world's consumption.

[100] Eurostat database: http://tinyurl.com/p23sff

Concentrating 9% of the global demand, the EU-27 was the third largest consuming region of ceramic tiles. Six member states (Italy, Spain, France, Germany, Poland and the UK) jointly concentrated 70.2% of the intra-EU consumption, namely 625 million sq. m. (D. Stock 2012).

Table 3. Ceramic tiles consumption by geographical areas (in 2011)

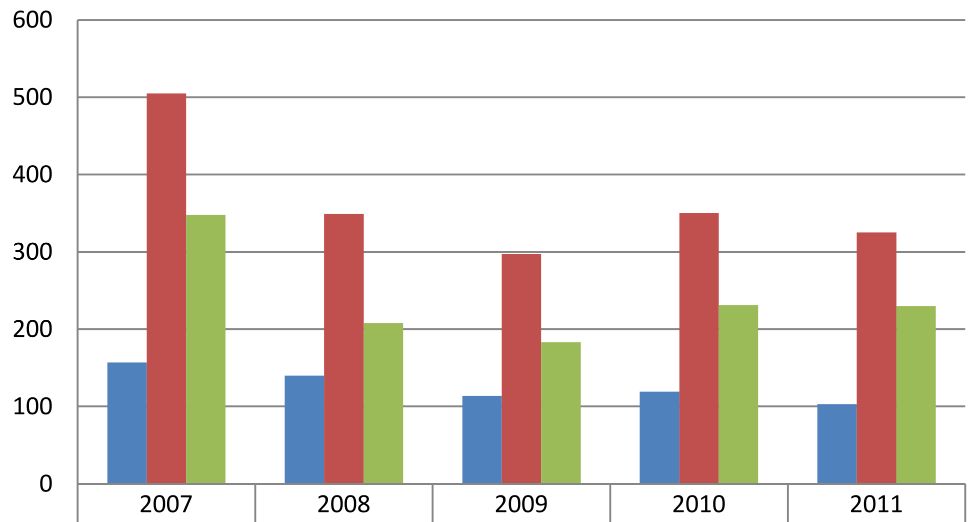
GEOGRAPHICAL AREAS	**2011 (sq. m MM.)**	**Percentage of world consumption**
China	4000	38.6
Other Asia (excluding China)	2,844	27.4
Central and Southern America	1,118	10.8
European Union (EU-27)	929	9.0
Other Europe (including Turkey)	520	5.0
Africa	517	5.0
Other America (including Mexico)	398	3.8
Oceania	44	0.4
WORLD TOTAL	10,370	100

Source: D. Stock (2012).

Trade

Due to their nature, ceramic tiles are highly tradable goods. As shown by Figure 3, the EU was a net exporter of ceramic tiles in 2011. The equivalent of roughly 27% of the EU production (i.e. 325 million sq. m.) was exported to third countries. EU-made ceramic tiles were mainly shipped to Russia, Switzerland, North Africa and North America. In 2011, the EU recorded a trade surplus of 230 million sq. m. worth €2.1 bn. (Cerame-Unie 2013).

Figure 3. EU-27: Exports and import of ceramic tiles (in million sq. m.)



	2007	2008	2009	2010	2011
Imports	157	140	114	119	103
Exports	505	349	297	350	325
Trade balance	348	208	183	231	230

Source: Cerame-Unie (2013).

Box 1. Chinese imports

The sector of wall and floor tiles generates a net contribution to the trade balance of the EU. However, European producers are facing an increasing competition from foreign manufacturers. According to the industry, non-EU producers (especially based in Asia) benefit from:

- The abundant availability of some of the raw materials employed in the production process;
- Lower energy prices;

- Different (i.e., often laxer) environmental, health and labour regulations.

While clay can be commonly found in Europe, Beijing controls several additive raw materials employed in the production process. For instance, more than 80% of the world reserves of Bauxite and Graphite are located in China.

Moreover, China is the biggest exporter of ceramic tiles and fast growing. More importantly, Chinese counterfeited tiles, as well as pricing (dumping) of refractory products, have been major issues for EU producers. Following a request of the European Ceramic Tile Manufacturers' Federation, the European Commission initiated an anti-dumping investigation on ceramic tiles imported from China. As a consequence, import duties have been raised from 26.3% to 36.5% for the Chinese companies - which cooperated in the investigation - and up to 69.7% for all other producers based in China.

Sources: Ecorys (2008), Cerame-Unie (2011).

6.3 Selection of the sample and sample statistics

6.3.1 The selection of typical facilities

The objective of this sub-chapter is to define and assess the composition and drivers of energy prices and costs in the case of wall and floor tiles. A total of twelve plants have been sampled for the purpose of this exercise. To define the sample of typical facilities, the authors of this study applied the following criteria:

- Geographical coverage
- Capacity of plants
- Ownership
- Production technology

Not all of these general criteria are relevant for this sector; moreover, it was not possible to obtain sufficient information on the universe with regards to this criterion. This issue is further described hereunder.

Geographical coverage

In this case, the following criteria were applied:

- Production per member state: three member states (Italy, Spain and Poland) account for 77% of the EU production of wall and floor tiles. Therefore, a representative number of sampled plants are located therein.

- Heterogeneity: to the extent possible, and without undermining the representativeness of the sample, an element of geographical diversity of the selected plants has been taken into consideration. In short, the sampled facilities are located in member states differing in (i) geographical location and (ii) size and in (iii) the length of their membership in the EU.

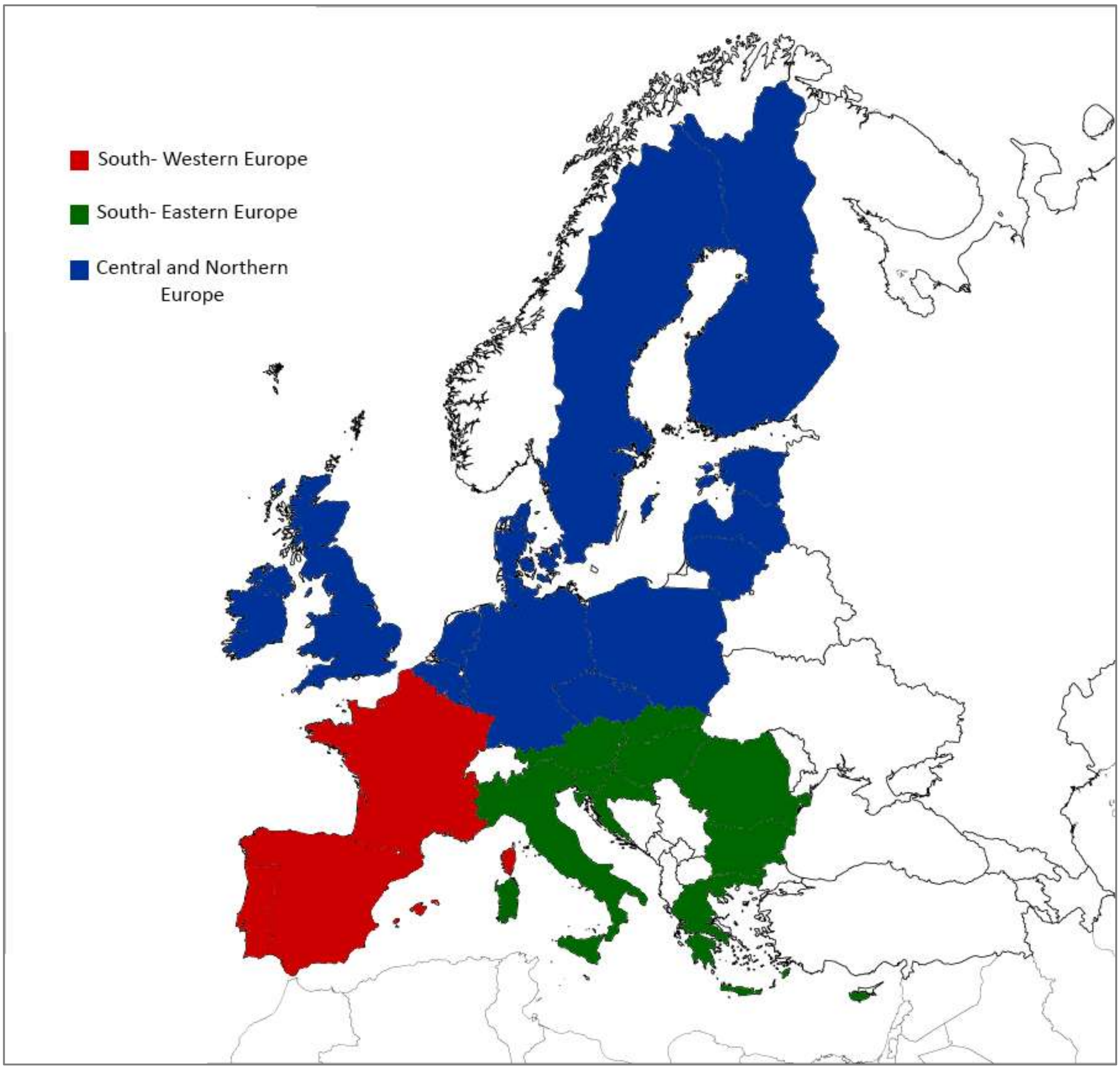
For the abovementioned reasons, twelve sampled facilities have been allotted in the three geographical areas (as illustrated by Figure 4):

a. **South-western Europe** (Spain, Portugal, France), which concentrated approximately 42% the EU production in 2012. Five of the sampled facilities are located in this geographical area.

b. **Central and Northern Europe** (UK, Ireland, Belgium, the Netherlands, Luxembourg, Denmark, Germany, Poland, the Czech Republic, Latvia, Lithuania, Estonia, Sweden and Finland), which concentrated approximately 20% of the EU production in 2012. Three of the sampled facilities are located in this geographical area.

c. **South-eastern Europe** (Italy, Slovenia, Austria, Hungary, Slovakia, Croatia, Bulgaria, Romania, Greece, Malta and Cyprus), which concentrated approximately 38% of the EU production in 2012. Four of the sampled facilities are located in this geographical area.

Figure 4. Wall and floor tiles: division by regions



Source: Own illustration.

Capacity of plants

Plant capacity is an important determinant of production costs and margins, and of technical efficiency, including energy efficiency. Ideally, plants that represent the spectrum of production sizes should figure among the sample. The authors of this study experienced difficulties in obtaining plant capacity data for the sub-sector of wall and floor tiles, as there is no external source of information. However, due to the fragmentation of the sub-sector, the European Ceramic Industry Association was not in a position to provide this information. Nevertheless, Cerame-Unie identified 22 plants producing wall and floor tiles willing to participate in the exercise. Two additional questionnaires were submitted by producers operating in third countries. Having received questionnaires from these facilities, CEPS researchers adjusted the sample, including plants of varied production capacities (ranging from >40.000 to <250.000 t/year).

Ownership

The sub-sector of wall and floor tiles is densely populated by SMEs amounting for 80% of the production. The sample aims at reflecting the structure of the sub-sector. For this reason, out of twelve sampled plants, eight are owned by SMEs and four by large multinational producers.

Production technology

The technology used by producers of wall and floor tiles is standardised and had little bearing as a criterion for the sample.

6.4 Methodology

As previously described, the data sample consists of 12 plants, which have been allotted to 3 different regions[101]. For all 12 plants, cost and consumption data are available, i.e. annual and specific costs for the total amount of electricity and the natural gas consumed. One monthly energy bill is available for 2 out of the 12 sampled plants. Annual bills (i.e. 12 monthly bills) are available for 5 more plants. Five facilities were unable to provide energy bills. This enabled CEPS researchers to perform a basic plausibility check of the information specified in the questionnaires.

6.4.1 Data collection

The analysis of the energy prices and costs for the sector of wall and floor tiles was based on questionnaires sent to all sampled plants. A confidentiality agreement was signed with Cerame-Unie. This agreement provided assurance that all collected data will be strictly treated as confidential.

All participants provided detailed data about their energy prices, structure of energy bills, and energy consumption. Having conducted a quality assessment of data collected from all participants, the consultant could use 12 questionnaires for the analysis.

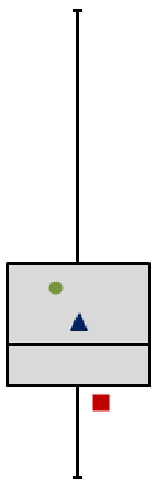
6.4.2 Data analysis and presentation

Box plots are used to display the reported cost ranges and to give an indication of the distribution among the units in the sample. An exemplary a box plot is illustrated in Figure 5. The whiskers below and above the box represent the minimum and

[101] Regions were developed by taking into account the need to reconcile the need for an adequate geographical coverage with confidentiality considerations.

maximum value of the sample. The box itself is divided in two parts by a horizontal line. This line indicates the median of the sample, i.e. the numerical value separating the higher half of the data sample from the lower half. The lower border of the box represents the first (lower) quartile of the sample. It splits off the lowest 25% of the data sample from the highest 75%. Correspondingly, the upper border of the box indicates the third (upper) quartile of the sample, thus separating the highest 25% of data from the lowest 75%. Put differently, the box contains exactly the middle half of the data. The height of the box is also referred to as inter-quartile range (IQR). It is a robust way of showing the variability of a data sample without having to make an assumption on the underlying statistical distribution.

Figure 5. Exemplary box plot



Source: Own illustration.

In order to ensure that no data are attributable to any specific plant, box plots are not created for the regional subsets of the sample, as these consist of only 3-5 plants. Instead, weighted average values are calculated and displayed next to or inside the box plots (see Figure 5). As weighting factors, the corresponding consumption data are applied, i.e. the annual consumption for electricity or natural gas, respectively[102].

6.4.3 Calculation of indirect ETS costs

The objective of the ETS cost calculations per sector in this study to provide the indirect ETS cost for the sub-sector between 2010 and 2012. The level of information is aggregated on a regional level, though the definition of those regions differs from sector to sector.

The model for the indirect cost of EU ETS in is defined as:

[102] The same methodology has also been applied for the sub-sector of bricks and roof tiles. Alternatively, annual production data can be used as a weighting factor. This was not possible, as the data on annual production provided in the questionnaires was incomplete. However, consumption and production values are typically correlated, i.e. the difference between the two approaches is expected to be minor.

Indirect costs

Indirect cost (€/Tonne of product) = Electricity intensity (kWh/Tonne of product)

** Carbon intensity of electricity (Tonne of CO_2/kWh)*

** CO_2 Price (€/Tonne of CO_2) * Pass-on rate*

Where:

- Electricity intensity of production: the amount of electricity used to produce one tonne of product. This amount is sector, plant and process specific;
- Carbon intensity of electricity generation indicates the amount of tonnes of CO_2 emitted by utilities to generate one kWh;
- CO_2 Price: is the average yearly market price of CO_2.
- Pass-on rate: the proportion of direct costs faced by utilities (disregarding any mitigating effects from free allocation) that they pass on to electricity consumers.

Sources:

- Electricity intensity of production; this was acquired from interviews with and questionnaires answered by industry members.
- Carbon intensity of electricity generation: the maximum regional carbon intensity of electricity is utilised, provided by the Commission's Guidelines on State aid measures.[103] Note that these figures are not national. Member States who are highly interconnected or have electricity prices with very low divergences are regarded as being part of a wider electricity market and are deemed to have the same maximum intensity of generation (for example, Spain and Portugal).
- CO_2 Price:
  - o Yearly averages of the daily settlement prices for Dec Future contracts for delivery in that year. The daily settlement prices were reported by the European Energy Exchange.

Table 4. Average yearly prices per tonne of CO2 (€)

Year	**2010**	**2011**	**2012**
CO_2 Price	14.48	13.77	7.56

[103] Communication from the Commission: Guidelines on certain State aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012 (2012/C 158/04)

6.4.4 Validation of information

All sampled participants provided detailed figures on the level and structure of energy prices as well as on energy consumption. The data was assessed, e.g. through a plausibility check and then evaluated. Table 5 presents the number of questionnaires received, selected in the sample and used in the analysis of each section. Note that sampling has been carried out after the reception of the questionnaires due to lack of prior information about the universe[104].

CEPS conducted a validation of the collected data thought EU energy statistics publications[105]. To further assess consistencies in the responses, the research team performed targeted interviews with sampled producers. The consultant was not able to validate the energy prices data, for example, through external sources of information about the costs borne by EU producers at plant level.

Table 5. Number of questionnaires used in each section

Total number received	24
Number included in the sample	12
Energy prices trends	12
Energy bill components	12
Energy intensity	6
International comparison	6
Indirect ETS costs	10
Production costs and margins	4

Please note that all of the figures presented in chapters 6.5, 6.6 and 6.8 include possible exemptions from taxes, levies or transmission costs. The consultant asked the producers to communicate the prices they paid for energy carriers between 2010 and 2012. Therefore, their answers include exemptions/reductions if these are applicable.

The consultant decided to use only 12 out of 24 collected questionnaires to (i) ensure the geographical representativeness of the sample and (ii) due to the poor quality of

104 In other words, we constructed the sample on the basis of the selection criteria illustrated above, once we received all answers to the questionnaires

105 Validation was conducted through the EU Statistical Pocketbook 2013 (European Commission, 2013; available at: http://ec.europa.eu/energy/publications/doc/2013_pocketbook.pdf) and the EU Market Observatory & Statistics.

some of the submitted questionnaires. Note that all the questionnaires used by the consultant were submitted on a plant level[106].

6.5 Energy prices trends

6.5.1 Introduction

The most energy intensive stage of the production process is firing, where heating is typically provided by natural gas[107]. This is reflected by the ratio of natural gas and electricity costs, which is in the range of 2.0 and 2.3. This means that electricity has a share of 30 to 34% on total energy costs, whereas natural gas has a share of 66 to 70%.

6.5.2 Natural gas

General trends

As shown by the median in Figure 6, the prices of natural gas paid by the sampled producers of wall and floor tiles are on the rise. In 2010, the median EU price of natural gas paid by the producers was of 25.7 €/MWh. By 2012, the price rose by 30.6% to a level of 33.5 €/MWh.

Furthermore, since 2010, the gap of prices paid by different EU producers kept growing. The increasing inter-quartile range, i.e. the difference between the lower and upper quartile, which represents the middle half of the data, also reflects this trend. From 2011 to 2012, the range between the median and the upper quartile increased considerably. This is particularly well illustrated when compared to the length separating the median from the lower quartile. Moreover, the total range of prices has also been increasing since 2010, as indicated by the whiskers of the box plot. According to the data, one or more producers are exposed to natural gas prices of up to 37.8 €/MWh.

Regional differences

Figure 6 also illustrates the average prices of natural gas paid by European producers operating in different geographical regions. The following trends can be observed at regional levels:

Central and Northern Europe

Augmenting from 25.7 €/MWh in 2010, to 28.7 €/MWh in 2012, the average price of natural gas in Northern Europe increased moderately. It is noteworthy to mention

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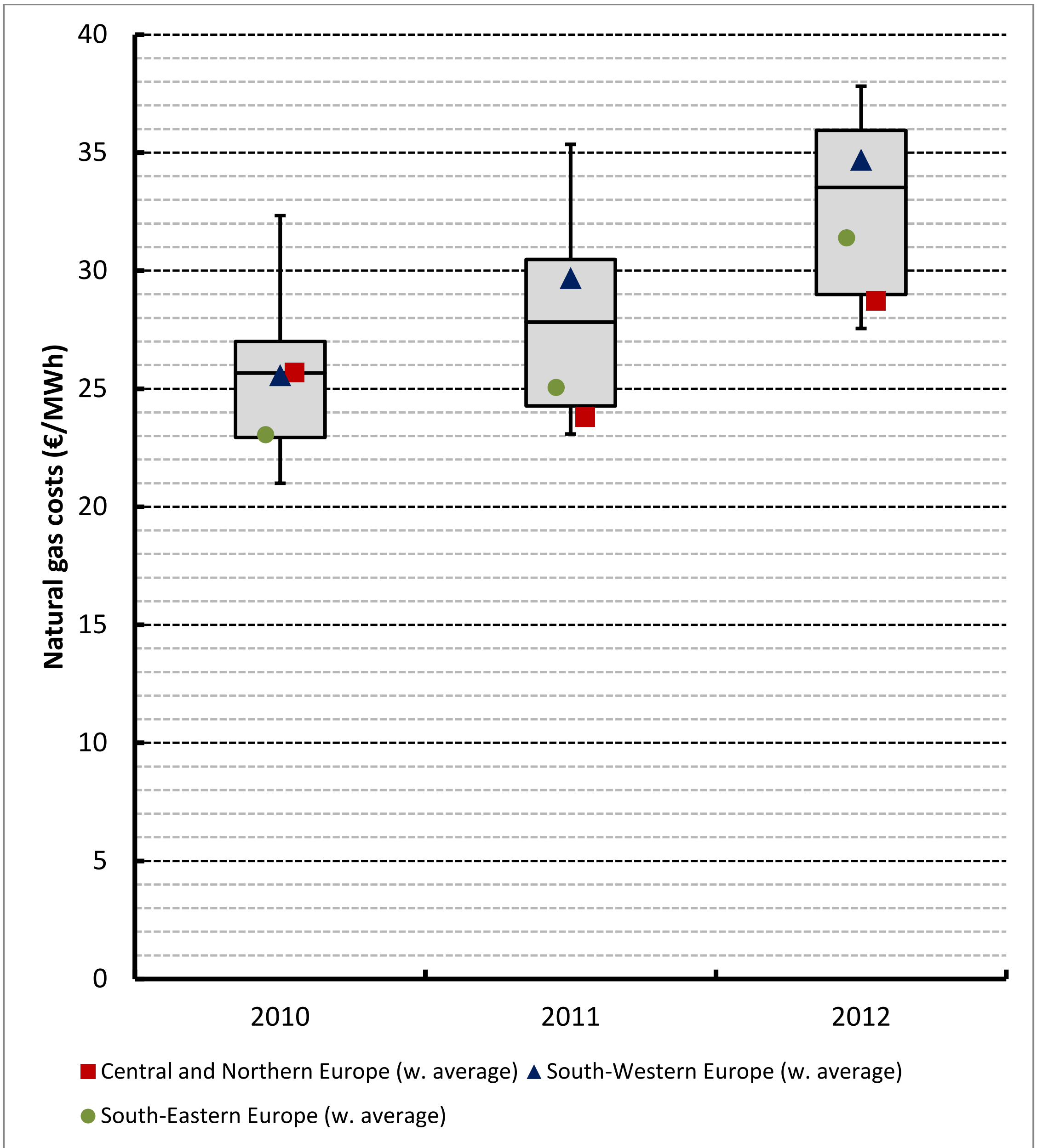
[106] In some cases, respondents provided information at company level, not at plant level, as they were not able to attribute costs and consumptions to different plants.

[107] Alternatives to natural gas such as solid fuels were not used by the sampled producers.

that from 2010 to 2011, the average price paid by Central and Northern European producers decreased by 1.9 €/MWh, falling below the lower quartile of prices for the whole sample. In 2012, despite rising prices (the average price increased by 4.9 €/MWh), the average price of gas paid by producers based in this region was still below the lower quartile of prices for the whole sample. This development is due to the soaring prices of gas in Southern Europe. Therefore, in 2012:

- Producers based in Central and Northern Europe paid lower prices than producers operating in South-Eastern and South-Western Europe;
- An average producer operating in Central and Northern Europe paid lower prices than 75% of the plants in the sample.

Figure 6. Prices of natural gas paid by sampled EU producers (2010-2012)



Source: Own illustration.

South-Western Europe

Ranging from 25.6 €/MWh in 2010 to 34.7 €/MWh in 2012, the average price of natural gas in South-Western Europe rose by 35.5% and was the highest among the three compared regions (see Table 6). The average price of natural gas paid by producers based in South-Western European was located between the median and the upper quartile of prices for all of Europe in 2011, remaining in this range in the following year.

South-Eastern Europe

In 2010, the price of natural gas in South-Eastern Europe was the lowest among the three compared regions (23.0 €/MWh). Between 2010 and 2012, this price rose by 36.5% to a level of 31.4 €/MWh. It is worth noting that in 2012, the average price of natural gas in South-Eastern Europe was closest to the average European price, namely 31.7 €/MWh.

Table 6. Descriptive statistics for natural gas prices paid by sampled EU producers (€/MWh)

	2010	**2011**	**2012**
Europe (average)	25.0	26.2	31.7
Europe (median)	25.7	27.8	33.5
Europe (IQR)	4.0	6.2	7.0
Europe (minimum)	21.0	23.1	27.6
Europe (maximum)	32.3	35.3	37.8
Central and Northern Europe (average)	25.7	23.8	28.7
South-Western Europe (average)	25.6	29.7	34.7
South-Eastern Europe (average)	23.0	25.0	31.4

Source: Own calculation.

6.5.3 Electricity

General trends

Similar to natural gas, the median of electricity prices is on the rise (see Figure 7). Overall, i.e. for all plants in the sample, the median of costs has increased steadily from 83.5 €/MWh in 2010 to 101.4 €/MWh in 2012. This corresponds to an increase of 21.4%, which is 9.2 percentage points less than the value for natural gas. In 2012, electricity costs up to 89.2 €/MWh (or less) occurred for 25% of the sampled units (first quartile). In the same year, electricity expenses for 25% of the units were higher than 114.4 €/MWh (third quartile). Between 2010 and 2012, the inter-quartile range enlarged moderately. This means that - for the middle half of the plants in the data sample - the spread of electricity costs has slightly increased within this period of time.

The whiskers of the box plot, which represent the outliers, indicate that the spread between the minimum and maximum cost levels was also on the rise between 2010 and 2012. Augmenting from 63.5 to 86.8€/MWh in 2012, the total range of electricity prices paid by the sampled facilities increased by 24.7 €/MWh with a limited number of plants exposed to electricity costs of up to 163.7 €/MWh.

Regional differences

The same figure also shows the weighted average prices of electricity paid by European producers in different geographical regions. Overall, the regional developments are in line with the EU trend. Between 2010 and 2012, the prices of electricity increased in all of the geographical regions. However, price levels are different across the regions. The following trends can be observed at regional levels:

Central and Northern Europe

The prices in Central Northern Europe show a slight upward tendency, increasing from 74.4 €/MWh to 92.0 €/MWh (+23.6%). For all years considered in the analysis, the price is below the median price of the sample. In other words, during the entire observation period, an average producer based in Central and Northern Europe benefited of lower electricity prices than at least 50% of the sampled plants. Moreover, during the same period of time, the average price of electricity paid by producers based in Central and Northern Europe was the lowest among the three compared regions.

South-Western Europe

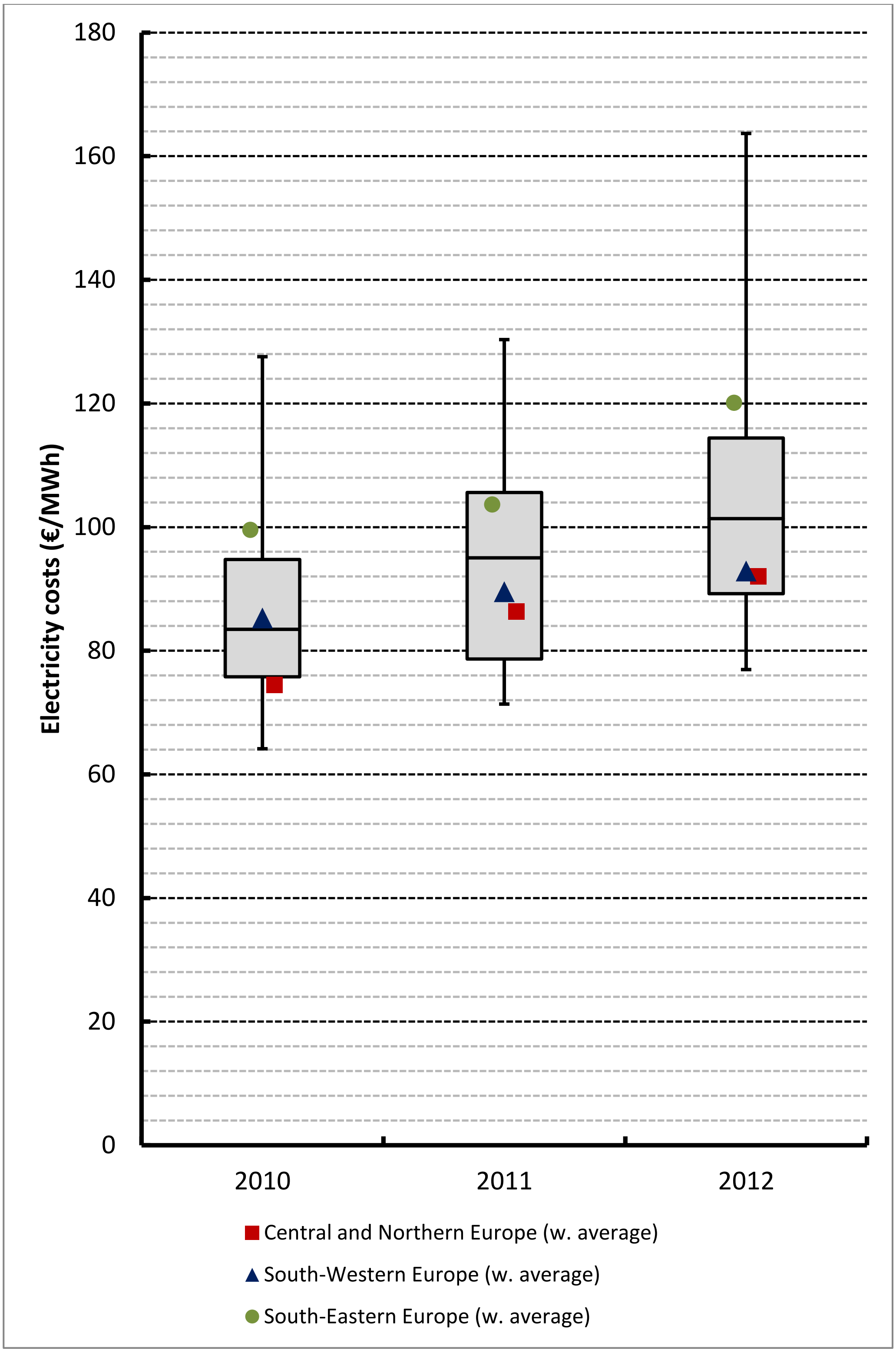
In South-Western Europe, the upward tendency is weaker than in Central and Northern Europe, as prices augmented from 85.3 €/MWh in 2010 to 92.9 €/MWh in 2012 (+8.9%). Since 2011, the price in South-Western Europe is located below the median price of the sample, meaning that in 2011 and 2012 an average producer based in this region paid lower electricity prices than at least 50% of the sampled plants. Furthermore, the costs of electricity in South-Western & Central and Northern Europe almost aligned in 2012 (92.9 €/MWh vs. 92.0 €/MWh respectively).

South-Eastern Europe

During the entire observation period, South-Eastern Europe was exposed to the highest prices of electricity. In 2010, the average price of electricity paid by producers based in South-Eastern Europe was of 99.5 €/MWh, exceeding the upper quartile of EU prices. In 2011, this price increased to 103.6 €/MWh (+4.1%), but because of the stronger increase in other European regions, it felt under the upper quartile of EU prices. Between 2011 and 2012, the average price of electricity in South-Eastern

Europe increased by 7.2% to 120.1 €/MWh again surpassing the upper quartile of EU prices. In other words, in 2012, an average producer of ceramic tiles based in South-Eastern Europe paid higher electricity prices than 75% of all EU producers.

Figure 7. Prices of electricity paid by sampled EU producers (2010-2012)



Source: Own illustration based on questionnaires.

Table 7. Descriptive statistics for electricity prices paid by sampled EU producers (€/MWh)

	2010	**2011**	**2012**
Europe (average)	80.8	88.8	97.6
Europe (median)	83.5	95.0	101.4
Europe (IQR)	19.0	27.0	25.2
Europe (minimum)	64.1	71.4	76.9
Europe (maximum)	127.6	130.3	163.7
Central and Northern Europe (average)	74.4	86.3	92.0
South-Western Europe (average)	85.3	89.5	92.9
South-Eastern Europe (average)	99.5	103.6	120.1

Source: Own calculation.

6.6 Analysis of energy bills components

6.6.1 Introduction

In order to better understand the price developments, we now break down the total cost into its components. For natural gas, the total costs are grouped into the following three components: (i) the energy component, (ii) the grid fees and (iii) other levies and taxes (excluding VAT). For electricity, there is one additional component, the RES levies.

6.6.2 Natural gas

General trends

As shown by Figure 8 and Figure 9, the energy component is the major driver of natural gas prices for the sampled plants in Europe. In 2012, it accounted for 89.5% of the averaged price of gas. Between 2010, the cost of the energy component increased from 22.1 €/MWh, to 28.4 €/MWh (+ 28.5%).

Due to the importance of the energy component, the impact of grid fees, taxes and other levies on the prices of natural gas was limited. In 2012, transmission costs accounted for 9.7% of the average price of gas. Between 2010 and 2012, these costs augmented from 2.7 €/MWh to 2.9 €/MWh (+ 7.4%). Finally, the costs of taxes (excl. VAT) and other levies increased from 0.1 €/MWh in 2010 to 0.4 €/MWh in 2012 (+400%). Despite this significant increase, in 2012, they accounted for roughly 1.6% of the averaged price of gas paid by producers of wall and floor tiles.

Regional differences

Figure 8 also illustrates the breakdown of costs for the three different regions. The following trends can be observed at regional levels:

Central and Northern Europe

As shown by Figure 6, since 2010, the prices of gas in Central and Northern Europe increased slightly. In 2012, the prices of gas in this region were lower than in South-Western and South-Eastern Europe. This trend is reflected by the evolution of the different price drivers of natural gas in this geographical region. As illustrated by Figure 8, between 2010 and 2012, the cost of the energy component increased moderately from 23.5 €/MWh to 26.5 €/MWh (+12.7%). Therefore, in 2012, the cost of the energy component in Central and Northern Europe was lower than in the other two regions assessed. The impact of taxes and other levies remained insignificant, yet stable. In 2012, these costs accounted for less than 0.6% of the average price of natural gas paid by producers based in Central and Northern Europe.

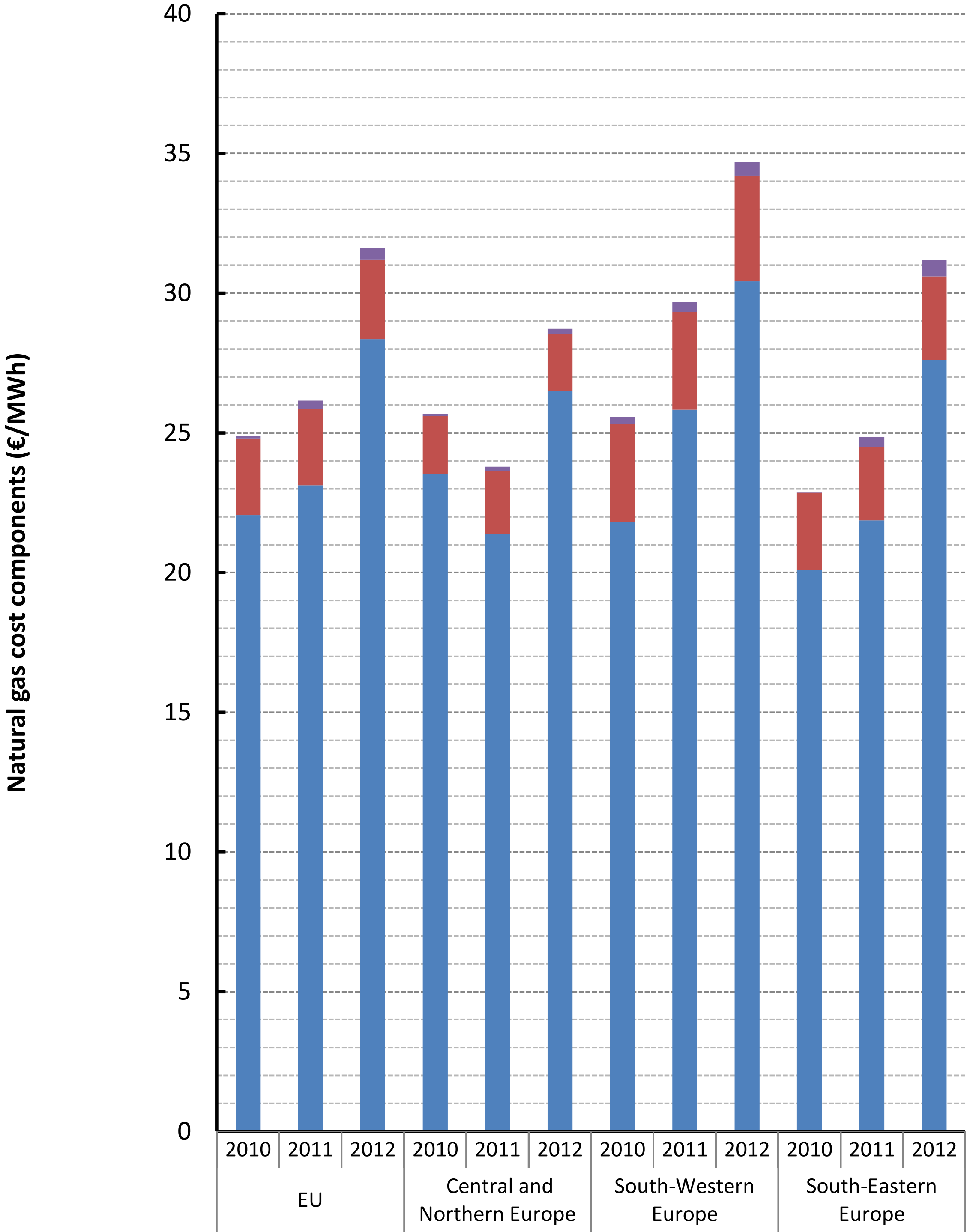
South-Western Europe

The developments in South-Western Europe are in line with the EU trends (i.e. increase of all price drivers). It is noteworthy to mention that between 2010 and 2012, the cost of the energy component augmented by 39.5%, to the highest level among the three compared regions, namely 30.4 €/MWh in 2012. In the same period, grid fees have also increased (+8.6%) to the highest level among the compared regions, namely 3.8 €/MWh. Although the costs of taxes and other levies (excl. VAT) increased sharply (+67%), their impact on the final price of gas remained marginal. In 2012, they accounted for 1.4% of the average price of gas paid by producers operating in South-Western Europe.

South-Eastern Europe

Between 2010 and 2012, all price drivers in South-Eastern Europe were on the rise. During this period of time, the cost of the energy component increased by 37.7%, to 27.6 €/MW. It is worth noting that prior to this increase, the cost of the latter was lower in South-Eastern Europe (20.1 €/MW in 2010) than in the other geographical regions. After having decreased by 0.02 €/MW in 2011, the costs of transmission increased by 0.04 €/MW in 2012. Overall, between 2010 and 2012, costs related to grid fees augmented by 7.1% to a level of 3.0 €/MWh. It is noteworthy to remark that in 2010, costs related to taxation were nonexistent in South-Eastern Europe (namely 0.01 €/MWh). By 2012, they rose to a level of 0.6 €/MWh (+6000%). However, just as in other geographical regions, their impact on the final price of natural gas was marginal. In 2012, they accounted for 1.8% of the average price of gas paid by producers operating in South-Eastern Europe.

Figure 8. Components of the natural gas bills paid by the sampled producers in Europe (in %)

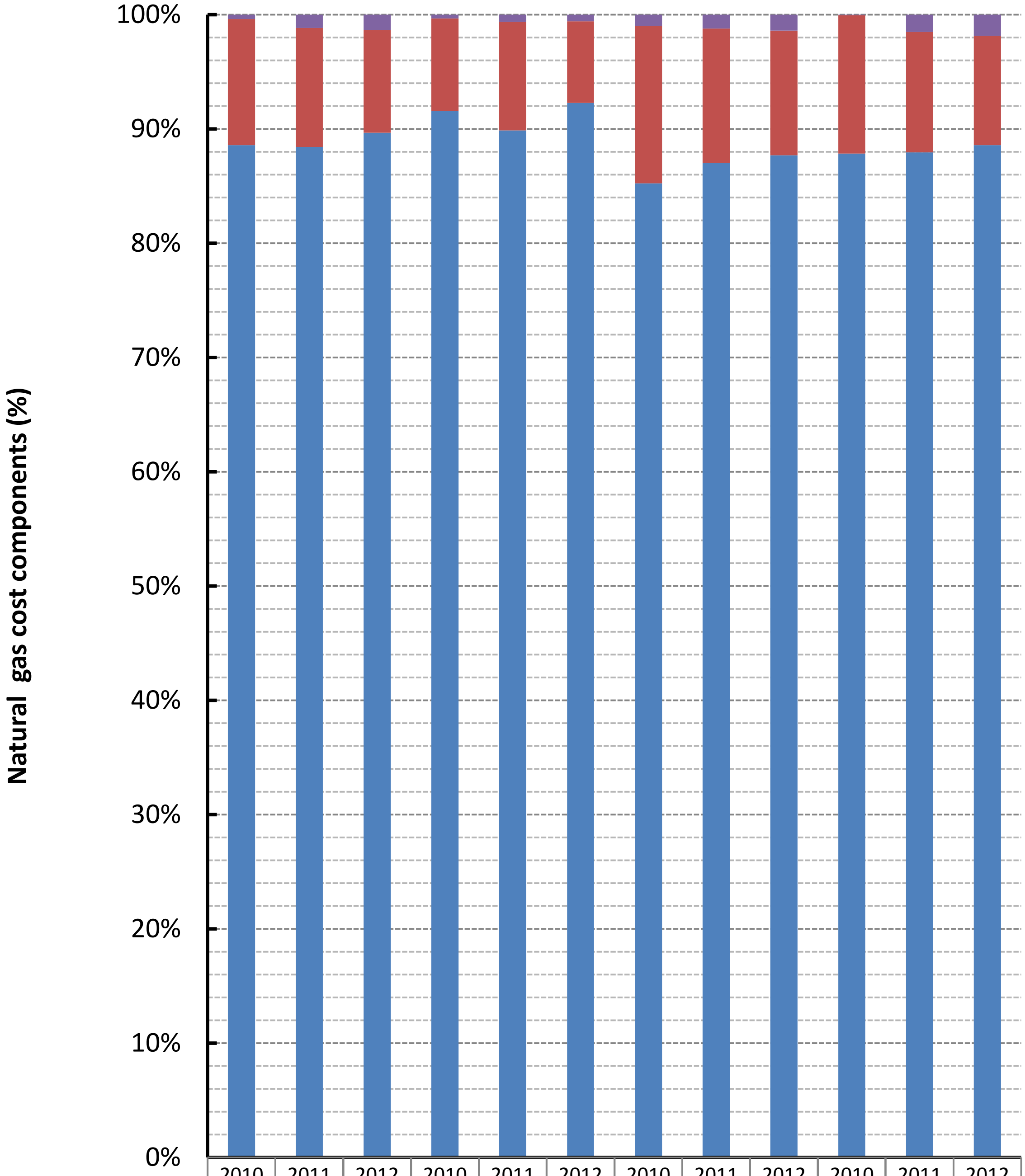


	EU 2010	EU 2011	EU 2012	Central and Northern Europe 2010	Central and Northern Europe 2011	Central and Northern Europe 2012	South-Western Europe 2010	South-Western Europe 2011	South-Western Europe 2012	South-Eastern Europe 2010	South-Eastern Europe 2011	South-Eastern Europe 2012
Other (excl. VAT)	0.1	0.3	0.4	0.1	0.2	0.2	0.3	0.4	0.5	0.0	0.4	0.6
Grid fees	2.7	2.7	2.9	2.1	2.3	2.0	3.5	3.5	3.8	2.8	2.6	3.0
Energy component	22.1	23.1	28.4	23.5	21.4	26.5	21.8	25.8	30.4	20.1	21.9	27.6

Energy component Grid fees Other (excl. VAT)

Source: Own calculation based on questionnaires.

Figure 9. Components of the natural gas bills paid by the sampled producers in Europe (in €/MWh)



	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
	EU			Central and Northern Europe			South-Western Europe			South-Eastern Europe		
Other (excl. VAT)	0%	1%	1%	0%	1%	1%	1%	1%	1%	0%	2%	2%
Grid fees	11%	10%	9%	8%	10%	7%	14%	12%	11%	12%	11%	10%
Energy component	89%	88%	90%	92%	90%	92%	85%	87%	88%	88%	88%	89%

Energy component   Grid fees   Other (excl. VAT)

Source: Own calculation based on questionnaires.

6.6.3 Electricity

General trends

In accordance with the structure of natural gas prices, the energy component is the most significant component of the electricity price paid by the sampled production facilities in Europe (see Figure 10 and Figure 11). However, in comparison to natural gas, this component is less dominant. In 2010, the energy component amounted for roughly 56.2 €/MWh, that is a share of 69.5% of the electricity price paid by an average sampled European producer of ceramic tiles. In the same year, grid fees amounted to 16.1 €/MWh (19.9%), RES levies to 6.7 €/MWh (8.3%) and other levies & taxes (excl. VAT) to 1.8 €/MWh (2.2%).

Augmenting from 56.2 in 2010 to 61.3 €/MWh in 2012 (+9.0%), the costs for the energy component remained fairly stable in absolute terms. Since 2010, its share diminished, reaching a value of 62.8%. This development is related to the stronger increase of other price drivers, mainly RES levies. From 2010 to 2012, grid fees have augmented by 3.3 €/MWh (+20.5%), RES levies by 8.0 €/MWh (+119.4%) and other levies & taxes (excl. VAT) by 0.4 (+22%).

Regional differences

On a regional level, the following trends can be observed:

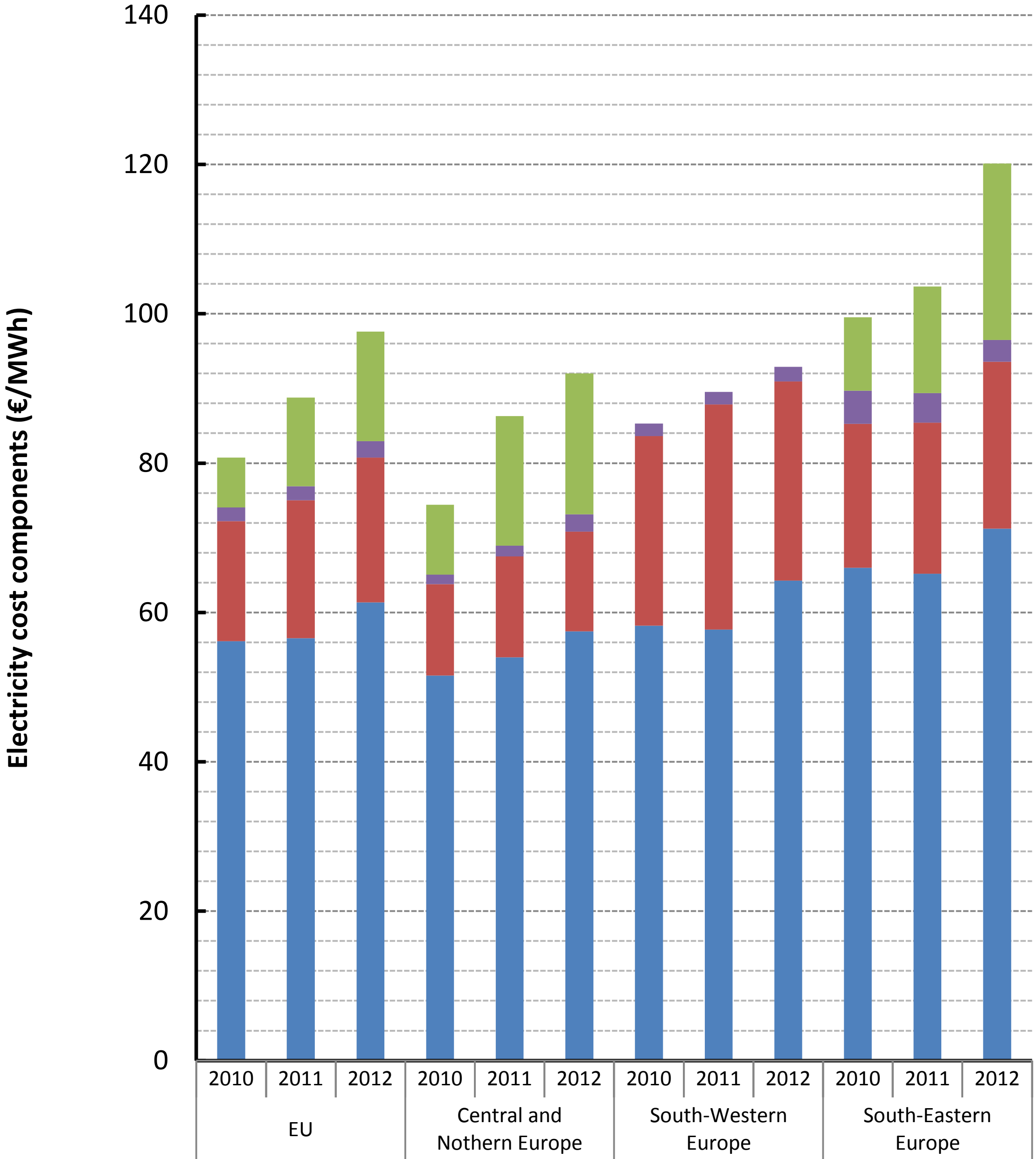
Central and Northern Europe

In comparison to the general situation, Central and Northern Europe is marked by the smallest cost of the energy component. In 2012, the latter was of 57.5 €/MWh. Transmission costs were also lower than in other parts of Europe (namely 13.3 €/MWh in 2012). The sum of all components has increased from 74.5 to 91.9 €/MWh (+23.6%) in the observation period.

South-Western Europe

According to the questionnaires, sampled plants based in this region had no costs for RES levies between 2010 and 2012. In other words, it was not possible to single out RES costs for the plants in the sample. Possible reasons could be: (i) the producers were fully exempted from the payment, (ii) these costs were not reported separately (and instead fully or partly included in other cost components). In comparison to other geographical regions, South-Western Europe experienced higher transmission costs (26.7 €/MWh in 2012). The cost of the energy component augmented from 58.2 €/MWh in 2010 to 64.3 €/MWh in 2012 (+10.4%) and was the closest to the EU average (i.e. 61.3 €/MWh) among the three compared regions in that year.

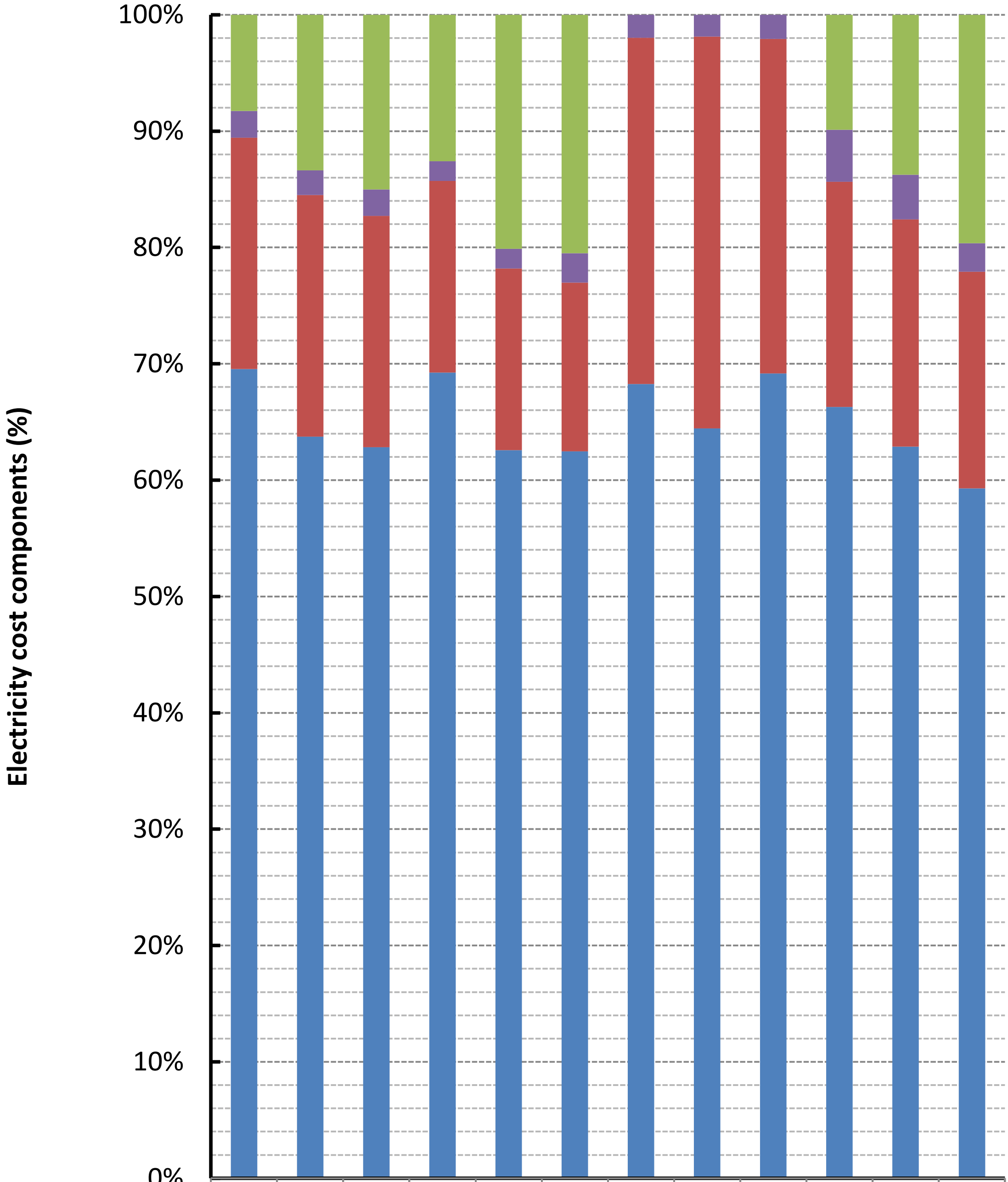
Figure 10. Components of the electricity bills paid by the sampled producers in Europe (in €/MWh)



	EU 2010	EU 2011	EU 2012	Central and Nothern Europe 2010	Central and Nothern Europe 2011	Central and Nothern Europe 2012	South-Western Europe 2010	South-Western Europe 2011	South-Western Europe 2012	South-Eastern Europe 2010	South-Eastern Europe 2011	South-Eastern Europe 2012
RES levy	6.7	11.9	14.7	9.4	17.4	18.9	0.0	0.0	0.0	9.8	14.3	23.6
Other (excl. VAT)	1.8	1.9	2.2	1.3	1.4	2.3	1.7	1.7	1.9	4.4	4.0	2.9
Grid fees	16.1	18.4	19.4	12.2	13.5	13.3	25.4	30.1	26.7	19.3	20.2	22.4
Energy comp.	56.2	56.6	61.3	51.6	54.0	57.5	58.2	57.7	64.3	66.0	65.2	71.2

Source: Own calculation based on questionnaires.

Figure 11. Components of the electricity bills paid by the sampled producers in Europe (in %)



	EU 2010	EU 2011	EU 2012	Central and Northern Europe 2010	Central and Northern Europe 2011	Central and Northern Europe 2012	South-Western Europe 2010	South-Western Europe 2011	South-Western Europe 2012	South-Eastern Europe 2010	South-Eastern Europe 2011	South-Eastern Europe 2012
RES levy	8%	13%	15%	13%	20%	21%	0%	0%	0%	10%	14%	20%
Other (excl. VAT)	2%	2%	2%	2%	2%	3%	2%	2%	2%	4%	4%	2%
Grid fees	20%	21%	20%	16%	16%	15%	30%	34%	29%	19%	20%	19%
Energy component	70%	64%	63%	69%	63%	62%	68%	64%	69%	66%	63%	59%

Energy component Grid fees Other (excl. VAT) RES levy

Source: Own calculation based on questionnaires.

South-Eastern Europe

During the observation period, South-Eastern Europe has shown the strongest increase of electricity prices among the three compared regions. Power prices have augmented from 99.5 to 120.1 €/MWh, which corresponds to a 20.7% increase. What is more, as of 2012, the sampled plants of South-Eastern Europe were exposed to the highest electricity prices among all the sampled facilities. Rising power prices in this region are mainly driven by the soaring costs of RES levies. Augmenting from 9.8 €/MWh in 2010 to 23.6 €/MWh in 2012, the costs of the RES levies increased by 140.8%. During the same period of time, the costs of transmission and the cost of the energy component have also been on the rise in this part of Europe (+16.0% and +7.8% respectfully). It is noteworthy to mention that South-Eastern Europe was the only region to have experienced a continuous decrease of one of the price drivers during the entire observation period. Since 2010, taxes and other levies (excl. VAT) decreased by 34.1% to a level of 2.9 €/MWh in 2012. Nevertheless, despite this reduction, the cost of this price driver in South-Eastern Europe was the highest among the three compared regions.

6.7 Energy intensity

6.7.1 General trends

The consultant asked the producers to provide information about the energy efficiency of their plants by disclosing figures on the energy intensity of their production processes[108]. Intensity is typically measured in terms of value added (unit: MWh/€) or in terms of physical output (unit: MWh/tonne). As more than one energy carrier is used in the production process, separate intensities should be calculated for each energy source (e.g. electricity, natural gas) to allow for a correct interpretation of the data. Producers did not provide such a breakdown. However, it is possible to calculate carrier-specific energy intensities based on the consumption values of each energy source given in the questionnaires.

The completeness of answers on intensity data was varied. Out of the 12 sampled plants, only 10 provided intensity data in terms of physical output. In terms of value added, complete data was available for only 6 plants. The reduced size of the regional samples impedes the consultant to disclose regional statistics due to confidentiality reasons. Instead, only EU-wide figures are given. The weighted average[109] and the median of both electricity and natural gas intensities in terms of physical output were calculated. To give an indication for the variability of the sample the inter-quartile

[108] It is worth noting that energy intensity does not only depend on the physical features of machines and processes, but also on the capacity utilisation rate. Hence, difference in efficiency across multiple years may not only signal investments in energy efficiency, but also a better utilisation rate.

[109] Weighting factor: consumption.

range (IQR) is used. Minimum and maximum values cannot be disclosed due to confidentiality reasons.

Table 8. Descriptive statistics for the natural gas intensities for 10 out of 12 sample production plants in terms of physical output (MWh/tonne)

	2010	**2011**	**2012**
Europe (average)	1.81	1.79	1.81
Europe (median)	1.73	1.68	1.69
Europe (IQR)	0.91	0.89	0.93

The figures for natural gas are reported in Table 8. Although some plant owners have indicated in the questionnaire that investments in energy efficiency have been made, the trend is not clear. The median of the intensity decreased from 2010 to 2012, while the weighted average stagnated during the observation period. Without further information, no interpretation for this development can be given. As indicated by the IQR, the difference between the 25% of the plants with the highest intensity and the 25% with the lowest intensity increased slightly from 2010 to 2012.

The figures for electricity are reported in Table 9. The median and the weighted average remained at the same level during the entire observation period. On the other hand, the IQR increased, but insufficiently to allow the observation of any particular trend.

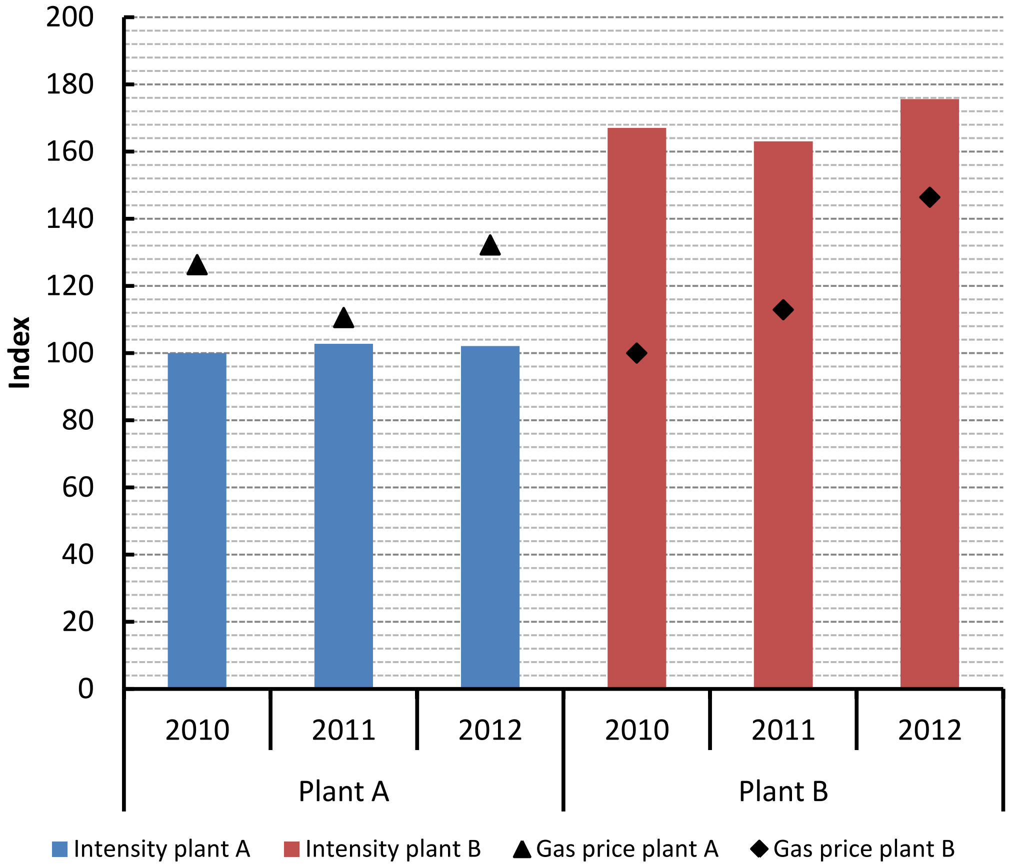
Table 9. Descriptive statistics for the electricity intensities for 10 out of 12 sampled production plants in terms of physical output (MWh/tonne)

	2010	**2011**	**2012**
Europe (average)	0.23	0.23	0.23
Europe (median)	0.19	0.19	0.19
Europe (IQR)	0.14	0.14	0.15

6.7.2 Plant case study

Figure 12 illustrates the gas intensity of two sampled plants. Natural gas prices paid by the two producers were also indexed and added to the figure. During the entire observation period plant “A” was more efficient than plant “B”. As of 2012, the latter showed a 71% lower intensity when compared to plant “A”. Between 2010 and 2012, the energy intensity of plant “A” increased by 2.5%. This development was more visible in the case of plant “B”: During the same period of time, its energy intensity augmented by 5.1%. This decreasing energy efficiency was accompanied by a significant augmentation of gas prices during the observation period (+46.6%).

Figure 12. Natural gas intensity and natural gas prices of two plants (indexed values, lowest value = 100)



Source: Own calculation.

6.8 International comparison

The aim of this chapter is to compare the prices of energy carriers paid by producers based in the EU with the prices paid by manufacturers based in third countries, namely Russia and the US. This section is based on a series of plant case studies. Data collected from two manufacturing sites located in Russia and the US has been confronted with figures collected through the questionnaires submitted by the sampled EU plants. All the plants selected for this assessment are of comparable production capacities in order to avoid distortions that are due to different consumption levels of natural gas or electricity. In other words, the Russian plant and the EU plants “A” and “B” have similar production capacities. Likewise, the US plant and the EU plants “C” and “D” have comparable production levels.

As the consultant received only monthly energy bills for the Russian and US plant, only plausibility checks could be performed. It is worth noting that the consultant cannot assess the representativeness of the Russian or US plants.

6.8.1 Natural gas

EU vs. Russia

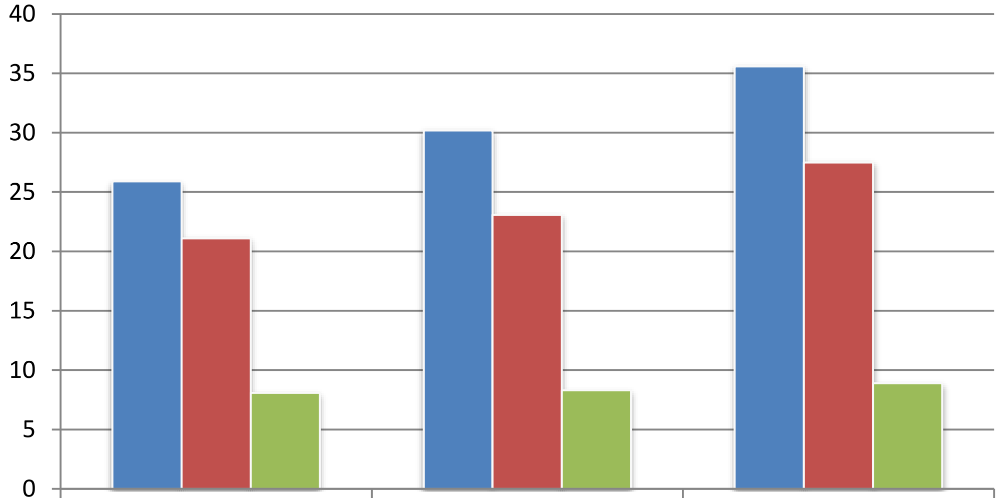
As shown by Figure 13, between 2010 and 2012, the selected Russian facility benefited from the lowest price of natural gas among the three compared plants. Moreover, the prices paid by the Russian plant kept a fairly stable level. Between 2010 and 2012, the price of gas paid by the Russian-based facility increased from 8.1 to 8.9 €/MWh (+9.8%). In contrast, during the same period of time, the prices paid by plant "A" augmented from 25.9 €/MWh, to 35.6 €/MWh (+37.4%). The pace of increase was similar for plant "B", as the prices increased from 22.1 €/MWh in 2010, to 27.5 €/MWh in 2012 (+30.3%). It is interesting to note, that despite this augmentation, the prices of gas paid by the second plant were lower than prices paid by all other European plants included in the sample (regardless of their size[110]). Put differently, the prices of gas paid by this specific Russian plant were lower than that in any EU sampled plant. In 2012, the price of natural gas paid by plant "A" was four times higher than the price paid by the Russian-based facility. The differences between the two regions are probably due to the fact that prices are regulated in Russia.

EU vs. US

The natural gas prices paid by the selected US facility were the lowest among the three compared plants (see Figure 14). Decreasing from 11.3 €/MWh in 2010, to 8.7 €/MWh in 2012, prices diminished by 23.1%. Therefore, alike the selected Russian plant, during the entire observation period, the prices of gas paid by the US-based facility were lower than in all the European plants included in the sample. Contrary to the trend experienced by this specific US plant, the prices of natural gas paid by the European facilities increased constantly between 2010 and 2012. The prices paid by plant "C" augmented from 26.4 €/MWh, to 31.1 €/MWh (+17.8%). In the case of plant "D" the increase was more important, as prices rose from 24.1 €/MWh in 2010, to 32.6 €/MWh in 2012 (+35.2%). The differences between the two regions are probably due to the fact that US consumers have access to abundant resources of unconventional fossil fuels driving natural gas prices down.

[110] As indicated by the whiskers of Figure 6.

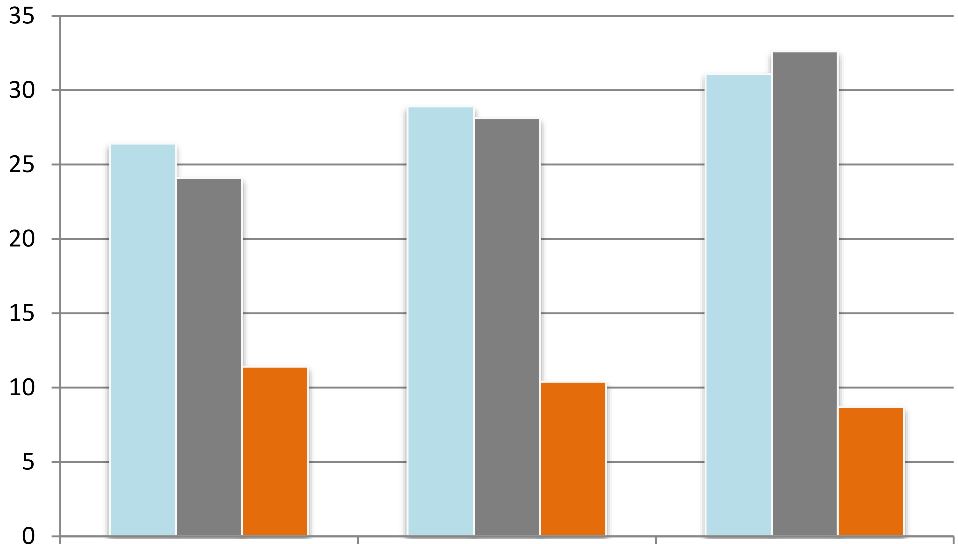
Figure 13. Prices of natural gas - EU vs. Russia (plant level data expressed in €/MWh)



	2010	2011	2012
EU Plant "A"	25.9	30.2	35.6
EU Plant "B"	21.1	23.1	27.5
RU Plant	8.1	8.3	8.9

Source: Own illustration.

Figure 14. Prices of natural gas - EU vs. US (plant level data expressed in €/MWh)



	2010	2011	2012
EU Plant "C"	26.4	28.9	31.1
EU Plant "D"	24.1	28.1	32.6
US Plant	11.4	10.4	8.7

Source: Own illustration.

6.8.2 Electricity

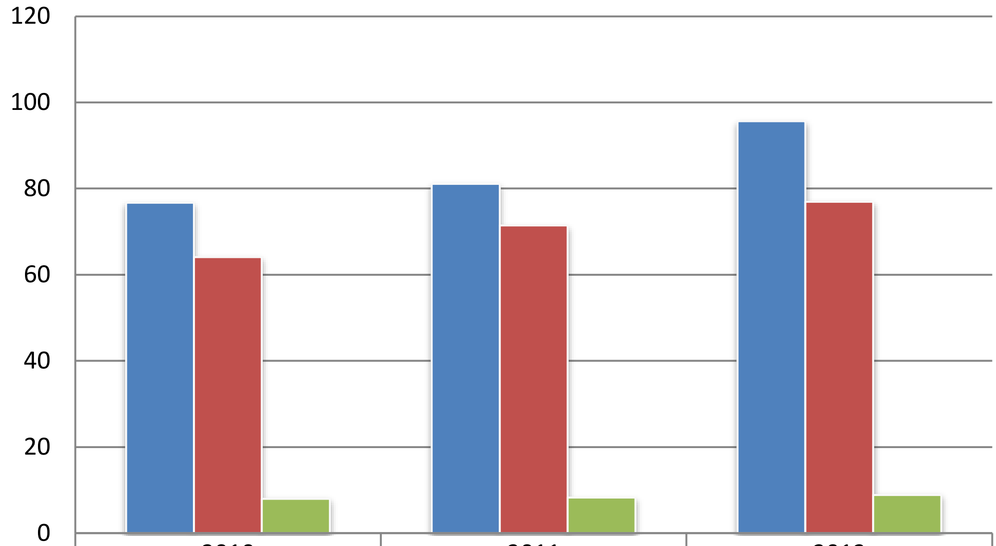
EU vs. Russia

As shown by Figure 15, during the entire observation period, the selected Russian plant benefited from the lowest power prices among the three production sites. It is worth to note that in the same period of time, plant "B" paid lower power prices than any of the sampled EU facilities (see Table 7). In other words, between 2010 and 2012, this specific Russian plant paid lower power prices than any EU facility included in the sample. What is more, while the prices of electricity were on the rise in all of the plants presented in Figure 15, the prices paid by the two EU plants augmented more than in the manufacturing site based in Russia, both in absolute and relative terms. Between 2010 and 2012, the prices paid by the Russian facility increased by 0.9 €/MWh (+11.2%). The prices paid by plant "A" rose from 76.7 €/MWh in 2010, to 95.6 €/MWh in 2012 (+24.5%). In the case of plant "B", this increase was less important, as prices augmented from 64.1 €/MWh, to 76.9 €/MWh (+20%), namely to the lowest level among the sampled EU plants. Yet the power prices paid by the latter were roughly nine times higher than the prices paid by the selected Russian plant. The differences between the two regions are probably due to the fact that prices are regulated in Russia.

EU vs. US

As shown by Figure 16, the power prices paid by the selected US plant were the lowest among the three compared facilities. However, it is worth to note that the prices of electricity paid by the US plant decreased from 2010 to 2011 (-11%) and then increased again from 2011 to 2012 (+3.9%). Without further information, no interpretation for this dip can be given. Overall, since 2010, the power prices paid by this specific US plant decreased by 7.4% and were lower than any of the EU plant included in the sample as of 2012. During the observation period power prices in Europe were on the rise (see Figure 7); plant "D" followed an opposite trend: between 2010 and 2012, power prices paid by this plant decreased from 98.9 €/MWh to 92.4 €/MWh (-6.6%). Plant "C" followed the EU overall development as prices power prices paid by that facility augmented from 93.3 €/MWh to 108.7 €/MWh (+16.5%). The differences between the two regions are probably due to the fact that US consumers have access to abundant resources of unconventional fossil fuels driving natural gas prices down, which also affects electricity prices. As no information was provided on the US structure of the electricity bill, no further interpretation is possible.

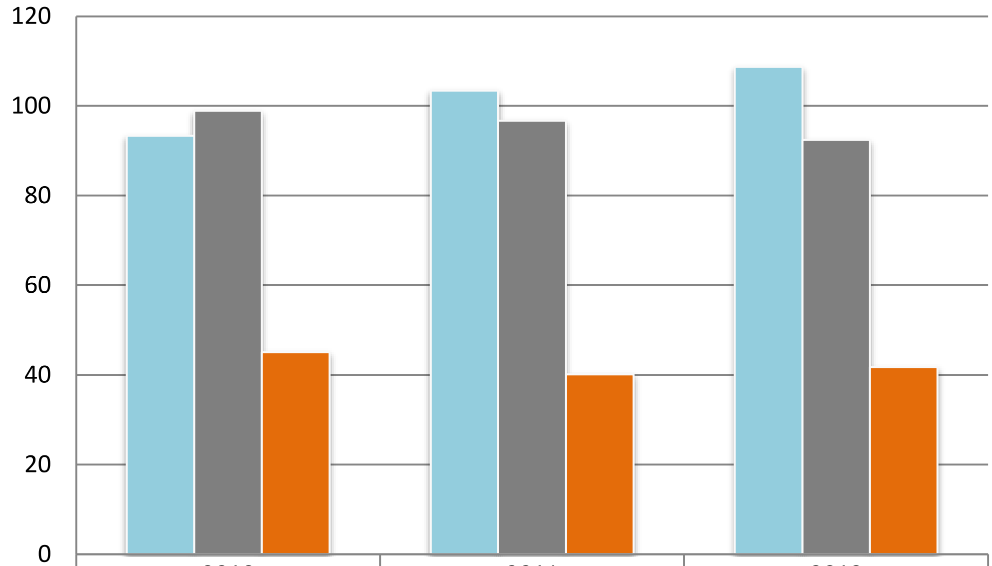
Figure 15. Prices of electricity - EU vs. Russia (plant level data expressed in €/MWh)



	2010	2011	2012
EU plant "A"	76.7	81.1	95.6
EU plant "B"	64.1	71.4	76.9
RU plant	8	8.3	8.9

Source: Own illustration.

Figure 16. Prices of electricity - EU vs. US (plant level data expressed in €/MWh)



	2010	2011	2012
EU plant "C"	93.3	103.4	108.7
EU plant "D"	98.9	96.7	92.4
US plant	45	40.1	41.7

Source: Own illustration.

6.9 Indirect ETS costs for the wall and floor tiles sector

6.9.1 Sample

Information on the indirect costs of ETS was obtained from the industry via questionnaires. As mentioned above, wall and floor tiles producers are grouped in 3 different regions.

6.9.2 Results

In this sectorial analysis of indirect ETS costs, none of the plants in the sample have indicated that they have a long term contract with a utility. Two plants in the South-Eastern region generate electricity themselves. One of these plants covers around 40% of its electricity needs with self-generated electricity, the second one around 80%.

There are significant inter-regional differences in indirect costs, primarily caused by two outliers in the sample. One South-Eastern European plant has an average electricity intensity that is 16 times higher than the average electricity intensity over the sample. One Central and Northern European plant has an average electricity intensity that is 25 times higher than the average over the sample.

Because the sample size is limited, the effect of the outliers on the regional averages is significant. The regional average electricity intensity in Central and Northern Europe drops from around 1.7 MWh/tonne of wall and floor tiles to around 0.3 MWh/tonne of wall and floor tiles if the outlier in this region is excluded.

Therefore the analysis is presented without the two aforementioned outliers[111].

Table 10. Wall and floor tiles indirect costs, averages per region (Euro/tonne of wall and floor tiles)

	South-Western Europe	Central and Northern Europe	South-Eastern Europe
2010	0.76	1.63	0.92
2011	0.73	1.50	0.84
2012	0.42	0.78	0.45

Pass-on rate: 0.6

111 The analysis for the indirect cost for the Wall and Floor Tiles sector uses data from 10 plants.

Table 11. Wall and floor tiles indirect costs, averages per region (Euro/tonne of wall and floor tiles),

	South-Western Europe	Central and Northern Europe	South-Eastern Europe
2010	1.02	2.17	1.22
2011	0.97	2.00	1.11
2012	0.56	1.03	0.59

Pass-on rate: 0.8

Table 12. Wall and floor tiles indirect costs, averages per region (Euro/tonne of wall and floor tiles),

	South-Western Europe	Central and Northern Europe	South-Eastern Europe
2010	1.27	2.72	1.53
2011	1.21	2.51	1.39
2012	0.70	1.29	0.74

Pass-on rate: 1

The inter-regional differences are lower when excluding both outliers, but remain significant. Indirect ETS costs in South-western Europe and South-eastern Europe are comparable.

The significantly higher indirect cost per tonne of wall and floor tiles in Central and Northern Europe is caused by one factor: a higher average electricity intensity of production in that region. The plants in the South-Western and South-Eastern European regions consume on average circa 0.15 MWh/tonne of wall and floor tiles they produce, compared with circa 0.28 MWh/tonne of wall and floor tiles in Central and Northern-Europe.

The drop in indirect-ETS costs across all regions between 2011 and 2012 can be largely attributed to a sharp decrease in EUA prices (from a yearly average of 13.77 Euros per EUA in 2011 to a yearly average of 7.56 Euros per EUA in 2012).

6.9.3 Key findings

Two plants in the initial sample report significantly higher levels of electricity consumption per tonne of wall and floor tiles produced. The following key findings are based on the sample without these plants.

Indirect costs in Central and Northern Europe are significantly higher than indirect ETS costs in South-Western and South-Eastern Europe.

The inter-regional variations are caused by higher electricity consumption per tonne of wall and floor tiles in Central and Northern Europe and by differences in electricity intensity of production between plants.

The ETS indirect cost was significantly lower in 2012 compared to the previous years, because the price of EUAs was significantly lower in 2012.

6.10 Production costs and margins

6.10.1 General figures

This section presents an analysis of the production costs and margins for EU producers of wall and floor tiles. As already pointed out, nine plants provided complete data on production costs and on financial indicators (e.g. EBITDA). However, seven out of nine plants are from the same EU member state. Thus, instead of presenting average values for the whole sample as in other sector reports, a case study covering four plants was prepared. It is worth noting that validating the data on margins provided by the producers was not possible.

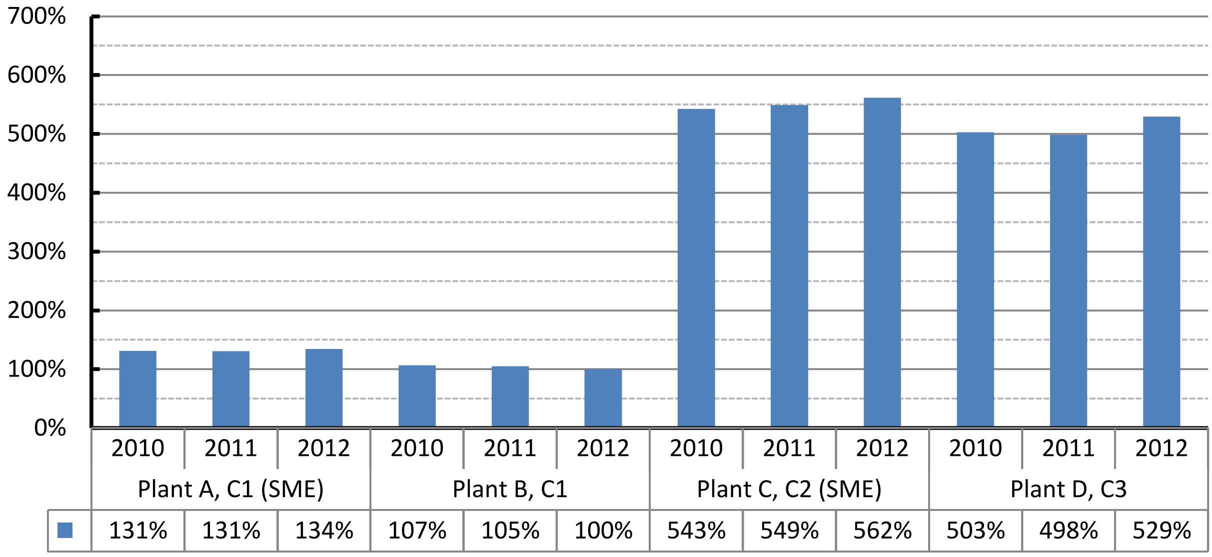
For the case study, four producers from three different countries[112] were selected. Two producers are SMEs, two are large enterprises. The original data was provided in Euro per tonne of product at current prices. Due to confidentiality reasons, it is not possible to present plant-specific figures in absolute terms. Therefore, all values presented in Figure 17 and Figure 18 are indexed to the lowest value. For the plants included in the sample, the following elements are estimated for the years 2010, 2011 and 2012:

- Total production costs per tonne of product, whose estimate includes all production costs, *inter alia* cost of finished goods, other operating expenses, depreciation, amortization and financial expenses referred to the product line;
- EBITDA,[113] i.e. the difference between plant market price and production costs, excluding capital costs.

[112] Referred to as C1 (1st country), C2 (2nd country) and C3 (3rd country).

[113] EBITDA stands for Earnings Before Interest, Taxes, Depreciation and Amortisation.

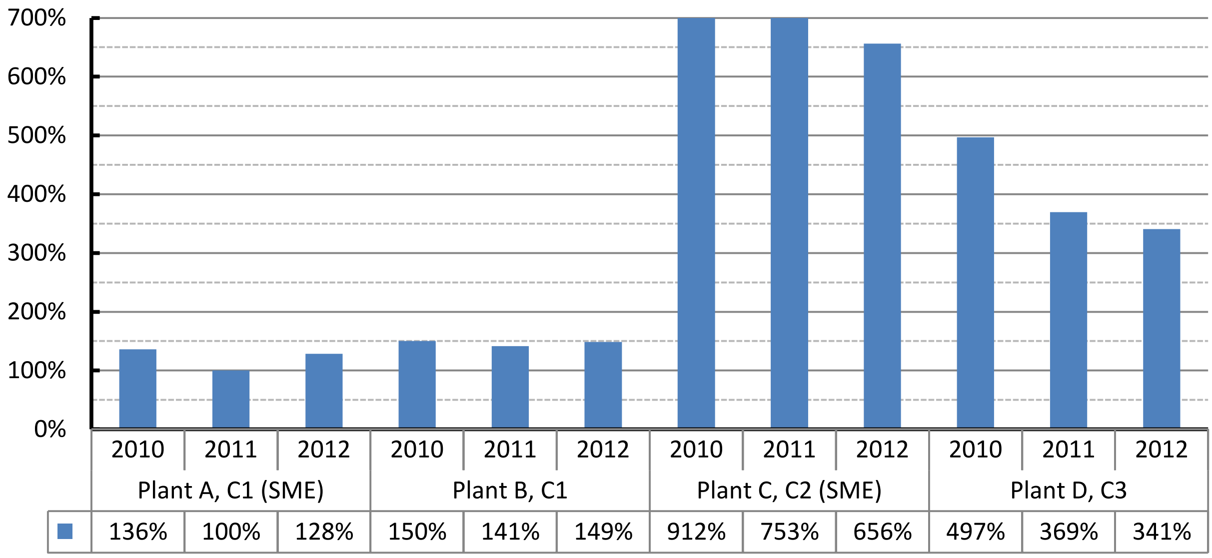
Figure 17. Production costs (indexed values), 2010-2012



Source: Authors' own elaboration.

As shown in the Figure above, production costs differ significantly between plants. This is likely due to the fact that, for wall and floor tiles, final products are not as homogeneous as in the case of e.g. float glass.

Figure 18. EBITDA (indexed values), 2010-2012



Source: Authors' own elaboration.

The same consideration applies for EBITDA figures. Moreover, it is worth noting that it is not possible to estimate a trend for financial indicators from only three years of observation.

6.10.2 Impact of energy costs on production costs and margins

This subsection presents the impact of energy costs on production costs and on profit margins. Energy costs in terms of €/MWh have been converted into costs in terms of €/tonne using the corresponding energy intensities (electricity, natural gas). Then, the ratio between these energy costs and production costs was calculated. The figures are reported in Table 13.

Table 13. Impact of total energy costs on production costs (%), 2010-2012

	Electricity			Natural gas		
	2010	***2011***	**2012**	**2010**	**2011**	**2012**
Plant A, C1 (SME)	8.7%	9.4%	10.1%	18.8%	24.2%	25.6%
Plant B, C1	8.1%	7.4%	8.9%	23.0%	29.2%	37.3%
Plant C, C2 (SME)	1.6%	1.5%	1.8%	13.0%	13.4%	17.9%
Plant D, C3	6.5%	6.4%	7.2%	12.9%	14.8%	16.4%

Source: Authors' own elaboration.

Again, the differences between the various plants are significant: electricity costs have a share of 1.6% to 10.1% on total production costs, natural gas costs have a share of 12.9% to 37.3%. However, the sample indicates an upward trend when comparing 2010 and 2012 values.

A similar method has been applied to assess the impact of energy costs on EBITDA. Here, the focus is not on total energy costs but only on regulated costs (i.e. grid fees, RES levies and non-recoverable taxes). As before, the costs in terms of €/MWh were converted into costs in terms of €/tonne using the corresponding energy intensities. Then, the ratio between regulated energy costs and EBITDA was calculated. The figures are reported in Table 14. Here again, the spread between the values reported by the various plants is broad due to the heterogeneity of the final products.

Table 14. Impact of regulated energy costs on margins (%), 2010-2012

	Electricity			Natural gas		
	2010	***2011***	**2012**	**2010**	**2011**	**2012**
Plant A, C1 (SME)	28.4%	31.9%	33.5%	23.3%	34.3%	26.6%
Plant B, C1	18.0%	14.5%	18.2%	21.4%	24.4%	26.4%
Plant C, C2 (SME)	1.9%	2.4%	4.0%	1.0%	2.5%	4.8%
Plant D, C3	9.6%	18.0%	24.3%	15.9%	20.8%	23.1%

Source: Authors' own elaboration.

6.11 General impressions

The consultant used the questionnaires to (*inter alia*) ask EU producers about their impressions of the effects of liberalisation, investments in energy efficiency or the energy intensity of the sector.

Some producers admitted that the liberalisation of the energy markets engendered increased competition among energy suppliers. However, the same interviewees claimed that liberalisation did not lead to lower energy prices. Roughly half of the respondents claimed that their facilities were not entitled to any reductions/exemptions from networks tariffs, taxes or levies. Nevertheless, manufactures listed favourable tax treatment as one of the main reasons behind investments in energy efficiency; most of the respondents admitted that investments in this field were savings-driven. Only few producers admitted that the price of CO_2 was included in their electricity contracts. Most of the manufacturers had yearly contracts with their energy utilities. Depending of their geographical location, wall and floor tiles producers associated the costs of natural gas with oil prices or spot prices. In the case of electricity, interviewees claimed that prices at power exchanges, taxes and oil prices were the main price drivers in their power contracts.

A producer based in Central Europe claimed that his competiveness is more affected by possible exemptions/reductions than by energy prices. In other words, this producer was more concerned by the obtention of the possible exemptions/reductions than changing energy prices.

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