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Composition and drivers of energy prices and costs: case studies in selected energy-intensive industries

FINAL REPORT

CEPS (Consortium leader)

Andrei Marcu (Project Leader)
Wijnand Stoefs (Project Coordinator)
Katja Tuokko
Prof. Christian Egenhofer
Prof. Dr. Andrea Renda
Dr. Felice Simonelli
Dr. Fabio Genoese
Edoardo Storti
Eleanor Drabik

Ecofys (Partner)

Thomas Hähl
Martijn Overgaag
Katharina Grave
Michele Koper

Economisti Associati (Partner)

Dr. Giacomo Luchetta
Maximilian Freudenthaler
Alberto Bolognini

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Executive Summary

Methodology

This study examines energy prices for a selection of five energy-intensive (sub-)sectors of EU industry, it includes three sectors and two sub-sectors of the ceramics industry:

- Steel (section 3)
- Aluminium (primary & downstream) (section 4)
- Wall and floor tiles (section 5)
- Bricks and roof tiles (section 6)
- Refineries (section 7)

For each of these five (sub-)sectors, the study aims to provide:

- An overview of energy price developments with particular attention to i) energy price levels, and ii) the structure of energy prices, i.e. the components of energy bills. Note that all energy prices reported and used throughout the study are net-prices (as reported on energy bills), exemptions or reductions for specific components are counted in. However, tax rebates, subsidy schemes or other financial compensation mechanisms that are not visible in bills are not accounted for due to a lack of data on these elements;
- An overview of the evolution of energy intensity;
- An international comparison with non-EU production sites in those sectors where data was available; and
- An assessment of the impact of energy prices and their components on the unit production costs and other key performance indicators, such as the price-cost margin, EBIT (earnings before interest and taxes) and EBITDA (earnings before interest, taxes, depreciation and amortisation).

The analysis was conducted between December 2015 and June 2016, with the primary information collected between February and March 2016 via a questionnaire sent to the selected plants. The questionnaire contains (inter alia) questions on production levels, financial data and energy costs and consumption.

Table 1 shows the total number of questionnaires received per (sub-)sector, as well as used in this study. In total, 151 EU plants provided data for this study. In addition, data from non-EU plants and third party data providers were used to conduct an international comparison between energy costs for EU plants and major competitors.

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

Industry	Number of responding plants				Number of questionnaires used	Energy bills collected
	Total EU	*NWE**	*CEE**	*SE**		
Cross-sectoral	116 (electricity), 108 (natural gas)	N/A	N/A	N/A	116 (electricity), 108 (natural gas)	N/A
Steel (BOF)	5	2	3	0	5	1
Steel (EAF)	17	13	2	2	17	0
Aluminium (primary)	14	N/A	N/A	N/A	14	4
Aluminium (downstream)	18	N/A	N/A	N/A	17	6
Wall and floor tiles	22	1	8	13	22	4
Bricks and roof tiles	60	43	9	8	60	20
Refineries	15	11	0	4	15	2

* EU Member States were divided in three regions: North-Western Europe, Central-Eastern Europe and Southern Europe. More information on countries in each region can be found in section 1.3 in the Introduction and Methodology chapter.

As Table 1 shows, data from nearly all questionnaires was included in the analysis as the research team worked actively with companies to improve both the scope and the quality of the data provided. More information on the approach followed, representativeness and possible limitations of results can be found in the methodology chapter, as well as in the case studies.

Table 2 presents the shares of total EU capacity covered by the study for each of the sectors. For each of the sectors, respondents accounted for at least 10% of total EU capacity. Note that the downstream aluminium sample is not mentioned in this table. The capacity share for this sample could not be indicated as it contains plants (rolling mills, refiners, remelters and extruders) from sub-sectors with very different products, and with varying degrees of vertical integration.

Table 2. Sectoral share of total capacity covered by respondents

Industry	Share of *total EU capacity*	Share of *total NWE capacity*	Share of *total CEE capacity*	Share of *total SE capacity*
Steel (BOF)	13.6%	7.8%	50.9%	0%
Steel (EAF)	11.4%	22.3%	9.7%	3.5%
Aluminium (primary)	93%	N/A	N/A	N/A
Wall and floor tiles*	10%	N/A	N/A	N/A
Bricks and roof tiles*	10.5%	N/A	N/A	N/A
Refineries	24.5%	34.2%	0%	14.3%

* As EU capacity data is not available for the two ceramic sub-sectors, EU production value is used to discuss sectoral coverage.

The period covered by the assessment ran from 2008 to 2015.

Sectoral studies show EU and regional averages, with the exception of the aluminium sector where only EU averages are presented for confidentiality reasons. While general trends can be depicted and explained, there can be shortcomings in presenting regional averages compared to the situation in Member States. In some cases, trends in Member States cancelled each other out, e.g. an increase in energy prices in one Member State, can be 'matched' with a decrease in another one, thereby concealing Member State trends.

This shortcoming was addressed in the cross-sectoral analysis (section 2); for electricity in nine Member States: Italy, the UK, Germany, Romania, the Czech Republic, Spain, France, the Netherlands and Portugal); and for natural gas 11 Member States are included (Italy, the UK; Germany Romania, Portugal, Hungary, France, Spain, the Czech Republic, Belgium and the Netherlands).

A sufficient number of plants in each of these countries agreed to participate in the study across all covered sectors to allow us to carry out country-specific analyses whilst ensuring the anonymity of plants.

Energy prices trends

The study presents information on the prices of natural gas and electricity purchased by the plants that responded to the questionnaire. Our cross-sectoral analysis of the responses to the questionnaires deemed usable for analysis (116 questionnaires for electricity and 108 for natural gas) shows that electricity prices and natural gas prices have been declining in most Member States since 2012. No clear trend can be drawn with regard to pre-2012 study period.

Prices for natural gas for primary aluminium producers, recyclers and downstream aluminium producers, refineries sector and bricks and tiles producers, for example, demonstrate the following trends:

- A substantial increase from 2008 to 2013 (primary aluminium: 26.15€/MWh to 31.78€/MWh, recyclers and downstream producers: 27.75€/MWh to 31.89€/MWh); a subsequent decrease up to 2015 (primary producers: to 26.37€/MWh, recyclers and downstream producers: to 26.38€/MWh).
- Respondents in the refineries sector reported a similar trend with the exception of 2008, when prices were higher (26.4€/MWh) compared to 2010 (21.89€/MWh). Average natural gas prices (weighted by consumption) in the refineries sector increased from 2010 to 2013 (30.17€/MWh) with an overall decrease observed over the entire study period 2008-15 from 26.4€/MWh /MWh to 23.4€/MWh.
- Similarly, in the bricks and tiles sector, natural gas prices on average increased from 2008 (27.19€/MWh) to 2013 (30.09€/MWh), decreasing again up to 2015 (27.04€/MWh).

At Member State level, the analysis across the five sectors of this study shows that the UK, Belgium, Germany, Romania and Italy appear to benefit from relatively low gas prices, compared to Portugal, Hungary and Spain. The sample, however, is too small to draw any strong conclusions.

The responding plants in the EU refineries sector reported a trend of declining electricity prices over the entire study period, as electricity prices (averages weighted by consumption) went down from 2008 (62.37 €/MWh) to 2015 (57.82 €/MWh).

The sectoral study of primary aluminium producers shows that the EU average of electricity prices (weighted by consumption) increased for our sample from 35.77€/MWh in 2008 to 44.52€/MWh in 2012, and has since decreased to 40.08€/MWh in 2015, which is 12% higher than in 2008.

This decreasing trend, however, is not present in all sectoral studies. Questionnaires received from the wall and floor tiles subsector show a general upward trend in the weighted average values of electricity prices (+8.3%) over the study period. At the same time, weighted average electricity prices in the bricks and tiles sub-sector show such prices increasing until 2014 (90.72€/MWh), and remaining stable in 2015 (89.82€/MWh).

A cross-sectoral comparison of energy prices categorised by consumption bandwidths shows that while electricity prices for small and medium installations are relatively similar, larger plants (with consumption levels of between 100,000 MWh and 1,000,000 MWh per year) generally benefit from lower electricity prices.

Electricity and gas prices have mostly decreased, largely due to a decrease in primary energy prices, such as coal and gas, driven by the shale-gas boom in the US. Other contributors to this trend may include:

i. a reduction in electricity demand, due to the 2008 economic crisis and improvements in energy efficiency; and
ii. a decrease in EUA (European emission allowances) prices.

Energy bill components

This study presents an analysis of the various components of the price paid by sampled installations for natural gas and electricity, with different components applicable to the two energy carriers.

The price of **natural gas** is split into three components, two of which depend on the regulatory framework:

i. Energy supply
ii. Network costs
iii. Other taxes, fees, levies and charges (excluding recoverable taxes, such as VAT)

The cross-sectoral analysis of the components of natural gas bill shows a varying importance of the regulated components, with differences across sectors and Member States.

Data from EU plants in the wall and floor tiles sector shows that over the entire study period, network costs and other taxes and fees were below 10% of total costs. Network costs represented 7.2% of EU gas costs in 2015, while other taxes and fees represented 2.1%. Accordingly, the energy component represented more than 90% of costs across all years.

Similarly, responses from plants in steel sector demonstrate the importance of the energy component, which represents more than 90% of natural gas costs for the steel producers over the entire period (92.8% in 2008 to 91.4% in 2015). Steel plants faced relatively stable network costs for their natural gas.

Other taxes, fees, levies and charges increased moderately, but continuously at the beginning of the study period, and then stabilised from 2012 to 2015, at a level of around €0.47/MWh.

The cross-sectoral analysis shows that the importance of network costs in natural gas prices differs between EU Member States. Installations in the UK, Belgium, Germany, Romania and Italy appear to face lower network costs than plants in Portugal and Hungary. The sample, however, is too small to draw any strong conclusions.

The price of **electricity** is split into four components, three of which depend on the regulatory framework:

i. Energy supply
ii. Network costs
iii. Renewable support
iv. Other taxes, fees, levies and charges (excluding recoverable taxes, such as VAT)

As opposed to natural gas, regulated components played a more significant role in the composition of the final electricity price. Overall results from respondents show that the share of electricity bills represented by RES support payments and network costs has mostly been increasing since 2012. However, the increase in these costs does not outweigh the decrease in the electricity supply cost component.

This trend is reflected in the responses received from EU steel producers who report continuously increasing other taxes, fees, levies and charges since 2008. Their responses show increasing RES payments up to 2013, with a decreasing trend after 2013.

Despite these fluctuations with regards to the regulatory components, the overall trend suggests decreasing energy supply costs of electricity starting in 2012. Weighted average electricity supply costs from respondents peaked in 2012 at €51.10/MWh, and decreased to €41.26/MWh in 2015 (-20%). Over the entire period, the share of the energy component in total electricity prices decreased from 86.0% (2008) to 78.2% (2015).

The cross-sectoral analysis shows differences in all price components across Member States, with a more pronounced cross-EU difference in ‘regulatory components’ (network costs, renewable support, other taxes & levies).

Italian and Portuguese plants experienced significantly higher electricity prices than some other EU Member States, mainly as a result of higher taxes, levies and network costs. Italian and Portuguese plants also appear to have experienced higher energy supply costs compared to German and Romanian plants.

The significance of price components differs significantly between Member States, mainly due to three national differences 1) differences in exemptions granted for electricity-intensive consumers 2) differences in which price components are reported in electricity bills and 3) differences in funding schemes of the network grids and renewable energy.

Energy intensity

This study presents the analysis of natural gas intensity, electricity intensity and overall energy intensity (limited to the combination of electricity and natural gas) via box plots and descriptive tables.

The heterogeneity of production in several sectors presented a challenge for the analysis on energy intensity as the energy intensities of final products within the steel, downstream aluminium, bricks and roof tiles, wall and floor tiles and refineries sectors vary significantly.

The trends found across sectors show variations: the refineries sector experienced an increase in average natural gas intensity from 0.77 MWh/t in 2008 to 0.84 MWh/t in 2015, mainly in Southern European Member States (increase from 0.5 MWh/t to 0.77 MWh/t). EU weighted averages of electricity intensity remained stable over the entire period, ranging between 0.09 MWh/t and from 0.10 MWh/t. Maximum electricity intensity values fluctuate between 0.15 and 0.17 MWh/t, whereas minimum values are stable at approximately 0.03 MWh/t.

The bricks and roof tiles sector shows a decreasing average (weighted by production) in natural gas intensity from 2008 (0.56 MWh/t) to 2015 (0.52 MWh/t) and a stable electricity intensity (0.06 MWh/t) across the whole period. Similarly, the primary aluminium study presents a stable electricity intensity (weighted by production) of approximately 14.5 MWh/t.

International comparison

An attempt to acquire data on non-EU plants via a bottom-up method of data collection was largely–unsuccessful as data was not made available by industry, and alternative means had to be found.

In light of the limited number of observations gathered through bottom-up data collection, the international comparison is complemented through data purchased from CRU for the primary aluminium and steel sectors.

For similar reasons, the international comparison is provided for the entire “manufacture of clay building materials” sector (NACE Rev. 2 code C23.3), which comprises both producers of ceramic tiles and brick and tiles. For the refineries sector, public reports from Solomon Associates were used.

Prices for each of the energy carriers differ across sectors and countries. For example, the aluminium study shows that EU producers in 2015 paid significantly more for electricity (42.44€/MWh) than producers in some other regions such as Canada (13.13€/MWh), Russia (23.48€/MWh), Nordic countries (24.23€/MWh), the US (30.62€/MWh) and the Middle East (36.90€/MWh). The differences in electricity prices between the EU and the regions mentioned above have fallen between 2008 and 2015 (except in the case of Canada).

In the ceramic tiles and brick and tiles sectors, the differences are especially stark for natural gas, particularly in comparison with Russian plants. In 2015, Russian plants paid approximately 6€ €/MWh for natural gas, which is approximately 78% less than the EU average, and 75% less than the CEE average, their closest neighbours. While there is a clear impact on wall and roof tiles, the impact of these price differentials on trade patterns is less clear as bricks and tiles is not widely traded across regions, due to the low value-to-weight ratio.

Public data from Solomon Associates (2015) for the refineries sector show that refiners in Asia experienced stronger increases in energy expenditure per barrel compared with the EU refineries, while energy expenditures per barrel for US refineries has been clearly declining since 2008. Energy expenditure per barrel for refineries in the Middle East remained fairly stable.

According to CRU data, electricity prices in the EU and Turkey decreased the most for steel producers (by 12% and 15%, respectively), whereas the prices in Japan (51.8%) and China (38.7%) increased the most.

Impact on competitiveness

The study presents the information retrieved from sampled companies concerning Key Performance Indicators (KPI) (production costs, margins, and turnover) with the aim of analysing the impact of energy costs over financial indicators, namely production costs and margins.

The data received from the surveyed EU producers show that in many sectors energy costs have a major impact on financial performance. In the wall and floor tiles sector, total energy costs were higher than EBITDA during the economic crisis. The same was true during the whole study period for the primary aluminium producers and the brick and roof tiles sector.

Data from EU aluminium producers shows that electricity costs vary between 22.2% and 29.2% of production costs. In the bricks and roof tiles sector, the EU weighted average of energy costs over total production costs ranges between 28% and 35%. In the steel sector, the data demonstrate variations in the electricity cost as a share of production costs ranging from 4.9% to 6.8% (average across BOF and EAF) over the study period. The share of natural gas costs in production costs was considerably lower for all years, ranging between 2.5% (2015) and 3.6% (2010).

It is therefore clear that the cost of energy has an impact on competitiveness for EU enterprises, but that impact is not uniform and nor can it be attributed everywhere to the same causes. Drivers vary across countries and sectors. It is quite clear that, in a period during which the energy-cost component has decreased substantially, the cost of regulation is an important factor that merits attention.

The impact of the regulatory components currently remains relatively limited compared to the impact of the energy price component. However, the importance of the regulatory components could continue to increase, especially if the energy price component would halt its downward trend and potentially, due to changes in the international energy scene, even increase.

1 *Introduction and methodology*

1.1 Context of the study

In May 2013 the European Council called on the Commission to present an analysis of the composition and drivers of energy prices and costs in Member States, with a particular focus on the impact on households, SMEs and energy intensive industries.

After the first analysis, in June 2014, energy ministers asked the Commission to extend its analysis and produce a follow-up review.

The Commission emphasized the importance of the review in its Communication on Energy Union adopted in February 2015 which indicated that the Commission will "ensure greater transparency in the composition of energy costs and prices by developing regular and detailed monitoring and reporting, including on impacts of energy costs and prices on competitiveness. Particular attention will be paid to public interventions such as regulated tariffs, energy taxation policies and the level of public support, as well as their impact on pricing mechanisms, including electricity tariff deficits".

Drawing on that call for action and the following work initiated by the Commission, this study was commissioned in order to collect and present representative bottom-up evidence on composition and drivers of energy prices and costs through primary data collection and direct contacts with representatives at company and plant level. The analysis has been conducted between December 2015 and June 2016 with primary information collected between February and May 2016.

This study focuses on a selection of five energy-intensive (sub-)sectors, that were chosen in conjunction with the Commission services:

- Steel
- Aluminium
- Wall and floor tiles
- Bricks and roof tiles
- Refineries

Additionally, a chapter on cross-sectoral analysis is included which brings together the data gathered throughout all five (sub-)sectors and analyses this data across sectors and Member States. Each sector study consists of the following elements:

- The main highlights from the research
- A more general overview of the sector (production process, trade analysis, geographic distribution throughout the EU, literature review on energy)
- The sampling strategy and the description of the actual sample
- An analysis of energy prices, both total prices and split per components. All energy prices used throughout the analysis are net-prices, as reported on energy bills: exemptions or reductions for specific components are counted in. However, tax rebates, subsidy schemes or other financial compensation mechanisms that are not visible in bills are not accounted for due to a lack of data on these elements

- An analysis of sectoral energy intensity, defined, in line with general literature, as: energy consumption per unit of production.
- A comparison with relevant international competitors for which data was available or obtained
- An analysis of Key Performance Indicators (KPI) and the impact of energy costs over production costs and margins
- Sectoral conclusions

1.2 Scope

This section describes the methodology used during the gathering and handling of data, and during the drafting of the cross-sectoral analysis and the five sectoral case studies.

To undertake this study, data was collected at plant level for each sector through a questionnaire. This questionnaire covered energy consumption and energy prices paid by the plant, the structure of energy bills (energy component, network costs, RES levies and other taxes, fees and levies) as well as information on production levels, energy efficiency/energy intensity and Key Performance Indicators (margins and other financial data).

The report takes into consideration 1) interruptibility schemes, ii) self-produced energy and iii) energy sold to the grid when presenting energy costs. Self-produced energy and energy sold to the grid are considered when presenting results on energy intensity.

A potential source of double counting is the electricity that is generated on-site using natural gas (for example in a combined heat and power plant). In order to reduce the risk of double counting:

i. The sections on natural gas intensity include natural gas volumes purchased for self-generation of electricity.
ii. The sections on electricity intensity include the self-generated electricity.
iii. The sections on overall energy intensities (aggregate of electricity and natural gas) of production, the electricity generated using natural gas on-site fired generation are dropped out of the analysis.

1.3 Sampling

The different sectoral samples were established on the basis of *four* criteria:

- The *plant capacity* criterion was applied to ensure that the sample resembles 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 in particular with regard to the steel sector;
- The *ownership i.e. 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 (multinational) companies. Throughout this Study, as agreed with the relevant Commission services, a simple definition of SMEs is used: companies are defined

as SMEs if they have less than 250 full-time employees[1]. Out of these 22 responding plants in the wall and floor tiles sector, 9 were owned by SMEs. In the bricks and roof tiles sector analysis, 19 plants belong to SMEs, while 41 plants belong to large companies. 3 respondents among the 17 responding downstream aluminium companies were SMEs while all primary aluminium, steel and refineries respondents did not include any SMEs thus limiting the possibility to conduct a cross-sectoral analysis on SMEs.

- The *geographical criterion* has been used with a dual objective. First to reflect 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. A division of the EU in geographic regions was used for sample selection. Table 3 below describes the regional split used in the sample selection and in regional analysis throughout the study:

Table 3. Geographic regions used throughout the study

EU region	Countries
Southern	Italy, Spain, Portugal, Greece, Malta, Cyprus
Central-Eastern	Poland, Slovenia, Hungary, Romania, Bulgaria, Czech Republic, Slovakia, Estonia, Latvia, Lithuania
North-Western	France, Ireland, UK, Belgium, Netherlands, Germany, Denmark, Austria, Sweden, Finland

1.4 Data collection

The research team developed, in accordance with Commission services, a questionnaire that was used for the collection of data from the industry sectors. The questionnaire is country-specific and adapted for each of the (sub-)sectors, in order to take sectoral characteristics with respect to technology and vertical integration on board. These questionnaires were sent to and filled in by industrial sites and/or corporate head offices.

A pilot test was carried out in order to test the questionnaire and avoid that time and resources are wasted through sending companies an inadequately drafted questionnaire that might need revisions or time intensive explanatory interviews. The questionnaire was discussed with experts in each of the sectors, ensuring that:

- The technical specifications of the relevant sector are properly reflected
- Questions are clear
- Data requested are available at a plant and/or company level

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[1] SMEs are defined in the Commission Recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises and in the European Commission (2015): User guide to the SME definition. SMEs are considered companies with less than 250 employees and an annual turnover of less than €50 million. Throughout this Study, as agreed with the relevant Commission services, a simpler definition of SMEs is used: companies are defined as SMEs if they have less than 250 full-time employees.

- Questions are relevant

Altogether 151 EU plants provided data to this study. Table 4 shows the total number of questionnaires received per (sub-)sector and used in this study. One aluminium plant initially provided a questionnaire, but was unwilling to improve the quality of the data in that questionnaire in conjunction with the research team. The data from that plant did therefore not pass the validation process and was dropped.

Table 5 shows the share of total EU capacity represented by the respondent plants for each sector and geographic region. Note that for primary aluminium no geographic division is made due to confidentiality concerns. The downstream aluminium sample is not mentioned in Table 5. The capacity share for this sample could not be indicated as it contains plants (rolling mills, refiners, remelters and extruders) from sub-sectors with very different products, and with varying degrees of vertical integration.

Table 4. Total number of questionnaires received and used in the study

Industry	**Number of responding plants**				**Number of questionnaires used**	**Energy bills collected**
	Total EU	*NWE*	*CEE*	*SE*		
Cross-sectoral	116 (electricity), 108 (natural gas)	N/A	N/A	N/A	116 (electricity), 108 (natural gas)	N/A
Steel (BOF)	5	2	3	0	5	1
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Aluminium (primary)	14	N/A	N/A	N/A	14	4
Aluminium (downstream)	18	N/A	N/A	N/A	17	6
Wall and floor tiles	22	1	8	13	22	4
Bricks and roof tiles	60	43	9	8	60	20
Refineries	15	11	0	4	15	2

Table 5. Sectoral share of total capacity covered by respondents

Industry (sub-sector)	**Share of *total EU capacity***	**Share of *total NWE capacity***	**Share of *total CEE capacity***	**Share of *total SE capacity***
Steel (BOF)	13.6%	7.8%	50.9%	0%
Steel (EAF)	11.4%	22.3%	9.7%	3.5%
Aluminium (primary)	93%	N/A	N/A	N/A
Wall and floor tiles	10%	N/A	N/A	N/A
Bricks and roof tiles	10.5%	N/A	N/A	N/A
Refineries	24.5%	34.2%	0%	14.3%

1.5 Data validation

A possible shortcoming arising from adopting a bottom-up approach is the validation of data. To address this, the research team has consistently carried out the validation of data through own sources, follow-up interviews or supporting evidence delivered by companies (including energy bills and balance sheets).

Received questionnaires have been followed up by telephone calls to plant managers to discuss the findings and address issues that were unclear. The research team remained in close contact with each plant for the entire duration of the study both by telephone and e-mail to clarify open issues, increase understanding of plant specifics and expand the scope of data that was initially delivered.

Several approaches have been used for data validation

(i) accessing relevant supporting company documents, e.g. energy bills for energy costs, balance sheets and profit and loss accounts for margins, under strict confidentiality agreements to be used exclusively for validation purposes;
(ii) triangulating results and estimates provided by the various companies with secondary sources or drawing conclusions on their validity;
(iii) using commercial data providers, e.g. AMADEUS, that cover a wide range of firms to verify the accuracy and credibility of the data collected by the research team across the EU and
(iv) conducting interviews with the companies for which the analysis of the data received through the questionnaires reveal possible consistency issues.

1.6 International comparison

A key step carried out has been the **collection of data for international comparison** from non-EU plants and third party international data providers.

The collection of international data was done through the identification of EU producers with plants outside the EU and identifying possible databases that could provide meaningful data for this comparison. Non-EU plants provided data for the primary aluminium (6 plants), steel (3 plants, refineries (1 plant) and the ceramic sectors (4 plants).

In sectors were it was not possible to collect sufficient international data from companies (often due to the sensitivity of this information), the bottom-up approach was complemented, by using data from international data providers when possible. In the case of **aluminium and steel sector**, data on electricity and natural gas prices for non-EU plants was acquired from commercial data provider CRU.

For **refineries** contact was made with Solomon Associates, who have done extensive surveys in the refinery sector over the last decade collecting information, including energy price data and production costs data. Due to confidentiality reasons Solomon Associates could not share any data on international price or production cost values with the research team. The research team therefore had to rely on publicly available studies (such as reports from Solomon Associates), which mainly show indexed and not absolute figures.

The international comparison for the ceramics producers in both the **bricks and tiles and the wall and floor tiles** sub-sectors was combined. This is mainly due to data limitations: unlike other sectors, there is no international database of production and energy costs for the ceramic industry; hence the research team had to retrieve primary data from extra-European plants.

From a methodological perspective, the choice to combine the international comparison of wall and floor tiles with bricks and roof tiles is not problematic, given that the analysis is limited to energy prices in €/MWh, without considering costs over physical output or on financial indicators. With respect to energy prices, the consumption level per plant in the two sub-sectors is homogeneous, hence the analysis is not affected by different consumption levels.

An attempt to contact extra-European companies and plants in neighbouring regions present in the Amadeus database was carried out, but this was unfruitful.[2] Therefore, multinational European companies already participating in the study and managing plants in non-EU countries were contacted.

Thanks to the cooperation of EU multinationals, data on four plants could be retrieved: two bricks and tiles plants in Russia, one wall and floor tiles plant in Russia, and one bricks and tiles plant in the US.[3] More in detail, a Russian average price was calculated based on the weighted average of the prices of the three plants, weighted by energy consumption. For the EU, representative prices for the two-sectors combined were calculated as the average of the EU weighted average prices. Given the number of data points, the generalisability of the analysis remains limited.

Supporting evidences were received only from one plant. Hence, for other plants, the research team could only carry out a plausibility check based on secondary sources and other data retrieved during the study, which led to the validation of data, including revision of outliers. Data retrieved from foreign plants concerned a more limited number of years (2010, 2014, and 2015) and a more limited set of information.

With regards to **exchange rates**, when plants operate outside the Eurozone, or report data in another currency than the Euro, ECB statistical warehouse data is used to convert other currencies into Euro. This also applies to the international comparison.

Using such exchange rates does not take account of differences in purchasing power parity (PPP). However, such 'nominal' translation allows for better comparison of Energy Prices across Member States. It is beyond the scope of this Study to investigate drivers of price differences in 'real' terms, though this means that potential undervaluation of currencies can have a large impact on international comparisons.

CRU data is used for the aluminium and steel international comparisons. CRU uses the concept of equilibrium exchange rate to convert local currencies into USD in a manner

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[2] Fifty Bricks and Tiles plants were contacted in Balkan and CSI countries, without success.

[3] For two Russian plants, data were provided jointly.

that seeks not to undervalue or overvalue the local currency. CRU's historical exchange rates are provided by Oxford Economics.

1.7 Confidentiality

This study was carried out in strict compliance with confidentiality and anti-trust rules. The research team will only use the data collected for this study in the context of this study, and no company or plant data can be identified throughout the study. Therefore, the research team provided participating companies with an optional confidentiality agreement. In addition to the confidentiality agreement, contacts with surveyed companies were facilitated by a letter of introduction from the Commission services.

All information that is presented via box plots and descriptive tables is 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 used regions (listed above) to present results, along with EU averages. For the aluminium sector only EU-wide analysis was included to ensure the anonymity of respondents and the confidentiality of data.

1.8 KPI analysis

Respondents were asked to provide KPI data at plant level, to allow a consistent analysis of the impact of plant energy costs on financial performance. However, retrieval of KPI at plant level was not always possible, and in some cases respondents provided KPI at company (or national subsidiary) level. The following cases were possible and the related analysis was undertaken:

i. KPI provided at plant level: no further analysis was necessary before estimating impacts;
ii. KPI provided at company level, single-product company, and single-product plant: KPI were allocated to the plant(s) included in the sample based on each plant's share of output;
iii. KPI provided at company level, multi-product company and single-product plant: respondents were asked to report the share of turnover generated by each product in 2015; based on this values, company KPI were allocated across different products, and then KPI are further allocated to the plant(s) included in the sample based on each plant's share of output;
iv. KPI provided at company level, multi-product company and multi-product plant: no sound estimation was possible and the plant was not used in the KPI analysis (this resulted in excluding one plant).

Data on Key Performance Indicators is not available to the same extent for all sectors, therefore case studies may differ in terms of scope of the analysis.

1.9 Methodological choices

Below is a collection of short methodological notes on various subjects:

- Across all sector studies the sectoral chapters present the weighted averages of energy prices paid at the plant level by EU producers as well as the differences among the major EU regions. The same approach is used for the presentation energy bill components as well as for the presentation of production costs and margins.

EU averages are the averages of all plants in the sample weighted using plant energy consumption. These averages are compared with averages weighted with plant production data. If the difference between the two is significant, results with both weights are presented, compared and explained. The regional averages combine the results of all plants in a given region.
In exceptional cases where weighting by consumption has not been possible due to e.g. lack of data, the results have been weighted by production with a clear indication that a different weight has been used.

- The research team also did not discard data points in order to balance response rates between regions or company segments. In particular, this has meant that ex-post weights have been applied to regional data in the two ceramics sub-sectors, due to the overrepresentation of some regions. In the other sectoral case studies no regional weights have been used.

  In the case of bricks and roof tiles, the sample is skewed towards NWE plants. In the case of wall and floor tiles sub-sector, the sample is skewed towards SE plants.

  Even though an overwhelming number of responses from one region were received, in the final analysis regional weights have been applied to so that the impact of over-represented regions on EU averages is somewhat compensated. Regional weights for bricks and tiles sector are as follows:

  1. North-Western Europe: 48%
  2. Southern Europe: 34.5%
  3. Central-Eastern Europe: 17.5%.

  In the final analysis of the wall and floor tiles subsector, regional weights have been determined using yearly production figures. For 2014 they were:

  1. North-Western Europe: 5.9 %
  2. Southern Europe: 82.1%
  3. Central-Eastern Europe: 12%

  Further details on these methodological choices and the weights can be found in the respective sector studies.

- The composition of the final sample has been dependent on the data provided by companies. As not all respondents reported answered the full questionnaire (out of necessity or choice), some years include more data points than other years. The research team did not discard data points, and this means that 2014 and 2015 (the most recent years) often contain more data points than 2008 and 2010.

  For comparability reasons, the study also reports results using only those plants that provided full data for years 2008-15 when the differences are significant between the results based on all data and those based on only plants that reported data for all years.
- Companies were not always able to provide both overall prices and price components. Often detailed components were not visible on energy bills. There are

significant differences between the average energy prices as reported above in the section energy prices and the results reported in this section on energy components. This is caused by different numbers of respondents included in both sections of the analysis.

- In all sectors, ''tonne of output" is expressed in metric tonnes except in wall and floor tiles sector where millions of m^2 of product are used.

- The electricity intensity of production was measured by summing (i) electricity purchased from the grid; and (ii) electricity self-generated; then subtracting (iii) electricity sold to the grid; and (iv) dividing by production.

- Whilst general trends can be depicted and explained, there can be shortcomings in presenting regional averages compared to the situation in Member States. In some cases, trends in Member States have cancelled themselves out, e.g. an increase in energy prices in one Member State, was 'matched' with a decrease in another one, thereby concealing Member State trends in regional averages.

  This shortcoming was addressed in the Cross Sectoral Analysis (chapter 2); for electricity nine Member States are included (Italy, UK, Germany, Romania, Czech Republic, Spain, France, The Netherlands and Portugal); and for natural gas eleven Member States are included (Italy, UK, Germany Romania, Portugal, Hungary, France, Spain, Czech Republic, Belgium and The Netherlands).

  For the countries listed above, 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 cross-sectoral study presents national data for those Member States and compares big consumers with small consumers with three different bandwidths of yearly energy consumption used. Analysis of SMEs and non-SMEs was not possible as only respondents from 2 sectors (Bricks and roof tiles & Wall and floor tiles) had significant numbers of SMEs.

- No estimates are used in the Report.

- As a rule of thumb, the same analysis has been done for all sectors, however, this is subject to data availability. Therefore, some sections of analysis could not be done to the same level of depth for each (sub-)sector. This is most notable for the sections on Key Performance Indicators, as some sectors deemed this information more confidential than others.

1.10 Detailed methodology on estimates of indirect EU ETS costs

The objective of the indirect ETS cost calculations per sector in this study is to provide an estimation of the indirect ETS cost for each sector between 2008 and 2015. Indirect EU ETS costs are not presented at the plant level, but rather as sector-wide averages.

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

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

** Carbon intensity of electricity (Tonne of CO_2/kWh)*
** CO_2 Price (€/t 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[4] and reported below in Table 6.
    - These figures are not national. Member States who are deemed 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).
    - These figures were set in 2012 and have changed significantly since then. There is however no updated data reported by EU institutions.

Table 6. Maximum regional CO_2 emission factors (tCO_2/MWh)

Regions	tCO_2/MWh
Austria, Belgium, France, Germany, Netherlands, Luxembourg	0.76
Czech Republic, Slovakia	1.06
Portugal, Spain	0.57
Denmark, Sweden, Finland, Norway	0.67
Bulgaria	1.12
Cyprus	0.75
Estonia	1.12
Greece	0.82
Hungary	0.84
Ireland	0.56
Italy	0.60
Latvia	0.60
Lithuania	0.60
Malta	0.86
Poland	0.88
Romania	1.10
Slovenia	0.97

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[4] 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)

United Kingdom	0.58

Source: Guidelines on certain State aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012 (2012)

- CO_2 Price: Yearly averages of the daily settlement prices for Dec Future contracts for delivery in that year (as reported in Table 7). The daily settlement prices were reported by the European Energy Exchange.

Table 7. EUA prices in the EU ETS, 2008-2015

	2008	2010	2012	2013	2014	2015
EUA price	23.03	14.48	7.56	4.50	5.92	7.61

Source: Authors' elaboration on data from European Energy Exchange (2016).

It is important to note that electric utilities face increased production costs through their ETS compliance cost. They pass those costs on to their customers via higher electricity rates. Both industry and households therefore face an extra cost because of the cost of CO2 embedded in electricity prices. Industries cannot fully pass on this additional cost to the ultimate customers if they are active in a globally competitive sector. Electricity intensive industries faced indirect costs, even if they were or are not covered by the EU ETS.

Note that these estimates are characterized by some limitations:

- The pass-on rate of the CO_2 cost for producing electricity is subject to considerable debate and may vary significantly between Member States. Interviews with various stakeholders revealed a possible range for the actual pass-on rates. This information is very challenging to ascertain for each installation, or even Member State. Therefore, the decision was made to undertake a basic sensitivity analysis, with two pass-on rates (0.6 and 1).
- the carbon intensities of electricity generation used here are likely to be an overestimation, especially for the latter years in this period
- some industries were shielded from indirect costs in the past through self-generation and long-term electricity contracts, however most – if not all – of these contracts have ended by now. In 2013 at least 4 primary smelters had long term contracts with electricity providers that date from before the launch of the EU ETS. In other words, those plants did not face any indirect costs because their electricity price was negotiated before the EU ETS was incorporated into the price structure[5].
- In a number of Member States some industries (including steel, refineries and primary aluminium) are eligible for (partial) compensation of their indirect EU ETS costs based on performance benchmarks for the 2013-2020 period. The level of compensation differs for each country. The countries that have received clearance from the European Commission to give indirect ETS compensation are Germany, Netherlands, Belgium (Flanders only), UK, Norway, Spain, Greece, Slovakia and Lithuania. A few notes here:

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[5] CEPS-EA (2013) Cumulative Cost Assessment

  - Spain has only indicated to give compensation for 2014-2015. So far, there is no indication of compensation for the remaining period of Phase 3 of the EU ETS.
  - The research team has not been able to confirm that Greece is actually handing out compensation, despite them also having adopted national legislation to enable this.
  - No comprehensive data is publically available on the monetary value of these compensation measures.

2 *Cross-sectoral analysis*

Highlights

- **Electricity and gas prices** (net of exemptions and reductions) **have been declining in most Member States since 2012.** Electricity and gas prices have generally reduced in absolute value since 2012, largely due to a decrease in primary energy prices, such as coal and gas, driven by the shale-gas boom in the US. But also as a result of a reduction in electricity demand, related to the 2008 economic crisis and a decrease in carbon allowance prices.
- Overall, results from respondents show that **RES support payments and network costs, as reflected in electricity bills, have mostly been increasing since 2012**. The **increase in these costs, however, do not outweigh the decrease in the electricity supply cost component**. For example, the data from Italian plants demonstrate that the RES support payment increased from approximately 35.9€/MWh in 2012 to approximately 42.5€/MWh, while total electricity prices decreased by 7.7€/MWh over the same period. Despite the data from most Member States showing decreasing total electricity prices, it appears from respondents in the UK that prices have increased since 2012 from 84€/MWh to over 100€/MWh in 2015. This increase seems to be a result of both increasing energy supply costs and increasing RES support payments.
- **There is a clear relationship between electricity consumption and electricity prices.** It is evident from the data received that as consumption increases, prices decline. This is seen in two sections of the analysis: the grouping of plants by sector and the grouping by consumption. This is shown by the relatively low consumption rates in the brick industry with a median annual consumption of 4.6 GWh of electricity per plant and an average electricity price of 87.6€/MWh, compared with the primary aluminium industry, which has a median annual consumption of 2,215 GWh of electricity per plant and an average electricity price of 38.9€/MWh. This result has several possible explanations: larger consumers may negotiate more favourable supply contracts, they may still benefit from old long-term contracts and they may be granted exemptions from certain taxes and levies.
- **Gas price are less divergent across sectors compared to electricity.** In contrast to electricity prices, the relationship between gas consumption and gas prices was less apparent from the data provided by respondents. No significant trends can be observed in relation to price variations in gas across the different sectors. There are two possible reasons for this lower variation; firstly, with the exception of refineries, there is lower disparity of consumption across sectors and so plants have similar opportunities to negotiate supply discounts. Secondly, since the proportion of taxes, levies and network costs in gas prices is significantly lower compared with electricity prices, there is less opportunity for governments to adapt prices through discounts and exemptions. For example, in the UK, regulated price component costs amount to between 18-31% of total electricity prices over the period studied, whereas regulated price component costs amount to 6% of total gas prices. Similarly, in Romania, regulated price component costs range between 21

to 33% of total electricity prices, and regulated price component costs amount to 0-10% of total gas prices.

- **The cross-sectoral analysis of natural gas bill components shows varying relative shares of the regulated components, but with differences across Member States.** The sum of the regulated price components (network costs and taxes and levies) on natural gas bills in Portugal appears to be increasing. However, in Hungary, the Czech Republic and Germany, regulated components remain relatively consistent over the period studied. It should be noted that regulated components play a relatively small role in the overall composition of natural gas prices.
- **Generally, larger consumers receive higher proportions of RES support payment exemptions in their electricity bills.** There are levy and tax exemptions for electricity-intensive or high-electricity consumers in most Member States, which have been included in the electricity price component analysis. The rules and magnitude of these exemptions, however, differ from one Member State to another. In the Czech Republic, for example, industrial consumers receive no exemptions of RES or CHP support payments. Conversely, in Germany, electricity-intensive consumers receive exemptions after their first GWh consumed and Romanian plants can receive exemptions for up to 85% of RES support payments, although this depends on the electricity intensity of a plant. Since many exemptions are only issued after a certain threshold of electricity is purchased, larger plants often receive a higher proportion of RES support payment exemptions and therefore benefit from lower electricity prices. As a consequence, in general, smaller plants profit less than larger plants as a result of having received a lower proportion of exemptions from regulated components in their electricity bills.

2.1 Introduction

This section presents a cross-sectoral analysis of total energy prices and the structure of energy prices in Europe. The analyses in the sectoral case studies are presented at the EU and regional level rather than the Member States level in order to ensure that no data can be attributed to any particular plant. This cross-sectoral analysis, however, presents findings across all sectors at the EU level as a whole and selected Member States. The Member State-level analysis shows the different levels of taxes, levies, network costs and other components in energy prices at the national level.

Electricity bills and the price of electricity can be broken-down into the following four components:

i. energy supply costs
ii. network costs
iii. support payments to finance renewables (“RES support payment”)
iv. other levies and taxes (excluding VAT)

A gas bill and gas price can be broken-down into the following three components:

i. energy supply costs
ii. network costs
iii. levies and taxes (excluding VAT)

This cross-sectoral analysis includes the decomposed annual data for those Member States with reliable data for three or more plants. The analysis comprises the sectors bricks & roof tiles ("bricks"), wall & floor tiles ("tiles"), refineries, steel, aluminium primary ("Aluminium P") and aluminium recyclers and downstream ("Aluminium D").

Note that all energy prices reported in this section, and used throughout the analysis are net-prices, as reported on energy bills: exemptions or reductions for specific components are counted in. However, tax rebates, subsidy schemes or other financial compensation mechanisms that are not visible in bills are not accounted for due to a lack of data on these elements.

2.2 Sample size and methodology

In total, 150 plants across all sectors provided electricity and gas prices and consumption data. After removing plants whose data were inconsistent or incomplete, 116 plants remained in our sample for the analysis on electricity consumption and 108 plants remained for the analysis on gas consumption.

A number of plants reported that they consumed no natural gas, and therefore the number of plants in the electricity analysis is slightly higher. The data were further filtered for the price component analysis, which is described later in this section.

Table 8 shows the number of questionnaires that were evaluated for this cross-sectoral analysis. In total, 150 plants across all sectors provided electricity and gas prices and consumption data. After removing plants whose data were inconsistent or incomplete, 116 plants remained in our sample for the analysis on electricity consumption and 108 plants remained for the analysis on gas consumption.

A number of plants reported that they consumed no natural gas, and therefore the number of plants in the electricity analysis is slightly higher. The data were further filtered for the price component analysis, which is described later in this section.

Table 8. Number of plants in the various sectors included in the cross-sectoral analysis

Sector	Bricks	Tiles	Refineries	Steel	Aluminium P	Aluminium D	Total
Electricity	60	22	14	22	10	17	116
Natural gas	60	22	14	20	7	14	108

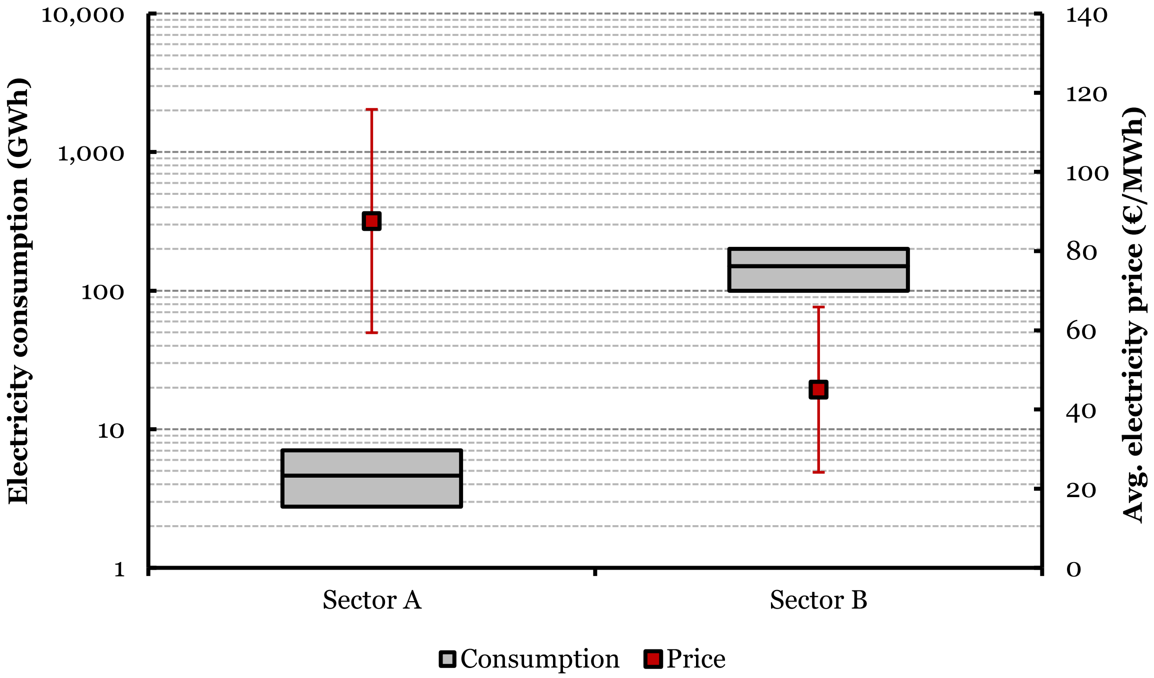
To provide a picture of consumption and price ranges in the various sectors, graphs like the one shown in Figure 1 were prepared for both electricity and gas. The consumption range is illustrated by a box plot, in which the upper and lower boundary line of the grey box represent the first and third quartile 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. In other words, the box comprises the middle half of the data sample. Moreover, the middle line that divides the box into two parts represents the median value, where 50% of the values are below the median.

The red squares in the graphs represent average prices. These are the weighted averages of energy prices in each sector, weighted by the consumption of electricity or gas. For the cross-sectoral analysis, weighted averages based on production are not relevant as products and production processes are different in each sector.

The vertical lines below and above the square illustrate the standard deviation of the price distribution. The standard deviation is used to quantify the variation of values within a set of data values. Roughly 68% of the observations lie within one standard deviation of the mean. Two different y-axes have been used: one for price, which is linear, and one for consumption, which is logarithmic due to the disparity in plant consumption.

Figure 1. Exemplary plot



Source: Authors' own elaboration.

The data on price components are analysed at the national level. An analysis at the regional level would not be appropriate since each Member State has different arrangements in place and grouping Member States together would conceal information. Only those plants with available and reliable component data could be included in this part of the analysis. In the analysis on price components, additional plants were removed, mostly due to the lack of comprehensive and consistent component data from the companies. Member states with less than three observations were omitted from this analysis to ensure the confidentiality of data.

After filtering the data, a sufficient number observations were available to analyse electricity price components in nine Member States, with data from 66 plants. Ten

Member States, representing 81 plants, are included in the analysis of gas price components.

2.3 Electricity

2.3.1 Electricity consumption and price analysis across sectors

This section analyses the relationship between electricity consumption and price levels across both the various sectors and consumption bandwidths for the all EU respondents. The average electricity prices presented below are the averages of the respondents across the EU in the respective sectors, weighted by the consumption of those respondents.

Figure 2 illustrates the differences in both electricity consumption and average electricity prices (weighted by consumption) in and between each of the five sectors, with an average over the entire study period 2008-15, with aluminium split into downstream and primary plants. In general, the data show a clear and intuitive correlation between increased consumption levels and decreased power prices.

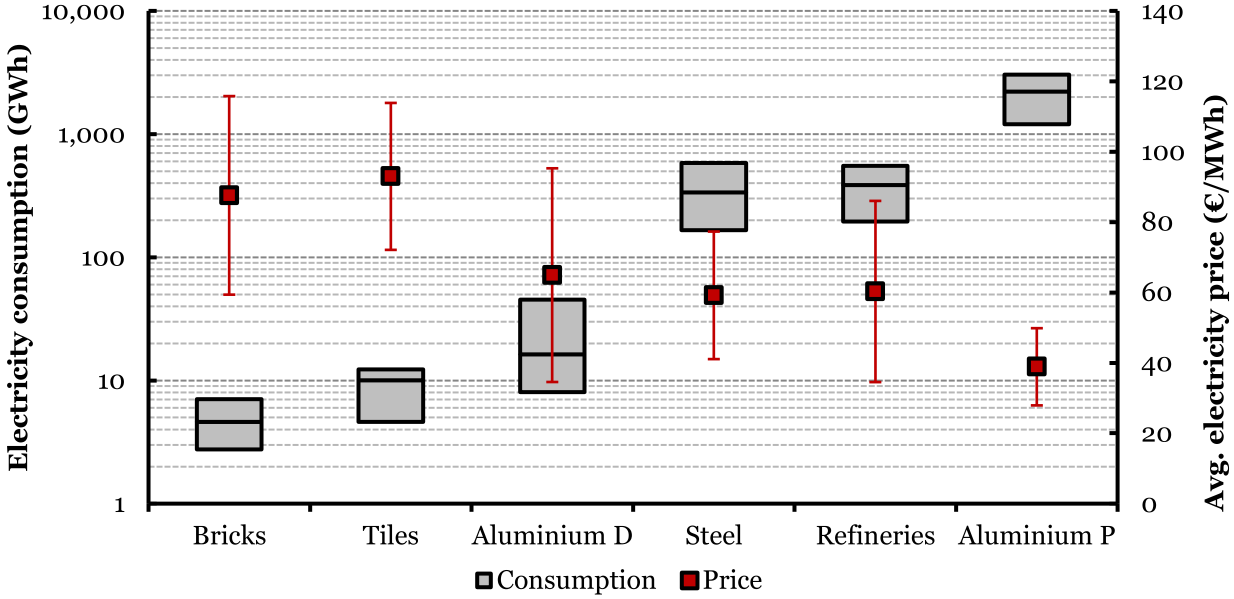
This correlation is illustrated by the low consumption rates found in the brick industry, with a median consumption of 4.6 GWh of electricity per plant and an average electricity price of 87.6€/MWh, compared with the primary aluminium industry, which has a median consumption of 2,215 GWh of electricity per plant and an average electricity price of 38.9€/MWh. This trend is also present within the aluminium industry between primary and downstream plants. Downstream aluminium plants are smaller, with a median consumption of 16.3 GWh and an average electricity price of 64.9€/MWh.

There are a number of possible reasons for the trend of lower prices for industries that have plants with high electricity consumption:

i. Larger consumers may negotiate more favourable supply contracts in exchange for purchasing large amounts of power in advance.
ii. A limited number of large-scale consumers may still benefit from old long-term contracts, established before the unbundling process had come into effect.
iii. Larger consumers from energy-intensive sectors may be granted exemptions from certain taxes and levies, or be provided with lower prices in Member States with regulated prices. The possible role of exemptions is discussed later in this section.

These average prices represent the values aggregating multiple Member States with different price levels and a different legislative framework. Price spreads are high because electricity prices and price components are specific to each Member State. To isolate the effects of national policies, national analyses of the price structure are also conducted within this section.

Figure 2. Electricity consumption and price variations grouped by sector (116 facilities) weighted average, 2008-15



Source: Authors' own elaboration.

Table 9 provides the values of the electricity consumption and the analysis of price variations that are visualised in Figure 2.

Table 9. Average electricity prices and median electricity consumption in the various sectors, 2008-15 (116 plants)

	Bricks	Tiles	Refineries	Steel	Aluminium P	Aluminium D
			Price			
Weighted average price* (€/MWh)	87.6	93.0	60.3	59.2	38.9	64.9
Standard deviation (%)	32%	22%	43%	31%	28%	47%
Min price	26.9	66.3	23.7	33.4	25.6	42.1
Max price	188.3	155.2	171.8	122.8	161.6	62.9
			Consumption			
Median Cons.** (GWh)	4.6	10.0	386.7	336.7	2,215.1	16.3
Upper quartile cons (GWh)	7.1	12.3	551.1	582.8	3,030.7	45.4
Lower quartile cons (GWh)	2.8	4.6	194.6	165.7	1,200.3	8.1

* Weighted average of sampled plants.

** Median value of sampled price.

Source: Authors' own elaboration.

2.3.2 Electricity consumption and price analysis across consumption bandwidths

Figure 3 shows the average electricity price of plants grouped by consumption bandwidths. The same plants included in Figure 2 have been included in this analysis.

Three bandwidths have been defined using a logarithmic scale:

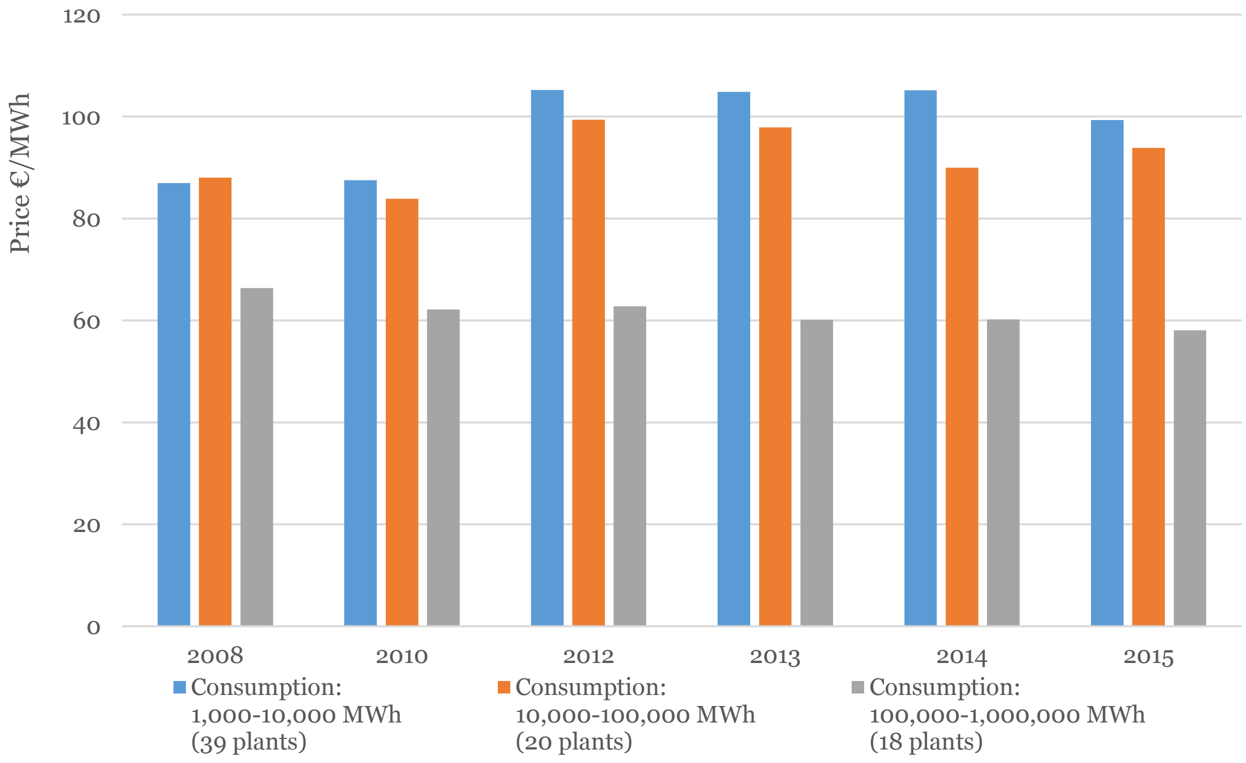
i. annual electricity consumption between 1000 and 10,000 MWh (39 plants)
ii. annual electricity consumption between 10,000 and 100,000 MWh (20 plants)
iii. annual electricity consumption between 100,000 and 1,000,000 MWh (18 plants)

The majority of plants are within the first group in which annual consumption is between 1,000 MWh and 10,000 MWh.

Plants with a consumption greater than 1,000,000 MWh or smaller than 1,000 MWh were also not included. These plants are considered outliers, and defining more bandwidths would result in a very limited number of plants within these lower and upper bandwidths.

It is clear that electricity prices for small and medium plants are relatively similar and that larger plants (consumption levels of between 100,000 MWh and 1,000,000 MWh) generally benefit from lower electricity prices. In general, prices have also been decreasing since 2012 for the plants in all three consumption bandwidths.

Figure 3. Electricity consumption and price variations grouped by plant consumption (116 plants)



Source: Authors' own elaboration.

2.3.3 Electricity price component analysis across Member States

This section discusses the various components that together make up electricity prices at the Member State level.

Figure 4 and Figure 5 show the structure of absolute electricity prices, and Figure 6 and Figure 7 show the information in relative terms in nine Member States:

1) Italy (8 plants, total consumption 145.4 GWh/a)
2) UK (21 plants, total consumption 336.3 GWh/a)
3) Germany (9 plants, total consumption 4,863.0 GWh/a)
4) Romania (7 plants, total consumption 2,932.2 GWh/a)
5) Czech Republic (6 plants, total consumption 60.8 GWh/a)
6) Spain (12 plants, total consumption 908.4 GWh/a)
7) France (12 plants, total consumption 8,819.4 GWh/a)
8) The Netherlands (3 plants, total consumption 640.5 GWh/a) and
9) Portugal (3 plants, total consumption 7.2 GWh/a).

Weighted averages of price components (based on consumption) at the Member States level are used. To ensure that confidentiality agreements are met, only Member States with reliable data available for three or more plants have been included in this part of the analysis.

Data were considered reliable if price components add up to total electricity prices. Consequently, results for Dutch and UK plants in 2008 were not included in the analysis.

Estimations have not been used in this study, and, as a consequence prices in some years may include fewer observations than in others.

Since the sample in each Member State is relatively small, the electricity price is not representative for all plants in that Member State. For example, if only larger plants are included among respondents from a Member State, then the results might be biased towards lower electricity prices. On the other hand, Member States with mostly small plants among respondents of this study may show higher electricity prices.

In Portugal, Italy, UK and Czech Republic the majority of plants included in the analysis are small plants with low consumption rates. Plants in France, Spain and the Netherlands included in our analysis are generally large with high consumption rates. It is unclear if this represents all plants within these Member States or simply sampled plants. As a consequence, the energy prices shown in Figure 4 and Figure 5 may not represent average energy prices for the sectors included in the analysis. It is important to consider this when comparing energy prices across Member States.

The national results verify the study's general finding that large energy-intensive plants have far lower prices than small- and medium-sized enterprises.

Generally, respondents in most Member States show decreasing electricity prices from 2012 onwards. Decreased electricity prices are mostly related to the energy component, which is largely linked to electricity wholesale market prices. As discussed in the CEPS

Task Force Report on electricity market design,[6] wholesale electricity prices have decreased by 30-40% in most EU Member States from 2008-14. This is mainly a result of a reduction in electricity demand, which is related to the 2008 economic crisis and a decrease in EUA prices.

The UK is the only Member State amongst the ones assessed in which the energy component has been increasing, albeit gradually. All price components in the UK have increased, particularly in 2015, but, increases in the energy supply component and the renewable support component are the most significant.

Differences can be observed between all price components across the Member States analysed. The differences in the so-called 'regulatory components', i.e. network costs, renewable support, other taxes & levies, however, are more pronounced.

Italian and Portuguese plants experience significantly higher electricity prices than most Member States included in this analysis, particularly the Netherlands, France, Germany and Romania, which is mainly a result of higher taxes, levies and network costs. Italian and Portuguese plants also appear to experience higher energy supply costs, which in 2015 were 58.9€/MWh and 69.2€/MWh respectively, compared with the same costs faced by German and Romanian plants in that same year, 39.8€/MWh and 37.5€/MWh respectively.

A likely underlying cause is the differences in electricity mixes: gas has a higher share in the Italian, Spanish and Portuguese power mix than in Germany or Romania, where coal plays a more important role. In the absence of a strong EUA price, coal-fired electricity production typically is more competitive than gas-fired generation, resulting in lower energy prices.

In the UK (and to lesser extent in Germany), the renewable support components have fluctuated. Following a gradual annual increase in renewable support costs since 2010, it decreased in 2014 and then increased again in 2015.

In Romania, the renewable support component started decreasing in 2013.

In Member States where renewable electricity generation has increased significantly in recent years, a drop in the renewable support component points out that additional exemptions from paying these levies have been granted (e.g. in Italy, Germany and Romania). These exemptions are described in more detail later in this section.

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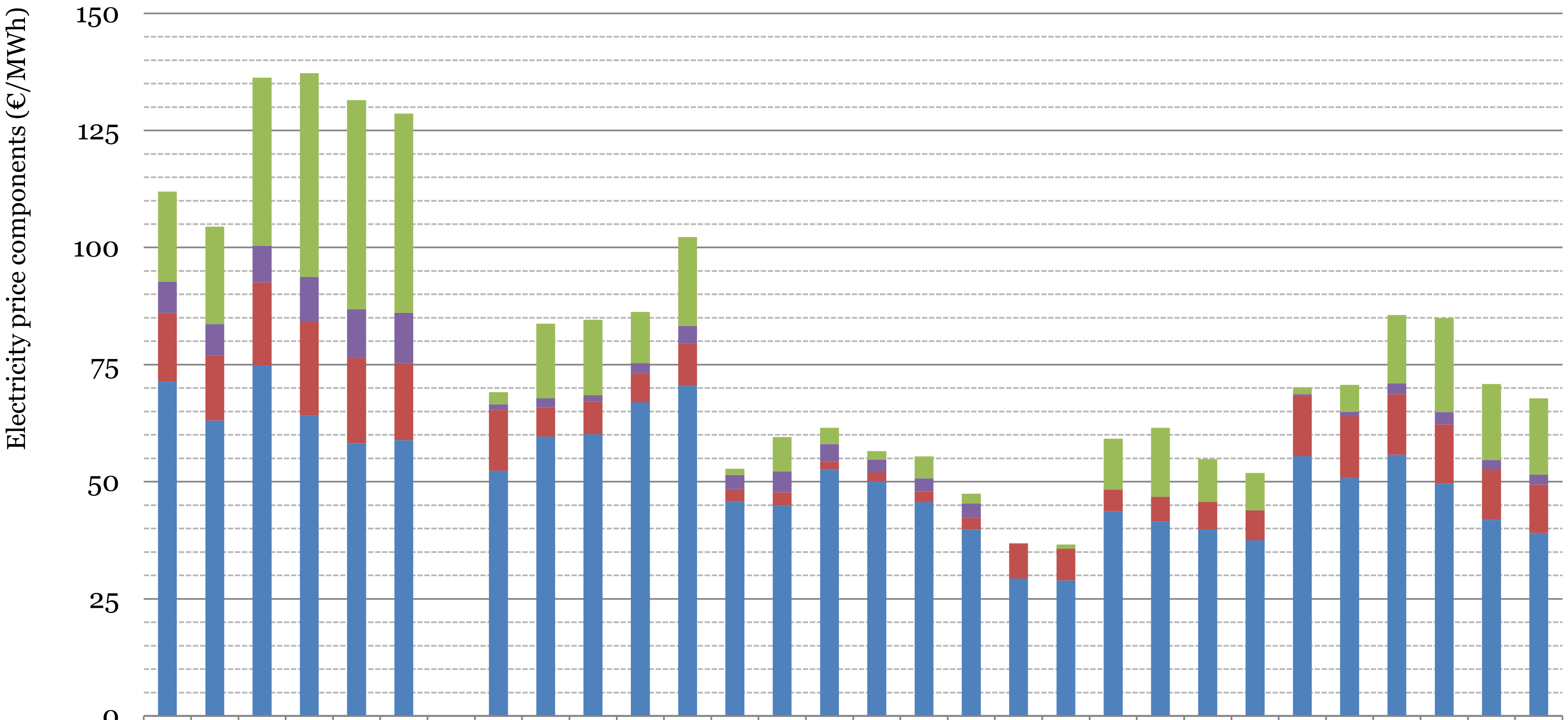
[6] See F. Genoese and C. Egenhofer (2015), "Reforming the Market Design of EU Electricity Markets: Addressing the Challenges of a Low-Carbon Power Sector", CEPS Task Force Report, CEPS, Brussels, 27 July.

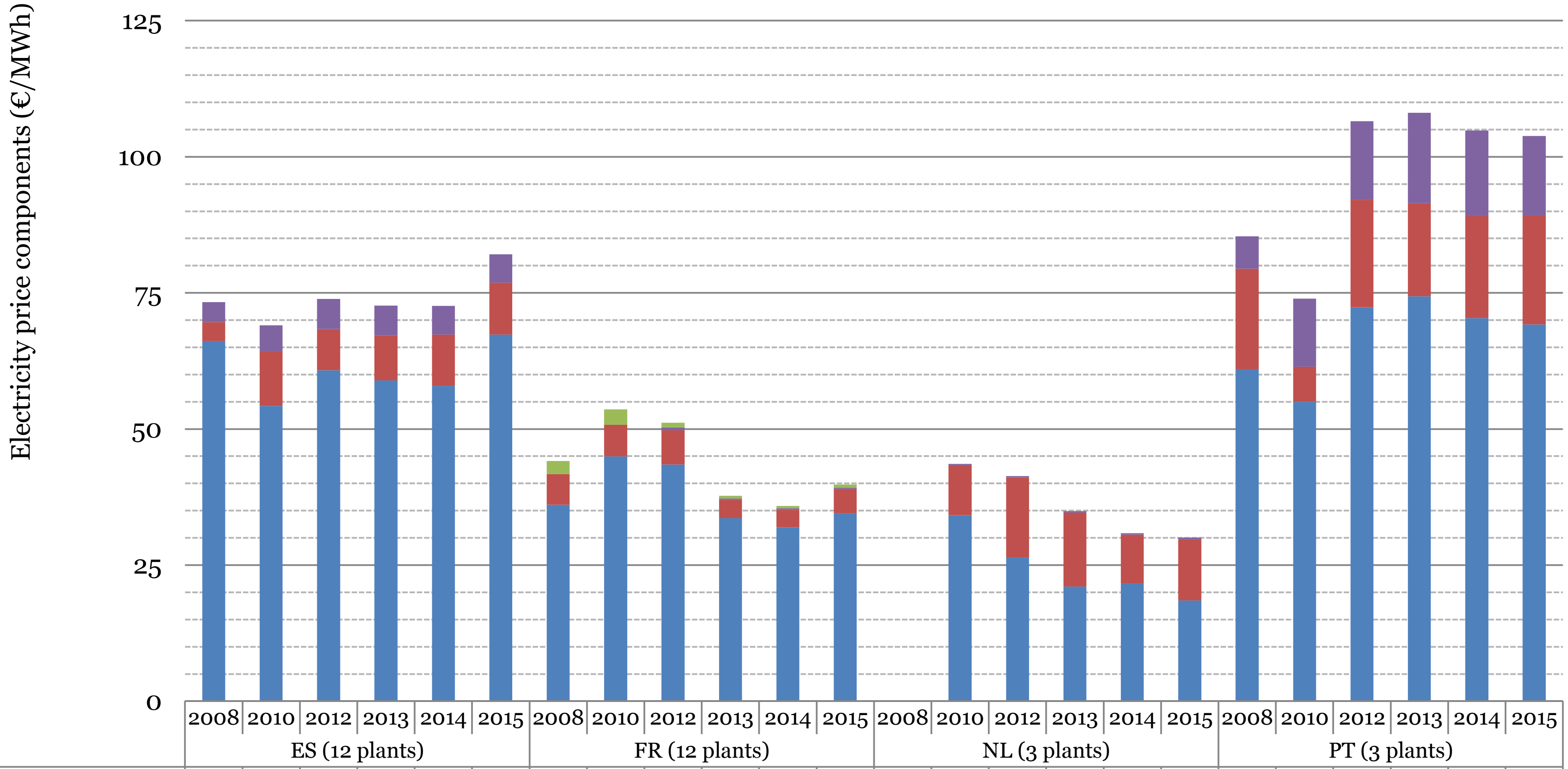
Figure 4. Structure of electricity prices in Italy, UK, Germany, Romania and Czech Republic in absolute terms (€/MWh)



	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
	IT (8 plants)						UK (21 plants)						DE (9 plants)						RO (7 plants)						CZ (6 plants)					
🟩 RES support payment	19.2	20.8	35.9	43.5	44.6	42.5	0.0	2.6	16.0	16.1	10.9	19.0	1.3	7.3	3.5	1.8	4.7	2.1	0.1	0.9	10.9	14.7	9.1	8.0	1.4	5.8	14.6	20.1	16.2	16.3
🟪 Other taxes and levies (excl. VAT)	6.7	6.7	7.8	9.5	10.4	10.7	0.0	1.2	1.9	1.4	2.2	3.8	3.0	4.5	3.8	2.8	2.8	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.0	2.3	2.6	2.0	2.1
🟥 Network costs	14.7	13.8	17.6	20.2	18.3	16.5	0.0	13.0	6.3	7.0	6.2	8.9	2.7	2.8	1.7	1.9	2.3	2.5	7.5	6.8	4.6	5.3	5.8	6.4	12.9	13.1	12.9	12.6	10.7	10.4
🟦 Energy supply costs	71.3	63.1	74.9	64.1	58.2	58.9	0.0	52.4	59.6	60.1	67.0	70.5	45.8	44.9	52.6	50.1	45.7	39.8	29.4	29.0	43.7	41.5	39.8	37.5	55.5	50.8	55.8	49.6	41.9	39.1

Note: Network costs are sometimes flat fees. Expressing them in €/MWh may be misleading but was chosen for consistency reasons.
Source: Authors' own elaboration.

Figure 5. Structure of electricity prices in Spain, France, the Netherlands and Portugal in absolute terms (€/MWh)

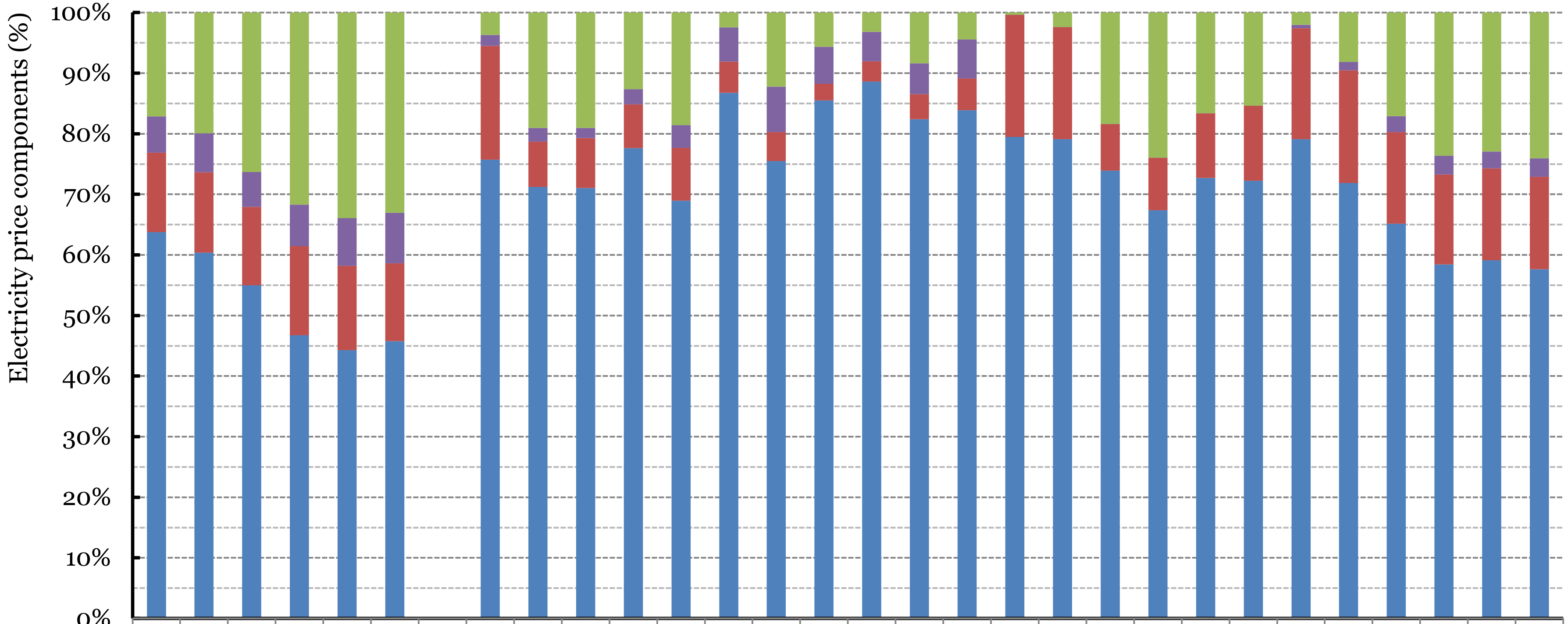


	ES (12 plants)						FR (12 plants)						NL (3 plants)						PT (3 plants)					
	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
🟩 RES support payment	0.0	0.0	0.0	0.0	0.0	0.0	2.4	2.8	0.9	0.5	0.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
🟪 Other taxes and levies (excl. VAT)	3.6	4.8	5.5	5.4	5.3	5.2	0.0	0.0	0.5	0.3	0.3	0.2	0.0	0.2	0.3	0.3	0.3	0.4	6.0	12.5	14.5	16.6	15.7	14.6
🟥 Network costs	3.5	10.0	7.5	8.3	9.4	9.5	5.6	5.8	6.3	3.4	3.3	4.5	0.0	9.2	14.7	13.6	8.9	11.2	18.4	6.4	19.7	17.1	18.7	20.1
🟦 Energy supply costs	66.2	54.2	60.8	58.9	57.9	67.3	36.1	45.0	43.5	33.6	31.9	34.5	0.0	34.2	26.4	21.1	21.7	18.5	61.0	55.0	72.4	74.4	70.4	69.2

Note: Network costs are sometimes flat fees. Expressing them in €/MWh may be misleading but was chosen for consistency reasons.

Source: Authors' own elaboration.

Figure 6. Structure of electricity prices in Italy, UK, Germany, Romania and Czech Republic in relative terms (%)



	2008	2010	2012	2013	2014	2015
	IT (8 plants)					
🟩 RES support payment	17%	20%	26%	32%	34%	33%
🟪 Other taxes and levies (excl. VAT)	6%	6%	6%	7%	8%	8%
🟥 Network costs	13%	13%	13%	15%	14%	13%
🟦 Energy supply costs	64%	60%	55%	47%	44%	46%

	2008	2010	2012	2013	2014	2015
	UK (21 plants)					
🟩 RES support payment	0%	4%	19%	19%	13%	19%
🟪 Other taxes and levies (excl. VAT)	0%	2%	2%	2%	2%	4%
🟥 Network costs	0%	19%	7%	8%	7%	9%
🟦 Energy supply costs	0%	76%	71%	71%	78%	69%

	2008	2010	2012	2013	2014	2015
	DE (9 plants)					
🟩 RES support payment	2%	12%	6%	3%	8%	4%
🟪 Other taxes and levies (excl. VAT)	6%	8%	6%	5%	5%	6%
🟥 Network costs	5%	5%	3%	3%	4%	5%
🟦 Energy supply costs	87%	76%	86%	89%	82%	84%

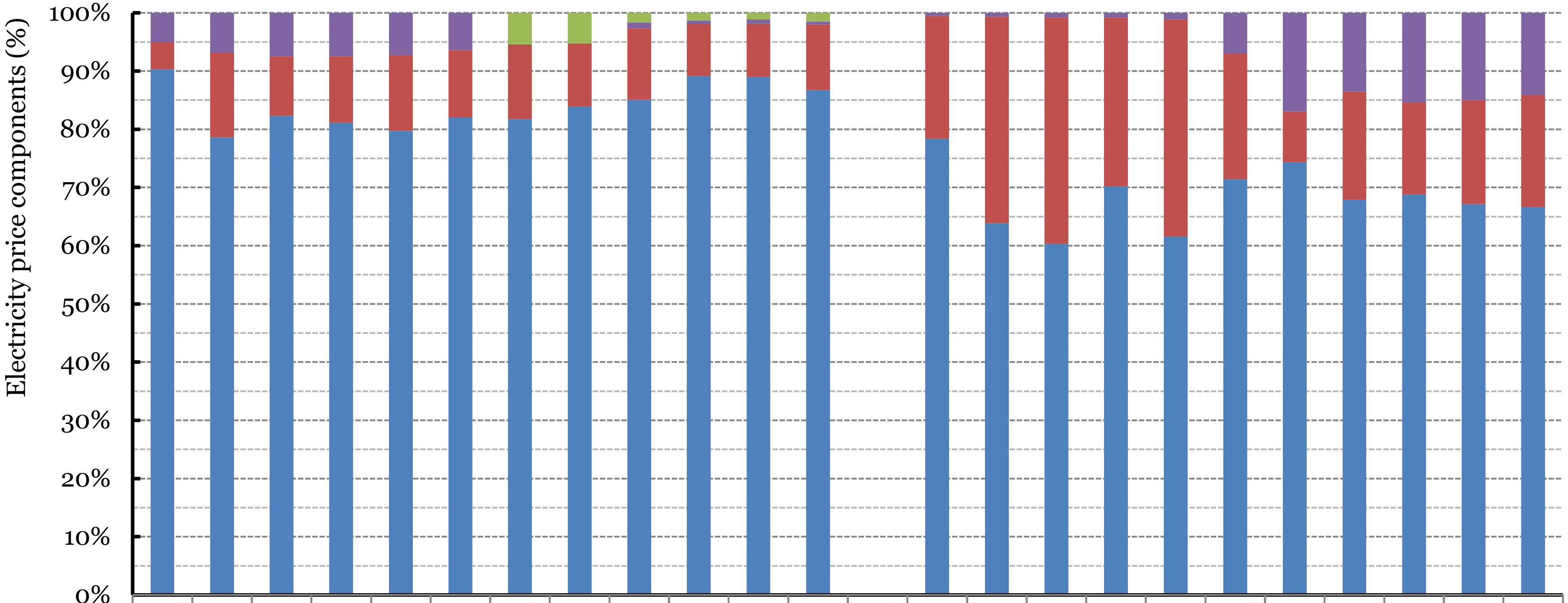
	2008	2010	2012	2013	2014	2015
	RO (7 plants)					
🟩 RES support payment	0%	2%	18%	24%	17%	15%
🟪 Other taxes and levies (excl. VAT)	0%	0%	0%	0%	0%	0%
🟥 Network costs	20%	19%	8%	9%	11%	12%
🟦 Energy supply costs	79%	79%	74%	67%	73%	72%

	2008	2010	2012	2013	2014	2015
	CZ (6 plants)					
🟩 RES support payment	2%	8%	17%	24%	23%	24%
🟪 Other taxes and levies (excl. VAT)	1%	1%	3%	3%	3%	3%
🟥 Network costs	18%	19%	15%	15%	15%	15%
🟦 Energy supply costs	79%	72%	65%	58%	59%	58%

Note: Network costs are sometimes flat fees. Expressing them in €/MWh may be misleading but was chosen for consistency reasons.

Source: Authors' own elaboration.

Figure 7. Structure of electricity prices in Spain, France, the Netherlands and Portugal in relative terms (%)



	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
	ES (12 plants)						FR (12 plants)						NL (3 plants)						PT (3 plants)					
🟩 RES support payment	0%	0%	0%	0%	0%	0%	5%	5%	2%	1%	1%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
🟪 Other taxes and levies (excl. VAT)	5%	7%	7%	7%	7%	6%	0%	0%	1%	1%	1%	0%	0%	0%	1%	1%	1%	1%	7%	17%	14%	15%	15%	14%
🟥 Network costs	5%	15%	10%	11%	13%	12%	13%	11%	12%	9%	9%	11%	0%	21%	35%	39%	29%	37%	22%	9%	19%	16%	18%	19%
🟦 Energy supply costs	90%	79%	82%	81%	80%	82%	82%	84%	85%	89%	89%	87%	0%	78%	64%	60%	70%	62%	71%	74%	68%	69%	67%	67%

Note: Network costs are sometimes flat fees. Expressing them in €/MWh may be misleading but was chosen for consistency reasons.

Source: Authors' own elaboration.

The relative share of different price components varies significantly between Member States for three main reasons:

- Firstly, there are **exemptions** for electricity-intensive sectors or consumers, the rules and magnitude of which differ considerably between Member States.
- Secondly, the **visibility of price components in bills** varies from one Member State to another. For example, in some Member States, renewable support levies are not visible and therefore these costs may have been included in either the "energy supply costs" component or the "network costs" component. As a result, some costs appear higher and RES support payments are absent. Please note that for 2008 and 2010 a limited number of plants have indicated that some components were not visible in their bills. In the aluminium downstream sample alone, three plants indicated that network components were not separately disclosed on bills. The energy component can therefore be slightly overrepresented, especially for 2008. Over the 2012-15 period, no plants indicated that this might be the case.
- Thirdly, there are different overall network costs and RES support payments within Member States, as these costs depend on the way in which **renewables and the network grid are funded**, the extent of renewable deployment and the level of grid upgrades within a Member State.

These three points are described in more detail in the following sub-sections.

2.3.4 *Exemptions*

The rules determining levy exemptions differ between Member States.

The magnitude of levy exemptions for electricity-intensive consumers is increasing and therefore in some Member States renewable support components on bills are decreasing. For example, in Romania, data from the 7 plants show that the renewable support component fell from 14.7€/MWh in 2013 to 8€/MWh in 2015. In many Member States, certain consumers are exempted from both levies and taxes, as illustrated in the examples below:

- In Italy, consumers have been given tariff exemptions from energy-intensive industries since 2014. As a result, larger plants have more exemptions and lower electricity prices. This could explain why our data show a decrease in renewable support payments in 2015.
- In the UK, businesses entering into an agreement to reduce CO2 emissions (so-called 'Climate Change Agreement') can receive a reduction of 90% in the climate change levy.
- Respondents from Germany show a significantly lower share of RES support payments in their electricity bills than plants in the UK or Italy, although the German RES support payments are considered some of the highest in Europe. This is likely because electricity-intensive consumers in Germany receive exemptions after consuming their first GWh. The scheme has changed many times in the period 2008-15, which may also explain why RES support payment prices have fluctuated slightly.
- In Romania plants can receive RES levy exemptions. Electricity-intensive consumers can receive exemptions up to 85% of their RES support costs. This

policy corresponds with the observation that the Romanian RES costs in bills is decreasing.

- In Spain plants receive discounts on network costs and RES support. Spanish access tariffs, which include access to the network, CHP and renewable compensation, depend on i) peak load, ii) energy consumption and iii) grid connection level. In general, large companies with flat consumption profiles connected to a medium- or high-voltage power line pay significantly lower access tariffs than small companies with high peak loads.
- Industrial consumers within the Czech Republic pay the full RES support payment with no exemptions available for these customers.
- In France industrial consumers pay a public service obligation (CSPE), which includes support for CHP, vulnerable consumers and RES. However, the magnitude of CSPE on electricity bills for industrial consumers is limited, a price cap has been fixed so companies do not pay more than €627,783 in 2015, this cap was introduced in 2011 when it was €550,000 and has steadily been increasing.
- For Dutch plants there are two main regulated price components, an energy tax for electricity and a RES levy. The tariff for these components depends on the electricity usage and this tariff is reduced for business users with a large consumption (above 10GWh). Furthermore, energy intensive consumers with consumption larger than 10GWh are eligible for a tax refund of both the tax and the levy if they enter into an energy efficiency agreement.
- In Portugal, similar to France, plants pay a public service obligation (CIEG) that covers the cost of several policies including RES support payments. It is reported that large industrial consumers pay the minimum value of €0.5/MWh.

It is evident that respondents are affected differently by exemptions; small plants may profit less than larger plants because exemptions might be only issued after a certain threshold of purchased electricity.

The research team tested this assumption by comparing the level of reported RES support costs with plants' electricity consumption levels from 2013-15, a period when respondents have generally reported decreasing RES support costs. An analysis of all EU plants respondents, however, did not reveal that plants with high consumption would have benefitted more from RES support exemptions than smaller plants.

Similarly, a country-level analysis does not confirm the assumption that large plants would profit more from exemptions than smaller plants. This is particularly true in the case of Italy where no link has been found between data on decreasing RES payments and high electricity consumption. Data from responding Romanian plants partly confirm this assumption, however, as the RES levies of large consumers decreased over the period 2013-15.

Despite the data not entirely confirming the assumption that smaller plants profit less as a result of exemptions, the number of plants included in this part of the analysis is small and therefore does not represent all plants within a Member State. It is evident from the policies implemented in many Member States that the price of RES support payments and taxes and levies decreases as consumption of purchased electricity increases.

2.3.5 *Visibility of price component costs*

In most Member States offering exemptions, plants are exempted for only a proportion of the RES costs. However, the data collected for this study indicate that plants in Spain, the Netherlands and Portugal do not face any renewable support component. However, this could be misleading as plants that pay RES levies might not have this cost visible on their electricity bill during the full period and these costs may have been included in either the “network costs” or the “energy supply costs”. For example:

- In Spain electricity bills have a component called “Access to network” (ATR payment), which includes the access to networks, CHP and renewable compensation. It is likely that respondents have included these costs under the “network costs” components.
- In Portugal there is a public service obligation (PSO) that appears on electricity bills and covers the cost of certain policies including renewables support. It is likely that Portuguese plants have included this PSO in the “other taxes and levies” component. Similarly, in France, a PSO also appears on bills rather than a break-down of the components in the study.
- In the Netherlands a RES levy was introduced in 2013 with a steadily increasing tariff. This tariff, however, does not appear in the replies to the questionnaire. It has probably been incorporated into the electricity tax and therefore has been included in the “other taxes and levies” component instead. Some plants may receive complete exemption from this tax as they are part of the metallurgical sector, which explains the low “other taxes and levies” price component figures.

It is clear that the data received from respondents do not always reflect the actual component break-down in electricity bills. However, the questionnaires do indicate that reporting of the various energy components on bills have improved significantly since 2012.

2.3.6 *Funding of network costs and renewable support components*

The level of the renewable support component in electricity prices is determined by a number of factors.

Firstly, the absolute level of RES deployment and its technology mix play a major role in the deployment of mature and less mature RE technologies. One notable example is deployment of solar PV in the early 2010s, when technology costs were at least twice as high as they are today. From 2010 to 2012, solar PV was aggressively deployed especially in Italy and Germany, leading to a sharp increase in end-consumer prices for non-exempted consumers.

Secondly, the RES levy depends on the design of RES support systems, i.e. whether they enable RES investors to recover their full costs, even if wholesale electricity prices decrease. Feed-in tariffs belong to this category, as they offer a fixed compensation, whereas green certificate systems do not. As a result, the decline in wholesale electricity prices led to an increase in the level of RES support payments in countries with feed-in tariffs, for example in Germany, Italy, Spain, Romania and Bulgaria.

Thirdly, the RES levy depends on whether public money is well spent. In this context, economic efficiency is an important performance indicator, as it compares the subsidy payments to the actual generation costs, thus disclosing potential overcompensation for renewable energy generators (Boie et al, 2014). An extensive analysis made within the DiaCore project for the year 2014 revealed that the level of remuneration for onshore wind farms exceeded actual generation costs by at least 10 €/MWh in Greece, Hungary, Romania and Slovenia - indicating higher-than-necessary profit margins for generators (Held et al, 2014).

Network costs also differ largely between Member States. Generally, these costs are higher if there have been extensive grid upgrades. Yet, in many Member States, network costs are funded through both consumer bills and generator access fees. The level of network costs observed in this study, therefore, strongly depends on how these costs are distributed between consumers and generators. This analysis only observes funding of costs from the consumer side, hence, it does not fully represent the total sum of network costs in each Member State.

2.4 Natural gas

2.4.1 Gas consumption and price analysis across sectors

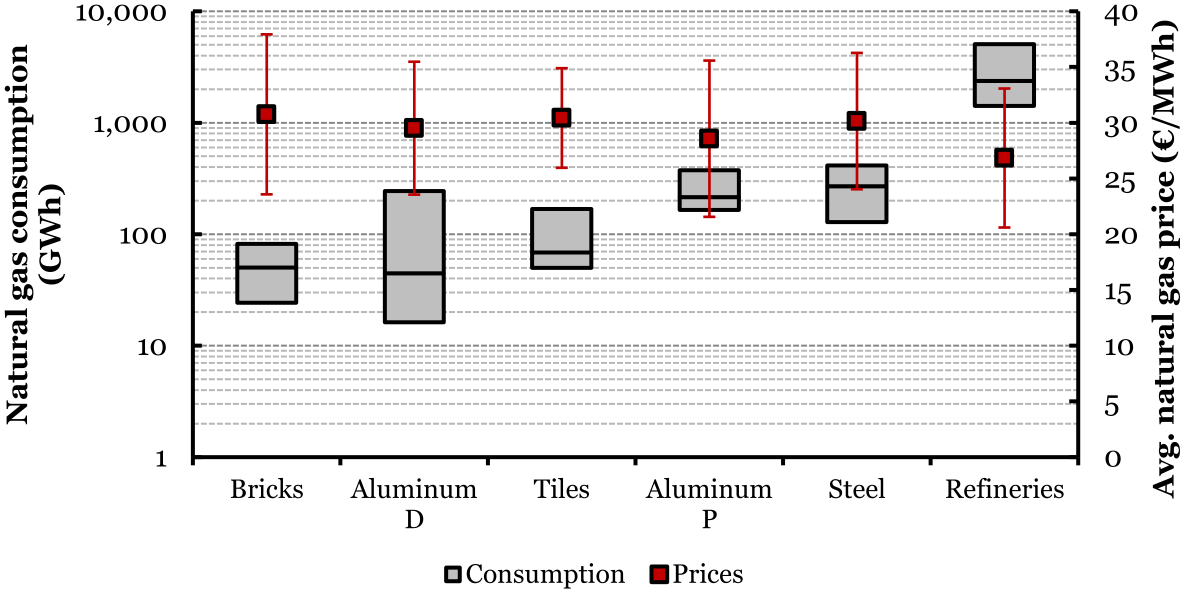
This section analyses the relationship between gas consumption and price levels across both the various sectors and across consumption bandwidths for the all EU respondents. Average gas prices presented below are the averages of the respondents across the EU in the respective sectors, weighted by the gas consumption of those respondents. Figure 8 illustrates the variation in the data for each of the five sectors with an average over the entire study period 2008-15, with aluminium split into primary and downstream plants.

Contrary to the findings in the analysis on electricity prices, no significant correlation can be observed between the variations in natural gas prices for the respondents across different sectors. Consumption levels in the steel sector are slightly higher than in the brick sector, but, this difference is minor compared to power. Only the refineries sector has a significantly higher natural gas consumption than the other sectors with a linked lower natural gas price.

The variation in prices across all sectors is lower than in the case for electricity, due to the fact that:

1. The lower disparity of consumption across sectors means that plants generally have similar opportunities to negotiate supply contracts and discounts.
2. The proportion of taxes, levies and network costs is relatively small in the total gas price. Consequently, there is less opportunity for governments to adapt prices through discounts and exemptions. Figure 10 and Figure 11 illustrate this situation.

Figure 8. Natural gas consumption and price variations grouped by sector (108 plants), weighted average, 2008-15



Source: Authors' own elaboration.

Table 10 provides the values of the gas consumption and price variations analysis that are visualised in Figure 8.

Table 10. Average natural gas prices and median natural gas consumption in the various sectors, 2008-15 (108 plants)

	Bricks	Tiles	Refineries	Steel	Aluminium P	Aluminium D
Price						
Weighted average price* (€/MWh)	28.0	30.1	26.0	28.8	33.1	27.6
Standard deviation (%)	26	15	24	21	21	22
Min price	13.2	20.9	7.9	9.3	15.2	15.1
Max price	52.9	41.8	41.6	49.9	44.9	44.9
Consumption						
Median cons.** (GWh)	50.3	68.6	2,368.3	270.1	214.7	44.7
Upper quartile cons (GWh)	82.0	168.9	5,067.3	414.5	374.7	243.3
Lower quartile cons (GWh)	24.2	49.8	1,413.7	128.5	164.6	16.2

* Weighted average of sampled plants.

** Median value of sampled price.

Source: Authors' own elaboration.

2.4.2 Natural gas consumption and price analysis across consumption bandwidths

Figure 9 shows the average gas price of plants grouped by consumption levels. The same plants included in Figure 8 have been included in this analysis, however, but the plants have been grouped by consumption level rather than sector.

Three bandwidths have been used following a logarithmic scale:

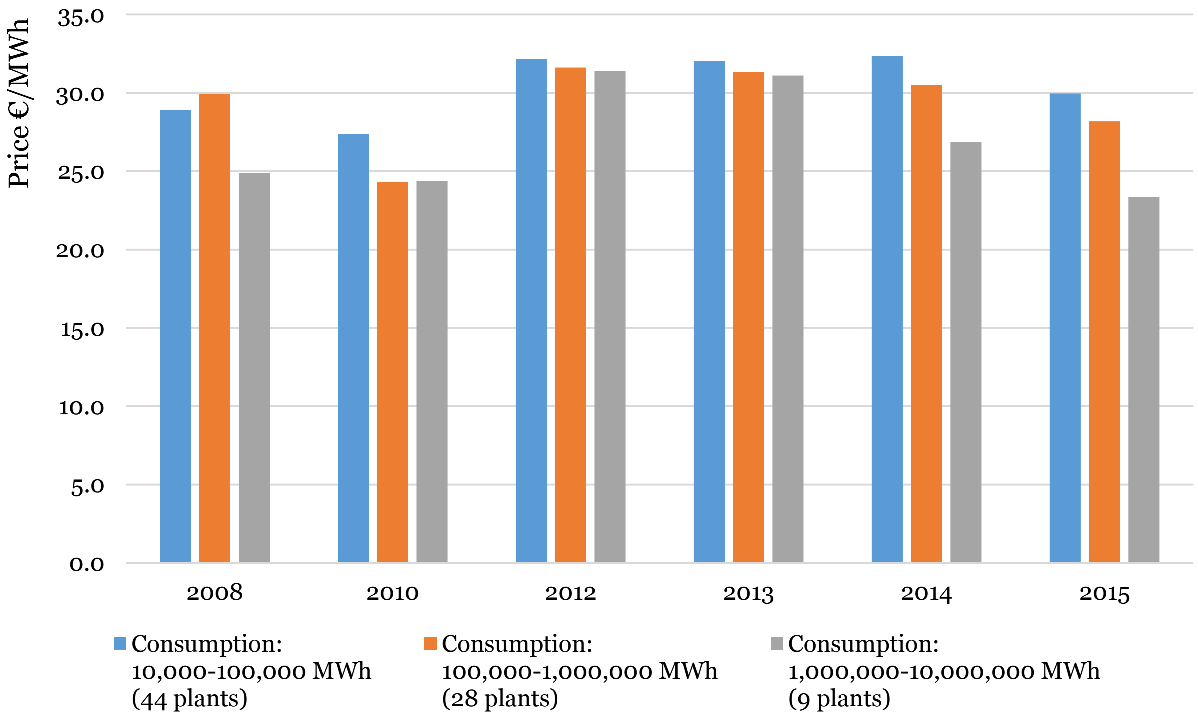
i. Annual natural gas consumption between 1000 and 10,000 MWh (44 plants)
ii. Annual natural gas consumption between 10,000 and 100,000 MWh (28 plants)
iii. Annual natural gas consumption between 100,000 and 1,000,000 MWh (9 plants)

The majority of plants fall within the first group.

Plants with a consumption greater than 1,000,000 MWh or smaller than 1,000 MWh were also not included. These plants are considered outliers, and defining more bandwidths would result in a very limited number of plants within these lower and upper bandwidths.

Just like electricity prices, gas prices also decrease as consumption increases, but this trend is not as significant as electricity prices for reasons described above. There is also a trend of lowering gas prices for large consumers, especially in the years 2014 and 2015, which could be related to the increasing liquidity of spot-market trading.

Figure 9. Natural gas consumption and price variations grouped by consumption (108 facilities)



Source: Authors' own elaboration.

2.4.3 Gas price component analysis across Member States

Figure 10 and Figure 11 show the structure of relative gas prices in eleven Member States:

1) Italy (9 plants, average total consumption 1,059.4 GWh/a)
2) UK (21 plants, average total consumption 1,762.7 GWh/a)
3) Germany (4 plants, average total consumption 5,171.8 GWh/a)
4) Romania (6 plants, average total consumption 818.5 GWh/a)
5) Portugal (3 plants, average total consumption 63.3 GWh/a)
6) Hungary (3 plants, average total consumption 165.4 GWh/a)
7) France (10 plants, average total consumption 14,050.3 GWh/a)
8) Spain (11 plants, average total consumption 8,773.4 GWh/a)
9) Czech Republic (6 plants, average total consumption 389.7 GWh/a)
10) Belgium (5 plants, average total consumption 2,747.6 GWh/a)
11) The Netherlands (3 plants, average total consumption 8,281.2 GWh/a)

Results for Romanian, UK and Belgian plants in 2008 were removed from the graphs, as the data received at price component level for that year were considered unreliable.

Weighted averages of price components (based on consumption) at the Member State level are used. To ensure confidentiality agreements are met, only Member States with reliable data available for three or more plants have been included in this part of the analysis. The data were considered reliable if price components add up to total gas prices.

The general trend is that gas prices have been decreasing in all Member States since 2012/13. For example, natural gas prices for Italian respondents declined by 17.6% in the period from 2012 until the end of 2015, and in France gas prices decreased by 20.6% during the period from 2013 until the end of 2015. Previously, overall gas prices in both Member States increased from 2008.

Less variation in gas prices was observed across Member States compared to electricity prices. This is again due to less leverage governments have to adapt gas prices through intervening with regards to taxes and levies, as well as the fact that there are no differences in generation costs.

However, it is important to keep the small sample sizes in mind when comparing Member States, especially since large plants generally benefit from lower gas prices and therefore a Member State with mostly large plants in this analysis will show lower gas prices, which is not representative for all plants within that Member State.

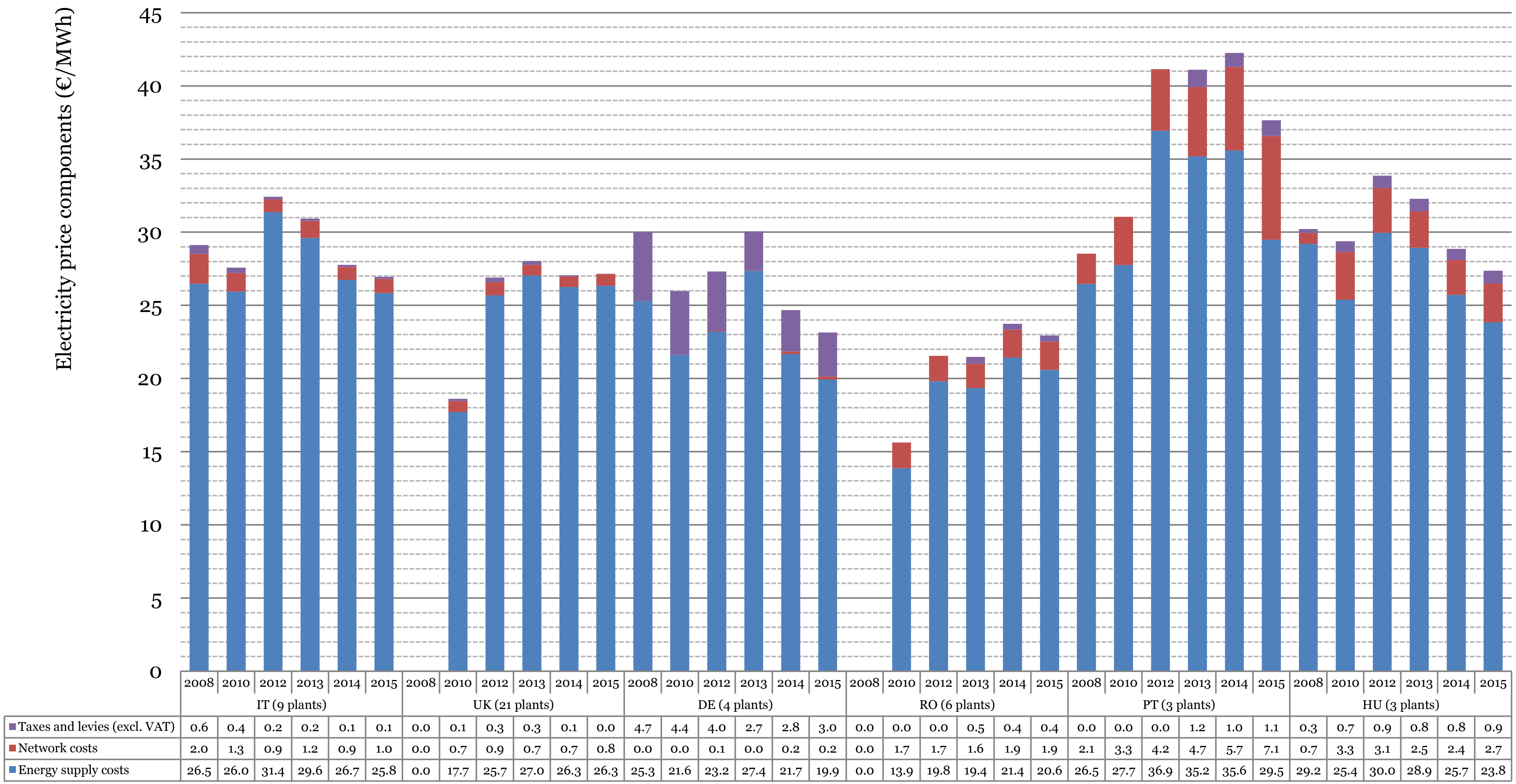
In the Netherlands, the majority of plants included in the analysis are large plants with high natural gas consumption rates. In Portugal, Czech Republic and Hungary, plants included in the analysis are generally small with relatively low natural gas consumption rates. It is unclear if this represents all plants within these Member States or simply sampled plants. As a consequence, the energy prices shown in Figure 10 and Figure 11 may not represent average national energy prices for the sectors included in the analysis. It is therefore important to consider this when comparing energy prices across Member States.

Plants in the UK, Belgium, Germany, Romania and Italy appear to benefit from relatively low gas prices, compared to other Member States. This is mostly attributable to lower wholesale gas prices, but also to lower network costs.

Plants in Portugal, Hungary and Spain experience the highest gas prices. Although this is largely due to higher wholesale gas prices, these Member States (with the exception of Spain) also have higher network costs or taxes and levies.

No general trends are observed from the respondents' data in the regulated price components “network costs” and “other taxes and levies”. For example, the sum of these components appears to be increasing on Portuguese gas bills, whereas in Hungary, the Czech Republic and Germany, regulated components remain relatively consistent over the studied period. Nevertheless, the proportion of taxes, levies and network costs is relatively small in the total gas price when compared to electricity, and so there is limited importance of these regulated gas components when analysing gas prices.

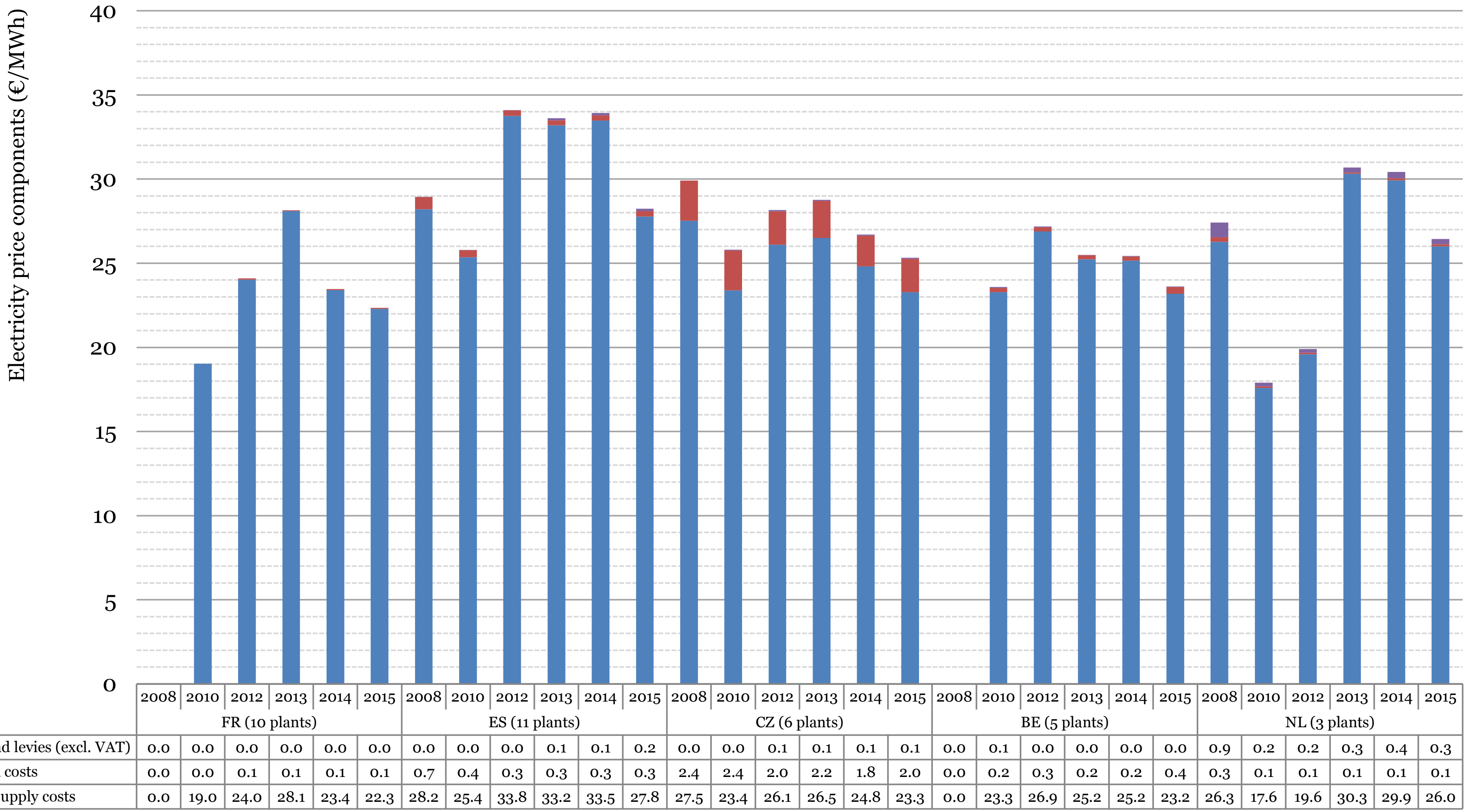
Figure 10. Structure of gas prices in Italy, UK, Germany, Romania, Portugal and Hungary in absolute terms (€/MWh)



	IT (9 plants)						UK (21 plants)						DE (4 plants)						RO (6 plants)						PT (3 plants)						HU (3 plants)					
	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
🟪 Taxes and levies (excl. VAT)	0.6	0.4	0.2	0.2	0.1	0.1	0.0	0.1	0.3	0.3	0.1	0.0	4.7	4.4	4.0	2.7	2.8	3.0	0.0	0.0	0.0	0.5	0.4	0.4	0.0	0.0	0.0	1.2	1.0	1.1	0.3	0.7	0.9	0.8	0.8	0.9
🟥 Network costs	2.0	1.3	0.9	1.2	0.9	1.0	0.0	0.7	0.9	0.7	0.7	0.8	0.0	0.0	0.1	0.0	0.2	0.2	0.0	1.7	1.7	1.6	1.9	1.9	2.1	3.3	4.2	4.7	5.7	7.1	0.7	3.3	3.1	2.5	2.4	2.7
🟦 Energy supply costs	26.5	26.0	31.4	29.6	26.7	25.8	0.0	17.7	25.7	27.0	26.3	26.3	25.3	21.6	23.2	27.4	21.7	19.9	0.0	13.9	19.8	19.4	21.4	20.6	26.5	27.7	36.9	35.2	35.6	29.5	29.2	25.4	30.0	28.9	25.7	23.8

Note: Network costs are sometimes flat fees. Expressing them in €/MWh may be misleading but was chosen for consistency reasons.
Source: Authors' own elaboration.

Figure 11. Structure of gas prices in France, Spain, Czech Republic, Belgium and the Netherlands in absolute terms (€/MWh)



	FR (10 plants)						ES (11 plants)						CZ (6 plants)						BE (5 plants)						NL (3 plants)					
	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
■ Taxes and levies (excl. VAT)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.9	0.2	0.2	0.3	0.4	0.3
■ Network costs	0.0	0.0	0.1	0.1	0.1	0.1	0.7	0.4	0.3	0.3	0.3	0.3	2.4	2.4	2.0	2.2	1.8	2.0	0.0	0.2	0.3	0.2	0.2	0.4	0.3	0.1	0.1	0.1	0.1	0.1
■ Energy supply costs	0.0	19.0	24.0	28.1	23.4	22.3	28.2	25.4	33.8	33.2	33.5	27.8	27.5	23.4	26.1	26.5	24.8	23.3	0.0	23.3	26.9	25.2	25.2	23.2	26.3	17.6	19.6	30.3	29.9	26.0

Note: Network costs are sometimes flat fees. Expressing them in €/MWh may be misleading but was chosen for consistency reasons.

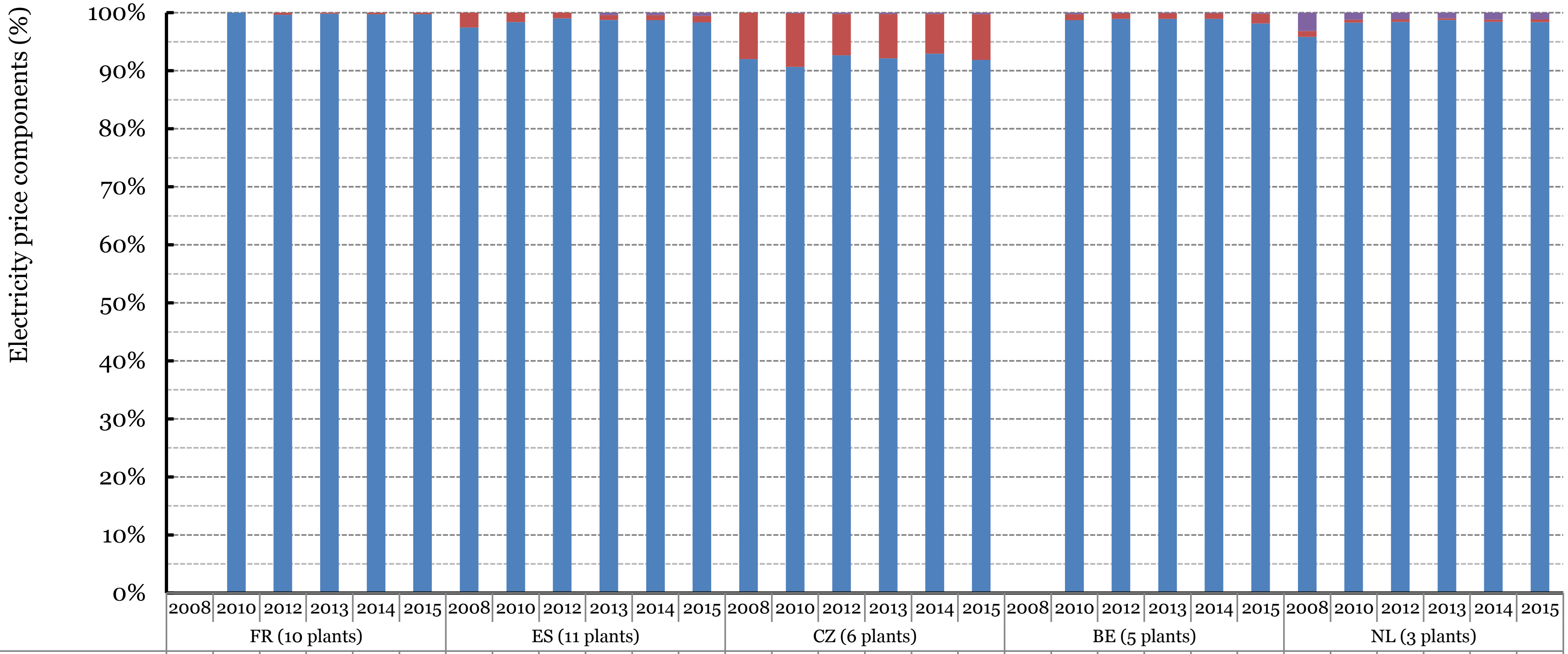
Source: Authors' own elaboration.

Figure 12. Structure of gas prices in Italy, UK, Germany, Romania, Portugal and Hungary in relative terms (€/MWh)

	IT (9 plants)						UK (21 plants)						DE (4 plants)						RO (6 plants)						PT (3 plants)						HU (3 plants)					
	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
▪ Taxes and levies (excl. VAT)	2%	1%	1%	1%	1%	0%	0%	1%	1%	1%	0%	0%	16%	17%	15%	9%	11%	13%	0%	0%	0%	2%	2%	2%	0%	0%	0%	3%	2%	3%	1%	3%	3%	3%	3%	3%
▪ Network costs	7%	5%	3%	4%	3%	4%	0%	4%	3%	3%	3%	3%	0%	0%	0%	0%	1%	1%	0%	11%	8%	8%	8%	8%	7%	11%	10%	12%	14%	19%	2%	11%	9%	8%	8%	10%
▪ Energy supply costs	91%	94%	97%	96%	96%	96%	0%	95%	96%	96%	97%	97%	84%	83%	85%	91%	88%	86%	0%	89%	92%	90%	90%	90%	93%	89%	90%	86%	84%	78%	97%	86%	88%	90%	89%	87%

Note: Network costs are sometimes flat fees. Expressing them in €/MWh may be misleading but was chosen for consistency reasons.
Source: Authors' own elaboration.

Figure 13. Structure of gas prices in France, Spain, Czech Republic, Belgium and the Netherlands in relative terms (€/MWh)



	FR (10 plants)						ES (11 plants)						CZ (6 plants)						BE (5 plants)						NL (3 plants)					
	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
🟪 Taxes and levies (excl. VAT)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	1%	1%	1%	1%	1%
🟥 Network costs	0%	0%	0%	0%	0%	0%	3%	2%	1%	1%	1%	1%	8%	9%	7%	8%	7%	8%	0%	1%	1%	1%	1%	2%	1%	1%	0%	0%	0%	0%
🟦 Energy supply costs	0%	100%	100%	100%	100%	100%	97%	98%	99%	99%	99%	98%	92%	91%	93%	92%	93%	92%	0%	99%	99%	99%	99%	98%	96%	98%	98%	99%	98%	98%

Note: Network costs are sometimes flat fees. Expressing them in €/MWh may be misleading but was chosen for consistency reasons.

Source: Authors' own elaboration.

3 Sector study: Steel

Highlights

- Since the 1980s, the EU steel industry has developed from a process- and product-oriented industry to a market-oriented industry. The transformation process included privatisation of state-owned plants, consolidation and closure of inefficient and obsolete plants. In general, the industry has become more capital intensive and labour productivity has increased considerably. It is dominated by large, multinational companies. The main customer base lies within the EU home markets, particularly in high-end segments. Recently, however, the European steel industry has been facing a number of serious challenges, fuelled by global overcapacity, an increasing dependency on exports and an unprecedented wave of distorting trading practices.
- ***Sample.* The responses cover respectively 13.6% and 11.4% of European BOF and EAF steel production capacity.** Southern Europe (SE) however is relatively underrepresented with no SE BOF plants among respondents and only 3.5% of the EAF plant capacity covered. For North-Western Europe (NWE), BOF are underrepresented, while EAF capacity is overrepresented. In total, the regional coverage of NWE is high with 7.8% of BOF capacity and 22.3% of EAF capacity covered. Central-Eastern Europe (CEE) is overrepresented for BOF plant sites and adequately represented for EAF plant sites. The regional coverage of CEE is high with 50.9% of BOF capacity and 9.7% of EAF capacity covered.

- ***Energy price trends.* Average natural gas prices** paid by responding steel producers **show a clearly falling trend since 2012,** with 33.16 €/MWh in 2012 to 26.11 €/MWh in 2015, corresponding to a decrease of over 21%. Respondents from CEE had a similar but less volatile price level than those from NWE. There were no clear price differences between BOF and EAF plant sites.
- **The average of electricity prices paid by responding steel plant sites has been significantly decreasing since 2012.** Prices peaked in 2012 at 65.43 €/MWh and decreased to a level of 53.03 €/MWh by 2015, a value 8.7% lower than the price in 2008 (57.65 €/MWh). Responding steel plant sites from NWE faced lower prices than those from CEE for all years.
- **Energy supply costs of natural gas were falling since 2012, network costs were fairly stable, whereas taxes, fees, levies and charges were moderately but continuously increasing.** The weighted average energy supply cost for natural gas decreased from 31.10 €/MWh in 2012 to 23.74 €/MWh in 2015, reducing the share in total costs from 93.4% in 2012 to with 91.4% in 2015. Weighted average of other taxes, fees, levies and charges was increasing at the beginning of the study period and then stabilising from 2012 to 2015 at a level of around 0.47 €/MWh.
- **Energy components of electricity was falling significantly since 2012**, whereas **taxes, fees, levies and charges continuously increased** since 2008 while **RES payments increased up to 2013 and then decreased again.** The weighted average of the energy component peaked in 2012 at 51.10 €/MWh and decreased to 41.26 €/MWh in 2015 (-20%). Its share

in total electricity prices decreased from 86.0% in 2008 to 78.2% in 2015. Weighted average for the renewable support component peaked in 2013 at 1.92 €/MWh and reached 1.47 €/MWh in 2015, in comparison to 0.83 €/MWh in 2008. Its share increased from 1.5% to 3.1% in 2013 and reduced to 2.8% by 2015. For NWE plant sites, RES payments were clearly higher than for the EU average. Taxes, fees, levies and charges have been increasing continuously and substantially over the study period, from 0.63 €/MWh in 2008 to 3.43 €/MWh in 2015 (more than 5-fold increase). Its share increased from 1.2% in 2008 to 6.5% in 2015.

- ***Energy intensity.* From 2008 to 2015, the natural gas intensity of EAFs seems stable, whereas the natural gas intensity of BOFs is highly volatile.** The weighted natural gas intensity of BOFs is between double to four-times the size of the intensity of EAFs (e.g. in 2013, it was 1.59 MWh/t for BOF and 0.36 MWh/t for EAF).
- **From 2008 to 2015, the electricity intensity of EAFs and BOFs, remained relatively stable.** The weighted average intensity of EAFs (0.42 MWh/t in 2012) is roughly 20 to 60% higher than the intensity of BOFs (0.27 MWh/t in 2012).

- ***International comparison.* In 2010, the EU producers paid less for their natural gas** (26.89 €/MWh) than producers in Japan and South Korea, but significantly more than producers in the United States (12.99 €/MWh). **By 2015, the EU prices decreased slightly** by 3% to a level of 26.11 €/MWh. Natural gas prices in China increased significantly (54.59 €/MWh), making China the highest priced country in the international comparison conducted by the research team. Prices in the United States decreased by 16%, in contrast.
- **In 2010, the EU with €60.21/MWh had a lower electricity price than China** (65.19 €/MWh) but, at the same time, higher than the United States (43.70 €/MWh) and South Korea (49.26 €/MWh). Producers in Turkey and Japan faced the highest electricity price with 92.62 €/MWh and 82.06 €/MWh respectively. **In 2015, the EU with 53.03 €/MWh saw a substantial decrease of its prices**. Japan (124.54 €/MWh) and China (90.39 €/MWh) faced the highest prices among the surveyed countries. At the same time, data from the United States (56.77 €/MWh) and South Korea (68.04 €/MWh) shows a significant price increase. **Electricity prices in the EU and Turkey decreased the most by 12% and 15% respectively, whereas the prices in Japan (51.8%) and China (38.7%) increased the most.**

- ***Impact on competitiveness.*** A differentiation between regions and technologies (BOF vs. EAF) could not be provided as the number of plant sites for which KPIs can be calculated is too low, raising confidentiality issues. The significance of the following results is therefore very limited.
- **The turnover per tonne of output is continuously decreasing over the study period, whereas the production costs started to decrease only after 2012, at a lower rate than turnover though**. This lead to lower profit shares in total turnover. The share of EBITDA in turnover was highest in 2008 (15.61%) and lowest in 2012, where the EBITDA share was 3.08%. Since 2013, the EBITDA seems to be slowly recovering, while remaining much below 2008 levels.

- No clear trend can be identified in the **electricity cost share** of production costs which **ranged between 4.9% and 6.8% over the study period**. **The share of natural gas costs in production costs** was for all years considerably lower than the share of electricity costs in production, and shows a clear decreasing trend from 2010 to 2015. It **ranged between 2.5% and 3.6%,** with a maximum in 2010 and a minimum in 2015.
- **The share of regulated electricity costs in EBITDA shows an increasing trend from 2008 to 2015**. Within the years 2012 to 2015, the share increased from 13.9% to 35.4%. **The share of regulated natural gas costs in EBITDA from 2012 to 2015 shows a less pronounced increase.** In 2012, this share was 3.2%, whereas in 2015 it was 6.8%.
- Overall, this shows that if energy prices returned to their values from 2012, without having higher steel prices and thus higher turnover, European steel plant sites might face economic difficulties.

3.1 Introduction

According to the NACE (Rev.2) statistical classification of economic activities in the European Union, steel makers are included in the division 24 Manufacture of basic metals. Steel plants covered by this analysis report under at least four groups: 24.1: Manufacture of basic iron and steel and ferro-alloys, 24.2 Manufacture of tubes, pipes, hollow profiles and related fittings, of steel, 24.3 Manufacture of other products of first processing of steel and 24.5 Casting of metals. The groups 24.3 and 24.5 are further split in separate classes like 24.31 Cold drawing of bars, 24.32 Cold rolling of narrow strip, 24.51 Casting of iron and 24.52 Casting of steel.

The steel industry value chain includes all the processes required to transform raw materials (mainly coal, iron ore, electricity and scrap) into finished steel products. Generally, the following infrastructures are required to produce steel:

- Coke ovens
- Sinter and pellet plants
- Blast furnaces
- Steel furnaces
- Rolling and finishing mills

Since the 1980s, the EU steel industry has developed from a process- and product-oriented industry to a market-oriented industry. This evolution is the result of a restructuring effort characterised by consolidation and closure of inefficient and obsolete plants as well as by selective investment in new technologies. During this transformation process – often accompanied by privatisation of state-owned plants – the industry has become more capital intensive and labour productivity has increased considerably.

Today, the EU steel sector is a modern customer-oriented industry with its main customer base found within the EU home markets, particularly in high-end segments. It focuses on high quality products, product innovation and value creation supported by technological development, efficiency, and skilled manpower. The EU steel industry is dominated by large, multinational companies.

The steel sector overall is confronted with major challenges, notably in terms of costs and access to raw materials and energy, having a serious impact on the industry's performance. Moreover, the increasing capacity, production and international engagement outside the EU constitutes a threat as market shares are being lost to non-European countries such as China. The Chinese steel market has an excess in supply due to a lower growth in demand and considerable new production capacity. As a result, China is exporting more steel, including to the EU, affecting the market price. Furthermore, the EU steel industry is affected by the new and expected tightening of European environmental and climate legislation (Eurofer, 2013).

The competitiveness of the EU steel industry is, among other things, highly dependent on access to and prices of inputs such as energy and raw materials. Moreover, labour-related input factors are important in this regard, notably in terms of skill levels and competence development strategies. The following factors comprise the most relevant inputs to the steel industry: iron ore and scrap metal, coking coal, energy, transport and labour (Ecorys, 2008).

Today, in terms of geographical regions, the EU is still the world's second largest producer of crude steel, after Asia, accounting for 10-11% of world output (World Steel, 2015). However, there was no growth in EU steel production in recent years. While the EU steel industry is structured to produce all types and qualities of steel products, its competitiveness remains mainly linked to high quality and often tailor-made products in demanding end-user segments.

This sectoral case study is structured as follows:

1. In the beginning of the case study (above) the main highlights from the research are presented;
2. Sections 3.2 to 3.5 provide the sectoral overview. In particular, 3.2 Section describes the production process and production characteristics in the EU; Section 3.3 presents the main characteristics of the EU industry; Section 3.4 provides an analysis of trade patterns; and Section 3.5 shows the analysis of the industry's energy consumption;
3. Section 3.6 presents the sampling strategy based and the description of the actual sample of manufacturing plants included in the study, including sectoral coverage;
4. Sections 3.7 and 3.8 report the results of the analysis of energy prices, both total prices and split per components;
5. Section 3.9 describes sectoral energy intensity;
6. Section 3.10 provides a comparison of energy prices paid by EU, Russian and US ceramic manufacturers – covering both the brick and roof tiles and the wall and floor tiles sectors
7. Section 3.11 provides the analysis of Key Performance Indicators (KPI) and the impact of energy costs over production costs and margins.
8. Section 3.12 provides a brief conclusion.

3.2 Overview of the production process

Based on the degree of vertical integration, steel-making plants can be classified in two different groups:

a) **Integrated plants**: both fully integrated plants, where all the production stages are performed (from coke-making to product-finishing), and partially integrated plants, where coke ovens are not installed and coke-making is outsourced. Integrated plants use Blast Furnaces (BFs) or Basic Oxygen Furnaces (BOFs) to transform iron ore and coke into steel, also referred to as primary steel-making. Steel scrap is usually also added.

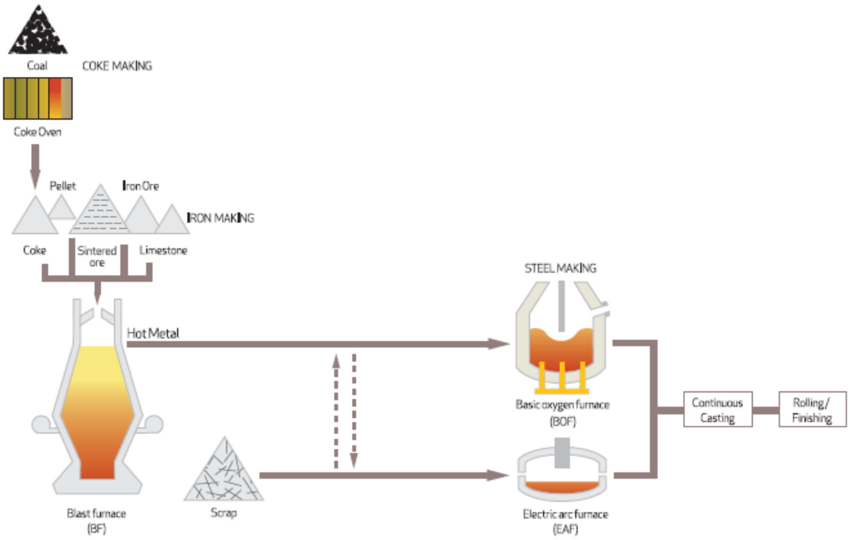
b) **Minimills**: plants comprising only steel furnaces and rolling and finishing facilities. Minimills mostly utilize Electric Arc Furnaces (EAFs) to produce steel, and mainly rely on scrap, and only sometimes for a smaller part on raw iron, which is usually purchased as processed input, also referred to as secondary steel-making. In general, EAFs have much lower production capacities than BOFs.

According to the World Steel Association (2015), BOFs account for 61% of EU crude steel production whereas EAFs only account for 39%.

The steel-making industry's value chain can be separated into four major production stages: coke-making, iron-making, steel-making, and rolling and finishing (Egenhofer et al., 2013).

Figure 14 shows these major production stages.

Figure 14. How steel is made: main production routes



Source: World Coal Institute (2007).

Coke-making is the first production stage in fully integrated plants. Coke is the fuel for iron-making and is produced by processing low-ash low sulphur bituminous coal. Pulverised coal is added in the coke oven through an opening located in the top of the oven. When the ports are sealed, the coal is heated, in the absence of oxygen, at high temperatures (1200-1300°C). The necessary heat is provided by external combustion of fuels and recovered waste gases. Coke is the solid material remaining in the oven. Coke-making is an energy-intensive process. New technologies therefore aim at reducing the quantity of coke required.

In partially integrated plants, coke is purchased as a processed input and steel-making starts with the **iron-making** in BFs. These furnaces are vertical cylindrical vessels (up to 35 meters high and up to 15 meters wide) where iron ore, coke (the fuel), and limestone (the flux) are loaded at the top and are subject to a smelting reduction process mainly aiming at reducing iron ore and removing impurities. Hot air, usually heated through recovered exhaust gases, is blown into the base of the vessel, supplying heat and oxygen for combustion. At the bottom of the furnace, molten iron and slag are collected as outputs. Molten iron may either be casted into ingots (the so-called ‘pigs’) or transferred directly to a connected steel furnace.

The production of iron accounts for approximately 55% of the total cost per tonne of steel and constitutes the largest cost category in integrated steel plants (Madar, 2009). Also new technologies are being adopted for iron-making. Direct Reduction Ironmaking (DRI) is a new process, using gas rather than coke as fuel, being particularly cheap in countries with access to low-cost natural gas. In any case, BFs are still deemed the best solution for integrated facilities, considering both their efficiency improvement and their significant economies of scale. In integrated mills, sinter and pellet plants may also be installed, and this equipment is relatively common in Europe. Sinter plants enable recycling of iron-rich material, otherwise disposed of as production waste. Pellets are hard spheres which are preferred to lump ore in BFs because hot air can circulate more freely, thus improving the efficiency of the iron-making process.

Steel-making consists of a process of transforming raw iron into steel by removing impurities (mainly carbon, phosphorus and sulphur). The remaining quantity of carbon is crucial to determining the hardness of the steel. During the steel-making process, other metals (manganese, nickel, chromium and vanadium) may be added to create alloys, thus obtaining specific qualities of steel. In steel-making, the more production stages are integrated, the more production costs per tonne are reduced; therefore, the industry is moving towards full automation and continuous production flow.

Molten iron from BFs is traditionally refined in BOFs, which are cylindrical vessels lined with refractories where high-purity oxygen is blown under pressure. To eliminate impurities, limestone and other flux are added in the BOF process, thus producing slag that is removed from molten steel. As heat is produced in this exothermic process, scrap is usually added as coolant. In BOFs, up to 30% of scrap iron and steel can be combined with molten iron (Ecorys, 2008).

The EAF is a completely different technology for steel-making, usually adopted in minimills. The main inputs for the EAF are scrap and electricity. Electrodes installed within the furnace melt scrap through the heat created by an electric arc. Limestone and other flux are added in the EAF to remove impurities from molten steel. EAFs are economic and efficient at relatively small volumes of production compared to BOFs, in particular because they can be easily shut down and restarted.

In the last production stage, **rolling and finishing**, blooms, billets and slabs are transformed into finished steel products in rolling facilities. A traditional distinction is made between ‘flat’ and ‘long’ products. Long products are rolled from blooms and billets. Blooms (characterised by a rectangular cross-section of 16 cm or more) are rolled into structural beams. Billets (characterised by a square cross-section of 4 to 14 cm) are rolled into bars, rods and wire.

Long products for the construction market represent the bulk of the production. They have relatively limited production costs and are intended to comply with lower standards; hence, they are considered low added-value products. Slabs (flat cross-section) are rolled into steel plates and coiled sheets, the latter being produced in rolls. Coiled sheets are the most-used steel product, with automotive and appliance producers being the bigger customers. Rolling facilities form these products in a succession of stages where the steel passes through rollers characterised by narrower and narrower clearances.

Flat products have relatively higher production costs and comply with higher required standards, thus being high added-value products. One of the most crucial aspects of a finished product is the quality of the surface. In particular, to avoid corrosion, a protective coating has to be applied. Finished products also include tubes and pipes, which comprise two main production processes: seamless and welded pipes. The former are made in vertically integrated plants (BOF or EAF), whereas the latter is usually made by companies buying steel on the market.

A broader definition of the industry value chain would include upstream suppliers of raw materials (iron, ore, coking coal or coke, scrap) and, downstream, intermediaries (service centres, stockholding companies, etc.) and final customers (producers of steel end products comprising mainly automotive, construction, packaging, durable consumer goods and mechanical engineering industries) (Ecorys, 2008).

3.3 Industry characteristics

Fundamental for steel business conditions is the supply of raw materials, making strategic localisation decisions a key business strategy. Iron ore and (coking) coal are the most important commodities for steel production. Owing to cheaper iron ore and coal from abroad, new steel plants have been located along the coast near ports. Traditionally steel plants were located within or close to resource-rich European regions.

The steel industry is one of the most transport-intensive industries, as it produces heavy and often bulky goods, and almost 30% of the world’s finished steel products pass from one country to another. Therefore, transport costs amount to 5% to 15% of the selling price of the products. Freight transport within Europe makes use of three basic modes of transport, i.e. rail, road and water. The price of transportation from Central Europe (Poland, Hungary, Slovakia, etc.) often rules out deliveries to markets outside Europe.

High capital requirements constitute one of the main business conditions in steel production, and steel-making is characterised by high levels of fixed costs, especially in integrated steel mills. Large facilities are only profitable if annual production capacity equals or exceeds 2 million tonnes. Steel mills run for several years and it is difficult to adjust production to demand because of the cost and structural stress associated with heating and cooling of the furnaces.

EAF technology has lower capital requirements, because electric arc furnaces are more flexible and easy to adjust to demand.

The steel industry is an energy-intensive industry, consuming three main energy carriers, ranked in the following order: coal, natural gas and electricity.

The steel sector is characterized by economies of scale and scope, and achieving economies of scale for new producers requires mass production of steel. Therefore, along with new technologies and the privatisation of major European steel industries in the 1990s, a wave of takeovers and mergers occurred.

As a result of the consolidation in the European steel industry relatively few companies account for a large share of steel production. High capital investments, high economies of scale and excess capacities of existing plants are high entry and exit barriers (Ecorys, 2008).

The European steel industry is increasingly driven by customer requirements, therefore close relationships with customers are important for steel producers. The steel industry feeds parts and materials to other industries such as the automotive, construction and consumer appliances sectors and is fundamentally dependent on and very sensitive to developments in the general economy.

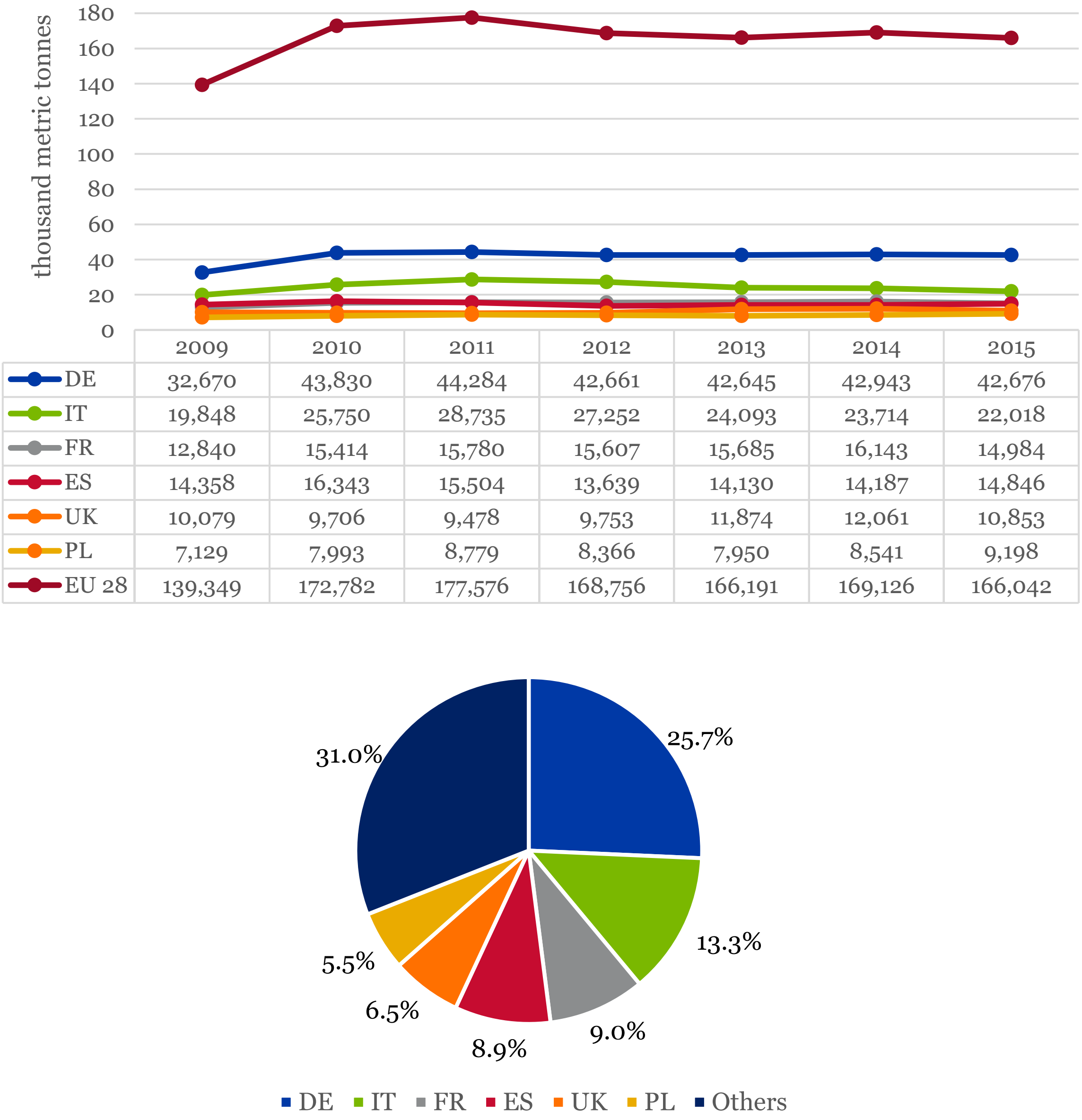
Because of international trade, the competitiveness of the EU steel industry is highly affected by exchange rates. When the euro appreciates significantly (such as in 2006-07), exchange rates put a lot of pressure on the EU steel industry.

3.3.1 Production in the EU

According to Eurofer (2015), total crude steel production in the EU-28 amounted to 166 million tonnes in 2015 (see Figure 15). During the economic and financial crisis (2007 – 200) EU production declined by roughly 24%. From 2010 to 2015, the industry's production was relatively stable and stagnated. Production levels are, however, still far from the peaks reached during the middle of the first decade of this century.

Crude steel production is concentrated in a relatively limited number of EU countries. In 2015, six countries – Germany, Italy, France, Spain, the United Kingdom and Poland – accounted for more than two-thirds of total EU crude steel production. With a market share of 25.7%, Germany represents the largest producer.

Figure 15. Total crude steel production and share of crude steel production (2015) within the EU



	2009	2010	2011	2012	2013	2014	2015
DE	32,670	43,830	44,284	42,661	42,645	42,943	42,676
IT	19,848	25,750	28,735	27,252	24,093	23,714	22,018
FR	12,840	15,414	15,780	15,607	15,685	16,143	14,984
ES	14,358	16,343	15,504	13,639	14,130	14,187	14,846
UK	10,079	9,706	9,478	9,753	11,874	12,061	10,853
PL	7,129	7,993	8,779	8,366	7,950	8,541	9,198
EU 28	139,349	172,782	177,576	168,756	166,191	169,126	166,042

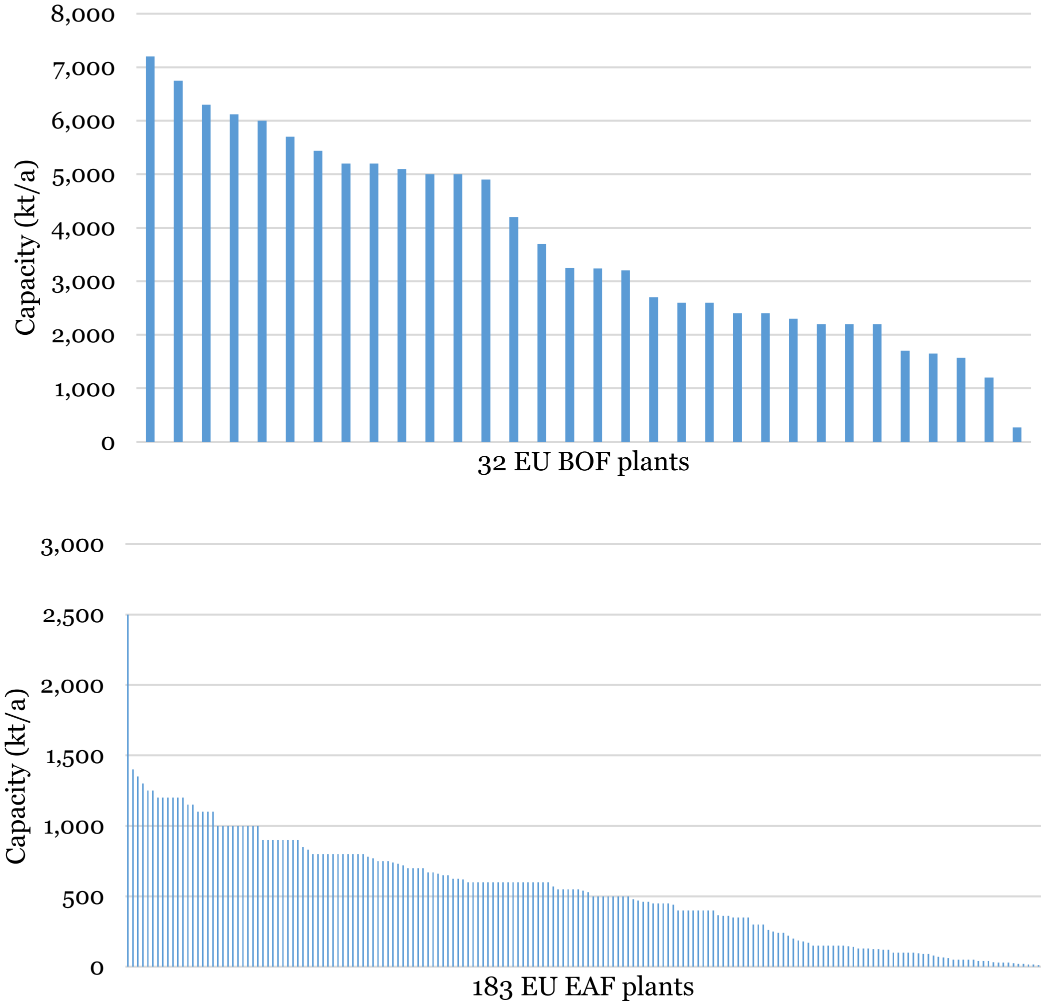
Source: Authors' own elaboration based on Eurofer (2016).

Figure 16 illustrates the plant-specific crude steel nominal capacities of BOF and EAF plants within the EU, sorted from large to small in terms of capacity (based on data from the German Steel Institute VDEh). The largest BOF plant operated by Tata Steel has an annual production capacity of 7.2 million tonnes, whereas the smallest has an annual capacity of roughly 0.27 million tonnes.

EAFs, in contrast, are generally much smaller. The largest EAF plant operated by the Arvedi Group has an annual production capacity of 2.5 million tonnes, whereas the smallest has an annual capacity of only 0.01 million tonnes. The average annual BOF capacity in the EU is 3.75 million tonnes with a standard deviation of 1.8 million tonnes. The average annual EAF capacity in the EU is 0.54 million tonnes with a standard deviation of 0.38 million tonnes. The total BOF and EAF crude steel production capacity in the EU adds up to respectively 119 million tonnes and 99 million tonnes, resulting in a total European crude steel production capacity of 218 million tonnes.

As the European total crude steel production in 2014 was 169 million tonnes, while the total crude steel production capacity was 218 million tonnes, the utilisation rate in the steel sector was around 77.5% in 2014. It is important to note, however, that the number of BOF plants included in the VDEh data (32) slightly deviates from the number of BOF plants provided by Eurofer (37). For this reason, this utilisation rate in the EU may be overestimated.

Figure 16. Total and plant-specific crude steel nominal capacities of total and BOF and EAF plants within the EU[7]



Source: Authors' own elaboration based on VDEh (2016).

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[7] Note that the number of BOF plants included in the VDEh data (32) slightly deviates from the number of BOF plants provided by Eurofer (37).

It is important to note that small- and medium-sized companies (SMEs) are not relevant among steel-making facilities.

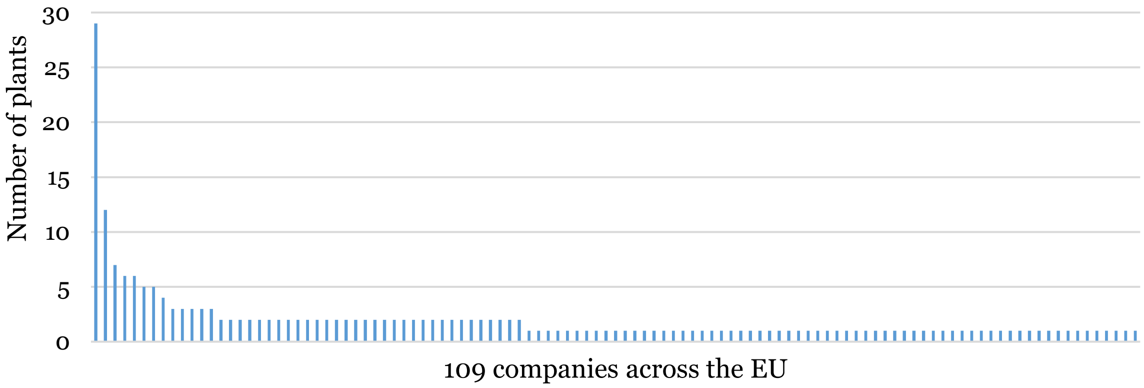
3.3.2 Number of companies and plants operating in the EU

According to Eurofer (2016), there are more than 500 steel production sites across 24 EU Member States, which can be distinguished between primary (BFs and/or BOFs) and secondary steel-making plants (EAFs) and steel-processing plants, e.g. rolling facilities, product mills and coating facilities. The number of facilities is subject to continuous changes due to ongoing consolidation processes.

Only primary and secondary steel-making plants are considered relevant in the scope of this study, as processing plants are too heterogeneous, small in size as well as relatively less energy-intensive in general. According to data provided by Eurofer, there are 37 BOFs and 183 EAFs (a total of 220 plants), with three plant sites having both a BOF and an EAF. Therefore, in total, there are 217 plant sites and 220 plants across the EU.

Across the EU, there are roughly 109 companies that operate primary and secondary steels plant sites. According to Figure 17, there are 64 companies that operate only one steel plant site, 37 that operate two or three, five that operate four to six, and three that operate more than six. ArcelorMittal (29) and RIVA (12) operate more than 18% of all plant sites.

Figure 17. Number of plant sites per company in the EU

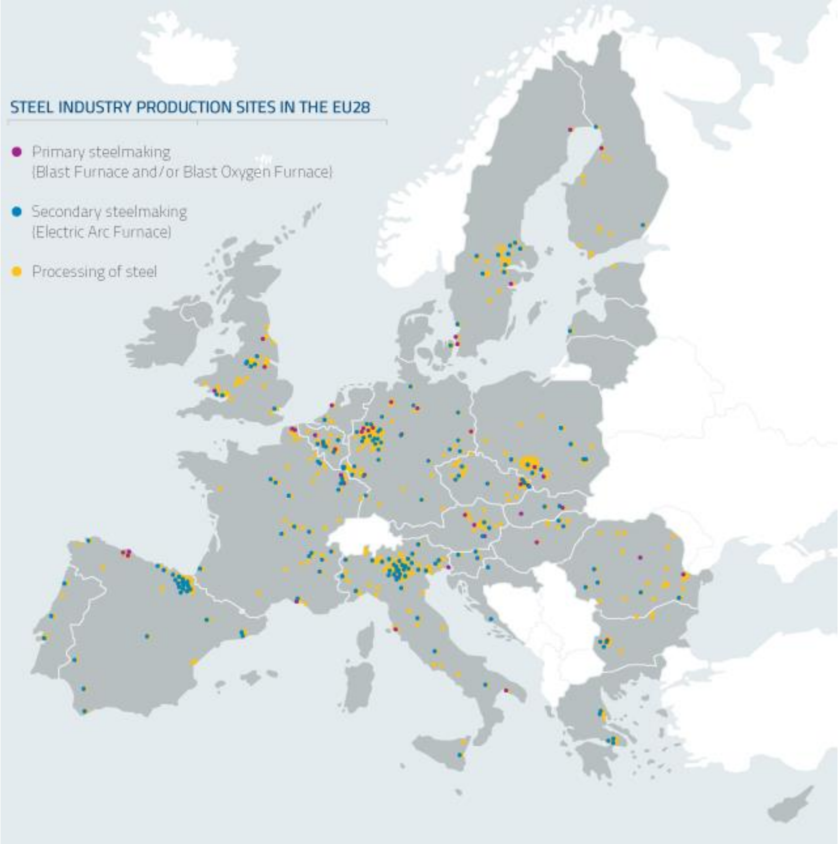


Source: Authors' own elaboration based on Eurofer, 2016.

3.3.3 Geographical distribution of production and plants over EU

The map in Figure 18 shows the geographical distribution of primary, secondary steel-making plants as well as steel-processing plants. Focussing on primary and secondary steel-making, one can see that there are several major regional steel-making clusters across Europe. Primary steel-making was traditionally clustered near resource-rich regions such as the Saar, Ruhr, Lorraine, the Midlands, Wallonia and Silesia. As a result of cheaper iron ore and coal from abroad, new plants have been located along the coast near ports to handle imported materials and energy. With secondary steel-making, northern Italy and the Basque region in Spain can also be identified as major European steel-making clusters.

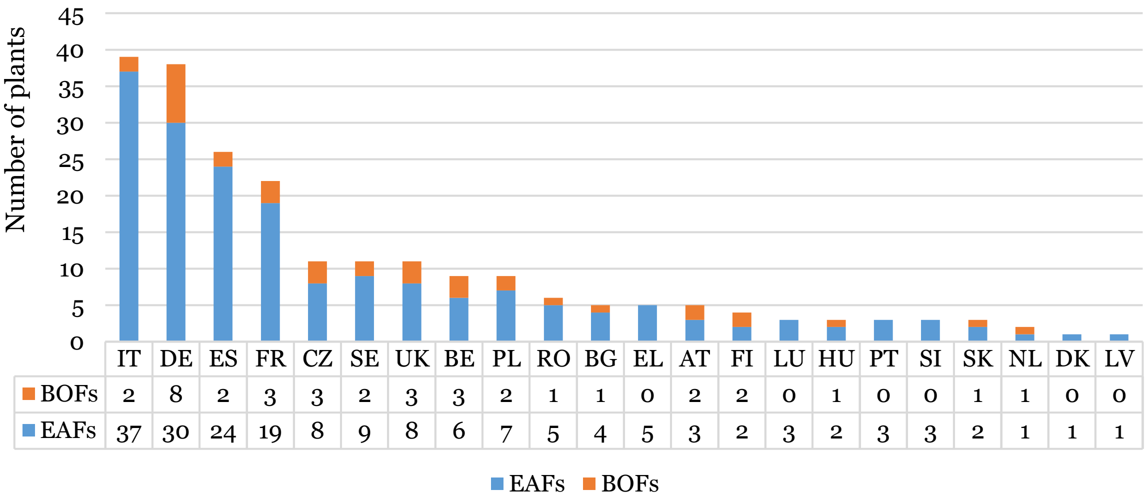
Figure 18. Steel industry production sites in the EU



Source: Eurofer (2016).

Figure 19 shows the share of BOF and EAF plant sites in the EU as well as the number of primary (BOF) and secondary (EAF) plants by country: 82% of all plant sites are EAFs, 17% are BOFs and less than 1% have both. Italy (39) and Germany (38) operate the largest number of steel plants, followed by Spain (26) and France (22). The remaining plants are distributed across other countries. It is worth noting that the UK operates the same number of plants as the Czech Republic and Sweden.

Figure 19. Steel industry plants in the EU



	IT	DE	ES	FR	CZ	SE	UK	BE	PL	RO	BG	EL	AT	FI	LU	HU	PT	SI	SK	NL	DK	LV
BOFs	2	8	2	3	3	2	3	3	2	1	1	0	2	2	0	1	0	0	1	1	0	0
EAFs	37	30	24	19	8	9	8	6	7	5	4	5	3	2	3	2	3	3	2	1	1	1

Source: Authors' own elaboration based on Eurofer, 2016.

3.3.4 Employment

According to Eurofer (2016), the European steel industry directly employs 335,000 people. According to Eurostat data on employment in the basic metals manufacturing sector from 2012, roughly 65% are employed by large enterprises. In general, it can therefore be assumed that approximately 218,000 people are employed by large steel producing companies.

3.4 Trade analysis

While steel production in the EU decreased by roughly 21% between 2007 and 2015, Asian countries, especially China, increased their production by more than 85% over the same period, satisfying both internal and external demand (see Figure 21). Between 2008 and 2009, steel production dropped by roughly 30% in the EU and North America, and underwent a weak recovery in the three following years. After Asia, the global leader with a share in 2015 of 68% global production, the EU ranks second (10%), followed by North America (7%) and CIS (6%). The EU, North America, CIS and Asian countries account for more than 90% of world steel production.

EU trade in iron and steel is still – though to a lesser extent than pre-2012 – represented by intra-EU flows. In 2012, intra-EU trade accounted for 72% of total trade, while only 28% of trade was directed towards extra-EU economies. The same trend is observed with regards to imports: 74% of imports comes from the EU and 26% from outside EU borders (Egenhofer et al., 2013).

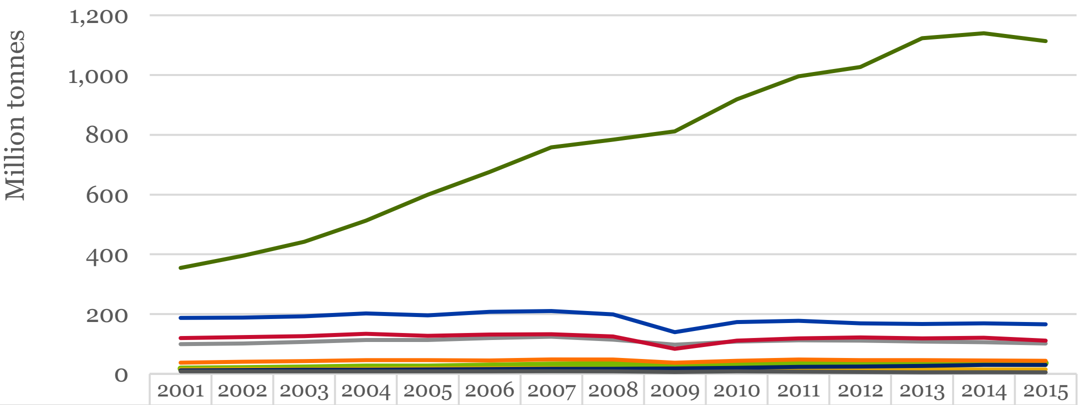
Figure 21 shows the export and import trade volumes of EU basic iron, steel and ferro-alloys products according to NACE4 (24.10) with the 10 most relevant (in terms of volume) G20 countries from 2008 and 2014. In 2014, the EU exported the largest volumes (roughly 5 million tonnes) of iron and steel to Turkey and the United States.

Additionally, the exports to the United States increased significantly since 2009. China imported roughly 1.2 million tonnes in 2014.

The largest importer into the EU was Russia, with fairly stable volumes of 7.5 to 8 million tonnes since 2010. Imports from China were the second highest in terms of volume, but fluctuated substantially between years. After the crisis years 2008 and 2009, import levels increased to 4.3 million tonnes in 2011, decreased to 2.8 million tonnes in 2012 and increased again to roughly 4.7 million tonnes in 2014.

Steel imports have become increasingly significant, mainly due to large overcapacities in and subsidised exports from China (and to a lesser extent, from Russia). Therefore, an EU action plan to help Europe's struggling steel industry is expected to include a proposal to levy tariffs on subsidised Chinese imports. In March 2016, the European Commission already announced that it is determined to restore a global level playing field by further extending the current record level of anti-dumping measures on steel products.

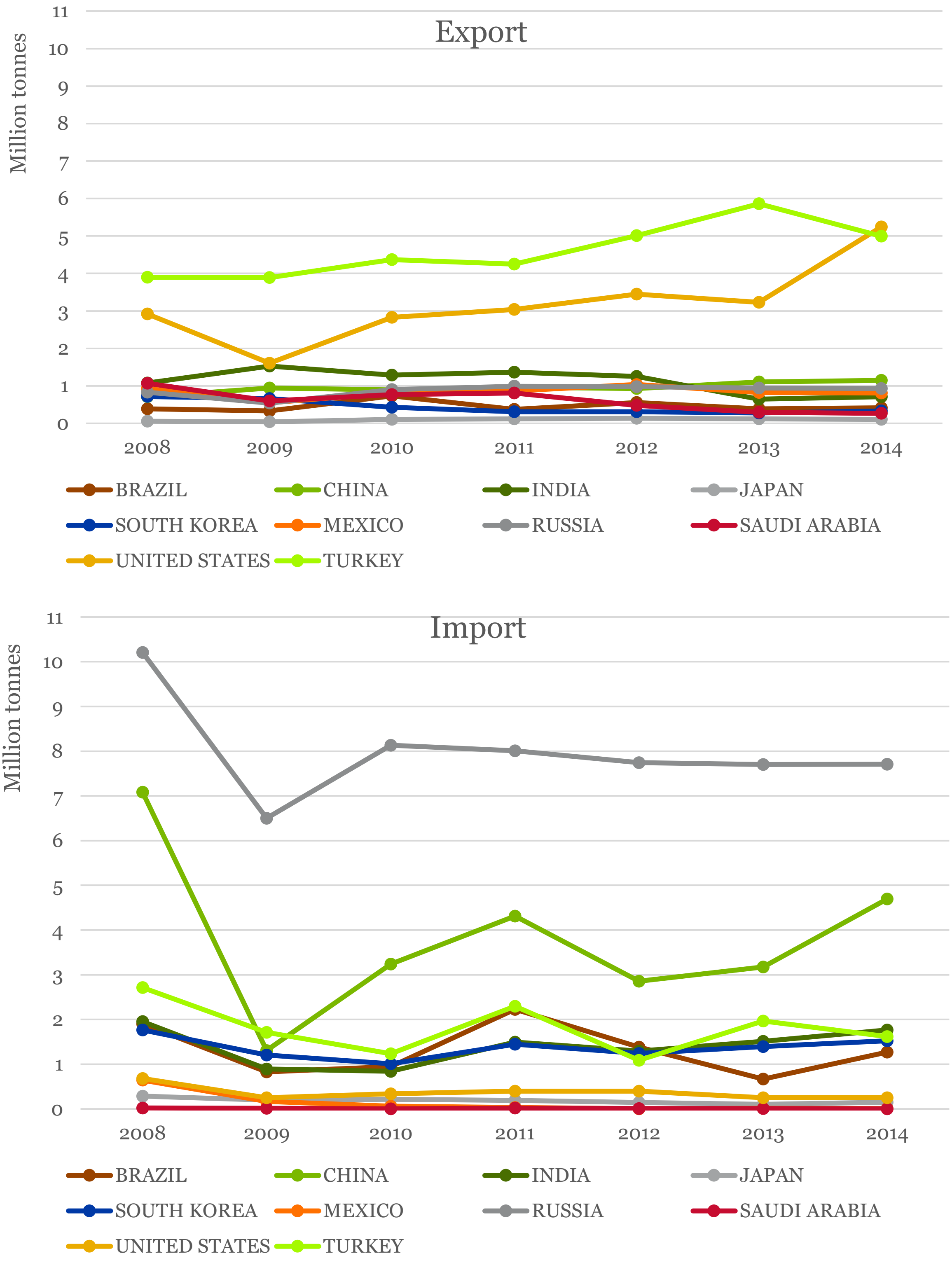
Figure 20. Crude steel production, 2001-15 (million tonnes)



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
European Union (28)	187	188	193	202	196	207	210	199	139	173	178	169	166	169	166
Other Europe	18	19	21	24	25	28	31	32	29	34	39	40	39	38	36
C.I.S.	100	101	106	113	113	120	124	114	98	108	113	111	108	106	102
North America	120	123	126	134	128	131	133	125	84	112	119	122	119	121	111
Sout America	37	41	43	46	45	45	48	47	38	44	48	46	46	45	44
Africa	15	16	16	17	18	19	19	17	15	17	16	15	16	15	15
Middle East	12	12	13	14	15	15	16	17	18	20	23	25	27	30	30
Asia	355	395	442	513	599	675	758	784	812	918	995	1027	1124	1140	1114
Oceania	8	8	8	8	9	9	9	8	6	8	7	6	6	5	6

Source: Authors' own elaboration based on World Steel (2015) and World Steel (2010).

Figure 21. EU export and import volumes of basic iron, steel and ferro-alloys with the 10 most relevant G20 countries (in terms of volume) from 2008 to 2014



Source: Eurostat (2015) (NACE 4, 24.10).

3.5 Energy - literature review

The energy-intensive steel industry consumes coal, natural gas, electricity and oil as energy sources.

Table 11 summarises the different applications of each of the different energy sources for steel production. Coal serves multiple roles including those of chemical reductant, furnace burden support and fuel. It is used as an energy and reducing agent for BOFs injection and coke production.

Electricity consumption is particularly intense in secondary steel-making (EAFs) when melting recycled steel. Electricity is furthermore needed for rolling, milling and running motors (both EAF and BOFs).

Natural gas serves as an energy source for furnaces and on-site power generators. It is also used as an energy and reducing agent for BOF injection as well as direct reduction iron-making (DRI), a relatively new process that uses gas rather than coke as a fuel.

Oil can also be used for steam production as well as BOF injection.

Table 11. Applications of energy sources in steel production

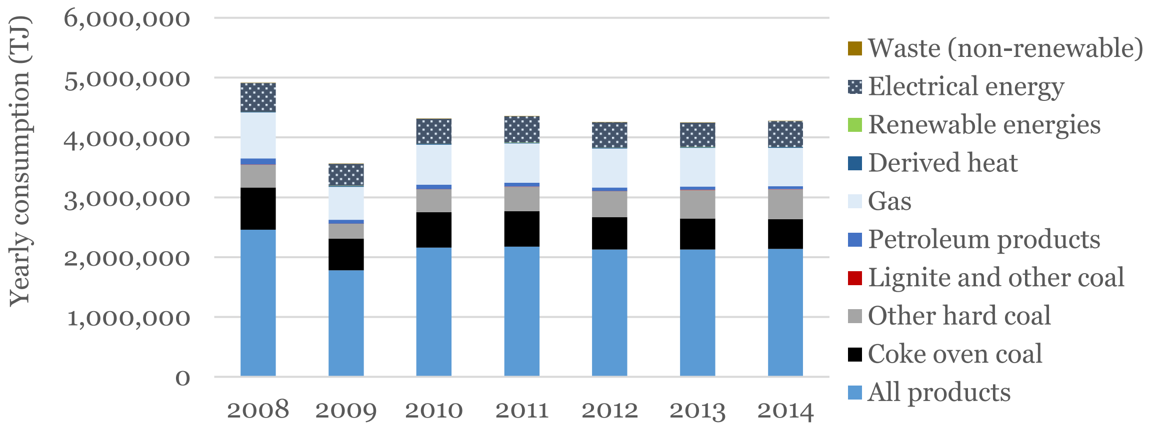
Energy input	Application as energy	Application as energy and reducing agent
Coal		Coke production, BOF pulverised coal injection
Electricity	EAF, rolling mills and motors	
Natural gas	Furnaces, power generators	BOF injection, DRI production
Oil	Steam production	BOF injection

Source: World Steel (2014).

Figure 22 shows the evolution in yearly energy consumption in the iron and steel sector. The sector was responsible for approximately 3.2% of the total European final energy consumption in 2014. In 2008, energy consumption reached nearly 2.5 million TJ, but fell by 28% in 2009. Since 2010, energy consumption did not exceed 2.2 million TJ.

Coal represents the largest energy source. It is mainly used as a raw material feedstock in coke ovens. The second largest energy source is natural gas. The third largest energy source is electricity, which is primarily used in EAFs. Fuel oil usage is limited.

Figure 22. Yearly energy consumption in iron and steel (EU) (TJ)



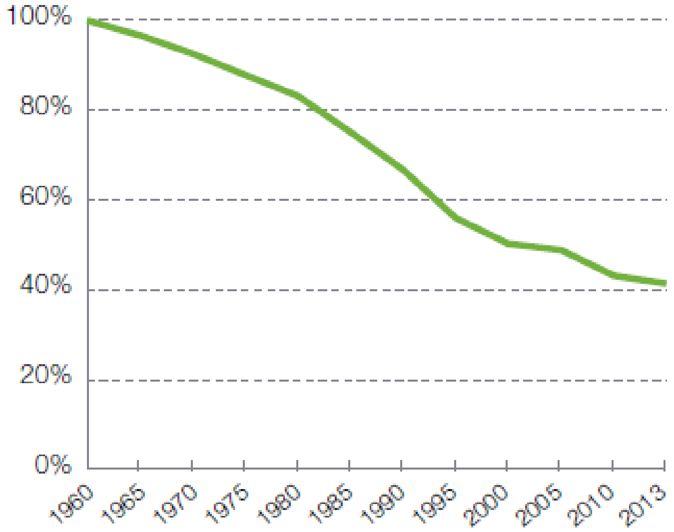
Source: Eurostat (2016)

The World Steel Association (2014) considers electricity, not natural gas, the second largest energy source. It states that approximately 50% of an integrated facility's energy input is supposed to come from coal, 35% from electricity, 5% from natural gas and 5% from other gases. This discrepancy may be caused by methodological differences on how purchased and on-site generated electricity is accounted for.

Additionally, the World Steel Association (2014) states that energy constitutes a significant share of steel production costs, ranging between 20% and 40% of total production costs. Therefore, the industry continuously seeks energy efficiency improvements in order to reduce energy costs and thereby improve its competitiveness.

Recent technical progress and energy efficiency improvements have resulted in significantly lower energy consumption per tonne of crude steel. As demonstrated in Figure 23, the indexed global energy consumption per tonne of crude steel decreased by almost 60% between 1960 and 2013.

Figure 23. Indexed global energy consumption per tonne of crude steel production



Source: World Steel (2014).

Energy consumption is highly dependent on the degree of vertical integration, production technologies and plant capacity. BOF integrated plants and EAF minimills therefore have different energy consumption profiles. EAFs, for example, are much more reliant on electricity than BOFs.

According to Egenhofer et al. (2013), large BOF integrated plants producing flat products may consume more than 1 million MWh of natural gas per year, rolling facilities accounting for a major share of natural gas consumption. EAFs also consume large quantities of natural gas, but generally less than BOF sites.

Consumption of electricity for steel-making also differs between BOFs and EAFs. Egenhofer et al. (2013) states that electricity intensity of BOFs is approximately one-third that of EAFs. Furthermore, BOF installations usually include a self-generation facility, where electricity is produced out of recycled waste gases from the furnaces. This means that, on average, most BOF producers procure electricity from external sources for approximately 60% of their total electricity consumption. Once these factors are accounted for, it comes as no surprise that much smaller EAF installations consume as much electricity as larger BOF ones.

In general, the major determinants of electricity consumption are plant capacity and the presence of hot- or cold-rolling facilities within the plant premises and production route.

Based on a survey of 15 steel plants, Egenhofer et al. (2013) calculated average electricity and gas intensities in the steel sector. Table 12 demonstrates that sampled BOFs reported an electricity intensity of around 0.175 MWh/t of crude steel, whereas EAFs showed a value of 0.553 MWh/t. Natural gas intensity, by contrast, was similar for BOFs and EAFs with a value of 0.135 and 0.151 respectively. While the findings of Egenhofer et al. (2013) show a significant difference in electricity intensity but a less pronounced difference in natural gas intensity between BOF and EAF plants, the current study, which is based on 22 surveys, shows a much clearer and more robust picture. It reveals that natural gas intensity of BOFs is between double to four-times the size of the intensity of EAFs whereas electricity intensity of EAFs is nearly double the size of the intensity of BOFs, clearly indicating the different energy consumption profiles of both production technologies.

Table 12. Energy intensity by production technology in Egenhofer et al. (2013) (MWh/t)

	Electricity	Natural Gas
BOF (crude steel)	0.175	0.135
EAF (Crude steel)	0.553	0.151

Source: Egenhofer et al. (2013).

The European Commission's report on best available techniques for iron and steel production by Remus et al. (2013) also provides values (minimum and maximum) for BOF and EAF electricity and natural gas intensities per tonne of crude steel (see Table 13). Their data reflects that the intensities not only differ between the two technologies but also within each technology, depending on the technical features and capacity of the respective BOF and EAF plant.

Table 13. Range of energy intensities by production technology (MWh/t) in Remus et al. (2013)

	Electricity		Natural Gas	
	Min	Max	Min	Max
BOF (crude steel)	0.010	0.060	0.032	0.396
EAF (Crude steel)	0.404	0.748	0.014	0.417

Source: Remus et al. (2013)

Overall, it can be seen that the energy intensities of Egenhofer et al. (2013), except for the BOF electricity intensity (0.175 MWh/t), lie within the ranges presented by Remus et al. (2013)[8], confirming that the magnitude of these energy intensities is realistic.

3.6 Selection of the sample and sample statistics

3.6.1 Sample strategy

For the purpose of the present study, the sampling for each sector should take into account the following criteria:

- **Geographical coverage**
- **Capacities**
- **Production technology**
- **Ownership**, i.e. company size

For the **geographical coverage** we will look at a representative sample including the following elements:

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[8] The discrepancy for BOF electricity intensity may be due to the fact that Remus et al. (2013) excludes any other electricity consuming entities on a BOF plant site, whereas Egenhofer et al. (2013) takes the electricity consumption of an entire BOF plant site into account.

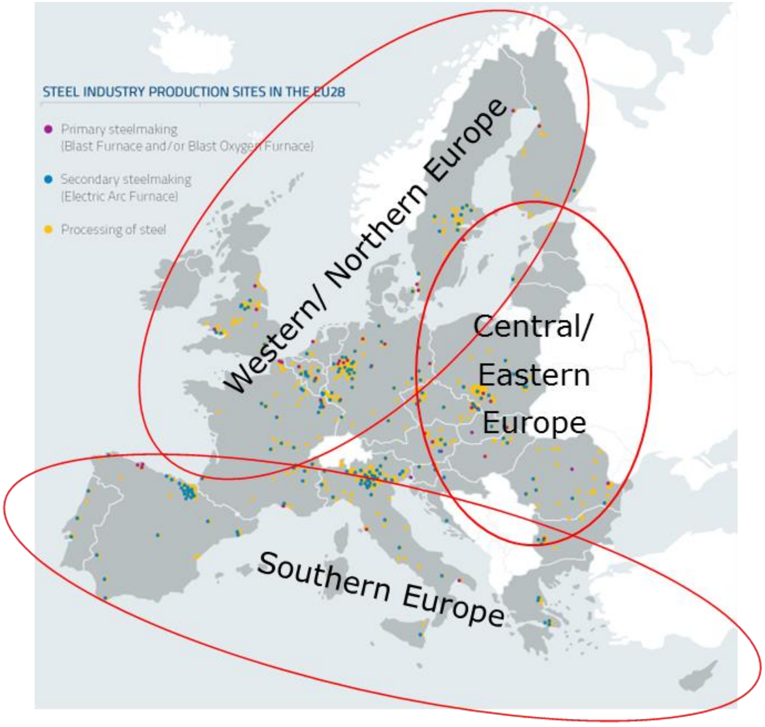
- Spread over three regions: Southern, Central-Eastern and North-Western Europe.
- Countries' capacity shares
- Large and small Member States (in terms of population)

Table 14 indicates how the EU countries are assigned to the indicated regions. Figure 24 presents an overview of the steel plant sites spread over the three regions.

Table 14. Coverage of countries by each of the three regions

EU region	Countries
Southern	Italy, Spain, Portugal, Greece, Malta, Cyprus
Central-Eastern	Poland, Slovenia, Hungary, Romania, Bulgaria, Czech Republic, Slovakia, Estonia, Latvia, Lithuania
North-Western	France, Ireland, UK, Belgium, Netherlands, Germany, Denmark, Austria, Sweden, Finland

Figure 24. Spread of plants over the different regions



Source: Eurofer (2016)

Regarding **capacity**, data was bought from the German Steel Institute VDEh, which provides an overview of the spread of the nominal capacities over countries and companies.

When it comes to **ownership**, the sample includes global as well as regional players. This is required as a large share of companies in the EU has a regional production focus (operating less than three plant sites), which might give these companies relatively less bargaining power and therefore make them be exposed to higher energy prices (see Figure 17). It is important to note that small and medium-sized companies (SMEs) are not relevant among steel-making facilities. For this reason, different plant sizes are not directly taken into consideration in the sampling strategy but are, to some extent, taken into consideration in the cross-sectoral analysis of this study.

When it comes to **production technology**, the following plant types are included and distinguished:

- Primary steel-making plants (BOF)
- Secondary steel-making plants (EAF)

The sampling accounts for the differentiation between production technologies, as BOF and EAF steelmaking plants differ highly in terms of capacity size and energy consumption profiles, and can therefore not be compared in a meaningful way within the scope of this study. Processing plants are not considered in this study, as these are too heterogeneous, smaller in size, relatively less energy-intensive and challenging to reach out to.

The research team approached European steel companies through the steel sector’s official representative body on EU-level: The European Steel Association Eurofer. Eurofer is located in Brussels and was founded in 1976. It represents 100% of steel production in the European Union. Its members are steel companies and national steel federations throughout the EU. The major steel companies and national steel federations in Switzerland and Turkey are associate members (Eurofer, 2016).

Eurofer supported the research team in terms of contacting member companies and providing additional information on existing plant sites across the EU. Based on plant location, plant capacity and company affiliation as well as the association’s experience with contacting its members, a representative sample was selected in order represent the entire EU steel sector as accurately and reliable as possible.

As not all EU steel companies are actively engaged within Eurofer, especially those from Southern Europe and those that are not considered to be international players, the research team also contacted a number of national steel associations to reach out to plant sites in order to improve the representativeness of the sample. For some countries, contacts via the national steel association worked well and resulted in a higher response rate from the respective region (in particular those from North-Western Europe such as Scandinavia), whereas for other countries and regions (in particular those from Southern Europe), it did not lead to a higher response rate.

3.6.2 Description of the sample

From the companies that initially confirmed their willingness to participate and additional companies that showed interest after been approached by the research team, 13 BOF (out of a total of 37 within the EU) and 33 EAF plant sites (out of a total of 183 within the EU) were requested to provide data. The selection of these plant sites was based on the sampling strategy in order to ensure that the country-specific steel production shares within the EU, both for EAF and BOF technologies, were represented in an adequate manner.

From the approached plant sites, initially 9 BOF and 19 EAF plant sites confirmed their participation in the study. In the end, 5 BOF and 17 EAF plant sites responded and provided filled-out questionnaires. The missing 6 steel plant sites did not provide data due to many different reasons, e.g. time constraints, confidentiality issues and internal company issues. One of the responding BOF plant sites comprises three BOF plant sites and one out of the responding EAF plant sites comprises two EAF plant sites, bringing the number of respondents, in fact, up to 7 BOF plant sites and 18 EAF plant sites.

Table 15 and Table 16 show an overview of the different replies by BOF and EAF plant sites, which were approached by the research team.

Table 15. Overview of the BOF plant sites approached by the research team

Region	Number of plants contacted	Confirmation to participate	Refusal to participate	Respondents
NWE	8	5	1	2
SE	2	1	1	0
CEE	3	3	0	3
Total	**13**	**9**	**2**	**5**

Source: Authors' own elaboration.

Table 16. Overview of the EAF plant sites approached by the research team

Region	Number of plants contacted	Confirmation to participate	Refusal to participate	Respondents
NWE	23	15	2	13
SE	8	2	5	2
CEE	2	2	0	2
Total	**33**	**19**	**7**	**17**

Source: Authors' own elaboration.

Out of the 22 plant sites that submitted data, 15 are situated in NWE, 2 are situated in SE and 5 are situated in CEE. Consequently, the respondents do not represent and cover Southern Europe sufficiently (see Figure 19: Italy alone already comprises 37 EAF and 2 BOF plant sites). In general, steel plant sites from Southern Europe, especially from Italy, were not interested in participating in the study.

In order to assess in how far the responding steel plant sites are representative for the entire European BOF and EAF steel industry, the research team introduced two indicators:

- **Regional representativeness.** Respondents' regional capacity shares in total respondents' capacity expressed as a percentage are compared with the "true" regional capacity shares within the EU. If the figures are similar, the regional representativeness of the responding plant sites can be considered high.
- **Regional coverage.** If the respondents' regional capacity represents more than 10% of all capacity from that region, the regional representativeness can be considered high.

Table 17 and Table 18 show the total regional capacity, the total regional capacity shares and the respondents' regional capacity as well as the derived representativeness indicators, i.e. regional representativeness and regional coverage, for all BOF and EAF steel plant sites respectively.

Table 17. Regional representativeness and coverage of responding BOF plant sites

Region	Total regional capacity (kt/a)	Total regional capacity shares (%)	Respondents' regional capacity (kt/a)	Regional representativeness (%):	Regional coverage (%):
NWE	83,340	69.7%	6500	39.9%	7.8%
SE	16,900	14.1%	0	0.0%	0.0%
CEE	19,250	16.1%	9800	60.1%	50.9%
Total EU	**119,490**	**100.0%**	**16300**	**100.0%**	**13.6%**

Source: Authors' own elaboration.

Table 18. Regional representativeness and coverage of responding EAF plant sites

Region	Total regional capacity (kt/a)	Total regional capacity shares (%)	Respondents' regional capacity (kt/a)	Regional representativeness (%):	Regional coverage (%):
NWE	37,059	37.6%	8270	73.4%	22.3%
SE	48,280	48.9%	1700	15.1%	3.5%
CEE	13,345	13.5%	1300	11.5%	9.7%
Total EU	**98,684**	**100.0%**	**11270**	**100.0%**	**11.4%**

Source: Authors' own elaboration.

Regarding the **regional representativeness**, the responding BOF plant sites are biased towards CCE, which represent 60.1% of total responding BOF capacity instead of only 16.1% under the total regional capacity shares within the EU. NWE is underrepresented with 39.9% (total regional capacity share would be 69.7%). SE is not represented at all.

EAF plant sites from CEE represent 11.5% of responding EAF plant sites, being almost identical to the total regional capacity share of 13.5%. NWE, however, is largely overrepresented (with 73.4% instead of 37.6%), whereas SE is significantly underrepresented.

Regarding the **regional coverage**, it can be noted that the responding BOF plant sites cover more than half of the total BOF capacity in CEE (50.9%). SE, in contrast, is not covered at all. In NWE, 7.8% of total BOF capacity is covered.

In terms of EAF plant sites, the responding EAF plant sites cover 22.3% of NWE, 9.7% of CEE and 3.5% of SE capacities.

Overall, based on capacity shares of responding plant sites, Southern Europe is significantly underrepresented and has a low coverage for both BOF and EAF plant sites. North-Western Europe, in contrast, is underrepresented for BOF and overrepresented for EAF plant sites. Central-Eastern Europe is overrepresented in terms of its BOF capacity, while it has a very high representativeness in terms of its EAF capacity.

The respondents provided detailed figures on the level and structure of energy prices as well as on energy consumption. This data was validated through expert judgement (on energy prices, energy intensities, economic indicators etc.), follow-up phone calls as well as cross-checks via energy statistics from Eurostat and energy price publications. Out of the 22 respondents, only one plant site was willing to share energy bills with the research team. For this reason, energy bills could not be used to evaluate the accuracy of all data the respondents provided.

Table 19 presents the number of questionnaires used in the analysis of each section. There were substantial data gaps in the submitted questionnaires, in particular for the key performance indicators.

Table 19. Number of questionnaires used in each section

Total number received	Total number usable[9]	Energy price trends	Energy bill components	Energy intensity	International comparison	Production costs and margins
22	*22*	*≤22 (elec.)* *≤20 (gas)*	*≤16 (elec.)* *≤15 (gas)*	*≤20 (elec.)* *≤18 (gas)*	*≤3 (elec.)* *≤3 (gas)*	*≤18*

Source: Authors' own elaboration.

The research team asked producers to communicate the prices they paid for electricity and natural gas between 2008 and 2015, notwithstanding the years 2009 and 2011. The figures exclude VAT and other recoverable costs.

All energy prices reported in this section, and used throughout the analysis are net-prices, as reported on energy bills: exemptions or reductions for specific components are counted in. However, tax rebates, subsidy schemes or other financial compensation mechanisms that are not visible in bills are not accounted for due to a lack of data on these elements.

3.7 Energy price trends

3.7.1 Natural gas

Not all of the plant sites provided figures on natural gas consumption level and costs. One plant did not consume any natural gas but used oil instead. In total, the descriptive statistics on natural gas prices are based on 14 to 20 out of the total respondents of 22. Based on the consumption and costs level provided, the respective natural gas prices were derived.

The following analysis focusses on natural gas prices and is therefore limited to purchased natural gas consumption and costs. Waste gases from steel production that

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[9] This refers to the number of questionnaires that made it through the verification process and were used in the subsequent data analysis.

were used on-site, for example, to produce electricity in a cogeneration plant were therefore not taken into account.

General trends

As shown by the median in Table 20, the prices of natural gas paid by the responding steel producers were falling from 2012 to 2015, whereas they trended upwards between 2010 and 2012. In 2008, the median EU price of natural gas paid by a steel producer was 29.45 €/MWh, whereas in 2015 the price was 27.47 €/MWh, corresponding to a price decrease of nearly 7.0 %. The weighted average values show a similar evolution as the median prices but were slightly lower than the median prices at 28.57 €/MWh in 2008 and 26.11 €/MWh in 2015. When only respondents providing data for all years are included, the trend of decreasing median and weighted average prices from 2012 to 2015 is even more pronounced.

The relative standard deviation decreased from 19.3% in 2008 to 16% in 2010 and increased again to 21.4% in 2015. The inter-quartile range, i.e. the difference between the lower and upper quartile, which represents the middle half of the data, shows an irregular spread, reaching its maximum in 2008 at 14.16 €/MWh in 2008 and its minimum in 2015 at 6.00 €/MWh. The total range of prices has also been fluctuating significantly throughout all years as indicated by the whiskers of the box plot. In particular, the year 2012 and 2013 showed the largest spread with a price difference of 25.57 €/MWh and 23.43 €/MWh respectively between the highest and lowest paying operators.

Minimum prices paid by the responding companies started at 21.12 €/MWh in 2008, increased to 24.35 €/MWh in 2012. In 2015, the minimum price reached a level close to the 2008 values at 21.86 €/MWh.

Maximum prices for natural gas paid by steel plant sites show similar but stronger variations over the years. After a nearly constant level at approximately 36 €/MWh in 2008 and 2010, there was a large increase in 2012 with values up to 49.91 €/MWh, followed by a significant decline by almost 10 €/MWh in 2014, to 40.74 €/MWh. In contrast to the median and minimum values, the maximum prices clearly stayed above the 2008 price level, at 44.84 €/MWh.

Regional differences

A comparison between regions can only be provided for North-Western Europe and Central-Eastern Europe. Less than 3 responding plant sites in Southern Europe provided data on their natural gas costs and therefore no analysis on Southern European region could be provided. Figure 25 shows the weighted average for North-Western European and Central-Eastern European with paid prices being weighted with the total natural gas consumption of each plant.

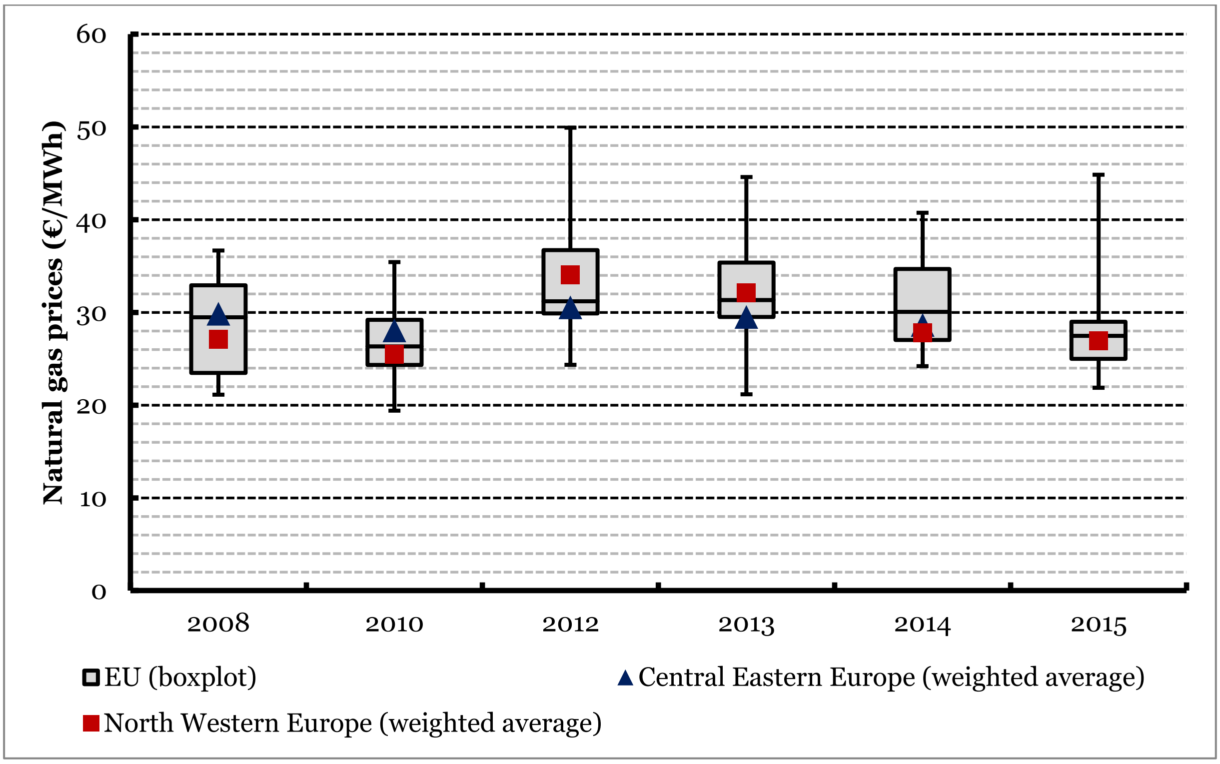
The weighted averages of natural gas prices paid by responding steel plants in North-Western Europe peaked in 2012 at 34.04 €/MWh and decreased to 26.92 €/MWh in 2015 - a similar level as the price in 2008 (27.09 €/MWh). Responding Central-Eastern European plant sites had a more stable natural gas price ranging between

29.83 €/MWh in 2008 and 28.64 €/MWh in 2014. The analysis cannot be expanded to include 2015 as only one plant site from this region provided data for 2015.

Technological differences

Both BOF and EAF weighted average prices peaked in 2012. BOF plant sites faced a price of 31.52 €/MWh and EAF plant sites a price of 34.23 €/MWh. Both weighted averages decreased to 27.12 €/MWh and 25.52 €/MWh respectively in 2015. It is important to note that a reliable comparison between EAF and BOF plant sites is difficult as only 5 BOF plant sites, one of them including 3 plant sites though, participated in the study. No significant price differences between EAF and BOF plant sites was observed.

Figure 25. Prices of natural gas paid by responding EU producers, 2008-2015 (€/MWh)



Source: Authors' own elaboration.

Table 20. Descriptive statistics for natural gas prices paid by responding EU producers

	2008	2010	2012	2013	2014	2015
Plant sites/total sample	14/22	16/22	20/22	20/22	20/22	17/22
EU (weighted average)	28.57	26.89	33.16	31.38	28.71	26.11
EU (median)	29.45	26.33	31.19	31.32	30.04	27.47
EU (relative standard deviation)	19.3%	16.0%	17.9%	16.8%	16.7%	21.4%
EU (IQR)	14.16	7.25	10.21	8.80	11.48	6.00
EU (minimum)	21.12	19.40	24.35	21.16	24.20	21.86
EU (maximum)	36.67	35.42	49.91	44.59	40.74	44.84
CEE EU (weighted average)	29.83	28.06	30.52	29.50	28.64	--
SE EU (weighted average)	--	--	--	--	--	--
NWE EU (weighted average)	27.09	25.50	34.04	32.11	27.78	26.92
BOF (weighted average)	31.08	29.24	31.52	30.55	28.52	27.13
EAF (weighted average)	26.48	24.84	34.23	31.98	28.86	25.51

Source: Authors' own elaboration.

3.7.2 Electricity

Except for the years 2008, 2010 and 2015, all responding plant sites provided data on electricity consumption levels and costs. Seven plant sites did not provide any data for the year 2008 and 4 plant sites are missing from the analysis for 2010 and 2015. Therefore, the descriptive statistics on electricity prices can be based on all responding 22 plant sites for half of the observed years. The respective electricity prices were derived from the consumption and costs level provided.

The analysis focusses on electricity prices and is therefore limited to purchased electricity consumption and costs. Self-produced electricity costs, revenues from self-produced electricity sold to the grid and/or remuneration from interruptibility schemes are not accounted for.

General trends

Total electricity prices paid by European steel plants fluctuated over time and peaked in 2012. In 2008, half of the steel plants paid less than 57.30 €/MWh, while in 2012, this median value reached 62.82 €/MWh. In 2014 and 2015, prices declined. The 2015 electricity price median of responding steel plant sites was 53.87 €/MWh (nearly 6% lower than the median in 2008). When using only respondents providing data for all years, the median and the weighted average price peak is reached in 2013 and not in 2012, while the trend of increasing and then decreasing median and weighted average prices between 2008 to 2015 is even more pronounced.

Absolute price spreads between respondents were highest in 2013 (80.16 €/MWh) and lowest in 2010, when the difference between minimum and maximum prices was 47.38 €/MWh. The difference between the first and the third quartiles was highest in 2008, namely 39.86 €/MWh.

Minimum prices paid by the responding plant sites started at 33.60 €/MWh in 2008, stabilize at a level of around 42 €/MWh between 2010 and 2013 and decreased again to approximately 33.50 €/MWh in 2014 and 2015. The values began to decline in 2014, one year after the decline in the median value. In 2015, the minimum price reached a level close to, but lower than, the 2008 values, 32.42 €/MWh.

Maximum prices for electricity paid by steel companies showed larger differences than the minimum prices over the years. In 2008 to 2010 maximum prices remained stable at approximately 90 €/MWh, but increased significantly to 111.95 €/MWh in 2012. In 2013 they increased again by more than 10 €/MWh to 122.80 €/MWh. Subsequently, maximum prices decreased again by more than 20 €/MWh in 2014. In contrast to the median and minimum values, the maximum prices consistently stayed above the 2008 levels, at 101.73 €/MWh.

Regional differences

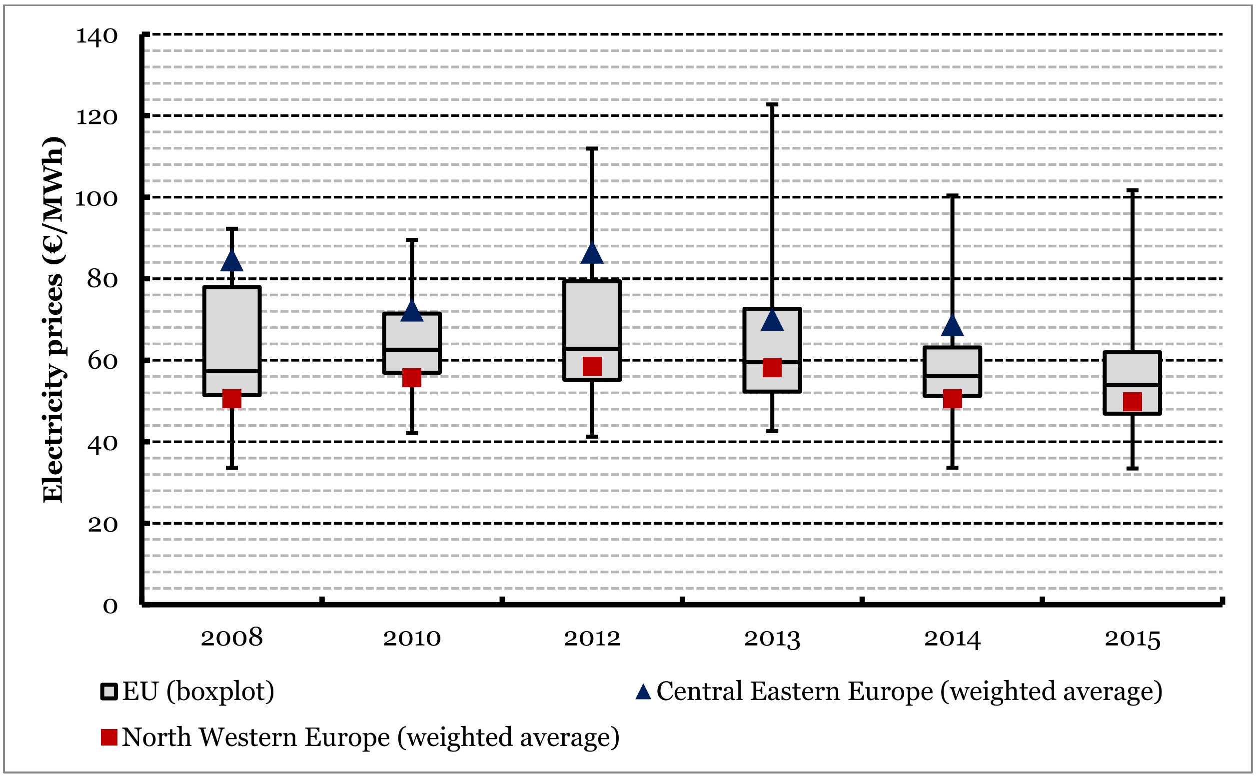
Figure 26 only includes a weighted average for North-Western European countries and Central-Eastern Europe. Southern Europe is again excluded due to an insufficient amount of observations (less than 3 single observations for each year). Electricity prices for each plant have been weighted by electricity consumption.

The weighted averages of electricity prices paid by steel plants in North-Western Europe are clearly below the median values of all responding European steel producers. In 2008, the average value was 50.47 €/MWh. Like the median prices of all respondents, the weighted average of the prices in North-Western Europe peaked in 2012 at 58.57 €/MWh and decreased again to 49.83 €/MWh by 2015 (1.3% lower than 2008 levels). Central-Eastern Europe in general observed higher electricity prices. This is also confirmed when only including plants that provided data for all years.

Technological differences

Both BOF and EAF average prices (weighted by electricity consumption) increased from 2008 to 2012/13, followed by a significant decline until 2015. The prices for BOF decreased from 72.86 €/MWh in 2013 to 52.12 €/MWh in 2015, a value lower than the 2008 levels (56.02 €/MWh). The prices for responding EAF plant sites peaked one year later in 2013 at 62.46 €/MWh and afterwards decreased to 53.55 €/MWh by 2015 (significantly lower than the 2008 price of 58.55 €/MWh). No significant price differences between EAF and BOF plant sites was observed.

Figure 26. Prices of electricity paid by responding EU producers, 2008-2015 (€/MWh)



Source: Authors' own elaboration.

Table 21. Descriptive statistics for electricity prices paid by responding EU producers

	2008	2010	2012	2013	2014	2015
Plant sites/total sample	15/22	18/22	22/22	22/22	22/22	18/22
EU (weighted average)	57.65	60.21	65.53	61.18	55.59	53.03
EU (median)	57.30	62.58	62.82	59.48	56.10	53.87
EU (relative standard deviation)	30.4%	21.4%	29.3%	34.5%	27.7%	33.0%
EU (IQR)	39.86	21.90	36.34	30.50	17.73	22.59
EU (minimum)	33.60	42.17	41.24	42.63	33.63	33.42
EU (maximum)	92.27	89.55	111.95	122.80	100.43	101.73
CEE EU (weighted average)	84.75	72.43	86.58	70.16	68.80	--
SE EU (weighted average)	--	--	--	--	--	--
NWE EU (weighted average)	50.47	55.68	58.57	58.13	50.51	49.83
BOF (weighted average)	56.02	62.71	72.86	59.45	56.33	52.12
EAF (weighted average)	58.55	57.35	60.12	62.46	55.03	53.55

Source: Authors' own elaboration.

3.8 Energy bill components

In this section, the analysis of the components of the price paid by sampled manufacturers for natural gas and electricity is presented.

Note that companies were not always able to provide both overall prices and price components. Often detailed components were not visible on energy bills. There are significant differences between the average energy prices as reported above in the section energy prices and the results reported in this section on energy components. This is caused by different numbers of respondents included in both sections of the analysis.

The price of natural gas is split into three components, two of which depend on the regulatory framework (the so-called 'regulatory components'):

1. Energy supply;
2. Network costs;
3. Other taxes, fees, levies and charges (excluding recoverable taxes, such as VAT).

The price of electricity is split into four components, three of which depend on the regulatory framework (the so-called 'regulatory components'):

1. Energy supply;
2. Network costs;
3. Renewable support
4. Other taxes, fees, levies and charges (excluding recoverable taxes, such as VAT).

3.8.1 Natural gas

Not all plant sites reported the exact composition of their natural gas costs that are needed to derive natural gas prices, i.e. energy supply costs, network costs as well as other taxes, fees, levies and charges (excl. VAT). Therefore, the number of questionnaires used is lower in comparison to the energy price analysis before. Table 22 shows the number of questionnaires that could be used to provide data on the natural gas price components.

Table 22. Questionnaires used for the analysis of natural gas price components

2008	2010	2012	2013	2014	2015
7/22	9/22	14/22	15/22	15/22	15/22

General trends and regional differences

Figure 27 shows the weighted averages for the responding steel plants in Europe as well as in North-Western Europe. For Central-Eastern and Southern Europe, no values were made explicit as there were less than 3 single observations for each year in the respective regions.

Total prices fluctuated mainly because of changes in the energy component. The value of this price component peaked in 2012 at 31.10 €/MWh and decreased to 23.74 €/MWh in 2015 - nearly as low as in 2010 (€23.41/MWh). This corresponds to a decrease of 23.6% between 2012 and 2015. This cost level is also significantly lower (-14%) than the 2008 level of 27.18 €/MWh.

The energy supply costs in North-Western Europe were, except for 2012 and 2013, higher than the EU average of responding plant sites (between 0.72 €/MWh and 1.70 €/MWh higher).

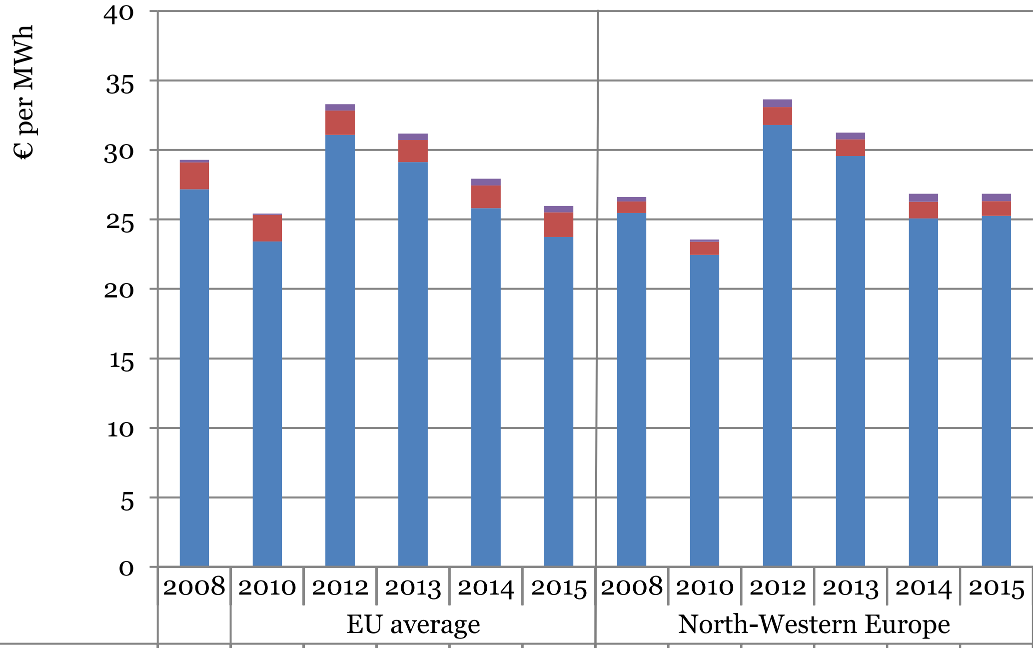
The network costs remained fairly stable across all years, between 1.61 €/MWh (the minimum reached in 2013) and 1.92 €/MWh (the maximum reached in 2008). From 2013 to 2015, however, it increased again to 1.78 €/MWh.

It is important to note that average network costs in North-Western European countries are significantly lower than the average for all EU respondents. From 2008 to 2015 they have been on average 0.8 €/MWh lower.

The weighted average values for EU responding plant sites concerning other taxes, fees, levies and charges increased significantly at the beginning of the period studied and then stabilised between 2012 and 2015. Between 2008 and 2010 they fell from 0.20 €/MWh to 0.09 €/MWh, followed by a steep increase to 0.47 €/MWh in 2012. Over the period 2013 to 2015, they ranged between 0.45 €/MWh and 0.49 €/MWh. Since 2012, the average values for North-Western European countries have been between 0.05 €/MWh and 0.9 €/MWh higher than the European weighted average of respondents.

When only including those plants that reported data for all years, the significant increase from 2010 to 2012 is less pronounced but still valid.

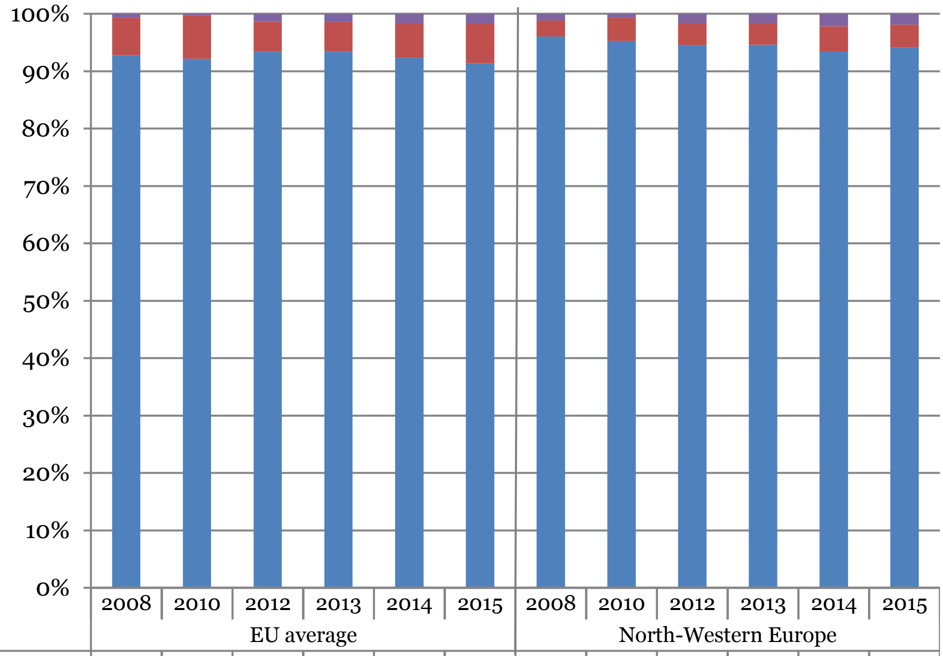
Figure 27. Components of the natural gas bills paid by the responding producers in the EU, 2008-2015 (€/MWh)



	EU average						North-Western Europe					
	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
🟪 Other taxes, fees, levies and charges (excl. VAT)	0.20	0.09	0.47	0.45	0.49	0.46	0.34	0.16	0.54	0.50	0.59	0.52
🟥 Network costs	1.92	1.91	1.75	1.61	1.64	1.78	0.81	0.96	1.29	1.19	1.18	1.07
🟦 Energy supply costs	27.18	23.41	31.10	29.12	25.81	23.74	25.48	22.44	31.81	29.57	25.09	25.26

Source: Authors' own elaboration.

Figure 28. Components of the natural gas bills paid by the responding producers in EU (%) 2008 -15



	EU average 2008	EU average 2010	EU average 2012	EU average 2013	EU average 2014	EU average 2015	North-Western Europe 2008	North-Western Europe 2010	North-Western Europe 2012	North-Western Europe 2013	North-Western Europe 2014	North-Western Europe 2015
🟪 Other taxes, fees, levies and charges (excl. VAT)	0.7%	0.3%	1.4%	1.5%	1.8%	1.8%	1.2%	0.7%	1.6%	1.6%	2.2%	1.9%
🟥 Network costs	6.5%	7.5%	5.2%	5.2%	5.9%	6.9%	2.8%	4.1%	3.8%	3.8%	4.4%	4.0%
🟦 Energy supply costs	92.8%	92.1%	93.4%	93.4%	92.4%	91.4%	95.7%	95.2%	94.6%	94.6%	93.4%	94.1%

Source: Authors' own elaboration.

Figure 28 shows the relative shares of the natural gas price components. The shares of the energy supply costs remained fairly constant across all years, reaching a minimum in 2015. They increased from 92.8% in 2008 to 93.4% in 2012/13 and decreased to 91.4% in 2015. The share of network costs was fairly volatile with no clear trend (between 5% and 7.5%). The shares of other taxes, fees, levies and charges in total natural gas costs, however, continuously increased from 0.3% in 2010 to 1.8% in 2015.

In North-Western European countries the relative share of energy supply costs is substantially higher and less volatile, whereas network costs are significantly lower. At the same time, the share of other taxes, fees, levies and charges is slightly higher.

3.8.2 Electricity

As not all plant sites reported the exact composition of their electricity costs that are needed to derive electricity prices, i.e. energy supply costs, network costs, renewable energy support costs as well as other taxes, fees, levies and charges (excl. VAT), the number of usable and evaluable questionnaires reduced in comparison to the energy price analysis before. Table 23 shows the number of questionnaires that could be used to provide data on the electricity price components.

Table 23. Questionnaires used for the analysis of electricity price components

2008	2010	2012	2013	2014	2015
10/22	11/22	16/22	16/22	16/22	16/22

General trends and regional differences

Figure 29 shows the weighted averages for all responding steel plant sites in EU as well as the North-Western European plant sites. For Central-Eastern and Southern Europe, no values were made explicit as there were less than 3 single observations for each year in the respective regions.

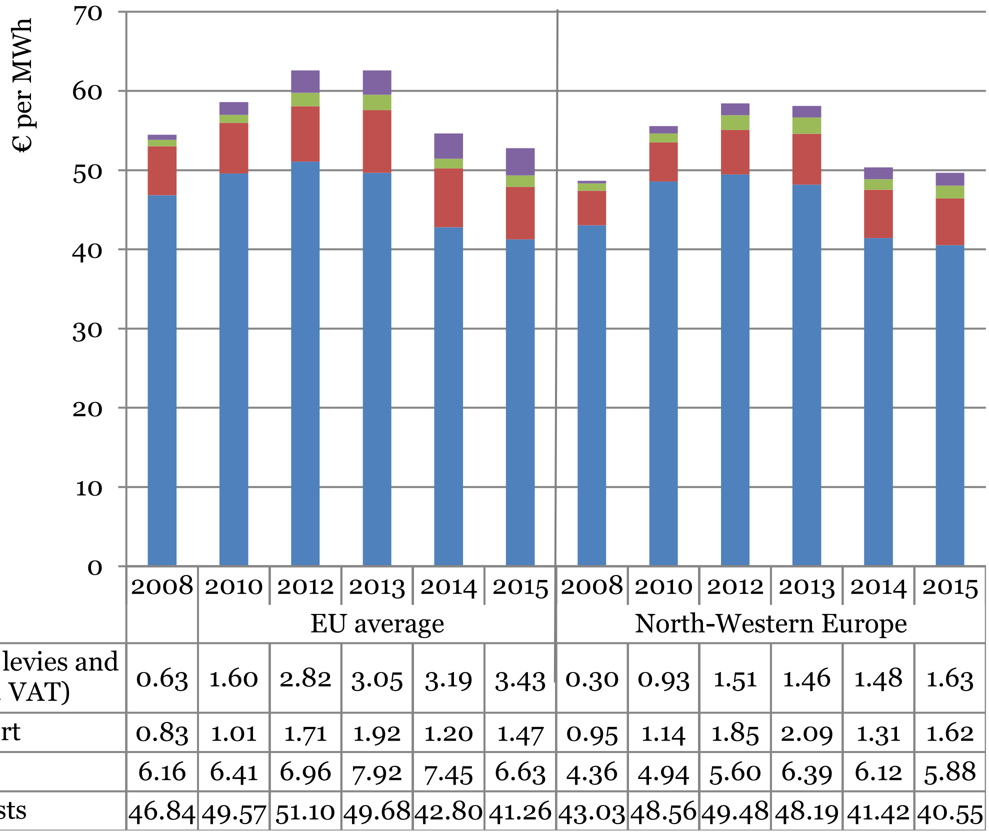
Total prices fluctuated mainly because of absolute changes in the energy component, making it the most important price driver. These costs peaked in 2012 at 51.10 €/MWh and decreased to 41.26 €/MWh by 2015, a value 13.5% lower than that of 2008 (46.84 €/MWh). From 2012 to 2015, this corresponds to a decrease of nearly 20%. The energy supply costs in North-Western Europe were for all years lower than the EU average of responding plant sites. The difference was the lowest in 2015 (€0.71/MWh) and the highest in 2008 (€3.81/MWh).

On average, network costs for the sampled plants in the EU peaked in 2013 at 7.92 €/MWh and decreased again to 6.63 €/MWh by 2015, a value similar to those of 2008/2010 (6.16 €/MWh and 6.41 €/MWh respectively). When only including plants that provided data for all years, the peak in 2013 is even more pronounced. Average network costs in North-Western European countries are substantially lower, but the spread decreased over the study period. In 2008, they were 1.80 €/MWh lower, whereas in 2015, values were only 0.75 €/MWh lower than the weighted average for all responding EU plant sites.

Like the network costs, average payments for renewable energy support peaked in 2013 at 1.92 €/MWh and reached 1.47 €/MWh in 2015, in comparison to 0.83 €/MWh in 2008 (an increase of 78%). North-Western European renewable energy support payments, in comparison, were between 0.11 €/MWh (2014) and 0.17 €/MWh (2013) higher for all years.

The value of other taxes, fees, levies and charges has increased continuously and quite substantially over the 2008-2015 period, from 0.63 €/MWh in 2008 to 3.43 €/MWh in 2015 (more than a 5-fold increase). For all years, the average values for North-Western European countries were lower than the average for all EU respondents. When only including plants that provided data for all years, this difference becomes slightly more significant.

Figure 29. Components of the electricity bills paid by the responding producers in the EU, 2008-2015 (€/MWh)



	EU average						North-Western Europe					
	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
🟪 Other taxes, fees, levies and charges (excl. VAT)	0.63	1.60	2.82	3.05	3.19	3.43	0.30	0.93	1.51	1.46	1.48	1.63
🟩 Renewable support	0.83	1.01	1.71	1.92	1.20	1.47	0.95	1.14	1.85	2.09	1.31	1.62
🟥 Network costs	6.16	6.41	6.96	7.92	7.45	6.63	4.36	4.94	5.60	6.39	6.12	5.88
🟦 Energy supply costs	46.84	49.57	51.10	49.68	42.80	41.26	43.03	48.56	49.48	48.19	41.42	40.55

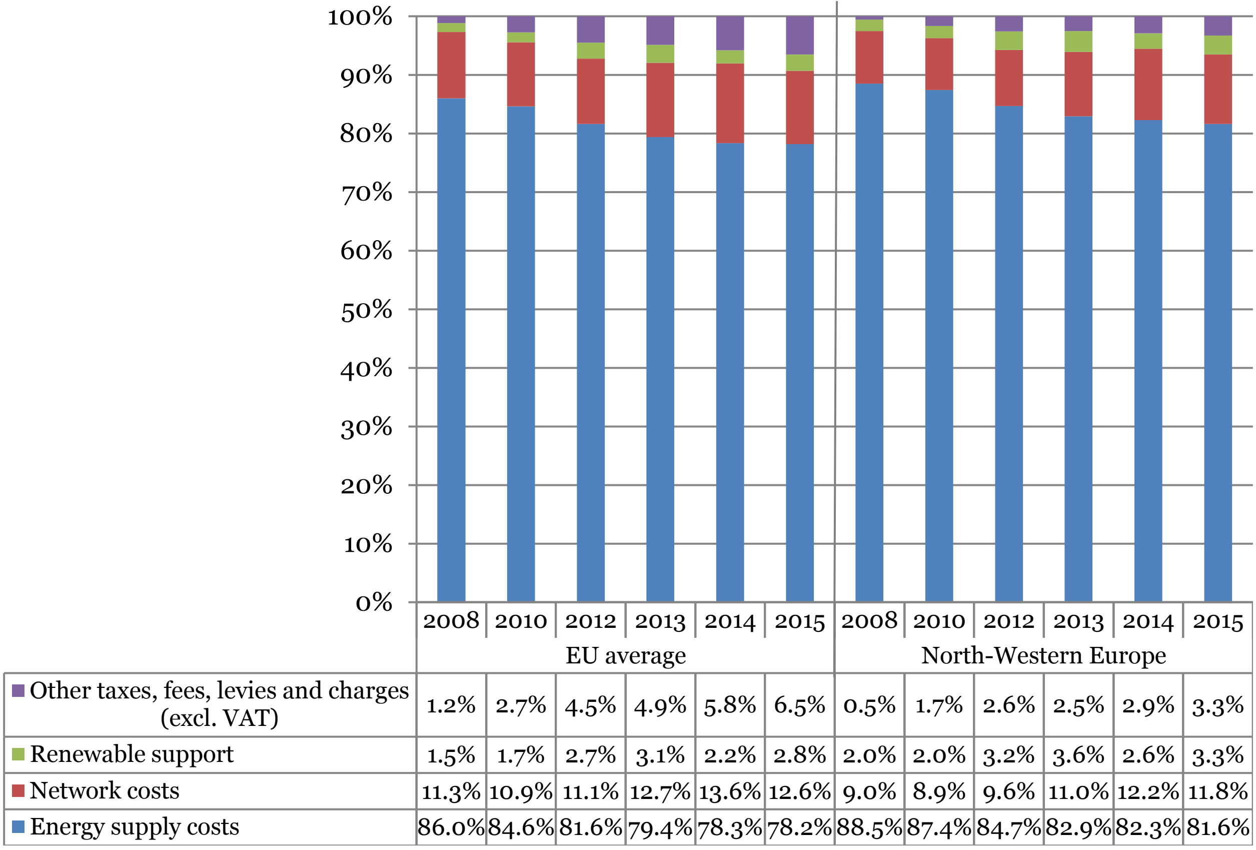
Source: Authors' own elaboration.

Figure 30 presents the relative shares of the electricity price components. Since the average electricity prices for EU respondents decreased between 2012 and 2015, the share of energy supply costs continuously decreased over the study period, from 86.0% in 2008 to 78.2% in 2015.

The share of network costs was fairly stable – around 11% - from 2008 to 2012. From 2013 to 2015, the share was more of the order of 13%. When only including plants that provided data for all years, this share is slightly higher, around 14%. Renewable energy support peaked at 3.1% in 2013 and decreased to 2.8% by 2015; in 2008 it accounted for approximately 1.5% of electricity bills for respondents. Other taxes, fees, levies and charges in total electricity prices, in contrast, show a clear upward trend. They continuously increased from 1.2% in 2008 to 6.5% in 2015.

In North-Western European countries, the shares of the energy supply cost and renewable energy support is higher for all years (respectably by 2.5 to 4.0 percent points and by 0.3 to 0.5 percent points). The share of network costs and taxes is lower for all years (respectively by 0.7 to 2.4 percent points and by 0.6 and 3.2 percent point).

Figure 30. Components of the electricity bills paid by the responding producers in the EU (%) 2008 -15



	EU average						North-Western Europe					
	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
🟪 Other taxes, fees, levies and charges (excl. VAT)	1.2%	2.7%	4.5%	4.9%	5.8%	6.5%	0.5%	1.7%	2.6%	2.5%	2.9%	3.3%
🟩 Renewable support	1.5%	1.7%	2.7%	3.1%	2.2%	2.8%	2.0%	2.0%	3.2%	3.6%	2.6%	3.3%
🟥 Network costs	11.3%	10.9%	11.1%	12.7%	13.6%	12.6%	9.0%	8.9%	9.6%	11.0%	12.2%	11.8%
🟦 Energy supply costs	86.0%	84.6%	81.6%	79.4%	78.3%	78.2%	88.5%	87.4%	84.7%	82.9%	82.3%	81.6%

Source: Authors' own elaboration.

Box 1. Indirect EU ETS costs in the steel sector

EU ETS compliance costs increase operating costs of electric utilities. The utilities pass those costs on to their customers via higher electricity rates. Indirect EU ETS costs are generally not visible in electricity bills, and cannot be distinguished as a separate component as they are part of the energy component. As a result, BOF and EAF steel plants have the cost of CO2 embedded in their electricity prices.

One out of the 22 responding steel plant sites indicated that indirect EU ETS costs are explicitly negotiated with their power utility, and are paid on top of the agreed electricity price using a EUA-indexed electricity cost formula. In contrast to the other steel plant sites, the indirect EU ETS cost paid by this company directly depends on the EUA daily future prices and the fuel mix used by the power utility.

Industries may not be able to fully pass EU ETS indirect costs on to downstream customers if they are active in a globally competitive sector, such as the steel industry. The following analysis is therefore intended to provide an estimation of the indirect ETS cost born by the steel sector between 2008 and 2015.

Estimates for indirect costs per tonne of product for both, BOF and EAF plant sites, are calculated using the following formula[10]:

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[10] This formula and the sources of the data used are discussed in depth in the Methodology Chapter.

Indirect cost (€/t of product) = Electricity intensity (kWh/t of product)
** Carbon intensity of electricity (Tonne of* CO_2*/kWh)*
*** CO_2 *Price (€/t of* CO_2*) * Pass-on rate*

- Yearly averages across the EU sample are simple averages. Weighing by consumption would bias the estimates as electricity consumption is a key variable in the formula above.
- Carbon intensity of electricity is a constant per region, and does not take the reductions in carbon intensity of electricity production since 2012 into account. These estimates are therefore likely to be overestimations for the more recent years.
- Only purchased electricity, i.e. excluding self-generation, is subject to indirect ETS costs
- Two scenarios are calculated, based on the pass on rates equal to 0.6 and 1

Electricity intensities are derived from the purchased electricity and production output levels provided by steel plant sites in the questionnaires. Note that the carbon intensity of electricity is a constant per region, and does not take the reductions in carbon intensity of electricity production since 2012 into account. These estimates are therefore likely to be overestimations for the more recent years. The CO2-prices are the yearly averages of the daily settlement prices for Dec Future contracts for delivery in that year. Two pass-on rates are used: 0.6 and 1. Also note that yearly averages across the EU sample are simple averages. Weighing by consumption would bias the estimates as electricity consumption is a key variable in the formula above.

The estimates for indirect EU ETS costs for both BOF and EAF plant sites (as shown in Table 24) have decreased steadily between 2008 and 2013 as EUA prices decreased sharply up to 2013. For EAF under a pass-on rate of 0.6, for example, the costs decreased from €5.86 in 2008 to 1.12€ per tonne of output in 2013, whereas for BOF they decreased from €4.40 to €0.56 per tonne of output. Over 2014-2015 the estimates for indirect EU ETS costs increased again as EUA prices showed a slow and partial recovery. One can see that, for all years, the BOF indirect ETS costs are below the EAF indirect ETS costs as the electricity intensity per tonne of output is lower for BOF than for EAF.

Table 24. Estimates for indirect EU ETS costs for BOF and EAF plant sites, 2008-2015, two pass-on rates (€/t of product)

	2008	2010	2012	2013	2014	2015
Pass-on rate: 0.6						
BOF	4.40	1.76	0.90	0.56	0.69	1.55
EAF	5.86	3.47	1.85	1.12	1.45	1.86
Pass-on rate: 1						
BOF	7.34	2.94	1.50	0.93	1.16	2.58
EAF	9.77	5.78	3.08	1.86	2.42	3.09

Source: Authors' elaboration based on data from European Energy Exchange (2016) and European Commission (2012)

Estimates show that a share of the energy component could be linked to indirect EU ETS cost. In 2008 for EAF plant sites – assuming a pass- on rate of 1 – 41.9% of electricity costs could have been accounted for by EU ETS indirect costs. By 2013 this share had fallen to 7.0%, while by 2015 it had recovered to almost 14%. For BOF plant sites, the value is lower for all years.

Table 25 Share of indirect EU ETS costs in weighted average production costs (%) of BOF and EAF plant sites (pas-on rate of 1)

	2008	2010	2012	2013	2014	2015
BOF	2.6%	0.7%	0.4%	0.2%	0.3%	0.4%
EAF	2.6%	1.8%	0.9%	0.5%	0.8%	1.0%

Source: Authors' own elaboration.

A similar – but much lower trend – can be observed for the proportion of indirect EU ETS costs in production costs (Table 25). EU ETS indirect costs, as estimated above, accounted for 2.6% of production costs for both, BOF and EAF plant site, in 2008. This share dropped markedly to just over 0.2% (BOF) and 0.5% (EAF) in 2013. Since then, it has recovered somewhat and accounted for 0.4% and 1.0% of production costs in 2015 respectively.

These evolutions are primarily driven by the evolution of EUA prices, though changes in electricity intensity, electricity costs and production costs also played a minor role.

Note that these estimates are characterized by some limitations:

- In some countries steel producers are eligible for (partial) compensation of their indirect EU ETS costs based on performance benchmarks. The level of compensation differs for each country. Currently, iron and steel companies are eligible for ETS compensation in all the countries that are giving or intend to give compensation. The countries that have received clearance from the European Commission to give indirect ETS compensation are Germany, Netherlands, Belgium (Flanders only), UK, Norway, Spain, Greece, Slovakia and Lithuania. A few notes here:
    - Spain has only indicated to give compensation for 2014-2015. So far, there is no indication of compensation for the remaining period of Phase 3 of the EU ETS.
    - The research team has not been able to confirm that Greece is actually handing out compensation, despite Greece having adopted national legislation to enable this.

3.9 Energy intensity

Plant sites provided information about purchased and self-produced energy consumption, and production output. From this data, energy intensity of production processes could be calculated for each plant. Intensity is generally measured in terms of physical output, i.e. MWh consumed per tonne of output. As several energy carriers are used in the production process, separate energy intensities are calculated for each energy source (i.e. electricity, natural gas).

Due to the fact that responding plant sites are very heterogeneous in terms of their energy consumption profile – e.g. (1) EAF and BOF technologies have different energy profiles; (2) some plants do not use natural gas but oil or coal; (3) some plants substitute purchased natural gas with plant-specific waste gases –a robust energy intensity comparison within the sector as well as subsequent interpretations is neither appropriate nor meaningful.

Also, as plant sites produce multiple commodities at a time depending on their degree of vertical integration and produced products differ between survey participants[11], the energy intensity analysis aggregates all output commodities to a generic "tonne of output". This "tonne of output" is the denominator of the energy intensity calculation. While this will not give precise information on energy intensities, the research team still considers the approach as the only one that is applicable to a sample of this minor size and the availability of submitted data from the responding plant sites.

For the calculation of EU and regional weighted average energy intensities, the respective production output levels were used.

3.9.1 Natural gas

For the natural gas intensity analysis, it is important to note that the term "natural gas" is equal to the sum of purchased natural gas and self-produced waste gases used on-site (e.g. in a cogeneration plant), subtracted by the amount of self-produced waste gas sold to the grid or any third party.

Most steel-makers are large gas consumers. The 5 responding BOF plant sites – note that one of them effectively comprises 3 plant sites – consume between 400 MWh and 9.4 TWh of natural gas per year. Responding EAF plant sites consume between 14 MWh and 1.45 TWh of natural gas per year. From the 5 responding BOF plant sites, three indicated that they consume self-produced waste gases on-site, with roughly 80% of total gas consumption being derived from such self-produced waste gases.

As not all of the plant sites provided figures on natural gas consumption for all years – one plant did not consume any natural gas but oil instead, whereas others simply did not provide any figures on natural gas –, and as some plant sites did not deliver

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[11] Though noting that the research team asked plant sites to provide annual data on crude steel output levels, plant sites mostly provided data on other commodity outputs such as stainless steel, raw iron/steel powder, rebar and wire rod, hot metal etc. making the production outputs not per se comparable with each other.

data on production levels, the descriptive statistics on natural gas intensity are based on 11 to 18 responding plant sites depending on the year. Figure 31 and Table 26 display all results.

General trends

The natural gas intensity of production of the respondents shows a large spread of results, ranging from 0.09 MWh/t to 2.09 MWh/t in 2008 and even further from 0.08 MWh/t to 2.3 MWh/t in 2015. Regarding the median value, a slightly decreasing development can be noted. The value has risen from 0.38 MWh/t in 2008 to 0.41 MWh/t in 2010, whereas from 2010 onwards it has been continuously decreasing to 0.33 MWh/t in 2015.

The weighted averages of respondents range between 0.32 MWh/t and 0.86 MWh/t, which is much higher than the median for all years except for 2015. Note that for 2015 a number of higher natural gas intensive plant sites (in particular BOF plant sites from Central-Eastern Europe) did not provide data. When only including plants that provided data for all years, the slightly decreasing evolution is confirmed. Median values decreased from 0.32 MWh/t in 2008 to 0.31 MWh/t in 2015, while average values decreased from 0.35 MWh/t in 2008 to 0.32 MWh/t to 2015 (see Table 27).

The lowest values remained similar at a level of roughly 0.08 MWh/t to 0.10 MWh/t. The maximum values have been more volatile with a low in 2014 (1.89 MWh/t) and a peak in 2015 (2.38 MWh/t).

The inter-quartile range shows a fluctuating spread between 2008 and 2013 ranging between 0.7 and 0.9 MWh/t, and a decreasing spread between 2013 and 2015, as it goes down from 0.84 MWh/t in 2013 to 0.28 MWh/t in 2015 (i.e. a decrease of more than 65%).

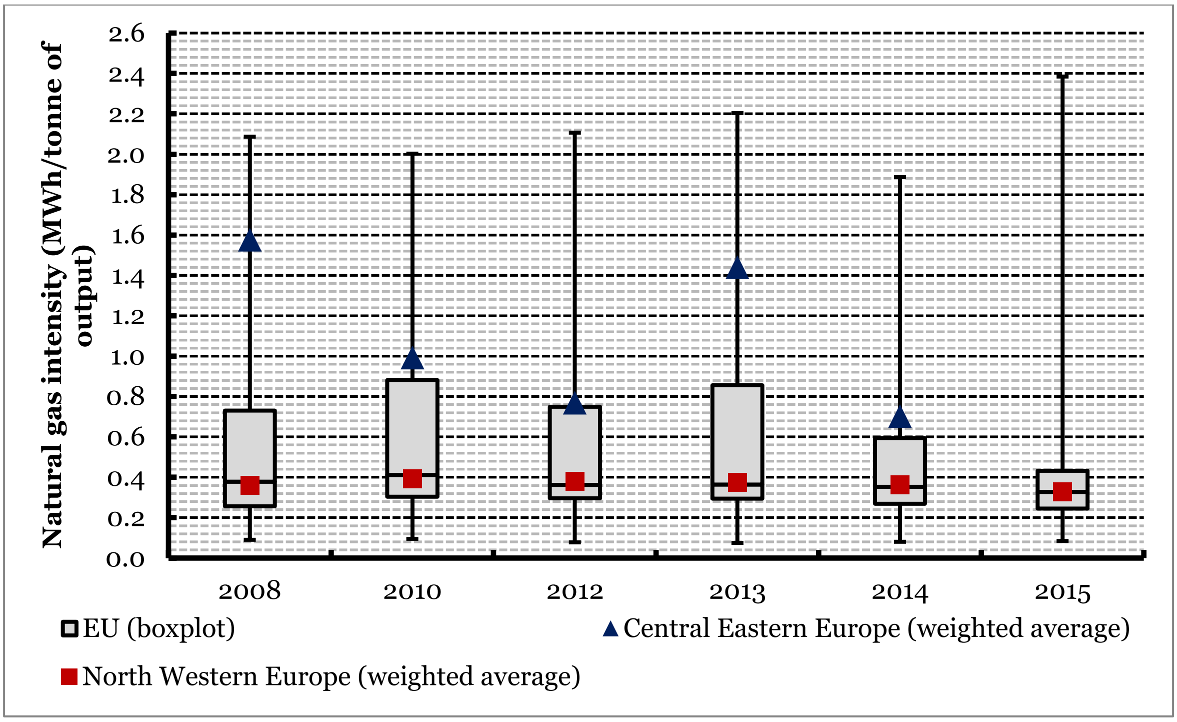
Regional differences

Weighted averages in North-Western Europe also show a slightly decreasing trend since 2010 – after a stable period with values of around 0.38 MWh/t for the years 2010 to 2013 –, decreasing to 0.36MWh/t in 2014 and 0.33 MWh/t in 2015. North-Western European steel plants showed values significantly lower than the EU weighted average of all responding plant sites. Responding plant sites from Central- Eastern European countries, in contrast, which often represent natural gas intensive BOF plant sites, clearly show a weighted average natural gas intensity significantly above the North-Western and overall European average value. This is caused by the relatively higher natural gas consumption of BOFs.

Technological differences

When comparing the natural gas intensity of BOFs with the natural gas intensity of EAFs one can clearly see that the intensity of BOFs over the entire study period is, at minimum (maximum), double (four-times) the size of EAFs intensity (e.g. in 2013, it was 1.59 MWh/t for BOF and 0.36 MWh/t for EAF). From 2008 to 2015, the natural gas intensity of EAFs seems to be fairly stable or even slightly decreasing, whereas the natural gas intensity of BOFs is highly volatile.

Figure 31. Natural gas intensity of steel plants in the EU (MWh/t of output)



Source: Authors' own elaboration.

Table 26. Descriptive statistics for natural gas intensity (MWh/t of output)

	2008	2010	2012	2013	2014	2015
Plant sites/total sample	11/22	14/22	18/22	18/22	18/22	15/22
EU (weighted average)	0.76	0.70	0.56	0.86	0.52	0.32
EU (median)	0.38	0.41	0.36	0.36	0.35	0.33
EU (relative standard deviation)	83.8%	80.7 %	81.8 %	67.0 %	89.1 %	192.3 %
EU (IQR)	0.71	0.87	0.68	0.84	0.49	0.28
EU (minimum)	0.09	0.10	0.08	0.08	0.08	0.08
EU (maximum)	2.09	2.00	2.11	2.20	1.89	2.38
CEE EU (weighted average)	1.58	0.99	0.77	1.44	0.70	--
SE EU (weighted average)	--	--	--	--	--	--
NWE EU (weighted average)	0.36	0.39	0.38	0.38	0.36	0.33
BOF (weighted average)	1.79	1.07	0.82	1.59	0.75	--
EAF (weighted average)	0.38	0.38	0.36	0.36	0.35	0.36

Source: Authors' own elaboration.

Table 27 Descriptive statistics when only using plants that provided data for all years for natural gas intensity (MWh/t of output)

	2008	2010	2012	2013	2014	2015
Plant sites/total sample	*8/22*	*8/22*	*8/22*	*8/22*	*8/22*	*8/22*
EU (weighted average)	*0.35*	*0.33*	*0.33*	*0.32*	*0.31*	*0.32*
EU (median)	*0.32*	*0.32*	*0.31*	*0.31*	*0.30*	*0.31*

Source: Authors' own elaboration.

3.9.2 Electricity

For the analysis on electricity intensity, it is important to note that both purchased as well as self-produced electricity is taken into account when calculating the electricity intensity of the steel plant sites[12].

Most steel-makers are large electricity consumers. The 5 BOF respondents – note that one of them effectively comprises 3 plant sites – consume between 600 MWh and 2.0 TWh of electricity per year. All 5 BOF plant sites make use of self-produced electricity. On average, roughly 30% to 33% of electricity comes from such self-production. Responding EAF plant sites, in comparison, consume between 30 MWh and 1.4 TWh of electricity per year. None of the EAF plant sites produces electricity on-site.

As some plant sites did not deliver data on production levels and/or purchased electricity for all the respective years, the descriptive statistics on electricity intensity are based on 13 to 20 instead of the total of 22 responding plant sites. Figure 32 and Table 28 display all results.

General trends

The division of electricity consumption by tonnes of output shows a large range of results, spreading from 0.10 MWh/t to 1.00 MWh/t in 2008 (smallest spread) and even further from 0.12 MWh/t to 1.19 MWh/t in 2015 (largest spread). There is no clear development of median values. They seem to be fluctuating around 0.53 MWh/t, except from 2010, where half of the respondents showed an electricity intensity of 0.42 MWh/t or lower, the lowest value over all years. In 2015, in contrast, the median was highest at a value of 0.56/MWh/t.

Overall, weighted averages are considerably lower than median values for all years (roughly 0.1 to 0.2 MWh/t). When analysing ‘consistent values’, both, median and weighted average values, are of a similar magnitude, at roughly 0.41 to 0.45 MWh/t, still no clear development over time can be identified.

The minimum values increased slightly from 0.1 MWh/t in 2008 to 0.12/MWh/t in 2015. The maximum values have been increasing constantly from 1 to 1.19 MWh/t, with a small decrease in 2014, when the maximum electricity intensity was 1.06 MWh/t.

The inter-quartile range was highest in 2008 (0.56 MWh/t), it was stable ranging between 0.39 MWh/t and 0.46 MWh/t from 2010 to 2014 and it was lowest in 2015 at 0.32 MWh/t. Overall, from 2008 to 2015, while the spread of electricity intensities in the EU was increasing, the inter-quartile range was decreasing.

Regional differences

Weighted averages in North-Western Europe do not show a clear trend. Figures range between 0.44 and 0.47 MWh/t. In general, responding North-Western European steel

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[12] Please note that a minor downside of this approach is that double counting between natural gas and electricity consumption may (to some extent) occur as self-produced electricity is mostly produced from purchased natural gas and on-site produced waste gases, both being also accounted for under natural gas intensity.

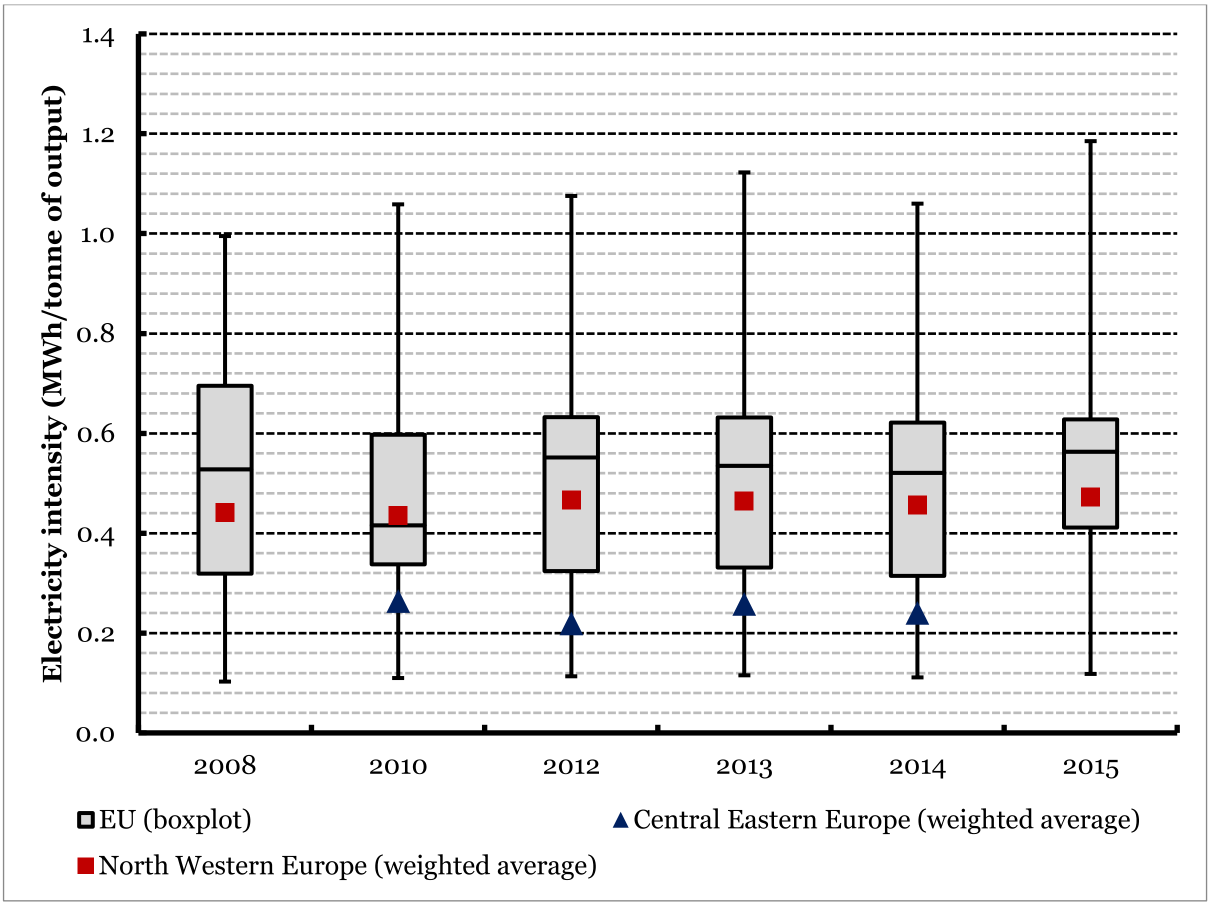
plant sites showed values higher than the EU weighted average of all responding plant sites.

On the other hand, responding plant sites from Central-Eastern European countries - often natural gas intensive BOF plant sites and not electricity-intensive EAFs - clearly show a weighted average electricity intensity significantly below the North-Western and overall European average value. This is caused by the relatively higher electricity intensity of EAFs, which, in the case of this study sample, are mostly situated in North-Western Europe.

Technological differences

When comparing the electricity intensity of EAFs with the electricity intensity of BOFs, one can clearly see that the intensity of EAFs over the entire study period is roughly 20 to 60% higher than the intensity of BOFs (e.g. in 2012, it was 0.42 MWh/t for EAF and 0.27 MWh/t for BOF). From 2008 to 2015, both, the electricity intensity of EAFs and BOFs, seem to be fairly stable.

Figure 32. Electricity intensity of steel plants in the EU (MWh/t of output)



Source: Authors' own elaboration.

Table 28. Descriptive statistics for electricity intensity (MWh/t of output)

	2008	2010	2012	2013	2014	2015
Plant sites/total sample	13/22	16/22	20/22	20/22	20/22	16/22
EU (weighted average)	0.44	0.35	0.35	0.37	0.35	0.45
EU (median)	0.53	0.42	0.55	0.54	0.52	0.56
EU (relative standard deviation)	61.0%	71.4%	67.7%	64.0%	66.0%	56.6%
EU (IQR)	0.56	0.39	0.46	0.45	0.46	0.32
EU (minimum)	0.10	0.11	0.11	0.12	0.11	0.12
EU (maximum)	1.00	1.06	1.08	1.12	1.06	1.19
CEE EU (weighted average)	--	0.26	0.22	0.26	0.24	--
SE EU (weighted average)	--	--	--	--	--	--
NWE EU (weighted average)	0.44	0.44	0.47	0.46	0.46	0.47
BOF (weighted average)	--	0.32	0.27	0.31	0.28	--
EAF (weighted average)	0.40	0.39	0.42	0.43	0.42	0.42

Source: Authors' own elaboration.

3.10 International comparison

For the international comparison of energy prices and production costs, the research team took a twofold approach. First, study participants were asked to provide data on some of their plant sites from outside the EU. Two European steel companies were willing to provide data of their international plant sites and filled out a questionnaire that was explicitly designed for non-EU steel plant sites. Additional evidence on energy costs and consumption was gathered from one plant site in India and two plant sites in the United States.

Secondly, as the sample of international plant sites is fairly low, the research team decided to acquire data on electricity and natural gas prices from a third party data source[13] that continuously collects this data on plant-level and feeds it into a global steel cost model. The countries in the database have been selected based on their global crude steel production share and their trade volumes with the EU (see Figure 21). The ten countries with the highest shares can be assumed to be the most important competitor countries of Europe. Table 29 shows the competitor countries with the highest global production volumes. It also shows for which of these countries data was acquired from the third party.

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[13] The third party is CRU, an independent consultancy in the field of mining, metals and fertilizers.

Table 29. Steel production competitor countries of the EU

Ranking	Country	Production (kt)	Third party data acquired
1	China	803,830	x
2	Japan	105,152	x
3	India	89,582	x
4	United States	78,916	x
5	Russia	71,114	x
6	South Korea	69,673	x
7	Brazil	33,245	x
8	Turkey	31,517	x
9	Ukraine	22,933	
10	Taiwan, China	21,482	
11	Mexico	18,261	
12	Iran	16,110	
13	Canada	12,453	x
14	South Africa	7,614	x
15	Saudi Arabia	5,662	
16	Egypt	5,506	
17	Argentina	5,028	
18	Australia	4,925	x

Source: World Steel, 2015

3.10.1 Natural gas prices

Figure 33 shows the weighted average natural gas prices of responding EU steel plants and compares it to the natural gas prices paid by steel plants in major competing countries from 2010 to 2015, as reported by CRU. In contrast to the third party data, natural gas price data in 2011 is missing for the EU as this year was not asked for in the questionnaires. In 2010, the lowest natural gas prices were observed in India and Russia with 4.05 €/MWh and 5.58 €/MWh respectively. On the other hand, Japan (35.29 €/MWh), South Korea (27.54 €/MWh) and the EU (26.89 €/MWh) accounted for the highest natural gas prices in 2010. The EU was closely followed by China (26.76 €/MWh), whereas the United States (12.99 €/MWh) and Australia (10.06 €/MWh) observed much lower natural gas price levels.

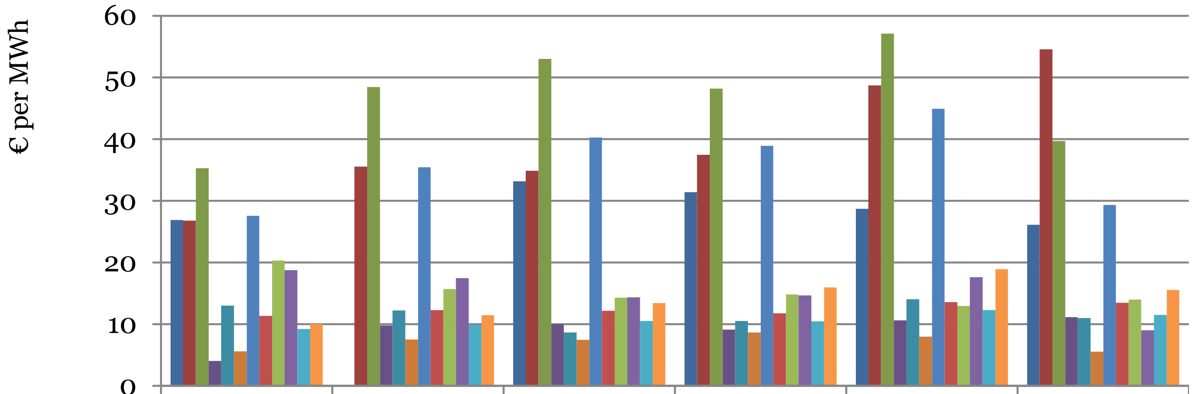
The figures for 2015 are pretty similar to those in 2010, except for China, where prices increased significantly (54.59 €/MWh), resulting in the highest price level for 2015. Japan with the second highest price also saw an increase of natural gas prices to 39.70 €/MWh. Russia with 5.55 €/MWh and Canada with 9.00 €/MWh respectively represent the lowest natural gas price countries in 2015. EU prices reduced slightly to a level of 26.11 €/MWh, accounting for the fourth highest natural gas price level. The United States (10.97 €/MWh), Turkey (13.97 €/MWh) and Canada (9.00 €/MWh) faced a significant price decrease.

Figure 34 shows the indexed natural gas price development in all regions. One can see that especially prices in Canada (52%), Turkey (31%) and the United States (16%) decreased from 2010 to 2015, whereas the prices in India (175%) and China (104%) increased significantly. The natural gas price for EU respondents decreased by 3%.

Natural gas price data from the third party data provider for the United States shows the same absolute level and trend in price reductions than the collected data for one of the surveyed steel plants in the United States. For the other surveyed plant site in the United States, the relative trend is also similar but the absolute level is roughly 40 % higher than the obtained third party data. This discrepancy might result from the small size of this particular plant site in terms of capacity.

In the case of the Indian plant site, there is a very large discrepancy between the third party data and the collected evidence, with the reported gas prices for 2010 and 2015 being 11 to 4 times higher respectively. Three factors explain this difference: 1) the Indian plant site is not purchasing natural gas but liquefied petroleum gas (being more expensive than natural gas), 2) it has a small capacity and 3) a remote location in India, a country wherein prices differentiate significantly.

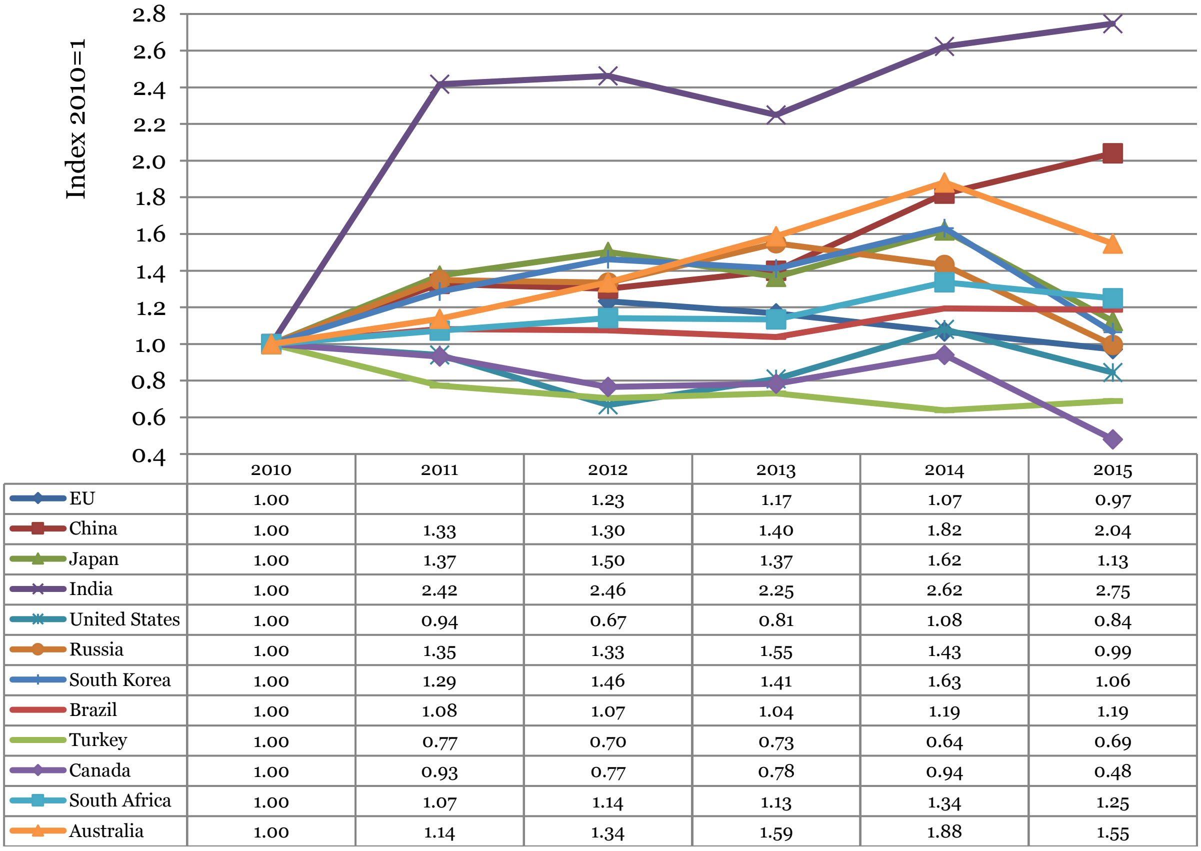
Figure 33. Prices of natural gas - EU vs. international (€/MWh) 2010 -15



	2010	2011	2012	2013	2014	2015
■ EU	26.89		33.16	31.38	28.71	26.11
■ China	26.76	35.54	34.85	37.47	48.71	54.59
■ Japan	35.29	48.44	53.00	48.21	57.12	39.70
■ India	4.05	9.79	9.97	9.11	10.62	11.12
■ United States	12.99	12.21	8.67	10.51	14.02	10.97
■ Russia	5.58	7.52	7.44	8.64	7.98	5.54
■ South Korea	27.55	35.44	40.27	38.91	44.95	29.33
■ Brazil	11.35	12.28	12.19	11.78	13.56	13.46
■ Turkey	20.29	15.67	14.30	14.84	12.95	13.97
■ Canada	18.73	17.47	14.34	14.67	17.62	9.00
■ South Africa	9.20	9.88	10.51	10.44	12.30	11.50
■ Australia	10.06	11.44	13.44	15.98	18.93	15.56

Source: Authors' own elaboration based on CRU (2015).

Figure 34 Indexed prices of natural gas - EU vs. international 2010 -15 (2010=1)



	2010	2011	2012	2013	2014	2015
EU	1.00		1.23	1.17	1.07	0.97
China	1.00	1.33	1.30	1.40	1.82	2.04
Japan	1.00	1.37	1.50	1.37	1.62	1.13
India	1.00	2.42	2.46	2.25	2.62	2.75
United States	1.00	0.94	0.67	0.81	1.08	0.84
Russia	1.00	1.35	1.33	1.55	1.43	0.99
South Korea	1.00	1.29	1.46	1.41	1.63	1.06
Brazil	1.00	1.08	1.07	1.04	1.19	1.19
Turkey	1.00	0.77	0.70	0.73	0.64	0.69
Canada	1.00	0.93	0.77	0.78	0.94	0.48
South Africa	1.00	1.07	1.14	1.13	1.34	1.25
Australia	1.00	1.14	1.34	1.59	1.88	1.55

Source: Authors' own elaboration based on CRU (2015).

3.10.2 Electricity prices

Figure 35 shows the weighted average electricity prices of the responding EU steel plants, and compares them to the electricity prices paid by steel plants in major competing countries from 2010 to 2015. It is important to note that, in contrast to the third party data, electricity price data in 2011 is missing for the EU as this year was not asked for in the questionnaires.

For 2010, Turkey and Japan represent the highest electricity price countries with 92.62 €/MWh and 82.06 €/MWh respectively. South Africa and Russia, in contrast, accounted for the lowest electricity prices in 2010, with 33.45 €/MWh and 34.19 €/MWh respectively. The EU with 60.21 €/MWh had a medium levelled electricity price, lower than China (65.19 €/MWh) but, at the same time, higher than the United States (43.70 €/MWh), India (44.69 €/MWh) and South Korea (49.26 €/MWh).

By 2015, for some countries, the figures changed significantly. Japan shows a significant price increase and is now the highest priced country, with a price of 124.54 €/MWh. China takes second place, having faced a significant price increase up to 90.39 €/MWh.

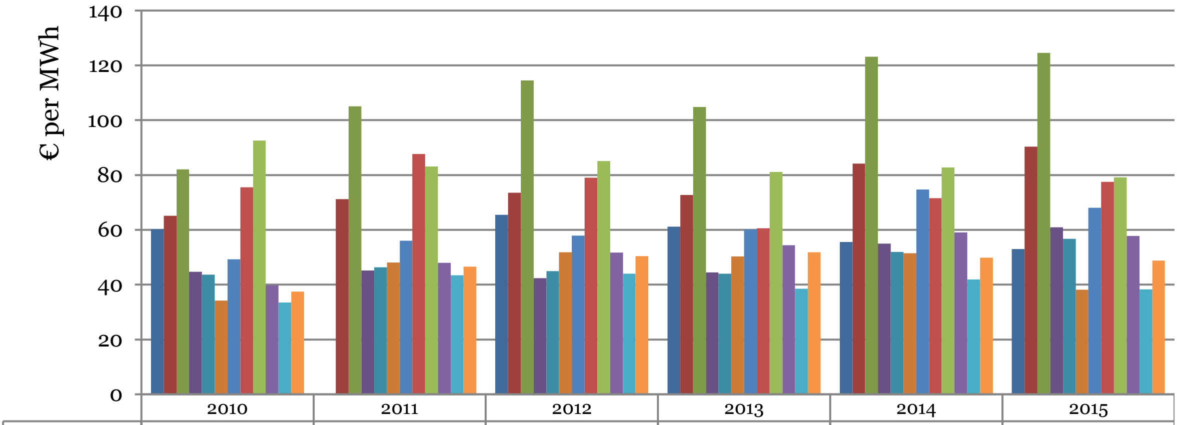
In 2015, South Africa and Russia remained the countries with the lowest electricity prices, with only moderate price increases to 38.26 €/MWh and 38.14 €/MWh respectively. In 2015, the EU saw a substantial decrease of its prices, becoming the region with the fourth lowest electricity price at 53.03 €/MWh. Only Australia, South Africa and Russia had a lower price level. At the same time, the United States (56.77 €/MWh), India (60.93 €/MWh) and South Korea (68.04 €/MWh) faced a significant price increase.

Figure 36 shows the indexed electricity price developments in all the countries. One can see that between 2010 and 2015, the prices in the EU and Turkey decreased the most (by 12% and 15% respectively), whereas the prices in Japan (51.8%), Canada (45.1%) and China (38.7%) increased most significantly over this period.

The electricity price data from the third party for the United States shows a similar absolute level and trend in price increases than the collected data for one of the surveyed steel plants in the United States. In contrary, the prices collected from another plant site indicate that electricity prices in the United States are significantly lower, by an order of 13 to 20 €/MWh, than the obtained third party data. Due to substantial electricity price differences within the United States, this deviation might simply be due to the low coverage of US steel plants, with only 2 plants included.

In the case of India, there seems to be a very large discrepancy between the third party data and reported evidence as the reported electricity price for 2010 and 2015 was much higher with 87.25 €/MWh (i.e. 95% higher) and 99.48 €/MWh (i.e. 63% higher) respectively. It is important to note that this discrepancy seems to be caused by the small size of the plant site in terms of capacity as well as its remote location within India, where prices differentiate significantly throughout the state.

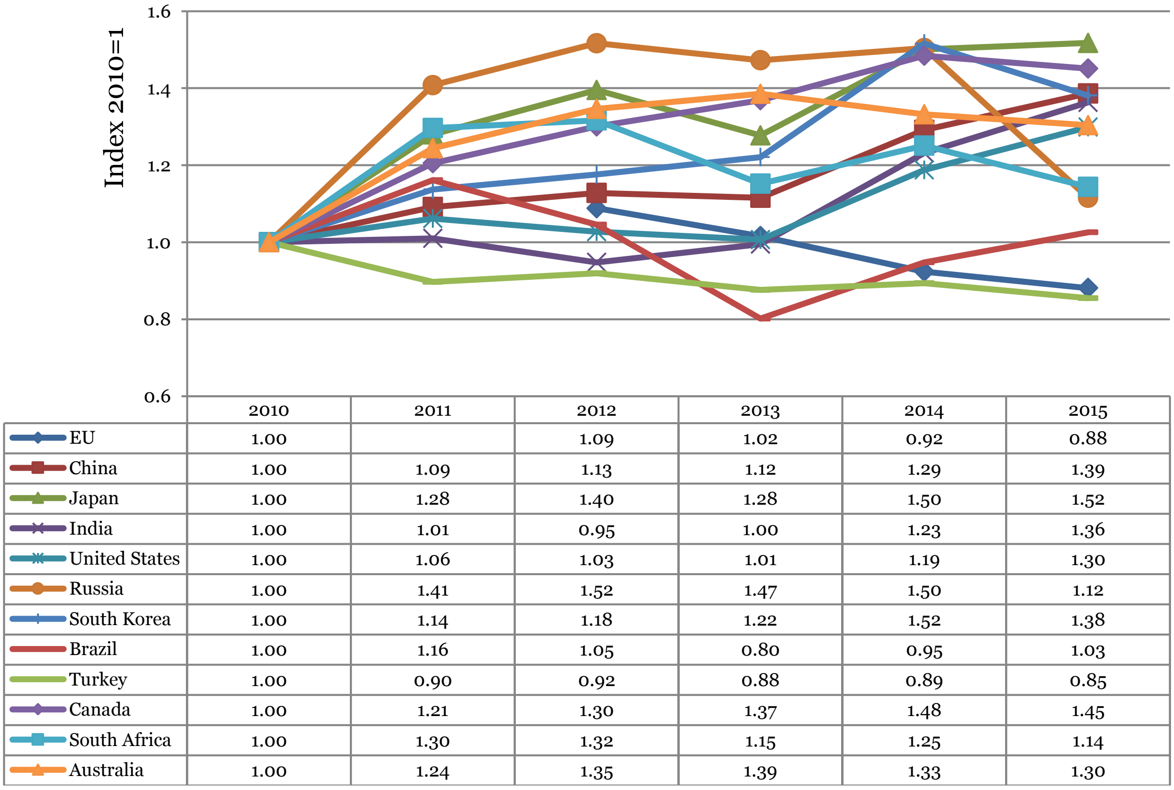
Figure 35. Prices of electricity - EU vs. international (€/MWh) 2010 -15



	2010	2011	2012	2013	2014	2015
■ EU	60.21		65.53	61.18	55.59	53.03
■ China	65.19	71.17	73.54	72.70	84.20	90.39
■ Japan	82.06	105.01	114.48	104.83	123.13	124.55
■ India	44.69	45.14	42.35	44.47	55.03	60.93
■ United States	43.70	46.40	44.90	44.00	51.90	56.77
■ Russia	34.19	48.13	51.87	50.35	51.43	38.14
■ South Korea	49.26	56.02	57.94	60.15	74.69	68.04
■ Brazil	75.52	87.71	78.99	60.55	71.56	77.49
■ Turkey	92.62	83.09	85.13	81.15	82.77	79.17
■ Canada	39.78	47.95	51.73	54.44	59.05	57.73
■ South Africa	33.45	43.38	44.04	38.53	41.86	38.26
■ Australia	37.44	46.57	50.40	51.87	49.87	48.83

Source: Authors' own elaboration based on CRU (2015).

Figure 36. Indexed prices of electricity - EU vs. international 2010 -15



	2010	2011	2012	2013	2014	2015
EU	1.00		1.09	1.02	0.92	0.88
China	1.00	1.09	1.13	1.12	1.29	1.39
Japan	1.00	1.28	1.40	1.28	1.50	1.52
India	1.00	1.01	0.95	1.00	1.23	1.36
United States	1.00	1.06	1.03	1.01	1.19	1.30
Russia	1.00	1.41	1.52	1.47	1.50	1.12
South Korea	1.00	1.14	1.18	1.22	1.52	1.38
Brazil	1.00	1.16	1.05	0.80	0.95	1.03
Turkey	1.00	0.90	0.92	0.88	0.89	0.85
Canada	1.00	1.21	1.30	1.37	1.48	1.45
South Africa	1.00	1.30	1.32	1.15	1.25	1.14
Australia	1.00	1.24	1.35	1.39	1.33	1.30

Source: Authors' own elaboration based on CRU (2015).

3.11 Key performance indicators and impact of energy costs

This section includes the information retrieved from sampled companies concerning Key Performance Indicators (KPI) – production costs, margins, and turnover. The purpose of retrieving and processing these data is not to provide a financial analysis of responding plants, but to analyse the impact of energy costs – for both gas and electricity – over financial indicators, namely production costs and margins.

Many plant sites did not provide data on key performance indicators (exact numbers are listed in the tables and graphs below). Assigning economic data to the plant while it is gathered at the company level and data confidentiality seem to be the major obstacles for the respondents to provide this information.

Some plant sites only reported information on some indicators and years respectively. For this reason, the data representativeness associated with the following analysis on production costs and margins is considered to be of low to medium level. A differentiation between regions and technologies (BOF vs. EAF) is not provided in the subsequent analysis as the number of plant sites for which key performance indicators can be calculated, is too low to avoid confidentiality issues. This is, in particular, the case for Southern European and Central-Eastern European as well as BOF plant sites.

Table 30 shows an overview of the averages for different key performance indicators of all respondents that reported the required data. For each of the indicators, the number of questionnaires used to derive the respective value is mentioned in between brackets in the table.

Table 30. Production costs, Turnover, EBITDA and EBIT, 2008-2015, number of plants in between brackets

	2008	2010	2012	2013	2014	2015
Production costs (€/t)	331.18 (13)	355.05 (14)	388.22 (15)	376.38 (15)	340.83 (15)	379.51 (11)
Turnover (€/t)	448.08 (14)	422.02 (15)	397.50 (15)	388.76 (15)	362.67 (15)	407.61 (11)
EBITDA (% of turnover)	15.61% (17)	6.98% (17)	3.08% (18)	4.63% (18)	5.82% (18)	5.32% (18)
EBIT (% of turnover)	12.76% (17)	2.46% (17)	-1.28% (17)	0.10% (17)	1.50% (17)	1.16% (17)

Source: Authors' own elaboration.

Table 31. Production costs and Turnover when only including plants that provided data for all years, 2008-2015, number of plants in between brackets

	2008	2010	2012	2013	2014	2015
Production costs (€/t)	370.31 (9)	300.43 (9)	335.95 (9)	319.02 (9)	298.54 (9)	278.45 (9)
Turnover (€/t)	545.59 (10)	425.42 (10)	443.18 (10)	406.89 (10)	399.59 (10)	384.16 (10)

Source: Authors' own elaboration.

The production costs were calculated based on 11 to 15 responding plant sites. Across all years the production costs per tonne of output ranged between 331 €/t and 389 €/t. In particular, from 2008 to 2015, the production costs increased from 331.18 €/t in 2008 to 379.51 €/t, with a peak in 2012 at 388.22 €/t. From 2012 to 2014, the production costs declined sharply again to a level of 340.83 €/t and then increased to the final level of 379.51 €/t in 2015, a value similar to that observed for 2013. When only including plants that provided data for all years, a smoother decrease in production costs from 370€/t in 2008 to 278€/t in 2015 – with an increase from 2010 to 2012 – can be observed, corresponding to a relative decrease over all years of almost 25% (see Table 31). In general, one can note that production costs started to decrease after 2012.

The average turnover per tonne of output ranged between 362 €/t (2014) and 448 €/t (2008) over the entire study period. It decreased from 2008 (448.08 €/t) to 2014 (362.67 €/t) while, in 2015, it increased again above 2012 values to 407.61 €/t. Similar to the production costs, it is important to note that the increase from 2014 to 2015 is caused by the four steel plant sites that fall out of the analysis for the year 2015. When analysing only the plants that provided data for all years, a continuous and much smoother decrease in turnover from 545€/t in 2008 to 384€/t in 2015 can be observed, corresponding to a relative decrease of almost 30% (see Table 31).

For all years, the turnover per tonne of output (this includes all available plant sites) is higher than the production costs per tonne of output. In contrast to the year 2008 and 2010, however, the spread (i.e. margin) between the turnover and the production costs for 2012 and 2013 was at its lowest level with roughly 9 €/t to 13 €/t. Since 2014, the spread seems to be slowly increasing again.

The share of EBITDA and EBIT in turnover (expressed in %) was used to further analyse the profits and profit developments of the steel sector over the period from 2008 to 2015. The share of EBITDA and EBIT in turnover both had its high in 2008 with 15.61% and 12.76% respectively. Since then both shares decreased sharply, reaching a minimum in 2012, where the EBITDA share was 3.08% and the EBIT share was negative, with -1.28%.

Since 2013, both key performance indicators seem to be slowly recovering, while still remaining much lower (5.32% EBITDA share and 1.16% EBIT share in 2015) than the boom year 2008.

Table 32 shows the share of electricity and natural gas costs in production costs from 2008 to 2015, weighted by individual plant production levels.

Regarding the share of electricity costs in production costs no clear trend can be identified. The share nearly continuously decreased from 2008 to 2014, but in 2015 it increased significantly again.

In contrast to the production costs and turnover analysis before, the electricity cost shares do not become smoother but more volatile – though a slight decreasing trend can be observed – when excluding the four steel plant sites that fall out of the sample in 2015 for the entire analysis. The share ranged between 4.9% (2014) and 6.8% (2008) throughout all the years of observation. The value was highest in 2008 with 6.8% and decreased to 4.9% in 2014, the lowest value of all years. In 2015, the value was back at a level of 6.5%.

The share of natural gas costs in production costs, in comparison, was considerably lower than the share of electricity costs in production costs for all years and it shows a decreasing trend from 2010 to 2015. This is also confirmed when only including plants that provided data for all years, noting that in that case, the decrease started in 2012 and not in 2010. It ranged between 2.5% and 3.6%, with the maximum share in 2010 and the minimum share in 2015. The share increased from 3.0% in 2008 to 3.6% in 2010 and then continuously decreased until 2015, to a natural gas cost share in production costs of 2.5%.

Table 32. Impact of electricity and natural gas costs on production costs (%), 2008-2015. Weighted averages from respondents, based on individual plant production. Number of plant sites between brackets.

	2008	2010	2012	2013	2014	2015
Electricity EU average	6.8% (7)	5.5% (10)	5.3% (15)	5.5% (15)	4.9% (15)	6.5% (11)
Natural gas EU average	3.0% (8)	3.6% (9)	3.4% (13)	3.4% (13)	3.4% (13)	2.5% (10)

Source: Authors' own elaboration

Table 33 shows the share of electricity and natural gas costs in EBITDA from 2008 to 2015, weighted by individual plant production levels. In general, the share was highly volatile, meaning that no clear trend was identified over time. In comparison to the 2008 -12 period however, the volatility seems to be decreasing after 2012.

In 2008, the share of electricity costs in EBITDA as well as the share of natural gas costs in EBITDA were lowest with 44.2% and 25.6% respectively. 2010, in contrast, marks the year with the highest respective shares (419.2% for the electricity cost and

197.7% for the natural gas cost share), caused by the low EBITDA during this year. When only including plants that provided data for all years, no clear trend can be identified as well.

Table 33. Impact of electricity and natural gas costs on EBITDA (%), 2008-2015. Weighted averages from respondents, based on individual plant production.

	2008	2010	2012	2013	2014	2015
Electricity						
EU average	44.2% (7)	419.2% (9)	187.3% (12)	236.6% (15)	107.9% (15)	233.1% (10)
Natural gas						
EU average	25.6% (7)	197.7% (7)	66.3% (12)	138.7% (12)	81.3% (12)	92.9% (9)

Source: Authors' own elaboration

Table 34 shows the share of regulated electricity and natural gas costs in EBITDA from 2008 to 2015, weighted by individual plant production levels. The share of regulated electricity costs in EBITDA shows a clearly increasing trend from 2008 to 2015, with some fluctuations during the study period. This is also the case when only analysing plants that provided data for all years. For 2012 to 2015, one can see that the share increased from 13.9% in 2012 to 35.4% in 2015.

For the share of regulated natural gas costs in EBITDA from 2012 to 2015, an increase – less pronounced than the increase in the share of regulated electricity costs though – can be identified. In 2012, the share was 3.2%, whereas in 2015 it was 6.8%.

Table 34. Impact of regulated electricity and natural gas costs on EBITDA (%), 2008-2015. Weighted averages from respondents, based on individual plant production. Numbers of plants in between brackets.

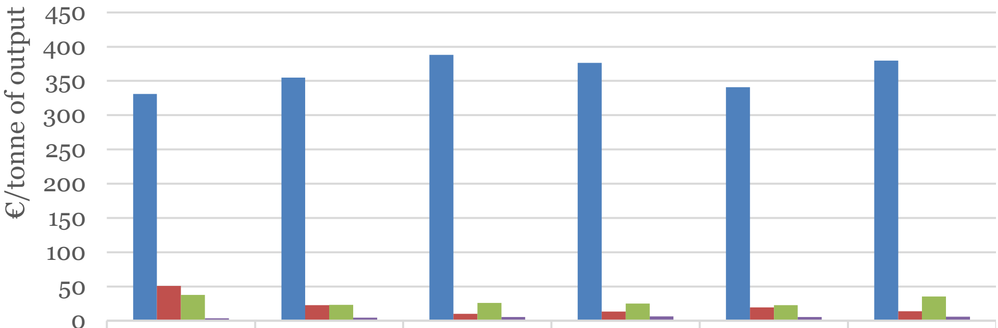
	2008	2010	2012	2013	2014	2015
Electricity						
EU average	3.9% (4)	21.5% (5)	13.9% (9)	27.6% (10)	16.4% (10)	35.4% (9)
Natural gas						
EU average	0.6% (3)	2.4% (4)	3.2% (9)	9.8% (9)	6.2% (9)	6.8% (9)

Source: Authors' own elaboration

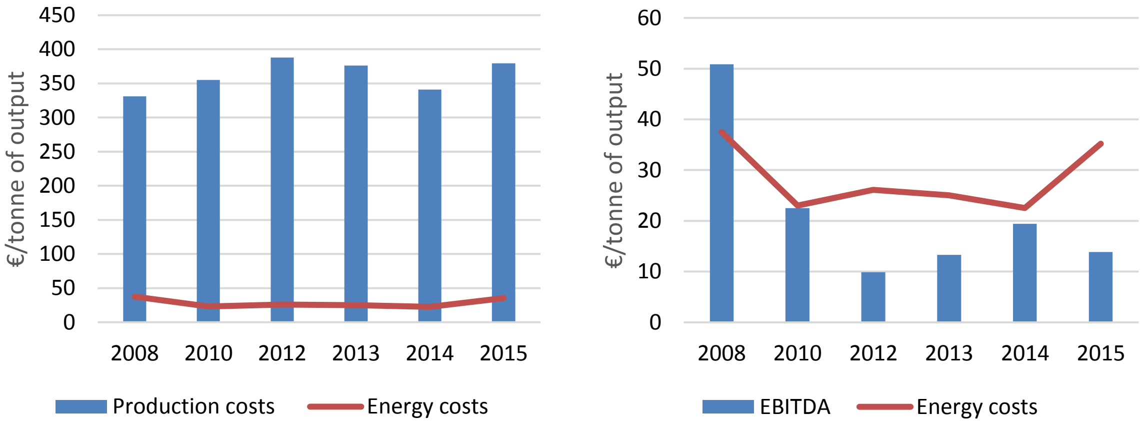
Figure 37 shows the production costs, EBITDA, energy costs and regulated energy costs per tonne of output from 2008 to 2015. One can see that from 2008 to 2015 the EBITDA per tonne of output decreased from 50.87 €/t to 13.84€/t (73%), whereas the regulated energy costs per tonne of output increased from 3.54 €/t to 5.95 €/t (68%). The production costs and energy costs per tonne of output, in contrast, do not show a clear trend.

For responding plants, energy costs represented between 2% and 36% of production costs in the period under analysis. The EU weighted average varied between 8% and 10%. When compared to EBITDA, one can see that total energy costs became larger than plants' margins in 2012 and remained higher since then.

Figure 37. Energy costs vs. production costs vs. EBITDA (euro/tonne of output)



	2008	2010	2012	2013	2014	2015
🟦 Production costs	331.18	355.05	388.22	376.38	340.83	379.51
🟥 EBITDA	50.87	22.52	9.91	13.28	19.40	13.84
🟩 Energy costs	37.49	23.03	26.12	25.04	22.53	35.22
🟪 Regulated energy costs	3.54	4.32	5.54	6.43	5.40	5.95



Source: Authors' own elaboration

3.12 Concluding remarks

This case study reveals valuable insights into the energy costs and energy consumption profile of the European steel industry. 5 BOF and 17 EAF plant sites[14] covering 13.6% and 11.4% of the respective European steel production capacity participated in the survey. North-Western European steel plants are slightly overrepresented. The analysis does not cover any BOF and only 3.5% of EAF production capacity in Southern Europe.

The data from respondents shows that natural gas prices fell between 2012 and 2015, with a median value of 33.16 €/MWh in 2012 and 27.47 €/MWh in 2015,

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[14] It is important to note that 1 of the responding BOF plant sites comprises 3 BOF plant sites and that 1 out of the responding EAF plant sites comprises 2 EAF plant sites, bringing the number of respondents, in fact, up to 7 BOF plant sites and 18 EAF plant sites.

corresponding to a decrease of 17.1%. From 2008 to 2015, the respective decrease was lower at 6.7%. The natural gas supply costs were falling since 2012, reducing the share in total natural gas costs from 93.4% in 2012 to 91.4% in 2015. Network costs remained fairly stable and other taxes, fees, levies and charges continuously, but moderately, increased.

Median electricity prices were decreasing even more strongly by 14.2% between 2012 and 2015. After a peak at 62.82 €/MWh in 2012, prices reduced to 53.87 €/MWh by 2015, a value much lower than the price in 2008 (57.30 €/MWh). From 2008 to 2015, the respective decrease was less significant with nearly 6.0%. Responding steel plant sites from North-Western Europe faced lower prices than those from Central Europe for all years. It is worth noting that energy supply costs fell significantly since 2012, that taxes, fees, levies and charges continuously increased since 2008 and that RES payments increased up to 2013 and then decreased again. By 2015, electricity supply costs made up 78.2%, being much lower than its initial share in 2008 (86.0%).

When comparing BOF and EAF steel production routes in terms of energy intensity, two major conclusions can be drawn.

1. Average natural gas intensity of BOF plant sites is between double to four-times the size of the intensity of EAF plant sites (e.g. in 2013, it was 1.59 MWh/t for BOF and 0.36 MWh/t for EAF).
2. On the other hand, electricity intensity of EAFs (0.42 MWh/t in 2012) is roughly 20% to 60% higher than the intensity of BOFs (0.27 MWh/t in 2012).

From 2008 to 2015, the natural gas intensity of EAFs seems to be fairly stable or even slightly decreasing, whereas the natural gas intensity of BOFs is highly volatile. At the same time, both, the electricity intensity of EAFs and BOFs, seem to remain fairly stable.

The analysis of plant sites' key performance indicators shows that that the turnover per tonne of output is continuously decreasing over the study period, whereas the production costs started to decrease only after 2012 and at a lower rate than the turnover.

This led to lower profit shares in total turnover. The share of EBITDA in turnover was highest in 2008 and lowest in 2012. Since 2013, the EBITDA seems to be slowly recovering, while remaining much below 2008 levels.

No clear trend can be identified for the electricity cost share in production costs, however, it seems to be rather decreasing than increasing. The share of natural gas costs in production costs, in comparison, was considerably lower than the share of electricity costs in production costs for all years and it shows a clearly decreasing trend from 2010 to 2015.

The share of regulated electricity costs in EBTIDA shows a fluctuating but increasing trend from 2008 to 2015. From 2012 to 2015, the absolute regulated energy costs per tonne of output, which accounts for electricity and natural gas costs, increased by roughly 7% to 5.95 €/t.

From the analysis of the key performance indicators, one can see that if energy prices returned to their values from 2012, without having higher steel prices and thus higher turnover, European steel plant sites might face severe competitive issues.

The comparison of international natural gas prices with EU prices reveals that, in 2015, the EU faced the fourth highest natural gas price. Prices decreased much less significantly from 2010 to 2015 than those in the United States. EU prices reduced slightly by 3% to 26.11 €/MWh, whereas prices in the United States decreased by 16%. China, in contrast, had a significant price increase, making it the highest priced country in 2015.

From 2010 to 2015, electricity prices in the EU, in contrast, decreased much more significantly than those in almost any other country. They decreased by 12 % to a level of 53.03 €/MWh, becoming the region with the fourth lowest electricity price level. The United States and China, in contrast, faced increasing electricity prices during the same time period.

4 *Sector study: Aluminium*

Highlights

- ***Sample.* The research team worked with two samples: (1) primary smelters, and (2) recyclers and downstream producers**. For primary aluminium 14 plants delivered questionnaires, covering over 93% of EU capacity. However, two questionnaires are very incomplete and were only included in selected parts of the analysis. The 12 more complete questionnaires account for 82% of EU capacity. The downstream sample contains 18 plants: 6 rolling mills, 8 extruders (two of which are integrated with remelting operations), 1 refiner and 3 remelters.

- ***Energy price trends.* The EU average of electricity prices for sampled primary aluminium producers (weighted by consumption) amounts to 40.08 €/MWh in 2015.** This weighted average increased from 35.77 €/MWh in 2008 to 44.52 €/MWh in 2012, and has since decreased. However, in 2015 average electricity prices were still 12% higher than in 2008.
- **The EU median of electricity prices for sampled recyclers and downstream aluminium producers was 104.1 €/MWh in 2015.** However, the average (weighted by consumption) amounts to 62.8 €/MWh in that same year. A small number of large plants with high electricity consumption paid significantly less, which skews the weighted averages downwards. Median electricity prices for the sample increased by 29% between 2008 and 2013, and stayed relatively stable since. The median electricity prices of the sampled recyclers and downstream producers was 32% higher in 2015 when compared to 2008. The weighted averages show the same trend as those for sampled primary smelters: increasing average electricity prices between 2008 and 2012, with a subsequent decrease to 2015.
- **The split of electricity price components for primary smelters shows that the regulated price components play a limited role.** The energy component accounted for nearly 90% for the entire 2012-2015 period. Renewable energy support accounted for 4.7% in 2015 (from 5.2% in 2012). Network costs increased significantly from 3.4% in 2012 to 6.5% in 2015.
- **For recyclers and downstream producers, the regulated components are more relevant, and accounted for 31.3% in 2015**. This share has increased substantially from 14.3% in 2008. Network costs increased from 9.7% in 2008 to 15.7% in 2015, the share of renewable support measures in electricity prices increased from 3.2% in 2008 to 10.6% in 2015. Please note that these increases are at least partially due to improved reporting of regulatory components on energy bills since 2010.
- The weighted average of the absolute value of renewable support measures and network costs paid by primary smelters and recyclers and downstream producers varied significantly. In 2015 smelters paid 1.63€/MWh in renewable support and in 2.27 €/MWh in network costs, recyclers and downstream producers paid 6.50 €/MWh in renewable support and 9.60 €/MWh in network costs. This indicates that **primary smelters were to a large degree exempted from network costs and renewable support measures, while recyclers and downstream producers were not.**

- **Natural gas prices for primary aluminium producers also saw a substantial increase from 26.15€/MWh in 2008 up to 31.78 €/MWh in 2012 (+5.3% YoY)**, and a subsequent decrease to 26.4 €/MWh in 2015. Note that natural gas prices are less relevant for primary smelters, which was reflected in a limited willingness from plants to share data on natural gas prices and components. The results for natural gas prices are less robust than those for electricity prices.
- **Natural gas prices for recyclers and downstream producers also saw a substantial increase from 27.8€/MWh in 2008 up to 31.9 €/MWh in 2013 (+4.5% YoY), and a subsequent decrease to 26.4 €/MWh in 2015.** Natural gas prices for the respondents in this sample were therefore nearly 5% lower in 2015 when compared to 2008.
- **Energy components accounted for 82.6% of natural gas bills in 2015, down from 87.9% in 2012 for sampled primary smelters, and for 87.7% of natural gas bills for sampled recyclers and downstream producers in 2015, a share that remained relatively stable since 2010.** The absolute values of taxes and network costs are also comparable between primary, and recycling and downstream producers.

- ***Energy intensity.*** **The average of electricity intensity of primary aluminium** production (weighted by production) remained relatively stable over the 2008-2015 period, around **14.5 MWh/t.**

- ***International comparison.*** The differences in electricity prices paid by primary aluminium producers across the world are stark. **EU producers in 2015 paid significantly more (42.44 €/MWh – simple average) than producers in some other regions such as Canada (13.13 €/MWh), CIS (23.48 €/MWh), Nordic region (Norway and Iceland - 24.23 €/MWh) the US (30.62 €/MWh) and the Middle East (36.90 €/MWh).** The Nordic countries (Iceland and Norway) and Canada are characterised by large hydro-electric power plants that are frequently owned or operated by the producers of primary aluminium. This enables the smelters to acquire electricity at production cost. CIS, the US and the Middle East are characterized by low electricity prices fuelled partially by an abundance of fossil fuels.
- **The differences in electricity prices between the EU and the regions mentioned above have fallen between 2008 and 2015** (except when comparing to Canada). The sharpest convergence in electricity prices can be observed with the US, Russia and especially the Middle-East. In 2008 EU primary aluminium producers paid over 60% more for their electricity than plants in the Middle East, this difference fell to 15% by 2015.
- China is characterized by consistently higher prices for electricity, though one important caveat needs to be taken into account: reported prices might not be meaningful as electricity providers as well as primary aluminium producers and their industrial customers are (at least partially) controlled by the local or central governments.
- Natural gas prices in the countries and regions that are the main aluminium trading partners of the EU are significantly lower than gas prices in the EU. The latter are 11% higher than Nordic gas prices, 340% higher than Canadian gas

prices (2015) and 289% higher than US gas prices. This could be caused by the abundance of fossil fuels (including shale gas) in those regions.

- ***Impact on competitiveness.*** In absolute terms, energy costs per tonne of production varied following energy price trends, i.e. peaking in the 2012-2013 period and slowly declining up to 2015, but remaining higher in 2015 than in 2008. **Energy costs are significantly larger than the sampled plants' EBITDA per tonne of primary aluminium across the whole period**.
- **Electricity costs represent between 22.2% and 29.2% of production costs.** The year 2015 was characterised by the lowest percentage in terms of total production costs, and this is mostly due to a decrease in the weighted average electricity price for the plants included in this analysis.
- Regulated energy costs (Network costs, Renewable support, Other taxes, fees, levies and charges) are not the main impacting components of energy prices for primary aluminium producers (between 3%-4.3% of EBITDA on average for the whole 2008-2015 period). The energy component itself is the dominant component.

4.1 Introduction

According to the NACE (Rev.2) statistical classification of economic activities in the European Union, aluminium makers are included in the class 24.42. This includes primary and secondary aluminium production, as well as semi-manufactured aluminium products. In this sector description three subsectors are covered: (1) primary aluminium, (2) secondary aluminium and (3) two downstream activities: rolling mills and extrusion plants.

This sectoral case study is structured as follows:

1. In the beginning of the case study (above), the main highlights from the research are presented;
2. Section 4.2 to 4.5 provide the sectoral overview. In particular, in Section 4.2 describes the production process; Section 4.3 presents the main characteristics of the EU industry; Section 4.4 provides an analysis of trade patterns; and Section 4.5 shows an overview of the literature on the industry's energy consumption;
3. Section 4.6 presents the sampling strategy based and the description of the actual sample of manufacturing plants included in the study, including sectoral coverage;
4. Sections 4.7 to 4.10 report the results of the analysis of energy prices, both total prices and split per components, both for primary and downstream aluminium sectors;
5. Sections 4.11 and 4.12 describe sectoral energy intensity for primary and downstream aluminium producers;
6. Section 4.13 provides a comparison of energy prices paid by primary aluminium EU respondents and producers in selected third countries;
7. Section 4.14 provides the analysis of Key Performance Indicators (KPI) and the impact of energy costs over production costs and margins;
8. Section 4.15 provides a brief conclusion.

Aluminium is the most abundant crustal metal on earth and its compounds account roughly for 7% of the earth's crust (Bergsdal et al., 2004). It was first produced in 1808, and has since then become a key metal at the core of industrialised economies.

Aluminium has a number of physical properties that make its usage particularly attractive across different industries:

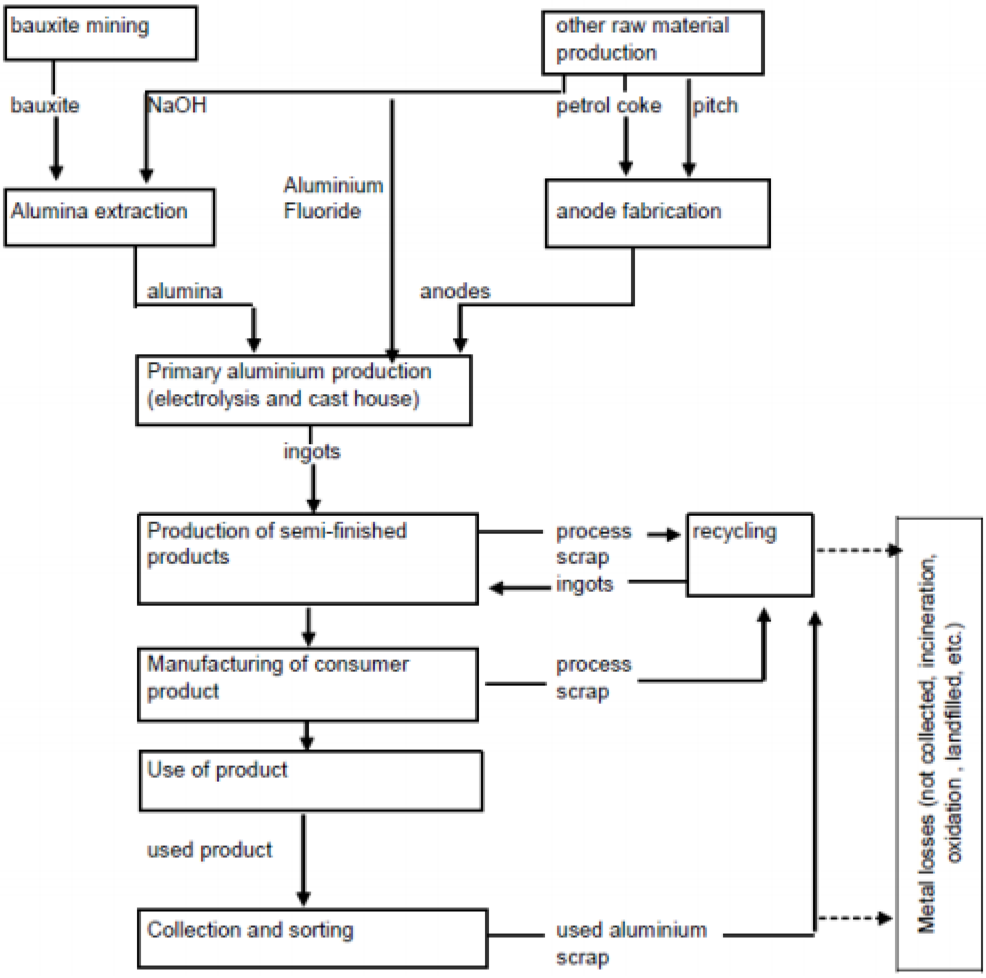
- Lightweight and excellent electrical conductivity; as a result, aluminium wires are used on a large scale for electricity transmission.
- High workability and strength, often used in the production of vehicles (cars, trains, aircraft) and other industries where the combination of strength and low weight allows for highly efficient fuels properties.
- High thermal properties and good resistance to corrosion. Aluminium is thus widely used in construction, conditioning, refrigerating and heating exchange industries.
- High malleability, which facilitates the production of thin rolls and sheets that are extensively used by the packaging industry (CEPS, 2013).

4.2 Overview of the production process

The aluminium production process is elaborate, costly and energy consuming. Once produced, however, aluminium can be recycled indefinitely without losing its major properties.

In order to obtain a final product suitable for industrial usage, three main production phases are generally distinguished: first, the basic raw material *bauxite* needs to be extracted. Bauxite is then refined into a product called *alumina* and eventually alumina is smelted into *primary aluminium* (using carbon-containing anodes as a second raw material). Primary aluminium can be recycled and brought back to the market as *secondary aluminium*. These different phases are illustrated in Figure 38 below. Both primary and secondary aluminium serve as inputs for downstream users such as rolling mills and extruders.

Figure 38. Simplified aluminium life-cycle material flow



Source: JRC (2015) and EA (2013).

4.2.1 Production of primary aluminium

The production of primary aluminium is done through the smelting of alumina into *primary aluminium*, which is then cast into ingots. The casting and smelting processes are integrated in all EU primary aluminium plants. The smelting process (the Hall-Heroult process) is very electricity-intensive, and is based on three main inputs: alumina, electricity and carbon (in the form of anodes). The smelting of alumina into aluminium is based on an energy-intensive electrolytic process, with temperatures as high as 960°C. During the process a high current (200 to 350 kA) is passed through the electrolytic bath to produce aluminium metal (IEA, 2012).

Two different technologies have been adopted to increase energy efficiency of the smelting: the Soderberg and Prebake technologies, which differ by the type of anode used (Bergsdal et al., 2004). The Soderberg technology is older and consumes more energy (energy intensity range 15.1-17.5 MWh/t). It is being slowly replaced by the Prebake technology (energy intensity range: 13.6-15.7 MWh/t). New plants and most modernisation programmes for existing plants adopt the new technology, mainly because of the financial savings from the higher electricity efficiency of the Prebake technology (Bergsdal et al., 2004). In 2014, 90% of EU primary aluminium was produced using the Prebake technology. The remaining 10% was produced using the Soderberg technology (Draft BREF, 2014).

Independent of the production technology employed, energy is a major driver of cost. Globally the primary aluminium cost structure generally consists of the following: alumina (34.8% of production costs), electrical power (32.5% of production costs), carbon (13% of production costs) and labour (6.8% of production costs) (CRU, 2012; CEPS-EA, 2013). The share of production costs accounted for by electricity found in this study for the sampled EU primary smelters is slightly lower (averages across the respondents between 21.1% and 30.1%).

Alumina is priced on the international level, and its cost is therefore roughly the same for all producers. Electricity costs, on the other hand, vary from country to country. Therefore, the smelting process is often sited close to supplies of cheap and constant electricity (CEPS, 2013).

4.2.2 Secondary aluminium production

Secondary aluminium is all aluminium produced through the recycling of aluminium scrap, such as wires, cables, casting alloys, used beverage cans, packaging and dross (mixture of metal, alumina and other materials) (OECD, 2010). Aluminium can be recycled indefinitely without losing fundamental properties, such as its light weight and durability. According to the International Aluminium Institute (2009), more than a third of all the aluminium globally produced comes from aluminium scraps. Bertram et al. (2009) estimate that 75% of all aluminium ever produced is still in use.

Since the 1950s, the production of secondary aluminium has been steadily growing, reaching 18 million tonnes of production globally in 2010. The factors contributing to this include: lower energy costs of production compared to primary aluminium (recycling requires only around 5% of the energy consumed during the production of primary aluminium according to the International Aluminium Institute, 2011), concerns about sustainable development, environmental legislation and the high market value of aluminium scrap due to the embedded energy from the primary smelting process (CEPS-EA, 2013).

There are two different processes to recycle aluminium, each tailored to different segments of the downstream market. The *refining process* produces secondary aluminium using very different types of scraps. This process has a 15% tolerance of impurity (relatively high) and, for this reason, the recycled aluminium can be used by downstream casters (mainly employed in the automotive sector). The *remelting* process is more complex and needs purer scraps (2-3% maximum impurity tolerance) and therefore recycles mostly industrial scraps. The remelting process generates secondary aluminium that can be used both in rolling mills and extrusion plants.

Recycling plays an important role in the EU. There is, however, a lack of scrap and the export of scrap (mostly to Asia) limits the availability of recycled aluminium.

Therefore, primary aluminium production remains necessary for now to cover EU demand for aluminium (JRC, 2015).

4.2.3 Downstream activities

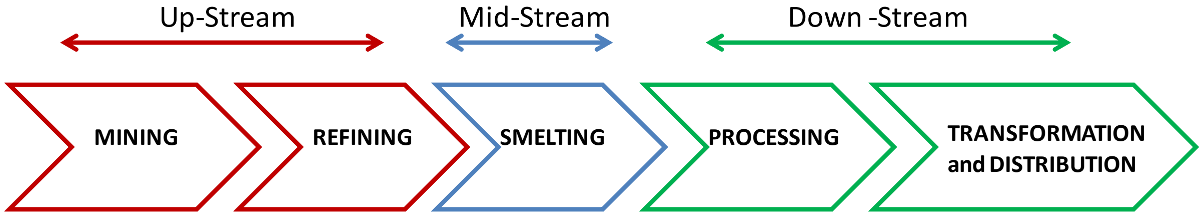
The downstream activities include processing and transformation, which turn aluminium ingots into semi-finished or finished products. The processing required depends on the final user (whether in transportation, packaging, electrical, engineering), who will set specific technical requirements. Automotive and construction sectors have constantly been the two largest aluminium end users, driving demand.

Two major downstream activities that are included in this study are *rolling mills* and *extruders*. Rolling mills use hot, cold or foil rolling to produce different types of sheets, plates and foils. The usual production process is rolling thick aluminium between rolls that reduce the thickness and lengthen the rolled product (Aluminium Association, 2008). Extruders transform aluminium alloys into objects with a cross-sectional profile. Aluminium is pushed through a die. Aluminium can be hot or cold extruded, which allows it to be shaped according to the specificities of consumers. Construction, transport and aerospace are three sectors that consume extruded aluminium (Spectra aluminium, 2010).

4.3 Industry characteristics

The aluminium value chain is described in Figure 39, following the definitions from Garren et al. (2009). The upstream and midstream phases are the stages that produce aluminium ingots or liquid aluminium. The downstream phases include the rolling, extruding and casting of aluminium.

Figure 39. Aluminium value chain



Source: CEPS and EA (2013).

Energy costs are the key factors in determining where the mid-stream (or smelting) part of the value chain is developed, as they represent on average 30% of the total costs of aluminium production (Garren et al., 2009). Placing aluminium smelters where they can be supplied with cheap energy is essential to being able to produce at a competitive cost.

Table 35. The aluminium sector according to the NACE Rev.2 classification

SECTION C — MANUFACTURING
24 Manufacture of other non-metallic mineral products
24.42 Aluminium production
24.42.11 Aluminium, unwrought
24.42.12 Aluminium oxide, excluding artificial corundum
24.42.21 Aluminium powders and flakes
24.42.22 Aluminium bars, rods and profiles
24.42.23 Aluminium wire
24.42.24 Aluminium plates, sheets and strip, of a thickness > 0.2 mm
24.42.25 Aluminium foil, of a thickness ≤ 0.2 mm
24.42.26 Aluminium tubes, pipes and tube or pipe fittings

Source: Authors' own elaboration on Eurostat (2016).

4.3.1 Production in the EU

European[15] aluminium production was approximately 8.9 million tonnes in 2013 (IAI, 2015), of which approximately 4.2 million tonnes primary aluminium and 4.7 million tonnes secondary aluminium (JRC, 2015). However, this data includes a number of major European countries that are not members of the EU such as Norway and Iceland. In 2012, 2.1 million tonnes of primary aluminium and 4.1 million tonnes of secondary aluminium were produced in the EU-27 (BREF, 2014). In 2015 primary aluminium production was slightly higher at 2.2 million tonnes (European Aluminium, 2016).

The total production value of aluminium dropped in all Member States in 2009 (see Figure 40), with only Poland and Germany showing significant growth between 2010 and 2014. Production values in Member States such as Greece, Italy and Spain have not yet recovered from the crisis, though all grew slightly between 2013 and 2014.

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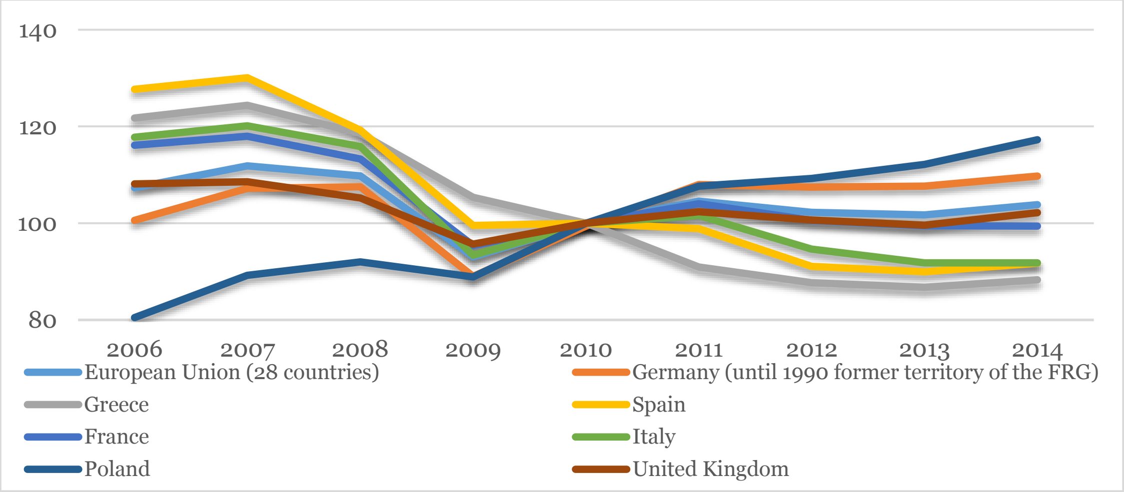
[15] The International Aluminium Institute does not make country level data publicly available. Europe consists of: EU, Albania, Belarus, Bosnia-Herzegovina, Iceland, Macedonia, Moldova, Norway, Serbia-Montenegro, Turkey and Ukraine.

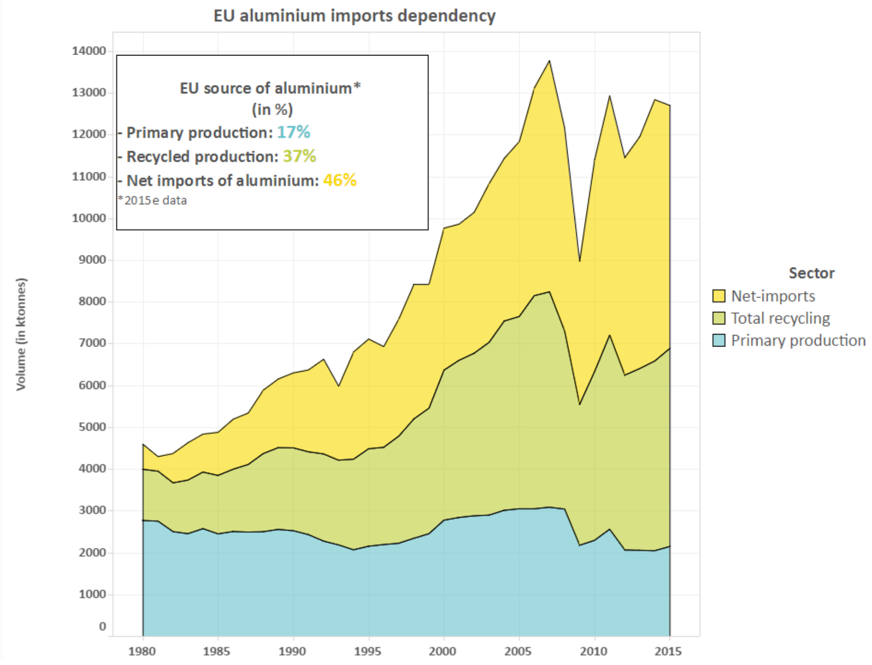
Figure 40. Trends in production values for EU-28 and selected Member States, indexed (2010=100)



Source: Authors' elaboration on EUROSTAT, 2016

Figure 41 shows that primary aluminium production remained more or less stable between 1980 and 2008, but decreased steadily since the start of the crisis in 2009 and only covered 14% of domestic consumption of aluminium in 2013. Secondary aluminium production increased steadily between 1980 and 2008 before being affected by the crisis. Secondary aluminium production was however less affected by the crisis than primary aluminium production. In 2013 it supplied 35% of the domestic consumption of aluminium. Because downstream consumption has continued to grow, and indeed recovered faster than aluminium production after 2009, the domestic demand for aluminium has increasingly outstripped domestic supply. Net imports reached 5.4 million tonnes in 2012.

Figure 41. EU production of primary and secondary aluminium and net imports



Source: European Aluminium (2016).

4.3.2 Number of companies and plants operating in the EU

Table 36. Number of enterprises in the EU aluminium sector (NACE Rev.2 24.42) by Member State

	2008	2009	2010	2011	2012	2013
Belgium	30	NA	32	NA	50	48
Bulgaria	13	10	11	11	NA	8
Czech Republic	NA	NA	NA	NA	NA	NA
Denmark	28	20	16	19	16	9
Germany	240	231	244	223	225	212
Estonia	2	2	2	2	1	1
Ireland	NA	NA	NA	NA	NA	NA
Greece	40	46	40	36	64	63
Spain	169	143	137	131	128	104
France	NA	76	93	67	57	62
Croatia	17	17	15	14	14	13
Italy	318	403	430	415	373	306
Cyprus	NA	NA	NA	NA	NA	NA
Latvia	7	6	4	5	6	5
Lithuania	2	1	1	1	1	1
Luxembourg	3	3	3	3	3	3
Hungary	19	16	17	16	15	16
Malta	NA	NA	0	0	0	0
Netherlands	68	71	68	63	61	76
Austria	22	23	24	25	24	23
Poland	53	64	87	107	127	132
Portugal	57	53	50	53	49	41
Romania	28	36	33	35	30	30
Slovenia	8	5	6	7	7	6
Slovakia	NA	NA	13	13	13	12
Finland	6	6	7	6	6	6
Sweden	52	52	48	43	43	48
United Kingdom	183	166	161	145	138	131

Source: Authors' elaboration on EUROSTAT (2016).

Table 36 gives an overview of the number of enterprises in the aluminium sector per Member State. These numbers do not match data from the industry association (European Aluminium), as the EUROSTAT data contains a wider scope of downstream activities. Table 36 does however serve to indicate the relative importance of a few Member States in the EU aluminium sector. Germany, Spain, Italy, Poland and the UK each have more than 100 aluminium enterprises. Italy and Germany lead the pack with 306 and 212 enterprises respectively.

a) Primary aluminium

As of the beginning of 2016, there were 16 primary aluminium smelters active in the EU, run by 10 different companies. The full list of plants can be found below in Table 37.

Table 37. Primary aluminium smelters in the EU

Member State	Company	Plant
SI	Talum	Kidričevo
FR	Rio Tinto Alcan	Dunkirk
FR	Trimet	St. Jean
DE	Trimet	Hamburg
DE	Hydro Aluminium	Neuss
DE	Trimet	AG Essen
DE	Trimet	Limited Voerde
GR	Aluminium de Greece	S.A. Distomon
NL	Aluminium Delfzijl	Delfzijl
RO	ALRO	Slatina
SK	Slovalco	Ziar nad Hronom
ES	Alcoa	San Ciprian
ES	Alcoa	Aviles
ES	Alcoa	La Coruna
SE	Kubikenborg Aluminium	Sundsvall
UK	Rio Tinto Alcan	Lochaber

Source: EA (2016).

b) Secondary aluminium

Data provided by European Aluminium indicated that there are 209 secondary aluminium plants located in the EU. In both the remelter and refiner industries there are a limited number of smaller and large players. Large players are often vertically integrated with primary aluminium, rolling and extruder operations, one major recycling player (Sapa), for example, is a joint venture between Hydro and Orkla. The 101 refining plants in the EU are operated by 86 companies, the 120 remelting facilities are operated by 77 companies. In both groups we find large players such as Hydro Aluminium and Alcoa (operating nine and five secondary plants respectively) and smaller companies that operate just one plant.

While definitive data on vertical integration is not available, phone interviews and desk research indicates that a large number of remelters are vertically integrated with downstream activities: 57.5% of all remelters are in the same location as a rolling mill or extruder operated by the same company. The research team estimates that less than 3% of all refiners are vertically integrated.

c) Downstream activities

Data provided by European Aluminium indicated that there are 59 rolling mills, and 307 extruders in the EU. The 59 rolling mills are operated by 40 companies; the 307 extruder installations are operated by 217 companies. These two groups also contain both smaller companies with one or two plants, and large companies such as Constellium and Sapa which respectively operate 10 and 39 extruders across the EU.

4.3.3 Geographic distribution of production and plants over the EU

1) Primary aluminium

In 2013, 16 primary aluminium plants were spread over 10 Member States. The six most important aluminium producing Member States (Germany, Spain, France, Romania, Greece and Slovakia) represented 78% of primary aluminium production (CEPS, 2013).

2) Secondary aluminium

Secondary aluminium plants are both more numerous and more widespread across the EU than primary aluminium plants. The refining industry is operational in 19 Member States, but with the bulk (79%) of EU refining facilities concentrated in seven Member States: France (17 plants), Italy (13), Spain (12), UK (12), Poland (9), Germany (9) and Czech Republic (8) (EA, 2016).

The remelting industry is active in 17 Member States, with 72.5% of all facilities in six Member States: Italy (30 plants), Germany (24), France (11), Spain (9), UK (7) and Netherlands (6) (EA, 2016).

3) Downstream activities

Rolling mills and extruders can be found in most Member States, and are less concentrated than secondary aluminium production facilities. Out of a total of 18 Member States with rolling facilities five Member States account for 66% of facilities: Germany (12 plants), Italy (11), Spain (6), France (6) and the UK (4). Extruders can be found in 23 Member States, with 90% in 12 Member States: Italy (72 plants), Spain (61), Germany (40), Greece (27), France (19), Poland (14), the Netherlands, Portugal, Romania, the UK (9) and Belgium (8).

Table 38 gives an overview of the primary, secondary (refiners and remelters), rollers and extruders per Member State. Note that a small number of secondary plants are not included in this table, as these plants can switch their production processes between the refiner and remelter processes.

Table 38. Numbers of plants per production process in each Member State

Member State	**Primary aluminium**	**Secondary aluminium**		**Rolling Mills**	**Extrusion**
		Remelters	Refiners		
Austria		3	2	1	4
Belgium		2	2	1	8
Bulgaria				1	3
Croatia				1	2
Cyprus					1
Czech Republic		1	8	1	2
Denmark					1
Estonia			1		
Finland		2	1		3
France	2	11	16	6	19
Germany	4	24	9	12	40
Greece	1	3	1	1	27
Hungary		1	6	2	1
Ireland					1
Italy		30	13	11	72
Latvia			1		
Lithuania			1		
Luxembourg		1		1	
Netherlands	1	6	1	1	9
Poland			9	2	14
Portugal			1		9
Romania	1	3	1	1	9
Slovakia	1	1	2		4
Slovenia	1	1		2	1
Spain	3	9	12	6	61
Sweden	1	4		1	3
UK	1	7	12	4	9

Source: European Aluminium (2016).

4.3.4 Employment

The aluminium industry is the largest of the non-ferrous metal industries in the EU. The EU aluminium industry directly represents a workforce of around 255,000 (BREF, 2014).

4.4 Trade analysis

Aluminium is an internationally traded commodity, and the EU is a net importer. Figure 41 shows that net-imports account for 54% of all aluminium processed in the EU. However, both scraps and downstream products are also traded internationally.

Net-exports of aluminium scrap reached nearly half a million tonnes in 2015 European Aluminium, 2016). The EU trade with third countries in downstream products is dominated by three products: rolled products, extruded products and aluminium wires.

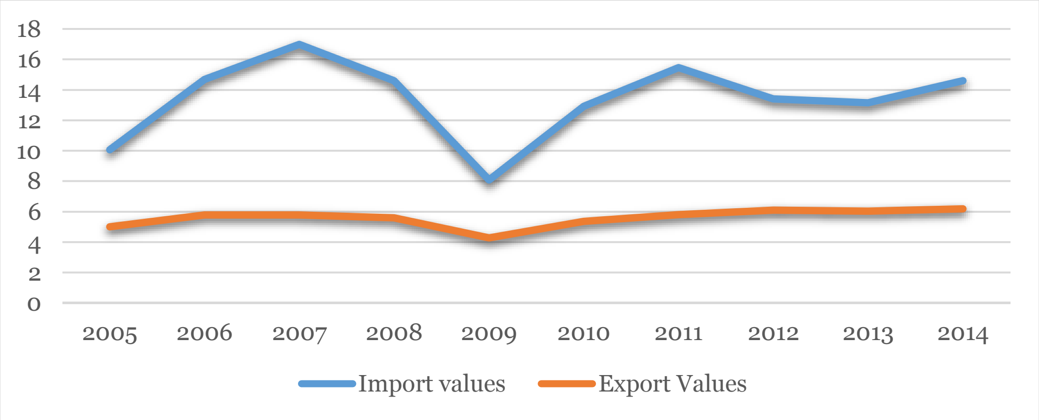
The EU is a net-importer of both extruded products (net-imports in 2013: 120.000 tonnes) and aluminium wires (net-imports in 2013: 214.000 tonnes). The two largest sources for imported extruded products were Turkey and China (each just over 80.000 tonnes in 2013). Switzerland was the largest destination for extruded products exported from the EU in 2013 (55.000 tonnes).

Over 87% of imports of aluminium wires in 2013 came from just three countries: Iceland (70.000 tonnes), Norway (59.000 tonnes) and Russia (57.000 tonnes).

With regards to rolled products the net-exports have decreased significantly, from 160.000 tonnes in 2008 to 46.000 tonnes in 2013. This due to a large increase of imports (from 814.000 to 1.013.000 tonnes). Exports of rolled products also increased over that period, but less rapidly (from 975.000 tonnes in 2008 to 1.060.000 tonnes in 2013). The main export markets for EU rollers in 2013 were the US (168.000 tonnes), Switzerland (131.000 tonnes) and Turkey (93.000 tonnes), while the majority of imports came from China (199.000 tonnes), Turkey (176.000 tonnes) and Switzerland (161.000 tonnes).

Figure 42 gives an overview of the entire NACE 24.42 sector, and shows the evolution of import and exports values for the EU (in € billions). The effects of the crisis that started in 2007 are clear. Export values fell by approximately 30% between 2007 and 2009; at the same time the value of imports more than halved; from nearly €17 billion in 2007 to just over €8 billion in 2009. Since 2010 export values have remained steady, while import values dropped significantly again in 2012, but recovered by the end of 2014.

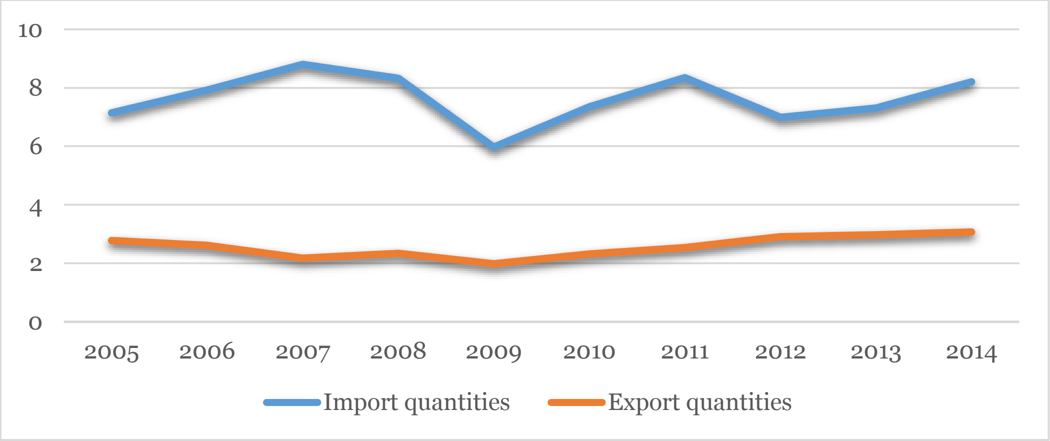
Figure 42. Total EU import and export values, 2005-14 (bns of €)



Source: Authors' elaboration on COMEXT (2016).

If we look at import and export quantities, we see a similar trend. Both import and export quantities dropped significantly between 2007 and 2009, but recovered within a few years. EU export quantities exceeded pre-crisis levels by 2012, and have remained steady since then. Import quantities dropped in 2012, but had nearly recovered by the end of 2014.

Figure 43. Total EU import and export quantities, 2005-14 (mns of tonnes)



Source: Authors' elaboration on COMEXT (2016).

Table 39 and Table 40 show two snapshots of the trade between the EU and the rest of the world in aluminium products; one for 2008 and one for 2014. It is clear that the EU is a significant net importer, though the gap between exports and imports has narrowed somewhat since 2008. In 2008 the EU imported nearly $10.5 billion more in aluminium and articles thereof than it exported. By 2014 the difference was slightly less than $9 billion.

The export values in Table 39 show three main export markets that account for over 35% of total exports: Switzerland, USA and China. While these three countries also figure in the list of main importers to the EU, Norway and the Russian Federation top that list.

Imports from the top three importers to the EU (the two latter countries and China) account for nearly $10.5 billion, or approximately 45% of total imports. It is apparent that the EU trade in aluminium is concentrated in a limited number of countries. In 2014, over 80% of all imports came from nine countries, and more than 60% of all EU exports went to nine countries.

Between 2008 and 2014 the relative position of trading partners changed. While Switzerland and the US were the top two markets to which EU aluminium companies exported in both 2008 and 2014, Russia fell from third place in 2008 to sixth place in 2014. With regards to importers to the EU, the top five have hardly changed between 2008 and 2014, but the respective values of imports have changed significantly. Norway accounted for nearly a sixth of all imports in 2008 ($5.8 billion), but only an eighth of imports in 2014 (just under $4 billion).

While overall imports decreased slightly between 2008 and 2014, the fall in Norwegian imports was offset by increased imports from two main sources: imports from the Russian Federation rose from $2.5 billion in 2008 to $3.6 billion in 2014, and imports from China increased from $1.9 billion in 2008 to $2.9 billion in 2014.

Table 39. Exports of aluminium and articles thereof between the EU and main trade partners (2008, 2014, in USD), sorted by export value in 2014

2008		2014	
Trade Partner	**Exports**	**Trade Partner**	**Exports**
Switzerland	2,014,955,607	Switzerland	2,239,901,354
USA	1,975,974,227	USA	1,885,849,349
China	967,053,555	China	1,143,096,756
India	373,119,730	India	639,893,056
Turkey	537,721,574	Turkey	624,611,456
Russian Federation	1,110,524,766	Russian Federation	610,683,076
Norway	692,962,763	Norway	608,846,595
Saudi Arabia	234,079,393	Saudi Arabia	562,091,152
Republic of Korea	377,075,723	Republic of Korea	427,595,389
TOTAL	**13,759,956,669**	**TOTAL**	**14,389,846,718**

Source: Authors' elaboration on Comtrade (2016).

Table 40. Imports of aluminium and articles thereof between the EU and main trade partners (2008, 2014, in USD), sorted by import value in 2014

2008		2014	
Trade Partner	**Imports**	**Trade Partner**	**Imports**
Norway	5,833,436,163	Norway	3,967,402,538
Russian Federation	2,547,862,978	Russian Federation	3,560,916,747
China	1,863,164,573	China	2,897,705,901
Switzerland	1,784,144,616	Switzerland	1,872,665,801
Iceland	1,890,128,637	Iceland	1,870,243,277
Turkey	1,142,957,021	Turkey	1,461,228,260
United Arab Emirates	631,606,095	United Arab Emirates	1,219,038,839
Mozambique	986,687,052	Mozambique	1,150,534,192
USA	1,111,067,976	USA	1,006,173,478
TOTAL	**24,227,743,175**	**TOTAL**	**23,362,706,256**

Source: Authors' elaboration on Comtrade (2016).

The main EU trading partners, as reported in Table 39 and Table 40, are considered the most relevant for the international comparison section of the study. During that section the focus is on those countries with significant primary aluminium production capacity that are important trading partners of the EU, most notably USA, China, Iceland, Norway, the Middle East and Commonwealth of Independent States (CIS).

4.5 Energy - literature review

4.5.1 Primary aluminium

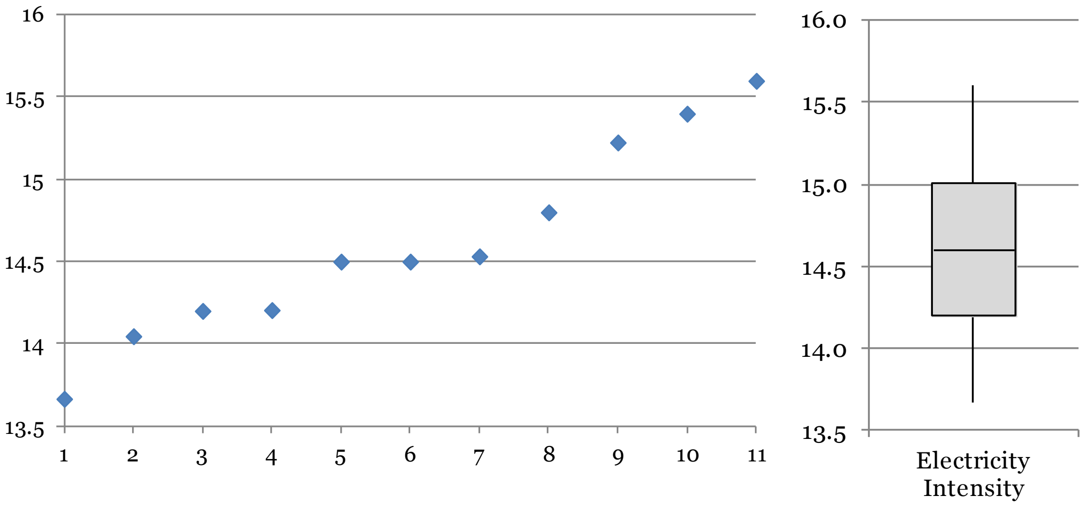
The smelting process (the Hall-Heroult process) is very electricity-intensive. The specific quantity of electricity consumed varies among companies and depends on the technology employed and the production plant. The consumption of electrical energy is approximately 55 GJ per tonne of aluminium; approximately half this energy is converted into heat in the process (JRC, 2015).

The most energy-efficient smelters consume approximately 13 MWh of electrical energy to produce one tonne of aluminium, while the world average is slightly below 15 MWh/t. This means that each additional €/MWh translates into around €15/t of aluminium, which represents approximately 1% of total production costs (CEPS-EA, 2013 and authors' own elaboration).

Most primary aluminium smelters have similar electricity intensities. Therefore, the electricity consumption profile of each plant impacts the competitive position of the plant less than the price of electricity for EU industry players. Figure 44 below shows the electricity intensity of the 11 plants sampled for the CEPS-EA (2013) Cumulated Cost Assessments, and their average and interquartile range.

Note that because of confidentiality concerns it is not possible to present the electricity intensities of the plants that responded with regards to this study. However, the numbers in Figure 44 are confirmed; yearly average electricity intensities vary between 14.3 MWh/t and 14.7 MWh/t (both weighted by consumption and production).

Figure 44. Electricity intensity (MWh/t)[16]



Source: CEPS and EconomistiAssociati (2013).

4.5.2 *Secondary aluminium*

Energy consumption in the secondary aluminium sector depends on two main variables: the process used (which depends in turn on the quality of scrap) and the form of aluminium to be delivered to downstream users. Ecofys et al. (2009) estimate that secondary remelting consumes between 120 and 340 kWh per tonne of product. Refining installations consume more electricity because salt is added to the mix. The electricity-intensity of refined aluminium depends on the degree to which the scrap is contaminated.

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[16] In the right-hand part of Figure 44, the vertical segment shows the whole range of values for electricity intensity, while the grey rectangle shows the interquartile range of values: the horizontal line represents the mean value.

The aluminium is delivered either as ingots, or in liquid form. In order to deliver liquid aluminium to downstream consumers, energy consumption is increased by 20-30%. However, no remelting is necessary at the downstream site which reduces the overall energy consumption of the final casting products (BREF, 2014).

Preliminary data for 2014 from European Aluminium indicates that the EU average for secondary aluminium is 204 kWh/t. Due to the limited number of remelters and refiners that provided comprehensive data for the analysis, it is not possible to confirm or correct these average energy intensity values.

4.5.3 Downstream activities

Ecofys (2009) indicates that a rolling mill consumes between 70 and 900 kWh/t of product, and an extruder between 300 and 1200 kWh/t of product. These wide ranges are caused by 1) the wide variety of specialised products produced by these two downstream sectors and 2) a lack of data on EU-wide energy consumption patterns in downstream aluminium sectors.

European Aluminium provided the research team with 2014 preliminary data on energy consumption in downstream sectors, but added a caveat that the variation from these industry averages is very wide. An average rolling mill in the EU consumes around 449 kWh/t, an average extruder around 787 kWh/t.

Due to the limited number of rollers and extruders that provided comprehensive data for the analysis, it is not possible to confirm or correct these average energy intensity values.

4.6 Selection of the sample and sample statistics

4.6.1 Sampling Strategy

For the purpose of the present study, the sampling strategy for each sector should take the following criteria into account:

- **Geographical coverage**
- **Capacity of plants**
- **Ownership**, i.e. company size
- **Production technology**

With regards to **geographical coverage**, the research team assembled detailed information on the distribution of plants across EU Member States for primary, secondary and downstream activities. This data was provided by European Aluminium. The data on geographical distribution is presented above under Section 4.3 Industry Characteristics.

Only **plant capacity data** for the primary aluminium refining plants is available at the EU level. European Aluminium shared estimated data for the EU remelters, refiners and downstream aluminium subsectors that can be found in Table 41, Table 42 and Table 43 below.

An overview of secondary and downstream producers, categorised by size, can be found in Table 41. Table 42 shows the criteria used to determine the categories. Table 43 shows the shares of overall capacity for each size category as a percentage of overall capacity.

Table 41. Secondary and downstream producers categorised by size (EU, 2016)

Category	Small	Medium	Large	Total
Refiners	61	29	11	**101**
Remelters	63	44	13	**120**
Rollers	42	14	3	**59**
Extrusion	108	122	77	**307**

Source: EA (2016).

Table 42. Criteria used to determine size categories in Table 43, in kt (EU, 2016)

Category	Small	Medium	Large
Refiners	<40	40 ≤X< 80	>80
Remelters	<60	60 ≤X< 200	>200
Rollers	<80	80 ≤X< 200	>200
Extrusion	<10	10 ≤X< 20	>20

Source: EA (2016).

Table 43. EU shares of overall capacity per category and estimates of total capacity (right column, in kt)

Category	Small	Medium	Large	Total Capacity
Refiners	19%	41%	40%	3,600
Remelters	17%	38%	45%	8,700
Rollers	36%	31%	33%	4,800
Extrusion	12%	37%	51%	4,200

Source: EA (2016).

There are large differences in plant size within the secondary and downstream aluminium sectors. Table 43 shows the capacities per category (as defined in Table 42), and estimates on the total capacities per segment. It becomes clear when analysed together with Table 41 that the few large plants are responsible for a large share of overall production capacity.

Ownership is also a sampling variable for the case study on the aluminium sector, but is considered the least important. The relatively limited number of players in the EU primary aluminium market includes both global players and national companies.

The secondary and downstream aluminium sectors contain both larger companies and SMEs. It is important to reflect the differences stemming from a specific type of ownership in the sample, however, it proved challenging to contact and convince SMEs[17] to cooperate with the research team, due to limited human resources these

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[17] SMEs are defined in the Commission Recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises and in the European Commission (2015): User guide to the

SMEs have available in comparison with larger companies. Consequently, some SMEs that the research team contacted explicitly expressed refusal to participate due to lack of human resources.

Primary aluminium plants are relatively homogeneous in terms of **production technology**. There are two main production technologies and both are included in the primary aluminium sample. Secondary aluminium is relatively homogeneous in terms of production output, but not so much in terms of production process and technologies.

Downstream rollers and extruders are not homogeneous. Not only do both downstream activities produce distinct products, they also use different production processes. Additionally, the high level of product specialisation within both the rolling and extrusion subsectors means that intra-subsector comparison is problematic. The results of comparing the energy consumption and cost of two rollers might be skewed by the specific production processes used and the value of final products.

The research team approached European aluminium companies directly, and the European Aluminium association helped by providing contact details of primary smelters, national associations and recyclers and downstream producers. Additionally, European Aluminium also provided data for the sampling strategy and assisted in convincing companies to cooperate with the research team.

National associations were also contacted in order to obtain contact details of relevant people in recyclers and downstream producers. However, this did not lead to substantially higher response rates.

4.6.2 Description of the sample

Initially the research team attempted to build the analysis further in this study on three different samples:

- Primary aluminium: sample to contain all primary aluminium plants.
- Refining: sample determined using the variables discussed above. Five plants in each of the seven Member States with eight or more refining installations.
- Remelting and downstream: combining these sectors was discussed with the Commission services and European Aluminium. The sample would be an amalgamation, aiming to gather data for the cross-sectoral analysis.

  The research team therefore proposed to follow a similar approach to the refining sample selection: focus on the countries with the majority of plants, and choose representative plants from those countries. The remelting and downstream have two specific problems which make comparing results very

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SME definition. SMEs are considered companies with less than 250 employees and an annual turnover of less than €50 million. Throughout this Study, as agreed with the relevant Commission services, a simpler definition of SMEs is used: companies are defined as SMEs if they have less than 250 full-time employees.

difficult between plants within the subsector: a high degree of vertical integration for remelting and downstream together, and a high product specialisation in the downstream sector.

While contacting plants across the various subsectors and during the process of data gathering, it became increasingly clear that this approach was untenable. The vast majority of primary aluminium smelters indicated interest in cooperating with the research team, and providing data and supporting evidence (such as balance sheets and energy bills). However, very few refiners, remelters, rolling mills and extruders wished to cooperate.

Therefore, in consultation with the Commission services, the choice was made to limit the analysis to two samples: extensive analysis on the primary aluminium sector and limited analysis on a sample containing an amalgamation of refiners, remelters, rollers and extruders. This sample is referred to as the recyclers and downstream producers' sample.

4.6.3 Information coverage and validation

A short overview of the number of plants contacted and the number of questionnaires received can be found below in Table 44 below.

Table 44. Descriptive statistics of response rates

Sector	Number of plants contacted	Questionnaires received	Expressed refusal to participate
Primary aluminium	16	14[18]	2
Aluminium refiners	41	1	18
Aluminium remelters and downstream producers	169	17	8

The sections on energy price trends and energy cost components covers both primary aluminium production and recyclers and downstream producers. The other sections are limited to the primary aluminium sector, as the recyclers and downstream producers sample is too heterogeneous in terms of plant size, products and production processes for meaningful analysis on these points.

Because of confidentiality concerns only EU wide averages are shown. Weighted EU averages are presented, with most figures including energy consumption as weight for primary aluminium, and some including aluminium production as weight. All figures include a note on the specific weight(s) used. For the recyclers and downstream producers however, EU averages are only weighted by energy consumption. The

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[18] Two questionnaires from primary smelters were incomplete.

diversity both in quantity and value-added of products does not allow for meaningful production-based weighing.

Electricity is the main energy carrier for the primary aluminium sector, while both natural gas and electricity are important for plants in the recycling and downstream sample. To give a full overview, the prices of natural gas and electricity and the components of their prices are discussed for both samples. The analysis of gas price trends, components and intensity for primary aluminium contains less plants than the respective sections for electricity. Four smelters have indicated that their gas costs are not relevant or even non-existent. One additional smelter is not connected to a natural gas grid, and consumes propane which can be transported by road transport. These five smelters could therefore not be included in the various segments on natural gas.

The figures in the following chapters for the primary sector include responses from 14 out of a total of 16 primary producers in the EU, which represents over 93% of EU-wide primary production capacity. One smelter, however, did not wish to disclose any information on energy prices and costs. This smelter was therefore only included in the analysis on energy intensity. Two smelters declined to participate in the study, one because it only recently restarted and the other because it will be either closed or sold in the near future.

Presenting analysis on specific sub-sectors in the recyclers and downstream producers sample was not deemed fruitful, as plants within the same sub-sector are also highly heterogeneous and integrate various production processes.

In total 7 extruders provided data, however, as 4 of them are owned or operated by the same company and two of the extruders are integrated with a remelter this subsample is not deemed representative of the EU population of extruders.

Only 1 refiner and 3 remelters have provided data, therefore neither of these subsectors are sufficiently represented for in-depth and robust analysis. Data from one the remelters was not deemed sufficiently comprehensive and reliable for inclusion in the analysis. The company was unwilling to maintain further dialogue in order to improve the quality of the data.

The six rolling mills that provided filled in questionnaires are also not representative of EU-wide industry as there is a significant overrepresentation of larger plants.

Not all plants are included in each figure or element of the analysis as questionnaires were delivered incomplete, data was dropped during the verification process and companies were not always willing to cooperate with respect to complementing, correcting and updating data as deemed necessary for the research team. Companies especially found it challenging to provide data for the 2008-2010 period.

Importantly, energy components are not available from all respondents. When components were not provided, respondents were further contacted to obtain additional information. This implies that the sum of the averages of price components is different from the averages of total prices for electricity and gas.

Follow-up interviews with smelters have shown that a number of the questionnaires are incomplete due to corporate acquisitions or changed ownership during the period that this study focusses on (2008-2015). Additionally, several plants and companies indicated that their internal process for consolidating data for 2015 was not yet finished, and some of these plants gave estimates for 2015 or partial figures. These estimates and partial figures have been left out by the research team.

Information on the number of plants included in every graph is presented below the graph or in a subsequent table. Table 45 presents a brief overview of the numbers of questionnaires used in each section of the analysis.

Table 45. Number of questionnaires used in each section

Sample	Total number received	Energy price trends	Energy bill components	Energy intensity	International comparison	Production costs and margins
Primary - electricity	14	10	8	12	5 (non-EU)	7
Primary – natural gas	9	7	5	7	0	7
Recyclers and downstream - electricity	18	15	11	--	--	--
Recyclers and downstream – natural gas	18	13	10	--	--	--

Source: Authors' own elaboration.

Data has been validated by the research team both through follow up emails and calls with the respondents, triangulation and secondary research, and via the analysis of supporting evidences. Energy bills were provided by 10 plants (4 primary smelters and 6 recyclers and downstream producers); when supporting evidences was used, an analysis was carried out to verify whether data provided therein matched those reported in the questionnaire.

Energy bills were not only used to verify the data from the same plant, but were also used to check the consistency of the data provided by all respondents, for example by checking whether trends on energy prices observed in the energy bills for plants in one country are consistent with the trends observed for a plant in the same country with a comparable energy consumption level.

Primary aluminium producers mostly reported very limited self-generation capacities (1 plant) or none at all (8 plants). Two plants choose not to disclose information on this.

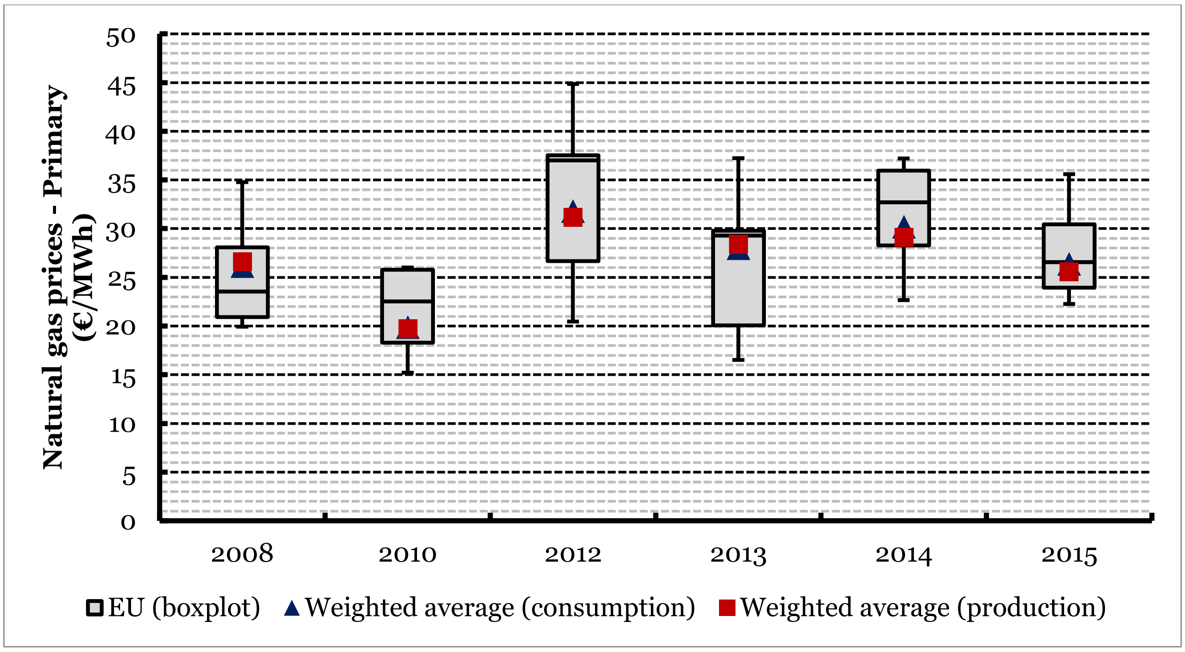
Only one smelter indicated that they had large self-generation capacity. They purchased large amounts of natural gas to power a CHP installation, which made them an outlier in terms of natural gas and energy intensity of production. However, all of the self-generated electricity was sold to the grid. The research team decided to drop the data on natural gas intensities and sold self-generated electricity for this plant from the relevant sections.

4.7 Energy price trends – primary aluminium

All energy prices reported in this section, and used throughout the analysis are net-prices, as reported on energy bills: exemptions or reductions for specific components are counted in. However, tax rebates, subsidy schemes or other financial compensation mechanisms that are not visible in bills are not accounted for due to a lack of data on these elements.

4.7.1 Natural Gas

Figure 45. Prices of natural gas paid by sampled EU primary aluminium producers (2008-15)



Source: Authors' own elaboration.

Table 46. Descriptive statistics for gas prices (2008-15)

Number of respondents	2008 4	2010 4	2012 5	2013 5	2014 6	2015 7
EU - Weighted Average (consumption)	€26.15	€19.87	€31.78	€27.97	€30.17	€26.37
EU - Weighted Average (production)	€26.66	€18.79	€30.40	€28.24	€29.03	€25.53
EU - Median	€23.54	€22.52	€37.01	€29.30	€32.70	€26.55
EU - Inter-Quartile Range	€7.15	€7.48	€10.89	€9.73	€7.69	€6.47
EU - Minimum	€19.93	€15.21	€20.47	€16.52	€22.67	€22.25
EU - Maximum	€34.79	€26.00	€44.86	€37.23	€37.21	€35.58
EU - Relative Standard Deviation (weighted average, consumption)	25.7%	26.4%	30.4%	29.6%	19.0%	18.8%
EU - Relative Standard Deviation (weighted average, production)	25.3%	26.6%	31.1%	29.2%	19.7%	19.4%

Source: Authors' own elaboration.

It is clear from Figure 45 that the price of natural gas paid by EU primary aluminium producers varied significantly from year to year, and between plants. In 2010 the gas prices paid by the plants in this particular sample showed the smallest variation (as defined by the difference between the lowest and the highest gas prices), the gas prices in 2012 showed the highest variation. Since 2012 the variation between the highest and the lowest gas prices has decreased significantly. The EU median of the primary smelters in this sample varied between 22€/MWh and 37 €/MWh, but specific plants had outlying gas prices between 15€ per MWh (in 2010) and 45€ per MWh (in 2012). The EU weighted averages (both weighted by energy consumption and plant production) are similar over the entire period, and vary between 19.71 €/MWh in 2010 and 31.78 €/MWh in 2012.

The 2014-2015 period is the most interesting to analyse, as the response rate was the highest. There is a clear decrease of EU sample average gas prices in 2015 when compared to 2014. This is partially due to the inclusion of an additional plant that had a gas price in 2015 that is somewhat lower than the weighted average. However, this plant is not the only factor causing the observed price decrease, as the 2015 weighted average without this plant is still lower than the 2014 weighted average. It is too early to conclude whether this decrease gas price can be considered a trend.

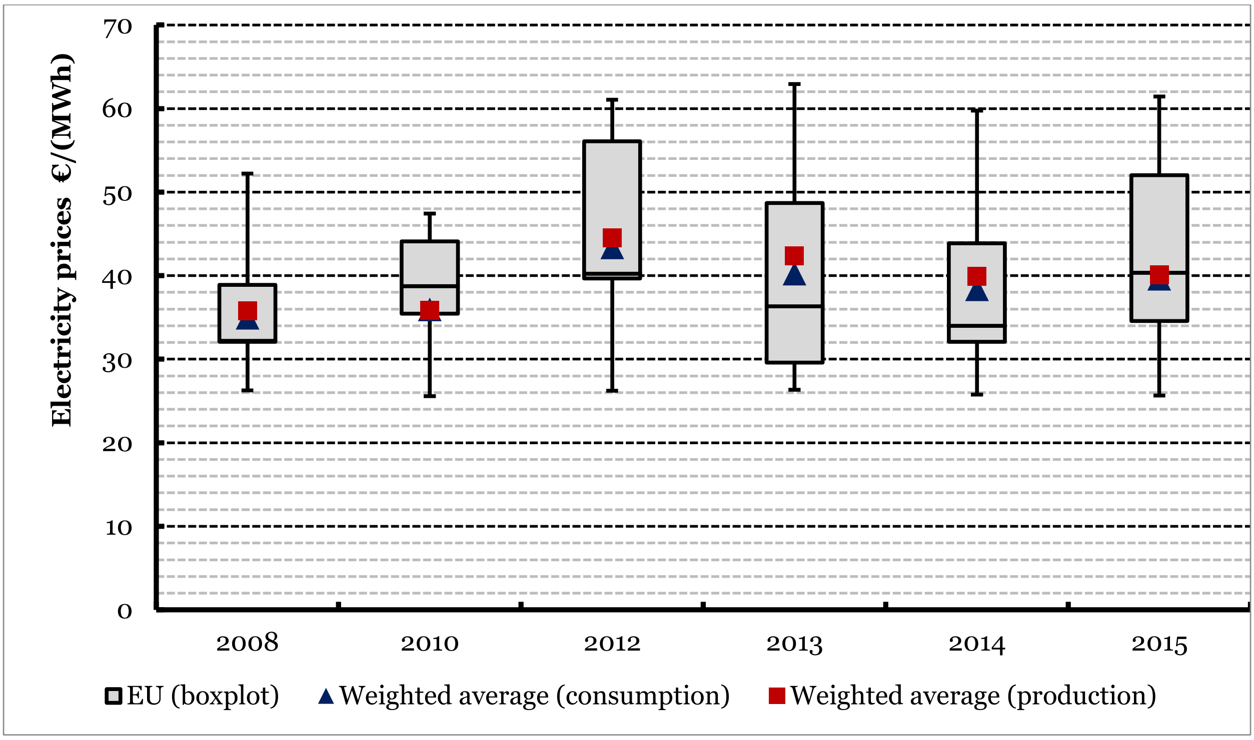
No clear trend can be discerned for the past 4 years, but it must be noted that the median and weighted average prices of gas in 2015 was significantly lower than those in 2012 (median gas price: 37 €/MWh in 2012 versus 27 €/MWh in 2015). The production weighted average EU gas price fell by 14.4% between 2012 and 2015.

If we only include in this analysis the respondents for which we have natural gas price data for all available years (4 in total), the picture does not change dramatically. We observe a similar upward trend towards 2014, with a high spread between individual high prices, followed by a significantly lower gas price for primary smelters in 2015. The average gas price for these 4 EU respondents decreased by over 10% between 2014 and 2015.

Weighted gas prices for the reduced number of respondents in 2014-2015 are slightly lower (~5% lower) than when using all available observations. This indicates that the plants that provided data only for the latter years faced higher gas prices.

4.7.2 *Electricity*

Figure 46. Prices of electricity paid by sampled EU primary aluminium producers (2008-2015)



Source: Authors' own elaboration.

Table 47. Descriptive statistics for electricity prices (2008-2015)

	2008	2010	2012	2013	2014	2015
Number of respondents	**8**	**8**	**9**	**9**	**10**	**10**
EU - Weighted Average (consumption)	€34.97	€35.93	€43.38	€40.24	€38.35	€39.62
EU - Weighted Average (production)	€ 35.77	€ 35.87	€ 44.52	€ 42.35	€ 39.93	€ 40.08
EU - Median	€32.2	€38.8	€40.2	€36.3	€34.0	€40.4
EU - Inter-Quartile Range	€6.8	€8.7	€16.4	€19.1	€11.8	€17.5
EU - Minimum	€26.27	€25.60	€26.24	€26.35	€25.78	€25.64
EU - Maximum	€52.2	€47.4	€61.1	€62.9	€59.8	€61.5
EU - Relative Standard Deviation (weighted average, consumption)	24.39%	19.61%	26.89%	34.93%	28.97%	30.78%
EU - Relative Standard Deviation (weighted average, production)	23.84%	19.65%	26.20%	33.19%	27.82%	30.43%

Source: Authors' own elaboration.

The data gathered for the comparison of electricity prices across EU primary plants is among the most comprehensive in this section on the aluminium industry. For 2014 and 2015 data from 10 out of 14 respondents was deemed sufficiently high quality to be included. For 2012 and 2013 data from 9 plants was used, and for 2008-2010 data from 8 plants was included.

Electricity prices paid by primary aluminium producers varied significantly over the 2008-2015 period. The median prices for the respondents however remained between 32.2 and 40.4€/MWh, while two plants indicated that their annual average electricity prices reached over 60€/MWh. The later years of the period (2012-2015) are characterised both by relatively high electricity prices for the upper quartile and by relatively low electricity prices for the lower quartile.

Over the full period there is a clear increasing trend in EU weighted averages, from 35.8 €/MWh to 40.1 €/MWh (weighted by consumption). Simple averages increased from 36.15 €/MWh in 2008 to 42.44 €/MWh in 2015. In 2012 there was a peak in prices (simple averages reached 44.64 €/MWh), but prices fell again the following years.

Consumption weighted price averages are consistently below production weighted averages over this period, which indicates that smelters with higher levels of electricity consumption pay relatively less for electricity than plants with higher levels of production (*ceteris paribus*). When only assessing plants that reported data for all years the results do not change significantly.

Note that one plant in the sample has indicated that they had a fixed price of electricity between 2012 and 2015.

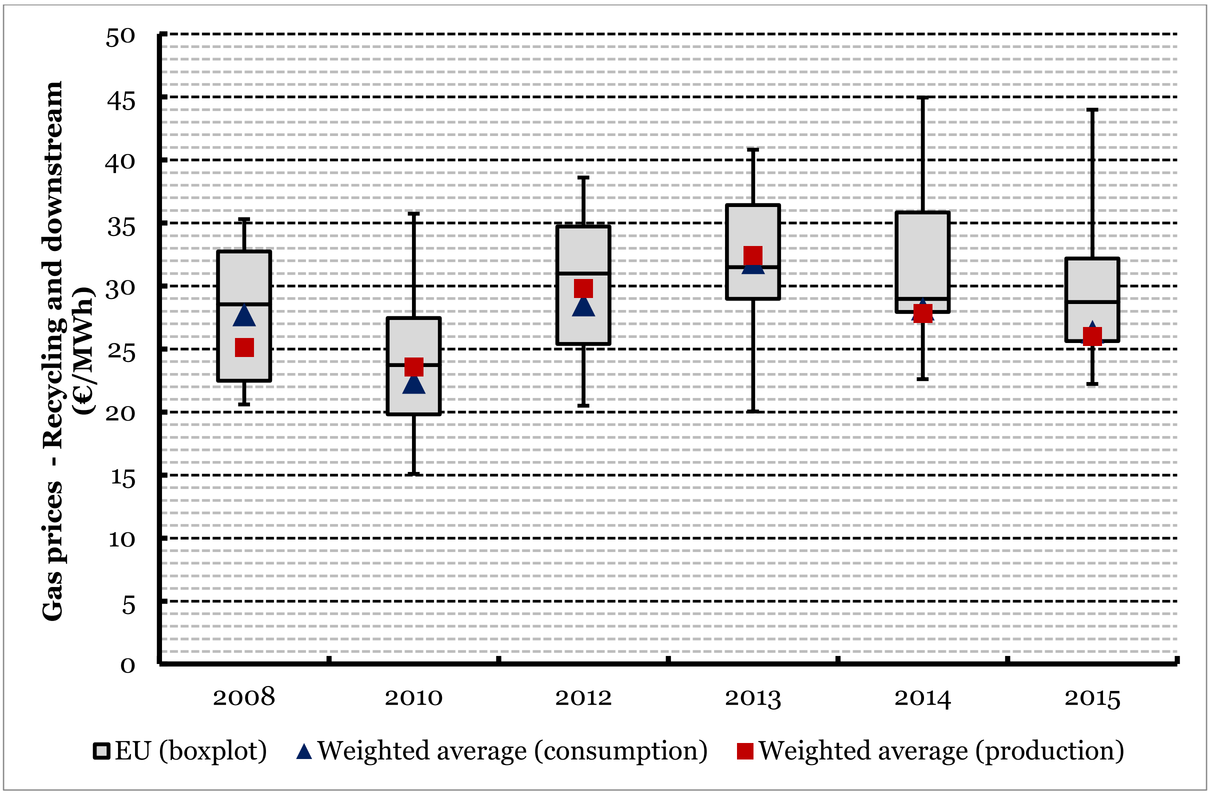
4.8 Energy price trends – recycling and downstream producers

The recycling and downstream producers sample contains a variety of plants that differ in terms of size, product, technology and geographic location. Therefore, the figures in this section show large differences in energy prices paid by the plants in this sample, mainly with regard to electricity.

Note that the averages weighted by consumption are skewed by the large differences in sizes between plants included in this analysis. Rolling mills are typically larger due to economies of scale, and are more energy intensive than extruders. The weighted averages are overly sensitive to the larger plants in the sample, and therefore do not represent an accurate picture of the EU recycling and downstream aluminium industry.

4.8.1 Natural Gas

Figure 47. Prices of natural gas paid by sampled EU recycling plants and downstream producers (2008-2015)



Source: Authors' own elaboration.

Table 48. Descriptive statistics for gas prices – recycling and downstream (2008-2015)

	2008	2010	2012	2013	2014	2015
Number of respondents	12	13	13	13	13	13
EU - Weighted Average (consumption)	€27.75	€22.38	€28.52	€31.89	€28.20	€26.38
EU - Median	€28.55	€23.74	€30.99	€31.50	€28.99	€28.73
EU - Inter-Quartile Range	€10.27	€7.65	€9.33	€7.45	€7.91	€6.55
EU - Minimum	€20.59	€15.10	€20.51	€20.05	€22.61	€22.23
EU - Maximum	€35.31	€35.73	€38.62	€40.81	€44.95	€44.00
EU - Relative Standard Deviation (weighted average, consumption)	35.41%	29.75%	19.09%	16.52%	21.00%	22.91%

Source: Authors' own elaboration.

The natural gas prices for EU recycling plants and downstream producers also vary widely, with significant differences between the minimum and maximum observations (the maxima are up to 137% higher than the minima). The quartiles are spread relatively evenly up to 2013. Starting in 2014 the observations become less evenly spread, with a strong concentration of observation in the price range €27 and €29 per MWh.

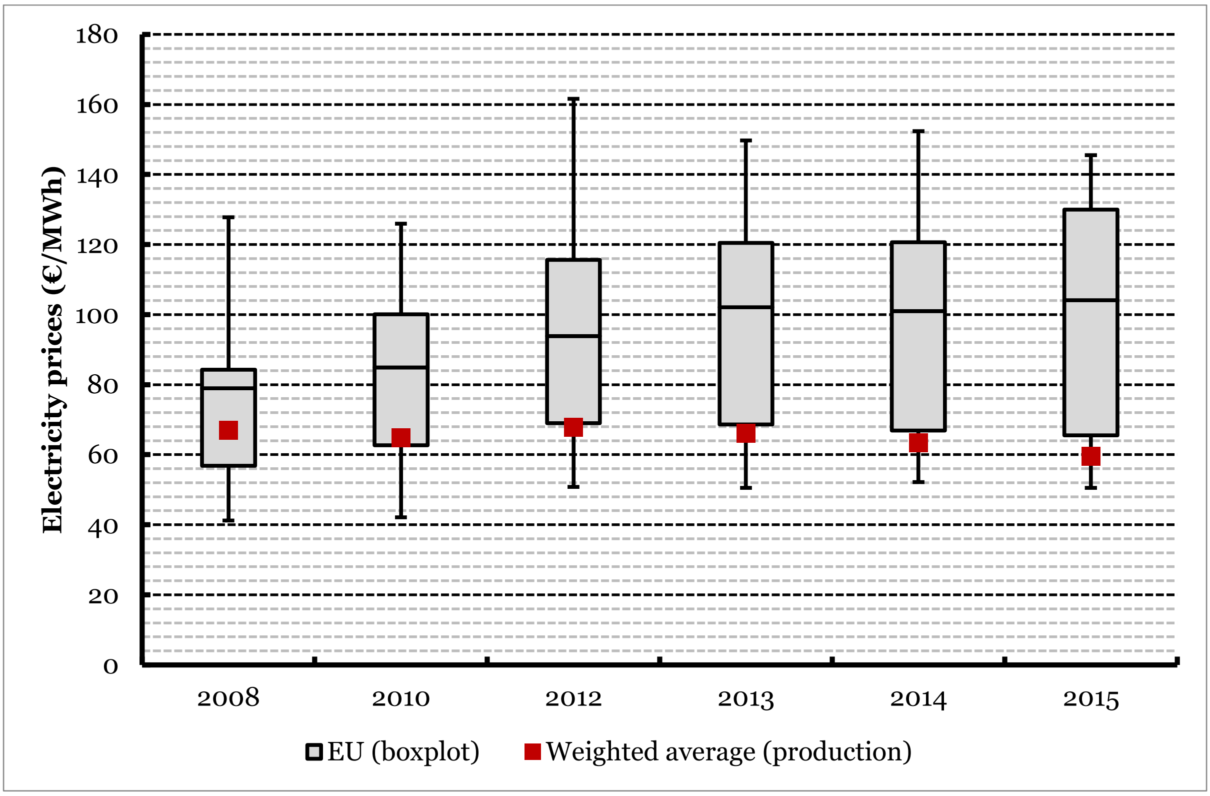
While the median prices vary between 23.74 €/MWh in 2010 and 31.50 €/MWh in 2013, the lowest observed price is just over 15 €/MWh in 2010 and the highest nearly 45 €/MWh in 2014. This divergence between gas prices can be at least partially explained by the differences in plant sizes in the sample and differences between EU Member States.

There is no clear trend in the natural gas price over the 2008-2015 period, however the median increased significantly from 23.74 €/MWh in 2010 (the year with the lowest median, weighted averages and minimum prices) to 31.50 €/MWh in 2013 (the year with the highest median, and weighted averages). Over the 2013-2015 period, median gas prices of the respondents dropped again from 31.50 €/MWh in 2013 to 28.73 €/MWh in 2015. The (consumption weighted) average gas price for the respondents was 22.38 €/MWh in 2010, but increased to 31.89 €/MWh by 2013. Since then it has fallen to 26.38 €/MWh in 2015.

It is not possible to draw any strong conclusions from this segment of the analysis, as the diversity between plants included in the sample is too large.

4.8.2 Electricity

Figure 48. Prices of electricity paid by sampled EU recycling plants and downstream producers (2008-2015)



Source: Authors' own elaboration.

Table 49. Descriptive statistics for electricity prices – recycling and downstream (2008-2015)

	2008	2010	2012	2013	2014	2015
Number of respondents	12	15	15	14	15	15
EU - Weighted Average (consumption)	€62.36	€62.76	€66.45	€65.77	€65.23	€62.77
EU - Median	€79.98	€84.93	€93.82	€102.09	€101.00	€104.06
EU - Inter-Quartile Range	€27.50	€37.35	€46.56	€51.87	€53.82	€64.49
EU - Minimum	€41.21	€42.12	€50.84	€50.58	€52.15	€50.52
EU - Maximum	€127.73	€125.93	€161.64	€149.75	€152.39	€145.47
EU - Relative Standard Deviation (weighted average, consumption)	41.02%	41.61%	49.55%	49.79%	51.26%	55.37%

Source: Authors' own elaboration.

Electricity prices for recycling plants and downstream producers in the aluminium value chain are relatively uniformly distributed with plants spread across the entire range of prices. However, electricity prices for recyclers and downstream producers have a wider spread and are overall significantly higher than the electricity prices of primary producers. While the highest observed prices for primary producers were around 61.5 €/MWh, most installations in the recycling and downstream sectors pay significantly more. The lowest electricity prices in this sample (except for 2010) are 40 €/MWh to 50 €/MWh. The highest prices are paid by the smaller electricity consumers, and can reach up to 160 €/MWh.

The median, 3rd quartile and especially maximum electricity prices for the respondents have increased significantly over the 2008-2012 period, with the median increasing by nearly 20%. Between 2012 and 2013 the median increased by another 10%, but has since remained relatively stable, and was 104 €/MWh in 2015. The median was more than 30% higher in 2015 compared to 2008.

Note that the weighted average is dominated by a limited number of large plants. Electricity prices for these plants have remained significantly more steady over this period; varying between 62.4€ in 2008 and 66.4€/MWh in 2012. The weighted average of electricity prices for the respondents in the recyclers and downstream sample in 2015 was 62.8 €/MWh.

It is not possible to draw any strong conclusions from this segment of the analysis as the diversity in plants included in this sample is too high.

4.9 Energy bill components – primary aluminium

In this section, the analysis of the components of the price paid by sampled manufacturers for natural gas and electricity is presented.

Note that companies were not always able to provide both overall prices and price components. Often detailed components were not visible on energy bills. There are significant differences between the average energy prices as reported above in the section energy prices and the results reported in this section on energy components. This is caused by different numbers of respondents included in both sections of the analysis.

The price of natural gas is split into three components, two of which depend on the regulatory framework (the so-called ‘regulatory components’):

1. Energy supply;
2. Network costs;
3. Other taxes, fees, levies and charges (excluding recoverable taxes, such as VAT).

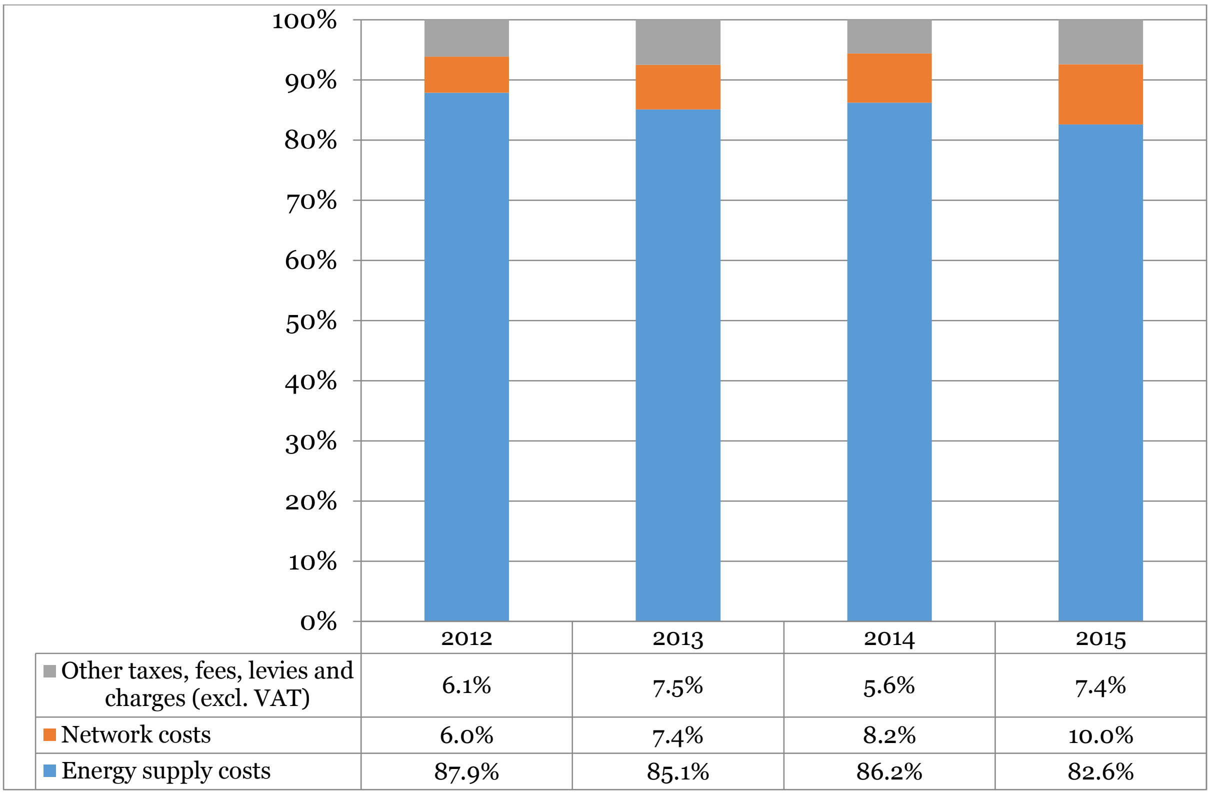
The price of electricity is split into four components, three of which depend on the regulatory framework (the so-called ‘regulatory components’):

1. Energy supply;
2. Network costs;
3. Renewable support
4. Other taxes, fees, levies and charges (excluding recoverable taxes, such as VAT).

Not all plants provided a split per component of natural gas and electricity costs, and in a number of Member States all plants indicated they have no explicit components in their bill. The research team made considerable efforts to acquire electricity bills from plants in those Member States in order to verify these statements with limited response from plants. Other companies indicated that individual components of their bills are more confidential than their overall energy prices. Additionally, 4 plants indicated that their gas bills do not account for a significant share of production cost, and would not warrant the efforts linked to researching and reporting the gas cost components.

4.9.1 Gas bill Components – primary aluminium

Figure 49. Components of the natural gas bills paid by the sampled primary aluminium producers in the EU (%) 2012 -15, EU annual averages, weighted by consumption.



	2012	2013	2014	2015
◼ Other taxes, fees, levies and charges (excl. VAT)	6.1%	7.5%	5.6%	7.4%
🟧 Network costs	6.0%	7.4%	8.2%	10.0%
🟦 Energy supply costs	87.9%	85.1%	86.2%	82.6%

Source: Authors' own elaboration.

For Figure 49 the research team was only able to use the gas bills of 5 primary smelters (4 for 2012-2013). Other plants did not wish to disclose this information or disclosed information that did not pass the validation process. Additionally, the number of valid observations for 2008 and 2010 was too small to be reported due to confidentiality concerns.

The sample represented by this figure is too small to draw any strong conclusions.

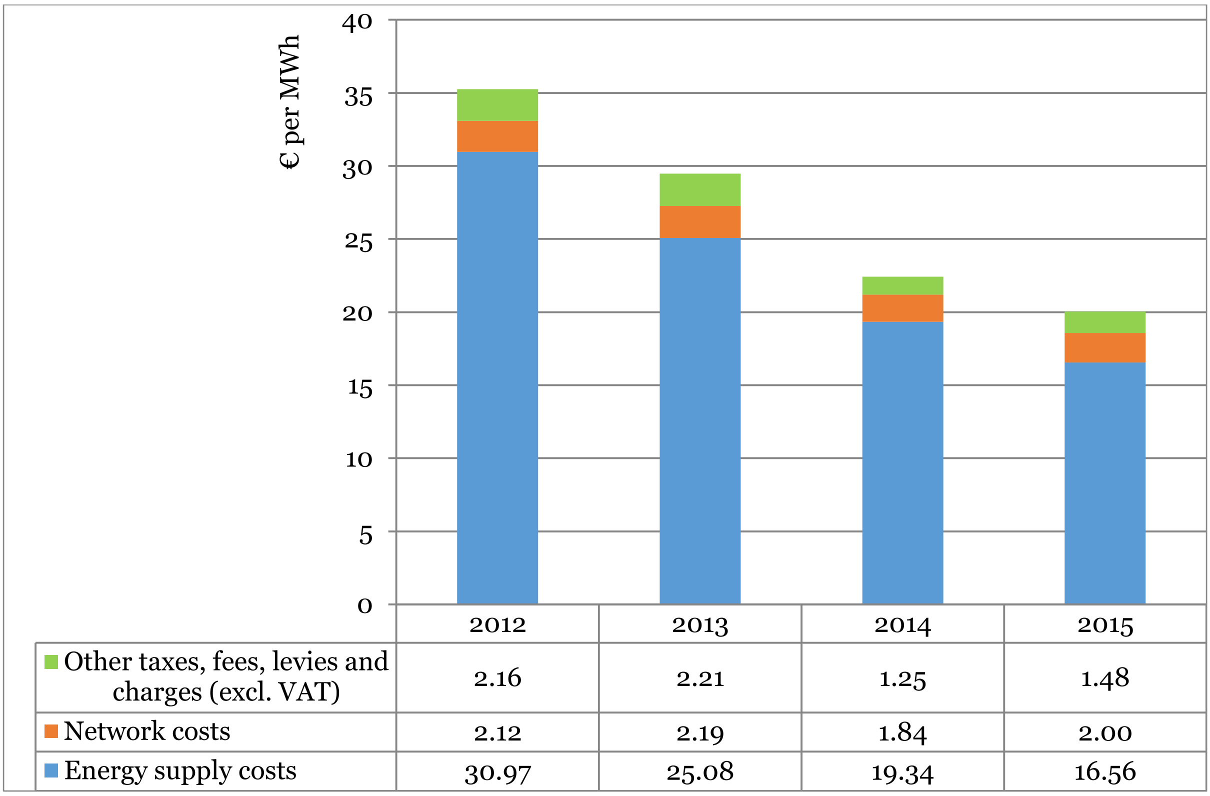
However, in Figure 49 the percentage of energy costs related to the energy component itself has decreased significantly for this small sample; from 87.9% in 2012 to 82.6% in 2015. On the other hand, the share of bills accounted for by the regulatory cost components (Network costs and Other taxes, fees, levies and chargers) have increased significantly over the same period. In 2012 they added up to 12.1 percent, but by 2015 they accounted for 17.4% of gas bills for this limited sample.

Figure 50 offers a possible explanation for the changes in relative weights of the different components. The annual average values of network costs and other taxes, fees, levies and charges decreased slightly between 2012 and 2015, but the absolute value of the energy component fell sharply from 30.97 €/MWh in 2012 to 16.56 €/MWh in 2015, a drop of close to 50%.

Note that there are significant differences between the component shares of gas bills when weighted by energy consumption or production. While the regulatory components of the energy price stay approximately constant using either method of weighting, the energy component decreases much faster when weighing by consumption. This means that more energy-intensive plants saw a larger decrease in the absolute value of the energy component of their natural gas bills than their less energy-intensive peers.

However, please note the sample represented in this section is too low to derive any strong conclusions on this issue.

Figure 50. Components of the natural gas bills paid by the sampled primary aluminium producers in the EU (%) 2012 -15, EU annual averages, weighted by consumption



	2012	2013	2014	2015
🟩 Other taxes, fees, levies and charges (excl. VAT)	2.16	2.21	1.25	1.48
🟧 Network costs	2.12	2.19	1.84	2.00
🟦 Energy supply costs	30.97	25.08	19.34	16.56

Source: Authors' own elaboration.

4.9.2 Electricity bill Components – primary aluminium

The analysis of electricity price components for the primary sector is more robust than the comparable analysis of gas price components as 6 plants are included for 2012, 7 for 2013 and 2015 and 8 for 2014.

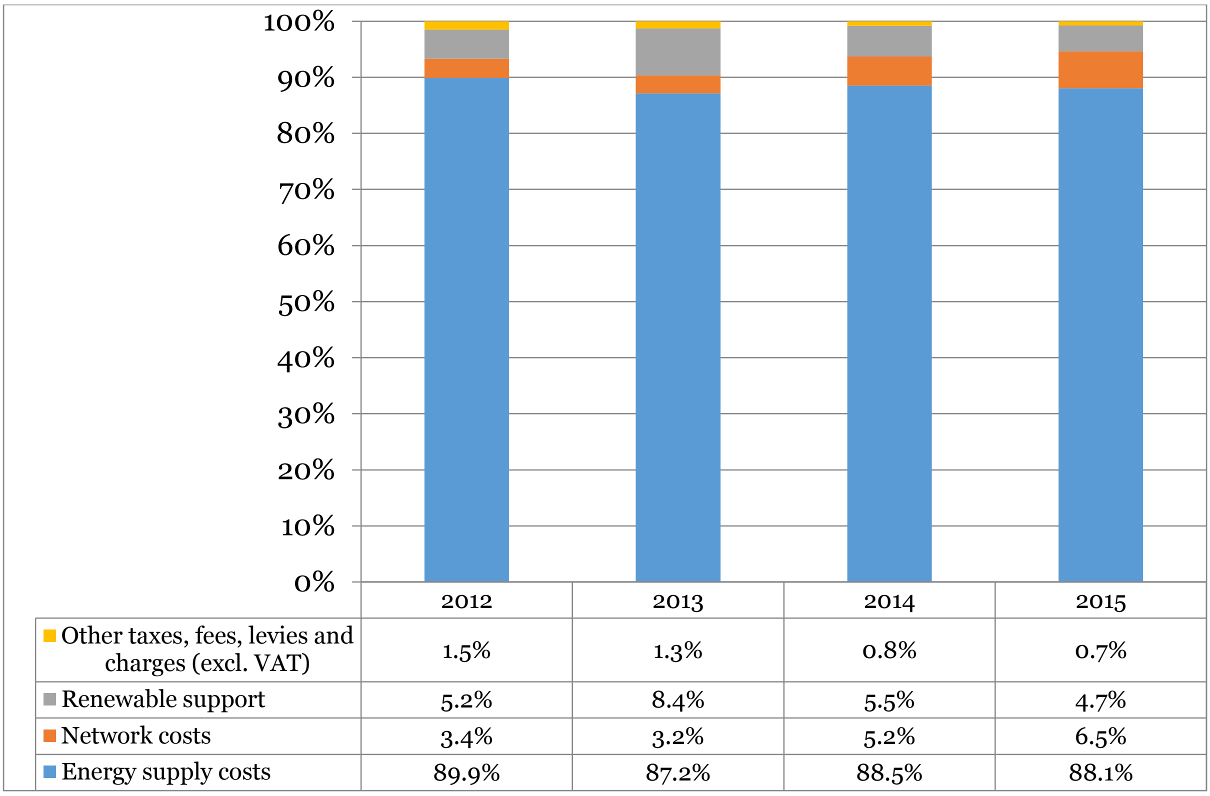
Figure 51 on electricity price components weighted by consumption shows a clearer picture than Figure 50 on gas price components. Regulatory components play a less important role in the electricity bill than in the gas bill for primary smelters. The energy component makes up nearly 90% of electricity bills. And that percentage has dropped slightly over the 2012-2015 period; going from 89.9% in 2012 to 88.1% in 2015.

Network costs have gained in importance, and grown from 3.4% of bills in 2012 to 6.5% by 2015. Renewable support (which includes support for CHP) gained in importance from 2012 to 2013 (5.2% to 8.4%), but then fell back to 4.7% by 2015.

Other taxes, fees, levies and charges are an insignificant component in electricity bills, varying between 0.7% and 1.5% of total bills.

These findings do not change significantly when either weighing by production or limiting the analysis to only those plants that provided useable data for the entire period.

Figure 51. Components of the electricity bills paid by the sampled primary aluminium producers in the EU (%) 2012 -15, EU annual averages, weighted by consumption



	2012	2013	2014	2015
🟨 Other taxes, fees, levies and charges (excl. VAT)	1.5%	1.3%	0.8%	0.7%
⬜ Renewable support	5.2%	8.4%	5.5%	4.7%
🟧 Network costs	3.4%	3.2%	5.2%	6.5%
🟦 Energy supply costs	89.9%	87.2%	88.5%	88.1%

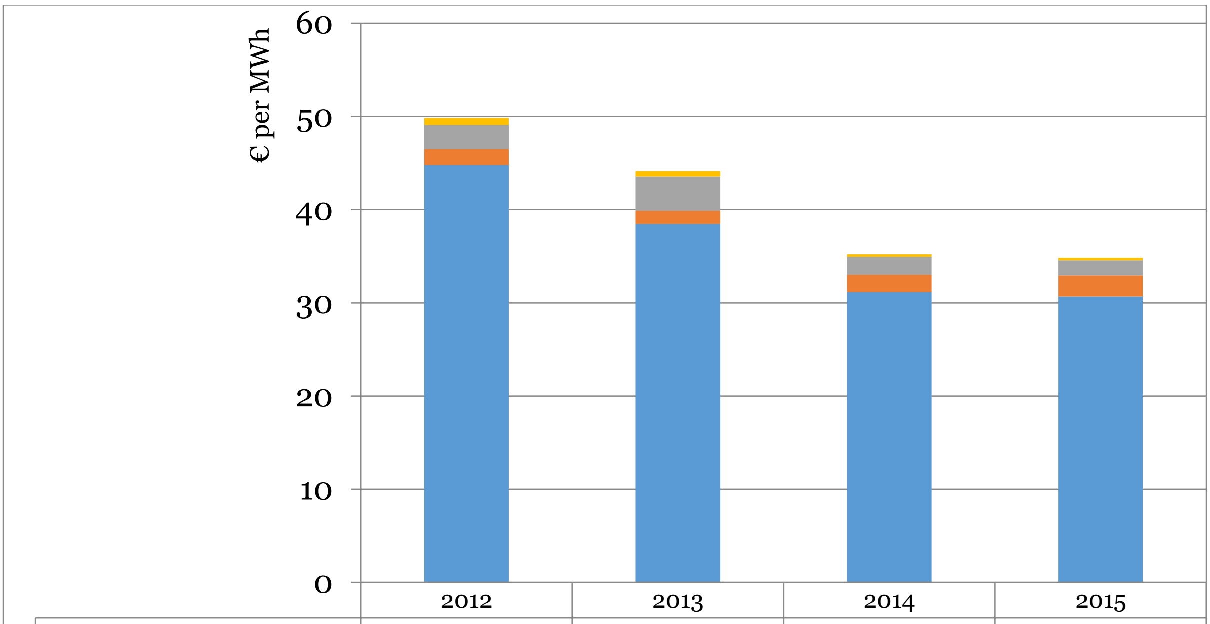
Source: Authors' own elaboration.

Figure 52 shows a comparable story. Energy supply costs – weighted by consumption - have fallen steadily since peaking at 44.78€/MWh in 2012. In 2015 it reached its minimum (for this period and sample) at 30.66 €/MWh; 14% lower than in 2008.

Other taxes, fees, levies and charges are not a significant part of electricity bills of any of the respondents, varying between 0.25 €/MWh and 0.73 €/MWh. Renewable support decreased steadily between 2013 and 2015, from 3.69 €/MWh to 1.63 €/MWh. Network costs have increased 61% between 2013 and 2015, but remain at relatively low levels, with a maximum of 2.27 €/MWh in 2015.

Interestingly, a different picture presents itself when comparing production-weighted averages with consumption-weighted averages. EU averages of the energy component of electricity bills weighted by energy consumption have fallen more than those weighted by production. This indicates that more energy-intensive plants observed a more significant decrease in the energy component. The Network costs and Renewable support components are comparable across both methods of weighting.

Figure 52. Components of the electricity bills paid by the sampled primary aluminium producers in the EU (€) 2012 -15, EU annual averages, weighted by consumption



	2012	2013	2014	2015
🟨 Other taxes, fees, levies and charges (excl. VAT)	0.73	0.56	0.29	0.25
■ Renewable support	2.60	3.69	1.92	1.63
🟧 Network costs	1.70	1.41	1.84	2.27
🟦 Energy supply costs	44.78	38.45	31.15	30.66

Source: Authors' own elaboration.

Box 2. Indirect EU ETS costs in the aluminium sector

Electric utilities face increased operating costs through their ETS compliance cost. They pass those costs on to their customers via higher electricity rates. Indirect EU ETS costs are not visible in electricity bills, and cannot be distinguished as a separate component as they are included in the energy component.

One primary smelter, however, indicated that indirect EU ETS costs are explicitly negotiated with their power utility, and are paid on top of the agreed electricity price. The indirect EU ETS cost paid by this company depends on the EUA daily future prices and the fuel mix used by the power utility. For this smelter EU ETS indirect costs amounted to between 5 and 25€ per tonne of primary aluminium produced. The more recent years are characterized by explicit indirect EU ETS costs close to the lower value of that range.

Primary and downstream aluminium producers therefore face an extra cost because of the cost of CO2 is embedded in electricity prices. This is an additional cost, which these industries may not be able to pass fully on to the ultimate customers if they are active in a globally competitive sector. The aluminium industry also faced indirect costs in between 2008 and 2015, even if it only became formally part of the EU ETS in 2012.

Estimates for indirect costs per tonne of product for both primary aluminium, downstream producers and recyclers range widely over time and between installations, and are calculated using this formula[19]:

Indirect cost (€/t of product) =
Electricity intensity (kWh/t of product)
** Carbon intensity of electricity (Tonne of CO_2/kWh)*
** CO_2 Price (€/t of CO_2) * Pass-on rate*

- Yearly averages across the EU sample are simple averages. Weighing by consumption would bias the estimates as electricity consumption is a key Variable in the formula above.
- Carbon intensity of electricity is a constant per region, and does not take the reductions in carbon intensity of electricity production since 2012 into account. These estimates are therefore likely to be overestimations for the more recent years.
- Only purchased electricity, i.e. excluding self-generation, is subject to indirect ETS costs
- Two scenarios are calculated, based on the pass on rates equal to 0.6 and 1.

The estimates for indirect EU ETS costs (as shown in Table 50) have decreased steadily between 2008 and 2013 as EUA prices decreased sharply. Over 2014-2015 the estimates for indirect EU ETS costs increased again as EUA prices showed a slow and partial recovery.

Table 50. Estimates for Indirect EU ETS costs for primary aluminium, and recyclers and downstream producers, 2008-2015, two pass on rates (€/t of product)

	2008	2010	2012	2013	2014	2015
Pass on rate: 0.6						
Primary aluminium	147.40	91.50	46.85	27.72	36.83	48.18
Downstream and recyclers	6.11	4.05	2.01	1.16	1.48	1.96
Pass on rate: 1						
Primary aluminium	245.67	152.49	78.09	46.19	61.38	80.23
Downstream and recyclers	6.11	4.05	2.01	1.16	1.48	1.96

Source: Authors' elaboration on data from: European Energy Exchange (2016) and European Commission (2012)

Estimates show that a share of the energy component could be accounted for by indirect EU ETS cost, with EUA prices as the main driver. In 2008, indirect EU ETS costs estimates (pass on rate 1) accounted for over 50% of electricity expenditure of the average of the EU sample per tonne of primary aluminium. By 2013 this had fallen to 9%, and by 2015 it had recovered to 19%.

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[19] This formula and the sources of the data used are discussed in depth in the Methodology Chapter under Section 1.10.

The same trend can be distinguished with respect to production costs. EU ETS indirect costs, as estimated above, accounted for 14% of production costs for primary smelters in 2008, but this share dropped markedly to just over 2% in 2013. Since then it has recovered somewhat and accounted for 3.5% of production costs in 2015.

Table 51 Share of indirect EU ETS costs in weighted average production costs (%) (pass -on rate of 1)

2008	2010	2012	2013	2014	2015
13.99%	9.04%	3.63%	2.38%	3.26%	3.55%

Source: Authors' own elaboration.

These changes are primarily driven by the evolution of EUA prices, though changes in electricity intensity of production also played a minor role.

Note that these estimates are characterized by some limitations:

- primary aluminium smelters were shielded from indirect costs in the past through self-generation and long-term electricity contracts, however most – if not all – of these contracts have ended by now. In 2013 at least 4 smelters had long term contracts with electricity providers that date from before the launch of the EU ETS. In other words, those plants did not face any indirect costs because their electricity price was negotiated before the EU ETS was incorporated into the price structure[20]. In 2013 one smelter also indicated that half their electricity was provided by carbon-neutral generation. This plant did however not provide data on this issue for this study.
- In some countries aluminium producers are eligible for (partial) compensation of their indirect EU ETS costs based on performance benchmarks. The level of compensation differs for each country. Currently, aluminium companies are eligible for ETS compensation in all the countries that are giving or intend to give compensation, for the 2013-2020 period. The countries that have received clearance from the European Commission to give indirect ETS compensation are Germany, Netherlands, Belgium (Flanders only), UK, Norway, Spain, Greece, Slovakia and Lithuania. A few notes here:
    - Spain has only indicated to give compensation for 2014-2015. So far, there is no indication of compensation for the remaining period of Phase 3 of the EU ETS.
    - The research team has not been able to confirm that Greece is actually handing out compensation, despite them also having adopted national legislation to enable this.
    - 12 out of 16 EU smelters are located in these Member States, however no comprehensive data is publically available on the monetary value of these compensation measures.

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[20] CEPS-EA (2013) Cumulative Cost Assessment

Estimates for downstream producers and recyclers are in a different order of magnitude because of far lower electricity consumption. The average of estimates for indirect costs for the plants in this sample also decreased between 2008 (6.11€/) and 2013 (1.16 €/t), after which they started rising and reached 1.96 €/t. Please note that the respondents in the downstream and recyclers sample are highly diverse, and that these estimates are dominated by a small number of high electricity consuming plants. Estimates that exclude the largest plants are around 5% higher, as these large plants are typically located in North-Western Europe, a region with a relatively low maximum regional carbon intensity of electricity production.

4.10 Energy bill components – recycling and downstream producers

The recycling and downstream producers sample contains a variety of plants that differ in terms of size, product, technology and geographic location. Therefore, the figures in this section show large differences in energy prices paid by the plants in this sample.

Please note that the EU averages in this section are only weighted by energy consumption, as weighting by production would not provide a meaningful comparison due to the large differences in products and value added of products across the respondents. As the respondents include both small and large plants, weighing by consumption does skew the averages towards the large plants (typically the already more energy-intensive rolling mills).

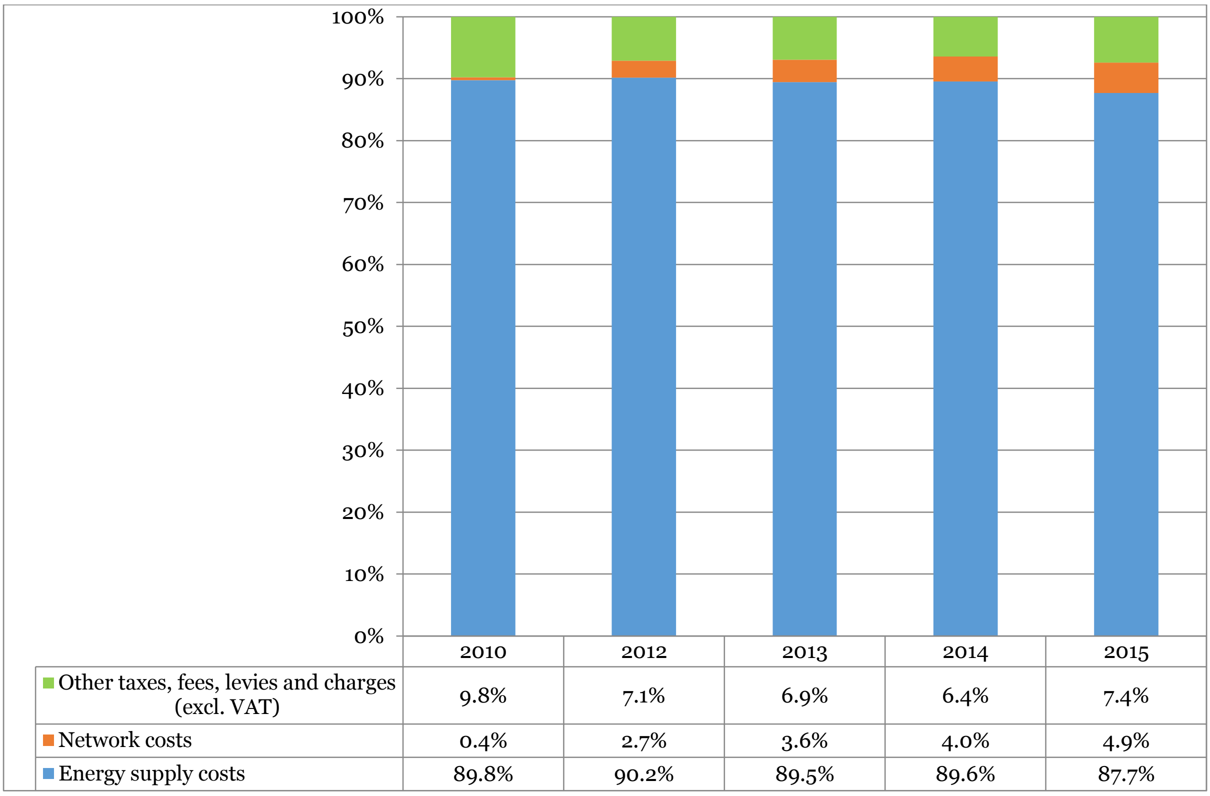
4.10.1 Gas bill components – recycling and downstream producers

Figure 53 represents the shares of the different gas price components in the natural gas bills of the sampled recycling and downstream producers. For 2008 only six observations made it through the validation process. For 2010-2015 10 plants are in these graphs. The differences between plant sizes between the six plants in 2008 and the 10 plants for the rest of the period were too large, therefore the research team has chosen to limit this analysis to the 2010-2015 period.

Figure 53 shows a different picture than Figure 49 (components of natural gas bills for primary producers). Energy supply costs are consistently around 90% of the total bills, with a minimum of 87.7% in 2015. Network supply costs increased significantly from 0.4% of gas bills in 2010 to 4.9% in 2015. However, this result is biased as two plants indicated that their network costs were not separately reported on their bills in 2010 and 2012, but were a part of the reported energy supply component. When replicating the analysis without these two plants the network component increases to 6% of natural gas bills for the plants that have responded in in 2012, with a corresponding decrease in the energy component.

The third component (Other taxes, fees, levies and charges) was more significant than Network costs, but decreased from 9.9% in 2010 to 7.4% in 2015. It is not possible to drive any robust conclusions from this increase as the contents of this component vary between Member States, between small and large plans and over years.

Figure 53. Components of the natural gas bills paid by the sampled recycling and downstream producers in the EU (%) 2010 -15, EU annual averages, weighted by consumption



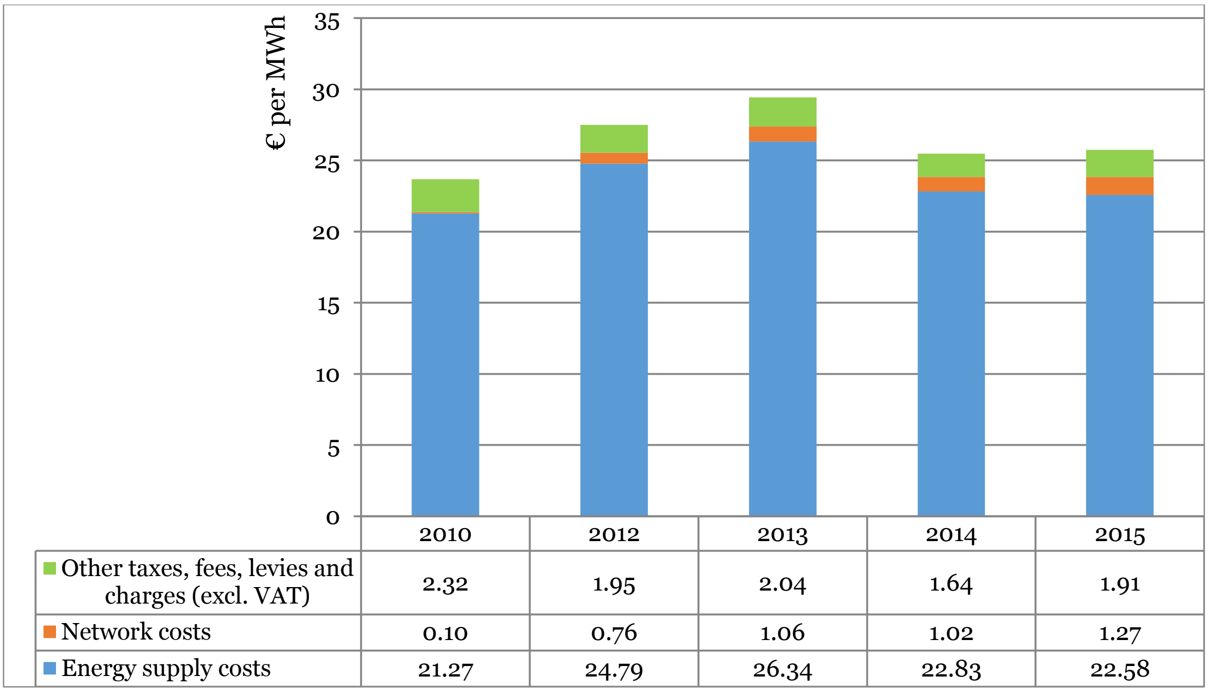
	2010	2012	2013	2014	2015
🟩 Other taxes, fees, levies and charges (excl. VAT)	9.8%	7.1%	6.9%	6.4%	7.4%
🟧 Network costs	0.4%	2.7%	3.6%	4.0%	4.9%
🟦 Energy supply costs	89.8%	90.2%	89.5%	89.6%	87.7%

Source: Authors' own elaboration.

Figure 54 shows that gas prices and their components have evolved over time. Energy supply costs were at a low of 21.27 €/MWh in 2010 and increased to 26.34 €/MWh in 2013. By 2015 they had fallen again to 22.58 €/MWh. Network costs were relatively small in 2010 (0.10 €/MWh), but increased by a factor of 12 to reach 1.27 €/MWh in 2015. If we leave out those plants that indicated that their network costs were not presented separately on their energy bills, network costs were 0.20€/MWh in 2010, and increased to 1.46 €/MWh by 2012 and consequentially the energy component was 0.18 €/MWh higher at 24.97 €/MWh.

Other taxes, fees, levies and charges have been significant over the 2010-2015 period, between 1.64 €/MWh in 2014 and 2.32 €/MWh in 2010. In 2015 Other taxes, fees, levies and charges stood at 1.91 €/MWh for these respondents.

Figure 54. Components of the natural gas bills paid by the sampled recycling and downstream producers in the EU (€) 2010 -15, EU annual averages, weighted by consumption

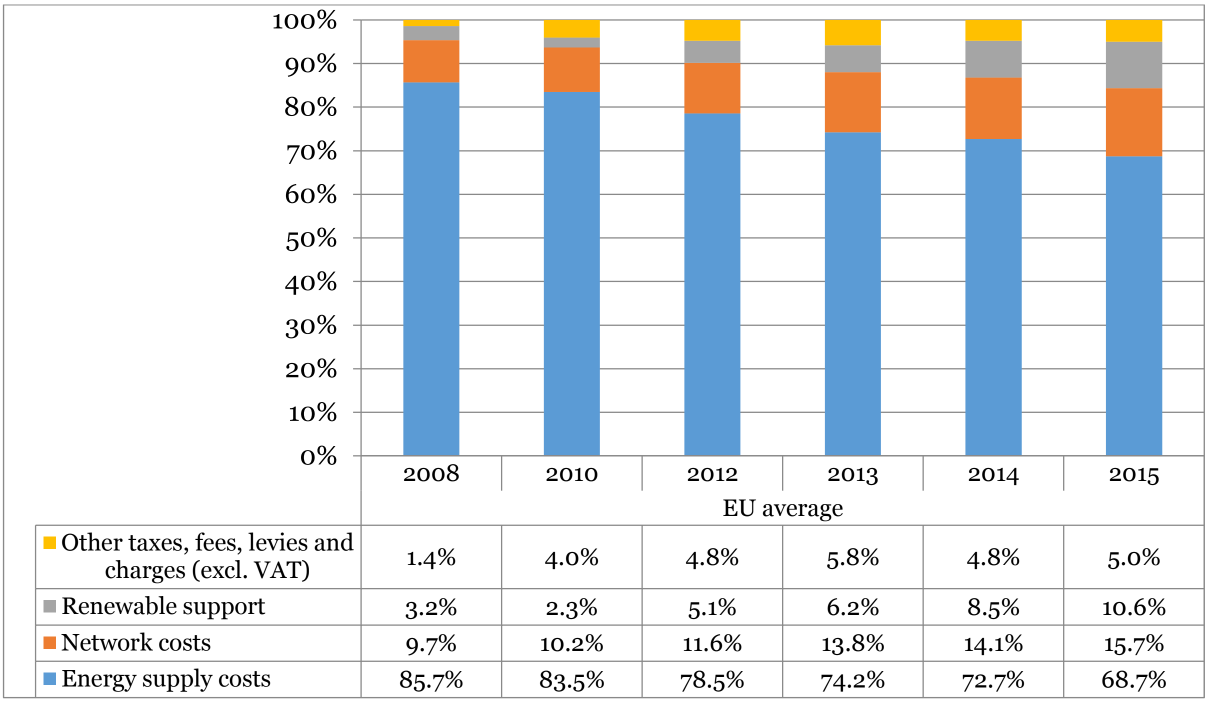


	2010	2012	2013	2014	2015
🟩 Other taxes, fees, levies and charges (excl. VAT)	2.32	1.95	2.04	1.64	1.91
🟧 Network costs	0.10	0.76	1.06	1.02	1.27
🟦 Energy supply costs	21.27	24.79	26.34	22.83	22.58

Source: Authors' own elaboration.

4.10.2 Electricity bill components – recycling and downstream producers

Figure 55. Components of the electricity bills paid by the sampled recycling and downstream producers in the EU (%) 2008 -15, EU annual averages, weighted by consumption



	2008	2010	2012	2013	2014	2015
	EU average					
🟨 Other taxes, fees, levies and charges (excl. VAT)	1.4%	4.0%	4.8%	5.8%	4.8%	5.0%
⬜ Renewable support	3.2%	2.3%	5.1%	6.2%	8.5%	10.6%
🟧 Network costs	9.7%	10.2%	11.6%	13.8%	14.1%	15.7%
🟦 Energy supply costs	85.7%	83.5%	78.5%	74.2%	72.7%	68.7%

Source: Authors' own elaboration.

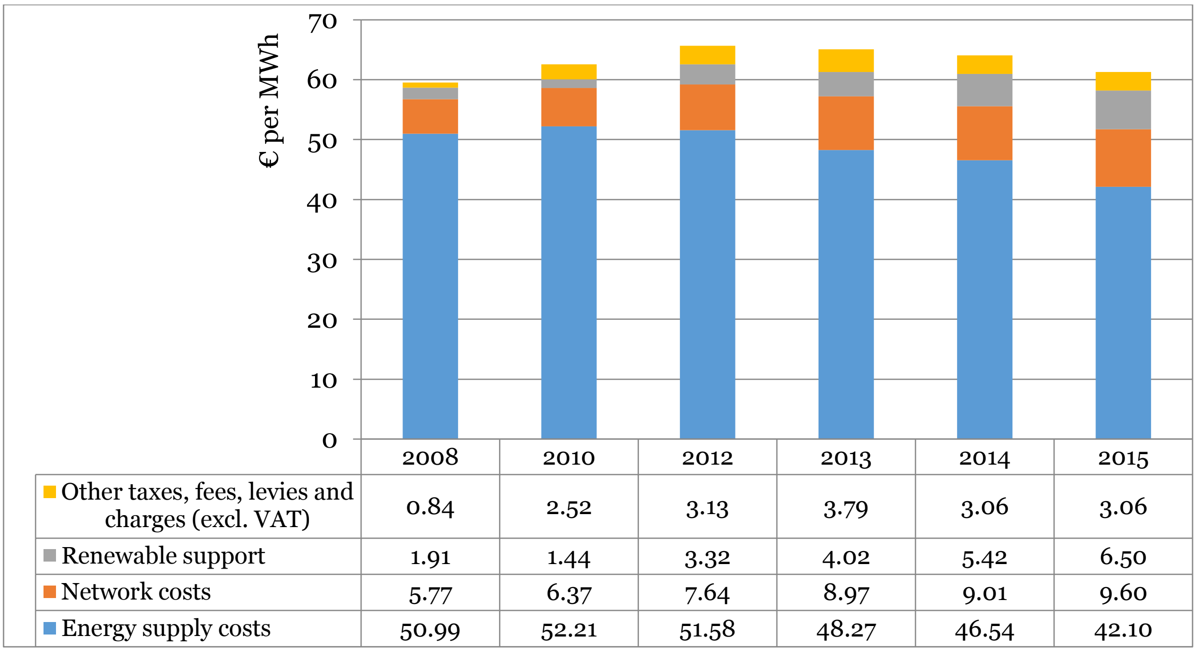
In Figure 55 data from 9 recyclers and downstream producers is included for 2008 and 11 plants are included for 2010-2015.

Figure 55 shows a very different picture than Figure 51 (electricity price components for primary aluminium producers) as the energy supply component is far less dominant for recyclers and downstream producers. For primary producers the energy supply component accounted for around 90% of electricity bills, but for recyclers and downstream producers its share has decreased steadily from 85.7% in 2008 to just 68.7% in 2015.

Renewable energy support and network costs have grown steadily. Renewable support grew from 3.2% in 2008 to 10.6% in 2015, while network costs went from 9.7% of electricity bills in 2008 to 15.7% in 2015.

Other taxes, fees, levies and charges fluctuated over this period; increasing from 1.4% of costs in 2008 to 5.8% in 2013 and subsequently decreasing to 5% in 2015.

Figure 56. Components of the electricity bills paid by the sampled recycling and downstream producers in the EU (%) 2008 -15, EU annual averages, weighted by consumption



	2008	2010	2012	2013	2014	2015
🟨 Other taxes, fees, levies and charges (excl. VAT)	0.84	2.52	3.13	3.79	3.06	3.06
⬜ Renewable support	1.91	1.44	3.32	4.02	5.42	6.50
🟧 Network costs	5.77	6.37	7.64	8.97	9.01	9.60
🟦 Energy supply costs	50.99	52.21	51.58	48.27	46.54	42.10

Source: Authors' own elaboration.

Analysis of the EU average prices in Figure 56 sheds more light on the evolutions described in Figure 55. The share of energy supply costs in the EU-average electricity bill for recycling and downstream producers has dropped steadily, mostly caused by a decrease in the absolute value of the energy supply cost component. Energy supply costs fell from 50.99 €/MWh in 2008 to 42.10 €/MWh in 2015. During the same period the average total price per MWh for the respondents from 59.5€/MWh in 2008 to 65.67€/MWh in 2012, but by 2015 is had fallen to 61.27 €/MWh.

Regulated cost components are, together with the evolution of the energy component, also a factor behind this evolution of electricity prices for recycling and downstream producers. While the energy component decreased steadily over the 2012-2015 period, the regulated components (Renewable support, Network costs and Other taxes, fees, levies and charges) increased from 8.51 €/MWh in 2008 to 19.17 €/MWh in 2015. All three regulated cost components grew over this period, but Renewable support increased the most in absolute terms (from 1.91 € in 2008 to 6.50 € in 2015, a growth of over 340%).

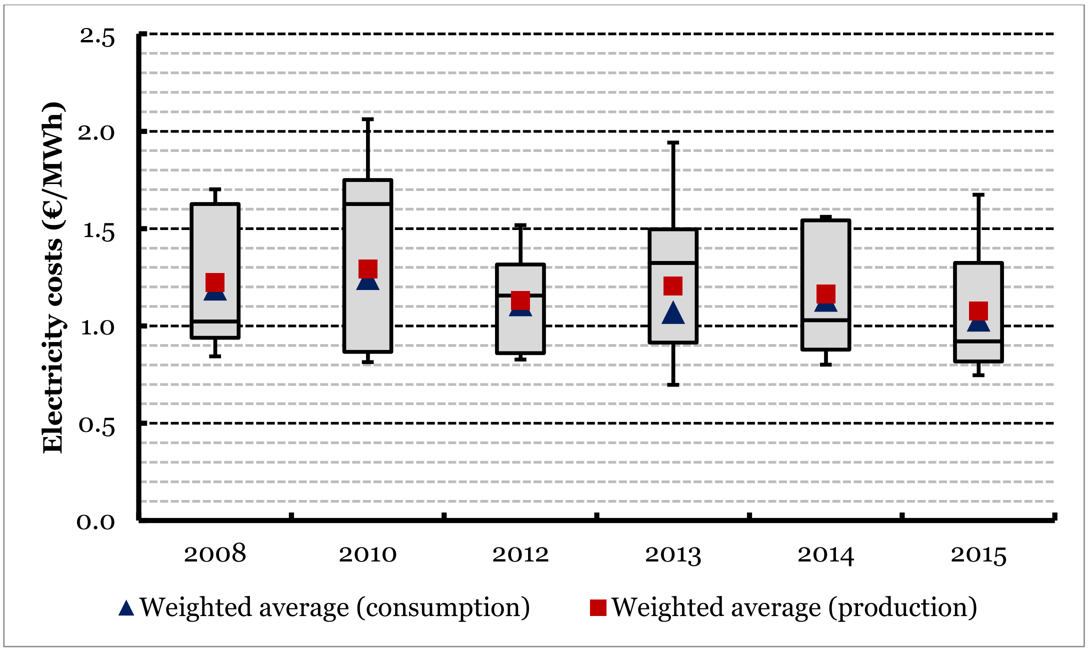
4.11 Energy intensity – primary aluminium

Energy intensity is calculated as the ratio between the consumption of electricity and gas consumption in MWh over total production in tonne. In this section, the analysis of natural gas intensity, electricity intensity and energy intensity (that is electricity and natural gas) are described via box plots.

4.11.1 Natural gas intensity

Natural gas is a minor carrier for the primary aluminium sector, and therefore it was considerably more challenging to engage with companies on providing comprehensive natural gas figures.

Figure 57. Natural gas intensity per tonne of primary smelter production (2008-2015)



Source: Authors' own elaboration.

Table 52. Descriptive statistics for gas intensity (MWh/t, 2008-2015)

	2008	2010	2012	2013	2014	2015
Number of respondents	**5**	**5**	**5**	**6**	**7**	**6**
EU - Weighted Average (consumption)	1.19	1.24	1.11	1.07	1.13	1.03
EU - Weighted Average (production)	1.22	1.29	1.13	1.20	1.16	1.08
EU - Median	1.02	1.63	1.16	1.32	1.03	0.92
EU - Inter-Quartile Range	0.7	0.9	0.5	0.6	0.7	0.5
EU - Minimum	0.84	0.82	0.83	0.70	0.80	0.75
EU - Maximum	1.70	2.06	1.52	1.94	1.56	1.67
EU - Relative Standard Deviation (weighted average, consumption)	34.01%	44.66%	26.65%	43.45%	31.46%	36.82%
EU - Relative Standard Deviation (weighted average, production)	33.13%	43.00%	26.16%	38.66%	30.62%	35.26%

Source: Authors' own elaboration.

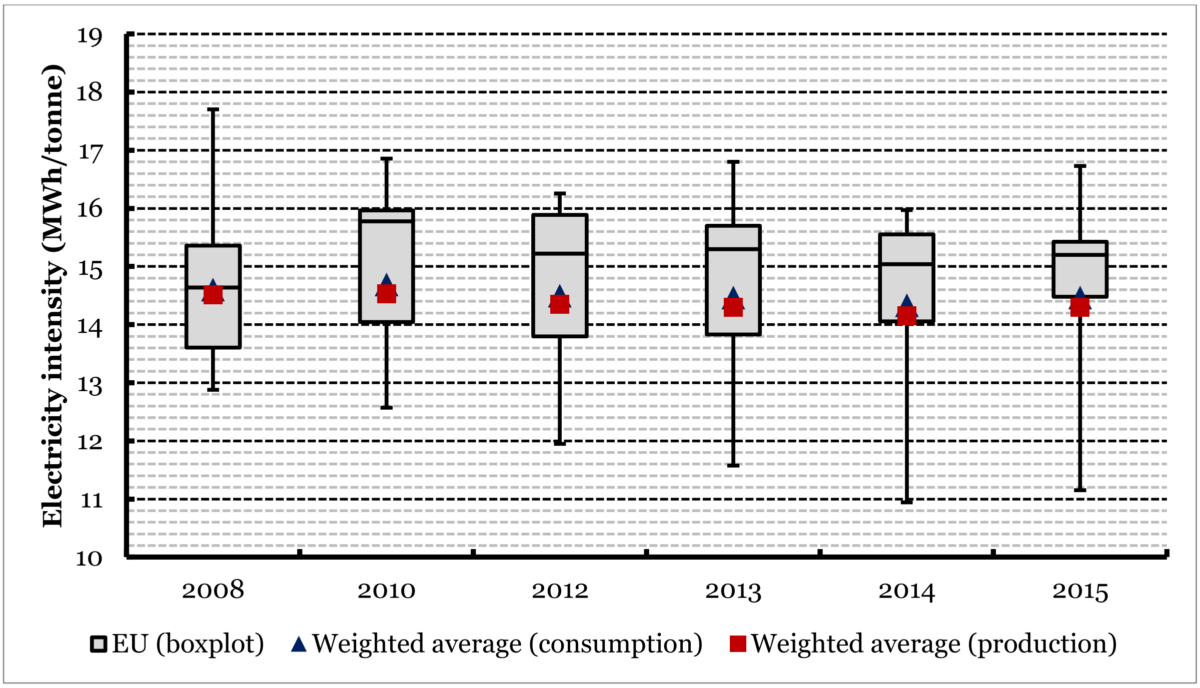
The natural gas intensity of primary aluminium production is significantly lower than the electricity intensity discusses below. However, per tonne of aluminium on average 1-1.3 MWh of natural gas is consumed across the respondents. There is however a very large disparity between different plants, which is shown by high relative standard deviations (between 26 and 45%).

This large variation is caused by a limited number of plants that are more gas intense that their peers with natural gas intensities above 1.7 MWh/t. The majority of the sample consumes significantly less: 1 MWh/t or less. The main outlier in 2010 (with a natural gas intensity of over 2 MWh/t) is one plant that lowered production by nearly 20% since 2008, likely due to the economic crisis. That same plant reached a natural gas intensity of just over 1.3 MWh/t in 2012 as production came close to levels reached in 2008. The decrease in production led the plant away from its normal level of energy efficiency.

When replicating the analysis using only those 5 plants for which useable data was available for the entire 2008-2015 period, similar findings appears. Note that one of the plants that didn't provide data for the entire period is the outlier in 2013 (natural gas intensity of over 1.9 MWh/t). Dropping this plant does result in slightly lower weighted averages of natural gas intensity for the respondents.

4.11.2 Electricity intensity

Figure 58. Electricity intensity per tonne of primary smelter production (2008-2015)



Source: Authors' own elaboration.

Table 53. Descriptive statistics for electricity intensity (MWh/t, 2008-2015)

	2008	2010	2012	2013	2014	2015
Number of respondents	**8**	**9**	**8**	**8**	**10**	**12**
EU - Weighted Average (consumption)	14.60	14.69	14.49	14.46	14.33	14.46
EU - Weighted Average (production)	14.51	14.53	14.35	14.29	14.15	14.30
EU - Median	14.64	15.78	15.22	15.30	15.04	15.20
EU - Inter-Quartile Range	1.76	1.92	2.09	1.87	1.50	0.95
EU - Minimum	12.88	12.57	11.95	11.57	10.94	11.15
EU - Maximum	17.70	16.85	16.26	16.80	15.97	16.73
EU - Relative Standard Deviation (weighted average, consumption)	10.38%	10.97%	10.60%	11.73%	11.03%	10.33%
EU - Relative Standard Deviation (weighted average, production)	10.44%	11.09%	10.71%	11.87%	11.17%	10.45%

Source: Authors' own elaboration.

The analysis of electricity intensity for the primary sector is more robust than the comparable analysis of gas intensity of production as 12 plants are included. For 2008, 2012 and 2013 8 plants are included, this increases to 10 for 2014 and 12 for 2015. In 2010 9 plants were included. One smelter that provided data was dropped from the analysis as other production processes on site (such as remelting) were significantly skewing their data.

Three things are clear from this data. First, one large plant is significantly less energy intense than its peers. Overall larger smelters in Europe are significantly less electricity intensive than the smaller plants, which pulls the weighted averages down.

Second, the weighted averages stayed relatively stable, the average of these respondents weighted by production was between 14.15 and 14.53 MWh/t. The simple EU average of the responding plants varied between 14.54 and 15.07 MWh/t. However, the observed slight decrease in electricity intensity of production (consumption weighted averages decreased from 14.60 MWh/t in 2008 to 14.46 MWh/t in 2015) cannot be identified as a robust trend due to the observed fluctuations over this relatively short period.

The changes in electricity intensity are more likely to have been caused by changes in production output, and not by structural changes caused by investments in electricity efficiency. The data does however not present a clear case for either hypothesis.

Primary aluminium production is a very electricity intensive sector, and makes it an outlier in terms of electricity consumption and intensity when compared to the other sectors analysed in this study.

Third, the divergence in electricity intensity between plants is high, with the small number of plants using the Soderberg technology in the upper ranges, and plants using various pre-baked anodes, the majority of EU plants, in the lower ranges of electricity intensity.

The picture changes somewhat when only using the 8 smelters with data for all years under scrutiny (representing over 60% of EU production capacity). The electricity intensity of production of these plants (weighted by production) has decreased from 14.51 MWh/t in 2010 to 14.03 MWh/t in 2015. Over the same period time the simple EU average of these respondents has decreased from 14.97 MWh/t to 14.50 MWh/t. Comparing these two different averages show us that the plants with higher levels of production have (*ceteris paribus*) lower electricity intensities.

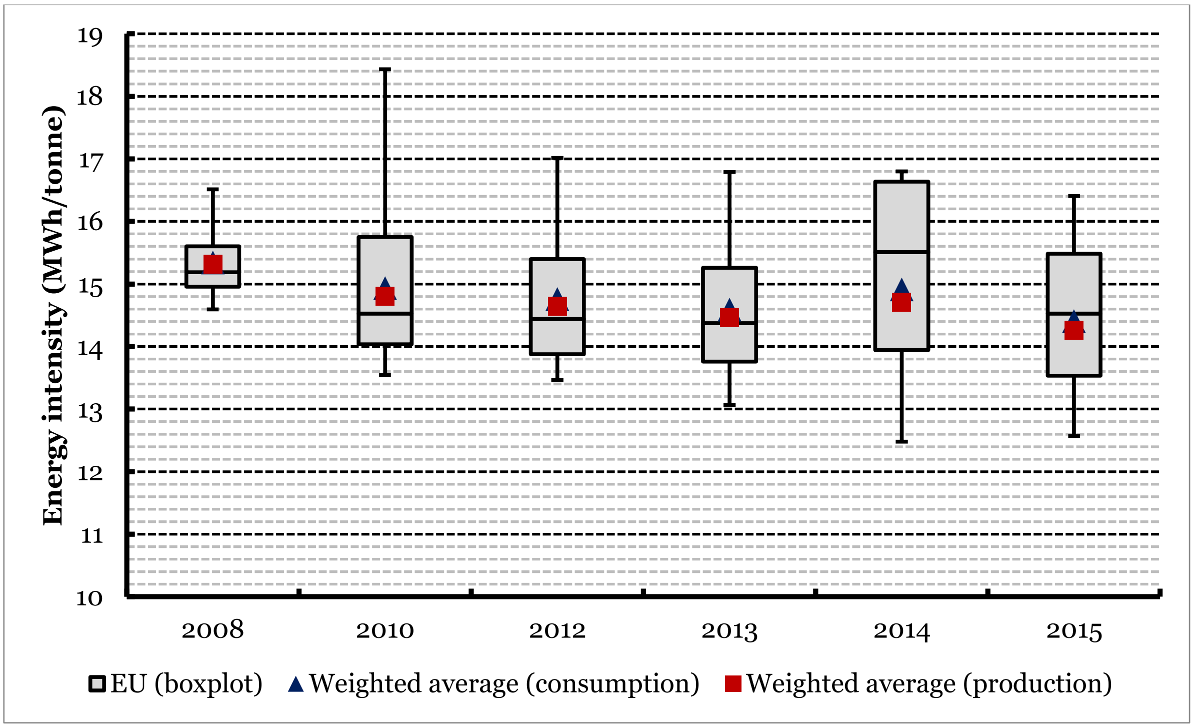
Table 54. Descriptive statistics when only using plants that provided data for all years for electricity intensity (MWh/t, 2008-15)

	2008	2010	2012	2013	2014	2015
Number of respondents	8	8	8	8	8	8
EU - Weighted Average (consumption)	14.60	13.43	14.49	14.46	14.12	14.24
EU - Weighted Average (production)	14.51	14.48	14.35	14.29	13.92	14.03
EU - Median	14.64	15.50	15.22	15.30	14.91	15.31
EU - Inter-Quartile Range	1.76	2.44	2.09	1.87	1.90	2.09
EU - Minimum	12.88	12.57	11.95	11.57	10.94	11.15
EU - Maximum	17.70	16.85	16.26	16.80	15.97	16.73
EU - Relative Standard Deviation (weighted average, consumption)	10.38%	12.60%	10.60%	11.73%	11.95%	12.88%
EU - Relative Standard Deviation (weighted average, production)	10.44%	11.69%	10.71%	11.87%	12.12%	13.08%

Source: Authors' own elaboration.

4.11.3 Energy intensity

Figure 59. Energy intensity per tonne of primary smelter production (2008-2015)



Source: Authors' own elaboration.

Table 55. Descriptive statistics for energy intensity (MWh/t, 2008-2015)

	2008	2010	2012	2013	2014	2015

Number of respondents	**4**	**4**	**4**	**4**	**4**	**4**
EU - Weighted Average (consumption)	15.3	14.9	14.8	14.6	14.3	14.2
EU - Weighted Average (production)	15.3	14.8	14.6	14.5	14.1	14.1
EU - Median	15.19	14.53	14.44	14.37	14.16	14.03
EU - Inter-Quartile Range	0.6	1.7	1.5	1.5	1.6	1.7
EU - Minimum	14.59	13.54	13.46	13.07	12.48	12.57
EU - Maximum	16.51	18.43	17.01	16.79	16.45	16.41
EU - Relative Standard Deviation (weighted average, consumption)	47.94%	50.31%	48.86%	48.89%	49.00%	49.05%
EU - Relative Standard Deviation (weighted average, production)	48.03%	50.75%	49.26%	49.34%	49.57%	49.57%

Source: Authors' own elaboration.

For the analysis on total energy intensity of production, only those 4 plants with full questions were used. Two other plants provided data that was useable for respectively 1 and 2 years. However, this data was not used as one of those plants is an outlier in terms of gas intensity of production.

Relative standard deviations are very high for this sample (circa 50%), which indicates that the energy intensity of production of the respondents is very diverse. This makes it challenging to analyse in detail the trend in energy intensity and possible factors behind it. The extreme outlier in 2010 is due to a plant that greatly reduced production between 2008 and 2010, after which production recovered by 2012 to levels close to the 2008 production levels.

Average energy intensity (weighted by production) reached 15.31 MWh/t in 2008, but dropped to 14.26 MWh/t in 2015. However, these results cannot be deemed to be as representative of the full EU primary aluminium industry as other sections of the analysis, as these 4 plants account for 36% of EU production capacity. The section on electricity intensity of production is therefore deemed more robust and representative.

Note that the weighted averages of energy intensity are only slightly higher (and for 2015 even lower) than the weighted averages of electricity intensity above. Though not intuitive, this is due to the differences between respondents. The section on electricity intensity contains three extra plants that are more electricity intensive, while data on their gas intensity was not available. The section on natural gas intensity contains one plant with relatively high natural gas intensity, however the electricity intensity data of this plant could not be used for this section on total energy intensity.

4.12 Energy intensity – recycling and downstream producers

The recycling and downstream producers sample contains a variety of plants that differ in terms of size, product, technology and geographic location. Therefore, it is not considered useful to include in-depth analysis of the overall recyclers and downstream sectors. Comparisons within subsectors (such as rollers or extruders) is also not possible as even within subsectors the heterogeneity of production processes included in each individual plant is too large as described in chapter 4.6.3.

4.13 International comparison

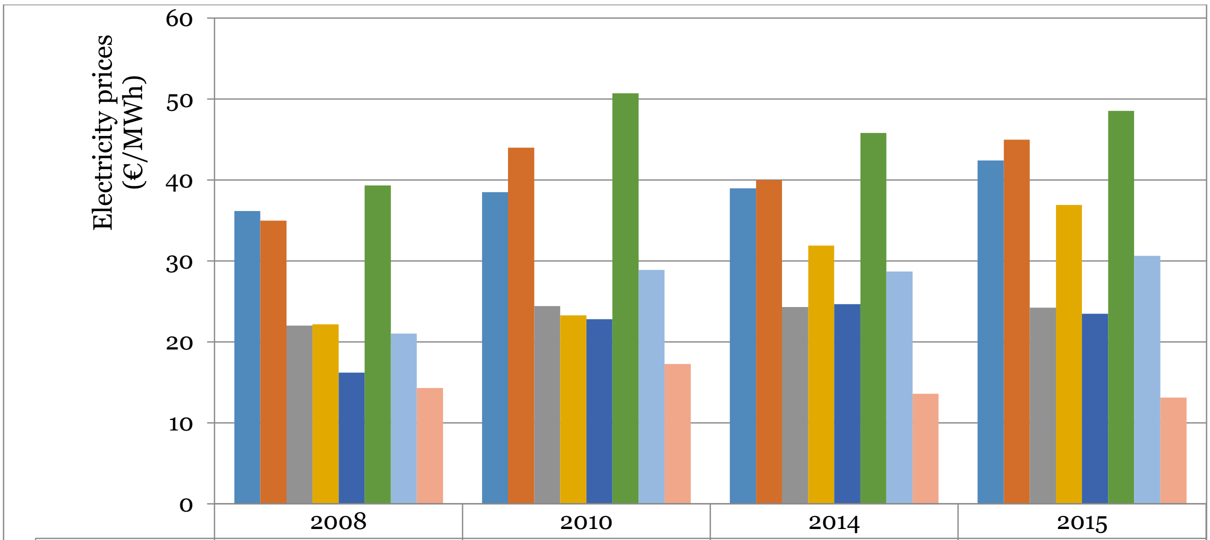
The non-EU data on gas and electricity prices and plant production used for this international comparison between the EU and major aluminium trading partners has been acquired from CRU. The research team validated the CRU data using detailed data from five Norwegian smelters obtained through a dedicated international questionnaire and phone call interviews with Norwegian primary aluminium producers.

The EU data used in this international comparison is the data gathered during this study (through questionnaires to EU primary smelters) and is the data used in the other sections of the aluminium section of this report.

The choice of countries for this comparison is based on the major aluminium producing regions and the EU's main import and export markets for primary aluminium as discussed in Section 4.4.

4.13.1 International comparison of electricity prices

Figure 60. International comparison of electricity prices paid by primary aluminium producers[21] (2008-2015), in €/MWh[22]



	2008	2010	2014	2015
■ EU	36.15	38.51	38.98	42.44
■ Australasia	35.00	44.00	40.00	45.00
■ Nordic region	22.02	24.44	24.31	24.23
■ Middle East	22.17	23.26	31.90	36.90
■ CIS	16.21	22.82	24.65	23.48
■ China	39.33	50.72	45.82	48.53
■ USA	21.04	28.88	28.68	30.62
■ Canada	14.31	17.27	13.58	13.13

Source: CEPS and EA (2013) *Cumulative Cost Assessment for the Aluminium Industry,* CRU (2013 and 2016) and Authors' own elaboration.

The differences in electricity prices paid by primary aluminium producers across the world are stark. EU producers in 2015 paid significantly more (42.44 €/MWh) than producers in some other regions such as Canada (13.13 €/MWh), CIS (23.48 €/MWh), Nordic countries (24.23 €/MWh) the US (30.62 €/MWh) and the Middle East (36.90 €/MWh).

These differences are caused by different factors depending from region to region. The Nordic region (Island and Norway) and Canada are characterised by significant hydro-electric power plants that are often owned or operated by the producers of primary aluminium. This enables the smelters to acquire electricity at production cost. CIS, the US and the Middle East are characterized by low electricity prices fuelled partially by an abundance of fossil fuels. It is clear that EU producers have a significant competitive disadvantage when compared to producers in these regions, especially as

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[21] EU respondents: 8 (2008 -10), 10 (2014 -15), CIS: 8, China 47 (2008), 58 (2010), 93 (2014), 93 (2015), USA: 8, Canada: 9 (2008 -10), 10 (2014 -15), Australasia: 3 (2008-2010), 6 (2014-2015) Middle East: 2 (2008), 3 (2010 -15)

[22] Countries included in each of the regions: Australasia – Australia, Nordic region - Iceland, Norway, Middle East - Turkey, UAE, CIS - Azerbaijan, Kazakhstan, Russia, Tajikistan, Ukraine

aluminium prices are set at the international level at the London Metals Exchange. However, primary aluminium plants that operate close to downstream users, or have a certain degree of vertical integration, face a considerably lower competitive disadvantage.

While electricity prices for EU producers are higher than those for primary aluminium producers in these other countries and regions, the differences have fallen between 2008 and 2015 (except when comparing to Canada). The sharpest decreases of differences in electricity prices can be observed when comparing with the US, CIS and especially the Middle-East. In 2008 EU primary aluminium producers paid over 60% more for their electricity than plants in the Middle East. This difference has fallen to 15% by 2015.

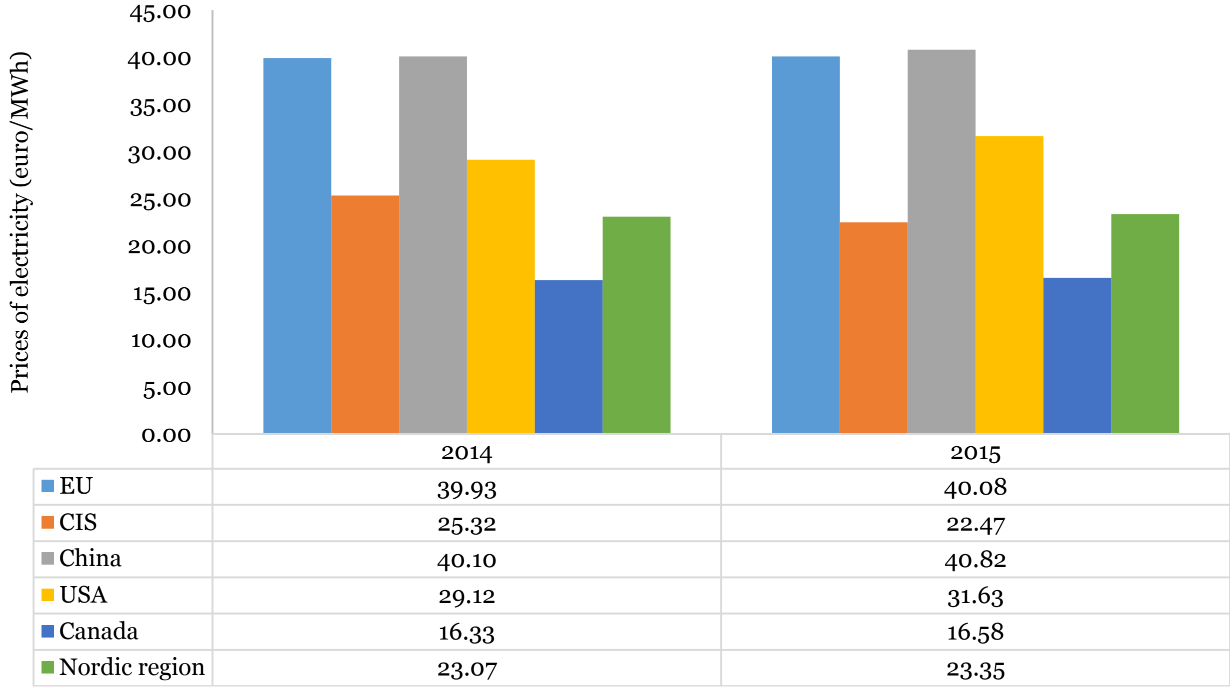
Electricity prices in one region – Australasia – were lower than prices paid by EU producers in 2008, but have since caught up and even surpasses EU price levels by 2015.

One other aluminium producing and trading country is characterized by consistently higher prices for electricity: China. However, the picture for China is unclear as both primary aluminium producers and electricity providers are (at least partially) controlled by the local or central governments. CRU takes the potential under- or overvaluation of currencies into account when compiling international data.

Figure 60 also makes it clear that electricity prices for primary aluminium smelters across the world vary significantly from year to year. It is therefore unwise to use this data to forecast future evolutions or differences in competiveness.

When comparing the averages prices, weighted by production, across a smaller set of countries and regions (see Figure 61) for 2014 and 2015, the same picture appears. Main competitors such as the Nordic region (Iceland and Norway), USA, Canada and CIS have significantly lower prices. Note that the weighted averages in China are significantly lower for 2014 and 2015 than the simple averages represented above.

Figure 61. Prices of electricity - EU vs. international (€/MWh, averages weighted by production) (EU, CIS, US, China, Canada, Nordic region) 2014 -15[23]

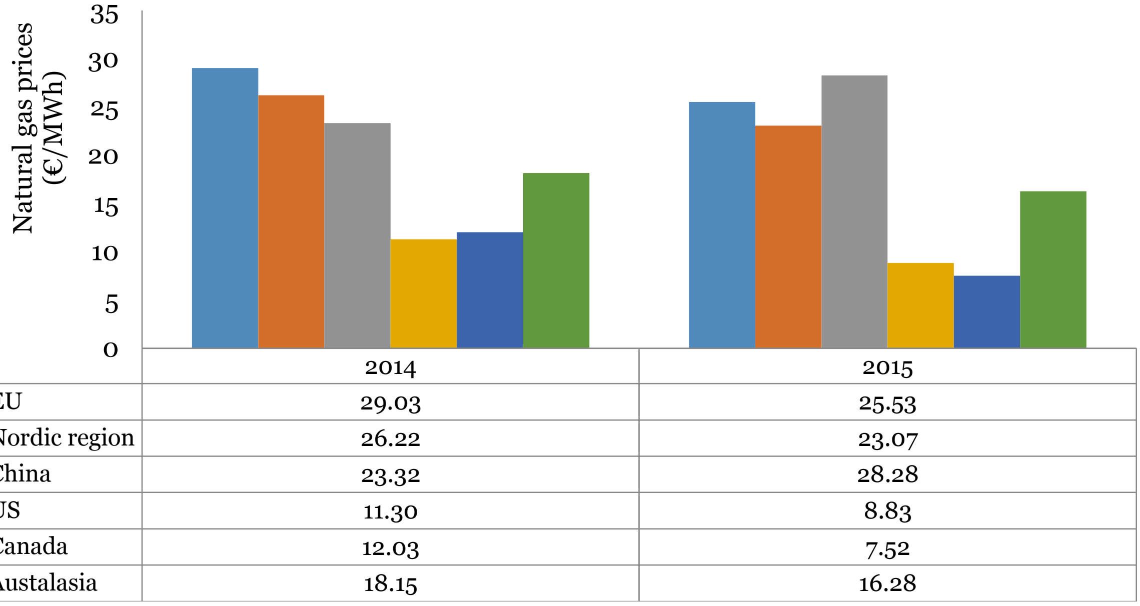


	2014	2015
EU	39.93	40.08
CIS	25.32	22.47
China	40.10	40.82
USA	29.12	31.63
Canada	16.33	16.58
Nordic region	23.07	23.35

Source: CRU (2016) and Authors' own elaboration.

4.13.2 International comparison of gas prices

Figure 62. Prices of natural gas - EU vs. international (€/MWh, weighted by production) (EU, Nordic region, CIS, US, China, Canada, Australasia) 2014 -15[24]



	2014	2015
EU	29.03	25.53
Nordic region	26.22	23.07
China	23.32	28.28
US	11.30	8.83
Canada	12.03	7.52
Austalasia	18.15	16.28

Source: CRU (2016) and Authors' own elaboration.

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[23] Number of observations: EU respondents: 8 (2008 -10), 10 (2014 -15), CIS: 8, China 47 (2008), 58 (2010), 93 (2014), 93 (2015), USA: 8, Canada: 9 (2008 -10), 10 (2014 -15)

[24] Number of observations: EU respondents: 6 (2014), 7 (2015), Nordic region: 6, China: 33 (2014), 34 (2015), Australasia: 5, US: 5, Canada: 9

Differences between international gas prices are less relevant for the competitive position of EU smelters, as natural gas is far less important than electricity as energy carrier.

Natural gas prices in the EU are the highest over regions analysed for 2014. In 2015 however, Chinese natural gas prices surpassed EU prices. However, as mentioned above, it is challenging to draw strong conclusion from this as in China both primary aluminium producers and electricity providers are (at least partially) controlled by the central government.

More relevant is the comparison with the Nordic region (Iceland and Norway), the US and Canada as these regions are major aluminium trading partners of the EU. EU natural gas prices are significantly higher than in all the three regions; 11% higher than Nordic gas prices, 340% higher than Canadian gas prices (2015) and 289% higher than US gas prices. This could be caused by the abundance of fossil fuels (including shale gas) in those regions.

4.14 Key performance indicators and impact of energy costs

This section includes the information retrieved from sampled companies concerning Key Performance Indicators (KPI), which are production costs, margins, and turnover. The purpose of retrieving and processing these data is not to provide a financial analysis of responding plants, but to analyse the impact of energy costs – for both gas and electricity – over financial indicators, namely production costs and margins. Descriptive cumulative values for KPI, as provided by responding plants are shown in Table 56. Note that this analysis is also limited to the primary aluminium sector.

The number of respondents per variable are shown in between brackets. The research team has chosen, due to confidentiality concerns, not to include data for variables and years with less than 5 observations. As this data is considered very sensitive by companies, it has proven challenging to gather and validate data on KPIs. As in other sections, only the data that is considered robust has been included in this analysis.

The lower rate of response for 2015 is due to companies still being in the process of compiling their internal data for these variables.

Table 56. Production costs, Operating costs, EBITDA, EBIT, Turnover, Profit/loss before tax, 2008-2015, weighted by consumption. Number of plants in brackets.

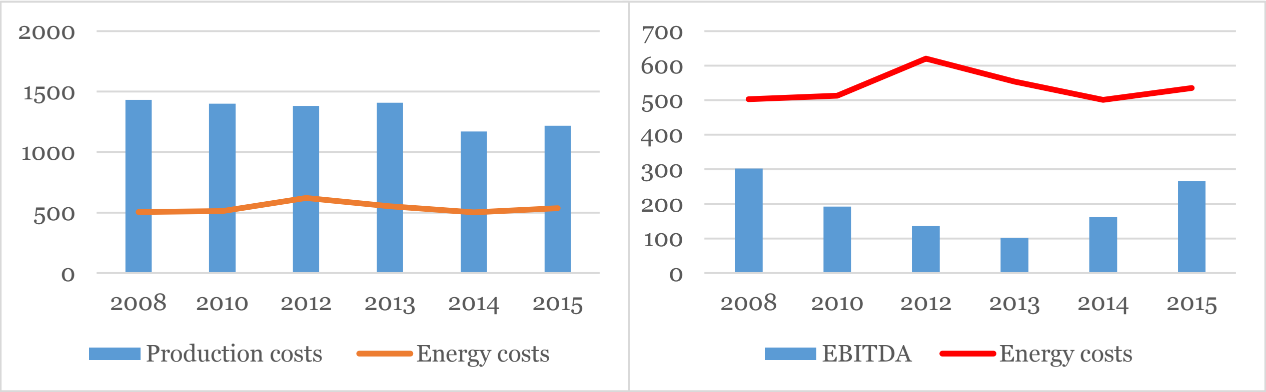
	2008	2010	2012	2013	2014	2015
Production costs (€/t)	--	€ 1600.73 (6)	€ 1766.33 (6)	--	€ 1706.89 (6)	--
Operating costs (€/t)	€ 2070.69 (6)	€ 2183.49 (6)	€ 2706.86 (6)	€ 2470.37 (6)	€ 2379.52 (6)	€ 2673.52 (6)
Turnover (€/t)	€ 2222.33 (7)	€ 2172.68 (7)	€ 2549.71 (7)	€ 2310.58 (7)	€ 2286.57 (7)	€ 2856.44 (6)
EBITDA (% of turnover)	15.75% (7)	11.37% (7)	8.01% (7)	5.66% (7)	9.03% (7)	10.26% (6)
EBIT (% of turnover)	12.27% (6)	9.09% (6)	4.83% (6)	0.74% (6)	4.80% (6)	7.26% (5)
Profit/loss before tax (% of turnover)	9.91% (6)	6.82% (6)	0.18% (6)	0.15% (6)	0.85% (6)	4.37% (5)

Source: Authors' own elaboration.

below represents the impact of energy costs over production costs based on the financial information provided by responding companies. Later below in this section, weighted averages at EU level are also provided.

For responding plants, energy costs represented between 12% and 46% of production costs in the period under analysis. The EU weighted average varied between 22.32% (2015) and 31.39% (2010). In absolute terms, energy costs per tonne of production varied following energy price trends, i.e. peaking in the 2012-2013 period and slowly declining up to 2015, but remaining higher in 2015 than in 2008. When compared to EBITDA, the importance of energy costs for primary aluminium producers are even clearer, as they are significantly larger than plants' margins across the whole period.

Figure 63. Impact of energy costs over production costs and EBITDA (2008-2015), in €.



Source: Authors' own elaboration.

Table 57 shows that energy costs, especially electricity costs, are a significant factor in overall production costs. Gas costs are less significant, but still account for between 1.21% and 1.67% of EU average production costs (weighed by production). Electricity costs represent between 21.1% and 30.1% of production costs. The year 2015 was characterised by the lowest percentage in terms of total production costs, and this is mostly due to a decrease in the weighted average electricity price for the plants included in this analysis.

Five plants are included in this analysis for 2008-2010; six plants for 2012-2015. The results do not change significantly when only including the five plants that reported data for all years.

Table 57. Impact of total energy costs on production costs (%), 2008-2015. Weighted averages from respondents of the sample, based on individual plant production.

	2008	2010	2012	2013	2014	2015
Electricity	29.58%	30.10%	26.90%	24.90%	22.24%	21.11%
Natural gas	1.67%	1.29%	1.25%	1.25%	1.42%	1.21%
Total	***31.25%***	***31.39%***	***28.16%***	***26.15%***	***23.66%***	***22.32%***

Source: Authors' own elaboration.

Table 58 includes data from 5 plants for 2008-2010 and 6 plants for 2012-2015. It indicates that regulated energy costs (Network costs, Renewable support, Other taxes, fees, levies and charges) are not the main impacting components of energy prices, but that the energy component itself is the dominant impacting component. For natural gas the impact of regulated cost components cannot be presented as not enough plants have reported both gas price components and margins.

Table 58. Impact of regulated energy costs on EBITDA (%), 2008-2015. Weighted averages from respondents of the sample, based on individual plant production.

	2008	2010	2012	2013	2014	2015
Electricity	**3.0%**	**2.8%**	**3.5%**	**4.3%**	**3.7%**	**3.3%**

Source: Authors' own elaboration.

Table 59 shows the impact of total electricity costs on margins. This impact is highly unstable, as it depends heavily on the margins in a given year. Therefore, it is not possible to draw any meaningful conclusions from this table.

Table 59. Impact of total electricity costs on margins (%), 2012-2015. Weighted averages from respondents of the sample, based on individual plant production – six plants.

	2012	2013	2014	2015
Electricity	**-381.2%**	**-838.2%**	**1770.5%**	**225.2%**

Source: Authors' own elaboration.

4.15 Concluding remarks

The analysis on the aluminium sector was concluded in two samples: the primary aluminium sample, and the recyclers and downstream sample.

The analysis on primary aluminium presents robust results for electricity prices, electricity price components, electricity intensity and international comparison of electricity prices. However, the results on natural gas prices, components and international comparison of natural gas prices are less robust due lower response rates, presumably as it is a significantly less important energy carrier for this industry. The results on key performance indicators are also less robust as many companies indicated that this type of data is too confidential to be shared with the research team.

The analysis on the recyclers and downstream producers is limited to energy prices and components, and while the results cannot be deemed representative for each of the subsectors in this sample (refiners, remelter, extruders and rolling mills), the results do show the wide diversity of energy prices across plants. The data provided by these plants was also used in the cross-sectoral analysis.

The EU average of electricity prices for sampled primary aluminium producers (weighted by consumption) amounts to 40.08 €/MWh in 2015, which is 12% higher than in 2008 but lower than the level reached in 2012 (44.52 €/MWh).

The EU median of electricity prices for sampled recyclers and downstream aluminium producers was 104.1 €/MWh in 2015. However, this is significantly different from the average (weighted by consumption): 62.8 €/MWh in that same year. A small number of large plants with high electricity consumption paid significantly less, which skews the weighted averages downwards. The median electricity prices of the sampled recyclers and downstream producers were 30% higher in 2015 when compared to 2008.

The split of electricity price components for primary smelters shows that the regulated price components play a limited role. The energy component accounted for nearly 90% for the entire 2012-2015 period. Renewable energy support accounted for 4.7% in 2015 (from 5.2% in 2012). Network costs increased significantly from 3.4% in 2012 to 6.5% in 2015. For recyclers and downstream producers, the regulated components are more relevant, and accounted for 31.3% in 2015. This share has increased substantially from 14.3% in 2008. These differences indicate that primary smelters were to a large degree exempted from network costs and renewable support measures, while recyclers and downstream producers were not.

Natural gas prices for primary aluminium producers and recyclers and downstream producers went through comparable trends: a substantial increase from 2008 to 2013 (primary aluminium: 26.15€/MWh to 31.78 €/MWh, recyclers and downstream producers: 27.75 €/MWh to 31.89 €/MWh), and a subsequent decrease up to 2015 (primary producers: to 26.37 €/MWh, recyclers and downstream producers: to 26.38 €/MWh).

Regulatory components accounted for 82.6% of natural gas bills in 2015, down from 87.9% in 2012 for sampled primary smelters, and for 87.7% of natural gas bills for sampled recyclers and downstream producers in 2015, a share that remained relatively stable since 2010.

With regards to international comparison of electricity prices paid across the globe EU primary aluminium producers paid significantly more for electricity in 2015 than producers in some other regions such as Canada, CIS, Nordic region (Norway and Iceland) the US and the Middle East. However, these differences in electricity prices have fallen between 2008 and 2015 (except when comparing to Canada). The sharpest decrease of differences in electricity prices can be observed when comparing with the Middle-East with the EU. While in 2008 EU primary aluminium producers paid over 60% more for their electricity than plants in the Middle East, this difference fell to 15% by 2015.

China is characterized by consistently higher prices for electricity, though the picture is unclear as both primary aluminium producers and electricity providers are (at least partially) controlled by local and central governments.

Natural gas prices in the countries and regions that are the main aluminium trading partners of the EU are significantly lower than gas prices in the EU. 11% higher than Nordic gas prices, 340% higher than Canadian gas prices (2015) and 289% higher than US gas prices. This could be caused by the abundance of fossil fuels (including shale gas) in those regions.

Electricity costs represent between 22.2% and 29.2% of production costs. The year 2015 was characterised by the lowest percentage in terms of total production costs, and this is mostly due to a decrease in the weighted average electricity price for the plants included in this analysis. The energy price components of electricity bills are the main impacting component, regulated electricity components (Network costs, Renewable support, Other taxes, fees, levies and charges) are far less relevant.

5 *Sector study: Wall and floor tiles*

Highlights

- ***Sample.*** The research team gathered data from 22 plants producing wall and floor tiles in 7 Member States. The overall output of respondents represents some 10% of the total EU production in each year under investigation.

- ***Energy price trends.*** Gas prices paid by respondents have been fluctuating over the period 2008-2015 and in 2015 went down to 29.9 €/MWh, slightly below 2008 levels (30.6 €/MWh). On the other hand, **electricity prices showed an upward trend**, peaking in 2015 at 104.7 €/MWh.
- **Gas and electricity prices in the SE region were generally higher than those paid by CEE respondents.** More specifically, while SE figures were generally above the EU median, CEE figures showed a decreasing trend; this led to sharper divergence between the two regions over the years, especially for electricity prices (+39.9 €/MWh in 2015).
- The role of **regulated components** varied across regions and between gas and electricity. Network costs and taxes generally **constitute a very limited share of gas prices**, and only in the CE region such components represented more than 10% of the total price.
- On the contrary, **a substantial share of electricity prices is represented by regulated components** (41.8% in 2015), whose relevance increased both in absolute and relative terms over the period 2008-2015; while in CEE the lion's share was taken by RES levies (23.9% in 2015), in SE their increase was led by both RES levies (13.2% in 2015) and network costs (24.2% in 2015). Indirect EU ETS costs have a role in inflating electricity prices.
- **Plants with higher natural gas and electricity consumption showed to have access to such inputs at lower prices**; this is likely to reflect a better bargaining power by large consumers.
- SE manufacturers appear to have slightly reduced the gas intensity of their production (-2.4% over the period 2008-2015) in response to higher prices. In the same vein, electricity intensity is generally higher for plants with self-generation capacity. Nonetheless, no general conclusion can be drawn with regard to energy efficiency improvements as the time horizon under observation is too limited compared to the investment life cycle in the sector, which can go up to 40 years.

- ***International comparison.*** In 2015, Russian plants paid approximately 6 €/MWh for natural gas, which is approximately 78% less than the EU average, and 75% less than the CEE average, their closest neighbours. In 2014 and 2015, reported US prices for natural gas were in between 14 and 19 €/MWh; 35% lower than those paid by their European peers. This comparison was done jointly with the bricks and roof tiles subsector.

- ***Impact on competitiveness.*** Finally, energy costs have a major impact on the financial performance of respondents. Total **energy costs** were even higher than EBITDA in time of crisis and **represented some 20% of the total production costs over the entire period.**

5.1 Introduction

According to the NACE (Rev.2) statistical classification of economic activities in the European Community, wall and floor tiles are included in the class 23.31, comprising manufacturers of ceramic tiles and flags.

Wall and floor tiles (also known as 'ceramic tiles') are thin slabs made of clay and other inorganic materials (which give them their main physical characteristics), which are usually employed in the construction industry as a finishing material and/or to fulfil an aesthetic function (European Commission, 2007).

Ceramics tiles are heterogeneous products in terms of physical composition, dimension, weight, shape, surface and colour as well as use. Covering and/or decorating both internal, e.g. kitchen and bathrooms, and external surfaces, swimming pools and public areas are among the most traditional uses for tiles. Moreover, unlike many other ceramic products (such as bricks and roof tiles), wall and floor tiles are high value added and highly tradable goods; hence, they are more subject to international competition.

This sectoral case study is structured as follows:

1. In the beginning of the case study (above) the main highlights from the research are presented;
2. Sections 5.2 to 5.5 provide the sectoral overview. In particular, 5.2 Section describes the production process and production characteristics in the EU; Section 5.3 presents the main characteristics of the EU industry; Section 5.4 provides an analysis of trade patterns; and Section 5.5 shows the analysis of the industry's energy consumption;
3. Section 5.6 presents the sampling strategy based and the description of the actual sample of manufacturing plants included in the study, including sectoral coverage;
4. Sections 5.7 and 5.8 report the results of the analysis of energy prices, both total prices and split per components;
5. Section 5.9 describes sectoral energy intensity;
6. Section 5.10 provides a comparison of energy prices paid by EU, Russian and US ceramic manufacturers – covering both the brick and roof tiles and the wall and floor tiles sectors
7. Section 5.11 provides the analysis of Key Performance Indicators (KPI) and the impact of energy costs over production costs and margins.
8. Section 5.12 provides a brief conclusion.

5.2 Overview of the production process

The production process includes five main stages: i) preparation of the raw materials; ii) shaping; iii) drying; iv) glazing; and v) firing (Gabaldón-Estevan et al., 2014b).

Preparation of raw materials.[25] Raw materials preparation consists of selecting, grinding and mixing the necessary inputs. The body composition of the tile is determined by the amount and type of raw materials employed which ultimately influence factors such as colour, resistance and water absorption. As a consequence, batching, i.e. the selection of the raw material to be employed, has to take into account both physical properties and chemical composition of the inputs.

Once the right combination of materials is determined, they are grinded and mixed: inputs are transferred to primary crushers, i.e. jaw or gyratory crushers, which reduce them into large lumps, and to hammer mills for secondary crushing to obtain smaller particles. Sometimes water has to be added (the so-called 'wet milling' process) and, at a later stage, removed through filtering and spray drying[26] in order to improve the mixing of a multi-component batch.

It is worth noting that, even though 'dry milling' is more energy efficient,[27] wet milling is the most commonly used process in Europe as it allows for finer grinding and, thus, a better quality product.

Shaping. Shaping is needed to give the desired form to the input mix. This step can take place through two processes, namely dry pressing and extrusion. The former constitutes the most commonly used method and despite the name the materials still contain 3-10% water. Two types of presses could be employed, i.e. the hydraulic press and friction press. The first is more commonly used in this subsector as it offers the advantage of easier controllability thanks to consistently higher pressure. Unlike dry pressing, extrusion is used when the inputs are still in a wetter and more mouldable form.

Drying. Drying consists of the gentle expulsion of residual water through heat. Once shaped, tiles are heated in order to remove the water slowly enough to prevent shrinkage and cracks; this stage might take several days and employ continuous or tunnel driers heated using gas or oil or infrared lamps.

Glazing. Just before firing, tiles are glazed. The glaze is made using methods that are similar to those adopted for the preparation of the body: after a batch formulation is calculated, the raw materials are weighed, mixed and dry- or wet-milled.

Firing. Firing is the core of the production process and allows tiles to acquire their main characteristics, i.e. water-resistance, fire-resistance and hardness. More specifically, ceramic tiles are thermally consolidated into a dense and cohesive body

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[25] 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 and calcium carbonate could be added to obtain different colours or porosity. Finally, chemical additives might be necessary for the shaping process.

[26] Spray drying involves pumping the slurry into an atomizer which is composed of a rapidly rotating disk. Inside the atomizer droplets evaporate in a hot air column, leaving granulate powder which is suitable for shaping.

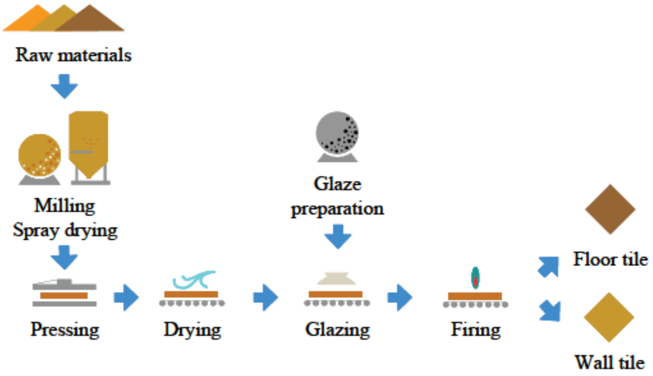
[27] The wet process entails a greater consumption of energy resources which are necessary to evaporate excess water and obtain granules of atomized powder suitable for being shaped by pressing.

through the use of kilns or ovens. This step can be performed via two different processes depending on whether wet milling or dry milling is used to prepare the raw materials.

Wet-milled tiles require a single firing process through roller kilns, usually taking more than 60 minutes and implying a temperature of at least 1,150°C. For other tiles, a two-step process is employed. First, they go through a preliminary firing before glazing in order to remove the volatiles; subsequently, the body and glaze are fired together in a tunnel kiln. In this case firing can take from two to three days with a temperature of about 1,300 °C.

Kilns for firing represent a major capital investment for ceramic tiles producers and are characterised by an investment life cycle of more than 40 years (Cerame-Unie, 2012). Finally, tiles are ready to be tested before being packed and shipped. Figure 64 provides a schematic illustration of the manufacturing process for a single-fired ceramic tile.

Figure 64. Schematic illustration of a single-fired ceramic tile manufacturing process



Source: Authors' elaboration on Mezquita et al. (2014).

5.3 Industry characteristics

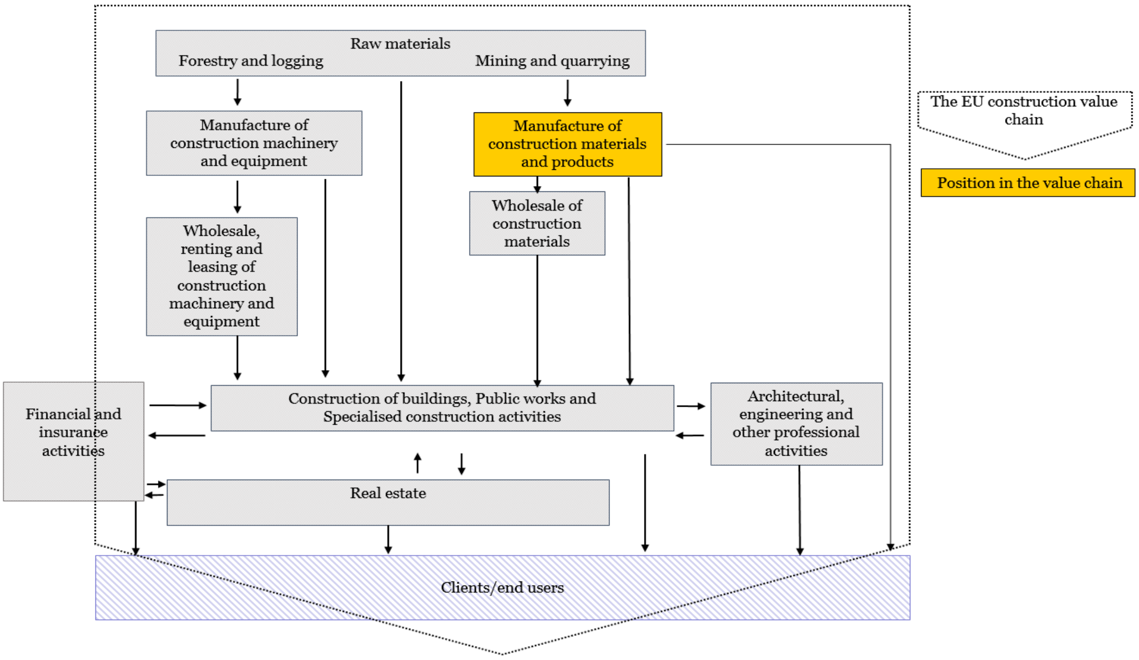
Table 60. The wall and floor tile sector according to the NACE Rev.2 classification

SECTION C — MANUFACTURING
23 Manufacture of other non-metallic mineral products
23.3 Manufacture of clay building materials
23.31 Manufacture of ceramic tiles and flags
23.31.10.10 Unglazed ceramic mosaic tiles, cubes and similar articles, with a surface area < 49 cm²
23.31.10.20 Glazed ceramic mosaic tiles, cubes and similar articles, with a surface area < 49 cm²
23.31.10.50 Unglazed ceramic and stoneware flags and paving, hearth or wall tiles; unglazed ceramic and stoneware mosaic cubes and the like, whether or not on a backing
23.31.10.71 Glazed ceramic double tiles of the spaltplatten type
23.31.10.73 Glazed stoneware flags and paving, hearth or wall tiles, with a face of > 90 cm²
23.31.10.75 Glazed earthenware or fine pottery ceramic flags and paving, hearth or wall tiles, with a face of > 90 cm²
23.31.10.79 Glazed ceramic flags and paving, hearth or wall tiles excluding double tiles of the spaltplatten type, stoneware, earthenware or fine pottery flags, paving or tiles with a face of not > 90 cm²

Source: Authors' own elaboration on Eurostat (2008).

Wall and floor tiles are mainly employed in construction activities, therefore the subsector is positioned in the upper part of the construction value chain together with the manufacture of other inputs, e.g. cement, concrete, mortars, bricks (Figure 65).

Figure 65. Wall and floor tiles' position in the value chain

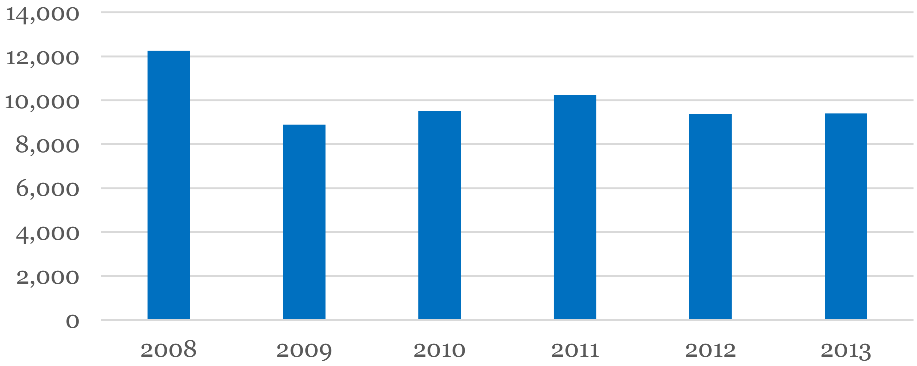


Source: Authors' own elaboration.

5.3.1 *Production in the EU*

The EU production value of ceramic tiles registered a substantial reduction over the period under investigation; more specifically, it went from €12,259 million in 2008 to €9,399 million in 2013 (-23.3%).[28] (Figure 66).

Figure 66. Production value (wall and floor tiles, EU-28, mln €)



Note: For France, Estonia, Austria, Romania, Slovenia, Slovakia and Sweden data estimates are based on trend extrapolation. Data is not available for Czech Republic, Denmark, Greece, Croatia, Ireland, Latvia, Netherlands and Finland.
Source: Authors' elaboration on Eurostat SBS (2016).

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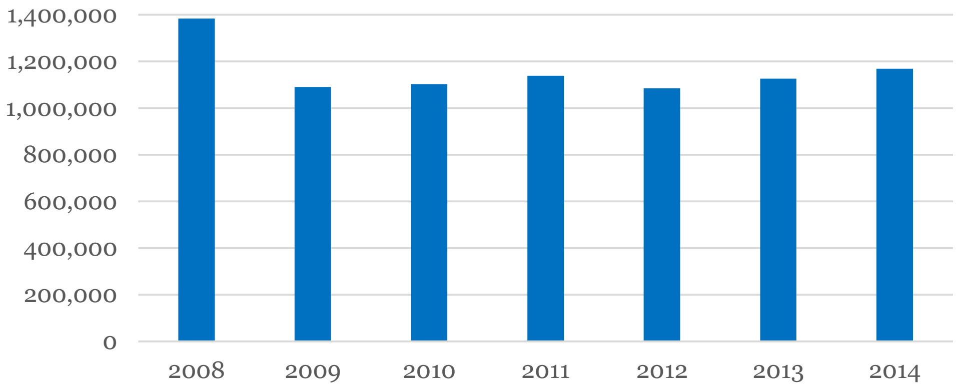
[28] 2013 is the last year available on Eurostat.

Signs of recovery are more apparent when taking into account the volumes of production sold by EU firms, which have grown in both 2013 (+3.8% YoY) and 2014 (+3.7% YoY) (Figure 67).

Figure 67. Sold volumes of production (wall and floor tiles, EU-28, thousand m²)

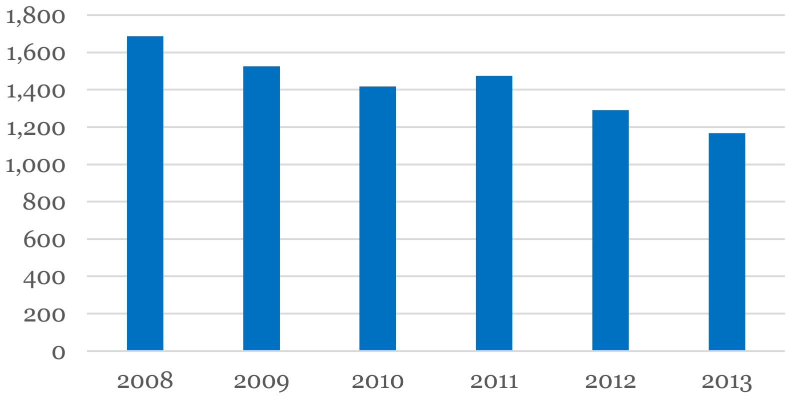


Source: Authors' elaboration on Eurostat Prodcom (2016).

5.3.2 Number of companies and plants operating in the EU

Ceramic tiles are mainly employed in construction activities; hence, this subsector is strongly influenced by the development of the construction industry. As a result of the construction output's contraction (see below), the number of enterprises producing wall and floor tiles drastically declined over the period 2008-13,[29] passing from 1,700 to just 1,200 (-30.8%) as can be seen in Figure 68.

Figure 68. Total number of enterprises (wall and floor tiles, EU-28)



Note: For France and Slovakia data estimates are based on trend extrapolation. Data is not available for Czech Republic and Ireland.
Source: Authors' elaboration on Eurostat SBS (2016).

Against this background, it is evident that the recent economic and financial crisis has strongly influenced the subsector, as reflected in the decline registered in the number of enterprises and their production values. The recovery experienced in 2013 and 2014

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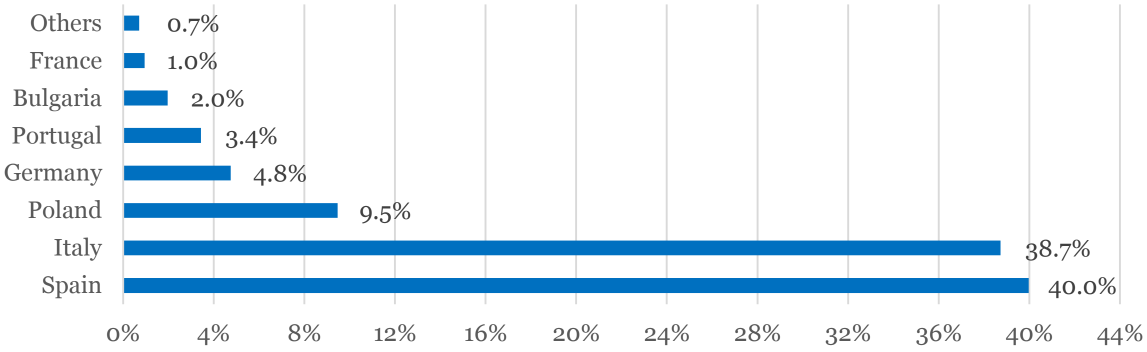
[29] 2013 is the last year available on Eurostat.

is accompanied by a stronger subsector concentration where a smaller number of firms accounts for a growing production share.

5.3.3 Geographical distribution of production and plants over EU

The distribution of production volumes sold by each Member State reveals a strong concentration: the top seven countries represented 99.3% of the 2014 total EU-28 sales, as can be seen in Figure 69.

Figure 69. Percentage of sold volumes by country (wall and floor tiles, EU-28, 2014)

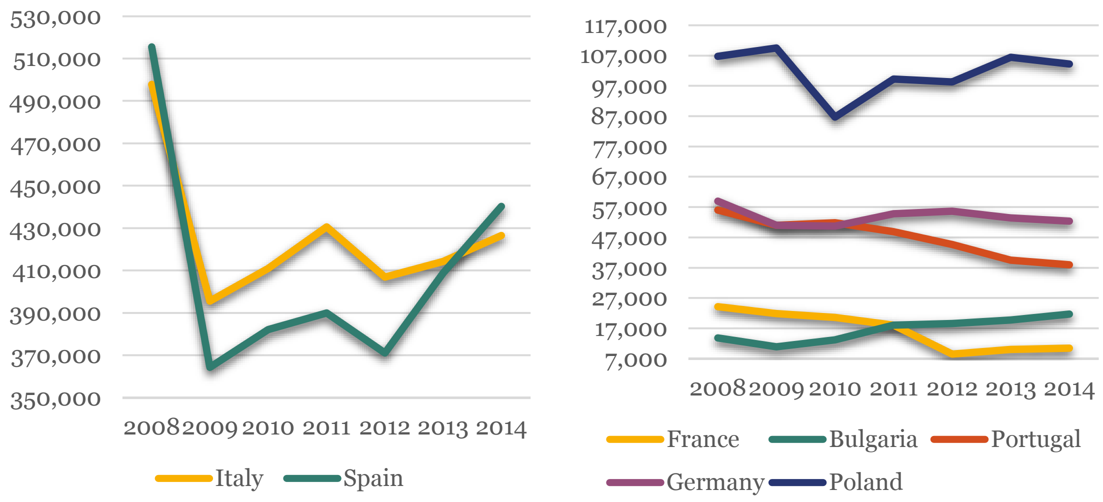


Note: Data for Czech Republic and Netherlands are not available as they are confidential.
Source: Authors' elaboration on Eurostat Prodcom (2016).

As shown in Figure 70, these seven Member States experienced an overall decline in sold volumes between 2008 and 2014, ranging from -56.6% for France to -2.4% for Poland. The only exception was Bulgaria (+56.4% overall), which showed uninterrupted growth from 2009 and for which the sold production in 2014 (21,700,000 m^2) was higher than in 2008 (13,870,000 m^2).

Due to their larger share, Spain and Italy mainly influenced the overall EU trend: more specifically the initial decline in 2009 (-29.3%, Spain, YoY; -20.5%, Italy, YoY) was interrupted by two years of consecutive growth in 2010 (+4.9%, Spain, YoY; +3.9%, Italy, YoY) and 2011 (+2.0%, Spain, YoY; +4.8%, Italy, YoY); after a decrease in 2012, the production grew again in 2013 and in 2014. Nevertheless, the recovery in Spain (+10.2%, 2013, YoY; +7.7%, 2014, YoY) was more sustained than in Italy (+1.8%, 2013, YoY; +3.0%, 2014, YoY).

Figure 70. Sold volumes of production by country (wall and floor tiles, thousand m²)



Source: Authors' elaboration on Eurostat Prodcom (2016).

The geographical distribution of production shares is also reflected in the location of plants, which reveals a strong concentration of the major installations in the above-mentioned countries. The largest number of installations were located in Spain (130), Italy (71), Poland (23), Portugal (23) and Germany (15). Interestingly, Bulgaria, while being one of the main producers in the EU, presented only one major plant in the EUTL database.

It is worth remarking that the accuracy of the analysis based on plant location is based upon and limited by the features of the EUTL database, which includes only installations covered by the EU ETS (Table 61).[30] In fact, some small installations might not be recorded in the EUTL database as, according to Article 27 of the ETS Directive (Directive 2003/87/EC), "[f]ollowing consultation with the operator, Member States may exclude from the Community scheme installations which have reported to the competent authority emissions of less than 25,000 tonnes of carbon dioxide equivalent and, where they carry out combustion activities, have a rated thermal input below 35 MW, excluding emissions from biomass, in each of the three years preceding the notification [...], and which are subject to measures that will achieve an equivalent contribution to emission reductions, if the Member State concerned complies with the following conditions". In addition, the ETS Directive does not apply to installations manufacturing ceramic products with a production equal to or less than 75 tonnes per day (See Annex I, Directive 2003/87/EC).

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[30] The EUTL database is accessible at:

http://ec.europa.eu/environment/ets/napMgt.do;EUROPA_JSESSIONID=gVFZD9JHmhzLIXeD7_3hp_ycJ57siAhFZ-wAHUqn7DBrx6KXtqC2!-198553537.

Table 61. Geographical distribution of major plants (wall and floor tiles, EU-28)

Member State	Plants
Spain	130
Italy	71
Poland	23
Portugal	23
Germany	15
Czech Republic	4
France	3
Hungary	3
Netherland	2
Bulgaria	1
UK	1
Croatia	1
Lithuania	1
Latvia	1

Source: Authors' elaboration on European Commission - EUTL database (2016).

5.3.4 Employment

The number of persons employed in the wall and floor tiles sector decreased from almost 82,500 in 2008 to fewer than 58,000 in 2013 (Eurostat, 2016).[31] Unfortunately, data on distribution of companies according to number of employees in the manufacture of wall and floor tiles are not publicly available; therefore, the analysis has to focus on the broader manufacture of clay building materials (NACE Rev. 2 code C23.3).

This includes both wall and floor tiles, i.e. manufacture of ceramic tiles and flags, NACE Rev. 2 code C23.31, and bricks and roof tiles, i.e. manufacture of bricks, tiles and construction products, in baked clay, NACE Rev. 2 code C23.32. As Figure 71 shows, in 2013,[32] the EU manufacture of clay building materials, in terms of number of firms, was almost entirely dominated by SMEs (97%) while large enterprises played only a marginal role (3%)[33]; such a pattern was replicated in almost all the major producing countries (see above).

Nevertheless, when it comes to production value, large enterprises were responsible for the main share in the EU (51%) and in all the major countries except Spain. Eurostat data on employment size for manufacture of clay building materials represent an 'upper bound' for the wall and floor tiles subsector as it is dominated by companies that are smaller than those operating in the brick and tiles subsector.

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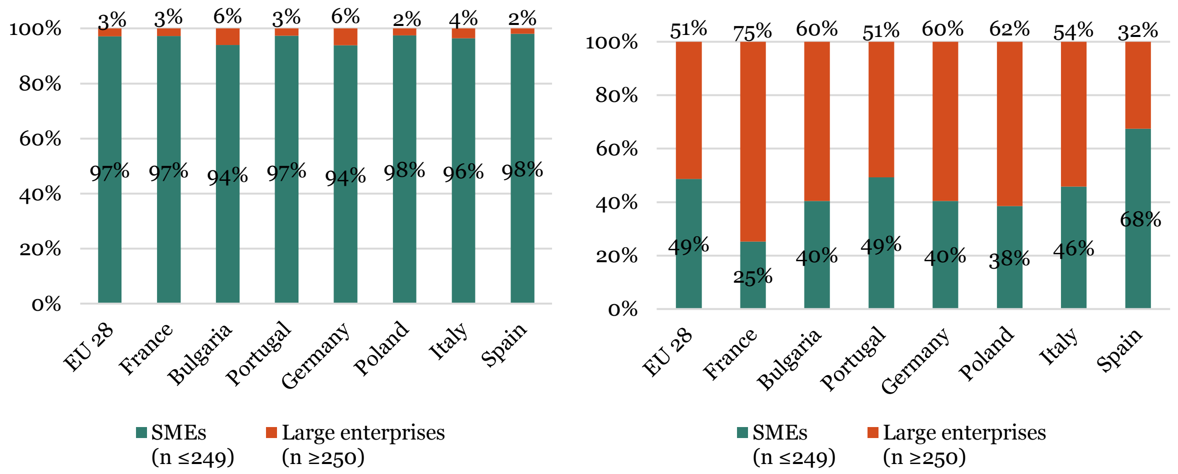
[31] 2013 is the last year available on Eurostat.

[32] Ibid.

[33] Enterprises have been classified by relying on the definition of SMEs adopted by Eurostat (Structural Business Statistics database), which is solely based on the number of employees. More specifically, enterprises employing less than 250 employees are classified as SMEs.

Figure 71. Percentage of enterprises (left) and production value (right) by employment size (manufacture of clay building materials, 2013)



Note: For Belgium, Bulgaria, Ireland, Greece, France, Croatia, Hungary, Netherland, Portugal, Slovenia, Slovakia, Sweden and UK data estimates are based on trend extrapolation. Data is not available for Czech Republic and Latvia.
Source: Authors' elaboration on Eurostat SBS (2016).

5.4 Trade analysis

The wall and floor tiles subsector[34] shows a relatively high trade intensity[35] which also increased over the period 2008-13;[36] in particular the extra-EU trade figures increased from 27% in 2008 to 39.2% in 2013 (Table 62).

Table 62. Trade intensity by extra-EU and intra-EU trade (wall and floor tiles, EU-28)

Trade intensity	2008	2009	2010	2011	2012	2013
Extra-EU	27%	28.3%	30.5%	29.6%	36.1%	39.2%
Intra-EU	49.9%	54.2%	51.4%	49.8%	51.5%	51.5%

Source: Authors' elaboration on Comext and Eurostat (2016).

Figure 72 illustrates the relative importance of intra-EU trade over extra-EU trade. In 2015, the intra-EU component accounted for 62.7% of the total trade value. When it comes to international trade, the EU has been a net exporter of wall and floor tiles in all the years under observation. In 2015, the EU ceramic tiles subsector had a positive

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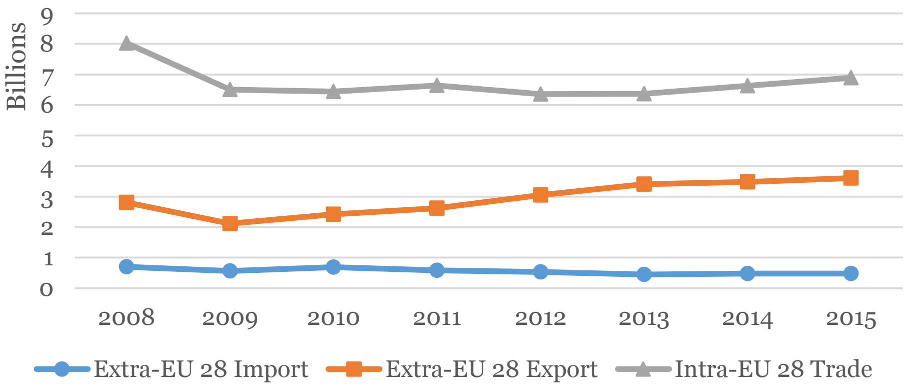
[34] For the purpose of trade data analysis, wall and floor tiles are here defined according to the Harmonized Commodity Description and Coding System (HS). It includes the following: unglazed ceramic flags and paving, hearth tiles (6907); sub-categories: unglazed ceramic tiles, cubes and similar articles (690710) and unglazed ceramic flags (690790); and glazed ceramic flags and paving, hearth tiles (6908); sub-categories: glazed ceramic tiles, cubes and similar articles (690810) and glazed ceramic flags (690890).

[35] According to Article 10a(15) of Directive 2003/87/EC the intensity of trade to third countries is defined as "*the ratio between the total value of exports to third countries plus the value of imports from third countries and the total market size for the Community (annual turnover plus total imports from third countries).*" In this Section annual production value is used as a proxy of annual turnover.

[36] 2013 is the last year available on Comext.

trade balance of around €3.1 billion. While extra-EU imports decreased over the period 2008-15, extra-EU exports have been steadily growing since 2009. One possible explanation is that the industry tried to overcome the fall in internal demand by following an internationalisation strategy.

Figure 72. Intra- and extra-EU trade of wall and floor tiles (EU-28, €)



Source: Authors' elaboration on Eurostat Comext (2016).

Table 63 and Table 64 illustrate the main extra-EU export and import flows of ceramic tiles in 2008 and 2015.

The US was the first destination country of EU tiles in both years, followed by Russia and Saudi Arabia. While the recent economic and financial crisis had some impact on exports to Russia, figures for US (+7.7%), Saudi Arabia (+65.2%) and other Middle Eastern countries increased over the period.

Table 63. Export of ceramic tiles by main trade partners (2008, 2015, tonnes)

2008		2015	
Trade Partner	**Export**	**Trade Partner**	**Export**
United States	917,265.9	**United States**	987,967.2
Russia	555,842.8	**Saudi Arabia**	704,999.5
Saudi Arabia	426,553.4	**Algeria**	447,413.6
Ukraine	326,079.9	**Israel**	432,884.7
Israel	213,680.3	**Jordan**	313,572.9
Switzerland	211,033.5	**Russia**	298,471.9
U.A.E.	201,309.2	**Morocco**	288,241.6
Canada	184,754.4	**Lebanon**	285,106.9
Albania	159,543.0	**Switzerland**	257,206.5
Nigeria	147,390.2	**Nigeria**	231,205.1

Source: Authors' elaboration on Eurostat Comext (2016).

In 2008, as in 2015, most of the imports came from Turkey and China; nevertheless, Turkey replaced China as main trade partner for imports in 2015. Also, the United Arab Emirates (U.A.E.) plays a significant role in imports, representing the third-largest importer country in both 2008 and 2015. It is worth highlighting that the recent crisis also had a clear impact on import flows.

The EU construction sector's slowdown influenced negatively the demand of wall and floor tiles, thus also leading to a reduction in imports. In addition, imports from China (-66.1% between 2008 and 2015) might have been affected by an anti-dumping duty imposed by the Council in 2011 on some Chinese companies operating in the subsector (AD 560).[37]

Table 64. Import of ceramic tiles by main trade partners (2008, 2015, tonnes)

2008		2015	
Trade Partner	**Import**	**Trade Partner**	**Import**
China	1,068,772.6	Turkey	5,60,238.1
Turkey	607,970.0	China	3,62,007.6
U.A.E.	175,361.6	U.A.E.	3,04,969.4
Brazil	58,500.0	India	62,109.1
Egypt	52,067.4	Vietnam	27,808.5
Malaysia	37,188.7	Brazil	26,679.3
Indonesia	24,658.7	Ukraine	21,640.7
Tunisia	21,398.0	Serbia	20,220.9
Thailand	21,237.3	Russia	16,599.3
Serbia	15,833.3	Malaysia	12,982.5

Source: Authors' elaboration on Eurostat Comext (2016).

5.5 Energy - literature review

Energy usually accounts for around 25-30% of total production costs, but the exact figure strongly depends on changes in fuel prices, which are ultimately influenced by political and market events beyond the control of industry (CEPS, 2014b). More specifically, wall and floor tile production requires the use of a significant amount of thermal energy, employed mainly in three stages: firing (55%), followed by spray drying (36%) and drying (9%) (Figure 73).

The majority of kilns used in the firing stage are heated by natural gas (roughly 85% of the cases) (CEPS, 2014b; Ecorys, 2009), as over the years the relative convenience of its use has increased over oil. When it is not available, alternative fuels such as coal, oil and biomass are employed (European Commission, 2014).

Electricity is also used to a lesser extent, and in particular for conveyor belts, robots, presses, water and gas cleaning systems and kiln fans. Moreover, in some countries the majority of spray-dried producers have installed cogeneration systems, thus increasing their energy efficiency and leading in some cases to self-generation larger than plant consumption (Gabaldón-Estevan et al., 2014a).

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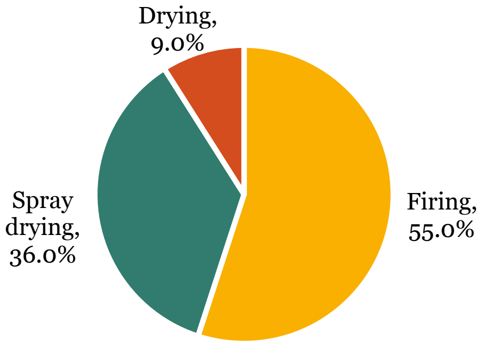
[37] Council Implementing Regulation (EU) No 917/2011 of 12 September 2011 imposing a definitive anti-dumping duty and collecting definitively the provisional duty imposed on imports of ceramic tiles originating in the People's Republic of China.

Figure 73. Thermal energy consumption (breakdown by production stage)



Source: Mezquita et al. (2014).

Several studies have already dealt with energy issues in the wall and floor tile subsector. For instance, a previous report from CEPS (2014b) calculated energy intensities for a sample of 10 production plants across Europe, broken down by natural gas and electricity intensity. This study pointed out that the average energy intensity for natural gas was almost constant over the period 2010-12 and equal to some 1.81 MWh/t (Table 65). In the same vein, the median and the weighted average for electricity intensity remained stable over the period 2010-12 (Table 66).

Recently, a study by ICF Consulting confirmed that kilns used in the production of wall and floor tiles represented the largest contributor to total energy consumption in the subsector, which ultimately amounted to 1.56 MWh/t in 2007 (ICF, 2015).

Table 65. Natural gas intensities for 10 production plants in terms of physical output (MWh/t)

	2010	2011	2012
Europe (average)[38]	1.81	1.79	1.81
Europe (median)	1.73	1.68	1.69
Europe (IQR)[39]	0.91	0.89	0.93

Source: CEPS (2014b).

Table 66. Electricity intensities for 10 production plants in terms of physical output (MWh/t)

	2010	2011	2012
Europe (average)[40]	0.23	0.23	0.23
Europe (median)	0.19	0.19	0.19
Europe (IQR)	0.14	0.14	0.15

Source: CEPS (2014) and Ecorys et al (2009).

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[38] Weighting factor: consumption.

[39] The interquartile range (IQR) is the difference between the 25% of the plants with the highest energy intensity and the 25% with the lowest. It is a robust way of showing the variability of a data sample without having to make any assumption on the underlying statistical distribution.

[40] Weighting factor: consumption

Additional analysis of energy consumption in the wall and floor tile industry mostly focused on Spain (together with Italy the largest producers in the EU). With an average consumption of 28kwh/m^2, i.e. 0.028MWh/m^2, Spanish manufacturers are intensive energy consumers (Gabaldón-Estevan et al., 2014b). This study also confirms that firing is the core of the production process as well as the most energy intensive phase. In terms of output weight, the average thermal energy intensity of the whole production process is 1.28MWh/t, i.e. 4608kj/kg, where firing accounts for 0.71MWh/t, i.e. 2556kj/kg (Mezquita et al., 2014). In line with CEPS findings (CEPS, 2014b), most recent studies confirm lower figures for electrical energy consumption, namely 3.2KWh/m^2, i.e. 0.0032MWh/m^2 (Gabaldón-Estevan et al., 2014b).

While taking into account the results of previous works, the current Study provides new data on the energy intensity of wall and floor tile production across Europe. More specifically, gas and electricity intensities computed for the whole Southern European region (0.031 MWh/m^2 for gas and 0.0035 MWh/m^2 for electricity in 2015) appear to be in line with those calculated previously for Spanish manufacturers (Gabaldón-Estevan et al., 2014b; Mezquita et al., 2014). By contrast, gas and electricity intensities computed in the current Study are not comparable with previous CEPS findings due to different units of measurement.[41]

5.6 Selection of the sample and sampling statistics

5.6.1 Sampling strategy

For the purpose of the present Study, the sampling strategy for each sector should take into account the following criteria:

- **Production technology;**
- **Geographical coverage;**
- **Capacity of plants;**
- **Ownership**, i.e. company size.

In spite of a certain heterogeneity regarding their physical characteristics, wall and floor tiles are relatively homogeneous in terms of **production process and technologies**. Different technical parameters, e.g. size of the kilns, dry versus wet milling, across plants do not result in different production routes. As a result, this sampling criterion does not apply to the ceramic tiles subsector

With regards to **geographical coverage**, no comprehensive information regarding the distribution of plants across Member States is available from either public sources or sectoral associations. In principle, to estimate geographical coverage, three proxy variables can be considered: (i) distribution of output; (ii) distribution of production value; and (iii) distribution of enterprises.

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[41] In fact, ceramic tiles' production was measured in tonnes in CEPS (2014) and in m2 in the present Study; it is not possible to convert tonnes of tiles in m^2 as ceramic tiles' weight depends on several variables such as porosity and thickness.

As wall and floor tile production is concentrated in a limited number of Member States, data need to be aggregated at a regional level, thus preventing disclosure of identifiable information on specific plants in the case of fewer than three respondents from a given Member State. Regions are defined as follows:

- North-Western Europe (NWE): Ireland, United Kingdom, France, Belgium, Luxembourg, the Netherlands, Germany, Austria, Denmark, Sweden and Finland (11 Member States).
- Southern Europe (SE): Portugal, Spain, Italy, Malta, Greece and Cyprus (six Member States).
- Central-Eastern Europe (CEE): Slovenia, Croatia, Czech Republic, Slovakia, Poland, Hungary, Romania, Bulgaria, Lithuania, Latvia and Estonia (11 Member States).

Table 67 shows the proxy values across the three regions in 2013 (last year available); as mentioned above, it is apparent that each proxy variable leads to slightly different results in terms of geographical distribution of the ceramic tiles production across the EU. This variability has been taken into account in Table 68, which proposes upper and lower thresholds for the geographical composition of the sample. More specifically, the share of enterprises per geographical area is adopted as an upper bound share for the NWE and CEE regions and as a lower bound share for the SE region. The lower bound shares for the NWE and CEE regions and the upper bound share for the SE region rely on the distribution of production value and output across regions. Figures are rounded up.

Table 67. Proxies for geographical distribution

Region	Output (2013)	Production Value (2013)	Enterprises (2013)
NWE	6%	11%	25%
CEE	13%	8%	18%
SE	81%	81%	57%

Source: Authors' own elaboration on Eurostat and Prodcom (2016).[42]

Table 68. Sample size: geographical regions

Region	Lower Bound	Upper Bound
NWE	10%	25%
CEE	10%	20%
SE	55%	80%

Source: Authors' own elaboration.

The two additional criteria affecting the sampling strategy in the subsector can only be addressed based on qualitative information:

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[42] For output: data for CZ, EL, LV, IR, NL and HU are not available as they are confidential. For production value: data for CZ, DK, EL, IE, HR, LV, NL, and FI are not available as they are confidential; data for FR, EE, AT, RO, SI, SK and SE are estimated based on a trend extrapolation. For enterprises: data for CZ and LV are not available as they are confidential; data for BE, BG, IR, EL, FR, HR, HU, NL, PT, SI, SK, SE and UK are estimated based on a trend extrapolation.

- **Ownership, i.e. company dimension.** Though the analysis remains plant-based, company dimensions may have an impact on energy prices, as larger companies may be able to negotiate better conditions. However, available evidence suggests that the ceramic tiles subsector is dominated by SMEs. In light of the figures presented in Figure 71, it is proposed to include between 10% and 50% of plants operated by large companies and between 50% and 90% of plants operated by SMEs.
- **Plant capacity.** Since no quantitative information can be retrieved via desk research, as a mitigating measure the sample will be investigated ex post to account for differences in energy prices and costs generated by different plant capacities.

Table 69 summarises the criteria used for the sampling strategy. Importantly, the composition of the final sample will depend also on the response rate; the research team suggests not discarding data points even though the sampling may be skewed towards certain regions or company segments, even beyond the upper limits listed below. In particular, it is suggested to apply ex post weights to regional data. This is further discussed in next section.

Table 69. Sampling criteria

Production Technology		
Geographical Distribution	**Lower Bound**	**Upper Bound**
NWE	10%	25%
CEE	10%	20%
SE	55%	80%
Ownership	**Lower Bound**	**Upper Bound**
Large	10%	50%
SMEs	50%	90%
Plant Capacity	**ex post verification of capacity**	

Source: Authors' own elaboration.

5.6.2 Sample statistics

As shown in Table 70, the questionnaire has been sent to 65 plants producing ceramic tiles across Europe and reflecting the sampling strategy described above. In total 22 plants shared relevant data with the research team: the respondents accounted for approximately 10% of total EU production for all the years in the scope of the Study (see Table 71). Out of these 22 plants, nine were owned by SMEs.[43] An analysis of existing differences in terms of energy prices and costs depending on company size has been carried out at the cross-sectoral level.

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[43] Enterprises have been classified by relying on the definition of SMEs adopted by Eurostat (Structural Business Statistics database), which is solely based on the number of employees. More specifically, enterprises employing less than 250 employees are classified as SMEs.

Table 70. Plants contacted for analysis on Ceramic tiles and Flags

Number of plants contacted	Questionnaires received
65	22

Source: Authors' own elaboration.

Table 71. Production by respondents out of total EU production (mln m2)

	2008	2010	2012	2013	2014	2015
Respondents	139.5	108.7	117.8	114.8	126.4	134.7
EU Total*	1,382.6	1,101.6	1,084.3	1,126.0	1,168.0	N/A
respondents/EU total	10.09%	9.87%	10.86%	10.20%	10.82%	N/A

Note: Figure for respondents are based on observations from 22 plants, except for 2008 where plant output is available for 21 plants; *sold production.

Source: Authors' own elaboration on primary data and Eurostat PRODCOM.

For all 22 plants, information on energy prices, costs and consumption are available. This information has been validated by the research team both through follow up emails and calls with the respondents, and via triangulation and secondary research.

Furthermore, validation has been facilitated by the supporting evidence shared by some respondents. Four plants have provided electricity and gas bills, which have been employed by the research team to validate the breakdown of electricity and gas components as well as relevant energy prices.

Not all questionnaires include the same amount and depth of information. The coverage of the 2008-2015 period is not always full, as in certain cases data for the year 2008 were not provided by respondents. In addition, not all plants provided a split per component of natural gas and electricity costs for the entire period under observation, as can be seen in Table 72.

Table 72. Number of questionnaires used in each section

Total number received	Total number used44	Energy price trends	Energy bill components	Energy intensity	International comparison	Production costs and margins
22	*22*	*22 (gas)* *22 (elec.)*	*20 (gas)* *22 (elec.)*	*22 (gas)* *22 (elec.)*	*4 (gas)* *4 (elec.)*	*22*

Source: Authors' own elaboration.

Further details on the number of observations used in each graph/table for each year are provided in the relevant sections of this report.

With respect to geographical coverage, eight plants are based in Central Eastern European (CEE) Member States, one in the North Western European (NWE) region

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[44] This refers to the number of questionnaires that made it through the verification process and were used in the subsequent data analysis.

and 13 in the Southern European (SE) area. One company has shared information on energy prices also for a plant based in Russia. In this respect, please note that:

- Averages for NWE cannot be presented due to confidentiality reasons; data from a single plant cannot be disclosed;
- In light of the limited number of observations from third countries, an international comparison for the entire "manufacture of clay building materials" sector (NACE Rev. 2 code C23.3, including both producers of ceramic tiles and brick and tiles) has been provided in the Chapter on brick and tiles (see below).

As different response rates have been registered in different geographic regions, the respondents do not fully reflect the structure of the EU population on the grounds of the sampling criteria discussed above. As one of the objectives of the study was to obtain data on energy prices from as many plants as possible, the research team has not discarded any data points.

Nonetheless, when calculating EU averages (both simple and weighted), weights are applied to regional averages in order to avoid over-representation of certain regions.

More specifically, a weight equivalent to the share of the overall regional output over the total EU output (sold production; Eurostat PRODCOM data) is attributed, for each year, to each regional average to account for the uneven distribution of production across the EU.[45]

The so-called 'EU simple average' are computed as weighted average of simple regional average, adopting as weight the shares of the overall regional output over the total EU output, based on Eurostat Prodcom data; 'EU weighted average' are computed as weighted average of consumption weighted regional average, again adopting as weight for EU aggregation the shares of the overall regional output over the total EU output.[46]

5.7 Energy price trends

In this section, information on the prices of electricity and gas purchased by ceramic tiles manufacturers are provided. In particular, EU and regional averages, both simple and weighted by plant consumption, are presented. Interestingly, weighted averages by plant production and capacity are aligned with consumption weighted averages. This is no surprise as larger production sites generally purchase larger quantity of energy inputs.

5.7.1 Natural gas

Natural gas is the main energy carrier in the ceramic tiles industry, and as such is a primary driver of the industry cost competitiveness. In 2015, the 'EU weighted average' price paid by respondents amounted to 29.9 €/MWh while the median price was equal to 29.0 €/MWh. As shown in Figure 74, both figures have been fluctuating

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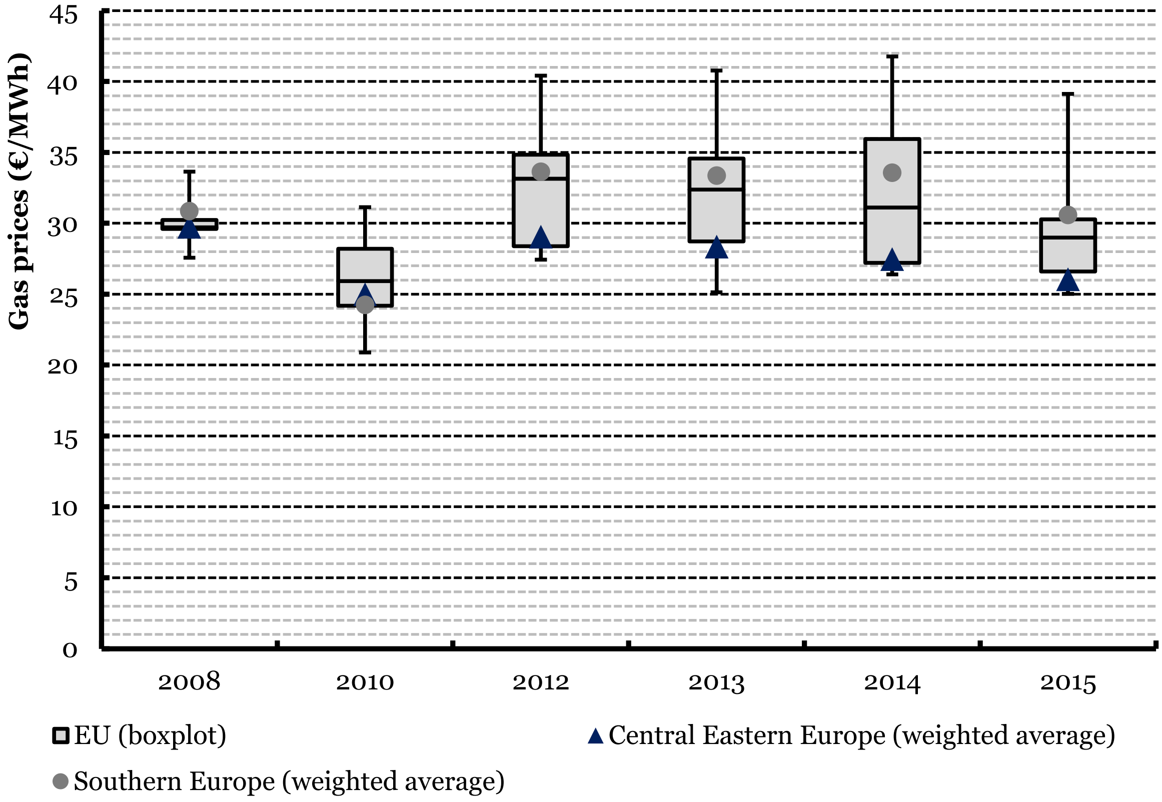
[45] In all years under investigation, more than 80%% of the EU production in volume was concentrated in the SE region (Eurostat Prodcom).

[46] Precise weights adopted to compute EU averages cannot be presented for confidentiality reasons.

over the period 2008-2015. It is worth remarking that, with the exception of 2008, EU gas prices computed as simple average are higher than those computed as consumption weighted average; this reveals that plants with higher consumption have access to natural gas at lower prices.

Trends across regions in the period 2008-2015 have been similar among each other and with the general EU trend. In this respect, the CEE region paid weighted average prices progressively lower than the EU median. On the other hand, prices in SE regions were always higher than the EU median, with the exception of 2010. SE manufacturers paid on average a price approximately 12% higher than the CEE weighted average; the largest gap was recorded in 2014 and equal to 6.09 €/MWh.

Figure 74. Prices of natural gas paid by respondents (2008-2015)



Note: Figures are based on observations from 22 plants, except for 2008 where observations from only 20 plants were available.

Source: Authors' own elaboration.

Table 73. Descriptive statistics for natural gas prices paid by respondents (2008-15, €/MWh)

	2008	2010	2012	2013	2014	2015
EU (average)[47]	29.8	25.8	33.9	33.8	34.2	30.6
EU (weighted average)[48]	30.6	24.1	32.8	32.5	32.6	29.9
EU (median)	29.7	25.9	33.1	32.4	31.1	29.0
EU (IQR)	0.6	4.0	6.5	5.9	8.7	3.7
EU (minimum)	27.6	20.9	27.4	25.1	26.4	25.0
EU (maximum)	33.6	31.1	40.4	40.8	41.8	39.1
Central Eastern Europe (average)	26.0	25.9	29.4	28.9	27.2	25.7
Southern Europe (average)	30.3	26.2	34.9	34.9	35.6	31.4
Central Eastern Europe (Consumption weighted average)	29.8	25.0	29.1	28.4	27.5	26.1
Southern Europe (Consumption weighted average)	30.9	24.3	33.6	33.4	33.6	30.6
% Relative standard deviation	4.7	11.6	11.9	12.5	16.9	12.8

Note: Figures are based on observations from 22 plants, except for 2008 where observations from only 20 plants were available.

Source: Authors' own elaboration.

5.7.2 Electricity

In 2015, the EU median price for electricity amounted to 99.4 €/MWh while the 'EU weighted average' to 104.7 €/MWh. Interestingly, the EU average price, both weighted and simple, is higher than the median signalling that the distribution is skewed towards a limited number of plants with higher prices.

Differently from gas, electricity prices showed a general trend upward over the period both in their median (+14.7%), simple average (+12.4%) and weighted average value (+8.3%). 'EU simple averages' are higher than consumption weighted averages - with the exception of 2008. This indicates that larger consumers can purchase electricity at lower prices.

When it comes to regional differences, as in the case of natural gas, SE producers face higher prices compared to CEE producers**.** Divergence in regional prices for electricity increased in 2014 (+32.1 €/MWh) and in 2015 (+39.9 €/MWh) (Figure 75). While for CEE plants prices have been consistently below the EU median and close to the

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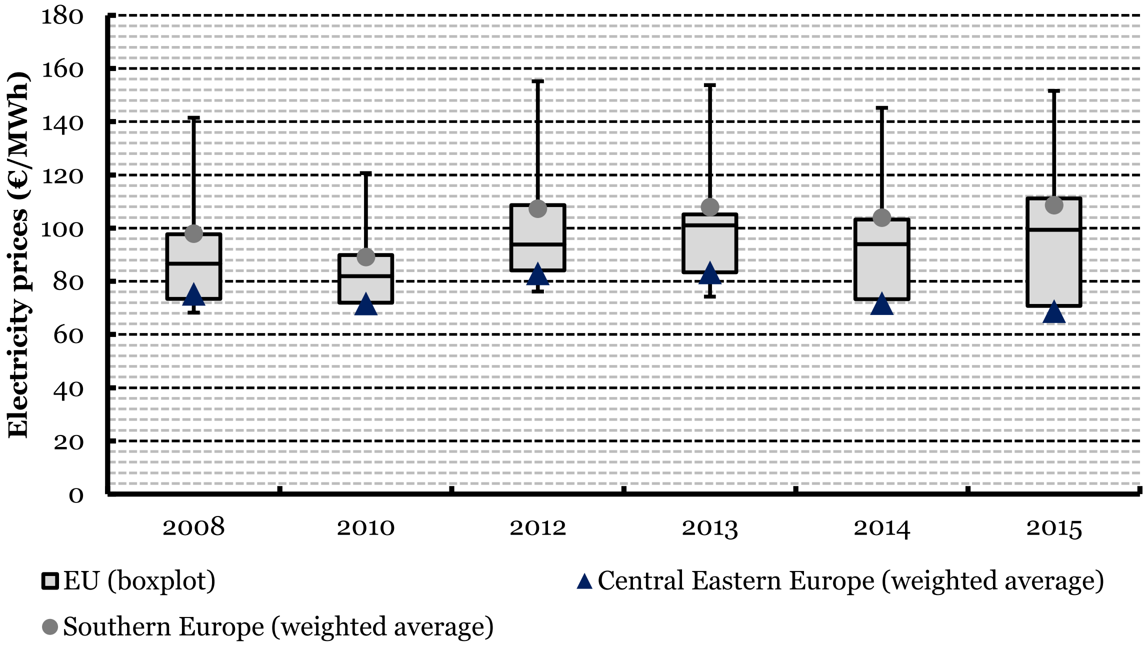
[47] This average is computed by aggregating the simple average in each region. Yet, as mentioned in the sampling strategy and sample statistics section above, a different weight is applied to each regional average to reflect the uneven distribution of production across the EU.

[48] Weighting factor: gas consumption. This average is computed by aggregating the weighted average in each region. Yet, as mentioned in the sampling strategy and sample statistics section above, a different weight is applied to each regional weighted average to reflect the uneven distribution of production across the EU.

minimum since 2012, for SE plants have been above the median and close to the third quartile.

Figure 75. Prices of electricity paid by respondents (2008-2015)



Note: Figures are based on observations from 22 plants, except for 2008 where observations from only 21 plants were available.
Source: Authors' own elaboration.

Table 74. Descriptive statistics for electricity prices paid by respondents (2008-2015, €/MWh)

	2008	2010	2012	2013	2014	2015
EU (average)[49]	95.3	87.3	104.6	105.2	101.7	107.1
EU (weighted average)[50]	96.6	86.3	103.8	104.5	100.0	104.7
EU (median)	86.6	81.9	93.9	101.0	93.9	99.4
EU (IQR)	24.3	18.0	24.6	21.7	30.0	40.3
EU (minimum)	68.2	69.0	76.2	74.3	69.3	66.3
EU (maximum)	141.4	120.7	155.2	153.7	145.2	151.6
Central Eastern Europe (average)	75.6	72.4	83.9	83.2	72.3	69.0
Southern Europe (average)	96.3	90.3	108.1	108.8	105.9	111.6
Central Eastern Europe (Consumption weighted average)	75.3	71.7	83.0	83.4	71.8	68.8
Southern Europe (Consumption weighted average)	97.9	89.2	107.3	107.9	103.9	108.7
% Relative standard deviation	22.6	15.9	19.8	19.8	22.9	27.4

Note: Figures are based on observations from 22 plants, except for 2008 where observations from only 21 plants were available.
Source: Authors' own elaboration.

5.8 Energy bill components

In this section, the components of the price paid by respondents for natural gas and electricity are discussed.

Note that companies were not always able to provide both overall prices and price components. Often detailed components were not visible on energy bills. There are significant differences between the average energy prices as reported above in the section energy prices and the results reported in this section on energy components. This is caused by different numbers of respondents included in both sections of the analysis.

The price of natural gas is split into three components, where the last two depend on the regulatory framework (regulated components):

1. Energy supply;
2. Network costs;
3. Other taxes, fees, levies and charges (excluding recoverable taxes, such as VAT).

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[49] This average is computed by aggregating the simple average in each region. Yet, as mentioned in the sampling strategy and sample statistics section above, a different weight is applied to each regional average to reflect the uneven distribution of production across the EU.

[50] Weighting factor: electricity consumption. This average is computed by aggregating the weighted average in each region. Yet, as mentioned in the sampling strategy and sample statistics section above, a different weight is applied to each regional weighted average to reflect the uneven distribution of production across the EU.

The price of electricity is split into four components, where the last three depend on the regulatory framework (regulated components):

1. Energy supply;
2. Network costs;
3. Renewable support;
4. Other taxes, fees, levies and charges (excluding recoverable taxes, such as VAT).

5.8.1 Natural gas

The split of natural gas price shows a very limited role for regulated components: over the 2008-2015 period network costs and other taxes and fees were always below 10% of total costs. Network costs represented 7.2% of EU gas costs in 2015, while other taxes and fees represented approximately 2.1%. Accordingly, the energy component represented more than 90% of costs across all years.

Regarding regional differences, the share of regulated components in SE was very close to the EU average across all years. A different pattern emerged for CEE where regulated components represented more than 10% of the total (with the exception of 2008) with network costs taking the lion's share. Finally, regulated components in SE remained fairly stable over the years, while in CEE their importance grew both in absolute and in relative terms between 2008 and 2010.[51]

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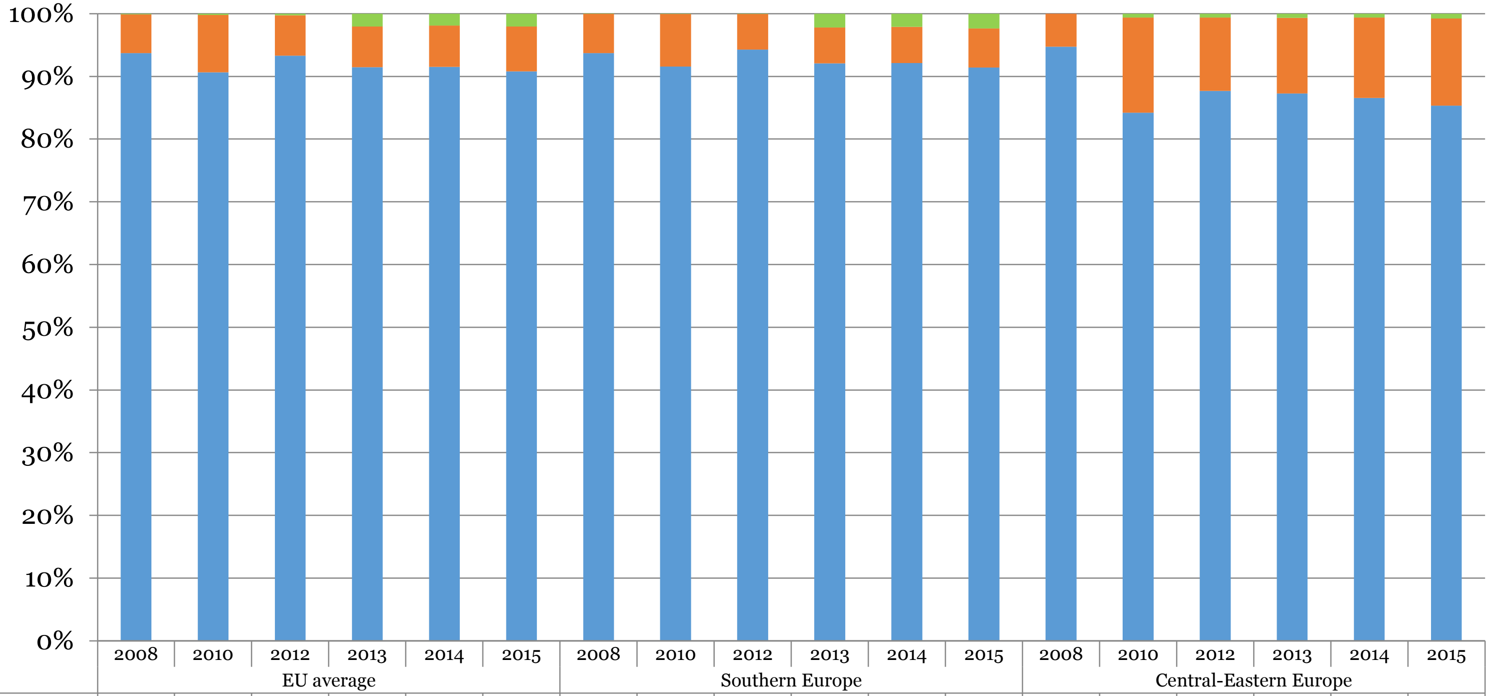
[51] Such increase was accompanied by an increase of average gas consumption of respondent plants.

Figure 76. Components of the natural gas bills paid by respondents (%, weighted averages[52], 2008-15)



	EU average 2008	EU average 2010	EU average 2012	EU average 2013	EU average 2014	EU average 2015	Southern Europe 2008	Southern Europe 2010	Southern Europe 2012	Southern Europe 2013	Southern Europe 2014	Southern Europe 2015	Central-Eastern Europe 2008	Central-Eastern Europe 2010	Central-Eastern Europe 2012	Central-Eastern Europe 2013	Central-Eastern Europe 2014	Central-Eastern Europe 2015
🟩 Other taxes, fees, levies and charges (excl. VAT)	0.1%	0.2%	0.3%	2.0%	1.9%	2.1%	0.0%	0.1%	0.1%	2.2%	2.1%	2.4%	0.0%	0.6%	0.6%	0.7%	0.6%	0.8%
🟧 Network costs	6.2%	9.1%	6.4%	6.5%	6.6%	7.2%	6.3%	8.4%	5.7%	5.8%	5.8%	6.2%	5.3%	15.1%	11.7%	12.1%	12.8%	13.9%
🟦 Energy supply costs	93.7%	90.6%	93.3%	91.5%	91.5%	90.8%	93.7%	91.5%	94.3%	92.0%	92.1%	91.4%	94.7%	84.2%	87.7%	87.3%	86.5%	85.3%

Note: Figures are based on observations from 20 plants, except for 2008 (16 plants) and 2010 (18 plants).

Source: Authors' own elaboration.

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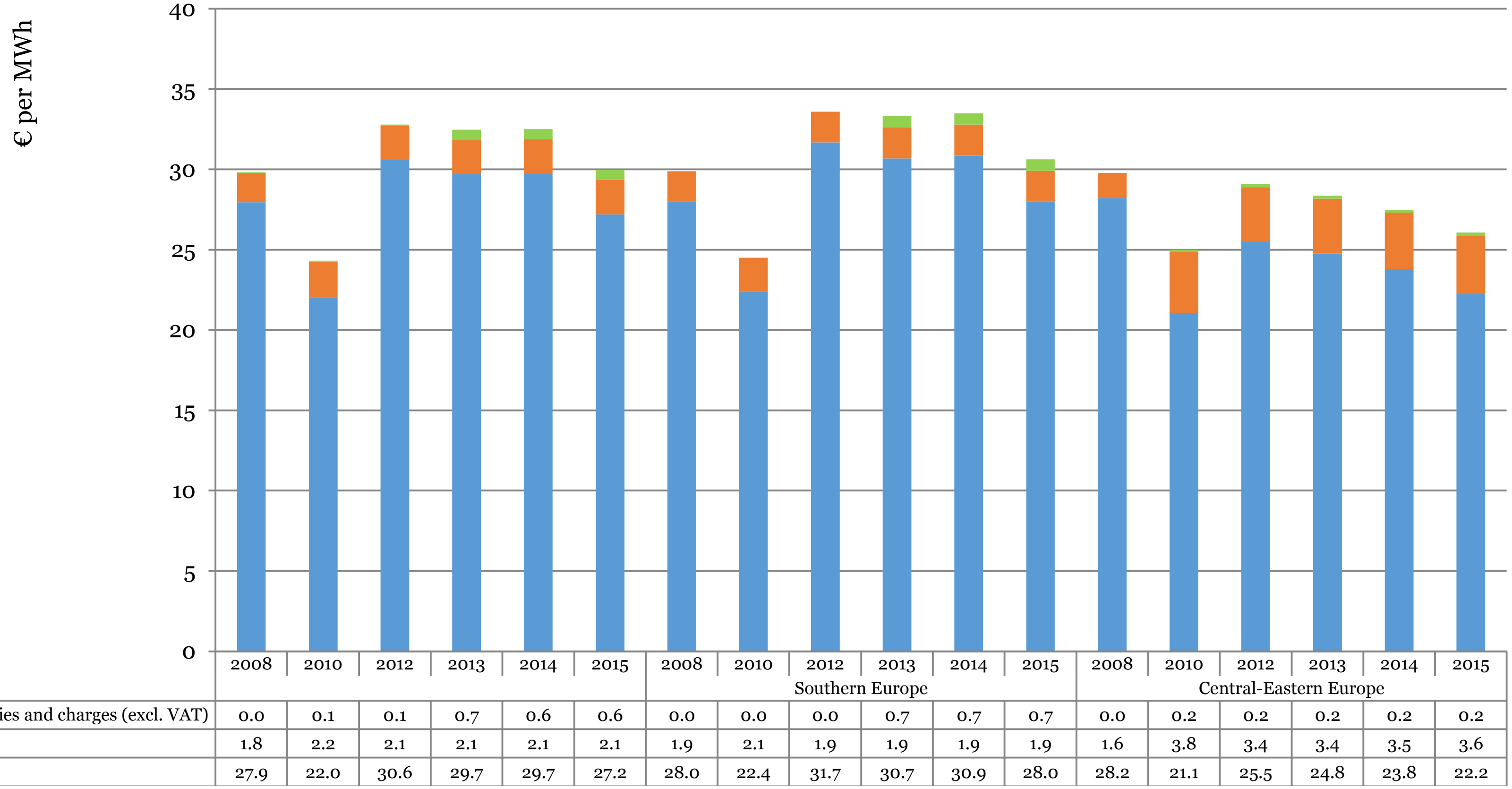
[52] Weighting factor: gas consumption. The EU average is computed by aggregating the weighted average in each region. Yet, as mentioned in the sampling strategy and sample statistics section above, a different weight is applied to each regional weighted average to reflect the uneven distribution of production across the EU.

Figure 77. Components of the natural gas bills paid by respondents (€/MWh, weighted averages[53], 2008-15)



	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
							Southern Europe						Central-Eastern Europe					
🟩 Other taxes, fees, levies and charges (excl. VAT)	0.0	0.1	0.1	0.7	0.6	0.6	0.0	0.0	0.0	0.7	0.7	0.7	0.0	0.2	0.2	0.2	0.2	0.2
🟧 Network costs	1.8	2.2	2.1	2.1	2.1	2.1	1.9	2.1	1.9	1.9	1.9	1.9	1.6	3.8	3.4	3.4	3.5	3.6
🟦 Energy supply costs	27.9	22.0	30.6	29.7	29.7	27.2	28.0	22.4	31.7	30.7	30.9	28.0	28.2	21.1	25.5	24.8	23.8	22.2

Note: Figures are based on observations from 20 plants, except for 2008 (16 plants) and 2010 (18 plants).

Source: Authors' own elaboration.

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[53] Weighting factor: gas consumption. The EU average is computed by aggregating the weighted average in each region. Yet, as mentioned in the sampling strategy and sample statistics section above, a different weight is applied to each regional weighted average to reflect the uneven distribution of production across the EU.

5.8.2 *Electricity*

As opposed to natural gas, regulated components played a more relevant role in the composition of electricity prices. Network costs, RES levies, and other taxes and fees (excluding VAT) accounted for 41.8% of the 2015 'EU weighted average' price for electricity paid by respondents. In 2008 this share was equal to 22.8% and it consistently increased over the years. This was also reflected at regional level where regulated components represented 44.1% and 41.5% of the 2015 total electricity bill respectively in CEE and in SE (Figure 78).[54]

Among regulated components at EU level, the lion's share was taken by RES levies and network costs. More specifically RES levies increased from 4.6% in 2008 to 14.3% in 2015; network costs increased from 14.8% to 23.8%. Conversely the energy component declined from 77.2% to 58.2% of the total price between 2008 and 2015. Moreover, this reduction occurred, not only in relative, but also in absolute terms as its value passed from 72.1 €/MWh in 2008 to €60.9 €/MWh in 2015.

The relative importance of each regulated component varied across regions. The increased relevance of regulated components for CEE plants was mainly due to soaring RES levies (8.8% in 2008 to 23.9% in 2015), while the share of network costs remained fairly stable across the years. For respondents in SE both the network and RES levies share increased between 2008 and 2015.

Please note that Spanish plants included in the sample did not provide data for RES levies as this component is not visible in their electricity bill. In this respect, it is not possible to conclude that Spanish plants are exempted from contributing to RES support scheme; rather, costs for RES support are supposedly included in the network component.[55]

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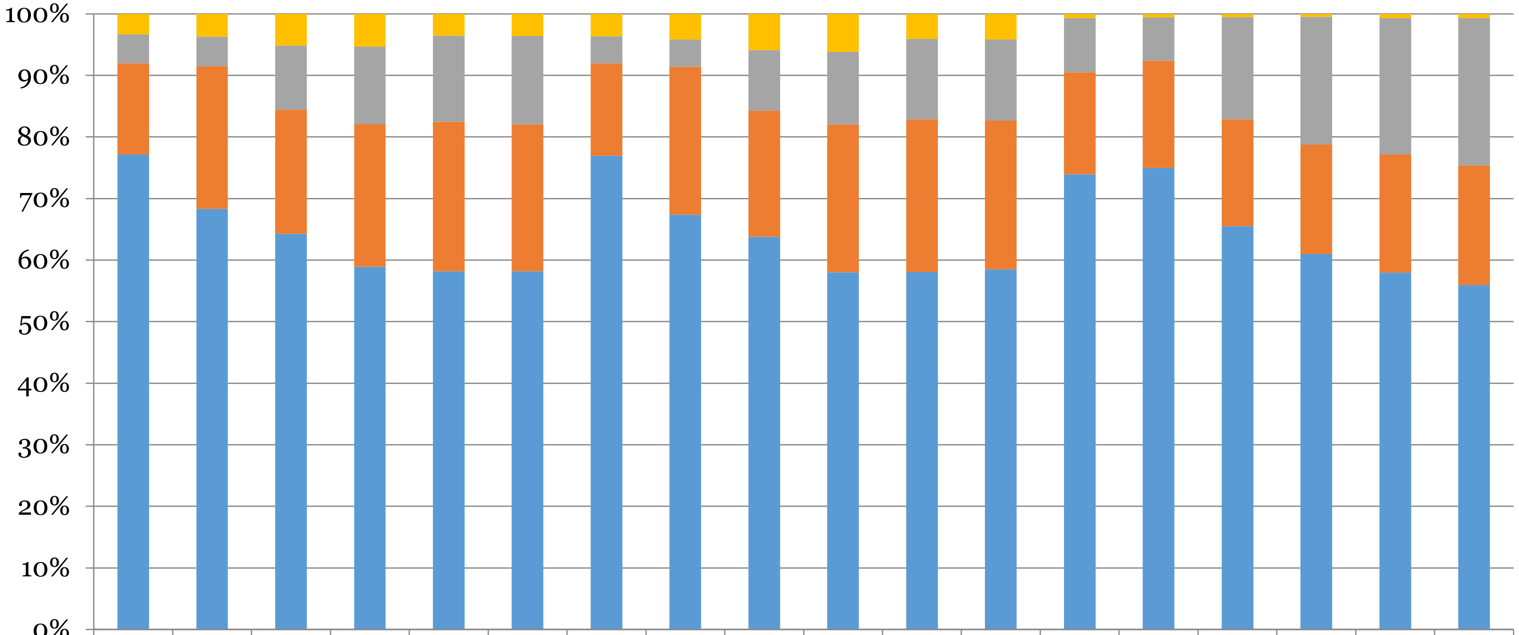
[54] The growing importance of regulated components was accompanied by an increase in average electricity consumption for respondents based in the CEE region and a decrease for respondents based in SE Member States.

[55] See European Commission (2014) - Commission Staff Working Document "Energy prices and costs report accompanying the document Communication from the Commission to the European Parliament, the Council, and the European Economic and Social Committee and the Committee of the Regions Energy prices and costs in Europe" - SWD(2014) 20 final, p.48. See also Eurelectirc (2013) – Power Statistics and Trends 2013 – p. 17. Available at: http://www2.warwick.ac.uk/fac/soc/pais/research/researchcentres/csgr/green/foresight/energyenvironment/2013_eurelectric_power_statistics__trends_2013.pdfesempio

Figure 78. Components of the electricity bills paid by respondents (%, weighted averages[56], 2008-15)



	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
	EU average						Southern Europe						Central-Eastern Europe					
🟨 Other taxes, fees, levies and charges (excl. VAT)	3.4%	3.7%	5.2%	5.3%	3.6%	3.6%	3.6%	4.2%	5.9%	6.2%	4.1%	4.2%	0.7%	0.6%	0.5%	0.5%	0.7%	0.7%
▪ Renewable support	4.6%	4.8%	10.4%	12.6%	14.0%	14.3%	4.4%	4.4%	9.8%	11.7%	13.0%	13.2%	8.8%	7.1%	16.6%	20.7%	22.1%	23.9%
🟧 Network costs	14.8%	23.2%	20.2%	23.2%	24.3%	23.8%	15.0%	24.0%	20.5%	24.0%	24.8%	24.2%	16.6%	17.4%	17.4%	17.8%	19.2%	19.4%
🟦 Energy supply costs	77.2%	68.3%	64.2%	58.9%	58.2%	58.2%	76.9%	67.4%	63.8%	58.0%	58.0%	58.5%	73.9%	75.0%	65.5%	61.0%	58.0%	55.9%

Note: Figures are based on observations from 22 plants, except for 2008 (18 plants), 2010 (20 plants) and 2012 (21 plants).

Source: Authors' own elaboration.

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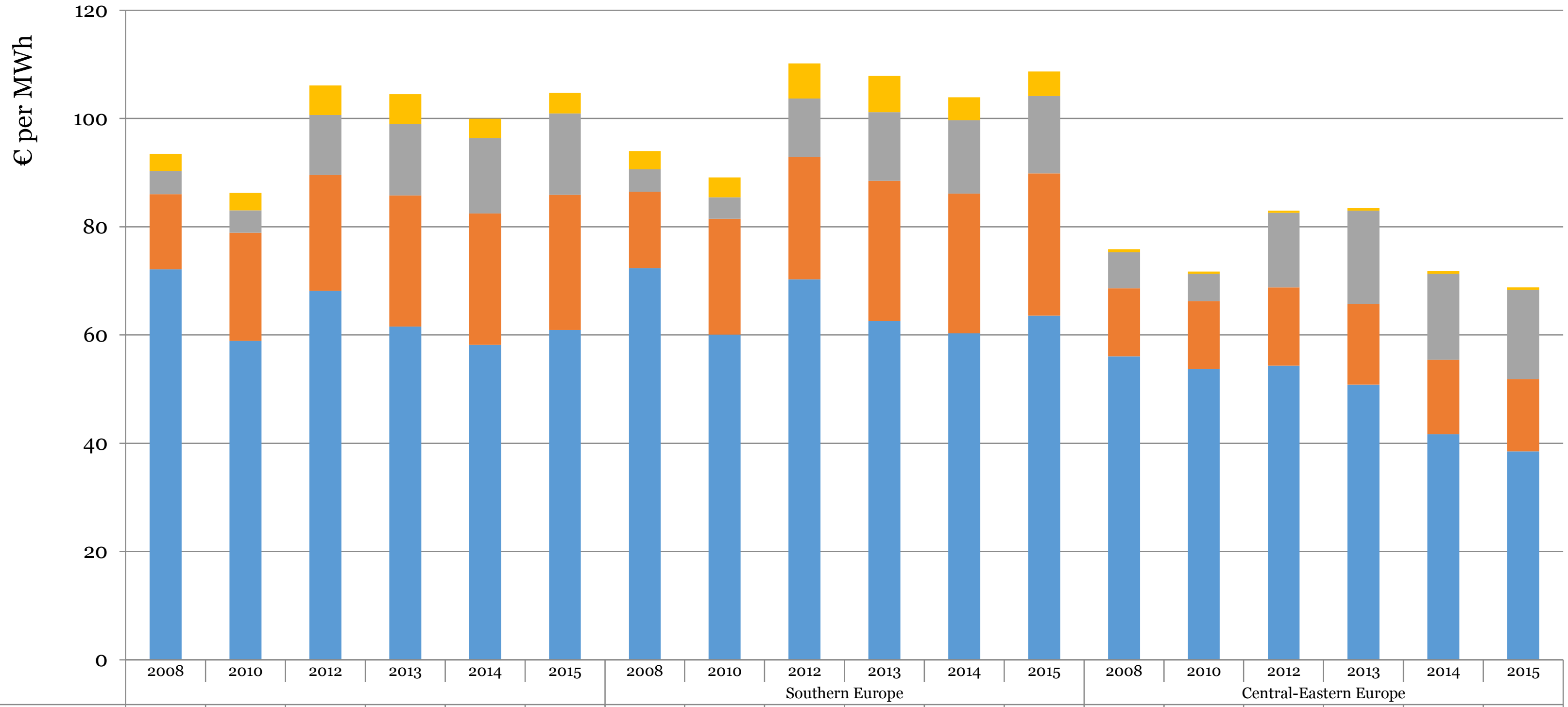
[56] Weighting factor: electricity consumption. The EU average is computed by aggregating the weighted average in each region. Yet, as mentioned in the sampling strategy and sample statistics section above, a different weight is applied to each regional weighted average to reflect the uneven distribution of production across the EU.

Figure 79. Components of the electricity bills paid by respondents (weighted averages[57], 2008-15, €/MWh)



	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
							Southern Europe						Central-Eastern Europe					
🟨 Other taxes, fees, levies and charges (excl. VAT)	3.2	3.2	5.5	5.6	3.6	3.8	3.4	3.7	6.5	6.7	4.3	4.6	0.5	0.4	0.4	0.4	0.5	0.5
◼ Renewable support	4.3	4.1	11.0	13.2	14.0	15.0	4.1	4.0	10.8	12.7	13.5	14.3	6.7	5.1	13.8	17.3	15.9	16.5
🟧 Network costs	13.9	20.0	21.4	24.2	24.3	25.0	14.1	21.4	22.6	25.9	25.8	26.3	12.6	12.5	14.4	14.8	13.8	13.4
🟦 Energy supply costs	72.1	58.9	68.2	61.6	58.1	60.9	72.3	60.1	70.3	62.6	60.3	63.6	56.1	53.8	54.3	50.9	41.7	38.5

Note: Figures are based on observations from 22 plants, except for 2008 (18 plants), 2010 (20 plants) and 2012 (21 plants).

Source: Authors' own elaboration.

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[57] Weighting factor: electricity consumption. The EU average is computed by aggregating the weighted average in each region. Yet, as mentioned in the sampling strategy and sample statistics section above, a different weight is applied to each regional weighted average to reflect the uneven distribution of production across the EU.

Box 3. Indirect EU ETS costs in the ceramic tiles sector

Electric utilities face increased operating costs as a result of ETS compliance cost. As indirect EU ETS costs are not visible in electricity bills, and cannot be distinguished as a separate component, it is likely that the related cost might be passed on to energy consumers via higher energy prices.

Estimates for indirect costs per m^2 of ceramic tiles are calculated using this formula:

Indirect cost (€/m2 of product) =
Electricity intensity (kWh/m2 of product)
** Carbon intensity of electricity (Tonne of CO2/kWh)*
** CO2 Price (€/t of CO2) * Pass-on rate*

- Yearly averages across the EU sample are simple averages. Weighing by consumption would bias the estimates as electricity consumption is a key variable in the formula above.
- Carbon intensity of electricity is a constant per region, and does not take the reductions in carbon intensity of electricity production since 2012 into account. These estimates are therefore likely to be overestimations for the more recent years.
- Only purchased electricity, i.e. excluding self-generation, is subject to indirect ETS costs.
- Two scenarios are calculated, based on the pass on rates equal to 0.6 and 1.

Indirect EU ETS costs (Table 75) have decreased steadily between 2008 and 2013 as European Emission Allowances (EUA) prices decreased sharply. In 2014 and 2015 the estimates for indirect EU ETS costs increased again as EUA prices showed a slow and partial recovery.

Table 75. Estimates for Indirect EU ETS costs for ceramic tiles producers, 2008-2015, two pass on rates (€/m^2 of product).

2008	2010	2012	2013	2014	2015
Pass on rate: 0.6					
0.022	0.017	0.010	0.005	0.006	0.007
Pass on rate: 1					
0.037	0.028	0.016	0.008	0.010	0.012

Source: Authors' elaboration on data from: European Energy Exchange (2016) and European Commission (2012)

Estimates show that a share of the energy component could be linked to indirect EU ETS cost. In 2008, indirect EU ETS costs estimates (pass on rate 1) accounted for 12.8% of electricity price per m^2 of ceramic tiles paid in average by EU respondents. By 2013 this had fallen to 3.6%, and by 2015 it had recovered to 5.9%. These changes are primarily driven by the evolution of EUA prices, which followed exactly the same path.

A similar trend can be detected with respect to production costs where EU ETS indirect costs declined steadily from 0.68% of production costs in 2008 to 0.20% in 2013, slightly increasing to 0.17% in 2014.[58]

Table 76 Share of indirect EU ETS costs in weighted average production costs (%) (pass -on rate of 1)

2008	2010	2012	2013	2014	2015
0.68%	0.50%	0.29%	0.14%	0.17%	N/A*

*Note: Figures are based on observations from 19 plants covered by the EU ETS, except for 2008 (10 plants), 2010 (11 plants) and 2012 (11 plants). * Data on the production costs (€/m2) are not available for EU respondents for 2015*

Source: Authors' elaboration on data from: European Energy Exchange (2016) and European Commission (2012)

This sector is not eligible for compensation for its indirect EU ETS costs according to the European Commission State Aid Guidelines (2012).

5.9 Energy intensity

Energy intensity is calculated as the ratio between the consumption of electricity and gas in MWh over total production in m². In this section, the analysis of natural gas intensity, electricity intensity and overall energy intensity (that is electricity and natural gas) are described via box plots and descriptive tables.

5.9.1 Natural gas

In 2015, sampled manufacturers showed an average natural gas intensity equal to 0.0293 MWh/m², with a median of 0.0247 MWh/m² (Table 77). The natural gas intensity fluctuated over the period under observation (Figure 80).

Strong differences can be found at regional level where CEE producers are the ones showing the lowest gas intensity (0.0202 MWh/m² in 2015), below the EU median and average. SE plants, however, experienced higher values with an average intensity of 0.0306 MWh/m² in 2015.[59] While producers based in the SE region registered a decrease in their gas intensity, an increase was experienced by CEE manufacturers.

In this regard, higher gas prices after 2010 (and up to 2014) might have induced SE producers to engage in energy efficiency interventions. Nevertheless, this consideration cannot be generalised due to the limited time span under analysis compared to investment life cycle in the sector, which as mentioned above can go up to 40 years.

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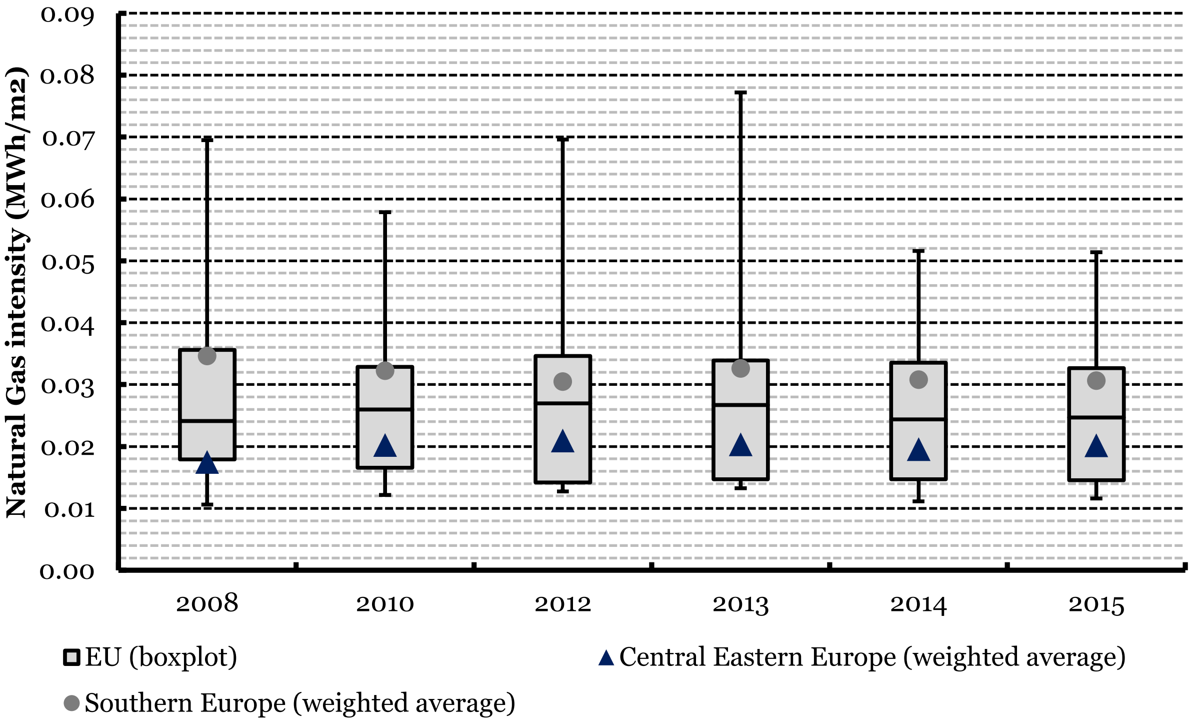
[58] Data on the production costs (€/m²) are not available for EU respondents for 2015.

[59] It is worth remarking that the gas intensity of one plant based in the SE region is almost double than the average. Nonetheless, trends in average intensity for SE plants as well as the substantial gap compared to CE plants are confirmed even when excluding this outlier.

Figure 80. Natural gas intensity per m² of production (2008-15)



Note: Figures are based on observations from 22 plants, except for 2008 when observations are available from 20 plants.
Source: Authors' own elaboration.

Table 77. Descriptive statistics for natural gas intensity (MWh/m², 2008-15)

	2008	2010	2012	2013	2014	2015
EU (weighted average)[60]	0.0327	0.0308	0.0292	0.0309	0.0294	0.0293
EU (median)	0.0242	0.0260	0.0270	0.0267	0.0244	0.0247
EU (IQR)	0.0177	0.0163	0.0205	0.0192	0.0188	0.0181
EU (minimum)	0.0106	0.0122	0.0128	0.0133	0.0111	0.0116
EU (maximum)	0.0695	0.0578	0.0696	0.0772	0.0516	0.0514
Central Eastern Europe (Consumption weighted average)	0.0175	0.0203	0.0210	0.0203	0.0196	0.0202
Southern Europe (Consumption weighted average)	0.0346	0.0322	0.0305	0.0326	0.0308	0.0306

Note: Figures are based on observations from 22 plants, except for 2008 when observations are available from 20 plants.
Source: Authors' own elaboration.

5.9.2 Electricity

The electricity intensity of production was measured by summing (i) electricity purchased from the grid; and (ii) electricity self-generated; then subtracting (iii)

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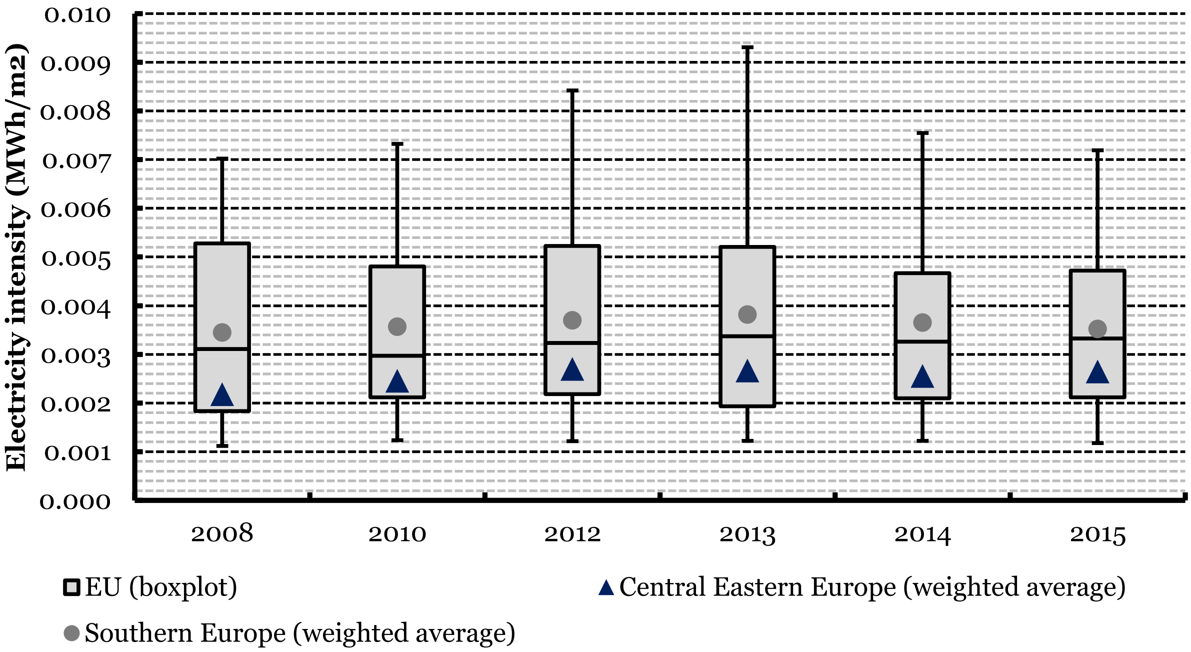
[60] Weighting factor: gas consumption. This average is computed by aggregating the weighted average in each region. Yet, as mentioned in the sampling strategy and sample statistics section above, a different weight is applied to each regional weighted average to reflect the uneven distribution of production across the EU.

electricity sold to the grid; and (iv) dividing by production. Self-generation is used by five respondents[61]. Electricity intensity is generally higher for plants with self-generation capacity.

In 2015, respondents had an average electricity intensity equal to 0.0035 MWh/m² and a median intensity of 0.0033 MWh/m². Electricity intensities increased over the period in median terms (+6.8%). Yet, the 'EU weighted average' remained quite stable. This trend was registered also in the SE region. However, the electricity intensity of CEE plants increased by 23% between 2008 and 2015; yet, these plants are less intensive than the EU median and SE plants (Figure 81). The trend shown by CEE producers might have been motivated by the progressively decreasing electricity prices in the region; on the contrary, as some SE producers engaged in self generation, electricity intensity in this region might have been influenced by the net cost of electricity rather than the market price.[62]

Figure 81. Electricity intensity per m² of production (2008-15)



Note: Figures are based on observations from 22 plants, except for 2008 when observations are available from 20 plants.

Source: Authors' own elaboration.

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[61] The five respondents engaging in self generation were all based in the SE region, where on average the net self-generated electricity (i.e. the electricity self-generated minus the electricity sold to the grid) ranged from 21.5% (2010) to 43.8% (2013) of the net electricity consumption (i.e. the sum of electricity purchased from the grid and electricity self-generated minus electricity sold to the grid).

[62] The net electricity cost is given by a) price paid for the electricity supply + b) cost of self-generated electricity - c) revenues from self-generated electricity sold to the grid + d) taxes on self-generation - e) remuneration for interruptability.

Table 78. Descriptive statistics for electricity intensity (MWh/m2, 2008-15)

	2008	2010	2012	2013	2014	2015
EU (weighted average)[63]	0.0035	0.0036	0.0036	0.0037	0.0036	0.0035
EU (median)	0.0031	0.0030	0.0032	0.0034	0.0033	0.0033
EU (IQR)	0.0034	0.0027	0.0030	0.0033	0.0026	0.0026
EU (minimum)	0.0011	0.0012	0.0012	0.0012	0.0012	0.0012
EU (maximum)	0.0070	0.0073	0.0084	0.0093	0.0075	0.0072
Central Eastern Europe (Consumption weighted average)	0.0022	0.0025	0.0027	0.0027	0.0026	0.0027
Southern Europe (Consumption weighted average)	0.0035	0.0036	0.0037	0.0038	0.0037	0.0035

Note: Figures are based on observations from 22 plants, except for 2008 when observations are available from 20 plants.
Source: Authors' own elaboration.

5.9.3 Energy intensity

The analysis of total energy intensity, i.e. covering both electricity and natural gas, is strongly influenced by the gas intensity as natural gas plays a key role in the production process. Average energy intensity showed a decrease over the period, going from 0.0356 MWh/m^2 in 2008 to 0.0326 MWh/m^2 in 2015 (-8.6%) (Table 79). In line with the previous analysis, sampled CEE plants result to be less energy-intensive than those based in the SE region, with an energy intensity equal to 0.0228 MWh/m^2 in 2015, compared to 0.0339 MWh/m^2. Yet, while energy intensity in SE plants is decreasing (-9.3% between 2008 and 2015), CEE plants were consuming more energy to manufacture one m^2 of ceramic tiles in 2015 than in 2008 (+15.9%).

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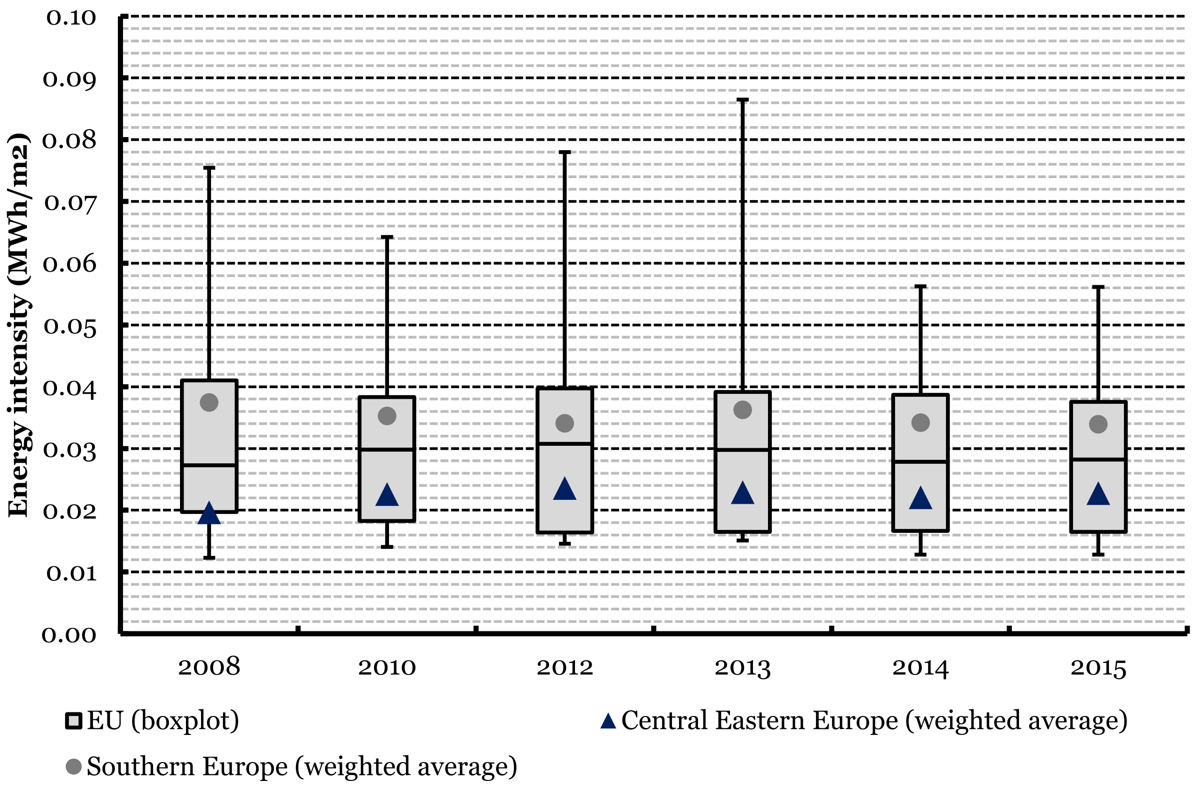
[63] Weighting factor: electricity consumption. This average is computed by aggregating the weighted average in each region. Yet, as mentioned in the sampling strategy and sample statistics section above, strategy, a different weight is applied to each regional weighted average to reflect the uneven distribution of production across the EU.

Figure 82. Energy intensity per m² of production (2008-15)



Note: Figures are based on observations from 22 plants, except for 2008 when observations are available from 20 plants.

Source: Authors' own elaboration

Table 79. Descriptive statistics for energy intensity (MWh/m², 2008-15)

	2008	2010	2012	2013	2014	2015
EU (weighted average)[64]	0.0356	0.0339	0.0327	0.0345	0.0327	0.0326
EU (median)	0.0273	0.0298	0.0308	0.0298	0.0279	0.0282
EU (IQR)	0.0213	0.0200	0.0233	0.0226	0.0221	0.0211
EU (minimum)	0.0123	0.0140	0.0146	0.0151	0.0128	0.0128
EU (maximum)	0.0755	0.0642	0.0780	0.0865	0.0563	0.0561
Central Eastern Europe (Consumption weighted average)	0.0196	0.0226	0.0236	0.0229	0.0221	0.0228
Southern Europe (Consumption weighted average)	0.0374	0.0353	0.0341	0.0363	0.0342	0.0339

Note: Figures are based on observations from 22 plants, except for 2008 when observations are available from 20 plants.

Source: Authors' own elaboration.

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[64] Weighting factor: total consumption. This average is computed by aggregating the weighted average in each region. Yet, as mentioned in the sampling strategy, a different weight is applied to each regional weighted average to reflect the uneven distribution of production across the EU.

5.10 International comparison

As mentioned above, in light of the very limited number of observations collected from ceramics plants based in third countries, confidentiality concerns require to present the international comparison at NACE 3-digit level, thus encompassing the entire "manufacture of clay building materials" sector (NACE Rev. 2 code C23.3, including both producers of ceramic tiles and brick and tiles). Hence, the overall international comparison is included in the next Chapter of this report covering the brick and tiles sector (see Section 6.10 below).

5.11 Key performance indicators and impact of energy costs

This section includes the information retrieved from sampled companies concerning Key Performance Indicators (KPI) – production costs, margins, and turnover. The purpose of retrieving and processing these data is not to provide a financial analysis of responding plants, but to analyse the impact of energy costs – for both gas and electricity – over financial indicators, namely production costs and margins.

Production costs and turnover per m^2 of output were quite stable over the period 2008-2014. All margins indicators are on average positive and in 2014 were higher than 2008. Data for 2015 are available only for plants based in the SE region; hence EU figures cannot be provided.

The impact of energy costs on the financial performance of respondents, and hence the importance of energy prices and consumption for the cost-competitiveness of the ceramic tiles sector, is apparent in Figure 83 and Figure 84. Total energy costs were substantial when compared with EBITDA, especially in the aftermath of the economic and financial crisis, when EBITDA was relatively lower in absolute value.

Finally, energy costs represent some 20% of total production costs over the entire period of observation.

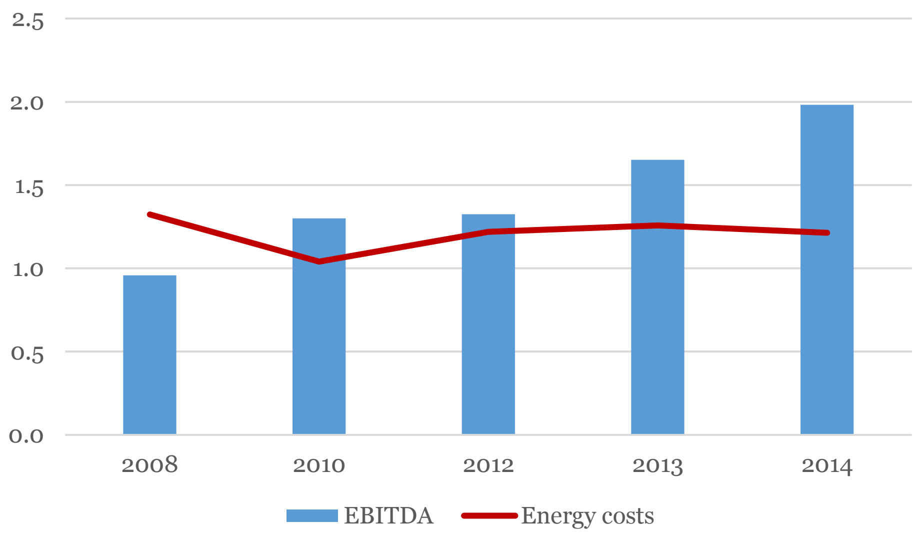
Table 80. Production costs, Turnover, EBITDA, EBIT, Profit/loss before tax (2008-15). Consumption weighted averages based on individual plant production

	2008	2010	2012	2013	2014	2015
Number of plants	22	22	22	22	22	11**
Production costs (€/m2)	5.48*	5.64	5.63	5.47	5.68	na**
Turnover (€/m2)	9.74*	9.50	9.87	10.21	10.45	na**
EBITDA (% of turnover)	11%	13%	12%	14%	17%	na**
EBIT (% of turnover)	4%	6%	6%	8%	11%	na**
Profit/loss before tax (% of turnover)	1%	1%	3%	5%	11%	na**

*Note: * data available for 21 plants; ** data available only for plants in the SE region, hence EU figures cannot be presented.*

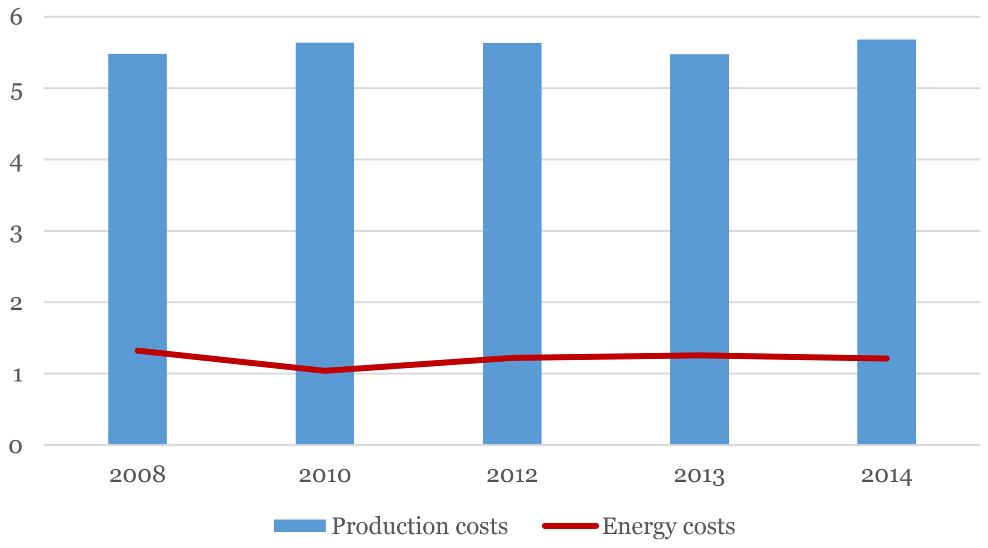
Source: Authors' own elaboration.

Figure 83. Energy costs vs. EBITDA (euro/m²). Weighted averages (total consumption) from respondents based on individual plant production



Note: Figures are based on observations from 22 plants; in 2008 observations are available from 21 plants and observations for Energy costs for 20 plants; in 2015 observations for EBITDA are available from 11 plants all based in SE Member States, hence it is not possible to present EU averages.
Source: Authors' own elaboration.

Figure 84. Energy costs vs. Production costs (euro/m²). Weighted averages (total consumption) from respondents based on individual plant production



Note: Figures are based on observations from 22 plants; in 2008 observations for Production costs are available from 21 plants and observations for Energy costs for 20 plants; in 2015 observations for Production costs are available from 11 plants all based in SE Member States, hence it is not possible to present EU averages.
Source: Authors' own elaboration.

5.11.1 Impact of energy costs on production costs and margins

While electricity costs represent some 6% of total production costs, natural gas costs are equivalent to some 20% of production costs, except for 2010. After this year, while the percentage of electricity costs over total production costs remained relatively stable, the figures for gas experienced stronger fluctuations (Table 81).

It is no surprise that both electricity and natural gas costs are quite high compared to the EBITDA. In fact, energy costs are even higher than EBITDA in 2008 when ceramic tiles manufacturers registered on average a very low EBITDA in absolute value (

Table 82). By comparing electricity and gas regulated components with EBITDA it is apparent that, in line with data presented above, regulated electricity components have a more prominent role than regulated gas components, especially in the more recent years (Table 83).

Table 81. Impact of total energy costs on production costs (%), 2008-15. Weighted averages (electricity consumption and gas consumption) from respondents, based on individual plant production

	2008	2010	2012	2013	2014	2015
Electricity						
EU average	**6.9%***	**5.7%**	**5.6%**	**5.7%**	**5.7%**	**na*** **
SE Region	6.8%	5.8%	5.4%	5.4%	5.5%	4.8%
CEE Region	5.3%	4.8%	6.5%	6.7%	5.6%	na
NWE Region	C	C	C	C	C	na
Natural gas						
EU average	**19.4%****	**14.8%**	**18.8%**	**19.5%**	**18.2%**	**na*** **
SE Region	20.9%	15.5%	19.2%	20.1%	18.6%	16.1%
CEE Region	10.2%	13.3%	19.3%	17.6%	17.6%	na
NWE Region	C	C	C	C	C	na

*Note: Figures are based on observations from 22 plants; *data available for 21 plants; **data available for 20 plants *** data available only for 11 plants in the SE region, hence EU figures cannot be presented; C=confidential.*

Source: Authors' own elaboration.

Table 82. Impact of total energy costs on EBITDA (%), 2008-15. Weighted averages (electricity consumption and gas consumption) from respondents, based on individual plant production

	2008	2010	2012	2013	2014	2015
Electricity						
EU average	**123.9%***	**31.6%**	**47.3%**	**69.2%**	**44.7%**	**na*****
SE Region	43.5%	35.1%	27.3%	23.6%	20.1%	17.5%
CEE Region	49.6%	-4.7%	126.5%	49.4%	29.1%	na
NWE Region	C	C	C	C	C	na
Natural gas						
EU average	**239.2%****	**69.8%**	**144.7%**	**170.7%**	**115.3%**	**na*****
SE Region	118.3%	82.2%	99.2%	92.1%	72.6%	58.2%
CEE Region	124.3%	-35.7%	379.5%	131.3%	92.1%	na
NWE Region	C	C	C	C	C	na

*Note: Figures are based on observations from 22 plants; *data available for 21 plants; **data available for 20 plants *** data available only for 11 plants in the SE region, hence EU figures cannot be presented; C=confidential.*

Source: Authors' own elaboration.

Table 83. Impact of regulated energy costs on EBITDA (%), 2008-2015. Weighted averages (electricity consumption and gas consumption) from respondents of the sample, based on individual plant production.

	2008	2010	2012	2013	2014	2015
Electricity						
Number of plants	**18**	**20**	**21**	**22**	**22**	**11**
EU average	**21.7%**	**10.9%**	**16.0%**	**22.7%**	**16.1%**	**na***
SE Region	7.2%	12.7%	9.3%	7.5%	5.9%	5.2%
CEE Region	12.3%	-4.1%	44.6%	18.6%	12.6%	na
NWE Region	C	C	C	C	C	na
Natural gas						
Number of plants	**17**	**18**	**20**	**20**	**20**	**9**
EU average	**15.2%**	**9.7%**	**15.9%**	**17.1%**	**11.8%**	**na***
SE Region	6.1%	10.1%	7.8%	9.2%	7.1%	6.2%
CEE Region	5.6%	7.5%	63.9%	18.4%	16.9%	na
NWE Region	C	C	C	C	C	na

*Note: * Data available only for plants in the SE region, hence EU figures cannot be presented; C=confidential.*

Source: Authors' own elaboration.

5.12 Concluding remarks

While gas prices have been fluctuating over the period 2008-2015 in the area of 25 to 34 €/MWh, an upward trend was registered for electricity prices, which went from 95€/MWh in 2008 to 107€/MWh 2015. Interestingly, plants based in SE Member States pay higher prices for both gas and electricity. A closer look at price components reveals that regulated components varied across regions and between gas and electricity. These components generally constitute less than 10% of the overall gas price. On the other hand, regulated components represented more than 40% of the 'EU weighted average' electricity prices in 2015 and their relevance have been increasing in both absolute (from some 20€/MWh in 2008 to more than 40€/MWh in 2015) and relative terms (from less than 25% in 2008 to more than 40% in 2015) over the period under observation.

Energy prices and costs are certainly key for the competitiveness of the EU wall and floor tiles industry. More specifically, energy costs are proven to have a major impact on the financial performance of respondents. Total energy costs were even higher than EBITDA in time of crisis and represented some 20% of the total production costs over the period under investigation. In addition, energy prices in the EU are substantially higher than those paid by manufacturers based in Russia and the US. Against this background, energy prices and costs are likely to be an important driver for investment decisions, especially in the field of energy efficiency. Nonetheless, it was not possible to detected such effects in the current Study as the time span under observation is too limited compared to the investment life cycle in the wall and floor tiles sector.

6 *Sector study: Bricks and roof tiles*

Highlights

- ***Sample.*** The research team received 31 questionnaires covering 60 plants in 16 MS. **The sample covers 10.5% of sectoral production, in terms of value**.

- ***Natural gas price trends.*** **The EU median price for natural gas paid by sampled bricks and tiles manufacturers amounts to 30.61 €/MWh.** The median price has been rising in the period 2008-2013 (+3.3% YoY), and then declined until 2015 (-4.5% YoY). With respect to regional differences, NWE and CEE producers stand up as paying average prices lower than the EU median in all or most years. To the contrary, on average SE manufacturers paid approximately 10% more than the EU median price. Regional time-trends were similar, both among each other and to the general trend.
- Split of the natural gas price into components shows a **very limited role of the regulated components.**

- ***Electricity price trends.*** **The EU median price for electricity paid by sampled bricks and tiles manufacturers amounts to 88.32 €/MWh**. The diachronic trend is similar to that of natural gas, with the price increasing between 2008 and 2013 (+2.5% YoY), and then decreasing (-5.0% YoY). Price dispersion is larger, possibly due to higher weight of regulated components and higher fragmentation of national policies. As in the case of natural gas, SE producers face the highest prices. Electricity prices for NWE manufacturers also do not show a favourable trend, as it is the only region in which prices did not decline in 2014 and 2015. For CEE plants, prices have been consistently below the median, and declining over the overall period: after a peak in 2013, electricity prices are now below the 2008 levels.
- **The impact of regulated components on the electricity price is more significant than in the case of natural gas**: in 2015, network costs, RES levies, and other taxes and fees (excluding VAT) accounted for 51% of the weighted EU average price. As a comparison, in 2010 this share was down at 44%, and constantly increased in the following 5 years. Among regulated components, the lion's share is taken by RES levies and network costs. The share of RES support has increased from 17.1% in 2010 to 21.1% in 2015 (+8.1% YoY in absolute value), while the share of network costs increased from 16.7% to 21.2% (+7.2% YoY in absolute value).

- ***International comparison.*** In 2015, Russian plants paid approximately 6 €/MWh for natural gas, which is approximately 78% less than the EU average, and 75% less than the CEE average, their closest neighbours. In 2014 and 2015, reported US prices for natural gas were in between 14 and 19 €/MWh; 35% lower than those paid by their European peers. This comparison was done jointly with the Wall and floor tiles subsector.

- ***Impact on competitiveness.*** **The EU weighted average of energy costs over total production costs range from 28% to 35%,** varying in line with energy price trends, i.e. peaking in the 2012-2013 period and slowly declining from 2014 onwards. Natural gas represents about two thirds of energy costs, with a weight of 19.5% on total production costs in 2015. When compared to EBITDA, the importance of energy costs for bricks and tiles manufacturers is even more prominent, as they are larger than plants' margins across the whole period.

6.1 Introduction

This section presents the analysis of energy prices and costs of **the ceramics sector 'Manufacture of bricks, tiles and construction products, in baked clay'** (NACE Rev.2 code 23.32), hereinafter the **'bricks and tiles'** sector. As it will be discussed below, being a four-digit NACE group, the bricks and tiles sector is **homogeneous**, as it includes companies with similar production processes and products – indeed, two main products, bricks and tiles, represent 96% of the sectoral output.

This sectoral case study is structured as follows:

1. In the beginning of the case study (above) the main highlights from the research are presented;
2. Sections 6.2 to 6.5 provide the sectoral overview. In particular, 6.2 Section describes the production process and production characteristics in the EU; Section 6.3 presents the main characteristics of the EU industry; Section 6.4 provides an analysis of trade patterns; and Section 6.5 shows the analysis of the industry's energy consumption;
3. Section 6.6 presents the sampling strategy based and the description of the actual sample of manufacturing plants included in the study, including sectoral coverage;
4. Sections 6.7 and 6.8 report the results of the analysis of energy prices, both total prices and split per components;
5. Section 6.9 describes sectoral energy intensity;
6. Section 6.10 provides a comparison of energy prices paid by EU, Russian and US ceramic manufacturers – covering both the brick and roof tiles and the wall and floor tiles sectors
7. Section 6.11 provides the analysis of Key Performance Indicators (KPI) and the impact of energy costs over production costs and margins.
8. Section 6.12 provides a brief conclusion.

6.2 Overview of the production process

The ceramics industry includes the manufacturing of products made from inorganic non-metallic minerals (such as clay) through a permanent firing process that changes their chemical properties (Fraunhofer ISI et al., 2009). Ceramics products are characterised by their strength, texture, longevity, chemical inertness, electrical resistance, and refractoriness, to a variable extent depending on the specific raw materials and treatments.

In particular, the bricks and tiles sector includes the manufacturing of (i) **building bricks**, including both clay blocks and facing bricks; (ii) **roof tiles**; (iii) **paving**

bricks; and (iv) **chimney bricks and other clay building products**. While the bricks and tiles sector includes manufacturers of products with diverse shapes and properties, the production process remains largely the same, as for most of the other ceramics products, and can be represented as in Figure 85 below.

Figure 85. Production process for the bricks and tiles sector

Source: Author's Elaboration based on European Commission (2007).

Though this Assignment focuses on manufacturing sectors, and hence not on quarrying activities, in many cases bricks and tiles producers are vertically integrated with quarrying operations, namely clay extraction. Due to the low value-to-weight ratio of raw materials, manufacturing plants of bricks and tiles are usually located near extraction sites (Ecorys et al., 2008).

After extraction, raw materials are transported and stored at the production site, where they are prepared, usually through dry or semi-wet processes. During the preparation step, the particle size of raw materials is reduced, water content is adjusted to the appropriate moisture level, and additives and other raw materials are added.

Raw materials are then shaped, through pressing, extrusion or moulding. Extrusion, the most widespread technique, consists in making the raw material sufficiently 'plastic', so that it can be forced through the die of the extruder, to acquire the desired form, and then be cut into units of the required length. Pressing, which is still used for the manufacture of bricks, consists in loading boxes of the desired shape with a certain volume of clay, and then applying pressure from above and below. Moulding, most often a residual technique, demands less power and energy than pressing or extrusion, but requires a wetter mix of raw materials, thus increasing the energy consumption and time required for drying.

Drying and firing are the most energy-intensive steps of the production process of bricks and tiles. Drying is used to reduce the water content of materials at relatively low temperature (45°-90°C) and mainly takes place in chamber (intermittent) or tunnel (continuous) dryers. The drying equipment is usually heated through either hot air recovered from the kiln or gas burners. With new and more efficient drying technology, the duration of the process has been significantly reduced and depending on the type of product, drying can last from as few as four hours to over 40 hours.

Once dried, 'green' tiles and bricks are fired in kilns. This is the key step to determining the properties of the finished products. Kilns may be either intermittent or continuous, the latter being more suitable for larger plants and more energy-efficient. Most bricks and roof tiles are nowadays fired in continuous tunnel kilns, whose temperature ranges between 800° and 1300°, depending on the type of products and the characteristics to be obtained. The firing process lasts from around six hours to over 40 hours, depending on the product. Kilns are usually gas-fired, though oil, coal, or biomass can also be used. Intermittent kilns can be used to produce smaller batches of specialised roof tiles or bricks.

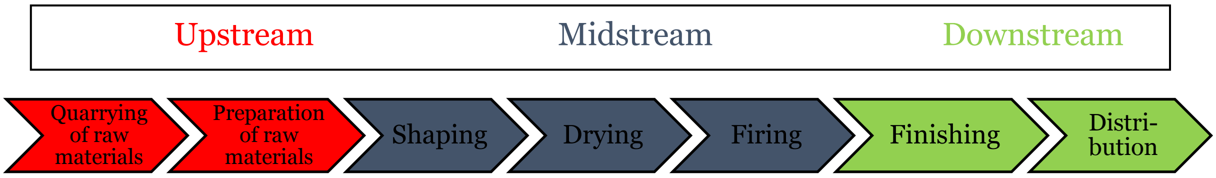
Once fired, products may either be ready for shipping and distribution, or require subsequent treatments, such as calibration, cutting or surfacing (European Commission, 2007).

6.3 Industry characteristics

In this section, the supply and demand features, including information on producers and products, in the bricks and tiles sector are discussed. This information is instrumental in defining a sample representing the typologies of companies and the EU geographical pattern specific to the sector. First, however, it is necessary to briefly analyse the bricks and tiles value chain.

The bricks and tiles value chain is illustrated in Figure 86. Upstream is defined as the process before the actual manufacturing process, the mining/quarrying of raw materials and their preparation. The actual manufacturing process, shaping, drying and firing, is defined as midstream. Finally, downstream refers to the post-manufacturing process, meaning finishing and distribution.

Figure 86. Bricks and tiles value chain



The main customer for bricks and tiles is the construction sector, which makes the demand volatile due to seasonality, e.g. lower in winter, higher in spring and fall. Furthermore, strong dependency on the construction sector has caused a strong downsizing of the production of bricks and tiles due to the economic and financial crisis, as discussed in Section 6.3.1 below (Ecorys et al., 2008).

Based on the input/output table by Eurostat, in 2012 the construction industry[65] absorbed more than 61% of the output of non-metallic mineral products[66], for a value of approximately €83 billion[67]. As a comparison, the next industrial sector buying non-metallic mineral products is food and beverages, at €4 billion. Private consumption by households account for an additional €13 billion.

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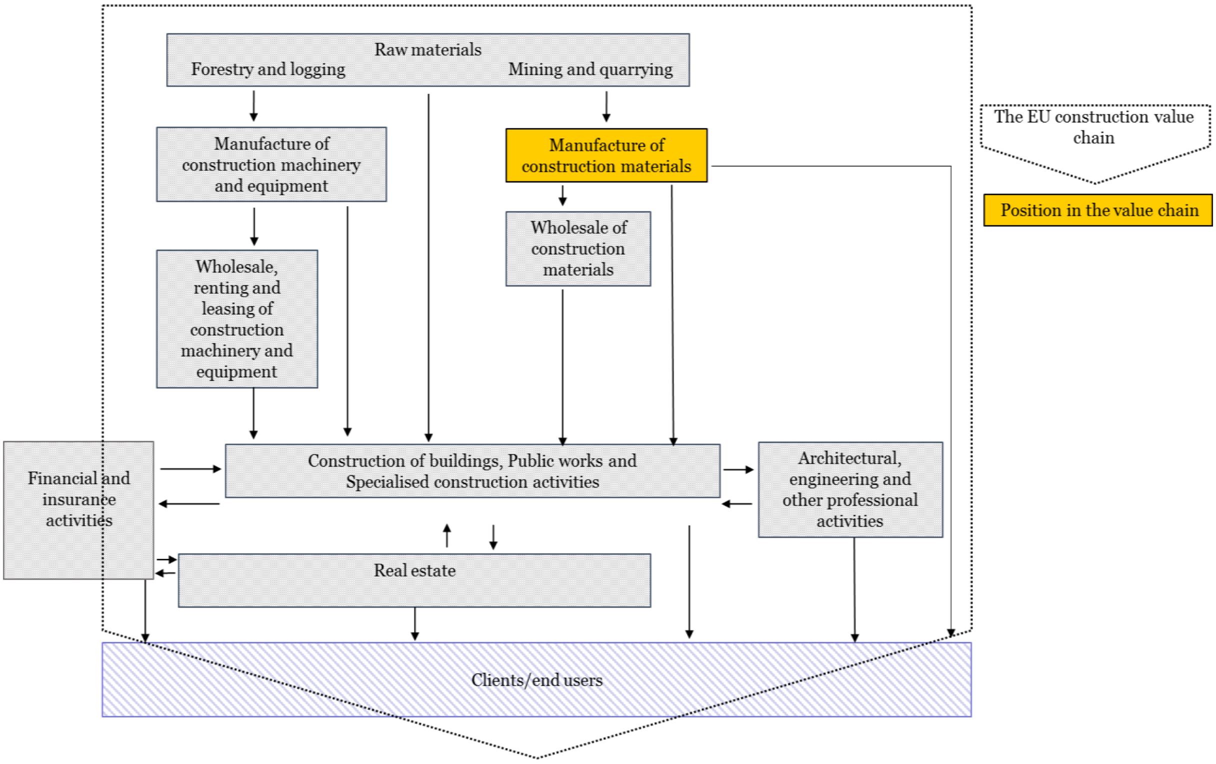
[65] NACE code F.

[66] Including all ceramics and glass products.

[67] Excluding intra-industry trade, which accounted for approximately €21 billion.

The positioning of the bricks and tiles sector within the larger construction value chain is shown in Figure 87. Bricks and tiles producers belong to the segment 'Manufacturer of construction materials', which is positioned in the upper part of the value chain, as a supplier of main contractors.

Figure 87. Bricks and tiles sector position in the construction value chain



Source: Authors' own elaboration.

6.3.1 *Production in the EU*

Figure 88 below presents the **production value** in the bricks and tiles subsector both over time and across Member States (Eurostat SBS, 2016). As for the time trend, the production value of the sector declined by approximately 13% between 2008 and 2013, from slightly more than €7 billion to €6 billion (in nominal values). The annual output was very volatile, with year-on-year changes amounting to 10% or more, as, for instance, from 2011 to 2012.

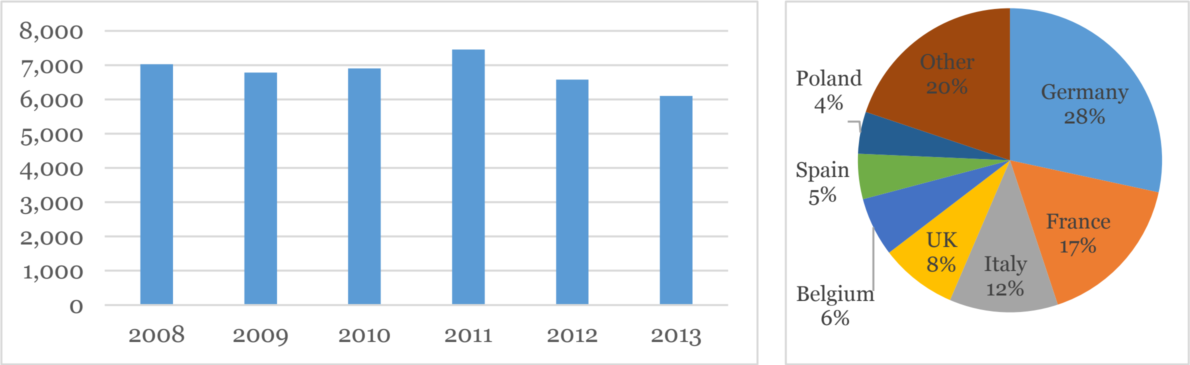
In general, the sector closely follows the economic trend of the construction sector, which is its main customer, and thus the overall GDP trend. The impact of the crisis has been severe, especially considering that in 2007 the production value had reached almost €9 billion (CEPS, 2014a). All in all, the economic and financial crisis brought the sectoral output down by almost 33%.

With regard to geographical distribution, the bricks and tiles sector is quite widespread across the EU and significantly correlated with the size of the national economy and construction sector. As sources of clay are uniformly dispersed across all Member States, and as the low value-to-weight ratio of both the raw materials and the finished products makes transport expensive, local production is required.

For both reasons, the largest producers closely overlap with the largest Member States. In particular, Germany, France, Italy and the UK account for about two-thirds of the market. Together with Belgium, Spain and Poland, these countries account for 80% of the total production value. Belgium is the only exception among the six biggest EU economies: structurally, Belgium has always been the EU Member State with the highest per capita production of bricks and tiles (European Commission, 2007); in addition, Belgium and Germany are among the healthiest construction markets in continental Europe.[68]

The different impact of the economic and financial crisis across different economies becomes apparent when analysing national production in 2008. In 2008, Italy was the largest producer of bricks and tiles, with output approximately double that of the present day. Similarly, Spain was the fourth largest producer, with a production which was approximately four times as high as the present day. A similar trend can be observed in Greece. The only countries showing an increase in production value between 2008 and 2013 are Belgium and Germany, whose shares of EU production rose from 4% to 6% and from 19% to 28% respectively.

Figure 88. Production value of the bricks and tiles sector: EU-28 in million € (left) and distribution across Member States in 2013 (right)



Source: Eurostat Structural Business Statistics (2016).

The Prodcom database allows for evaluating **production output**. Four categories of products relevant to the bricks and tiles sector are included in this database:

1) **Building bricks:** 23321110 - Non-refractory clay building bricks (excluding of siliceous fossil meals or earths).
2) **Flooring blocks:** 23321130 - Non-refractory clay flooring blocks, support or filler tiles and the like (excluding of siliceous fossil meals or earths).
3) **Roof tiles:** 23321250 - Non-refractory clay roofing tiles.
4) **Other clay building products:** 23321270 - Non-refractory clay constructional products (including chimneypots, cowls, chimney liners and flue-blocks, architectural ornaments, ventilator grills, clay-lath; excluding pipes, guttering and the like).

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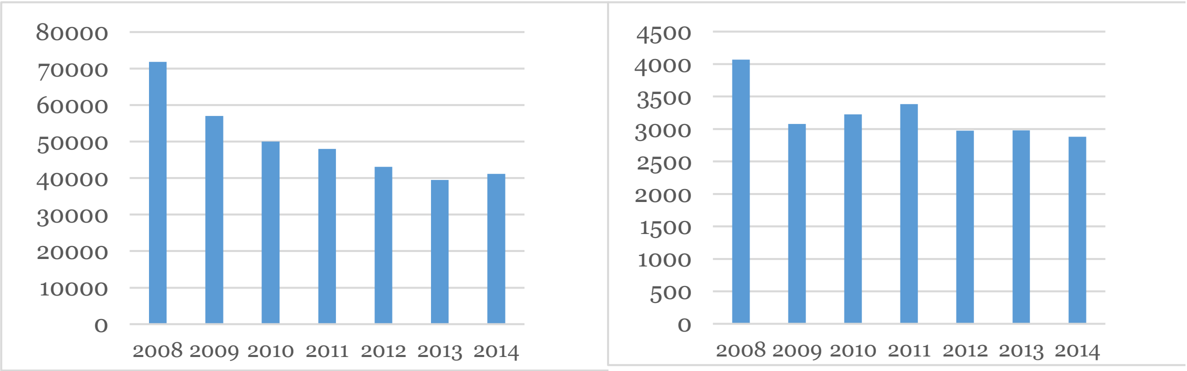
[68] Based on Euroconstruct data on size (in terms of value) of the construction market.

Data on the production output for these four products are measured in different units. As a result, a comprehensive analysis considering the entire output is not possible.[69] Building bricks and roof tiles account for almost all production in terms of value, while flooring blocks and other clay constructional products are marginal categories; hence the analysis below focuses on building bricks and roof tiles.[70]

Similar to the overall sector's production value, the output of building bricks and roof tiles declined by 47% and 29% respectively between 2008 and 2013, as shown in Figure 89 below. For sampling purposes, Figure 90 presents the geographical distribution of the output for both products in 2014. The production of roof tiles is more concentrated in a limited number of Member States compared to bricks. In particular, more than 80% of the output is concentrated in six Member States (included among the largest producers shown in Figure 88 above).[71]

For building bricks, the six largest producing Member States, again among those generating the largest production value in the sector, account for two-thirds of the output.[72] The higher concentration is probably due to the higher value-to-weight ratio of roof tiles compared to building bricks. In any case, analysis of companies in a limited number of countries may enable the research team to obtain results with general validity for the whole sector. The role of each Member State in both markets is rather similar, except for France, which plays a more significant role in roof tiles, and Italy which plays a more significant role in building blocks. Given the relative homogeneity across the two products, adopting different sampling strategies is not considered necessary.

Figure 89. EU output of building bricks (1000 m3, left) and roof tiles (million items, right)



Source: Eurostat Prodcom Database (2016).

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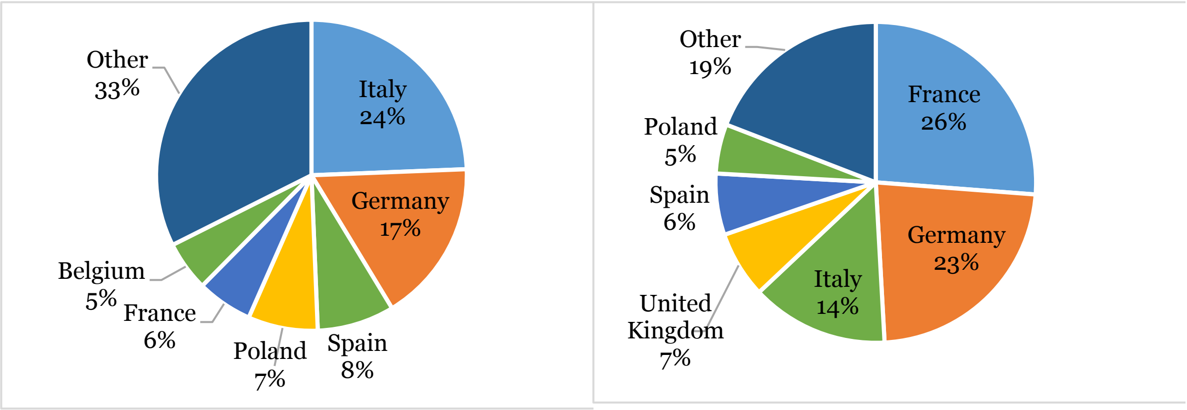
[69] Building bricks are measured in volume (m3); roof tiles are measured in number of items; flooring blocks and other clay constructional product are measured in weight (kg).

[70] In 2014, building bricks represented 57% of the sector's production value and roof tiles 39%; flooring blocks and other clay constructional products represented 2% each. Source: Eurostat Prodcom Database.

[71] Data for Belgium are confidential and thus not provided in the Prodcom Database.

[72] Data for the United Kingdom are confidential and thus not provided in the Prodcom Database.

Figure 90. Geographical distribution of output for building bricks (left) and roof tiles (right), 2014



Source: Eurostat Prodcom Database (2016).

6.3.2 *Number of companies and plants operating in the EU*

Figure 91 below contains similar information with regard to the **number of enterprises**. The number of enterprises fell even more dramatically than the production value, by approximately 30% between 2008 and 2013. At the same time, enterprises became larger in terms of production value and, as a result, the sector is becoming more consolidated. The bricks and tiles sector is considered more concentrated than other ceramics subsectors (Ecorys et al., 2008).

Data on the size class of enterprises in the bricks and tiles sector are not available at a sufficiently granular level of detail.[73] Nevertheless, the stakeholder association estimates that the sector consists of a roughly equal number of large producers and regionally settled SMEs (CEPS, 2014a).[74]

As for the geographical distribution, the largest Member States tend to have the highest number of companies. The per capita number of enterprises, however, is lower (that is, in larger markets, companies tend to have a larger dimension in terms of output). All in all, in 2013 Germany, France, Italy, the United Kingdom, Belgium, Spain and Poland hosted approximately 53% of the total number of EU enterprises in this sector.

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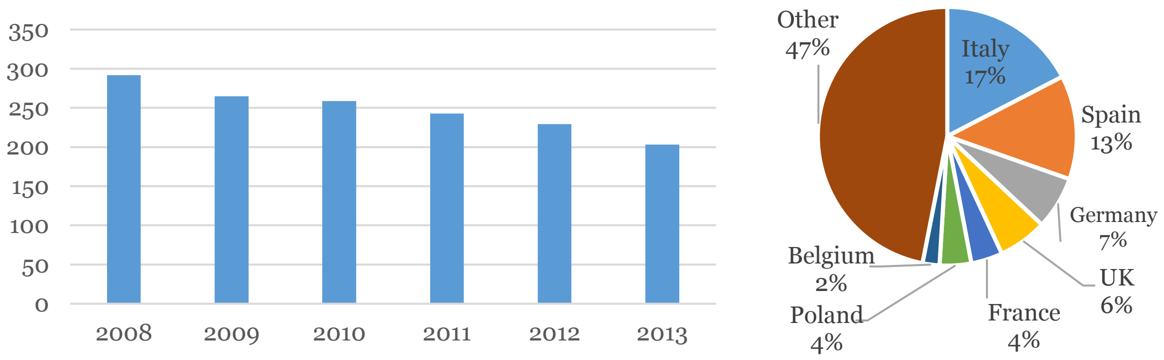
[73] Data on size distribution of enterprises are available at 3-digit NACE level, which also includes producers of wall and floor tiles, which are covered by another sectoral report within this Assignment.

[74] SME definition corresponds to that adopted by the European Commission: companies with (i) fewer than 250 employees and (ii) annual turnover lower than €50 million or annual balance sheet lower than €43 billion. Small companies are defined as those with: (i) fewer than 50 employees; and (ii) annual turnover or balance sheet less than €10 million. Micro companies are defined as those with: i) fewer than 10 employees; and (ii) annual turnover or balance sheet less than €2 million. Cf. European Commission (2015), User guide to the SME definition, 06.05.2015.

Figure 91. Number of enterprises in the bricks and tiles sector: EU-28 in 1000s (left) and distribution across Member States, 2013 (right)



Source: Eurostat Structural Business Statistics (2016).

6.3.3 Geographic distribution of production and plants over the EU

Comprehensive information on the **number and distribution of plants** is not available through public sources, and stakeholder associations could not provide comprehensive data or a statistical overview. The BAT Reference (BREF) document reports the number of plants for selected Member States shown in Table 84 below. Data refer to the early 2000s, and no information on Eastern European countries is available therein.

Table 84. Number of plants as reported in the BREF document

Member State	Plants
Italy	238
Germany	183
Portugal	150
France	136
United Kingdom	134
Netherlands	58
Belgium	40
Austria	30
Denmark	26
Total	995

Source: European Commission (2007).

Another source to estimate the number of plants and their distribution is the European Union Transaction Log (EUTL) Database, where all plants registered under the ETS system are listed. Based on this database, manufacturers of bricks and tiles are present in 24 Member States, as reported below in Table 85. However, some Member States excluded smaller plants from the ETS system.[75] Based on the available evidence, these could account for 90% of the installations in Spain[76] and 60% in France.

Another demonstration that the number of plants registered in the EUTL database and the number of installations in the bricks and tiles sector are not coherent is the low number of entries for Italy, which is the country with the largest number of enterprises according to Eurostat and the largest number of plants according to the BREF. Hence, though indications can be extrapolated from both the BREF and the EUTL, no consistent and comprehensive analysis of the number of plants is available for sampling purposes and proxies (such as the production value, the number of enterprises, and the production output) will be relied upon.

Table 85. Number of plants as reported in the EUTL Database

Member State	Plants	Member State	Plants
Germany	123	**Hungary**	17
Spain	64	**Bulgaria**	14
Italy	45	**Denmark**	14
France	44	**Romania**	14
Portugal	40	**Croatia**	12
Netherlands	34	**Cyprus**	8
Greece	28	**Slovakia**	6
Poland	27	**Finland**	4
Austria	24	**Lithuania**	3
Belgium	24	**Latvia**	2
Czech Republic	20	**Sweden**	2
United Kingdom	19	**Slovenia**	1
Total			**589**

Source: EUTL (2016).

6.3.4 Employment

Figure 92 below contains information on the employment level in the bricks and tiles sector. The figure shows the number of persons employed and their distribution over EU Member States. As the number of enterprises and the production value, the employment level too shows a drop, by approximately 30% from 2008 to 2013. This decline is comparable to the reduction in the number of enterprises, signalling that firm size remained, on average, constant; to the contrary, the reduction in the number of employees is lower than that of production value (-13%), implying growth in the apparent labour productivity.

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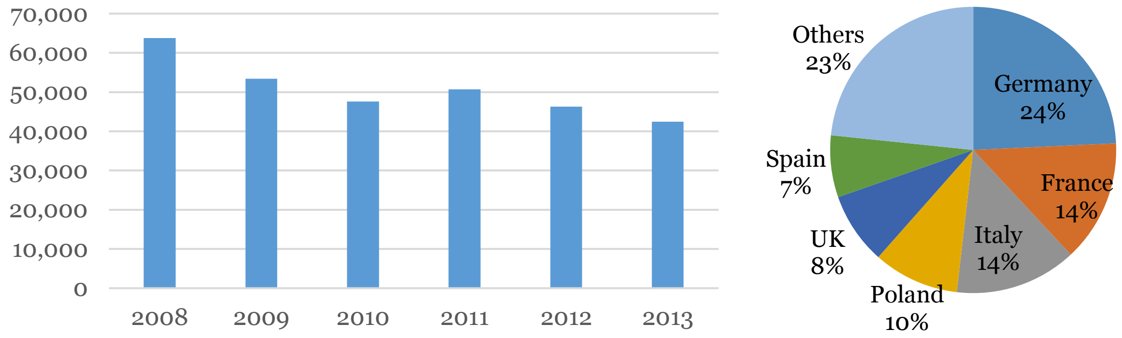
[75] Installations whose annual emissions are below 25 ktonnes of CO_2 can be opted out from the ETS system, provided that the Member State applies ‘equivalent measures’. Cf. Art. 27 of the Directive 2003/87/EC of the European Parliament and of the Council establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC.

[76] As a comparison, the EUTL database included 287 plants for Spain in 2009 and only 64 in 2016; the reduction by more than 75% can be due to the reduction in output but also to changes in the application of the opt-out clause (see Fraunhofer ISI et al., 2009, p. 2).

While the numbers were increasing in Germany, there was a significant decrease in countries such as Spain, Italy (almost 40%) and Greece (approximately 70% less). As for production value and number of enterprises, the six biggest EU Member States – Germany, France, Italy, the UK, Spain and Poland – are also those with the most persons employed in this sector, accounting for more than 75% of persons employed.

Figure 92. Number of persons employed in the bricks and tiles sector: EU-28 (left) and distribution across Member States, 2013 (right)



Source: Eurostat Structural Business Statistics (2016).

6.4 Trade analysis

The bricks and tiles sector[77] is characterised by a low intra-EU trade intensity, due to the limited intra-EU exchanges. This is consistent with the findings, discussed above, of low tradability, due to limited transportability of both raw materials and finished products. As tradability for bricks and tiles is correlated with distance from the production site, extra-EU trade intensity is even lower, if not marginal. All in all, extra-EU imports accounted for 0.4% of the EU market size in 2013, while extra-EU exports for 3.7%. The EU as a whole is therefore a net exporter of bricks and tiles.

In 2013, trade intensity[78] was only around 4% (extra-EU) and 19% (intra-EU). The trade intensity did not show significant changes between 2008 and 2013, except for a further drop during the peak period of the economic and financial crisis (2009-11), when, in particular, intra-EU trade intensity bottomed out at 16% in 2010. As Figure 93 shows, both intra- and extra-EU trade dropped in 2009. While intra-EU trade is still below pre-crisis level, the extra-EU trade has managed to get back to its pre-crisis level, especially thanks to an increase in extra-EU exports.

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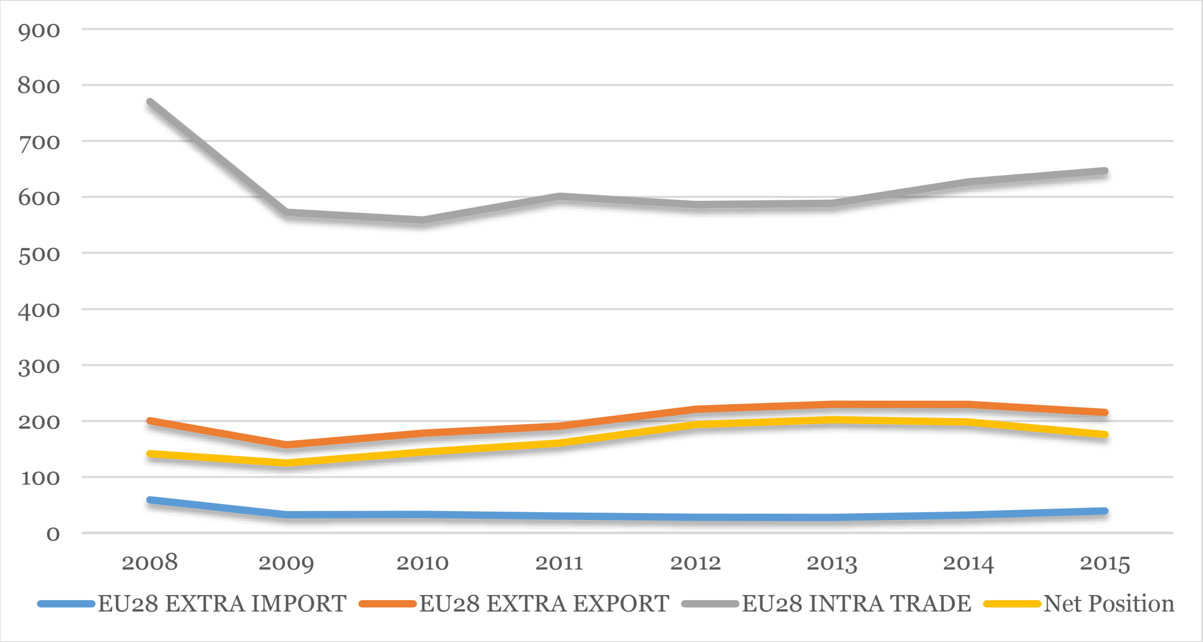
[77] For the purpose of trade data analysis, bricks and tiles are here defined according to the Harmonized Commodity Description and Coding System (HS). It includes the following: ceramic building bricks, flooring blocks, support or filter tiles and the like (6904); sub-categories: building bricks (690410) and other (690490); and: roofing tiles, chimney pots, cowls, chimney liners, architectural ornaments and other ceramic constructional goods (6905); sub-categories: roofing tiles (690510) and other (690590).

[78] Trade intensity is defined in Art. 10a of ETS Directive 2003/87/EC. Trade intensity with third countries is defined as the ratio between the total value of exports to third countries plus the value of imports from third countries and the total market size for the Community (production value plus total imports from third countries). Analogously, intra-EU trade intensity is defined as the ratio between total value of intra-EU exports plus the value of intra-EU imports and the production value.

Figure 93 illustrates the dominance of intra-EU trade over extra-EU trade. In 2014, intra-EU trade accounted for around 83% of total trade, while extra-EU trade only contributed 17%. An even bigger difference can be noticed for imports, where 95% of trade flows originate from EU countries and only 5% from countries outside of the Union. All in all, the EU was a net exporter of bricks and tiles for the whole period from 2008 until 2015.[79] In 2014, the EU had a positive trade balance for bricks and tiles of over €197 million. The balance between intra- and extra-EU trade has not changed significantly since 2008, although extra-EU trade increased its weight slightly. In 2008, extra-EU trade accounted for 14% and intra-EU for 86%.

Focusing on imports from non-EU countries, in 2013 they represented only 0.4% of the EU market size; this value did not change over the period in scope of assignment, being marginally higher only in 2008, at 0.8%, i.e. before the unfolding of the crisis. Those figures underline that the imports of bricks and tiles into the EU are extremely low. Extra-EU exports are marginally higher, representing 3.7% of the EU market size, up from 2.8% in 2008.

Figure 93. Intra and extra-EU trade of bricks and tiles 2008-15 (€ million)[80]



Source: Eurostat's COMEXT (2016).

The fact that the bricks and tiles sector is not global can also be clearly observed in trade patterns. Not only is trade intensity low, most of the important extra-EU trading partners are located at the European borders (including sea borders with Mediterranean countries). Table 86 shows 16 of the most important EU trading partners for bricks and tiles. In 2014, the top five trading partners were Russia (trade flows, including imports and exports, amounting to €43 million), Switzerland (€21

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[79] The data for 2015 is a projection based on the available data for January-October 2015.

[80] For intra-EU trade an average between intra-EU imports and exports was calculated and used for this figure.

million), Serbia (€19 million), Lebanon (€12 million) and Bosnia and Herzegovina (BiH) (€12 million).

These five countries accounted for more than 40% of the overall extra-EU trade. Compared to 2008, the top five trading partners remained almost the same, solely the United States changed, as it was the fourth most important trading partner, with Serbia, BiH, Russia and Switzerland rounding out the top five. In comparison to 2014, in 2008 trade flows were more concentrated and the top five partners accounted for around 50% of external trade.

In 2014, Russia (€43 million) was by far the top destination country for EU exports of bricks and tiles, well ahead of Switzerland (€20 million) and Lebanon (€12 million). Compared to 2008, the United States (-70%) and BiH (-50%) lost importance as export destinations, while Russia (+70%) and Switzerland (+30%) increased their shares.

The main origin countries of EU imports of bricks and tiles in 2014 were Serbia (€17 million), China (€3 million), and Macedonia (€3 million). The same three countries were the main source of EU imports in 2008, however, the value declined for all three of them: Serbia (-50%), China (-10%), Macedonia (-30%). A notable increase of imports can be noticed for India (€137,334 million in 2008 and €1 million in 2014).

Table 86. EU-28 exports, imports and net positions in bricks and tiles by selected destination countries, 2008 and 2014 (in €)

Destination Countries	2008			2014		
	Export	Import	Net	Export	Import	Net
Total Extra-EU	**200 543 795**	**59 094 840**	**141 448 955**	**229 733 214**	**31 849 599**	**197 883 615**
Russia	25 643 410	20 414	25 622 996	42 847 600	1 429	42 846 171
Switzerland	14 756 106	2 082 292	12 673 814	19 822 714	1 560 919	18 261 795
Lebanon	4 906 735	0	4 906 735	12 114 976	132	12 114 844
BiH	24 664 559	3 054 668	21 609 891	11 743 008	284 411	11 458 597
Norway	14 377 112	811 313	13 565 799	11 668 409	27 186	11 641 223
Algeria	4 027 015	22 123	4 004 892	10 934 220	800	10 933 420
Saudi Arabia	9 269 687	0	9 269 687	8 201 185	0	8 201 185
Ukraine	13 128 974	192 330	12 936 644	8 002 579	161 361	7 841 218
Arab Emirates	9 626 753	2 885	9 623 868	6 513 294	6 794	6 506 500
United States	21 790 739	870 588	20 920 151	6 326 174	691 968	5 634 206
China	2 633 020	3 134 154	- 501 134	3 444 230	2 842 621	601 609
Moldova	1 762 036	2 401 443	- 639 407	2 091 988	660 979	1 431 009
Turkey	1 218 972	1 673 311	- 454 339	1 991 279	2 455 145	-463 866
Serbia	1 670 551	36 358 552	- 34 688 001	1 701 240	16 958 682	-15 257 442
Macedonia	306 749	3 820 429	- 3 513 680	829 987	2 660 412	-1 830 425
India	389 462	137 334	252 128	743 073	1 066 672	-323 599

Source: Authors' elaboration on Eurostat COMEXT (2016).

6.5 Energy - literature review

The production of bricks and roof tiles requires 2.3 GJ of energy per tonne of production. Though included in the 2007 BREF and in the 2009 benchmark study (Fraunhofer ISI et al., 2009), this estimate of energy intensity refers to 2005, and hence it probably does not reflect the subsequent improvements in terms of energy efficiency.

The energy intensity of both building bricks and roof tiles is similar, though possibly slightly higher for the latter.[81] The most energy consuming step of the production process of bricks and tiles is, unsurprisingly, the firing stage, where the kiln needs to reach a temperature higher than 1000°C. Drying also requires energy, which is largely provided through the heat recovered from the firing stage. In addition to that, the mixing and shaping of raw materials are usually done through electricity-powered equipment.

The main energy carrier in the industry is natural gas. Natural gas is cost-efficient, reduces CO_2 and other emissions and, importantly for this industry, allows for a better control of the temperature and the oxidizing/reducing atmosphere in the firing phase. The energy carriers – other than electricity – used in the bricks and tiles sector include LPG, fuel oil and, residually, coal. Biomass is used, too, and as shown in Figure 94 below its use is growing: importantly, the emissions from biomass are not accounted for in the thresholds to qualify for the opt-out from the ETS Directive.[82] The fuel mix used by the bricks and tiles sector in Europe over time is shown in Figure 94. Currently, natural gas accounts for 80-90% of the fuel mix burnt by tiles and bricks manufacturers.

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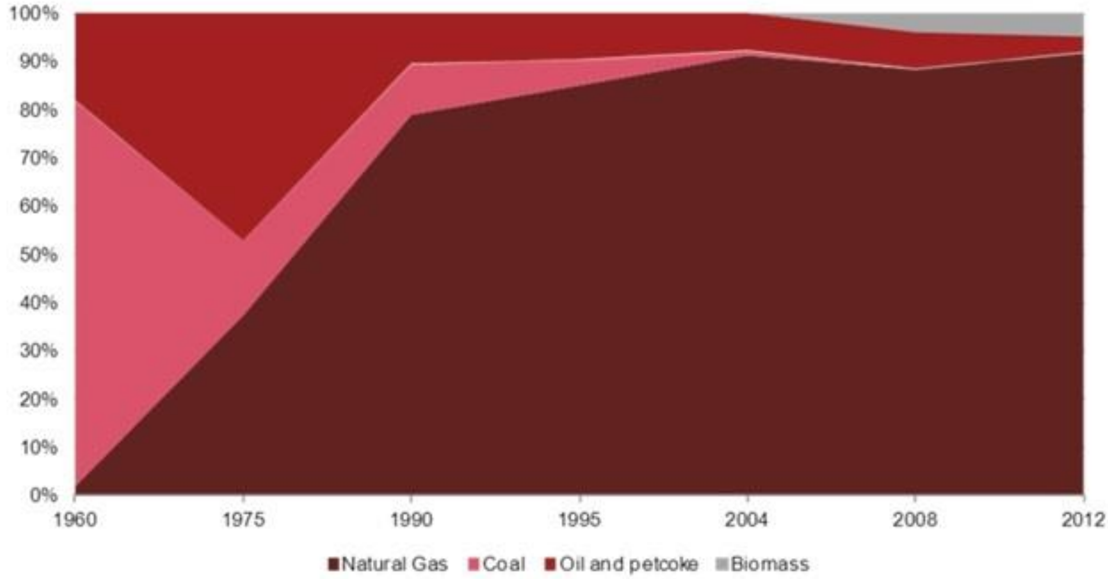
[81] According to the benchmark study (Fraunhofer ISI et al., 2009), production of roof tiles requires approximately 30% more CO_2 per tonne of product compared to building bricks. Considering that process emissions are likely to be similar, given that the raw materials and the manufacturing process are largely the same, such a difference in CO_2 emissions could be due to higher energy intensity. At the same time, data are not univocal, because the range of roof tile plants used for determining the benchmark value show higher minimum but lower maximum values compared to building bricks plants. This information is consistent with our initial hypothesis of similar energy intensity, though possibly higher for roofing tiles; the hypothesis will be verified based on the empirical data.

[82] See Art. 27 of ETS Directive (*supra* note 75), whereas "Member States may exclude from the Community scheme installations which have reported to the competent authority emissions of less than 25 000 tonnes of carbon dioxide equivalent [...] *excluding emissions from biomass*" (italics by the authors).

Figure 94. Energy carrier consumption in the bricks and tiles sector



Source: Tiles & Bricks Europe (2015).

As for energy intensity, CEPS (2014a) provides empirical information from the surveyed plants.[83] For natural gas, the median intensity in 2012 amounted to 0.56 MWh/t, with a rather high interquartile range of 0.29 MWh/t. The electricity intensity is significantly lower, if not marginal, amounting to 0.07 MWh/t, again with a high interquartile range of 0.04 MWh/t (CEPS, 2014a).

Consequently, the price of natural gas will be the most important driver of competitiveness covered in the study, while the price of electricity has a more limited impact. According to information retrievable in the literature, the share of energy costs over total costs is significant, reaching up to 30-35% of production costs (CEPS, 2014a).

6.6 Selection of the sample and sample statistics

6.6.1 Sampling Strategy

For sampling purposes, the bricks and tiles sector is, on one side, very homogeneous in terms of products and technologies; on the other side, it presents a series of ‘known unknowns’ concerning distribution of certain variables in the firm universe, i.e. plant capacity and plant geographical dispersion. Below, the sampling strategy that has been applied during the empirical part of the Study is discussed.

According to the methodology for this Assignment, the sampling strategy for each sector takes into account the following criteria:

- **Geographical coverage**

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[83] CEPS (2014a) includes 13 plants across three geographical regions (northern, southern and central Europe) and across various plant sizes (25 to 250 ktonnes/year).

- **Capacity of plants**
- **Ownership**, i.e. company size
- **Production technology**

To better refine the sampling, another variable, '**product**', is taken into account to verify whether any difference exists between brick manufacturers and tile manufacturers.

The bricks and tiles sector uses a uniform **production technology** and production process, resulting in comparable energy intensities. Differences across plants exist for technical parameters, e.g. size of the kilns or continuous versus batch drying and firing, but they do not amount to having different production routes, as it is the case in the steel sector. Hence, this sampling variable is not relevant to this industry.

As for **product**, the research team adopted a rebuttable presumption that the type of product does not affect energy intensity, or affects it only slightly and therefore does not have an effect on energy prices. This presumption was only partially correct. As discussed in section 6.9 below, the energy intensity per tonne of production of tile manufacturers is larger than in the case of bricks. However, given that the costs of production are also higher, the share of energy costs over total costs is roughly in line for both product lines.[84]

In any case, energy prices do not show any specific pattern across product lines. For this reason, tile and brick plants are kept separated only as far as the analysis of energy intensity per tonne of production is concerned.

With regards to **geographical coverage**, data will be aggregated at regional level. This indeed prevents disclosing identifiable information concerning specific plants in case there is only one respondent from a Member State. Regions are defined homogeneously across sectors as follows[85]:

1. North-Western Europe (NWE): Ireland, United Kingdom, France, Belgium, Luxembourg, the Netherlands, Germany, Austria, Denmark, Sweden and Finland (11 Member States).
2. Southern Europe (SE): Portugal, Spain, Italy, Malta, Greece and Cyprus (six Member States).
3. Central-Eastern Europe (CEE): Slovenia, Croatia, Czech Republic, Slovakia, Poland, Hungary, Romania, Bulgaria, Lithuania, Latvia, and Estonia (11 Member States).

The distribution of plants across Member States is a known unknown, as there is no comprehensive information from either public sources or sectoral associations. To proxy geographical coverage, three variables are resorted to: (i) distribution of output; (ii) distribution of production value; and (iii) distribution of enterprises. The use of three proxies allows for determining upper and lower bounds of the various sample segments.

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[84] Based on preliminary data not included in this version of the report.

[85] Regions represent by no means homogeneous countries in terms of energy prices. Further investigation on this aspect and provision of national data will be provided in the cross-sectoral analysis, to be included in the final report.

Table 87 below shows values for the three proxies across the three regions.

Table 87. Proxies for geographical distribution

Region	Output: Bricks (2014)	Output: Tiles (2014)	Output: Bricks and Tiles (2014)	Production Value (2013)	Enterprises (2013)
NWE	41%	64%	48%	71%	26%
SE	37%	29%	32%	22%	47%
CEE	22%	7%	15%	7%	27%

Source: Authors' own elaboration on Eurostat (SBS, Prodcom) 2016.[86]

Values for production output, production value and number of enterprises are significantly different across the three regions. In particular, production value appears to be an outlier, as the weight of the NWE is almost treble the number of enterprises and 1.5 times output, while CEE and SE show an opposite trend. Two reasons can account for this discrepancy:

1. Output and number of enterprises are physical variables, while production value is a monetary variable, hence it is affected by the price at which bricks and tiles are sold in each local market; since transportation costs are high and markets are regionally segmented, prices may not be converging across the EU and be higher in the NWE region.
2. Data quality: for production values, national data points are missing for 11 out of 28 Member States.

Based on this consideration, output (both bricks and tiles) and number of enterprises are used as lower and upper bounds for the size of the three regions within the sample, as summarised in Table 88 below.

Table 88. Sample size: geographical regions

Region	Lower Bound	Upper Bound
NWE	26%	48%
SE	32%	47%
CEE	15%	27%

Source: Authors' own elaboration.

Two other known unknowns affect the sampling strategy in the bricks and tiles sector and need to be addressed based on qualitative information

1. **Ownership, i.e. company dimension.** Though the analysis remains plant-based, company dimensions may have an impact on energy prices, as larger companies may be able to obtain better conditions from energy suppliers. For the ceramics industry, i.e. at a higher level of detail, large enterprises in 2013 represented 3% of the number of enterprises, but were responsible for 51% of the production value. Available evidence suggests a higher relevance of larger companies operating over multiple sites in the bricks and tiles sector compared to the ceramics sector as a whole. However, based on respondents' data, no

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[86] For 'output – bricks': missing data for UK, IE, SE, LV, SI. For 'output – tiles': missing data for BE, SE, AT, CZ, HU, BG, SI. Average for 'output – bricks and tiles' weighted for production value (weights: 0.57 bricks and 0.39 tiles). Production value: missing data for CZ, DK, EE, IE, HR, LV, NL, RO, SI, FI, SE. Enterprises: missing data for CZ, IE.

significant differences could be inferred concerning the energy prices and costs between plants managed by SMEs or large companies.

2. **Plant capacity**. The only information available on plant capacity comes from CEPS (2014a) on energy prices and costs in the bricks and tiles sector. Therein, the sample includes plants with capacity between 25 and 250 ktonnes per year. This means that capacity seems to vary within one order of magnitude, hence with a limited, though not negligible, impact on energy consumption, and thus prices. Since no more information could be retrieved, as a mitigating measure the sample will be investigated *ex post* to make sure that it does not only include plants in the lower or upper part of this range.

Table 89 below summarises the sampling strategy.

Table 89. Sampling variables

Production Technology	• ***not applicable***	
Product	• *no effect on energy prices* • *effect on energy intensity → separate analysis*	
Geographical Distribution	**Lower Bound**	**Upper Bound**
NWE	*26%*	*48%*
SE	*32%*	*47%*
CEE	*15%*	*27%*
Ownership	• *no effect on energy prices and costs*	
Plant Capacity	• ex post *verification of capacity dispersion within the sample*	

Source: Authors' own elaboration.

6.6.2 Description of the sample

The research team received 31 questionnaires covering 60 plants in 16 MS. For all 60 plants, information on energy prices and consumption is available. This information has been validated by the research team both through follow up emails and calls with the respondents, triangulation and secondary research, and via the analysis of supporting evidences. Energy bills for electricity were provided by 17 plants, and for natural gas by 20 plants; when supporting evidences was used, an analysis was carried out to verify whether data provided therein matched those reported in the questionnaire. Additional verification was carried out on selected topics when the legislative framework and the data provided were not clear. These checks concerned i.e. split of electricity components in the UK, RES levy and energy taxation in Germany, energy taxation in the Netherlands, RES levy and interruptibility schemes in Italy, network costs in Romania.

Importantly, energy components are not available from all respondents. When components were not provided, respondents were further contacted to obtain additional information. While estimates based on secondary sources were not carried out, in some cases the research team was able to reconstruct price components based on (i) the original split in tariffs and components provided by the respondents; (ii) information from the energy bills. However, the sample of respondents for which component data are available is different from the total sample. This implies that the sum of the averages of price components is different from the averages of total prices for electricity and gas.

The number of plants included in the sample is approximately four times those included in the previous study, which increases the robustness of the results. To assess sample coverage, an ex post estimation of the sectoral production value covered by respondents can be done comparing the plant turnover provided and the value of production as reported by Eurostat SBS[87]. Data on turnover in 2015 are available for 41 plants. Assuming that remaining plants have the same average production and turnover per tonne of product, total respondents' turnover amounts to €739 mln. The value of production of the bricks and tiles sector, whose most recent data refer to 2012, amount to €7,059 mln. Hence, coverage amounts to 10.5% of the sectoral production value (.

Not all questionnaires include the same amount and depth of information. Hence, the various sub-sections refer to a different number of valid respondents. Furthermore, coverage of the 2008-2015 period is not always complete, as in certain cases data for the period 2008-2010 or 2008-2012 were not provided by respondents. The number of valid questionnaires used in the various analytical parts included in this Final Report are detailed in Table 90 below.

Table 90. Number of questionnaires used in each section and coverage of sectoral production value

Total number received	Total number used[88]	Energy price trends	Energy bill components	Energy intensity	International comparison	Production costs and margins
60	*60*	*60 (gas)* *60 (elec.)*	*43 (gas)* *41 (elec.)*	*41 (gas)* *41 (elec.)*	*4 (gas)* *4 (elec.)*	*41*
10.5%	*10.5%*	*10.5%*	*8.9% (gas)* *8.5% (elec.)*	*8.5%*	*N/A*	*8.0%*

Source: Authors' own elaboration.

As shown in Figure 95 below, the main sample characteristics are as follows:

1. **Product.** 42 plants produce bricks and 18 plants produce tiles; furthermore, 3 of these plants also produce other products;
2. **Geographical distribution:** 43 plants are located in North-Western Europe, 9 plants in Central-Eastern Europe, and 8 plants in Southern Europe;
3. **Ownership.** 19 plants belong to SMEs, while 41 plants belong to large companies.[89]

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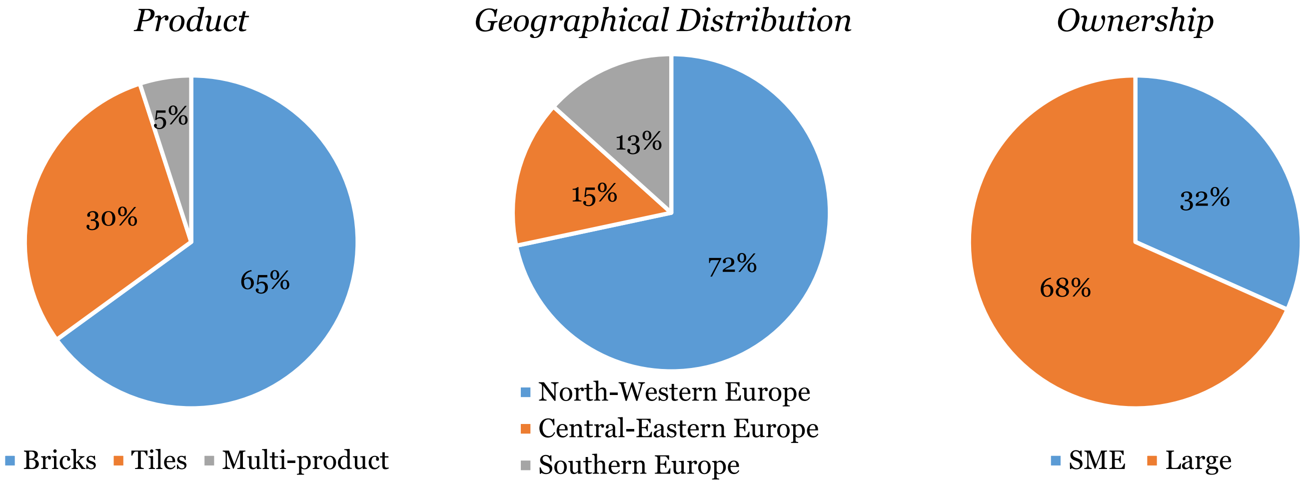
[87] Concerning sample coverage, information on the total number of plants or installed capacity in Europe is not available, hence it is not possible to provide a share of capacity covered by the analysis. As for production output, data were collected in tonnes, to ensure data comparability across sectors, while Prodcom data are available in 1000m3 for bricks and millions of items for tiles, hence not allowing for a comparison.

[88] This refers to the number of questionnaires that made it through the verification process and were used in the subsequent data analysis.

[89] In some cases, SMEs are a national subsidiary of a large multi-national.

Figure 95. Sample description



Source: Authors' own elaboration.

As already discussed in the Interim Report,[90] the sample used for the analysis depended not only on the research team's selection, but also on the response rate. As a result, compared to the available information on the sector, the sample is skewed toward NWE plants and to plants belonging to large companies.

Data from gathered questionnaires shows that company dimension has no impact on the data presented, hence this aspect does not affect the validity of the analysis. As for the geographical distribution, such a skewness would affect the analysis, as NWE companies face, on average, lower natural gas prices than the EU median company and in general a lower impact of energy costs.[91] As one of the objectives of the study is to obtain data on energy prices from as many plants as possible, the research team did not discard any data point, even though the sampling is skewed towards a region.

However, when calculating EU averages**, both weighted and simple, to avoid over-representation of NWE plants, *ex post* weights based on upper sampling limits are applied** (as shown in Table 89 above). Weights are as follows:

4. North-Western Europe: 48%
5. Southern Europe: 34.5%
6. Central-Eastern Europe: 17.5%.

With respect to **plant capacity**, 21 plants have provided information on this variable.[92] Sample features are in line with expected characteristics and the available preliminary information. Main indicators are summarised in Table 91 below.

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[90] Cf. Interim Report – Updated, at §8.6.

[91] Natural gas being the most important energy carrier in the industry. See Sections and below.

[92] Differences between bricks and tiles producers are not significant.

Table 91. Sample description: capacity.

EU Values	Tonne/year
Average	157,849
Median	139,100
3rd Quartile	93,955
1st Quartile	228,992
Max	292,000
Min	35,000
Total*	9,132,224

* average capacity assumed for plants which did not provide capacity data.

Source: Authors' own elaboration.

6.7 Energy price trends

In this section, information on the prices of electricity and gas purchased by bricks and tiles manufacturers is provided. While the price components are discussed in Section 6.8, here EU and regional averages, both simple and weighted by consumption, are presented. Other information on the distribution of energy prices among respondents are also provided.

Energy price trends and consumption include responses for 60 plants, making these the most reliable results among those included in the report. Diachronic coverage is good, as data for the least recent year, 2008, still cover 53 plants. Concerning regional coverage, this remains sufficient even in the least recent year.

6.7.1 Natural gas

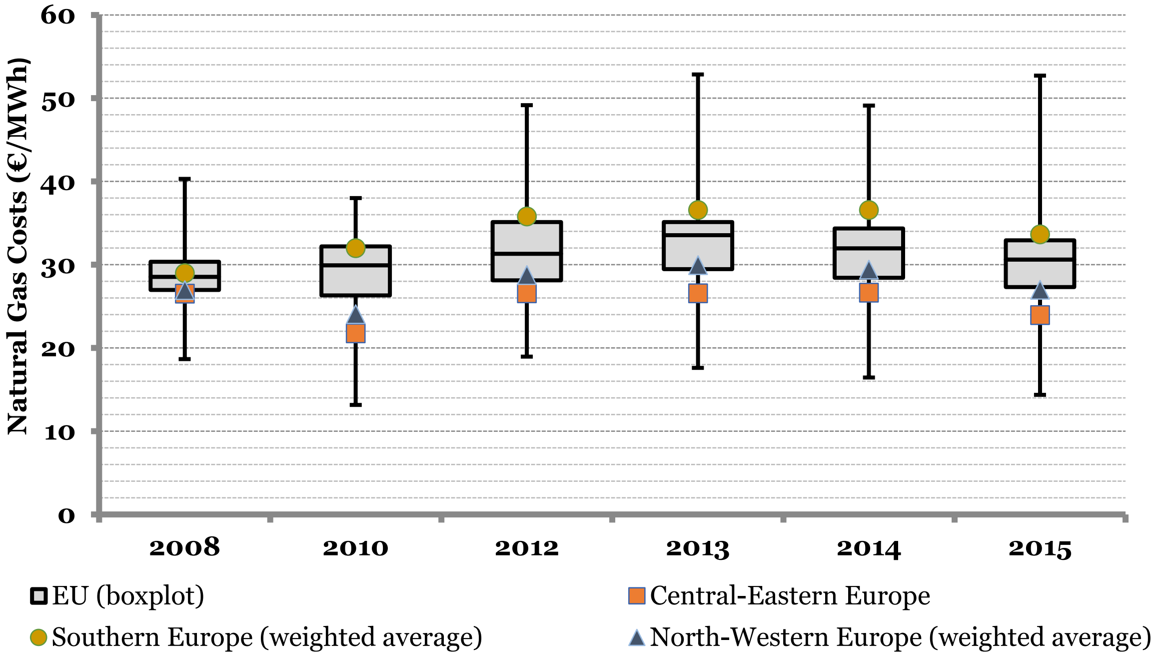
Natural gas is the main energy carrier in the bricks and tiles industry, and as such is a primary driver of the industry competitiveness. Currently, the EU median price for natural gas paid by sampled bricks and tiles manufacturers amounts to 30.61 €/MWh. The EU weighted average price is lower, between 27 and 30 €/MWh, signalling that the distribution is skewed towards a limited number of plants with lower prices.

As shown in Figure 96 below, the median price has been rising in the period 2008-2013 (+3.3% YoY), and then declined until 2015 (-4.5% YoY). EU average prices followed a similar pattern, though the increase until 2013 is milder and the decline sharper. Importantly, the EU simple average is higher than the EU weighted average (+12% in 2015), implying that plants with a larger gas consumption also enjoy lower prices – a typical trend in energy price analysis.

Finally, it is worth discussing that the IQR is limited compared to the max-min range, meaning that half of sampled manufacturers pay a natural gas price relatively close to each other.

With respect to regional differences, two regions stand up as paying average prices lower than the median in all or most years: NWE and CEE. In 2015, NWE producers paid on average approximately 88% of the EU median prices, while CEE approximately 78%. To the contrary, on average SE manufacturers paid approximately 10% more than the EU median price. Trends across the regions in the period 2010-2015 have been similar among each other and with the general trend. The price differential between SE and the other two regions has thus remained stable, at approximately 9-10 €/MWh with respect to CEE and 3-5 €/MWh with NWE.

Figure 96. Prices of natural gas paid by sampled EU producers (2008-2015)



Source: Authors' own elaboration.
Notes: Based on 60 respondents; 10.5% of Sectoral Production Value.

Table 92. Descriptive statistics for natural gas prices paid by sampled EU producers (€/MWh, 2008-2015)

Indicator	2008	2010	2012	2013	2014	2015
EU - Weighted Average	27.19	26.26	29.10	30.09	29.61	27.04
EU - Simple Average	28.79	28.59	32.51	33.26	30.01	30.93
EU - Median	28.56	29.93	31.30	33.54	31.97	30.61
EU - Inter-Quartile Range[93]	3.38	5.88	6.99	5.68	5.93	5.61
EU - Minimum	18.66	13.16	18.96	17.60	16.45	14.37
EU - Maximum	40.31	38.00	49.17	52.86	49.12	52.72
NWE - Weighted Average	26.96	19.63	22.50	29.95	29.42	27.00
SE - Weighted Average	29.02	32.00	35.83	36.59	36.59	33.66
CEE - Weighted Average	26.54	21.79	26.59	26.59	26.67	23.95
NWE - Simple Average	29.85	28.84	30.97	31.91	31.42	29.85
SE - Simple Average	28.71	31.67	37.58	39.37	39.13	36.62
CEE - Simple Average	26.04	21.84	26.73	26.26	26.52	23.99

Source: Authors' own elaboration.
Notes: Based on 60 respondents; 10.5% of Sectoral Production Value.

6.7.2 *Electricity*

Electricity is considerably less important than natural gas for bricks and tiles manufacturers, as the electricity intensity per tonne of production is approximately one ninth that of gas. Currently, the EU median price for electricity paid by sampled bricks and tiles manufacturers amounts to 88.32 €/MWh. The diachronic trend is similar to that of natural gas, with the price increasing between 2008 and 2013 (+2.5% YoY), and then decreasing (-5.0% YoY).

While both natural gas and electricity have similar price trends – as natural gas is one of the main fuels used for electricity production – electricity prices paid by bricks and tiles manufacturers had a milder trend in the period 2008-2013 - with lower increases - but higher decreases between 2013-2015. Weighted average prices have somewhat a different trend, increasing until 2014 and stagnating in 2015.

Compared to natural gas, the IQR is significantly larger, up to half the median value in 2015, and increasing over time. This means that price dispersion across sampled plants is larger. A possible explanation could be the higher weight of non-energy components (RES levy, network costs and other taxes) on electricity prices compared to gas prices, and the wider dispersion thus mirrors a regulatory fragmentation at national level.

As in the case of natural gas, SE producers face the highest prices. In line with the wider price dispersion, the difference is larger in the case of electricity: in all years except for 2010, the weighted average has been higher than the 75th percentile of the EU distribution. While the gap with NWE manufacturers is declining from 2012 onwards, thus still at approximately 30 €/MWh, the gap with CEE plants has been increasing, reaching more than 60 €/MWh in 2015, or approximately half the SE

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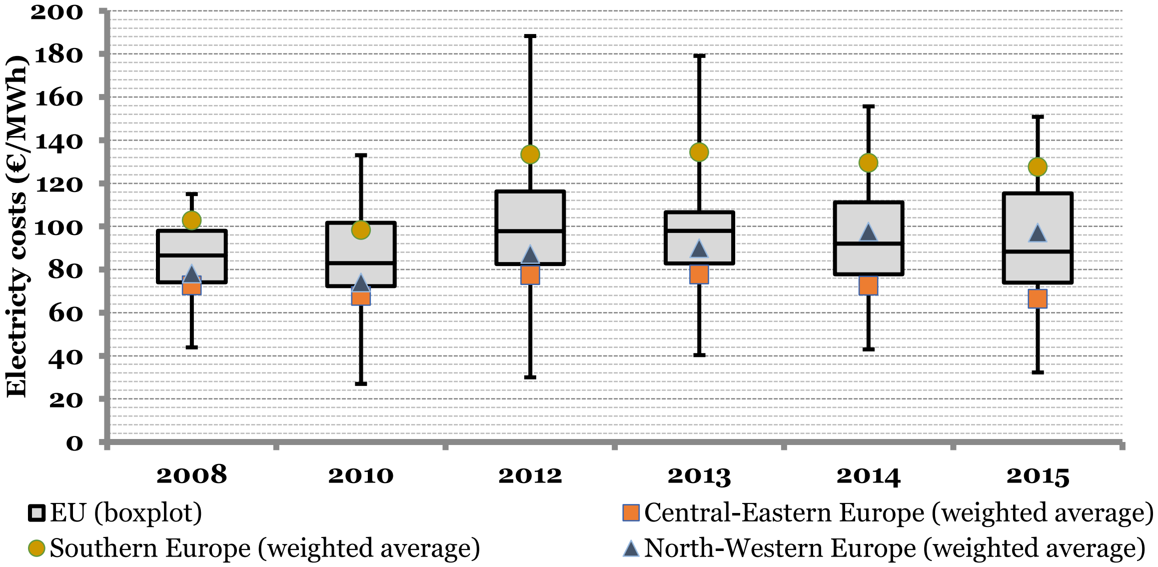
[93] In line with the box-plot analysis, IQR is presented in the table as a measure of dispersion, as it is more robust in case of samples varying across years and with this numerosity. The coefficient of variation is as follows: 2008: 0.16; 2010: 0.24; 2012: 0.23; 2013: 0.24; 2014: 0.23; 2015: 0.23.

average price. Electricity prices for NWE manufacturers also do not show a favourable trend, as it is the only region in which prices did not decline in 2014 and 2015. While on average NWE prices were lower than the EU median until 2013, this is no longer the case, and in 2015 NWE plants paid on average 10% more than the EU median installation. For CEE plants, prices have been consistently below the median, and declining over the overall period: after a peak in 2013, electricity prices are now below the 2008 levels.

Figure 97. Prices of electricity paid by sampled EU producers (2008-15)



Source: Authors’ own elaboration.

Notes: Based on 60 respondents; 10.5% of Sectoral Production Value.

Table 93. Descriptive statistics for electricity prices paid by sampled EU producers (€/MWh, 2008-2015)

Indicator	2008	2010	2012	2013	2014	2015
EU - Weighted Average	80.42	72.09	83.94	85.97	90.72	89.82
EU - Simple Average	88.70	89.17	108.65	109.29	107.43	103.42
EU - Median	86.52	83.05	97.82	97.95	92.09	88.32
EU - Inter-Quartile Range[94]	23.83	29.41	33.69	23.83	33.46	41.39
EU - Minimum	43.88	26.95	30.00	40.30	42.95	32.27
EU - Maximum	115.01	133.05	188.30	179.10	155.68	150.83
NWE - Weighted Average	78.17	74.02	87.30	89.95	97.62	97.26
SE - Weighted Average	102.94	98.40	133.49	134.49	129.56	127.68
CEE - Weighted Average	72.73	67.91	77.43	77.82	72.57	66.43
NWE - Simple Average	88.18	92.12	102.16	97.34	98.69	91.57
SE - Simple Average	96.70	95.82	133.74	141.73	137.78	138.04
CEE - Simple Average	74.35	67.99	77.00	77.72	71.62	67.59

Source: Authors' own elaboration.

Notes: Based on 60 respondents; 10.5% of Sectoral Production Value.

6.8 Energy bill components

In this section, the analysis of the components of the price paid by sampled manufacturers for natural gas and electricity is presented, with a different composition applicable to the two energy carriers.

Note that companies were not always able to provide both overall prices and price components. Often detailed components were not visible on energy bills. There are significant differences between the average energy prices as reported above in the section energy prices and the results reported in this section on energy components. This is caused by different numbers of respondents included in both sections of the analysis.

The price of natural gas is split into three components, two of which depend on the regulatory framework (the so-called 'regulatory components'):

1. Energy supply;
2. Network costs;
3. Other taxes, fees, levies and charges (excluding recoverable taxes, such as VAT).

The price of electricity is split into four components, three of which depend on the regulatory framework (the so-called 'regulatory components'):

1. Energy supply;
2. Network costs;
3. Renewable support
4. Other taxes, fees, levies and charges (excluding recoverable taxes, such as VAT).

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[94] In line with the box-plot analysis, IQR is presented in the table as a measure of dispersion, as it is more robust in case of samples varying across years and with this numerosity. The coefficient of variation is as follows: 2008: 0.19; 2010: 0.27; 2012: 0.30; 2013: 0.28; 2014:0.29; 2015: 0.30

Averages presented in this section are weighted by energy consumption – respectively natural gas and electricity. A sensitivity analysis was carried out by applying production output as a weight. However, given the high degree of multicollinearity between energy consumption and production output (i.e., the higher the production output, the higher the necessary energy consumption) for plants in the sample, the results did not show any significant difference. Furthermore, the research team controlled for whether consumption level had an impact on the weight of energy components, and the results were negative.

As already discussed, not all plants provided a split per component of natural gas and electricity prices. While estimates based on secondary sources were not carried out, in some cases the research team was able to reconstruct price components based on (i) the split in tariffs and components provided by the respondents; (ii) information from the energy bills. For this reason, the sample of plants providing information on components is smaller – respectively 43 plants for natural gas and 41 for electricity – compared to the full set of plants. This implies that values are different: in particular, the sum of average components is different than the average price of natural gas and electricity. Yet, the number of respondents remain sufficiently high to ensure validity of the results also for the component analysis.

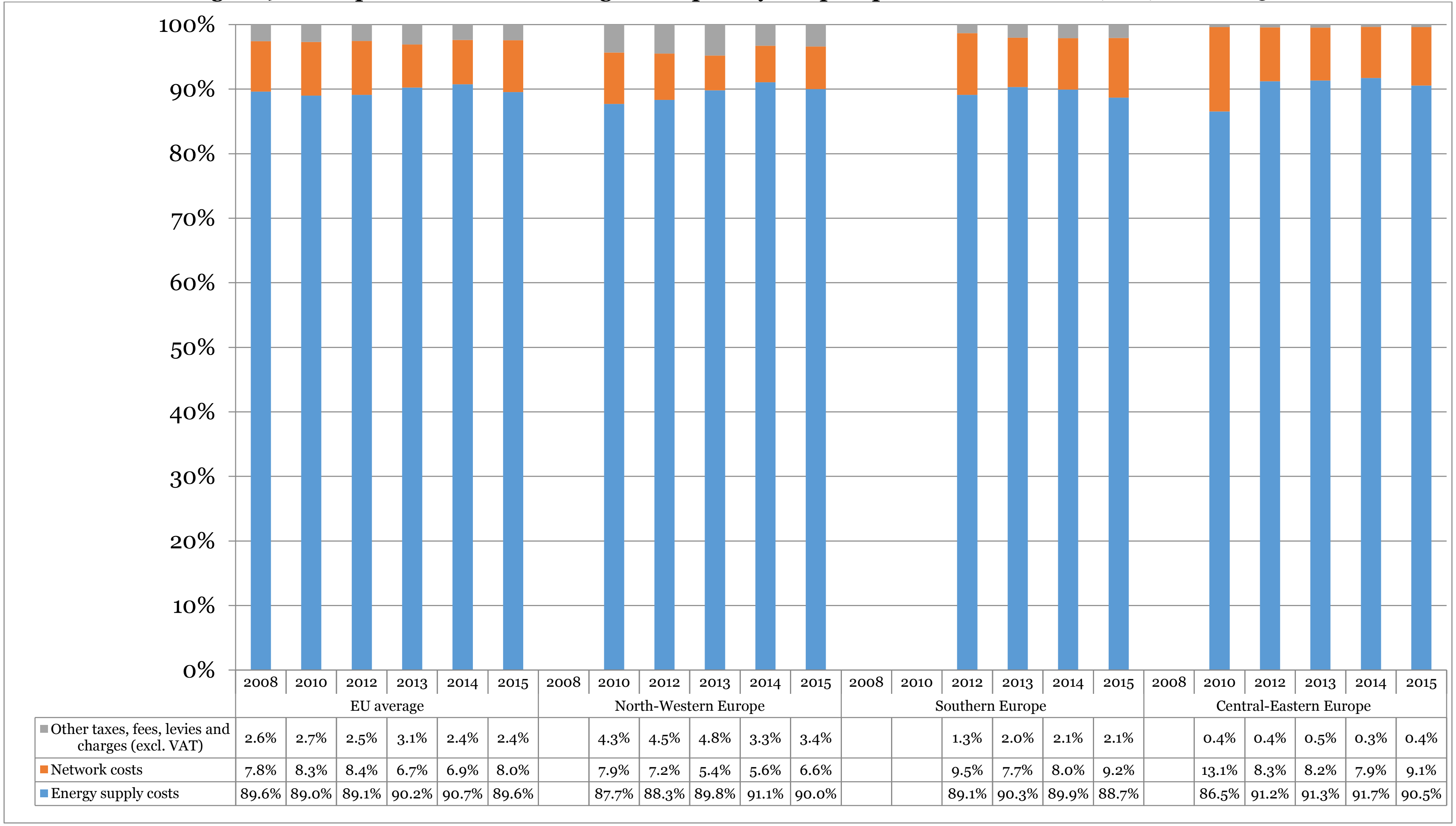
In addition, the number of respondents for NWE and CEE is too limited in 2008; for this reason, no regional disaggregation is presented for this year. For SE, the number of respondents allow presenting the analysis for the period 2012-2015.

6.8.1 Natural gas

The split of natural gas price shows a very limited role of non-energy components: in 2015, the EU weighted averages for network costs and other taxes and fees was slightly more than 10% of total price. This value has kept constant across the period, varying, without any noticeable pattern, between 9% and 11%. More in detail, network costs represented 8% of gas price in 2015, while other taxes and fees approximately 2.4%. Conversely, the energy component represented approximately or above 90% of price across all years.

Regional differences in terms of price compositions are of relatively minor significance. In all regions, the energy component value is 90%. In NWE, other taxes and fees are slightly higher, between 3% and 5%, but they are compensated by lower than average network costs. In CEE, the opposite is true, as other taxes and fees are almost negligible, between 0.3% and 0.5%, while network costs are higher than average. In SE, the share of regulated components is slightly higher, exceeding 11% in 2015. As in the whole EU, in all regions price components barely move without any apparent trend across the period.

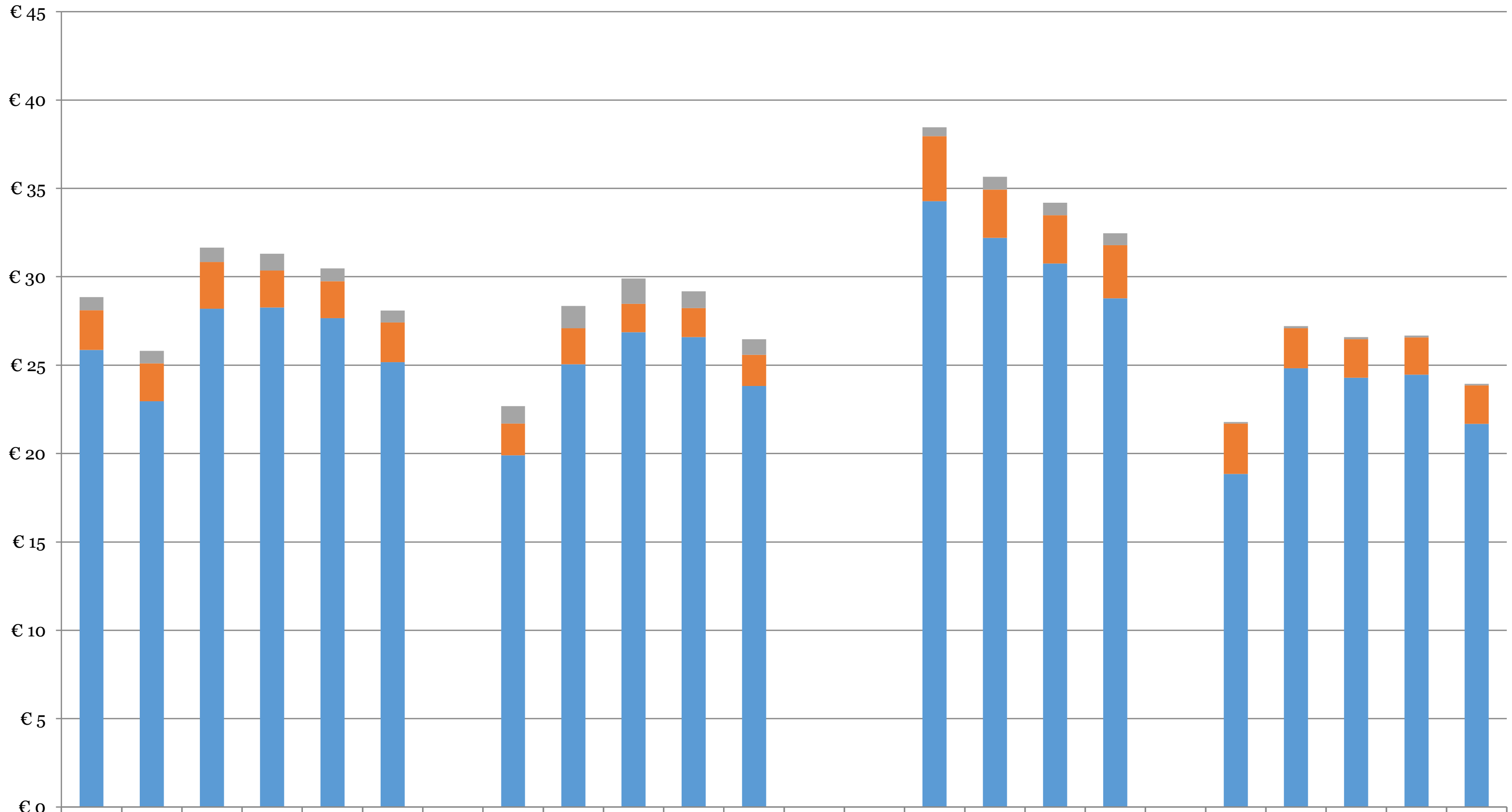
Figure 98. Components of the natural gas bills paid by sampled producers in the EU (in %) 2008 – 15



	EU average						North-Western Europe						Southern Europe						Central-Eastern Europe					
	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
▨ Other taxes, fees, levies and charges (excl. VAT)	2.6%	2.7%	2.5%	3.1%	2.4%	2.4%		4.3%	4.5%	4.8%	3.3%	3.4%			1.3%	2.0%	2.1%	2.1%		0.4%	0.4%	0.5%	0.3%	0.4%
🟧 Network costs	7.8%	8.3%	8.4%	6.7%	6.9%	8.0%		7.9%	7.2%	5.4%	5.6%	6.6%			9.5%	7.7%	8.0%	9.2%		13.1%	8.3%	8.2%	7.9%	9.1%
🟦 Energy supply costs	89.6%	89.0%	89.1%	90.2%	90.7%	89.6%		87.7%	88.3%	89.8%	91.1%	90.0%			89.1%	90.3%	89.9%	88.7%		86.5%	91.2%	91.3%	91.7%	90.5%

Source: Authors' own elaboration.
Notes: Based on 43 respondents; 8.9% of Sectoral Production Value.

Figure 99. Components of the natural gas bills paid by sampled producers in the EU (in €/MWh) 2008 – 15



	EU average						North-Western Europe						Southern Europe						Central-Eastern Europe					
	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
■ Other taxes, fees, levies and charges (excl. VAT)	0.75	0.69	0.81	0.96	0.72	0.68		0.99	1.27	1.44	0.96	0.90			0.51	0.72	0.72	0.67		0.08	0.12	0.12	0.09	0.09
■ Network costs	2.24	2.15	2.64	2.10	2.10	2.26		1.80	2.04	1.61	1.64	1.75			3.67	2.73	2.72	3.00		2.85	2.27	2.18	2.11	2.17
■ Energy supply costs	25.86	22.96	28.19	28.25	27.65	25.16		19.90	25.05	26.86	26.58	23.82			34.28	32.20	30.75	28.79		18.85	24.82	24.28	24.46	21.69

Source: Authors' own elaboration.
Notes: Based on 43 respondents; 8.9% of Sectoral Production Value.

6.8.2 Electricity

The impact of non-energy components on the electricity price is more significant than in the case of natural gas: in 2015, network costs, RES levies, and other taxes and fees (excluding VAT) accounted for 51% of the weighted EU average price paid by sampled plants. As a comparison, in 2010 this share was down at 44%, and constantly increased in the following 5 years.

Among non-energy components, the lion share is taken by RES levies and network costs, accounting each for slightly more than 20% of the total price. The share of RES support has increased from 17.1% in 2010 to 21.1% in 2015 (+8.1% YoY in absolute value), while the share of network costs increased from 16.7% to 21.2% (+7.2% YoY). Other taxes and fees showed a slight decline in relative terms, and in 2015 amounted to approximately 8% of the EU weighted average price.

With respect to the energy component, as already anticipated, it decreased from 56% to 49% of the total price between 2010 and 2015. The decline, however, is only in relative, and not absolute terms, as its estimated value passed from 52 to 55 €/MWh.

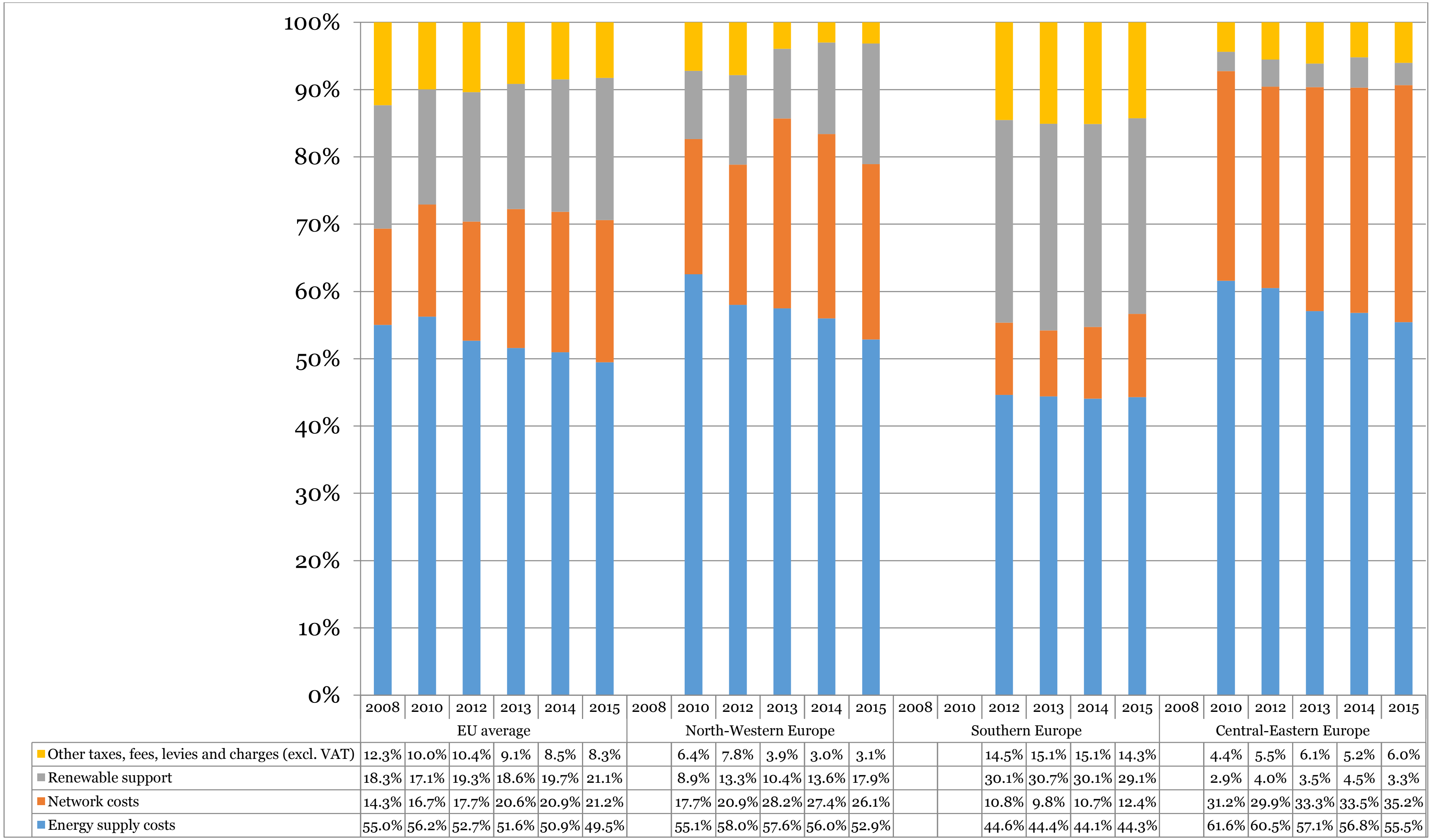
At regional level, the weight of the various components is different. CEE shows a lower share of non-energy components, at 45% in 2015, though increasing from 38% in 2010. In NWE, the share of non-energy components in 2010 was also at 38%, and increased up to 47% in 2015. The role played by regulated components is larger in SE, which, in 2015, not only has the highest energy component in absolute value, but also the highest share of non-energy components, at 56% (slightly up from 55% in 2012).

In a nutshell, regulatory components are more significant in SE, though NWE and CEE show a more marked upward trend.

The impact of the different regulated components also varies across regions. In 2015, network costs represented more than one third of the electricity price in CEE, while other taxes and fees and RES levies accounted for approximately 9%. In SE, RES levies have the largest weight, at approximately 30% of the total price, constant across the whole period. To the contrary, network costs are the lowest, both in relative and absolute terms, and in 2015 represented approximately 12% of the total price. Other taxes and fees are also the highest, both in absolute and relative terms, accounting for approximately 14% of the price.

In general, for respondents in SE the weight of components is constant across the period, except for an increase of the share of network costs. For respondents in NWE, RES levies represented approximately 18% of the total price in 2015, compared to 9% in 2010. Other taxes and fees were the lowest across the three regions, and the relative share is declining, while network costs represented more than a quarter of the electricity bill (up from 18% in 2010).

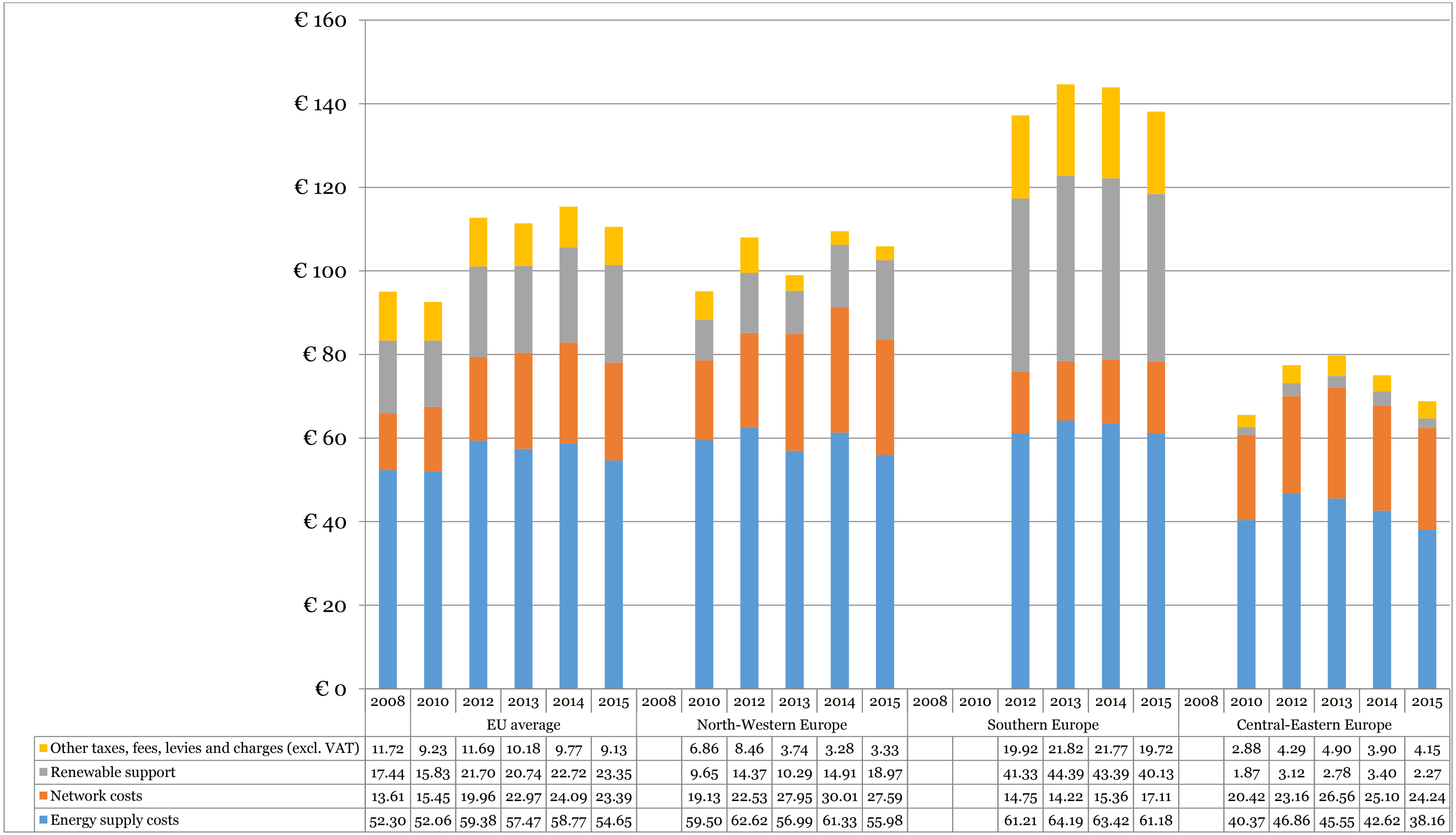
Figure 100. Components of the electricity bills paid by sampled producers in the EU (in %) 2008 -15



	EU average						North-Western Europe						Southern Europe						Central-Eastern Europe					
	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
🟨 Other taxes, fees, levies and charges (excl. VAT)	12.3%	10.0%	10.4%	9.1%	8.5%	8.3%		6.4%	7.8%	3.9%	3.0%	3.1%			14.5%	15.1%	15.1%	14.3%		4.4%	5.5%	6.1%	5.2%	6.0%
■ Renewable support	18.3%	17.1%	19.3%	18.6%	19.7%	21.1%		8.9%	13.3%	10.4%	13.6%	17.9%			30.1%	30.7%	30.1%	29.1%		2.9%	4.0%	3.5%	4.5%	3.3%
🟧 Network costs	14.3%	16.7%	17.7%	20.6%	20.9%	21.2%		17.7%	20.9%	28.2%	27.4%	26.1%			10.8%	9.8%	10.7%	12.4%		31.2%	29.9%	33.3%	33.5%	35.2%
🟦 Energy supply costs	55.0%	56.2%	52.7%	51.6%	50.9%	49.5%		55.1%	58.0%	57.6%	56.0%	52.9%			44.6%	44.4%	44.1%	44.3%		61.6%	60.5%	57.1%	56.8%	55.5%

Source: Authors' own elaboration.
Notes: Based on 41 respondents; 8.5% of Sectoral Production Value

Figure 101. Components of the electricity bills paid by sampled producers in the EU (in €/MWh) 2008 -15



EU average	2008	2010	2012	2013	2014	2015
■ Other taxes, fees, levies and charges (excl. VAT)	11.72	9.23	11.69	10.18	9.77	9.13
■ Renewable support	17.44	15.83	21.70	20.74	22.72	23.35
■ Network costs	13.61	15.45	19.96	22.97	24.09	23.39
■ Energy supply costs	52.30	52.06	59.38	57.47	58.77	54.65

North-Western Europe	2008	2010	2012	2013	2014	2015
■ Other taxes, fees, levies and charges (excl. VAT)		6.86	8.46	3.74	3.28	3.33
■ Renewable support		9.65	14.37	10.29	14.91	18.97
■ Network costs		19.13	22.53	27.95	30.01	27.59
■ Energy supply costs		59.50	62.62	56.99	61.33	55.98

Southern Europe	2008	2010	2012	2013	2014	2015
■ Other taxes, fees, levies and charges (excl. VAT)			19.92	21.82	21.77	19.72
■ Renewable support			41.33	44.39	43.39	40.13
■ Network costs			14.75	14.22	15.36	17.11
■ Energy supply costs			61.21	64.19	63.42	61.18

Central-Eastern Europe	2008	2010	2012	2013	2014	2015
■ Other taxes, fees, levies and charges (excl. VAT)		2.88	4.29	4.90	3.90	4.15
■ Renewable support		1.87	3.12	2.78	3.40	2.27
■ Network costs		20.42	23.16	26.56	25.10	24.24
■ Energy supply costs		40.37	46.86	45.55	42.62	38.16

Source: Authors' own elaboration.
Notes: Based on 41 respondents; 8.5% of Sectoral Production Value

Box 4. Indirect EU ETS costs in the bricks and tiles sector

Electric utilities face increased operating costs because of the costs to purchase ETS allowances. They pass those charges on to their customers via higher electricity rates, and these passed-on charges are considered the ‘indirect EU ETS costs’. Indirect EU ETS costs are not visible in electricity bills, and hence cannot be distinguished as a separate component, being included in the energy one.

Bricks and Tiles producers therefore face an extra energy cost because of the ETS charges embedded in electricity prices. This cost was paid over the whole period in scope of the study. This is an additional cost, which this industry may not be able to pass fully on to their customers, if they are active in a globally competitive sector.

Estimates for indirect costs per tonne of product for bricks and tiles producers are calculated using this formula[95]:

Indirect cost (€/t of product) = Electricity intensity (kWh/t of product)
** Carbon intensity of electricity (Tonne of CO2/kWh)*
** CO2 Price (€/t of CO2) * Pass-on rate*

Notes:

- Yearly averages across the EU sample are simple averages. Weighing by consumption would bias the estimates as electricity consumption is a key variable in the formula above.
- Carbon intensity of electricity is a constant per region, and does not take the reductions in carbon intensity of electricity production since 2012 into account. These estimates are therefore likely to be overestimations for the more recent years.
- Only purchased electricity, i.e. excluding self-generation, is subject to indirect ETS costs; self-generated electricity represents between 3% and 7% of total consumption across the whole period.
- Two scenarios are calculated, based on the pass on rates equal to 0.6 and 1.

The estimates for indirect EU ETS costs (as shown in Table 94) have decreased steadily between 2008 and 2013, following the sharp decline of EUA prices. Over 2014-2015 the estimates for indirect EU ETS costs increased again as EUA prices showed a slow and partial recovery.

Table 94. Estimates for Indirect EU ETS costs for bricks and tiles producers, 2008-2015, two pass on rates (€/t of product).

	2008	2010	2012	2013	2014	2015
Pass on rate: 0.6						
Bricks and Tiles Producers	0.62	0.39	0.21	0.13	0.17	0.23
Pass on rate: 1						
Bricks and Tiles Producers	1.03	0.64	0.35	0.21	0.28	0.38

Source: Authors’ elaboration on data from*:* European Energy Exchange (2016) and European Commission (2012); own surveys
Based on 41 respondents; 8.5% of Sectoral Production Value

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[95] This formula and the sources of the data used are discussed in depth in the Methodology Chapter under Section 1.10.

Estimates show that a share of the energy component could be linked to indirect EU ETS cost: a noteworthy proportion of electricity costs at the start of the period, and then this share has dropped significantly. In 2008, indirect EU ETS costs estimates accounted for 26% of electricity cost per tonne of bricks and tiles under the pass on rate 1 scenario, and for 16% under the pass-on rate 0.6 scenario. By 2013 this had fallen to 4%, and reached 7% in 2015.

With respect to the impact of indirect EU ETS costs on total production costs, this is marginal, given the low electricity intensity of the bricks and tiles sector. EU ETS in-direct costs (pass on rate 1 scenario) accounted for 1% of production costs for bricks and tiles in 2008, and this share dropped to approximately 0.3-0.4% in 2013/14. These changes are primarily driven by the evolution of EUA prices.

Table 95 Share of indirect EU ETS costs in weighted average production costs (%) (pass -on rate of 1)

2008	2010	2012	2013	2014	2015
1.2%	0.9%	0.4%	0.3%	0.3%	N/A

Source: Authors' own elaboration.

This sector is not eligible for compensation for its indirect EU ETS costs according to the European Commission State Aid Guidelines (2012).

6.9 Energy intensity

Energy intensity is calculated as the ratio between the consumption of electricity and gas consumption in MWh over total production in tonnes. In this section, the analysis of natural gas intensity, electricity intensity and energy intensity (that is the sum electricity and natural gas intensities) are described via box plots and descriptive tables. Averages are presented as both simple and weighted (by consumption) averages.

Bricks manufacturers and tile manufacturers are not homogeneous groups when it comes to energy intensity, as the latter requires a higher quantity of energy per tonne of production. Data presented below only concern brick manufacturers, as data points for tile manufacturers are insufficient to perform the analysis.

Data for energy intensity could be calculated for 41 brick plants, again a solidly large sample. In 2015, all 41 plants provided usable data; data remain sound back to 2010, where data are available for 39 plants. For 2008, 34 data points are available. As in one region the sub-sample in 2008 becomes too limited, regional averages are not provided for 2008; in addition, the analysis of trends at EU level starts from 2010, as the difference between 2008 and the following years is affected by the variation of the set of respondents.

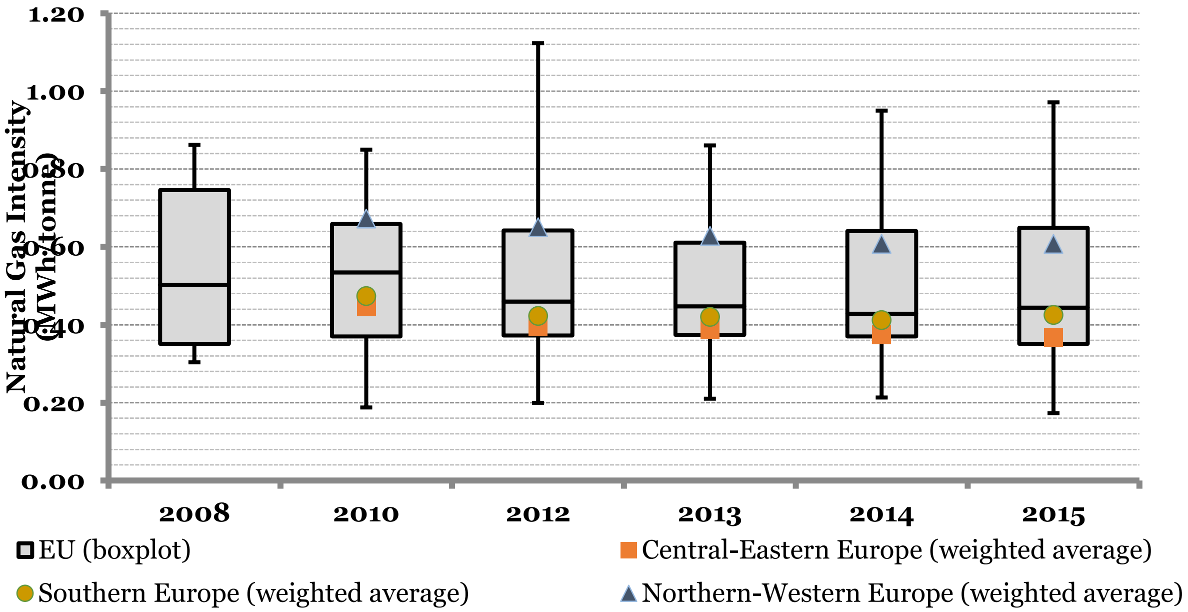
6.9.1 Natural gas

In 2015, sampled brick manufacturers had a weighted average natural gas intensity of 0.50 MWh/t and a simple average equal to 0.49 MWh/, with a median of 0.44 MWh/t. This value declined in the 2010-2015 period: in average terms by 11% and in median terms by 17%. The IQR, where 50% of the sampled plants are encompassed, is quite high at 0.30 MWh/t in 2015, implying that there is a considerable range of variation across plants. The IQR remained fairly stable between 2010 and 2015, around 0.30 MWh/t.

With respect to regional averages, CEE is the country with the lowest gas intensity, at 0.37 MWh/t, followed by SE at 0.43 MWh/t. As for NWE manufacturers, energy intensity is higher at 0.61 MWh/t. Declining trends are common across the three regions, though more pronounced in CEE.

There can be several reasons for regional variations. The most obvious concern the relative energy efficiency of plants; however, other factors may also be at play. Most importantly, the capacity utilization factor has a significant impact on energy efficiency and on its time trends.

Figure 102. Natural Gas intensity in terms of physical output, MWh/t (2008-2015)



Source: Authors' own elaboration.
Notes: Based on 41 respondents; 8.5% of Sectoral Production Value

Table 96. Descriptive statistics for natural gas intensity (MWh/t, 2008-15)

Indicator	2008	2010	2012	2013	2014	2015
EU - Weighted Average	0,54	0,56	0,53	0,51	0,50	0,50
EU - Simple Average	0,56	0,53	0,53	0,50	0,49	0,49
EU - Median	0,50	0,53	0,46	0,45	0,43	0,44
EU - Inter-Quartile Range[96]	0,39	0,29	0,27	0,24	0,27	0,30
EU - Minimum	0,30	0,19	0,20	0,21	0,21	0,17
EU - Maximum	0,86	0,85	1,12	0,86	0,95	0,97
NWE - Weighted Average	-	0,67	0,65	0,63	0,61	0,61
SE - Weighted Average	-	0,47	0,42	0,42	0,41	0,43
CEE - Weighted Average	-	0,45	0,39	0,39	0,37	0,37
NWE - Simple Average	-	0,65	0,70	0,63	0,63	0,64
SE - Simple Average	-	0,45	0,40	0,40	0,40	0,40
CEE - Simple Average	-	0.44	0.39	0.37	0.35	0.33

Source: Authors' own elaboration.

Notes: Based on 41 respondents; 8.5% of Sectoral Production Value

6.9.2 Electricity

Electricity intensity was measured by summing (i) electricity purchased from the grid; (ii) electricity self-generated; and then subtracting (iii) electricity sold to the grid. Self-generation is used by 9 sampled plants: in 5 cases, manufacturers produce electricity with photovoltaic systems, and the amount of electricity generated is in the area of hundreds of MWh per year; and in 4 cases plants reported having a co-generation plant, producing electricity in the area of thousands of MWh per year. Self-generated electricity represented between 3% and 7% of total consumption of electricity of sampled plants across the whole period. Hence, electricity intensity remains roughly the same for plants with or without self-generation capacity.

In 2015, sampled brick manufactures had a weighted average electricity intensity equal of 0.05 MWh/t, with simple average at 0.06 MWh/t and median at 0.05 MWh/t. The value remained stable across the whole period. Variation in the sample is quite large, as the IQR is approximately 33% of the median value, and the maximum value is approximately two times the median. However, given the low intensity, this variation does not have a significant impact on the sector competiveness. No significant variations exist concerning EU regions.

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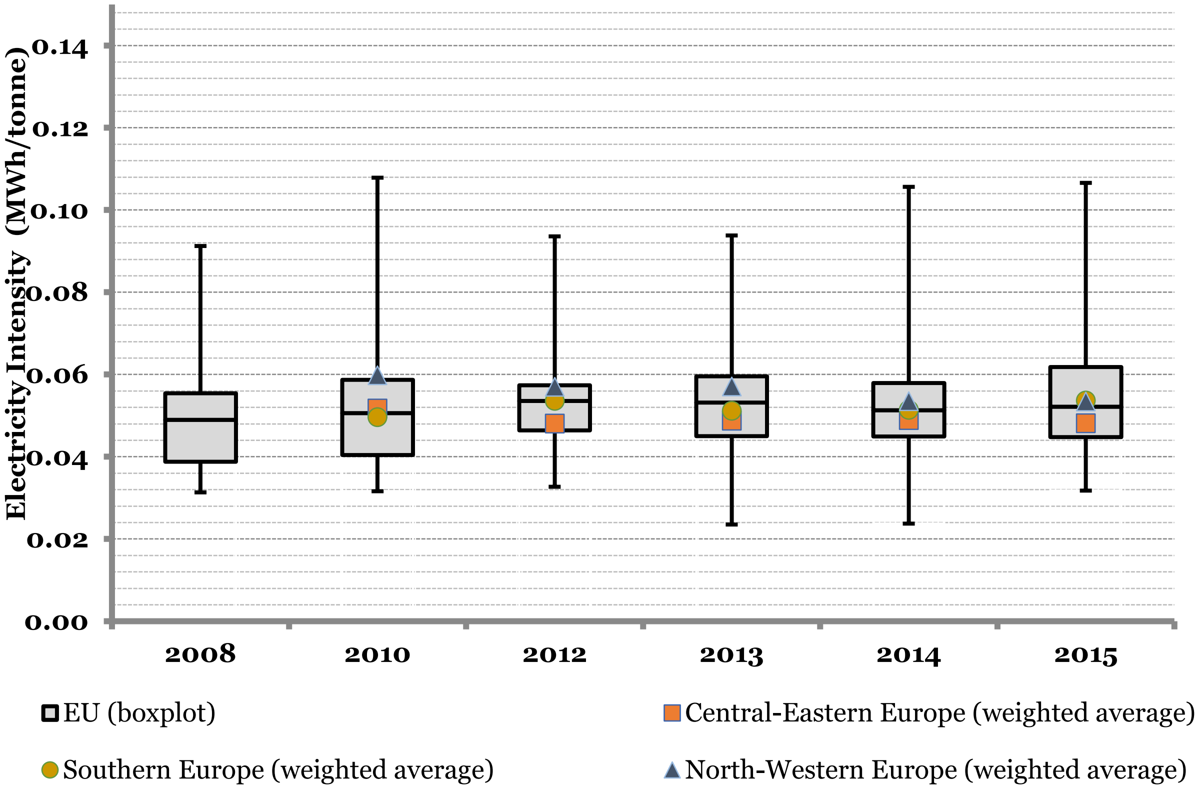
[96] In line with the box-plot analysis, IQR is presented in the table as a measure of dispersion, as it is more robust in case of samples varying across years and with this numerosity. The coefficient of variation is as follows: 2008: 0.38; 2010: 0.33; 2012: 0.48; 2013: 0.50; 2014: 0.60; 2015: 0.43.

Figure 103. Electricity intensity in terms of physical output, MWh/t (2008-2015)



Source: Authors' own elaboration.

Notes: Based on 41 respondents; 8.5% of Sectoral Production Value

Table 97. Descriptive statistics for electricity intensity (MWh/t, 2008-2015)

Indicator	2008	2010	2012	2013	2014	2015
EU - Weighted Average	0,05	0,05	0,05	0,05	0,05	0,05
EU - Simple Average	0,05	0,05	0,05	0,05	0,05	0,06
EU - Median	0,05	0,05	0,05	0,05	0,05	0,05
EU - Inter-Quartile Range97	0,02	0,02	0,01	0,01	0,01	0,02
EU - Minimum	0,03	0,03	0,03	0,02	0,02	0,03
EU - Maximum	0,09	0,11	0,09	0,09	0,11	0,11
NWE - Weighted Average	-	0,06	0,06	0,06	0,05	0,05
SE - Weighted Average	-	0,05	0,05	0,05	0,05	0,05
CEE - Weighted Average	-	0,05	0,05	0,05	0,05	0,05
NWE - Simple Average	-	0,06	0,06	0,06	0,06	0,06
SE - Simple Average	-	0,05	0,05	0,05	0,05	0,05
CEE - Simple Average	-	0,05	0,05	0,04	0,04	0,04

Source: Authors' own elaboration.
Notes: Based on 41 respondents; 8.5% of Sectoral Production Value

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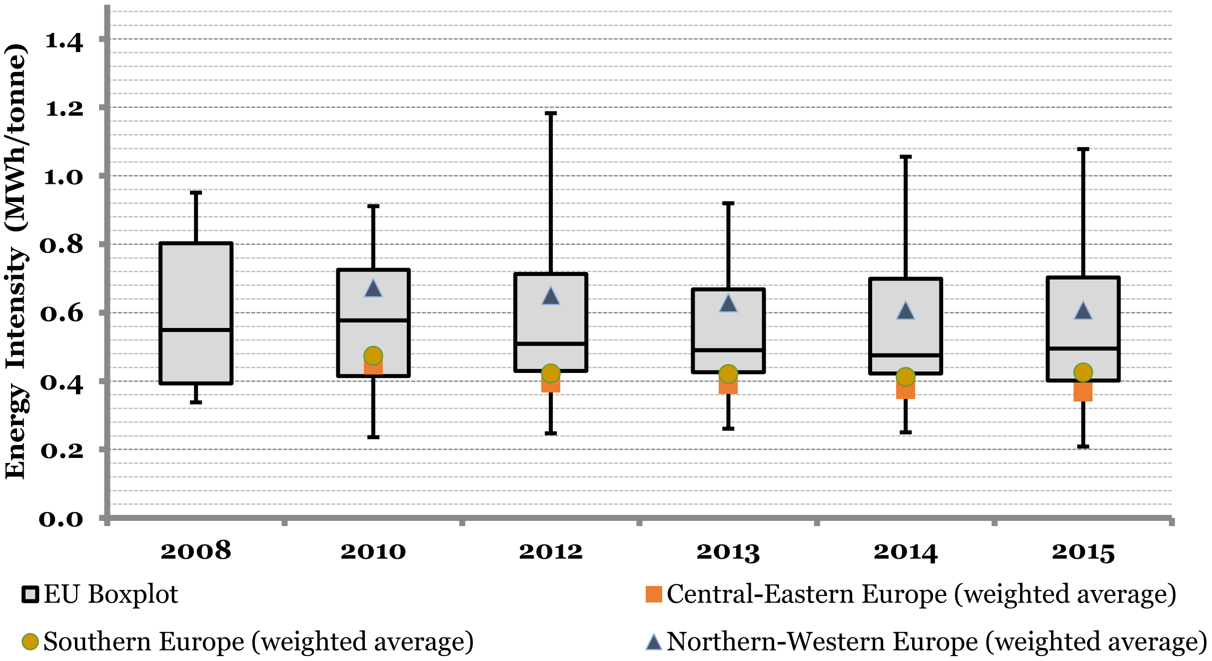
[97] In line with the box-plot analysis, IQR is presented in the table as a measure of dispersion, as it is more robust in case of samples varying across years and with this numerosity. The coefficient of variation is as follows: 2008: 0.51; 2010: 0.40; 2012: 0.48; 2013: 0.78; 2014: 0.70; 2015: 0.87.

6.9.3 Energy intensity

The analysis of total energy intensity, i.e. covering both electricity and natural gas, does not add significant information to the analysis, as the balance is strongly skewed towards natural gas, due to a 9:1 ratio of consumption between the two carriers. Hence, main trends for total energy intensity largely overlap with those reported for natural gas: (i) a declining energy intensity, which, on average, passed from 0.62 MWh/t in 2010 to 0.56 MWh/t in 2015; and (ii) a better performance of CEE plants, whose energy intensity in 2015 amounted to 0.42 MWh/t, compared to 0.66 MWh/t in NWE and 048 MWh/t in SE. The decline in energy intensity is due to the decline in natural gas intensity, and may be linked to variation of the plants' capacity utilisation factor.

Figure 104. Energy intensity in terms of physical output, MWh/t (2008-2015)



Source: Authors' own elaboration.
Notes: Based on 41 respondents; 8.5% of Sectoral Production Value

Table 98. Descriptive statistics for energy intensity (MWh/t, 2008-2015)

Indicator	2008	2010	2012	2013	2014	2015
EU - Weighted Average	0,60	0,62	0,58	0,57	0,55	0,56
EU - Simple Average	0,61	0,58	0,58	0,55	0,55	0,54
EU - Median	0,55	0,58	0,51	0,49	0,48	0,50
EU - Inter-Quartile Range[98]	0,41	0,31	0,28	0,24	0,28	0,30
EU - Minimum	0,34	0,24	0,25	0,26	0,25	0,21
EU - Maximum	0,95	0,91	1,18	0,92	1,06	1,08
NWE - Weighted Average	-	0,73	0,71	0,69	0,66	0,66
SE - Weighted Average	-	0,52	0,48	0,47	0,46	0,48
CEE - Weighted Average	-	0,50	0,44	0,44	0,42	0,42
NWE - Simple Average	-	0,71	0,76	0,69	0,70	0,70
SE - Simple Average	-	0,50	0,45	0,45	0,45	0,45
CEE - Simple Average	-	0,49	0,44	0,41	0,39	0,38

Source: Authors' own elaboration.

Notes: Based on 41 respondents; 8.5% of Sectoral Production Value

6.10 International comparison

This section includes the comparison of prices of energy carriers paid by ceramics producers in both the bricks and tiles and the wall and floor tiles sub-sectors. This is mainly due to data limitations and confidentiality reasons, as only four plants provided data for the international comparison. Furthermore, unlike other sectors, there is no international database of production and energy costs for the ceramic industry; hence the research team had to retrieve primary data from extra-European plants. An attempt to contact extra-European companies and plants in neighbouring regions present in the Amadeus database was carried out, but this was unfruitful.[99] Hence, an alternative way was followed, and multinational European companies already participating in the study and managing plants in non-EU countries were contacted to this purpose.

From a methodological perspective, the choice to combine the international comparison of wall and floor tiles with bricks and roof tiles is not problematic, given that the analysis is limited to energy prices in €/MWh, without considering costs over physical output or on financial indicators. With respect to energy prices, the consumption level per plant in the two sub-sectors is homogeneous, hence the analysis is not affected by different consumption levels.

Thanks to the cooperation of EU multinationals, data on four plants could be retrieved: two bricks and tiles plants in Russia, one wall and floor tiles plant in Russia,

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[98] In line with the box-plot analysis, IQR is presented in the table as a measure of dispersion, as it is more robust in case of samples varying across years and with this numerosity. The coefficient of variation is as follows: 2008: 0.38; 2010: 0.32; 2012: 0.47; 2013: 0.51; 2014: 0.60; 2015: 0.42.

[99] Fifty Bricks and Tiles plants were contacted in Balkan and CSI countries, without success.

and one bricks and tiles plant in the US.[100] More in detail, a Russian average price was calculated based on the weighted average of the prices of the three plants, weighted by energy consumption. For the EU, representative prices for the two-sectors combined were calculated as the average of the EU weighted average prices. Given the number of data points, the generalisability of the analysis remains limited.

Supporting evidences were received only from one plant. Hence, for other plants, the research team could only carry out a plausibility check based on secondary sources and other data retrieved during the study, which led to the validation of data, including revision of outliers. Data retrieved from foreign plants concerned a more limited number of years (2010, 2014, and 2015) and a more limited set of information.

In particular, energy components were not investigated, as they are not comparable across EU and non-EU jurisdictions. An attempt was also made to require information on KPI, but not all plants could provide comparable data. For this reason, only a comparison of natural gas and electricity prices between the EU[101] and non-EU jurisdictions[102] is presented here below.

Prices differential for energy carriers are remarkable, especially for natural gas, and especially in comparison with Russian plants. However, the impact of this price differentials on trade patterns is less clear. Bricks and Tiles is low-tradable good, due to the low value-to-weight ratio. In 2014, the whole EU imported approximately € 31 mln of bricks and tiles, which is slightly more than the 2015 average turnover of one of the sampled plants. For wall and floor tiles, which is a highly-tradable good, the situation is different; in fact, in the same year, the total extra-EU imports amounted to € 479 mln while total extra-EU exports amounted to € 3,478 mln.

6.10.1 Natural Gas

As shown in Figure 105 below, natural gas prices are significantly lower in the US and Russia compared to European prices. Russian gas weighted averages prices have been below 9 €/MWh across the whole period. In 2015, Russian plants paid approximately 6 €/MWh, which is approximately 78% less than the EU average, and 75% less than the CEE average, their closest neighbours.

When comparing the EU to a more similar economy, the US plant enjoyed lower gas prices as well, also because of the introduction of shale gas. In 2014 and 2015, reported US prices for natural gas were in between 14 and 19 €/MWh, that is respectively 55% and 35% lower than those paid by their European peers. Since, on average, natural gas costs represented approximately 20% of both bricks and tiles and wall and floor tiles

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[100] For two Russian plants, data were provided jointly.

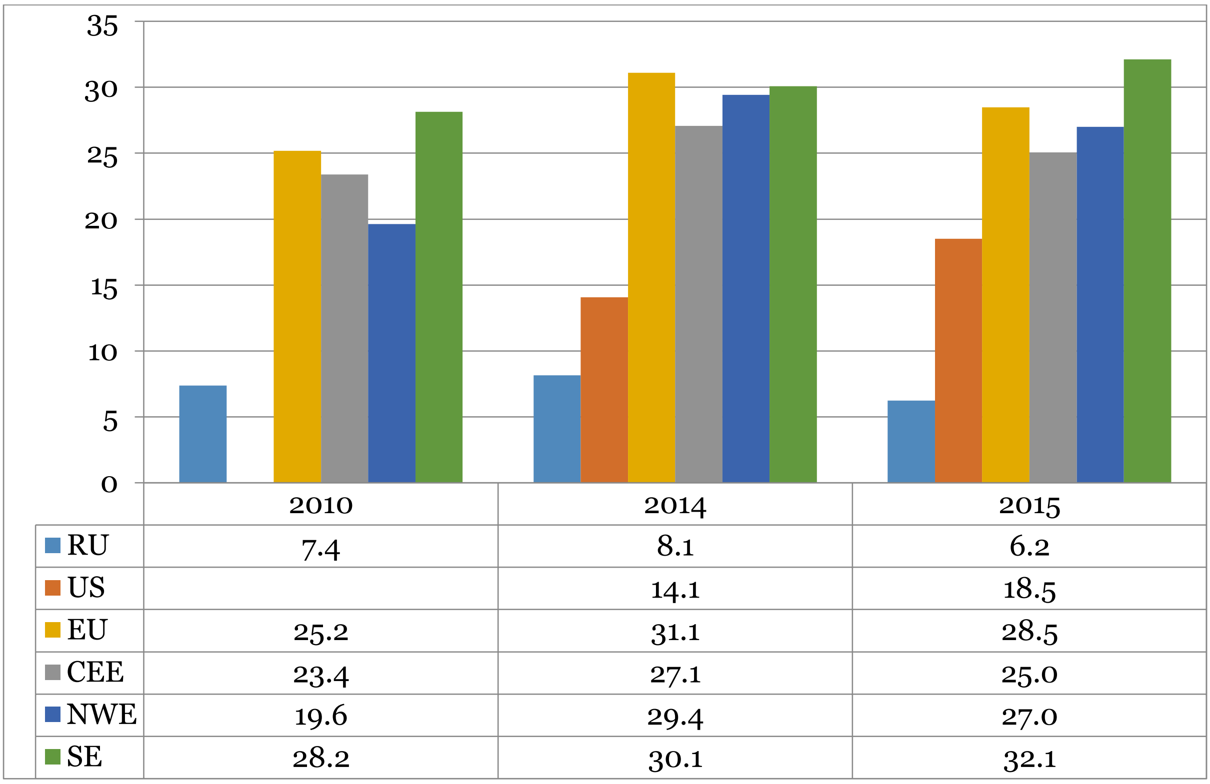
[101] EU and regional prices are the simple average of the EU and regional weighted averages in the two sectors.

[102] As in the case of EU MS with a currency other than the Euro, local prices were converted into € based on ECB data (annual average exchange rate).

production costs such a price gap has a strong effect on total production costs and, in principle, on industry competiveness.

In particular, *ceteris paribus,* i.e. taking into account energy costs only and the share of production costs represented by natural gas costs, Russian ceramic plants enjoy a 17% cost advantage, and the US plant a 7% cost advantage.

Figure 105. Prices of natural gas - EU average vs. plants in other jurisdictions (€/MWh) (2008 -15)



	2010	2014	2015
🟦 RU	7.4	8.1	6.2
🟧 US		14.1	18.5
🟨 EU	25.2	31.1	28.5
⬜ CEE	23.4	27.1	25.0
🟦 NWE	19.6	29.4	27.0
🟩 SE	28.2	30.1	32.1

Source: Authors' own elaboration.

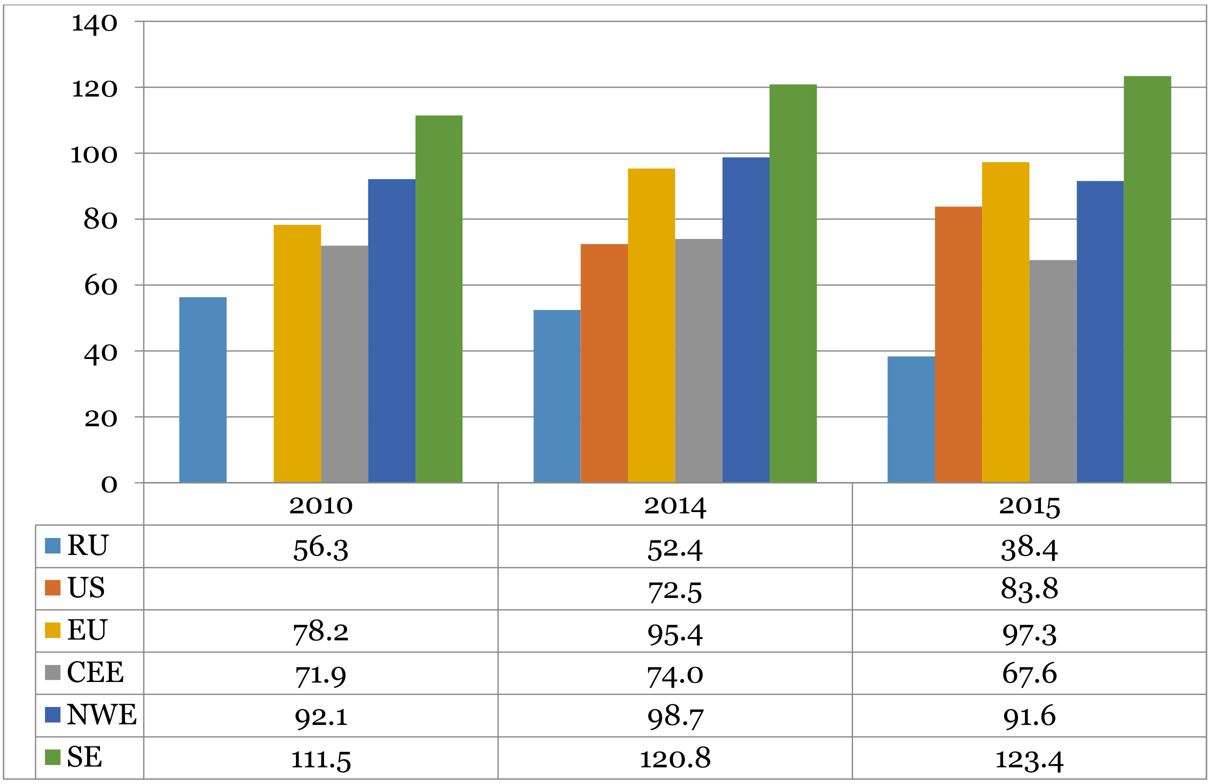
6.10.2 Electricity

Compared to natural gas, the electricity price differential is less stark. As shown in Figure 106 below, on average EU ceramic producers paid higher electricity prices across the whole period than their non-EU counterparts, both in Russia and the US. However, the differential is much smaller, and in 2015 CEE producers had a better electricity price compared to the US plant.

More in detail, Russian electricity prices declined from 56 €/MWh in 2010, down to €38 in 2015. In 2015, Russian prices were 61% lower than the EU average, and 43% than the CEE average. When comparing the EU and the US, the American plant enjoyed a lower electricity price in 2015, approximately 13% lower than the EU average. However, since this comparison only concerns one data point and the price gap is not sufficiently large, conclusions should not be drawn approximately whether EU manufacturers enjoy, on average, significantly lower electricity prices than their US counterparts.

As electricity costs represent 6 to 9% of production costs in the bricks and tiles sub-sector and 6 to 7% of production costs for wall and floor tiles, the impact of electricity price differentials on competitiveness is more limited than for natural gas.

Figure 106. Prices of electricity - EU average vs. plants in other jurisdictions (€/MWh) (2008 – 15)



	2010	2014	2015
🟦 RU	56.3	52.4	38.4
🟧 US		72.5	83.8
🟨 EU	78.2	95.4	97.3
⬜ CEE	71.9	74.0	67.6
🟦 NWE	92.1	98.7	91.6
🟩 SE	111.5	120.8	123.4

Source: Authors' own elaboration.

6.11 Key performance indicators and impact of energy costs

This section includes the information retrieved from sampled companies concerning Key Performance Indicators (KPI) – production costs, margins, and turnover. The purpose of retrieving and processing these data is not to provide a financial analysis of responding plants, but to analyse the impact of energy costs – for both gas and electricity – over financial indicators, namely production costs and margins.

Descriptive cumulative values for KPI, as provided by responding plants are shown in Table 99 below. Please note that 2015 is not covered by the analysis, as the number of respondents which could provide consolidated financial data for the last fiscal year was not sufficient.

Table 99. Production costs, Operating costs, EBITDA, EBIT, Turnover, Profit/loss before tax, 2008-15

	2008	2010	2012	2013	2014
Number of plants	35	40	40	41	41
Production costs (€/t)	€ 88,25	€ 75,57	€ 82,79	€ 78,57	€ 83,90
Turnover (€/t)	€ 116,91	€ 103,03	€ 111,77	€ 112,25	€ 123,46
EBITDA (% of turnover)	21,1%	21,5%	18,5%	16,9%	23,2%
EBIT (% of turnover)	8,6%	7,0%	3,1%	4,6%	4,8%
Profit/loss before tax (% of turnover)	1,2%	3,7%	-2,3%	1,7%	-6,8%

Source: Authors' own elaboration.
Notes: Based on 41 respondents; 8.0% of Sectoral Production Value

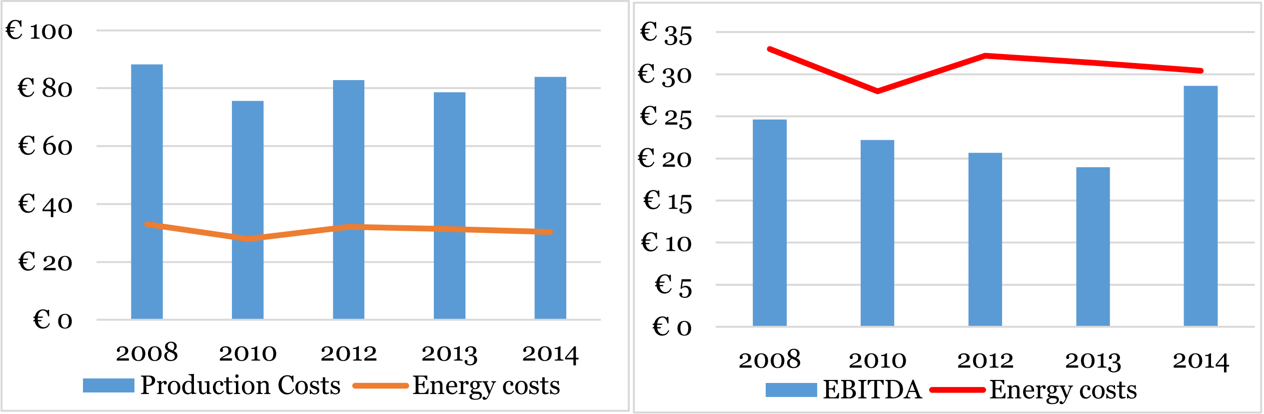
Figure 107 below represents the impact of energy costs over production costs based on the cumulative financial information provided by sampled companies. Later below in this section, weighted averages per region and at EU level are also provided. On one side, unweighted averages have not undergone any estimation and manipulation. On the other, they are not representative of the distribution of bricks and tiles production across EU regions, with specific respect to the relative significance of SE and NWE manufacturers.

The impact of energy costs over the financial performance of sampled plants, and hence the importance of energy prices and consumption for the cost-competitiveness of the bricks and tiles sector, appears clearly from Figure 107.

For responding plants, energy costs represented between 37% and 40% of production costs in the period under analysis; in absolute terms, energy costs per tonne of production varied following energy price trends, i.e. peaking in the 2012-2013 period and slowly declining in 2014.

When compared to EBITDA, the importance of energy costs for bricks and tiles manufacturers is even more prominent, as they are larger than plants' margins across the whole period.

Figure 107. Impact of total energy costs over production costs and EBITDA (2008-14)



Source: Authors' own elaboration.
Notes: Based on 41 respondents; 8.0% of Sectoral Production Value

The weighted average of the impact of energy costs over production costs[103] – where weights are given by energy consumption – show a slightly different situation, being lower than the unweighted average. This means that larger plants face a lower share of energy costs over total costs, possibly due to economies of scale in energy consumption. Share of energy costs over total costs vary between 29% and 35%, again peaking in 2012-2013 and then slowly declining. Though the share of energy costs is 5-8% lower than the unweighted average shown above, the importance of energy prices and consumption for the cost-competitiveness of the bricks and tiles sector remains evident.

Regional differences track regional energy prices, and as such the share of energy costs over total costs is the highest in SE. As for NWE manufacturers, the share of energy costs over total production costs is significantly lower than for CEE manufacturers, even though the latter enjoy on average lower energy prices. This may be due to a different importance of other cost components, e.g. labour costs, which are higher in NWE than in CEE, thus diluting the importance of energy costs.

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[103] Impacts on margins at regional level do not provide significant information, given the limited number of respondents providing this KPI in certain regions.

Table 100. Impact of total energy costs on production costs (%), 2008-14. Weighted averages from respondents of the sample, based on individual plant consumption[104]

	2008	2010	2011	2012	2013	2014
Electricity						
EU average	**6.9%**	**8.3%**	**9.4%**	**10.1%**	**10.0%**	**9.2%**
NWE	-	5.7%	6.0%	6.1%	6.3%	5.7%
SE	-	12.3%	14.7%	15.8%	15.9%	14.9%
CEE	-	7.7%	8.5%	9.9%	8.4%	7.3%
Natural gas						
EU average	**22.5%**	**25.6%**	**23.0%**	**24.9%**	**21.4%**	**19.5%**
NWE	-	19.4%	19.0%	20.2%	18.5%	15.4%
SE	-	37.3%	29.2%	32.0%	25.0%	25.0%
CEE	-	19.7%	22.0%	23.5%	22.4%	19.7%
Total						
EU average	**29.4%**	**33.9%**	**32.5%**	**35.0%**	**31.4%**	**28.6%**
NWE	-	25.1%	24.9%	26.2%	24.8%	21.1%
SE	-	49.6%	44.0%	47.9%	40.9%	39.9%
CEE	-	27.4%	30.4%	33.4%	30.8%	27.0%

Source: Authors' own elaboration.
Notes: Based on 41 respondents; 8.0% of Sectoral Production Value

6.12 Concluding remarks

Here below, the main conclusion of the analysis of energy prices and costs for the Bricks and Tiles sector are briefly recapped.

In 2013, the bricks and tiles industry generated €6 billion of production value; as the overall construction value chain, the sector was badly affected by the economic and financial crisis, and approximately a third of the output was lost since 2007 (Eurostat SBS, 2016). With regard to geographical distribution, the bricks and tiles sector is quite widespread across the EU.

As sources of clay are uniformly dispersed across all Member States, and as the low value-to-weight ratio of both the raw materials and the finished products makes transport expensive, local production is required. Compared to other non-ceramics sector covered by the study, the bricks and tiles sector is a dispersed industry, and information on the number and location of plants is not available, either in the public domain or from trade associations.

The bricks and tiles sector is characterised by a low trade intensity, and the limited trade mostly takes place via intra-EU exchanges, while extra-EU trade intensity is negligible: extra-EU imports accounted for 0.4% of the EU market size in 2013, while extra-EU exports for 3.7%.

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[104] Weighting for production, as done in the other sectors, was not possible, given that the analysis covers output in terms of both bricks and tiles.

The main energy carrier in the industry is natural gas, which account for 80-90% of the fuel mix burnt by tiles and bricks manufacturers. The energy carriers – other than electricity – used in this sector include LPG, fuel oil, biomass, and, residually, coal. Electricity has a lower importance compared to natural gas.

The research team received 31 questionnaires covering 60 plants in 16 MS. *Ex post* weights based on regional production values were used to correct for the high number of NWE respondents. The sample covers 10.5% of sectoral production, in terms of value, which is a positive indicator of the general validity of the analysis, especially taking into account the fragmentation of the industry.

The EU median price for natural gas paid by sampled bricks and tiles manufacturers amounts to 30.61 €/MWh. The median price has been rising in the period 2008-2013 (+3.3% YoY), and then declined until 2015 (-4.5% YoY). With respect to regional differences, NWE and CEE producers stand up as paying average prices lower than the EU median in all or most years. To the contrary, on average SE manufacturers paid approximately 10% more than the EU median price. Regional time-trends were similar, both among each other and to the general trend.

The split of natural gas price components shows a very limited role of non-energy components: in 2015, the EU weighted averages for network costs and other taxes and fees was slightly more than 10% of total price, and this value has kept constant across the period. More in detail, network costs represented 8% of gas price in 2015, while other taxes and fees approximately 2.4%. Regional differences in terms of price composition are of minor significance.

With respect to electricity, the EU median price paid by sampled bricks and tiles manufacturers amounts to 88.32 €/MWh. The diachronic trend is similar to that of natural gas, with the price increasing between 2008 and 2013 (+2.5% YoY), and then decreasing (-5.0% YoY). Price dispersion is larger, possibly due to higher weight of regulated components and higher fragmentation of national policies. As in the case of natural gas, SE producers face the highest prices. Electricity prices for NWE manufacturers also do not show a favourable trend, as it is the only region in which prices did not decline in 2014 and 2015. For CEE plants, prices have been consistently below the median, and declining over the overall period: after a peak in 2013, electricity prices are now below the 2008 levels.

The impact of regulated components on the electricity price is more significant than in the case of natural gas: in 2015, network costs, RES levies, and other taxes and fees (excluding VAT) accounted for 51% of the weighted EU average price. As a comparison, in 2010 this share was down at 44%, and constantly increased in the following 5 years. Among non-energy components, the lion share is taken by RES levies and network costs. The share of RES support has increased from 17.1% in 2010 to 21.1% in 2015 (+8.1% YoY in absolute value), while the share of network costs increased from 16.7% to 21.2% (+7.2% YoY in absolute value). At regional level, regulatory components are more significant in SE, though NWE and CEE show a more marked upward trend. CEE shows the lowest share of non-energy components, at 45% in 2015, though increasing from 38% in 2010. In NWE, the share of non-energy components in 2010 was also at 38%, and increased up to 47% in 2015. The role played by regulated components is the largest in SE: in this region, manufactures had, in 2015, both the highest energy component in absolute value, and the highest share of non-energy components, at 56% (slightly up from 55% in 2012).

In 2015, sampled brick manufacturers had a median natural gas intensity equal to 0.44 MWh/t. This value declined in the 2010-2015 period. The IQR, is quite high at 0.30 MWh/t in 2015, implying that there is a considerable range of variation across plants. Variation of gas intensity may be due to both pant efficiency, but also, and most frequently, to the plant load factor.

In 2015, sampled brick manufactures had a median electricity intensity equal of 0.05 MWh/t. The value remained stable across the whole period. Variation in the sample is quite large, as the IQR is approximately 35% of the median value, and the maximum value is approximately two times the median. However, given the low intensity, this variation does not have a significant impact on plant competiveness.

Due to data limitation, the international comparison jointly concerns bricks and roof tiles and wall floor tiles sub-sectors. Energy price differential for energy carriers are remarkable, especially for natural gas, and especially in comparison with Russian plants. However, the impact of this price differentials on trade patterns is less clear. Bricks and roof tiles are almost a non-tradable good, due to the low value-to-weight ratio. For wall and floor tiles, which are a highly-tradable good, the situation is different and international competitiveness is a more relevant factor.

In 2015, Russian plants paid approximately 6 €/MWh, which is approximately 78% less than the EU average, and 75% less than the CEE average, their closest neighbours. In 2014 and 2015, reported US prices for natural gas were in between 14 and 19 €/MWh, that is 35% lower than those paid by their European peers. Since, on average, natural gas costs represented approximately 20% of both bricks and tiles and wall and floor tiles production costs, such a price gap has a strong effect on total production costs and, in principle, on industry competiveness. In particular, *ceteris paribus*, i.e. taking into account energy costs only, Russian ceramic plants enjoy a 17% cost advantage, and the US plant a 7% cost advantage. Compared to natural gas, the electricity price differential is less stark. However, the weight of electricity costs on ceramic production costs is smaller and impact of electricity price differentials on competitiveness is more limited.

The impact of energy costs over the financial performance of sampled plants, and hence the importance of energy prices for the cost-competitiveness of the sector, appears clearly from the comparison of energy and production costs. The EU weighted average of energy costs over total production costs range from 28% to 35%, varying in line with energy price trends, i.e. peaking in the 2012-2013 period and slowly declining from 2014 onwards. Natural gas represents approximately two thirds of energy costs, with a weight of 19.5% on total production costs in 2015. Regional differences also track price trends, with Southern manufacturers' energy cost up to 40% of total costs, NWE manufacturers at 27%, and CEE manufacturers at 21%. When compared to EBITDA, the importance of energy costs for bricks and tiles manufacturers is even more prominent, as they are larger than plants' margins across the whole period.

7 Sector study: Refineries

Highlights

- The European refining sector has been going through a restructuring process. According to the IEA (2014), EU crude processing capacity has decreased by around 8% between 2008 and 2013, with 15 refineries closing and three reducing their output. Energy costs are an important factor for the competitiveness of European refineries; they account for over half of total operational expenditures.

- ***Sample.*** The research team received 15 questionnaires representing nearly 25% of the total European capacity. As no site from Central Eastern European (CEE) countries responded to the survey, the total capacity of CEE production (11%) is not represented in the sample.

- ***Energy price trends.*** **Weighted average natural gas prices decreased between 2008 and 2015 by 11%, from €26.4/MWh to €23.4/MWh.** Since 2013, weighted average prices decreased continuously, from a peak of 30.2 €/MWh. In 2015, the weighted average price in SE region (22.4 €/MWh) was lower than in NWE (23.8 €/MWh) for the first time. In 2012, prices in North-Western European countries have been nearly €10/MWh lower than in Southern European countries.
- **The main driver of natural gas prices is the energy component**. In the European weighted average prices, the share of the energy component was above 90% in all years. It showed a small decrease of approximately 1.7% between 2008 (€23.8/MWh) and 2015 (€23.4/MWh), peaking at €29.0/MWh in 2013. On average, the component covering taxes, fees, levies and charges has been higher in 2008 (1.1 €/MWh) than in 2015 (0.7 €/MWh). Among the respondents from the NWE region, energy supply costs were on average 1.2 €/MWh lower than the EU average of all responses. Although network costs and taxes, fees, levies and charges were according to the responses collected higher in the NWE region (0.8 €/MWh in 2015), the total price was lower (NWE: 23.9€/MWh, EU: 24.8 €/MWh in 2015).
- **Between 2008 and 2015, weighted average electricity prices for EU refineries decreased by approximately 7%, from €62.4/MWh to €57.8/MWh.** The median of electricity prices decreased by 19% between 2008 and 2015. Since 2013, it continuously decreased from 66.3 €/MWh in 2013 to 57.0 €/MWh in 2015. The observations show an increasing range in weighted average prices. The maximum price observed in 2014 (171.8 €/MWh) was six times higher than the lowest price observed (23.7 €/MWh) in the same year. In 2015 NWE refineries faced the lowest electricity prices since 2008 (50.7 €/MWh), while SE refineries reported the highest value (78.4 €/MWh).
- **The main driver of electricity prices is the energy component. Average values have decreased since 2013, from 46.5 €/MWh to 42.4 €/MWh in 2015. The initial value of €50.1/MWh in 2008 was 16%**

higher than the value in 2015. Network costs on the other hand **have been continuously increasing** since 2008, when their share in total costs was 3.9% to more than 13% in 2015. **Renewable energy support costs are fluctuating significantly** due to changes in the German renewable energy support scheme: in 2010 (8.8 €/MWh) and 2014 (3.5 €/MWh), German refineries in the sample were only partly covered by a scheme which reduces the RES tariffs of industrial companies. The electricity consumption of the refineries burdened with the full surcharge in 2010 and 2014 skewed the average trend. Consequently, there is no clear trend.

- ***Energy intensity.*** Final products supplied by refineries vary strongly. Depending on the degree of integration, one refinery can produce more than ten different products, sometimes within the same process. Instead of using tonnes of final product as basis for energy intensity calculations, the energy consumption is compared to the tonnes of crude oil processed.
- **The average natural gas intensity increased** from 0.77 MWh/t in 2008 to 0.84 MWh/t in 2015, mainly in Southern European Member States (increase from 0.5 MWh/t to 0.77 MWh/t). For North-Western European refineries, there is no clear trend. While the average value increased, the median value of natural gas intensity in all responding European refineries decreased since 2010, from 1.05 MWh/t to 0.83 MWh/t in 2015. For all years, the average natural gas intensity in NWE refineries is higher than in SE refineries, but the spread is continuously becoming smaller. Self-produced refinery fuel gases have been taken into account when showing natural gas intensity.
- **Average electricity intensity fluctuated between 0.09 and 0.10 MWh/t of crude throughput.** In general, both average as well as median electricity intensity values do not show a clear trend: it seems to be rather decreasing than increasing as weighted averages for NWE indicate a decline since 2008, with 0.09 MWh/t in 2008 and 0.08 MWh/t in 2015. The electricity intensity of Southern European refineries, in comparison to Northern/Western Europe, is higher and on an increasing trend. It increased from 0.10 MWh/t in 2008 to 0.13 MWh/t in 2014, followed by a small decline to 0.12 MWh/t in 2015. Self-produced electricity has been taken into account when showing electricity intensity.

- ***International comparison & impact on competitiveness.*** Only one refinery provided data on international energy costs, for one country and only for the year 2015. This information is no basis for a profound analysis. As Solomon Associates could not share nominal values for international prices and/or production costs with the research team, the **analysis had to be based on publicly available data from Solomon Associates**. According to this publication, **EU refineries' operational expenditures on energy have been growing strongly since the year 2000.** In 2014, they reached a level of 340 if the energy expenditures of EU refineries in 2000 are indexed to 100. **Refiners in Asia** (India and Korea/Singapore) **show stronger increases** in the parameter than the EU, **while energy expenditures of US refineries show a clearly declining trend since 2008. Energy**

expenditures of refineries in the Middle East remained fairly stable at a level of 61 in comparison to 100 in EU of the year 2000.

7.1 Introduction

According to the NACE (Rev.2) statistical classification of economic activities in the European Union, refineries are included in division 19. This includes manufacture of coke oven products (19.10) and manufacture of refined petroleum products (19.20).

A modern refinery is a highly integrated facility, separating and transforming crude oil into a wide variety of products, including transportation fuels, residual fuel oils, and lubricants. The simplest refinery type is a facility in which crude oil is separated into lighter and heavier fractions through the process of distillation. Modern refineries have developed more complex and integrated systems, in which hydrocarbon compounds are not only distilled, but also converted and blended into a wider array of products.

The European refining sector has been going through a restructuring process, necessitated both by changes in the global economy, as well as the necessity of addressing climate and environmental externalities.

Several international oil companies are divesting from refining capacity in Europe and are expanding in non-OECD countries, while non-European international companies are emerging as more important investors. However, they currently remain relatively minor players. Furthermore, refineries are more reluctant to make medium- to long-term investments in Europe. According to OPEC (2014), the announced European capacity additions and investments from 2014 to 2019 are lower than in other regions of the world.

According to IEA (2014), EU crude processing capacity has decreased by around 8% between 2008 and 2013, with 15 refineries closing and three reducing their output. In early 2012, Petroplus, Europe's largest independent refiner, filed for insolvency. Eni, an Italian company, transformed its Venice refinery into a so-called 'Green Refinery' by converting their conventional refinery into a bio refinery, producing high-grade biofuels (Eni, 2016).

The key dynamics underlying these changes are the weak local market conditions and uncertain future perspectives, especially as climate change will require increasingly strong policy responses. Since the 'golden years' of profit margins in the refining sector (2004-08), European refining margins have been shrinking continuously, mainly as a result of reduced demand, overcapacity and shifting product demand to (bio-)diesel.

This sectoral case study is structured as follows:

1. In the beginning of the case study (above) the main highlights from the research are presented;
2. Sections 7.2 to 7.5 provide the sectoral overview. In particular, 7.2 Section describes the production process and production characteristics in the EU; Section 7.3 presents the main characteristics of the EU industry; Section 7.4

provides an analysis of trade patterns; and Section 7.5 shows the analysis of the industry's energy consumption;
3. Section 7.6 presents the sampling strategy based and the description of the actual sample of manufacturing plants included in the study, including sectoral coverage;
4. Sections 7.7 and 7.8 report the results of the analysis of energy prices, both total prices and split per components;
5. Section 7.9 describes sectoral energy intensity;
6. Section 7.10 provides a comparison of energy prices paid by EU, Russian and US ceramic manufacturers – covering both the brick and roof tiles and the wall and floor tiles sectors
7. Section 7.11 provides the analysis of Key Performance Indicators (KPI) and the impact of energy costs over production costs and margins.
8. Section 7.12 provides a brief conclusion.

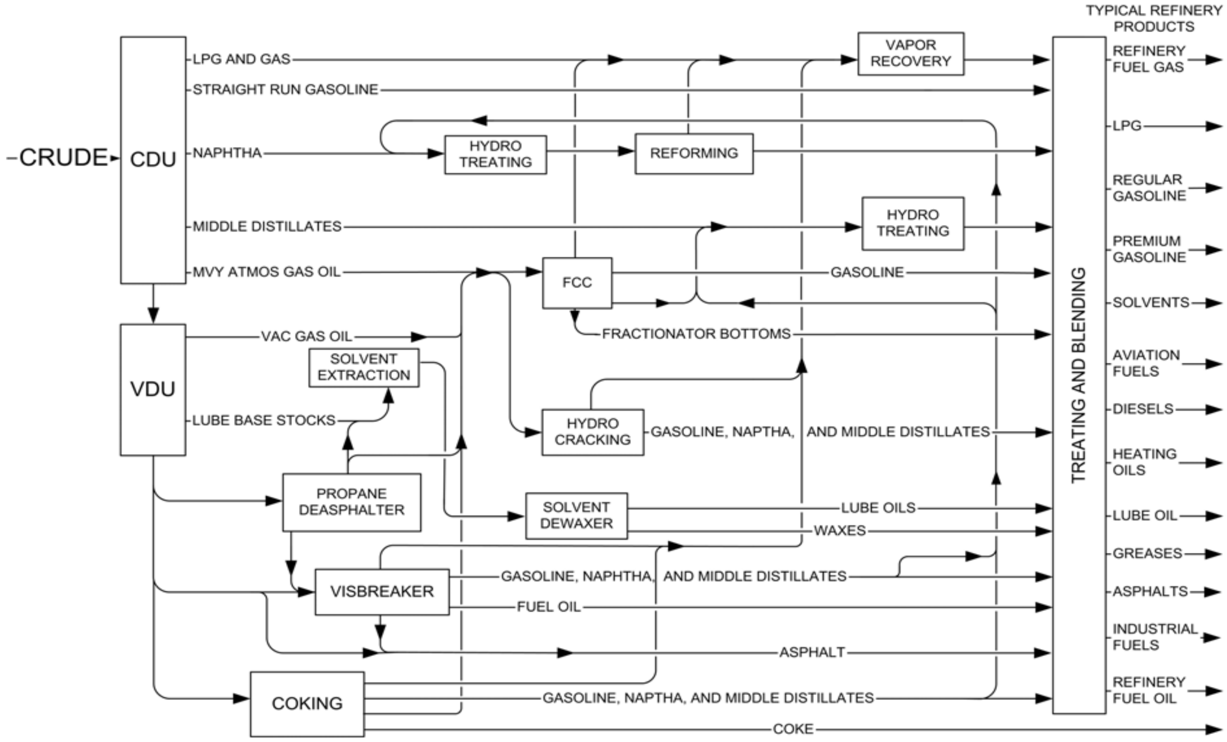
7.2 Overview of the production process

In all refineries, the first production process is the distillation of crude oil. The most important distillation processes are crude or atmospheric distillation, and vacuum distillation. Hydroskimming refineries and topping refineries only use these rather simple processes, while 'complex refineries' add more advanced conversion technologies after distillation.

Common conversion processes are thermal or catalytic processes. Newer processes, such as hydrocrackers, are used to produce lighter products from the heavy bottom products. Finally, all products can be treated further to upgrade the product quality, e.g. sulphur removal using a hydrotreater. Side-processes that are used to condition inputs or to produce hydrogen and other by-products include crude conditioning, e.g. desalting, hydrogen production, power and steam production, and asphalt production. Lubricants and other specialised products may be produced at separate locations. Most refineries are connected to a larger petrochemical complex, in which case they supply feedstock to chemical commodity producers. According to the Joint Research Centre (2015), refineries that are part of a petrochemical complex have better flexibility in optimizing their intermediate product streams, as well as benefit from shared operating costs. Such integration may thus significantly improve refining profitability.

Figure 108 provides a simplified flow diagram of a refinery, displaying the main production steps in refineries. The descriptions follow the flow diagram, starting with the intake of the crude through to the production of the final products. The flow of intermediates between the processes will vary by refinery, and depends on the structure of the refinery, the type of crude processes and the product mix.

Figure 108. Simplified flowchart of refining processes and product flows



Source: EPA (2005).

Fluid Catalytic Cracker (FCC): The fuel oil from the crude oil distillation unit (CDU) is converted into lighter products over a hot catalyst bed in the fluid catalytic cracker (FCC). This produces high octane gasoline, diesel and fuel oil. The FCC is mostly used to convert heavy fuel oils into gasoline and lighter products and has virtually replaced all thermal crackers. Fluid catalytic crackers are net energy users, due to the energy needed to preheat the feed stream. However, modern FCC designs also produce steam and power.

Hydrocracker (HCU): The HCU has become an important process in the modern refinery, and allows for flexibility in product mix. It provides a better balance of gasoline and distillates, improves gasoline yield and octane quality, and can supplement the FCC to upgrade heavy feedstocks. In the HCU, light fuel oil is converted into lighter products under a high hydrogen pressure and over a hot catalyst bed. The main products are naphtha, jet fuel and diesel oil. It consumes energy in the form of fuel, steam and electricity (for compressors and pumps). The hydrocracker also consumes energy indirectly in the form of hydrogen.

Coking: A new generation of coking processes has added additional flexibility to the refinery by converting the heavy bottom feed into lighter feedstocks and coke. Coking can be considered a severe thermal cracking process. Modern coking processes can also be used to prepare a feed for the hydrocracker

Visbreaker: Visbreaking is a relatively mild thermal cracking operation, used to reduce the viscosity of the bottom products to produce fuel oil. This reduces the production of heavy fuel oils, while the products can be used to increase FCC feedstock and increase gasoline yields. There are two main processes: coil (or furnace) cracking and soak cracking. Coil cracking uses higher reactor temperatures and shorter residence times, while soak cracking has slightly lower temperatures and longer residence times.

Alkylation and Polymerization: Alkylation (the reverse of cracking) is used to produce alkylates (used in higher octane motor fuels), as well as butane liquids, LPG and a tar-like by-product. Alkylation processes use steam and power. There are no large differences in energy intensity between both processes.

Hydrogen Manufacturing Unit or Steam reforming (HMU) are supporting processes that do not produce the main refinery products but intermediates used in the various refining processes. Hydrogen is generated from natural gas and steam over a hot catalyst bed. Energy is used in the form of fuel (to heat the reformer), steam (in the steam reforming) and power (for compression).

Gas Processing Unit: Refinery gas processing units are used to recover C_3, C_4, C_5 and C_6 components from the different processes, and to produce a desulfurised gas which can be used as fuel, or for hydrogen production in steam reforming.

Acid Gas Removal: Acid gases, such as H_2S, are produced as a by-product of higher quality refinery products and need to be removed to reduce air pollution (before 1970, they were simply burned off).

Bitumen Blower (BBU): Hot air is blown onto heavy fuel oil to produce bitumen or asphalt.

Other processes may be used in refineries to produce lubricants (lube oil), petrochemical feedstocks and other specialty products. These processes consist mainly of blending, stripping and separation processes. These processes are not discussed in detail here, as they are not found in a large number of refineries.

7.3 Industry characteristics

The European refinery sector is mature, consolidated and characterised by highly capital-intensive assets, high economies of scale and low margins. Market rivalry is strong as a result of historical refining overcapacity and the mature nature of the European oil product market.

Buyers of European oil products have consolidated and are now concentrated in the highly competitive marketing and retail market. The presence of supermarkets in the oil product retail market has increased these competitive pressures. Suppliers, on the other hand, are building up competitive pressure against European refiners. Despite significant entry barriers, European refiners are increasingly challenged by the entry of new competitors, as many emerging economies are ramping up complex, partially export-driven, domestic refining capacity, such as the Middle East and India. Consequently, both the supply and demand sides are challenging the European refinery sector (Meijknecht et al., 2012).

With the increased penetration of substitutes in the oil product markets, such as ethanol-based gasoline/diesel and electric vehicles, demand for oil products in the EU and export markets is declining. At the same time, EU-legislation supports these alternatives and also requires compliance with various emission standards on the industry aimed at addressing the externalities of this industry with regards to climate change. According to the Joint Research Centre (2015), the EU quantified average regulatory cost impact corresponds to, at most, 25% of EU refineries' observed net margin decline relative to competitor regions during 2000-12,

From the perspective of vertical integration and financial capabilities, there is a diverse pattern of refineries within the EU. On the one hand, vertically integrated and financially strong owners of European refineries are divesting from their European refineries. On the other hand, moderately vertically integrated and financially capable companies, such as national champions from emerging markets, are increasing their presence in the European refining sector (Meijknecht et al., 2012).

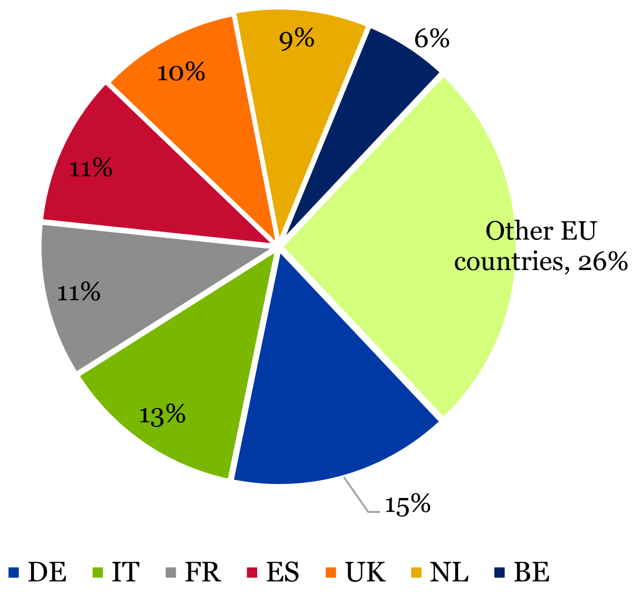
According to data presented in the EU’s annual competitiveness report in 2013, the EU refining industry was the leading industrial sector in process innovation, and ranked among the top four for product innovation. The European refining industry employs a large share of highly skilled workers out of all manufacturing industries.

FuelsEurope is the industry association for the European refinery industry. It was known until June 2014 as Europia, which was formed in 1989 to represent the interests of companies conducting refinery operations in the EU to the EU institutions. FuelsEurope is a division of the European Petroleum Refiners Association, operating in Belgium. This association represents 41 companies that operate petroleum refineries in the European Economic Area as of 2013. It comprises two divisions, FuelsEurope and Concawe, each having separate and distinct roles and expertise but administratively consolidated for efficiency and cost-effectiveness. Their members account for almost 100% of EU petroleum refining capacity, and more than 75% of EU motor fuel retail sales (FuelsEurope, 2016a).

7.3.1 Production in the EU

As presented in Figure 109, in 2014 Germany accounted for the highest share of EU refining capacity (15%), followed closely by Italy with a share of 13% (see Figure 109). France (11%), Spain (11%), the UK (10%) and the Netherlands (9%) have slightly lower shares. Due to its proximity to the sea, Belgium also has a relatively high share of refining capacity (6%) despite its relatively small economic size. According to FuelsEurope (2015a), the region Europe/Eurasia still remains the third largest refining region in the world, with a share of 19% of total global refining capacity in 2013 (following Asia Pacific with 33% and North America with 22.5%). The share, however, has decreased since 2006. The total EU refining capacity in 2014 was 671 million tonnes of crude oil.

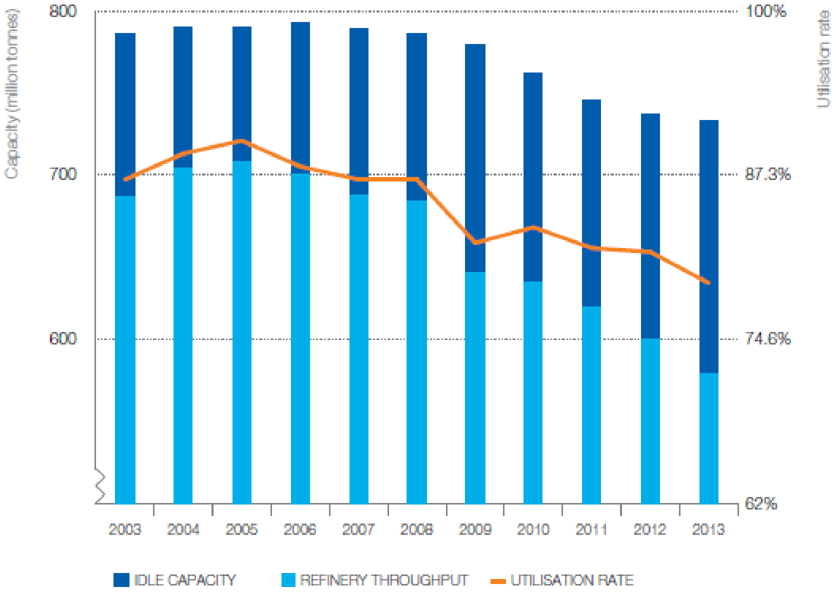
Figure 109. Share of refining capacity within the EU in 2014



Source: Authors' own elaboration based on FuelsEurope (2015a).

Figure 110 highlights the general downward trend in total European refinery capacity. From 2005 to 2013, the capacity declined by more than 10%. At the same time, the utilisation rate of European refineries dropped from 90% to below 80%. In 2013, this utilisation rate translated into approximately 600 million tonnes of crude oil throughput. Low utilisation rates and the related increasing competition to supply the remaining EU demand, forces the industry to further reduce its capacities. Due to locational disadvantages, inland refineries are likely to be affected more significantly by refinery closures (Oil and Energy Trends, 2014).

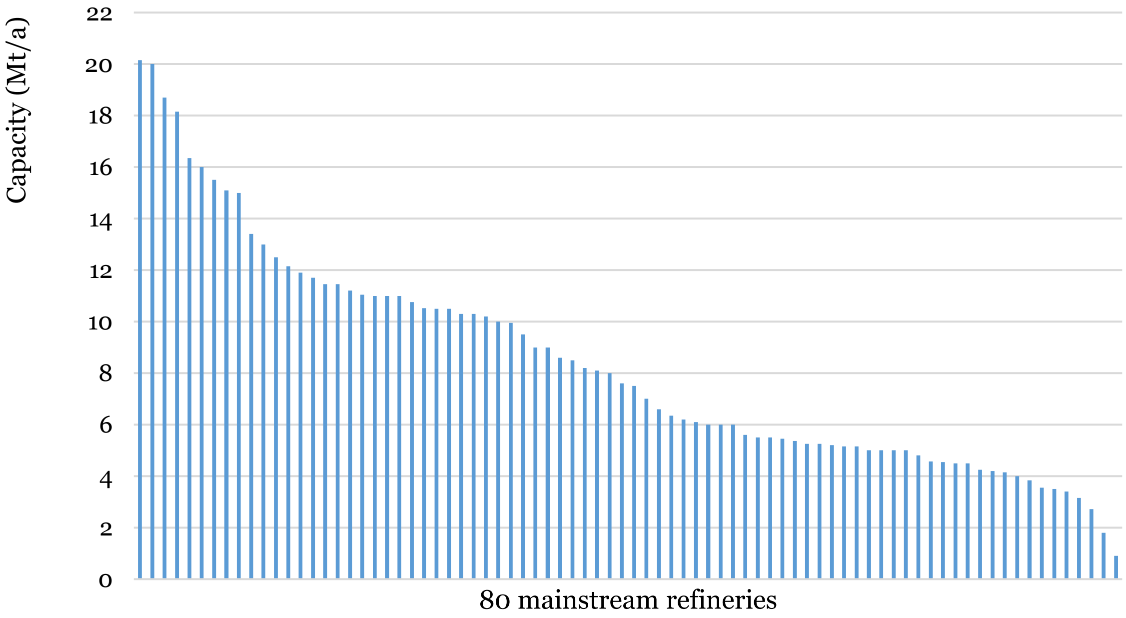
Figure 110. Capacity and production levels of European refineries



Source: FuelsEurope (2015a).

Based on recent (as yet unpublished) data from FuelsEurope, Figure 111 illustrates the capacities of all 80 mainstream refineries in the EU[105], sorted from large to small capacity levels. The largest refinery has an annual capacity of 20.15 million tonnes, whereas the smallest has an annual capacity of less than 1 million tonnes. The average annual capacity for refineries in the EU is 8.39 million tonnes, with a standard deviation of roughly 4.36 million tonnes. The total mainstream refinery capacity in Europe adds up to 871 million tonnes.

Figure 111. Capacities of all 80 mainstream refineries in the EU



Source: FuelsEurope (2016b).

None of the refineries fall under the EC definition of small and medium-sized companies (SMEs). They are defined as companies with less than 250 employees and an annual turnover of less than €50 million (European Commission 2015).

7.3.2 Number of companies and plants operating in the EU

According to the data provided by FuelsEurope, 80 mainstream refineries were operating within the EU at the end of 2014, not taking into account small or speciality sites across Europe (Figure 112). From 2008 to 2013, 15 European refineries shut down, mainly caused by a rapid reduction of demand (MathPro, 2015 & IEA, 2014).

Across Europe, 33 companies are operating all 80 refineries[106]. According to Figure 112, there are 15 companies operating only one refinery, 13 companies operating two

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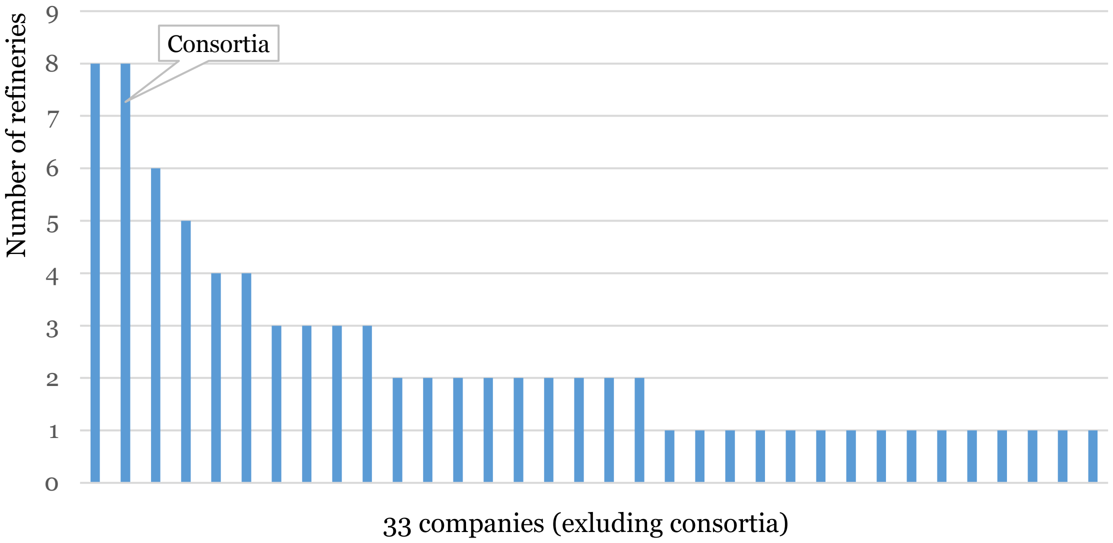
[105] It is important to note that so-called mainstream refineries exclude any small petroleum oil sites performing specialised functions (such as bitumen and lube oil manufacture) as they are atypical for the refinery sector (Concawe, 2012).

[106] Note again that small petroleum oil sites performing specialised functions (such as bitumen and lube oil manufacture) are excluded as they are atypical for the refinery sector according to Concawe (2012), reducing the 41 member companies of FuelsEurope to 33 companies.

or three refineries, four operating four to six refineries and only one operating more than six refineries. Eight refineries are run by more than one company (so-called "consortia"). Total (eight), ExxonMobil (six), Repsol (five), BP (four) and Eni (four) run nearly 38% of all refineries in the EU, without taking into account that these companies may also be part of some of the consortia.

Figure 112. Number of refineries operated by each company in the EU[107]



Source: FuelsEurope (2016b).

7.3.3 Geographical distribution of production and plants over the EU

The map in Figure 113 shows the geographical distribution of the refinery, steam cracker and integrated refinery/steam cracker locations across the EU. It is important to note that a large number of refineries are integrated with or located very close to steam crackers that produce products for the petrochemical industry. Such interconnections show that refining is an intrinsic part of the industrial value chain, and provides the basis for many products derived from crude oil. Most of the industry is situated close to the coast, or, as is the case of Germany, near the Rhine River, since shipping is an important means of transport for the sector.

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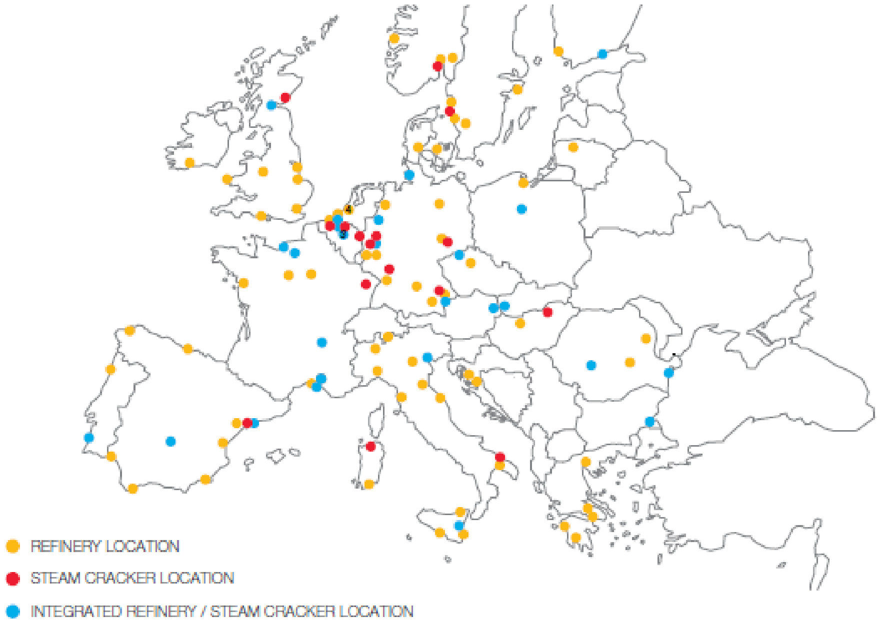
[107] Please note that eight refineries are simultaneously run by several companies; in the graph they are referred to as 'consortia'.

Figure 113: Refinery and steam cracker sites in the EU



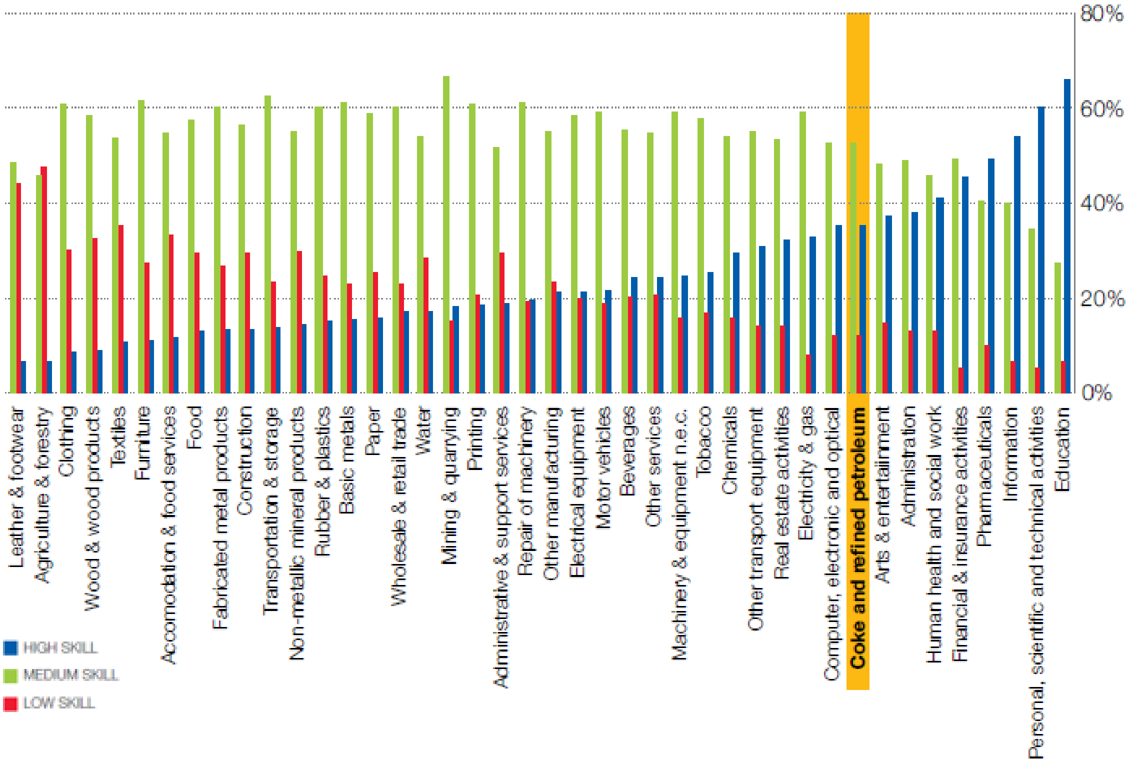
Source: FuelsEurope (2015).

7.3.4 Employment

According to FuelsEurope (2016a), refineries provide work for approximately 100,000 employees and contractors. Eurostat data for 2010 estimates that the refineries employed nearly 130,000 people in the EU-27, of which 83% were employed by large enterprises (Eurostat, 2016). As the focus of this study is large companies, it can therefore be assumed that roughly 108,000 people are employed by these large companies.

According to data presented by the EU's annual competitiveness report in 2013, the European refining industry employs one of the largest percentages of highly skilled workers out of all manufacturing industries, just after the pharmaceutical industry (see Figure 114).

Figure 114. Skill and knowledge intensities (% of total employment)



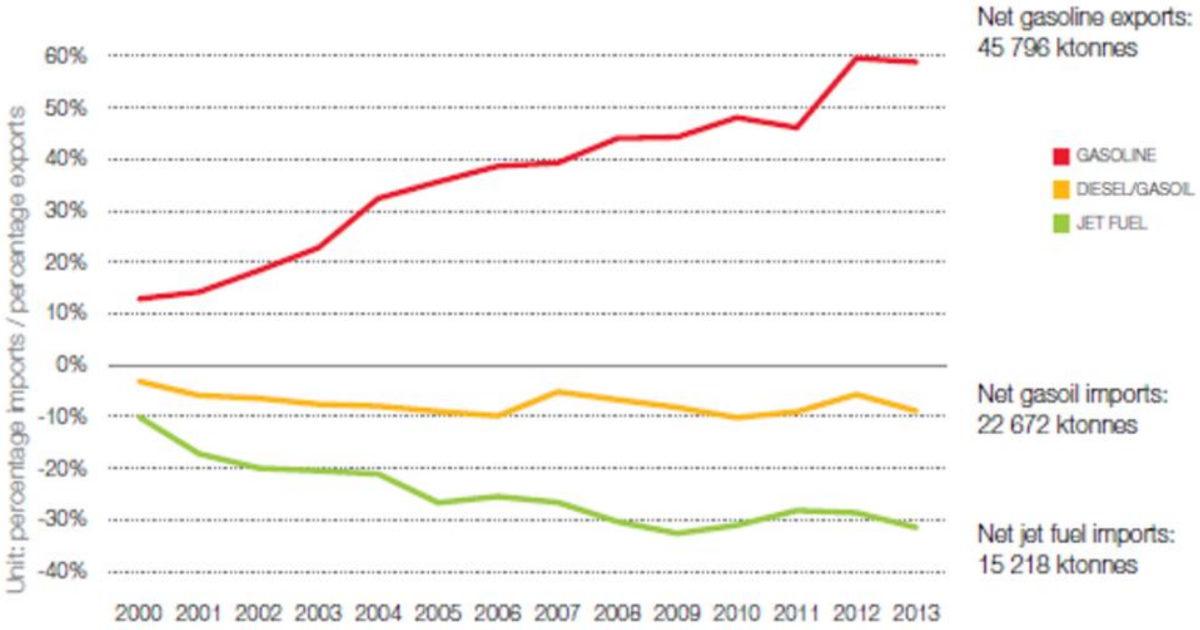
Source: FuelsEurope (2015a).

7.4 Trade analysis

Figure 115 shows net trade flows for refined products. Due to the significant excess gasoline production capacity, 60% of the EU refineries' net exports is gasoline. More than 50% of these exports go to North America, a traditional market for exporting gasoline surplus. However, North America is reducing its imports due to shale gas/oil production.

EU refineries have to find new export opportunities and compete in other markets. At the same time, the EU refineries do not cover the EU's demand for diesel and jet fuel, resulting in an import dependency on other countries, especially Russia, the Middle East and the US (FuelsEurope, 2015).

Figure 115. Net trade flows for refined products



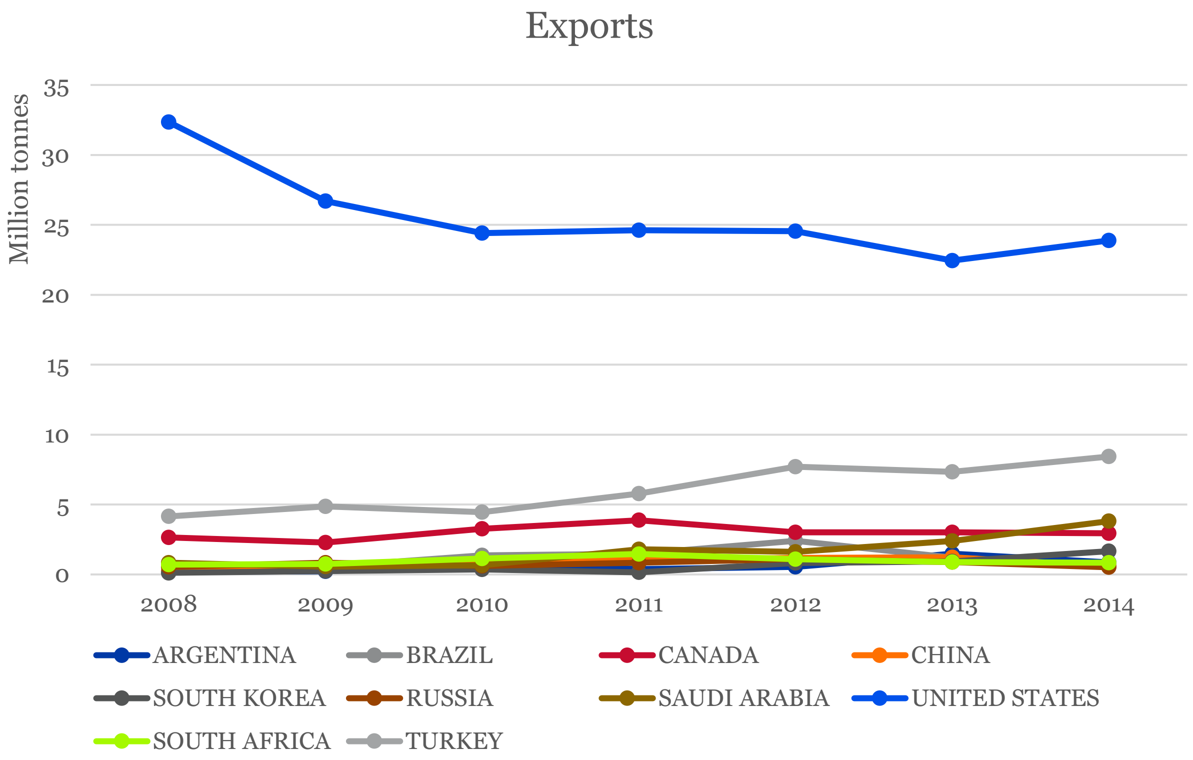
Source: FuelsEurope (2015a).

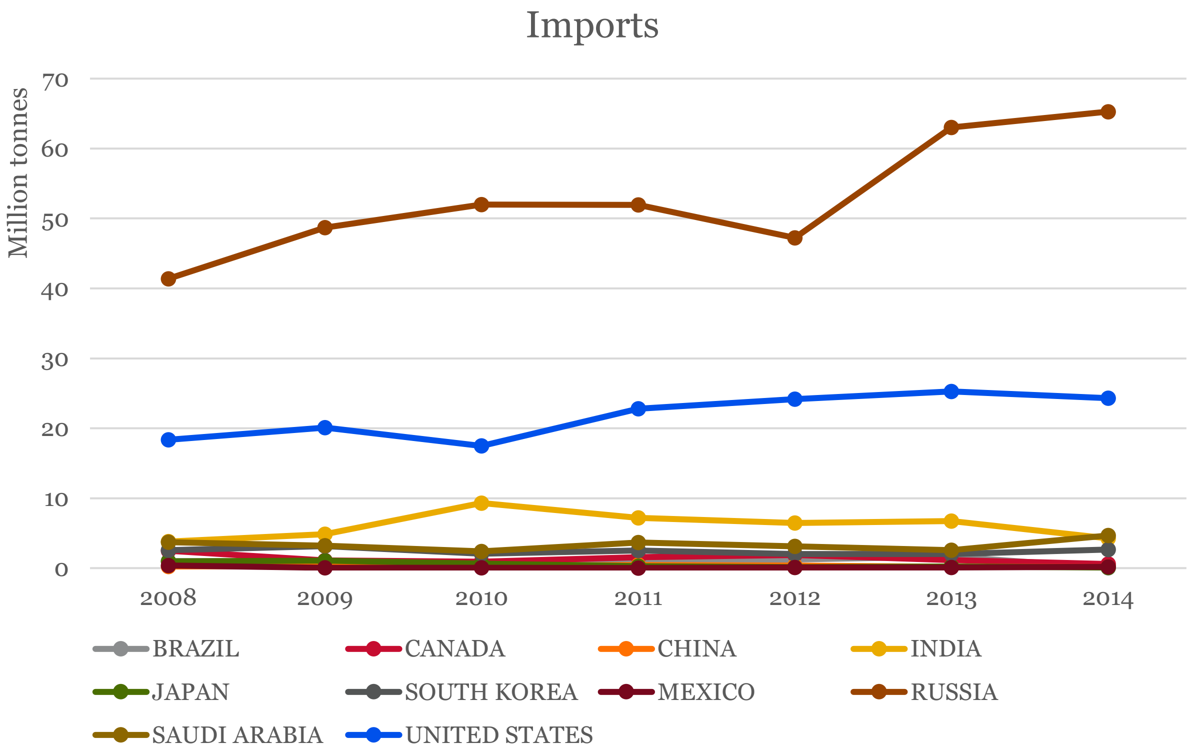
Figure 116 shows the EU export and import trade volumes of manufactured refined petroleum products with the 10 most relevant G20 countries from 2008 to 2014. It illustrates that, from 2008 to 2014, the EU exported the largest share of its refined petroleum products to the United States. These volumes, however, have been steadily decreasing from 32.3 in 2008 to 23.9 million tonnes in 2014.

With significantly smaller volumes, Turkey and Canada followed the United States as the second and third largest importers of EU products throughout the period from 2008 to 2013. Exports from the EU to Saudi Arabia also became quite substantial during 2013 and 2014. Exports to Turkey accounted for nearly 8.4 million tonnes in 2014, more than double the size of export to Canada or Saudi Arabia in the same year. China, in contrast, played an insignificant role regarding EU exports from the refining industry.

The highest imports to the EU, with a value of 65 million tonnes in 2014, came from Russia. This 2014 value was also Russia's highest export value to the EU from 2008 to 2014. The United States represents the second largest exporter to the EU. Since 2010, its export volume has been continuously increasing, from 17.5 million in 2010 to 25.2 and 24.3 million tonnes in 2013 and 2014 respectively. Between 2008 and 2013, India represented the third largest exporter to the EU. Its volumes, however, have been continuously decreasing since 2010 but according to FuelsEurope (2015b), at the Jamnagar refinery in India, a capacity expansion for export is underway increasing the refinery's capacity from 1.3 to 1.8 million barrel per day (i.e. 13% of EU refining capacity). China's exports to the EU, in comparison, are less significant.

Figure 116. EU export and import volumes of refined petroleum products with the 10 most relevant G20 countries (in terms of volume)





Source: Eurostat (2015) (NACE3, 192).

7.5 Energy - literature review

Energy is required in refineries for heating, reacting, cooling, compressing and transporting hydrocarbon streams in liquid and gaseous states. Cracking of large molecules into smaller ones is an endothermic process, i.e. absorbs energy. Manufacturing the extra hydrogen required is a particularly energy-intensive operation. Refining also involves fluid transportation, such as pumping of liquids and compression of gases both within the process units and for ancillary operations, such as product blending and storage, water treatment, etc. Energy required for lighting, space heating, etc., in contrast, is relatively small. For refineries, crude oil is a feedstock for the production of refined products. Energy intensity analysis therefore excludes crude oil.

Heating is by far the main energy consumer in a refinery. The type of equipment and the form of energy used depends on the required temperature level and, to an extent, the required thermal duty. The refinery core installation is the fired heater, where liquid or gaseous fuel is burned and heat is transferred to the process stream at temperatures well above 250°C. Many phases of refining do not require such high temperatures. Steam is the flexible heat medium of choice, applied in many ways at different levels of pressure/temperature.

Heat recovery is a key element of refinery design. Most refinery processes involve heating of the feedstocks while effluent products need to be cooled down before being routed elsewhere, e.g. to storage. The surplus heat available in hot streams can be transferred to the cold streams through a combination of heat exchangers. Another way of recovering heat is to transfer the heat from the hot effluent to water in order to generate steam.

Electricity can be used, though infrequently and under specific conditions, for pipe heating and process heating, via an intermediate thermal fluid, such as hot oil. Refineries also need electricity for pumps, compressors, instrumentation, lighting, etc. Rotating equipment, such as pumps and compressors can alternatively be driven by steam, when the steam supply is reliable and abundant.

Refineries traditionally use **internally produced fuels** (like waste gas) to generate most of their own energy needs. The reason for this is partly historical (as there were no or few alternative energy sources available) and also supported by the availability within the refinery of streams for which there are few or no attractive alternative uses. In practice, many refineries also import energy from third parties in the form of gas (mostly natural gas), heat (mostly as steam) and electricity, as they generally do not generate enough fuel gas to cover all their needs. Some refineries, on the other hand, also export heat and electricity, to some extent.

While **fuel oil** is still used, sometimes in combination with flue gas desulphurisation, it has been displaced in a fair number of refineries by natural gas, which is today easily available for import in large quantities. Crude oil, in contrast, is treated as feedstock and is therefore not included in refineries' energy consumption overviews.

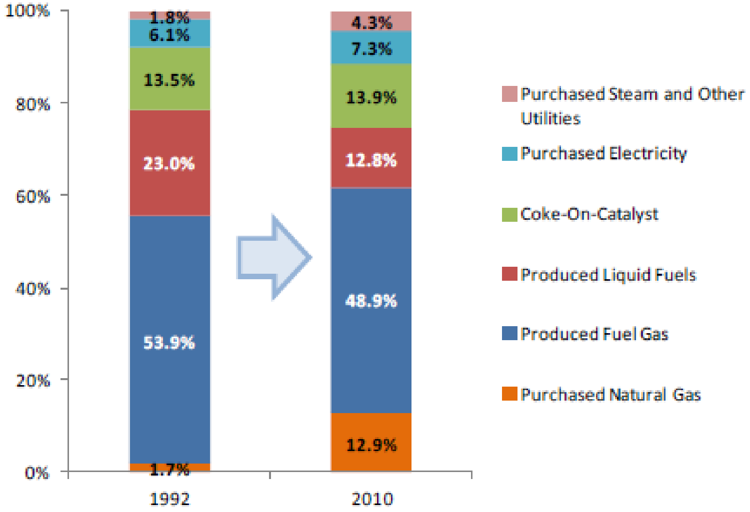
A large proportion of refinery energy needs can be provided by a heat-carrying fluid, in the vast majority of cases steam. At the same time refineries need electricity. This is a typical scenario for '**cogeneration**' of heat and power (CHP), and most refineries have applied this in some form for a long time.

According to Concawe (2012), in EU refineries' the percentage of electricity generated on site through CHP has increased from 76% to 92% between 1992 and 2010, while the total cogeneration capacity has increased by 125%. In energy terms, refineries usually require more steam than electricity so that cogeneration to cover only internal needs tends to be limited by the internal electricity demand.

The opening up of electricity markets has provided some refineries with a new opportunity to apply cogeneration, with the possibility to export surplus electricity to the local grid. However, the majority of EU refineries import some (or all) of their electricity needs. Import and export of heat (mostly as steam) is less frequent, but still fairly common, often as a result of integration with other local plants, such as petrochemicals (Concawe, 2012).

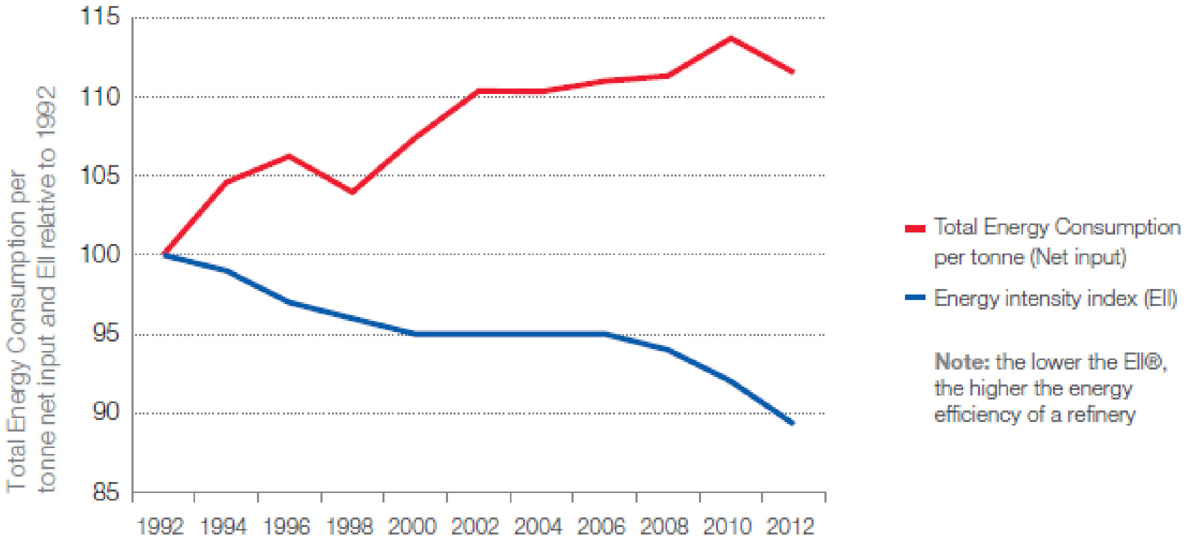
Figure 117 shows the evolution and composition of the refinery energy mix of EU refineries between 1992 and 2010. In both years, gas was the main fuel in the refinery fuel mix. Over time, produced liquid fuels have been replaced by purchased natural gas. Today gas (purchased natural gas and produced fuel gas) accounts for the major share (62%) of total refinery energy consumption.

Figure 117. Energy refinery fuel mix in EU refineries as % of total primary energy consumption



Source: Concawe (2012).

Figure 118. EU refineries' energy consumption and energy intensity, 1992-2012



Source: FuelsEurope (2015a).

Figure 118 shows the evolution of the total energy consumption of a consistent group of EU refineries and their combined Energy Intensity Index (EII®).[108] Refinery process has become increasingly complex to support tighter product specifications, most notably lower sulphur contents. For this reason, EU refineries have been gradually using more energy per tonne of net input. They have, however, improved efficiency by 10% over the last 18 years. Between 1992 and 2010, this resulted in an annual saving of approximately 60 ktoe on average per refinery, or over 4 Mtoe/a for all EU refineries together (Concawe, 2012).

Due to refineries' high energy demand, energy costs of EU refineries have always represented a substantial portion of total operating cost. According to FuelsEurope (2015), however, the proportion has increased substantially over the last two decades (Figure 119). In 1992, it made up 35% of total operating costs, by 2010 that share had grown to 60% (FuelsEurope, 2015a).

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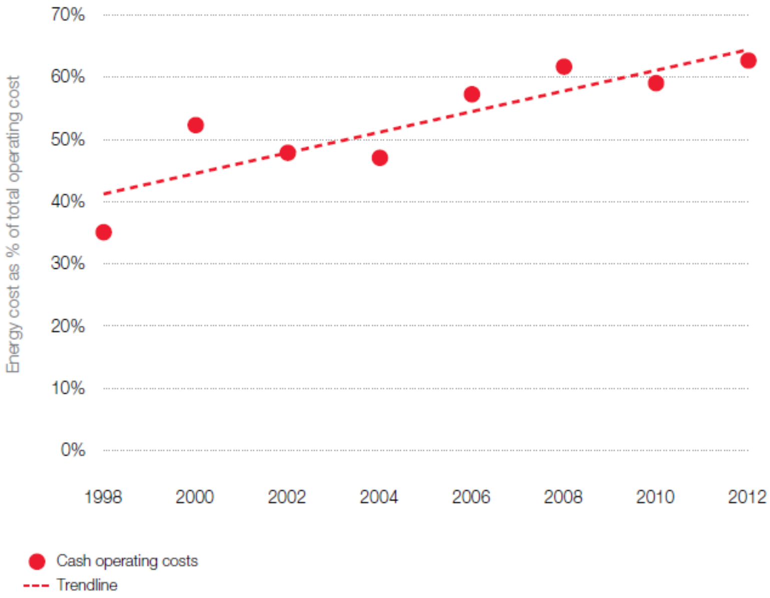
[108] Solomon Associates (SA) has developed its "Energy Intensity Index" or EII® which takes into account physical differences, such as refinery size and complexity to focus on measuring energy performance.

Figure 119. Share of energy costs as % of total operating costs



Source: FuelsEurope (2015a).

7.6 Selection of sample and sample statistics

7.6.1 Sample strategy

The sampling strategy for each sector takes into account the following criteria:

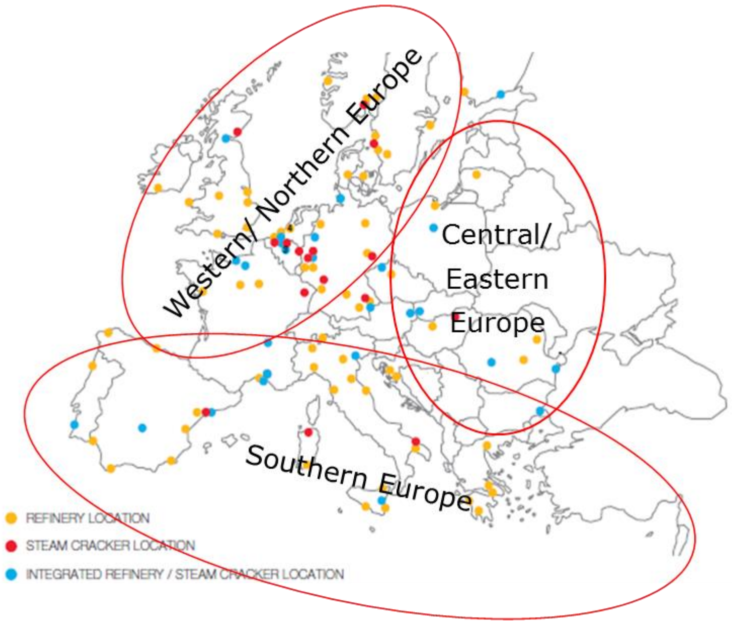
- **Geographical coverage**
- **Capacities**
- **Ownership, i.e. company size**
- **Production technology**

For the **geographical coverage** a representative sample should spread over three regions: Southern, Central-Eastern and North-Western Europe. Table 101 indicates how the EU countries are assigned to the indicated regions. Figure 120 presents an overview of the European refinery spread over the three regions.

Table 101. Coverage of countries by each of the three regions

EU region	Countries
Southern	Italy, Spain, Portugal, Greece, Malta, Cyprus
Central-Eastern	Poland, Slovenia, Hungary, Romania, Bulgaria, Czech Republic, Slovakia, Estonia, Latvia, Lithuania
North-Western	France, Ireland, UK, Belgium, Netherlands, Germany, Denmark, Austria, Sweden, Finland

Figure 120. Spread of refineries over the different regions



Source: Authors' own elaboration.

Data from FuelsEurope provides an overview of spread of the refinery **capacities** over countries and companies. As already noted, small and medium-sized companies (SMEs), are not relevant among refining facilities. For this reason, different plant sizes are not directly taken into consideration for the sampling. With regards to **ownership**, the sample includes global, as well as regional players.

The sample focuses on one type of **production technology**, the so-called mainstream refineries. Small petroleum oil sites performing specialised functions (mostly bitumen and lube oil manufacture), in contrast, are excluded as they are atypical for the refinery sector (Concawe, 2012).

FuelsEurope and Concawe supported the research team in terms of contacting member companies, providing in-house information on existing plant sites across the EU, reviewing non-disclosure agreements and collecting data from the refineries. Based on plant location, plant capacity and company affiliation as well as the association's experience in contacting its members, a representative sample was selected to cover the entire EU refinery sector as accurate and as reliable as possible.

Unfortunately, only one refining company provided information on a plant site outside of Europe. For information about energy prices outside of Europe, both Concawe and FuelsEurope members generally use data from Solomon Associates, who have done extensive surveys in the refinery sector over the last decade collecting information, including energy price data and production costs data. Due to confidentiality reasons Solomon Associates could not share any data on international price or production cost values with the research team. The research team therefore had to rely on publicly available studies, which mainly show indexed and not absolute figures.

7.6.2 Description of sample

31 plant sites were asked to provide data and 15 refineries participated in the survey. This number represents 19% of the 80 mainstream refineries across Europe, according to data provided by FuelsEurope. The sum of total production capacity of the plants was 165 Mt/a in 2014. This covers about 24.5% of the European mainstream refining capacity reported by FuelsEurope.

The sample covers 11 refineries in Western/Northern, and 4 refineries in Southern Europe (see Table 102). From Central-Eastern European, initial positive feedback on the survey did not result in any cooperation on filling questionnaires.

Table 102. Overview of the refinery plant sites approached by the research team

Region	Number of plants contacted	Number of plants initial confirmation	Refusal to participate	Respondent s
NWE	17	11	2	11
SE	8	5	0	4
CEE	6	0	2	0
Total	**31**	**16**	**4**	**15**

Source: Authors' own elaboration.

Table 103 compares the total capacities of each region with the capacity covered by the sample. The sample covered 4 global and 6 regional players (operating 2 or less plants).

Table 103. Regional representativeness and coverage of the responding plant sites

Region	Total capacity (Mt/a)	Capacity share (%)	Respondents' capacity (Mt/a)	Share of respondents' capacity (%)
NWE	399	59.5%	137	34.2%
SE	196	29.3%	28	14.3%
CEE	75	11.2%	0	0.0%
Total EU	**671**	**100.0%**	**165**	**24.5%**

Source: Authors' own elaboration.

In terms of **regional representativeness**, the final sample is biased towards North-Western Europe, which represent 83% of total responding capacity, instead of only 59.5% under the real regional capacity shares within the EU. Southern Europe is slightly underrepresented, 17% of total sample capacity in comparison to its real share of 29.3%. There is not one respondent from Central-Eastern European states, which skews the sample towards "older" Member States in the European Union.

Regarding the **regional coverage**, it can be noted that the responding plant sites cover nearly one fourth of total European capacity. The respondents from North-Western European states cover one third of the North-Western European capacity. The respondents from Southern Europe cover 14.3% of the regional capacity.

The respondents provided detailed figures on the level and structure of energy prices, as well as on energy consumption. Plausibility was assessed through expert judgement, energy bills provided by survey participants (two plant sites), follow-up phone calls, as well as energy statistics from Eurostat and energy price publications.

Table 104 shows the number of received questionnaires, the total number of questionnaires used for the entire subsequent analysis, as well as the number of questionnaires used in the analysis of each section. One questionnaire had to be omitted from the electricity price trend analysis, due to unrealistic price information. Several refineries filled in the section about gas prices only for the years 2014 and 2015. One plant did not consume any natural gas, but bought heat from the grid instead. Refineries were not willing to share any data on key performance indicators, therefore production costs and margins cannot be assessed as part of this study. Also, it was not feasible to acquire international energy price information for refinery plant sites outside of Europe, as only one refinery provided energy price information for plant sites outside EU borders and the main data provider for the refinery sector, Solomon Associates, could not share any data due to confidentiality reasons.

Table 104. Number of questionnaires used in each section

Total number received	Total number usable[109]	Energy price trends	Energy bill components	Energy intensity	International comparison	Production costs and margins
15	*15*	*≤ 14 (e)* *≤ 14 (g)*	*≤ 12 (e)* *≤ 12 (g)*	*≤ 10 (e)* *9 (g)*	*Public information*	*Public information*

Source: Authors' own elaboration.

All energy prices reported in this section, and used throughout the analysis are net-prices, as reported on energy bills: exemptions or reductions for specific components are counted in. However, tax rebates, subsidy schemes or other financial compensation mechanisms that are not visible in bills are not accounted for due to a lack of data on these elements.

Note that the 'weighted averages' in the following analysis refer to averages weighted by energy consumption of the respective plant sites.

7.7 Energy price trends

7.7.1 Natural gas

The descriptive statistics on natural gas prices are based on 5 plant sites for the year 2008. The number of gas price data points increased to 10 in 2012. For the years 2014 and 2015, the sample includes 14 plant sites out of the total 15 respondents. Based on the consumption and costs level provided, the respective natural gas prices were derived.

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[109] This refers to the number of questionnaires that made it through the verification process and were used in the subsequent data analysis.

The following energy price analysis focuses on comparing natural gas prices and is therefore limited to purchased natural gas consumption and costs. Refinery fuel gases that are produced during processing and subsequently used as an energy source in the refinery were not taken into account.

General trends

As shown by the median in Figure 121, the prices of natural gas paid by the responding refineries fell between 2013 and 2015, whereas they increased from 2010 to 2013. In 2008, the median EU refinery paid 28.3 €/MWh for natural gas, whereas in 2015 the price was only 23.5 €/MWh, a price decrease of 17.0 %. The weighted average values are slightly lower than the median prices with 26.4 €/MWh in 2008 and 23.4 €/MWh in 2015. This falling trend since 2013 is also confirmed when analysing 'consistent values', i.e. results including only respondents providing data for all years.

Except for the year 2013, the relative standard deviation continuously increased from 13.7% in 2008 to 29.4% in 2014. In 2015 it fell to 25.4%. The inter-quartile ranges fluctuated. Over the entire period it increased from 1.8 €/MWh in 2008 to 8.4 €/MWh in 2015. The highest spread was observed in 2014: 13.6 €/MWh.

The total range of prices also shows a significant increase, as indicated by the whiskers of the box plot. In particular, the year 2014 and 2015 showed the largest spread with a natural gas price difference of 32.7 €/MWh and 28.1 €/MWh respectively between the operator paying the highest and the operator paying the lowest price. Main reason for this change is the inclusion of one outlier with very low natural gas prices.

Minimum prices paid by the responding companies started at 23.92 €/MWh in 2008, increasing to 25.9 €/MWh in 2013. In 2015, the minimum price reached a level much lower than the 2008 values at 7.87 €/MWh. This minimum value is due to an outlier with a favourable gas supply contract. When dropping this outlier and only including refineries that provided data for all years the reducing trend over 2008-2013 is confirmed. However, the minimum price in 2015 would be substantially higher at 20.4 €/MWh (14% lower than the 2008 minimum price).

The maximum price for natural gas shows lower variation. From 2008 to 2010, the maximum decreased from 35.0 €/MWh to 26.5 €/MWh. There was a large increase up to 2014 (41.6 €/MWh) followed by a significant decline of almost 7 €/MWh in 2015, to 35.9 €/MWh. The maxima for 2014 and 2015 are however due to the inclusion of one Southern European refinery.

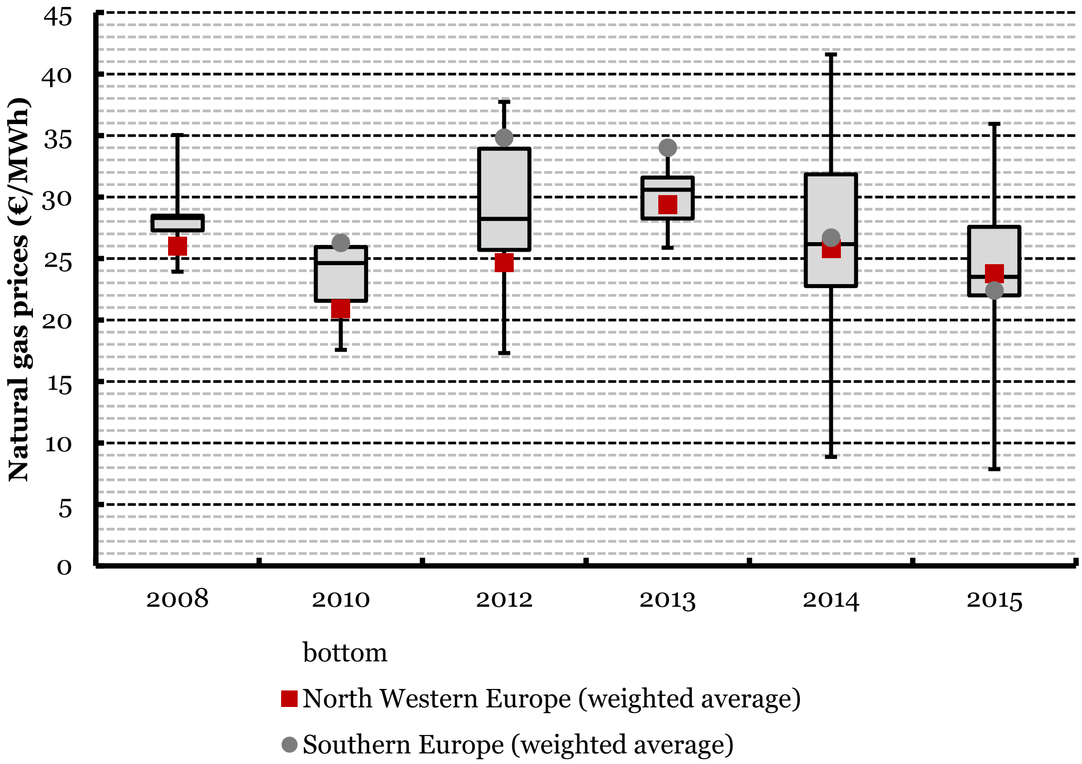
Regional differences

The data from respondents include 10 refineries from North-Western Europe and four plant sites from Southern Europe. No Central-Eastern European company has completed the questionnaire. Figure 121 therefore only includes a weighted average for North-Western and South Eastern European countries for the years with sufficient data, to prevent any confidentiality issues. Paid prices have been weighted with the total natural gas consumption of each plant.

The weighted averages of natural gas prices paid by refineries in North-Western Europe differ slightly from the level of the median. From 2008 to 2013, they are below the median, whereas in 2014 and 2015 they are very close to the median. In 2008, the average value was 26.0 €/MWh. Like the weighted average of all respondents, the weighted average of the prices in North-Western Europe peaked in 2013 at 29.4 €/MWh and closed at 23.8 €/MWh in 2015.

Average prices in SE Member States were higher than in NWE Member States between 2010 and 2014. In 2015, natural gas prices in Southern European Member States have been lower than those in North Western Europe. For the year 2008, only two plants from SE provided data, therefore, there is no value displayed in Figure 121. Average prices increased rapidly from 26.3 €/MWh in 2010 to 34.8 €/MWh in 2012. Prices then decreased continuously to 22.4 €/MWh in 2015; 1.4 €/MWh lower than NWE prices for natural gas.

Figure 121. Prices of natural gas paid by responding EU refineries, 2008-2015 (€/MWh)



Source: Authors' own elaboration.

Table 105. Descriptive statistics for natural gas prices paid by responding EU producers

	2008	2010	2012	2013	2014	2015
Plant sites/total sample	5/15	7/15	10/15	11/15	14/15	14/15
EU (weighted average)	26.36€	21.89€	26.41€	30.17€	26.00€	23.44€
EU (median)	28.31€	24.64€	28.22€	30.59€	26.17€	23.50€
EU (relative standard deviation)	13.7%	15.8%	23.6%	7.7%	29.4%	25.4%
EU (IQR)	1.81€	6.55€	12.36€	4.98€	13.62€	8.37€
EU (minimum)	23.92€	17.57€	17.31€	25.87€	8.86€	7.87€
EU (maximum)	35.03€	26.46€	37.73€	34.31€	41.59€	35.94€
CEE EU (weighted average)	--	--	--	--	--	--
SE EU (weighted average)	--	26.26€	34.80€	33.99€	26.68€	22.39€
NWE EU (weighted average)	26.02€	20.90€	24.66€	29.36€	25.80€	23.76€

Source: Authors' own elaboration.

7.7.2 Electricity

Except for the years 2008, 2010 and 2012, all responding plant sites provided data on electricity consumption levels and costs. One questionnaire was dropped due to unrealistic price information.

The descriptive statistics on electricity prices are based on all available and realistic data sets, starting with seven values in 2008 and including all 14 values from 2013 to 2015. The respective electricity prices take into account provided consumption and cost levels for each plant.

The analysis focusses on electricity prices and is therefore limited to purchased electricity consumption and costs. Electricity generation costs for self-consumption, revenues from self-produced electricity sold to the grid, and remuneration from interruptibility schemes are not accounted for.

General trends

Total electricity prices paid by European refineries decreased over time. In 2008, half of the refinery plant sites paid less than 70.71 €/MWh, the highest price over all years. In 2010, this median value reached a level of 66.29 €/MWh and remained close to this level until 2013. In 2015, prices declined further to 56.98 €/MWh. When analysing only those respondents that provided data for all years, this declining trend is confirmed, noting though that it is less pronounced.

Absolute price spreads between respondents were highest in 2014. With a spread of 148.1 €/MWh, the maximum price was seven times higher than the minimum price. The lowest price spread was observed in 2008 (39.8 €/MWh), the year with lowest response rate. The interquartile range was highest in 2015, namely 47 €/MWh.

Minimum prices paid by the responding companies continuously decreased, starting at 51.3 €/MWh in 2008 down to 23.4 €/MWh in 2015. The minimum price for the seven refineries with complete time series would be 47.8 €/MWh in 2015. The results using only plants that provided data for all years can be found in Table 107.

Maximum prices for electricity paid by refineries have been increasing from 91.1 €/MWh in 2008 to 171.8 €/MWh in 2014. In 2015, they decreased to a level of 134.8 €/MWh. For the seven refineries providing data for all requested years, the maximum value decreased from 91.1 €/MWh to 80.9 €/MWh.

Regional differences

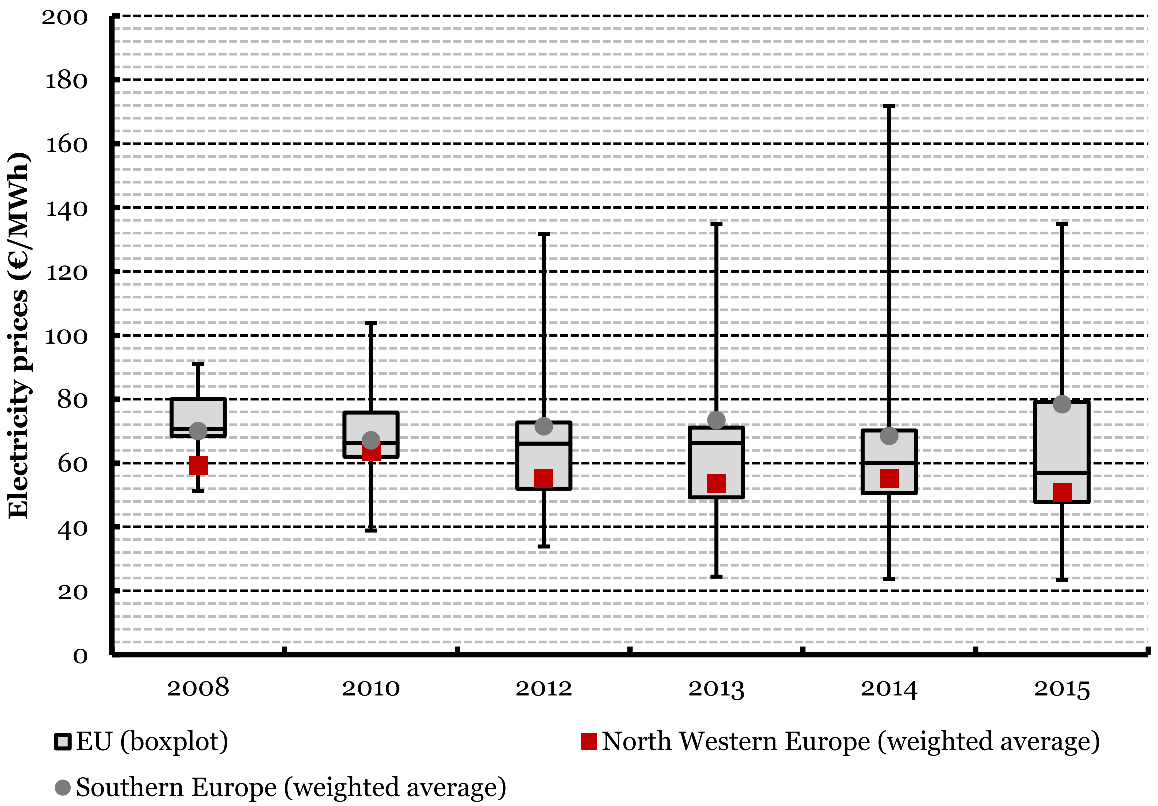
Figure 122 includes weighted averages for North-Western European countries and Southern European countries. For Central and Eastern European countries, no refineries provided information. Paid prices have been weighted with the total electricity consumption of each plant.

The weighted averages of electricity prices paid by refineries in North-Western Europe are in general clearly below the median values of all European refinery plant sites. In 2008, the average value was 59.1 €/MWh. The weighted average of the prices in North-Western Europe peaked in 2010 at 63.4 €/MWh and went down to 50.7 €/MWh in 2015 (14.2% lower than 2008).

The weighted averages of electricity prices in Southern European countries have a significantly different trend compared to the Northern Europe. Starting at a level of 70.0 €/MWh, the decreased to 67.1 €/MWh in 2010. In 2013, the values reached 73.5 €/MWh, and after a drop in 2014, they reached the maximum over the whole period in 2015, at 78.4 €/MWh (a 12% increase with respect to 2008).

When only including plants that provided data for all years, the difference between NWE and SE is still obvious but becomes less strong. For the year 2014, for example, price levels between both regions were fairly similar, whereas for the remaining years, NWE still had substantially lower prices.

Figure 122. Prices of electricity paid by responding EU producers, 2008-2015 (€/MWh)



Source: Authors' own elaboration.

Table 106. Descriptive statistics for electricity prices paid by responding EU producers

	2008	2010	2012	2013	2014	2015
Plant sites/total sample	7/15	8/15	13/15	14/15	14/15	14/15
EU (weighted average)	62.37€	64.59€	59.41€	58.89€	58.75€	57.82€
EU (median)	70.71€	66.29€	66.09€	66.34€	59.97€	56.98€
EU (relative standard deviation)	18.8%	30.1%	40.5%	41.0%	60.0%	44.4%
EU (IQR)	17.36€	20.61€	31.09€	32.68€	29.52€	47.05€
EU (minimum)	51.28€	38.88€	33.88€	24.43€	23.73€	23.35€
EU (maximum)	91.06€	103.9€	131.71€	134.89€	171.82€	134.82€
CEE EU (weighted average)	--	--	--	--	--	--
SE EU (weighted average)	70.03€	67.06€	71.46€	73.45€	68.48€	78.40€
NWE EU (weighted average)	59.12€	63.59€	55.09€	53.65€	55.32€	50.65€

Source: Authors' own elaboration.

Table 107. Descriptive statistics for electricity prices when only using plants that provided data for all years

	2008	2010	2012	2013	2014	2015
Plant sites/total sample	7/15	7/15	7/15	7/15	7/15	7/15
EU (weighted average)	62.37	68.21	66.46	66.74	70.34	65.24
EU (median)	70.71	67.65	69.81	70.40	69.99	59.87
EU (relative standard deviation)	18.8%	24.5%	16.7%	12.9%	25.6%	21.3%
EU (IQR)	17.36	25.57	10.75	7.00	29.08	41.33
EU (minimum)	51.28	53.58	57.13	48.77	57.99	47.76
EU (maximum)	91.06	103.90	95.47	77.63	111.07	80.89
CEE EU (weighted average)	--	--	--	--	--	--
SE EU (weighted average)	70.03	67.06	72.28	73.96	68.20	78.03
NWE EU (weighted average)	59.12	68.78	63.44	62.49	71.68	58.20

Source: Authors' own elaboration.

7.8 Energy bill components

In this section, the analysis of the components of the price paid by sampled manufacturers for natural gas and electricity is presented.

Note that companies were not always able to provide both overall prices and price components. Often detailed components were not visible on energy bills. There are significant differences between the average energy prices as reported above in the section energy prices and the results reported in this section on energy components. This is caused by different numbers of respondents included in both sections of the analysis.

The price of natural gas is split into three components, two of which depend on the regulatory framework (the so-called 'regulatory components'):

1. Energy supply;
2. Network costs;
3. Other taxes, fees, levies and charges (excluding recoverable taxes, such as VAT).

The price of electricity is split into four components, three of which depend on the regulatory framework (the so-called 'regulatory components'):

1. Energy supply;
2. Network costs;
3. Renewable support
4. Other taxes, fees, levies and charges (excluding recoverable taxes, such as VAT).

7.8.1 Natural gas

Not all plant sites reported the exact composition of their natural gas costs, i.e. energy supply costs, network costs, as well as other taxes, fees, levies and charges. The number of usable questionnaires is lower than in the energy price analysis. Table 108 shows the number of questionnaires that included data on the natural gas price components.

Table 108. Usable questionnaires for the analysis of natural gas price components

2008	2010	2012	2013	2014	2015
5/15	7/15	10/15	10/15	12/15	12/15

General trends and regional differences

Figure 123 shows the weighted averages for the responding refineries in Europe, as well as weighted average prices in North-Western Europe.

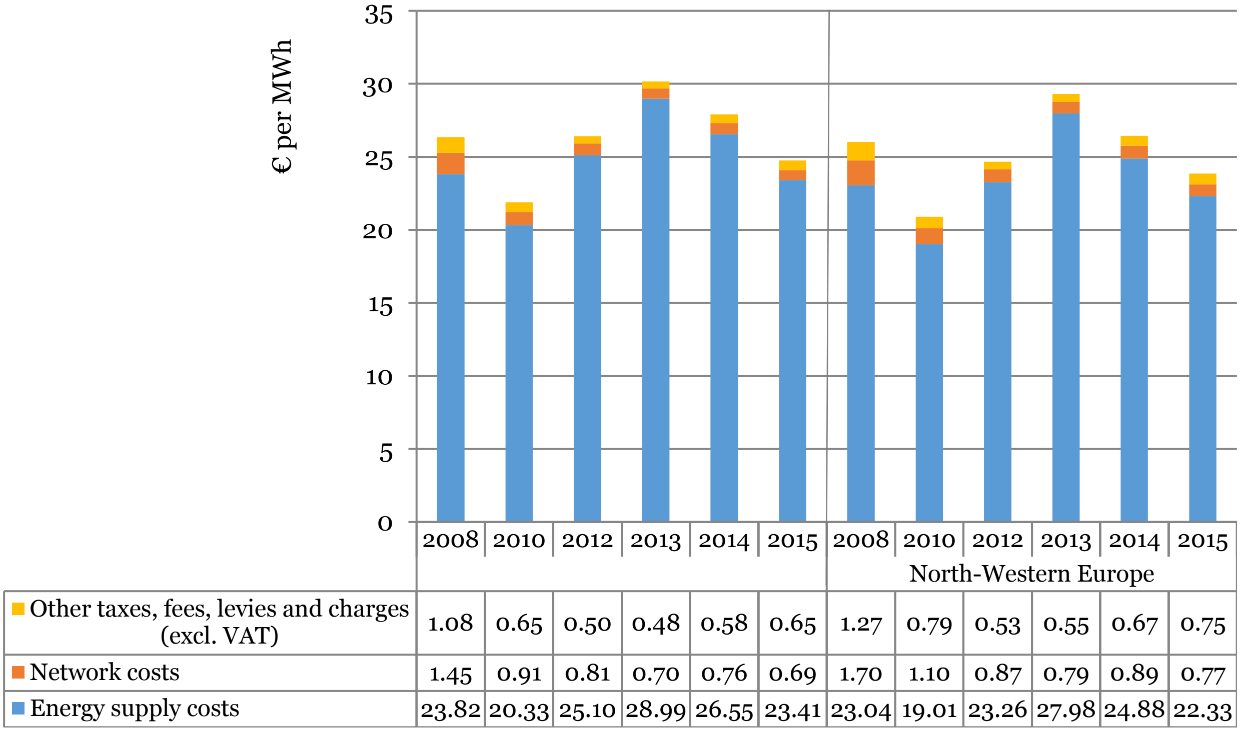
Total prices fluctuated mainly because of changes in the energy supply costs. These costs peaked in 2013 at 29.0 €/MWh, decreased to 26.6 €/MWh in 2014 and dropped further to 23.4 €/MWh in 2015, corresponding to a decrease of 19.2% in comparison to 2013 and 1.7% in comparison to 2008.

The network costs show a decreasing trend across all years and ranged between 0.7 and 1.45. The values for other taxes, fees, levies and charges were relatively volatile over the study period. Starting at a level of 1.1 €/MWh in 2008, they first decreased to 0.48 €/MWh in 2013, followed by an increase to 0.7 €/MWh in 2015. When only including plants that provided data for all years, this declining trend is confirmed, noting though that it is less pronounced.

While energy supply costs in North-Western Europe were, on average, approximately 1.3 €/MWh lower than the EU average, average network costs were substantially higher (roughly 0.2 €/MWh higher). Also, the values for other taxes, fees, levies and charges were higher in NWE when compared to the EU sample, by approximately 0.1 €/MWh.

Figure **124** shows the relative shares of the natural gas price components. The shares of other taxes, fees, levies and charges in total natural gas costs decreased from 4.1% in 2008 to 1.6% in 2013, but increased to 2.6% by 2015, which is still lower than the 2008 share. A very similar trend can be observed for network costs, which decreased from 5.5% in 2008 to 2.4% in 2013, and then slightly increased again to 2.8% in 2015. The share of the energy supply component fluctuated between 90.4% and 96.1%. In comparison, for the North-Western European refineries that provided data the relative share of energy supply costs was slightly lower. Both network costs, and the price component “taxes, fees, levies and charges” showed higher values for the NWE region.

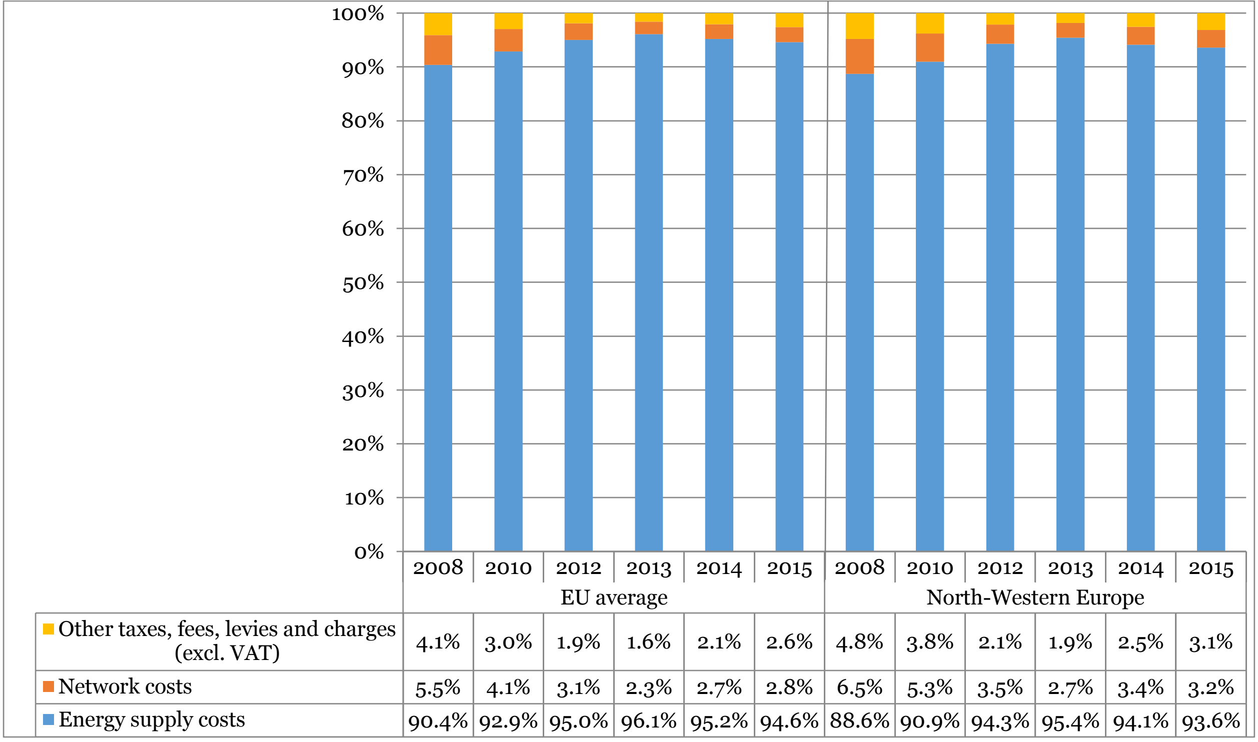
Figure 123. Components of the natural gas bills paid by the responding producers in the EU, 2008-15 (€/MWh)



	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
							North-Western Europe					
🟨 Other taxes, fees, levies and charges (excl. VAT)	1.08	0.65	0.50	0.48	0.58	0.65	1.27	0.79	0.53	0.55	0.67	0.75
🟧 Network costs	1.45	0.91	0.81	0.70	0.76	0.69	1.70	1.10	0.87	0.79	0.89	0.77
🟦 Energy supply costs	23.82	20.33	25.10	28.99	26.55	23.41	23.04	19.01	23.26	27.98	24.88	22.33

Source: Authors' own elaboration.

Figure 124. Components of the natural gas bills paid by the responding producers in the EU (%) 2008-15



	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
	EU average						North-Western Europe					
🟨 Other taxes, fees, levies and charges (excl. VAT)	4.1%	3.0%	1.9%	1.6%	2.1%	2.6%	4.8%	3.8%	2.1%	1.9%	2.5%	3.1%
🟧 Network costs	5.5%	4.1%	3.1%	2.3%	2.7%	2.8%	6.5%	5.3%	3.5%	2.7%	3.4%	3.2%
🟦 Energy supply costs	90.4%	92.9%	95.0%	96.1%	95.2%	94.6%	88.6%	90.9%	94.3%	95.4%	94.1%	93.6%

Source: Authors' own elaboration.

7.8.2 Electricity

Not all plant sites reported the exact composition of their electricity costs, which is necessary to derive electricity prices and components, i.e. energy supply costs, network costs, renewable energy support costs, as well as other taxes, fees, levies and charges. The number of questionnaires used reduced in comparison to the energy price analysis. Table 109 shows the number of questionnaires that could be used to provide data on the electricity price components.

Table 109. Questionnaires used for the analysis of electricity price components

2008	2010	2012	2013	2014	2015
6/15	7/15	12/15	12/15	12/15	12/15

General trends and regional differences

Electricity costs and prices include payments for energy supply costs, network fees, and taxes, fees, levies and charges. Renewable energy support is presented in a separate category. Figure 125 shows the consumption weighted averages for the all responding refineries in Europe.

Total prices fluctuated mainly because of changes in the energy supply costs. They decreased from 50.1 €/MWh in 2008 to 42.4 €/MWh in 2015 (-15% over the entire period). Omitting refineries with incomplete times series would result in a similar but smaller decrease (see Figure 126), from 50.1 €/MWh in 2008 to 46.5 €/MWh in 2015 (-7% over the entire period).

On average, network costs in Europe increased significantly from 2.4 €/MWh in 2008 to 7.25 €/MWh in 2015. This also holds for averages when only using plants that provided data for all years.

Average payments for renewable energy support were went from 1.1 €/MWh in 2008 to 8.8 €/MWh in 2010 but then decreased substantially, down to 0.9 €/MWh in 2015. The reason for the significant fluctuation in average impact on electricity bills is the German renewable energy surcharge (EEG-surcharge). In 2010, at least one of three German refineries out of the 7 considered had to pay the full surcharge of 20.5 €/MWh. Weighted with the high total consumption of this refinery, the effect on the average price was very strong.

In 2012, the impact of this plant's data was reduced significantly because of five additional observations in the sample. In 2013, the situation changed and the refinery was part of an exemption scheme (Besondere Ausgleichsregelung). In 2014, two German refineries were again not covered by the exemption scheme and paid the full surcharge of 62.4 €/MWh that year[110]. Due to the weighting, the effect of the far higher surcharge on the average value in 2014 is not as strong as the effect in 2010. In 2015,

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[110] Current and past values for each surcharge are published at www.netztransparenz.de

the refinery with the higher consumption was eligible for tariff reduction in the German renewable compensation scheme.

The values for other taxes, fees, levies and charges have been decreasing from 7.1 €/MWh in 2008 to 4.6 €/MWh in 2015 (-35%). When analysing respondents providing data for all years, this declining trend cannot be confirmed as the value for 2015 was only slightly lower than the value from 2008 (see Figure 127).

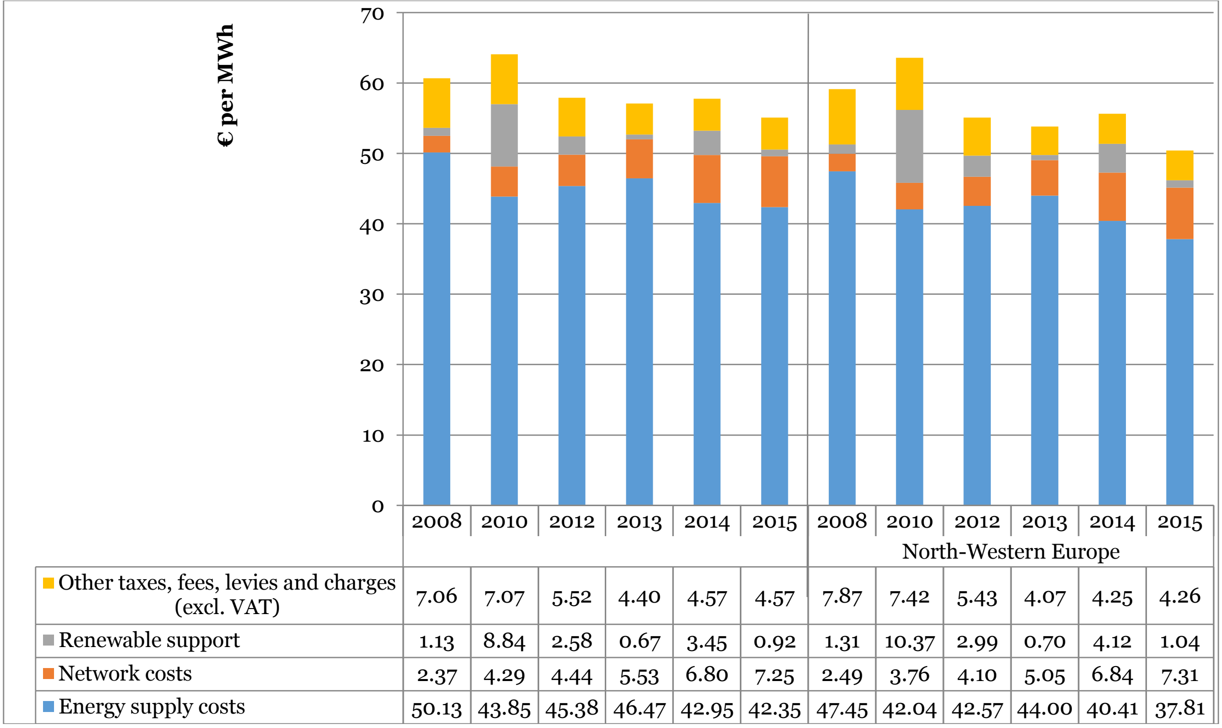
The average values for sampled plants in NWE were lower than the EU average. The energy cost components were, again, the main driver in all years. On average, price for NWE sampled refineries were 2.8 €/MWh lower than average prices for all EU respondents. In 2015, the difference was €4.5/MWh. As there is no data for Central and Eastern European countries, this finding shows that prices for the two Southern European refineries have been significantly higher than the average.

Network costs for NWE plants have been both higher and lower than the EU averages, depending on the year.

Renewable support payments were consistently higher for NWE plants than for SE plants.

No clear trends are observed for the category “other taxes, fees, levies and charges”.

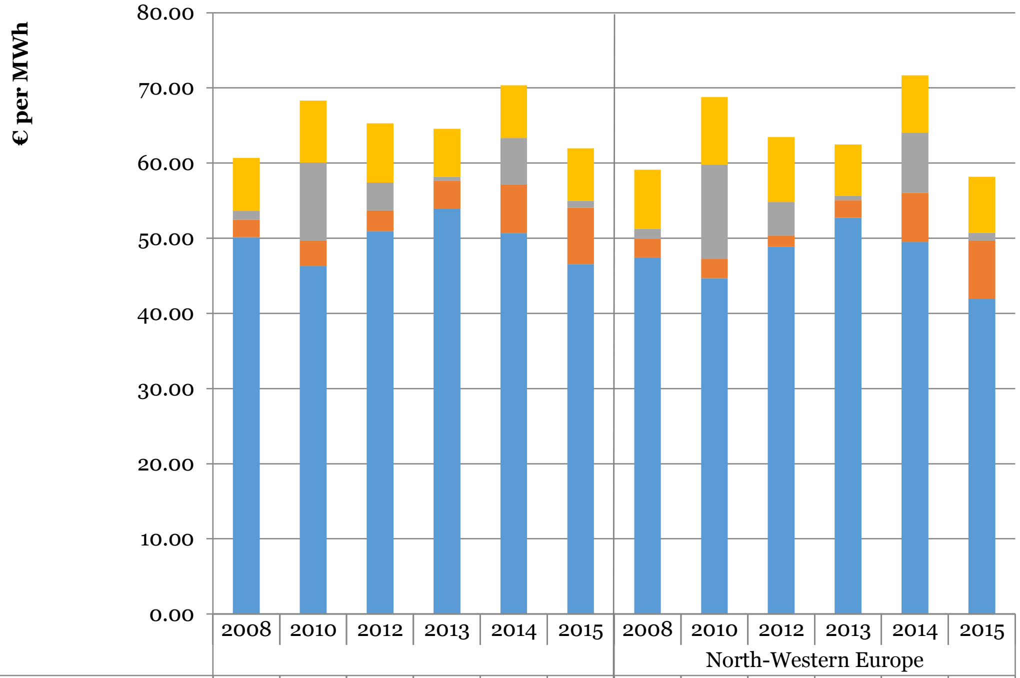
Figure 125. Components of the electricity bills paid by the responding producers in the EU, 2008-2015 (€/MWh)



	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
							North-Western Europe					
■ Other taxes, fees, levies and charges (excl. VAT)	7.06	7.07	5.52	4.40	4.57	4.57	7.87	7.42	5.43	4.07	4.25	4.26
■ Renewable support	1.13	8.84	2.58	0.67	3.45	0.92	1.31	10.37	2.99	0.70	4.12	1.04
■ Network costs	2.37	4.29	4.44	5.53	6.80	7.25	2.49	3.76	4.10	5.05	6.84	7.31
■ Energy supply costs	50.13	43.85	45.38	46.47	42.95	42.35	47.45	42.04	42.57	44.00	40.41	37.81

Source: Authors’ own elaboration.

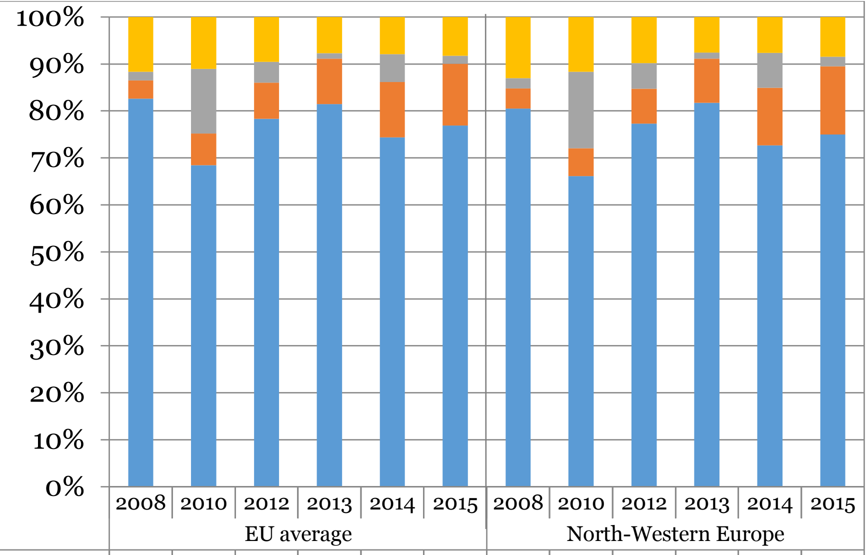
Figure 126. Components of the electricity bills paid by the responding producers in the EU, 2008-2015, when only using plants that provided data for all years (€/MWh)



							North-Western Europe					
	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
🟨 Other taxes, fees, levies and charges (excl. VAT)	7.06	8.27	7.86	6.37	7.04	6.97	7.87	8.98	8.62	6.88	7.61	7.45
◼ Renewable support	1.13	10.34	3.71	0.59	6.15	0.94	1.31	12.54	4.45	0.53	8.00	1.05
🟧 Network costs	2.37	3.44	2.75	3.63	6.46	7.52	2.49	2.59	1.51	2.34	6.56	7.80
🟦 Energy supply costs	50.13	46.28	50.95	53.98	50.70	46.54	47.45	44.66	48.87	52.74	49.51	41.90

Source: Authors' own elaboration.

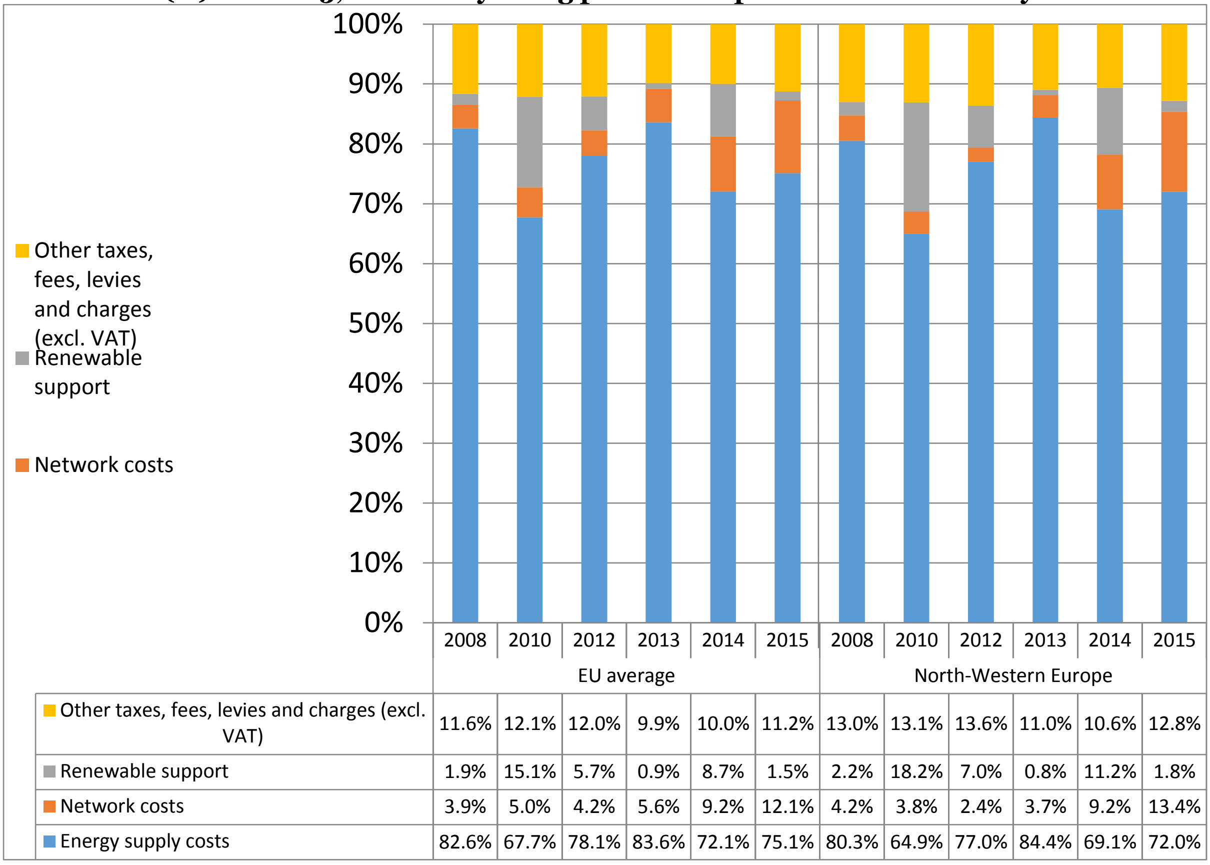
Figure 127. Components of the electricity bills paid by the responding producers in the EU (%) 2008 -15



	EU average						North-Western Europe					
	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
🟨 Other taxes, fees, levies and charges (excl. VAT)	11.6%	11.0%	9.5%	7.7%	7.9%	8.3%	13.0%	11.7%	9.9%	7.6%	7.6%	8.4%
◼ Renewable support	1.9%	13.8%	4.4%	1.2%	6.0%	1.7%	2.2%	16.3%	5.4%	1.3%	7.4%	2.1%
🟧 Network costs	3.9%	6.7%	7.7%	9.7%	11.8%	13.2%	4.2%	5.9%	7.4%	9.4%	12.3%	14.5%
🟦 Energy supply costs	82.6%	68.5%	78.4%	81.4%	74.4%	76.9%	80.3%	66.1%	77.3%	81.8%	72.7%	75.0%

Source: Authors' own elaboration.

Figure 128. Components of the electricity bills paid by the responding producers in the EU (%) 2008 -15, when only using plants that provided data for all years



	EU average						North-Western Europe					
	2008	2010	2012	2013	2014	2015	2008	2010	2012	2013	2014	2015
🟨 Other taxes, fees, levies and charges (excl. VAT)	11.6%	12.1%	12.0%	9.9%	10.0%	11.2%	13.0%	13.1%	13.6%	11.0%	10.6%	12.8%
⬜ Renewable support	1.9%	15.1%	5.7%	0.9%	8.7%	1.5%	2.2%	18.2%	7.0%	0.8%	11.2%	1.8%
🟧 Network costs	3.9%	5.0%	4.2%	5.6%	9.2%	12.1%	4.2%	3.8%	2.4%	3.7%	9.2%	13.4%
🟦 Energy supply costs	82.6%	67.7%	78.1%	83.6%	72.1%	75.1%	80.3%	64.9%	77.0%	84.4%	69.1%	72.0%

Source: Authors' own elaboration.

Figure 127 shows the relative shares of the electricity price components. The shares of network costs, renewable energy support and other taxes, fees, levies and charges in total energy costs increased over the years, due to lower energy supply costs. Since the weighted average electricity price for sampled EU refineries decreased from 2012/13 to 2015, the share for the energy component decreased from 82.6% in 2008 to 76.9% in 2015.

The share of network costs consistently increased each year, from 3.9% in 2008 to 13.2% in 2015.

The share of renewable energy support payments was highest in 2010, when it reached a value of 13.8%. In 2015, the share was down to 1.7% of the total price. The reason for this wide variation was described earlier.

Other taxes, fees, levies and charges decreased from 11.6% in 2008 to 8.3% in 2015. When only including plants that provided data for all years in the analysis, this declining trend cannot be confirmed. It decreased from 11.6% in 2008 to 10% in 2014 and 2015 increased again to 11.2%.

For NWE plants, the shares each component are slightly different. In particular, the energy supply costs' share was lower, while the share of renewable energy support and other taxes, fees, levies and charges components was higher.

Box 5. Indirect EU ETS costs in the refineries sector

Electric utilities face increased operating costs through their EU ETS compliance cost. They pass these costs on to their customers via higher electricity rates. Indirect EU ETS costs are generally not visible in electricity bills. They are included in wholesale market prices for electricity and cannot be distinguished as a separate component. As a result, refinery plants have the cost of CO2 embedded in their energy prices.

Three of the responding refineries indicated that indirect EU ETS costs are explicitly negotiated with their power utility, and are paid on top of the agreed electricity price using a EUA-indexed electricity cost formula. In contrast to other plant sites, the indirect EU ETS cost paid by these companies directly depends on the EUA daily or monthly future prices and therefore on the fuel mix used by the power utility.

Industries may not be able to pass these additional costs fully on to the ultimate customers if they are active in a globally competitive sector, like the refinery sector. The following analysis is therefore intended to provide an estimation of the indirect ETS cost born by the refinery sector between 2008 and 2015.

Estimates for indirect costs per tonne of product are calculated using the following formula[111]:

Indirect cost (€/t of product) =
Electricity intensity (kWh/t of crude oil processed)
** Carbon intensity of electricity (Tonne of* CO_2*/kWh)*
*** CO_2 *Price (€/t of* CO_2*) * Pass-on rate*

Electricity intensities are derived from the energy consumption and crude throughput, provided by refineries as part of the questionnaire.

Notes:
- Yearly averages across the EU sample are simple averages. Weighing by consumption would bias the estimates as electricity consumption is a key variable in the formula above.
- Carbon intensity of electricity is a constant per region, and does not take the reductions in carbon intensity of electricity production since 2012 into account. These estimates are therefore likely to be overestimations for the more recent years.
- Only purchased electricity, i.e. excluding self-generation, is subject to indirect ETS costs.
- Two scenarios are calculated, based on the pass on rates equal to 0.6 and 1.

The estimates for indirect EU ETS costs for refinery plant sites (as shown in Table 110) have decreased steadily between 2008 and 2013, as EUA prices were decreasing sharply up to 2013. Under a pass-on rate of 0.6, for example, the costs decreased from €0.46 in 2008 to €0.10 per tonne of output in 2013, whereas under a pass-on rate of 1, they decreased from €0.77 to €0.16 per tonne of output. From 2014-2015

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[111] This formula and the sources of the data used are discussed in depth in the Methodology Chapter under Section 1.10.

the estimates for indirect EU ETS costs increased again, as EUA prices showed a slow and partial recovery.

Table 110. Estimates for indirect EU ETS costs for refineries, 2008-2015, two pass-on rates (€/ of processed crude oil)

	2008	2010	2012	2013	2014	2015
Pass-on rate: 0.6	0.46	0.29	0.18	0.10	0.13	0.17
Pass-on rate: 1	0.77	0.49	0.29	0.16	0.22	0.28

Source: Authors' elaboration based on data from European Energy Exchange (2016) and European Commission (2012)

Estimates show that a share of the energy component could be linked to indirect EU ETS cost; in 2008, 15.4% with a pass-on rate 0.6 and 25.7% with a pass-on rate of 1. By 2013, this share had fallen to 3.1% and 5.2% respectively, while by 2015 it had recovered to 5.3% and 8.8% again.

Indirect EU ETS costs expressed as a percentage of production costs could not be calculated as refineries did not provide figures on plant-level production costs.

Table 111 Share of indirect EU ETS costs in energy component (%) (pass -on rate of 1)

2008	2010	2012	2013	2014	2015
31.2%	20.3%	11.6%	6.4%	9.1%	11.8%

Source: Authors' own elaboration.

The temporal changes were primarily driven by the evolution of EUA prices, though changes in electricity intensity and electricity costs also played a minor role.

This sector is not eligible for compensation for its indirect EU ETS costs according to the European Commission State Aid Guidelines (2012).

7.9 Energy intensity

Ten refineries have provided information on their energy consumption, both purchased and self-produced, and production output. The values have been used to calculate energy intensities of refining processes. Intensity is generally measured in terms of physical output, i.e. MWh consumed divided by tonne of output. As several energy carriers are used in the production process, separate energy intensities are calculated for each energy source (i.e. electricity, natural gas).

Responding refineries apply very heterogeneous production processes and have different energy consumption profiles. One of the responding plants, for example, does not use any natural gas for energy purposes but instead purchases its heat entirely on the market. The large majority of plants substitute purchased natural gas with plant-specific refinery fuel gases to fuel a co-generation plant. Additionally, all plant sites produce multiple commodities at a time. Depending on their degree of vertical integration, plant sites often provide more than ten different products. Provided information about output of commodities is therefore hard to compare.

Instead of aggregating all output commodities to a generic "tonne of output", the throughput of crude oil was used to calculate energy intensities. All refineries except five plant sites reported these values as part of the questionnaire. The energy intensity measure applied here therefore reveals the amount of energy in MWh used to process one tonne of crude oil.

For the calculation of EU and regional weighted average energy intensities, the respective actual crude throughput levels were used.

7.9.1 Natural gas

Within the analysis of natural gas intensity, the term "natural gas" sums the values for purchased natural gas and self-produced refinery fuel gases, if available.

One of the 15 plant sites did not consume any natural gas but purchased heat on the market. At the same time, five refineries did not deliver data on actual crude throughput and self-produced refinery fuel gases. Therefore, the descriptive statistics on natural gas intensity are based on the same 9 observations for all years, meaning that the analysis is fully based on 'consistent values'.

Most refinery plants are large gas consumers. The natural gas amount consumed by responding plant sites ranges between 46.6 GWh and 10.2 TWh of natural gas in 2015. Out of the 9 refinery plant sites having provided data on self-produced refinery fuel gases, on average, approximately 55% to 70% of total gas consumption (for energy purposes) is satisfied by self-produced refinery fuel gases.[112]

Figure 129 and

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[112] Note that out of the 15 refineries, 9 refinery plant sites provided data on self-produced refinery fuel gases, whereas the remaining ones did not provide data on refinery fuel gases but – to the knowledge of the research team – are still using them.

Table 112 display all results on the natural gas intensity of refineries. The division of natural gas consumption by actual crude throughput shows a large spread of results, ranging from 0.23 MWh/t to 1.27 MWh/t in 2008 and from 0.52 MWh/t to 1.35 MWh/t in 2015. The minimum and the maximum values both increased slightly from 2008 to 2015. One reason for this development might be the production shift to increasingly complex products. The year 2008 shows the highest spread of all years, with a range of 1.04 MWh/t. The high relative standard deviation of 33% to 46% underlines the wide dispersion between respondents.

There is no clear evolution in median values for the responding plants. The value increased from 0.88 MWh/t in 2008 to 1.05 MWh/t in 2010, and decreased again to 0.83 MWh/t in 2015. As the range and the relative standard deviation, the inter-quartile range, i.e. the difference between the lower and upper quartile, which represents the middle half of the data, is fairly large. In 2008, it was highest with 0.94 MWh/t. It slowly decreased to the minimum value of 0.52 MWh/t in 2015.

Weighted averages for all respondents are close to the median values, between 0.77 MWh/t in 2008 and 0.88 MWh/t in 2014. Weighted averages indicate an increasing trend from 0.77 MWh/t in 2008 to 0.84 MWh/t in 2015.[113] Northern and Western European refinery plants' weighted average fluctuated in very limited boundaries between 0.88 MWh/t and 0.93 MWh/t but did neither show a clear increasing nor decreasing trend. Southern European refineries' average natural gas intensity was lower than in Northern and Western Europe but it increased strongly from 0.5 MWh/t in 2008 to a maximum value of 0.82 MWh/t in 2014. In 2015, there was a slight decline to 0.77 MWh/t.

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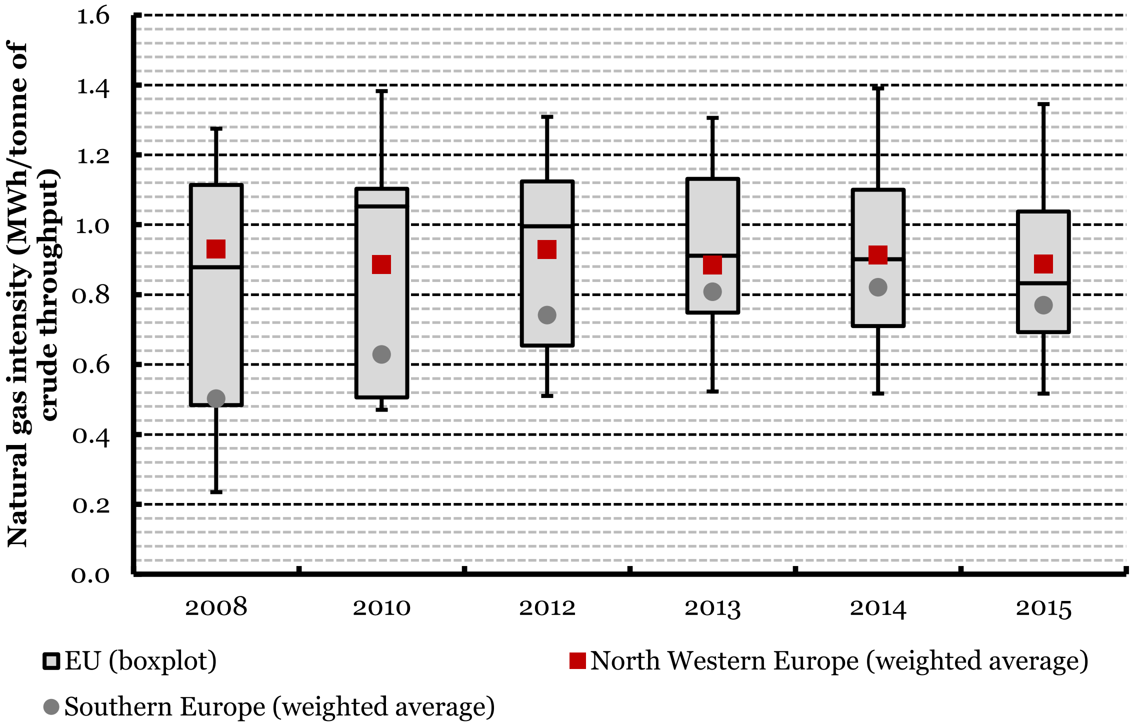
[113] One reason for this development might be the production shift to increasingly complex products, requiring more energy in the form of natural gas and/or refinery fuel gases.

Figure 129. Natural gas intensity of European refineries (MWh/t of crude throughput)



Source: Authors' own elaboration.

Table 112. Descriptive statistics for natural gas intensity (MWh/t of crude throughput)

	2008	2010	2012	2013	2014	2015
Plant sites/total sample	9/15	9/15	9/15	9/15	9/15	9/15
EU (weighted average)	0.77	0.79	0.85	0.85	0.88	0.84
EU (median)	0.88	1.05	1.00	0.91	0.90	0.83
EU (relative standard deviation)	45.9%	43.0%	34.0%	29.9%	33.1%	33.9%
EU (IQR)	0.94	0.90	0.70	0.57	0.59	0.52
EU (minimum)	0.23	0.47	0.51	0.52	0.52	0.52
EU (maximum)	1.27	1.38	1.31	1.31	1.39	1.35
CEE EU (weighted average)	--	--	--	--	--	--
SE EU (weighted average)	0.50	0.63	0.74	0.81	0.82	0.77
NWE EU (weighted average)	0.93	0.89	0.93	0.88	0.91	0.89

Source: Authors' own elaboration.

7.9.2 Electricity

For the analysis on electricity intensity, it is important to note that purchased and self-produced electricity are taken into account for the calculations on the electricity intensity of refinery plant sites[114].

As five refineries did not provide data on actual crude throughput, the descriptive statistics on electricity intensity are based on 10 plant sites: 6 refineries from North-Western Europe and 4 refineries from Southern Europe. For 2008 and 2010, one plant did not report their consumption of electricity, reducing the number of observations to 9. In 2008, another refinery did not provide information on crude throughput, the number of observations for 2008 is therefore 8 (NWE: 5, SE: 3).

The electricity consumed by responding refineries ranges between 175.9 GWh and 2.2 TWh of electricity in 2015. Eight out of 10 refineries indicated that they generate electricity on-site, on average satisfying approximately between 40% and 55% of electricity demand.

Figure 130 and Table 113 display the electricity intensities of responding refineries. Electricity consumption per tonne of actual crude throughput varies significantly, ranging between 0.03 MWh/t and 0.17 MWh/t. Maximum values fluctuate between 0.15 and 0.17 MWh/t, whereas minimum values are stable at approximately 0.03 MWh/t.

The median values show a slightly decreasing trend since 2010, from 0.11 MWh/t in 2010 to 0.09MWh/t to 2015. When only including those plants that provided data for all years, the median of natural gas intensity remained fairly stable.

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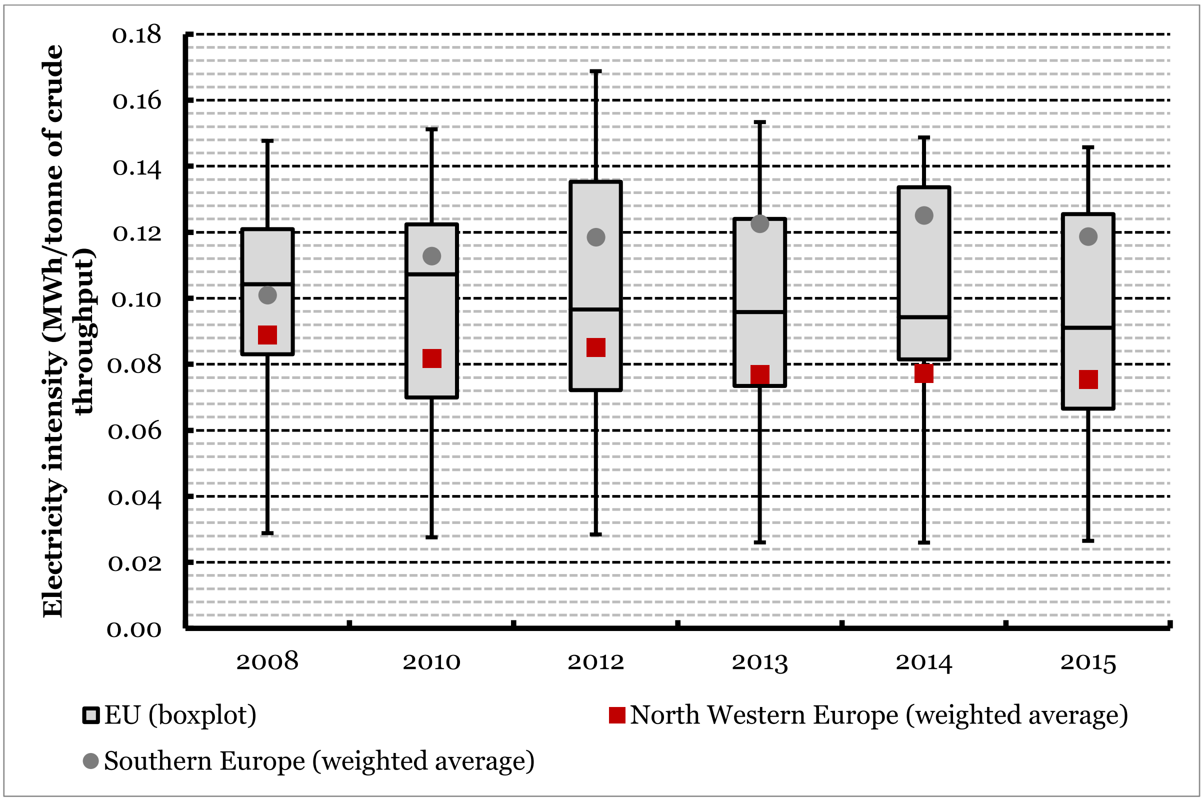
[114] Note that a downside of this approach is that double counting between natural gas and electricity consumption may (to some extent) occur as self-produced electricity is mostly produced from purchased natural gas and on-site produced refinery fuel gases, both being also accounted for under natural gas intensity.

EU weighted averages remained stable over the entire period. NWE weighted averages declined slightly since 2008, from 0.09 MWh/t in 2008 to 0.08 MWh/t in 2015. On the other hand, the electricity intensity of SE refineries is higher and, furthermore, following an increasing trend: from 0.10 MWh/t in 2008 to 0.13 MWh/t in 2014. There was a small decline to 0.12 MWh/t in 2015, similar to the one observed in the analysis on natural gas intensities of production.

Figure 130. Electricity intensity of refineries in Europe (MWh/t of crude throughput)



Source: Authors' own elaboration.

Table 113. Descriptive statistics for electricity intensity (MWh/t of crude throughput)

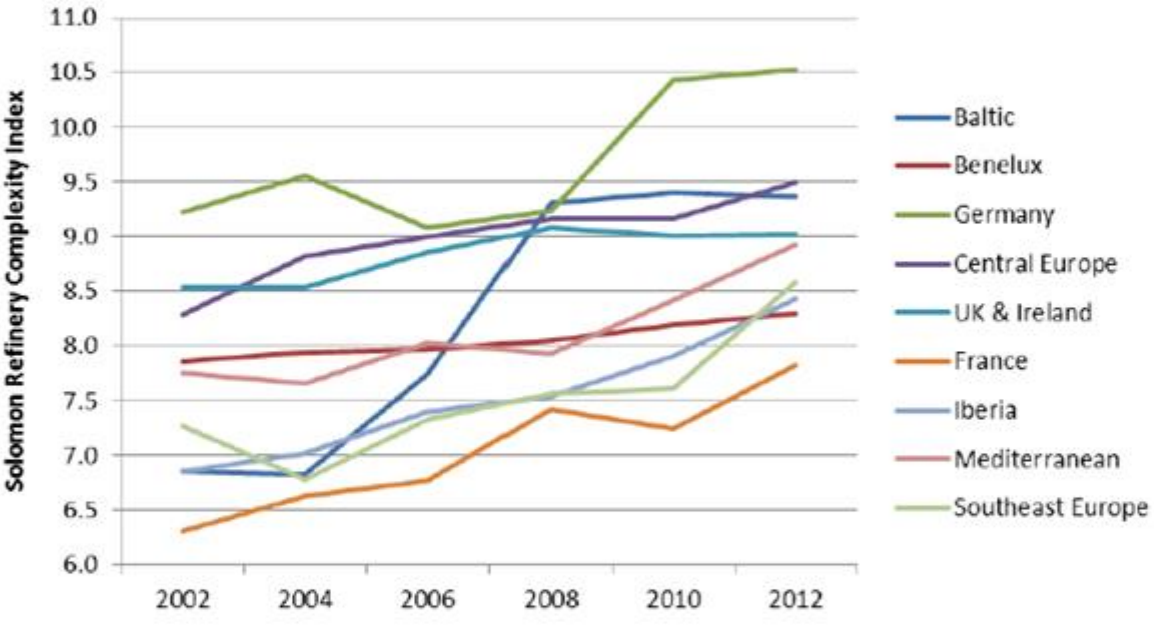
	2008	2010	2012	2013	2014	2015
Plant sites/total sample	8/15	9/15	10/15	10/15	10/15	10/15
EU (weighted average)	0.09	0.09	0.10	0.09	0.09	0.09
EU (median)	0.10	0.11	0.10	0.10	0.09	0.09
EU (relative standard deviation)	38.0%	44.9%	45.0%	42.7%	42.4%	43.5%
EU (IQR)	0.06	0.08	0.09	0.08	0.08	0.09
EU (minimum)	0.03	0.03	0.03	0.03	0.03	0.03
EU (maximum)	0.15	0.15	0.17	0.15	0.15	0.15
CEE EU (weighted average)	--	--	--	--	--	--
SE EU (weighted average)	0.10	0.11	0.12	0.12	0.13	0.12
NWE EU (weighted average)	0.09	0.08	0.09	0.08	0.08	0.08

Source: Authors' own elaboration.

7.9.3 Drivers of energy intensities

Average natural gas and electricity intensity both have been increasing over the study period from 2008 to 2015. Natural gas intensity increases in all European refineries, electricity intensity increases especially in Southern European refineries. One reason for this development might be the production shift to more complex products. The market has demanded a change in the refineries' product mix. At the same time, environmental legislation has required changes in processing. Figure 131 shows the development of the refineries' process complexity by region. For the analysis, different refining processes have been categorised by complexity. Shifts in production processes within refineries have been weighted to generate the index. Especially Baltic, Iberian and French refineries increased the complexity of their production processes.

Figure 131. Development of complexity by region, 2002 to 2012



Source: JRC (2015).

7.10 International price comparison

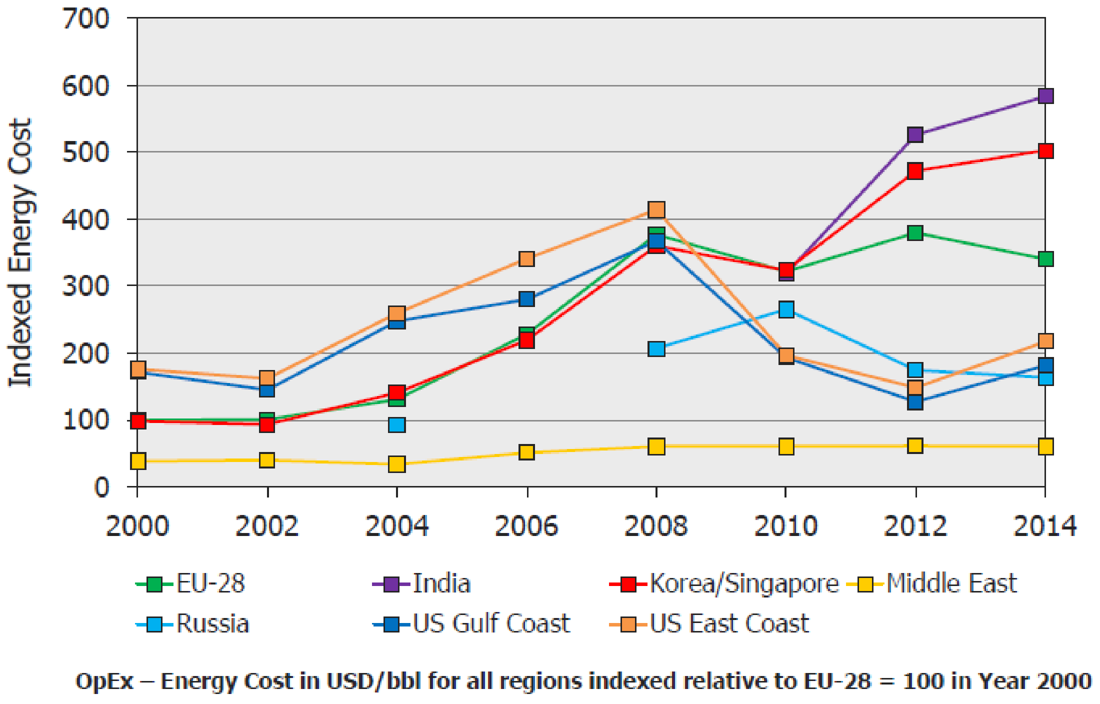
Only one refinery provided information on a refinery plant site outside of Europe. For information about energy prices outside of the EU, both Concawe and FuelsEurope members use data from Solomon Associates, who have done extensive surveys in the refinery sector over the last decade collecting information, including energy price data and production costs data. Unfortunately, due to confidentiality reasons, Solomon Associates could not share any data on international price or production cost values with the research team.

There is one publicly available graph comparing energy costs in the EU to other regions globally. Figure 132 presents this information. It shows the relative operational expenditures for energy costs in USD/barrel of crude oil throughput (bbl) indexed to the value of EU average costs in the year 2000. Crude oil as feedstock is not included in these "energy costs". At the same time, these energy costs go beyond electricity and natural gas costs as they also comprise the costs of other energy sources (e.g. steam, fuel oil).

The information for EU shows a clearly increasing trend for the years between 2000 and 2008 to some extent due to inflation rates. In 2010, costs decreased from a level of 377 to a level of approximately 322. After another small peak in 2012, prices have been quite stable in 2014, at a level of approximately 340.

Energy costs in the Asian regions of Korea/Singapore and India showed stronger increases in energy costs, especially after 2010. Energy costs in the US Gulf Coast and US East coast regions decreased significantly after the uptake of shale gas and shale oil production in Northern America, at the end of the last decade. This is shown by significantly decreasing energy costs in 2010. Russian energy expenditures also seem to have fallen since 2012, while Middle Eastern energy expenditures per unit of energy have always been significantly lower than in the EU.

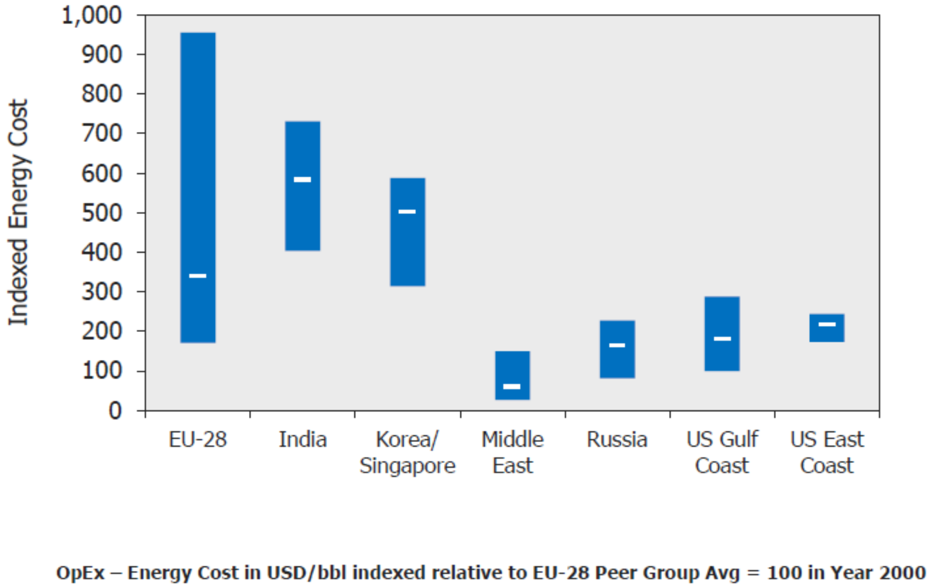
Figure 132. Energy costs in USD/bbl for all regions indexed relative to EU28=100 in year 2000



Source: Solomon Associates (2015).

Boxplots for the energy costs in operational expenditures for each year confirm the finding that the range of energy expenditures within European refineries increased strongly between 2010 and 2014. In 2014, highest values were more than five times higher than lowest values (Figure 133). Average values have been at the lower end of the range. The energy cost spread is not similarly broad in any other region.

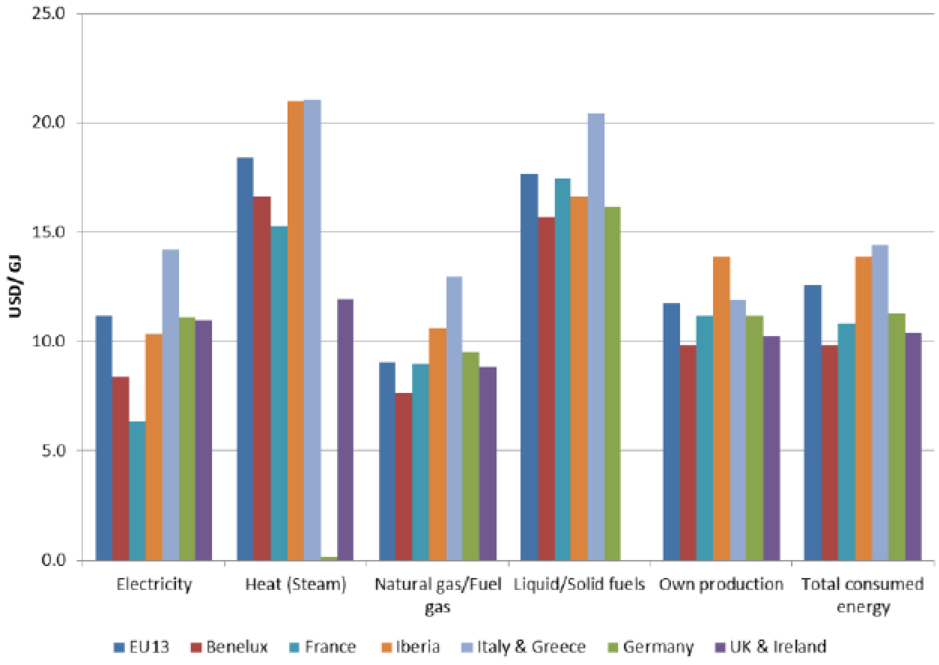
Figure 133. Maximum, minimum and average values for energy costs of refineries for the year 2014



Source: Solomon Associates (2015).

Figure 134 provides a less aggregated overview of energy prices in different EU countries for the year 2012. According to this overview, Italian and Iberian refineries face the highest total energy costs per unit while the EU 13 Member States (Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia) face somewhat lower prices. Electricity costs are especially low in France. Natural gas is cheapest in the countries of the Benelux-area.

Figure 134. Unit energy costs (EUR/GJ) for various forms of refining energy in various EU regions in 2012



Source: JRC (2015).

7.11 Key performance indicators and impact of energy costs

This section includes the information retrieved from sampled companies concerning Key Performance Indicators (KPI) – production costs, margins, and turnover. The purpose of retrieving and processing these data is not to provide a financial analysis of responding plants, but to analyse the impact of energy costs – for both gas and electricity – over financial indicators, namely production costs and margins.

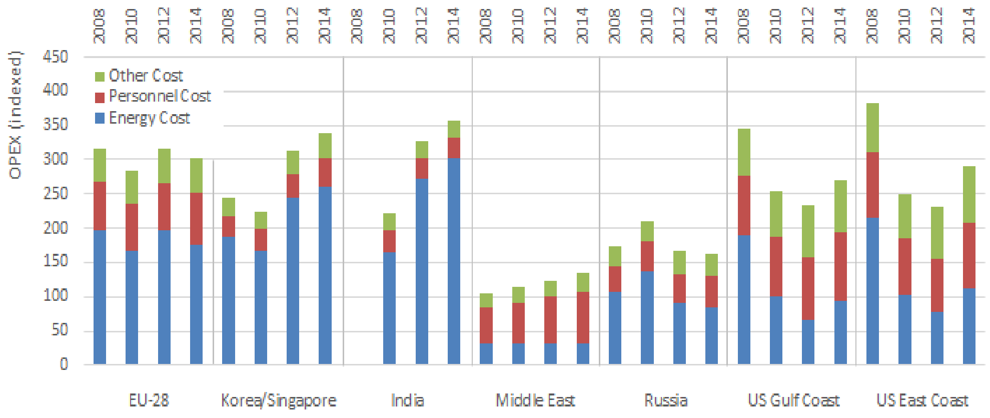
Only two refineries submitted information on key performance indicators. Others either had confidentiality concerns, difficulty with assigning company results to plant level, or could not work with the definitions and indicators requested. A minimum of 3 to 5 refineries would be required to ensure confidentiality of data.

The following analysis is based on Joint Research Centre (2015) as well as public information from Solomon Associates (2015). Solomon Associates could not provide further insights to the results of its own questionnaires.

Figure 135 provides an overview of indexed operational expenditures of global refineries for every second year between 2008 and 2014. The numbers are indexed to the EU value of the year 2000. In EU refineries, energy costs determined approximately 60% of the operational expenditures each year. The second big category was personnel costs, which determined about one quarter of the expenditures.

In countries that are major competitors, either costs for energy or personnel costs are much lower than in the EU. Middle Eastern states show the lowest energy costs, in Russia, they decreased between 2010 and 2012. The US American regions “Gulf Coast” and “East Cost” reported similar energy costs than in the EU for 2008. By 2010, however, they dropped by approximately 50%. In the Asian regions India and Korea/Singapore, the energy costs’ share in operational expenditures increased significantly between 2010 and 2012. There are few changes in personnel costs over time. They are high in the Middle East and the US and low in Russia, India and Korea/Singapore. EU values lie in between these higher and lower values.

Figure 135. Breakdown of OPEX in different regions for the years 2008 to 2014, indexed relative to EU=100 in the year 2000

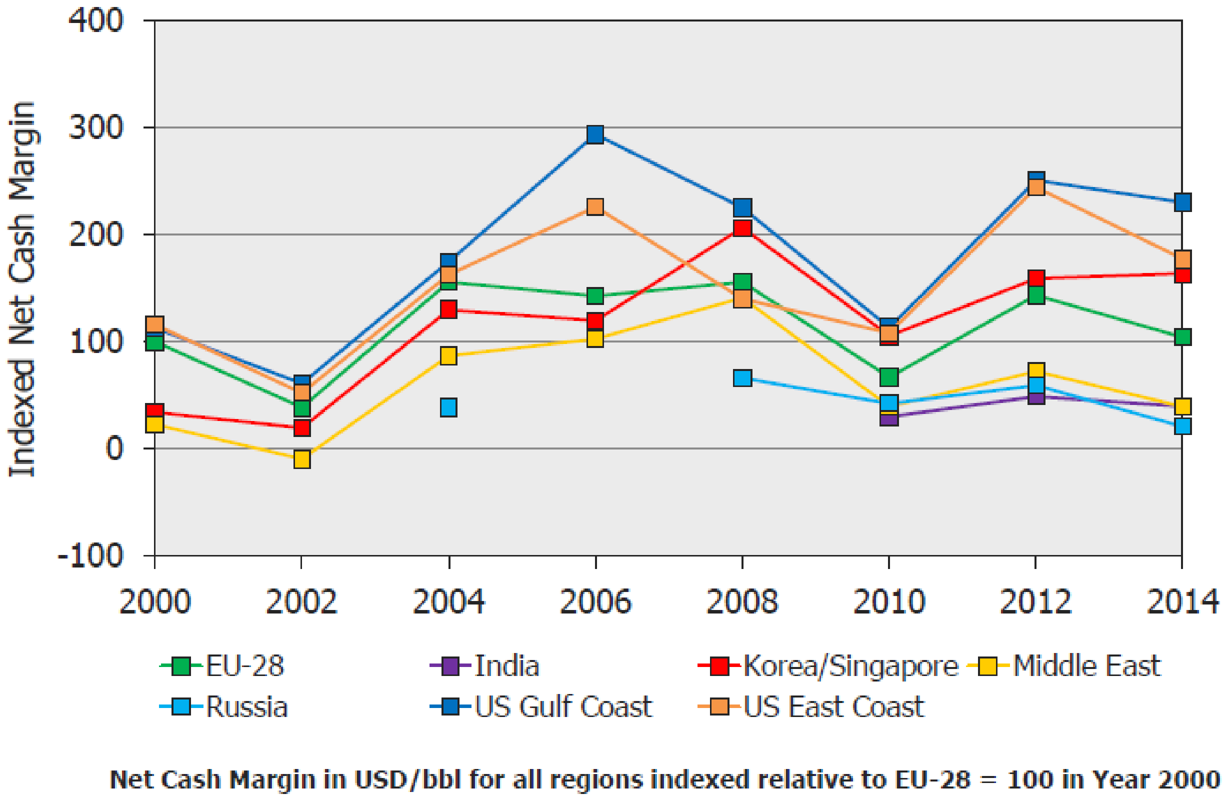


Each OPEX category is indexed to 100 = EU-28 Total Cash OPEX in operating year 2000.

Source: Joint Research Centre (2015).

Figure 136 provides information about net cash margins[115] for refineries in different regions for the years 2000 to 2014. Again, values are indexed to the level of EU net margins in the year 2000. In all displayed years, EU net margins in the refinery sector were lower than in the US regions (one exemption in 2008, when the value for the US East Coast was slightly lower than the EU value), but higher than in Russia, Middle East and India. Margins in Korea/Singapore increased more than in the EU, and have been higher since 2008.

Figure 136. Net cash margin for refineries in different regions for the years 2000 to 2014, indexed relative to EU-28=100 in the Year 2000



Source: Solomon Associates (2015).

Again, there is a broad range of results within EU refineries. Figure 137 provides information for the top and bottom quartile of refineries. The numbers are provided from a different data source and comparisons have to be treated with caution. The development of EU net margins shows at least a similar trend. While the average

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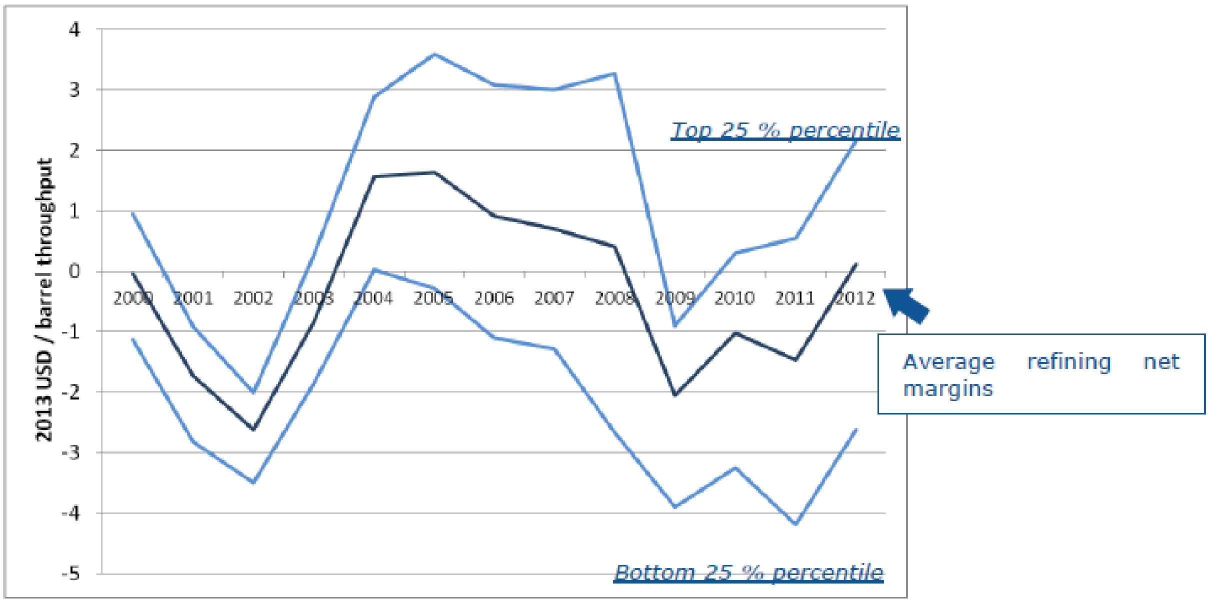
[115] Solomon Associates (2015) defines net cash margin as
(Gross Product Value – Raw Material cost + Other Revenue – Cash OpEX)/ (Net Raw Material Input) where:

1) Gross Product Value is the sum of net product quantity multiplying product price, plus net value of lube refinery & chemical plant transfers, and refinery-produced fuel, minus third party product terminalling
2) Raw Material Cost is the sum of crude quantity multiplying crude price, plus costs for other net raw materials, plus third-party raw material terminalling
3) Other Revenue are revenues from other sales or services such as gaseous and liquid CO2 sales, insurance payments, and reimbursement for services provided to third parties
4) Cash OPEX is the sum of personnel cost, energy cost and other cost
5) Net Raw Material Input is the net input barrel

margin was positive between 2003 and 2008, the lower 25th percentile experienced negative net margins for the whole period from 2000 to 2012.

Figure 137. Variability in EU refineries' net margins



Source: Joint Research Centre (2015).

7.12 Concluding remarks

The total coverage of all 15 received questionnaires, in terms of capacity, is good: nearly 25% of the total EU capacity is covered by evaluable questionnaires. Unfortunately, no site from Central Eastern European countries responded to the survey. Those 11% of the total refining capacity in the EU are, therefore, not represented in the sample.

Weighted average natural gas prices have decreased since 2013, from 30.2 €/MWh to 23.4 €/MWh in 2015. In 2015, the weighted average price in Southern Europe (22.4 €/MWh) was lower than in North-Western Europe (23.8 €/MWh) for the first time.

The range of electricity prices increased. The maximum price in 2014 (171.8 €/MWh) was more than seven times higher than the minimum price (23.7 €/MWh) of the same year. Prices for Southern European respondents evolved differently than those of North-Western European respondents: in 2015, NWE refineries faced the lowest electricity prices since 2008 (50.7 €/MWh). For the same year, SE refineries reported the highest value (78.4 €/MWh) since 2008. The median of prices decreased from 66.3 €/MWh in 2013 to 57.0 €/MWh in 2015.

The main driver of natural gas were energy supply costs. In the EU weighted average prices, they accounted for more than 90% for all years. They showed a small decrease of approximately 1.7% between 2008 (23.8 €/MWh) and 2015 (23.4 €/MWh), with a peak of 29.0 €/MWh in 2013. For respondents in NWE, energy supply costs were on average 1.2 €/MWh lower than the EU average of all responses.

Network costs showed a clearly decreasing trend across all years, whereas taxes, fees, levies and charges reduced from 2008 to 2013 and then increased again, still being substantially lower than the initial values in 2008. Although network costs and taxes, fees, levies and charges are higher for respondents in NWE (0.8 €/MWh in 2015), the total natural gas price is lower (NWE: 23.9 €/MWh, EU: 24.8 €/MWh in 2015).

Average values for the energy supply component in electricity prices decreased significantly from 46.5 €/MWh in 2013 to 42.4 €/MWh in 2015. Network costs on the other side have been continuously increasing since 2008, starting at 3.9%, their share in total costs was more than 13% in 2015.

Values for renewable energy support costs fluctuated greatly, due to the German renewable energy support scheme: in 2010 (8.8 €/MWh) and 2014 (3.5 €/MWh), German refineries in the sample were only partly covered by a scheme to reduce RES tariffs for industrial companies. The electricity consumption faced with the full surcharge of 20.5 €/MWh in 2010 and 62.4 €/MWh in 2014 skews the average trend. Consequently, there is no clear pattern.

Energy intensity calculations for the refining sector compare energy consumption to the tonnes of crude oil processed. For the natural gas intensity, purchased and also self-produced refinery fuel gases have been taken into account. The average natural gas intensity increased from 0.77 MWh/t in 2008 to 0.84 MWh/t in 2015, mainly due to increases in natural gas intensities of production for respondents in SE (increased from 0.5 MWh/t to 0.77 MWh/t). For NWE refineries, there is no clear trend. For all years, average natural gas intensity in NWE refineries is higher than in SWE refineries, but the spread is continuously decreasing. While the average value increased, the median value of natural gas intensity in all European refineries decreased since 2010, from 1.05 MWh/t to 0.83 MWh/t in 2015.

With respect to electricity intensity, purchased and self-produced electricity are taken into account. Average electricity intensity fluctuated between 0.09 and 0.10 MWh/t of crude throughput. No clear trend can be discerned for averages and median electricity intensities. Weighted averages for NWE show a slightly declining trend since 2008, from 0.09 MWh/t in 2008 to 0.08 MWh/t in 2015. The electricity intensity of Southern European refineries, however, was higher and increasing over the period: from 0.10 MWh/t in 2008 to 0.13 MWh/t in 2014, followed by a small decline to 0.12 MWh/t in 2015.

According to a publication by Solomon Associates (2015), average EU refineries' operational expenditures on energy have been growing strongly since 2000. In 2014, they reached a level of 340 if the energy expenditures of EU refineries in 2000 are indexed to 100. The Asian regions of India and Korea/Singapore show stronger increases in the parameter, while US-American energy expenditures show a clearly declining trend since 2008. Energy expenditures of refineries in the Middle East remained fairly stable at a level of 61 in comparison to the indexed value of 100 in the year 2000 for EU-28. The external analysis confirms the finding of increasing ranges in prices of energy faced by EU refineries.

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