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FINAL REPORT

FOR A STUDY ON COMPOSITION AND DRIVERS OF ENERGY PRICES AND COSTS IN ENERGY INTENSIVE INDUSTRIES: THE CASE OF THE FLAT GLASS INDUSTRY

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1. Flat glass

1.1 Flat glass description and production

1.1.1 Flat glass description and uses

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

There are two types of flat glass production processes in the EU: float glass and rolled glass. Float glass dominates the sector's output (around 95% of total production in Europe). The end-products in the float process, float glass, are large 'jumbo' sheets of glass (typically 6 per 3.1 m, or in sizes specific to customer orders)[1]. The float process is a standardised production process used by all European float glass manufactures. The end-product, float glass, is therefore a rather homogenous product with low variation.

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

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

Table 1. Main types of flat glass

Glass type	Description
Annealed glass	Annealed glass is the first result of the float process. Annealed glass is used in some end-products, often in double-glazed windows, but mostly as the starting material for more advanced products.
Toughened glass	Toughened glass is a type of safety glass that is more resistant to breakage than annealed glass. It breaks in more regular, square fragments than annealed glass and is made from annealed glass with a thermal tempering process. Toughened glass is produced through heating annealed glass to 600°C and then rapidly cooling the surface. The inside remains hot, which creates compressive stresses in the surface due to different physical properties. Toughened glass is used in buildings (e.g. facades, sliding doors); cars (windshields) and other applications (e.g. interior design and furniture).

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

Laminated glass	Laminated glass is a type of safety glass made of different layers of glass with one or more interlayer(s) of polymeric material between the layers. In the event of breakage, the glass is partly held together by the interlayer, which reduces the risk of shattered glass. The interlayer also allows for colouring, sound dampening, ultraviolet filtering and other technologies. Laminated glass can either be produced with a thin layer of PVB (Poly Vinyl Butyral) using heat and pressure or with Cast In Place, where a resin is poured into the space between two sheets. Laminated glass is often used in building facades and in the automotive industry.
Coated	Coatings are applied to glass to give it characteristics such as special reflections, scratch and corrosion resistance. The exposure of the glass surface to vapours forms a permanent coating. Coating can either be applied when the glass is still in the float process – so-called hard-coated glass, or as a vacuum-coating process where the vapour is applied onto the cold glass surface in a vacuum.
Mirrored glass	Mirrored glass is produced through applying a metal coating on one side of the glass. As well as for mirrors, mirrored glass is being used increasingly in the building sector.
Patterned	Patterned glass can be produced using different methods, the most common of which is to pass the heated glass between rollers with surfaces of the pattern, once it comes out of the furnace. It is mostly used for decoration and internal architecture.
Extra clear glass	Extra clear glass differs from other types of glass by its raw material mix and is not the result of processed annealed glass. It is made with a very low iron content to minimise sun reflection and is used for solar energy purposes, in particular.

Source: Glass for Europe, 2013a.

The most important markets for float glass are the building and automotive sectors. The building sector accounts for around 80-85% of the output and the majority of the remaining output (15-20%) goes into the automotive industry, including buses and coaches, trucks and off-road mobile machinery.

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

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

1.1.2 The float glass production process

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

1.1.2.1 Raw materials

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

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

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

Source: GLS-BREF, (2013).

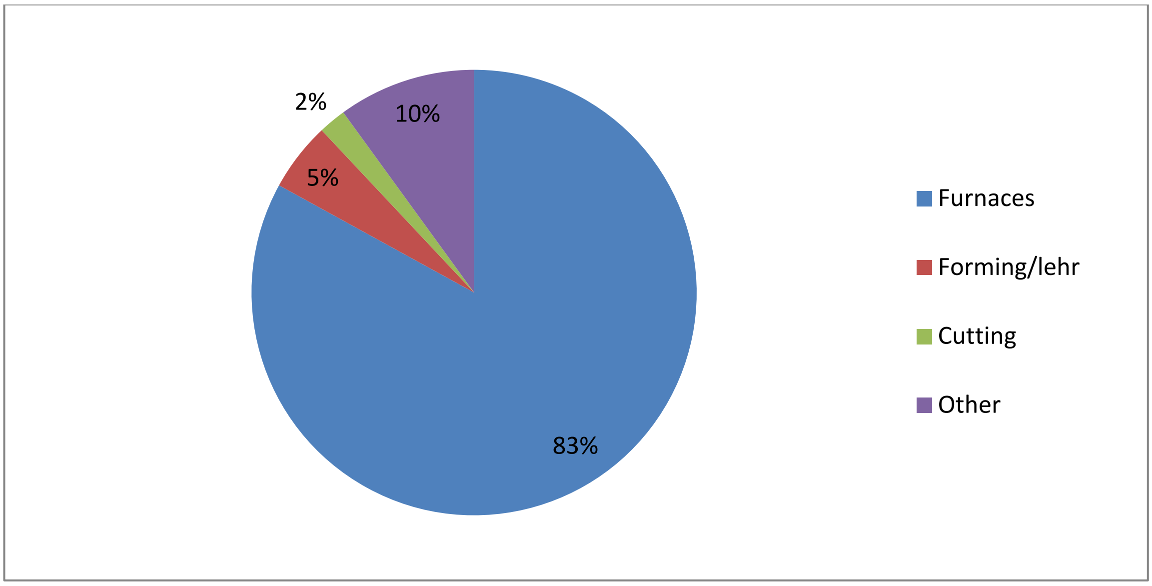
Cullet glass, i.e. recycled glass, is also used in the production process. When cullet glass is mixed with raw materials, CO2 emissions are reduced, both because of reduced process emissions (due to lower use of raw materials), and from less energy consumption in the melting process (Ecofys, 2009). Increasing the use of cullet by 10% in the melting mass decreases energy consumption by about 2-3% (IEA, 2007). In almost all cases, float glass plants recycle internal cullet directly to the furnace. The amount of cullet is limited by the availability of cullet of the right quality and right chemical compatibility. For this reason, external cullet is not extensively used in the float process, since the manufacturing process is highly sensitive to even low levels of contamination, with problems involving colour variation, bubbles and ream knots, among others (Glass for Europe, 2010). For different installations, it is unclear what the percentage of cullet used is. An average estimate is that it is usually around 20%, but it can vary from 10 to 40% (GLS-BREF, 2013).

1.1.2.2 Energy Use

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

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

Figure 1. Energy use distribution in the float process



Source: GLS-BREF, (2013).

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

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

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

Schmitz et al (2011) assessed the energy consumption and CO_2 emissions of European flat glass industries and arrived at an average energy intensity of around 9.2 GJ/tonne of saleable output. The corresponding figure in the US is around 10.7 GJ/tonne of output. These data, however, are for the year 2002 (Worell et al, 2008). Energy consumption in the EU deviates somewhat among Member States (see Table 3). In the study by Schmitz et al (2011), Italy had the highest energy intensity and Germany the lowest.

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

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

Source: Schmitz et al, (2011).

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

From 1960 to 1995, energy consumption in the EU flat glass sector was reduced by about 60%, associated with a corresponding reduction of CO_2 emissions. The glass sector believes it is possible to reduce CO_2 emissions by 5-10% per output unit by 2030 (Glass for Europe, 2013c). Beyond this, further reductions will require major technological breakthroughs in thermo-dynamics, raw material use and/or carbon capture and storage. Decarbonisation of the flat glass sector is expected to follow a slow path in the next 20 to 30 years as technologies and infrastructure are put in place and rolled out to installations (Glass for Europe, 2013c).

1.1.1.3 CO_2 Emissions

Around 75% of the CO_2 emissions from the float glass process originate from the fossil fuel used to fire the furnaces, while around 25% originate from process emissions. The latter source of CO_2 is not a function of efficiency but of the chemical process and therefore some emissions will always remain, unless new processes are developed. Nevertheless, the use of recycled glass (meaning fewer raw materials) is being increased, leading to a reduction in process emissions.

There are also indirect emissions from electricity use (electricity boosting in the melting process and downstream activities). The overall indirect emissions in the flat glass sector accounted, according to Schmitz et al (2011), for around 16% of overall CO_2 emissions for the saleable product.

1.1.1.4 The float glass process

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

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

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

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

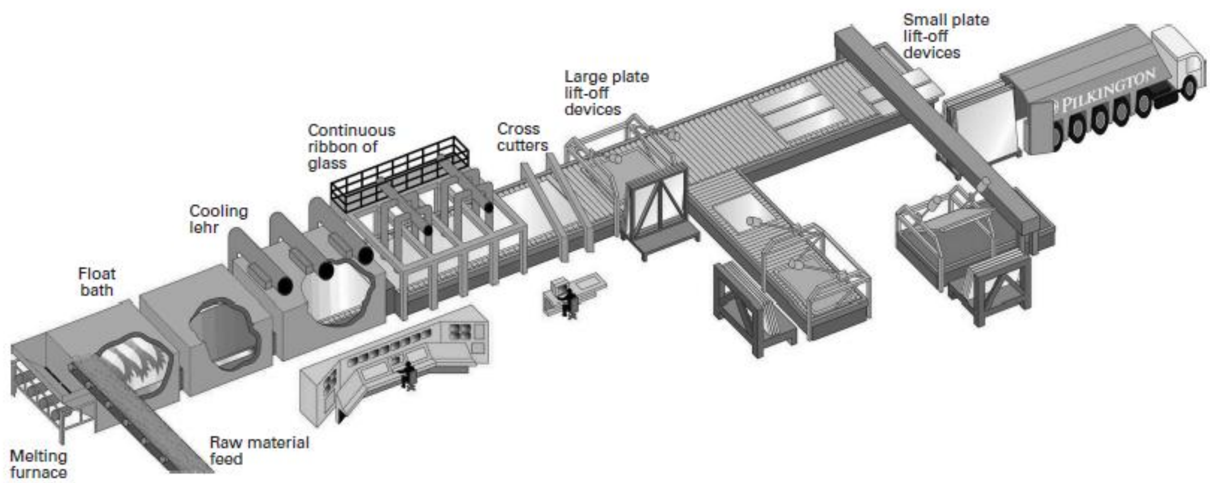
i. *Mixing raw materials in the batch plant*

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

ii. *Melting of raw material in furnace*

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

Figure 2. The Float glass process



Source: Pilkington, (2009).

iii. Tin bath

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

iv. Annealing lehr

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

v. Cutting the glass

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

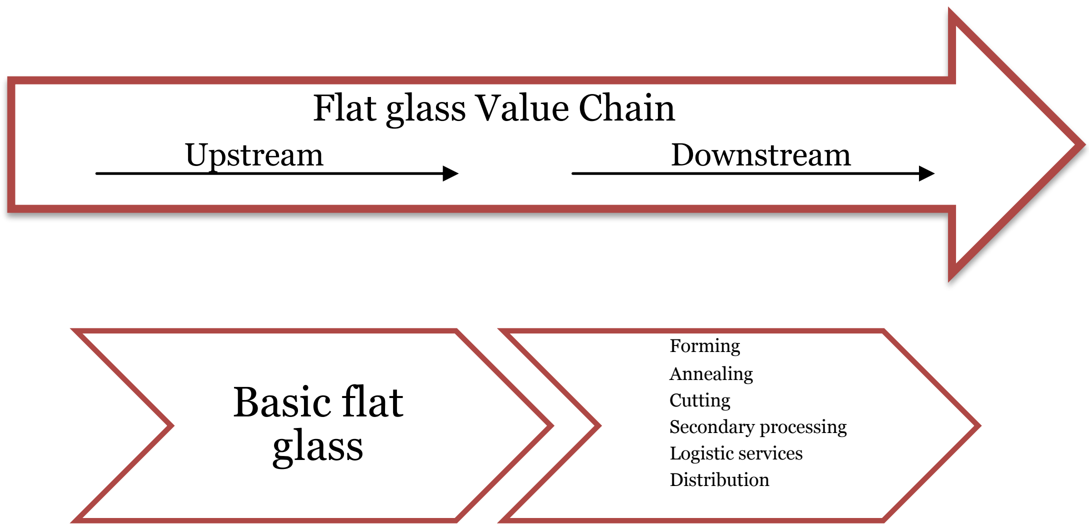
Diversification in glass composition and thickness can reduce nominal output. Production is lost when float production changes from one specification to another. For most complex changes, this can amount to as much as seven days of lost production.

1.1.3 The industry value chain

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

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

Almost all direct CO_2 emissions come from the upstream process. As a result, downstream processes are not included in the EU ETS.



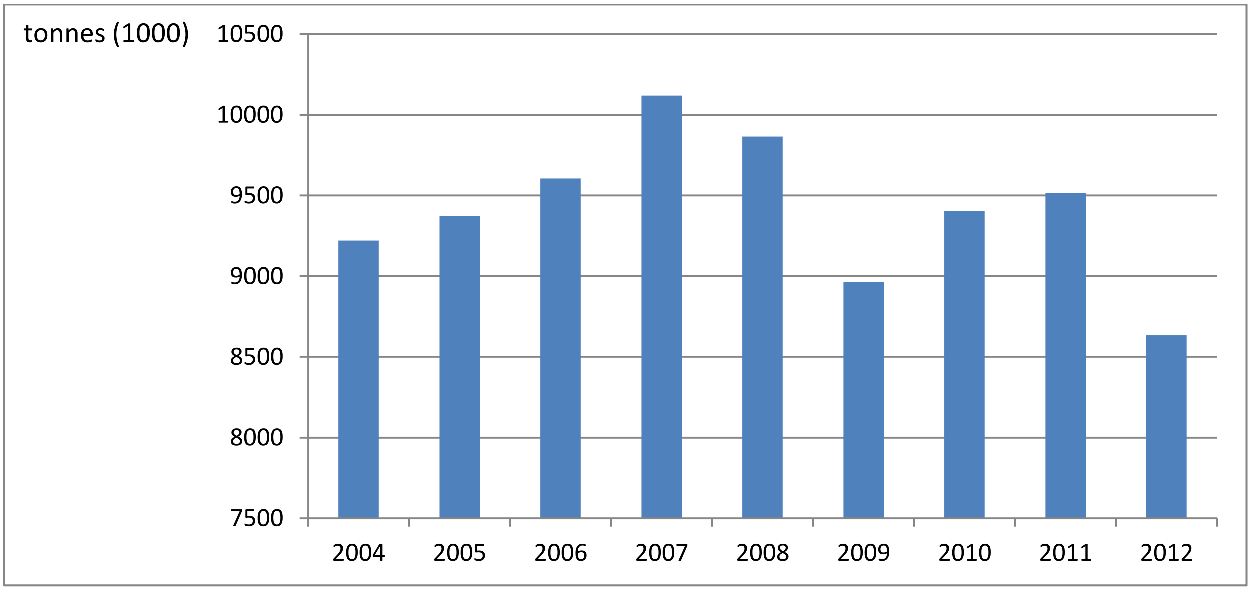
Note: secondary processing includes e.g. coating, insulating glass, laminated glass and vacuum glass production.

1.2 The European flat glass market

1.2.1 EU flat glass production and players

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

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



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

At the last count, the number of float tanks in the EU is 46 operating tanks[3]. Seven companies have running float installations in the EU today and four major groups dominate the European market: Saint Gobain, AGC, NSG Group (Pilkington) and Guardian (Table 4). Together, these four operate almost 90% of the European float tanks. All four companies are members of the European flat glass Association, Glass for Europe (henceforth the Association), together with Sisecam[4].

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

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

[1] The country in which the parent company is located.
Source: Glass for Europe[5].

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

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

Country	Nr. of float lines, 2013*	Total capacity, 2011 (metric tonnes per day)**
Germany	10	6 400
Italy	6	4 000
Spain	5	3 000
France	5	3 600
Poland	5	2 850
Belgium	4	2 400
UK	4	3 050

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

[4] Guardian is not a full member but works in association with Glass for Europe.

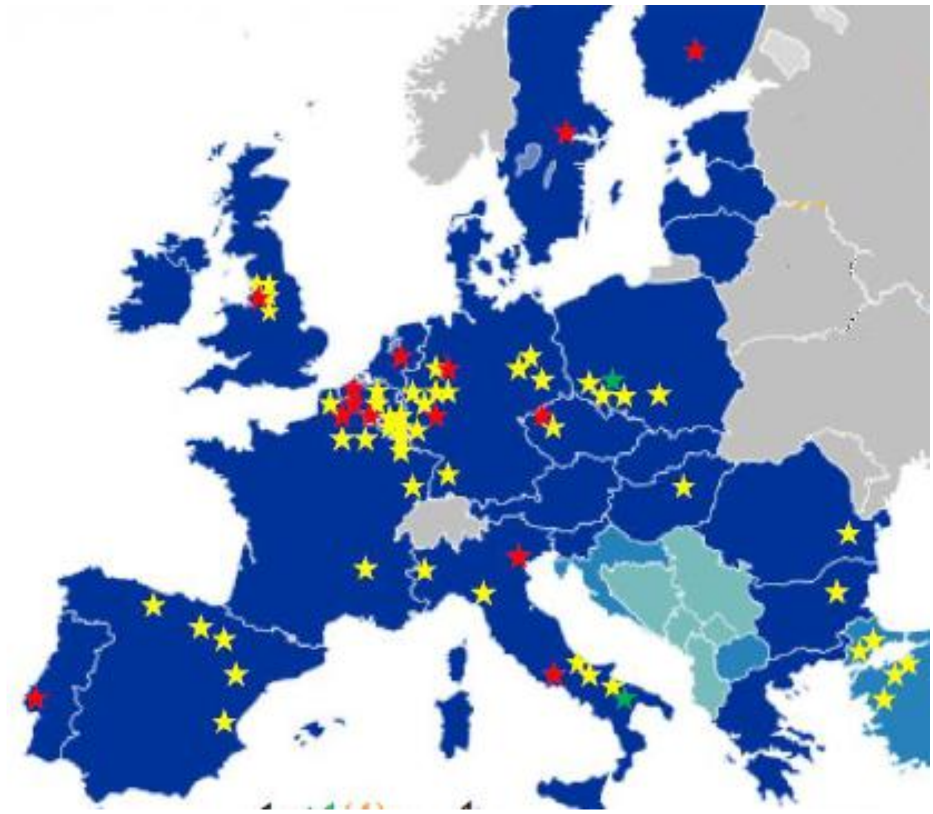
[5] Personal communication with Mr. Bertrand Cazes, CEO at Glass for Europe, based on publicly available information, to the best of Glass for Europe's knowledge, referring to the situation in 2013.

Czech Republic	2	1 600
Luxembourg	2	1 100
Bulgaria	1	650
Hungary	1	500
Romania	1	600
Finland	0	250
Netherlands	0	550
Portugal	0	550
Sweden	0	700
Total	46	31 570

Source: *Glass for Europe[6], **World flat glass, Freedonia (2013).

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

Figure 4. Location of float installations in Europe



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

The capacity of float plants in the EU lies at around 500 tonnes/day, but deviations exist, and capacity can be as great as 1100 tonnes/day. Table 6 illustrates the percentage of float capacity in the EU-27 within different capacity ranges, in 2007. Almost half of the float

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

tanks have a capacity of between 550-700 tonnes/day and around a third of the plants have a capacity of between 400-550 tonnes/day. In general, the plants that recently closed in the EU are, however, smaller plants, meaning that a larger proportion of running plants is probably found within the higher capacity ranges today.

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

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

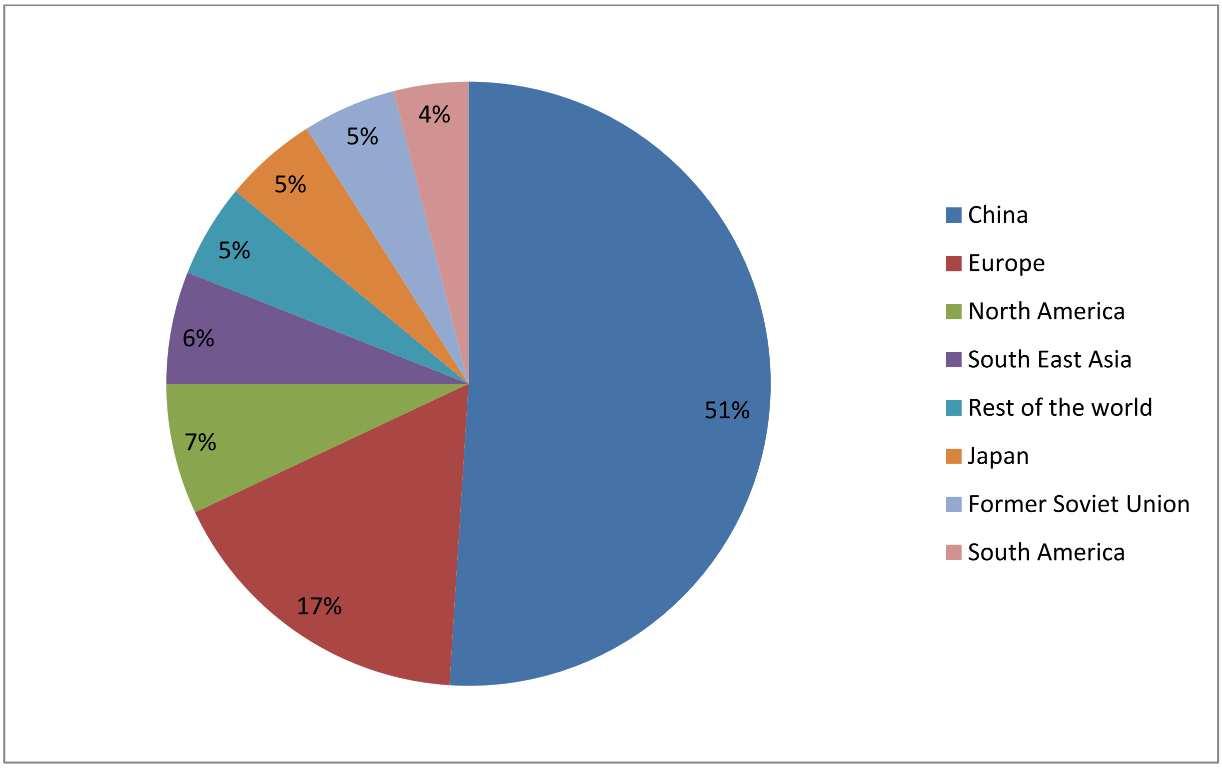
Source: GLS-BREF (2013).

1.3 International flat glass market

1.3.1 Global flat glass production and consumption

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

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



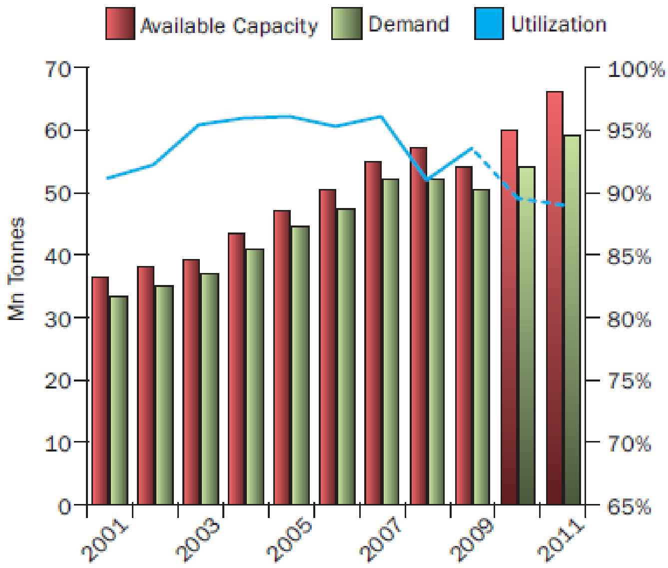
Source: Pilkington, (2011).

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

Over the past 20 years, global float glass demand has grown more quickly than GDP and demand continues to grow (Pilkington, 2011). World demand for flat glass is expected to grow by 7.1% annually through 2016 according to World Flat Glass (2013). In 2009, demand contracted by 3.6% due to the economic crisis. In 2010, however, demand increased again by 9.1% (Pilkington, 2011).

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

Figure 6. Global capacity utilisation



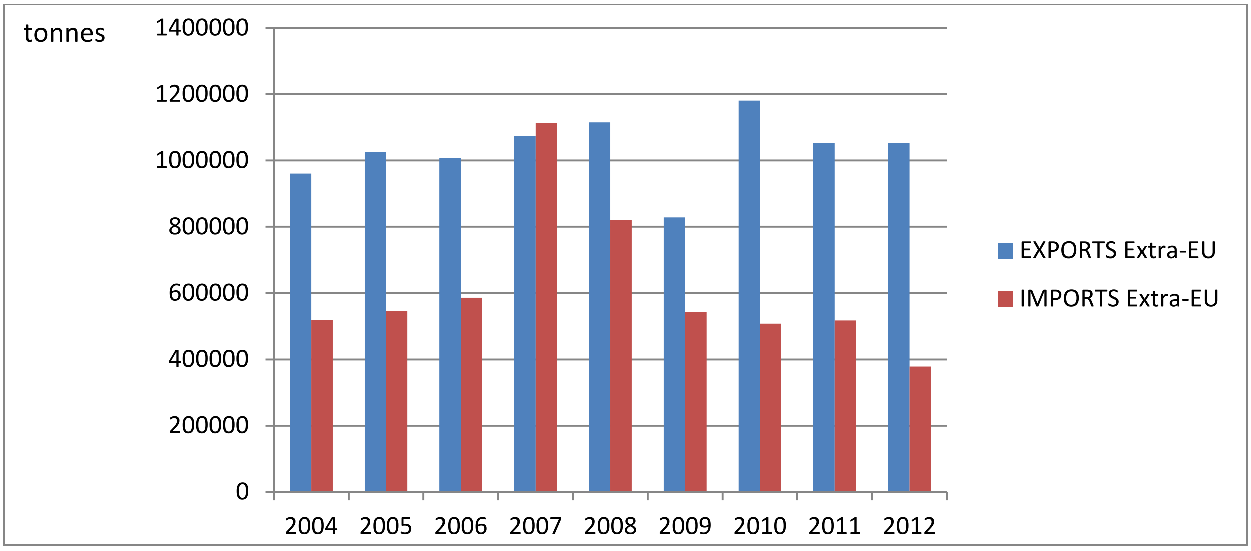
Source: Pilkington, (2010).

1.3.2 World and EU trade flows

Extra-EU Trade

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

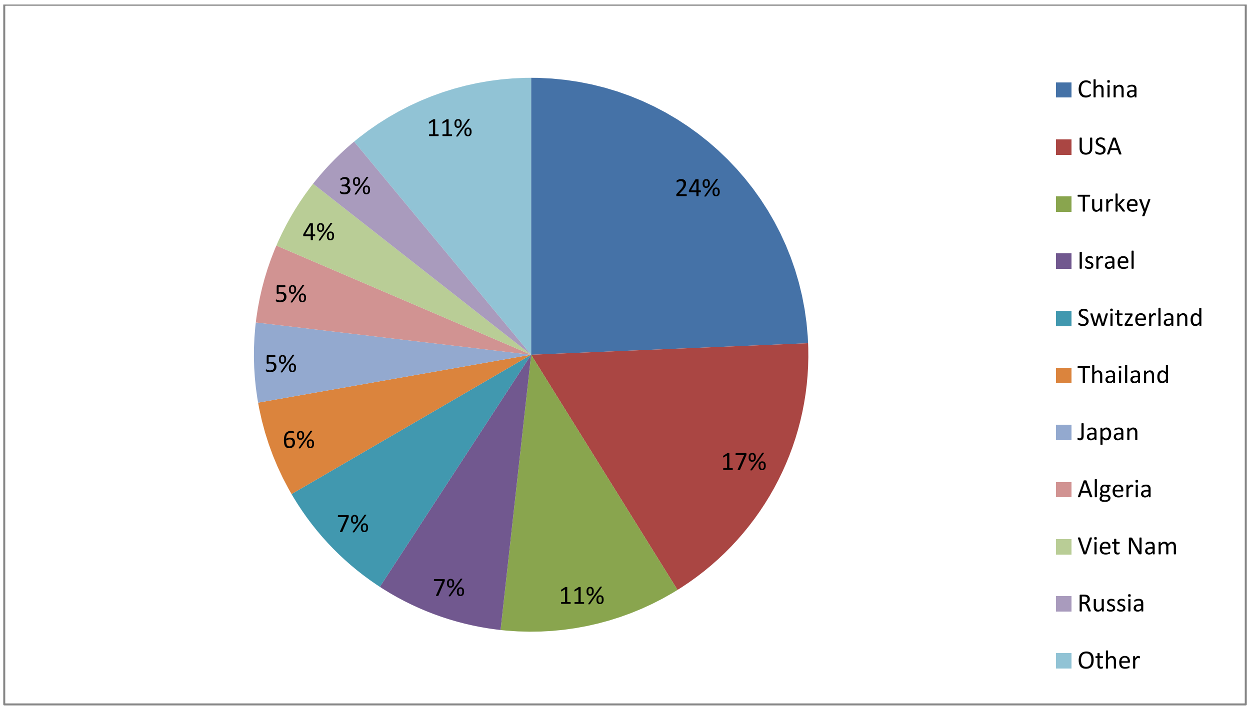
Figure 7. Flat glass (unworked), Extra-EU exports and imports, tonnes



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

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

Figure 8. EU-27 main importing countries in 2012



Source: UN comtrade (2013).

1.3.3 Cost structure

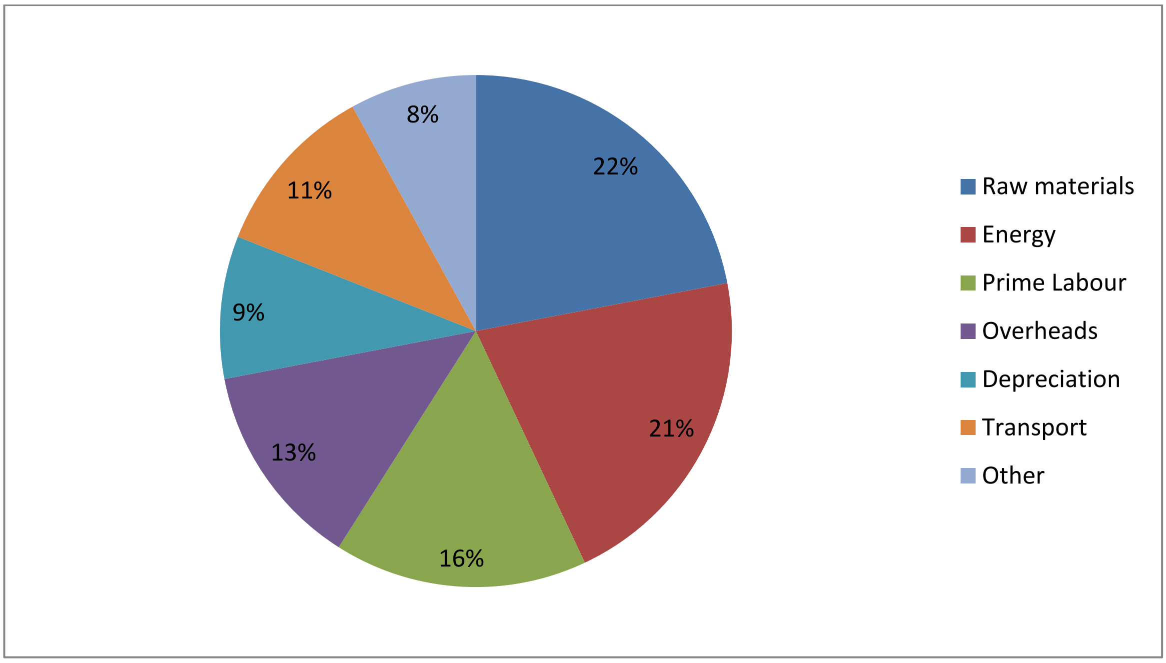
1.3.3.1 Cost of installations

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

1.3.3.2 Cost structure

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

Figure 9. Cost structure Float Glass Nominal Cost



Source: Pilkington, (2010).

1.3.3.3 Transportation

Transportation costs differ for transportation by land and sea. By land, flat glass is expensive to transport, which is why it is generally supplied on a local or regional basis. Distribution costs typically represent around 10-15% of total production costs (Pilkington, 2006). However, intense competition between companies has led to glass being transported over longer distances, ultimately limited by cost (Ecorys, 2008). For transportation by land, 200 km is seen as the norm and 600 km as the economic limit (Glass for Europe, 2013e).

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

1.4 Selection of sample and sample statistics

1.4.1 Sample criteria

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

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

Data on capacity for float glass installations has proved difficult to obtain, mainly for confidentiality reasons. Collecting data on capacity is complicated further by the fact that several float installations have stopped production recently. Therefore, all the individual companies involved in this study were asked for capacity data for all their plants. In parallel, capacity data was also obtained from an independent provider[8] on country and company level.

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

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

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

1.4.1.1 Geographical location

This criterion has been developed as follows:

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

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

1.4.1.2 Capacity of plants

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

[8] World Flat Glass, Freedonia.

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

1.4.1.3 Big and small companies

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

1.4.1.4 Technology

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

1.4.2 Sample statistics

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

As explained further in section 1.5.2, the plants were divided in three geographical regions: Western Europe, Eastern Europe and Southern Europe. The sample broadly reflects the situation in the EU with Western European Member States dominating with more than half of the installations. Southern and Western Europe, respectively, represent around one quarter each.

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

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

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

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

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

1.5 Methodology

1.5.1 Data collection

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

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

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

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

Table 8. Number of questionnaires used in each section

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

1.5.2 Data analysis and presentation

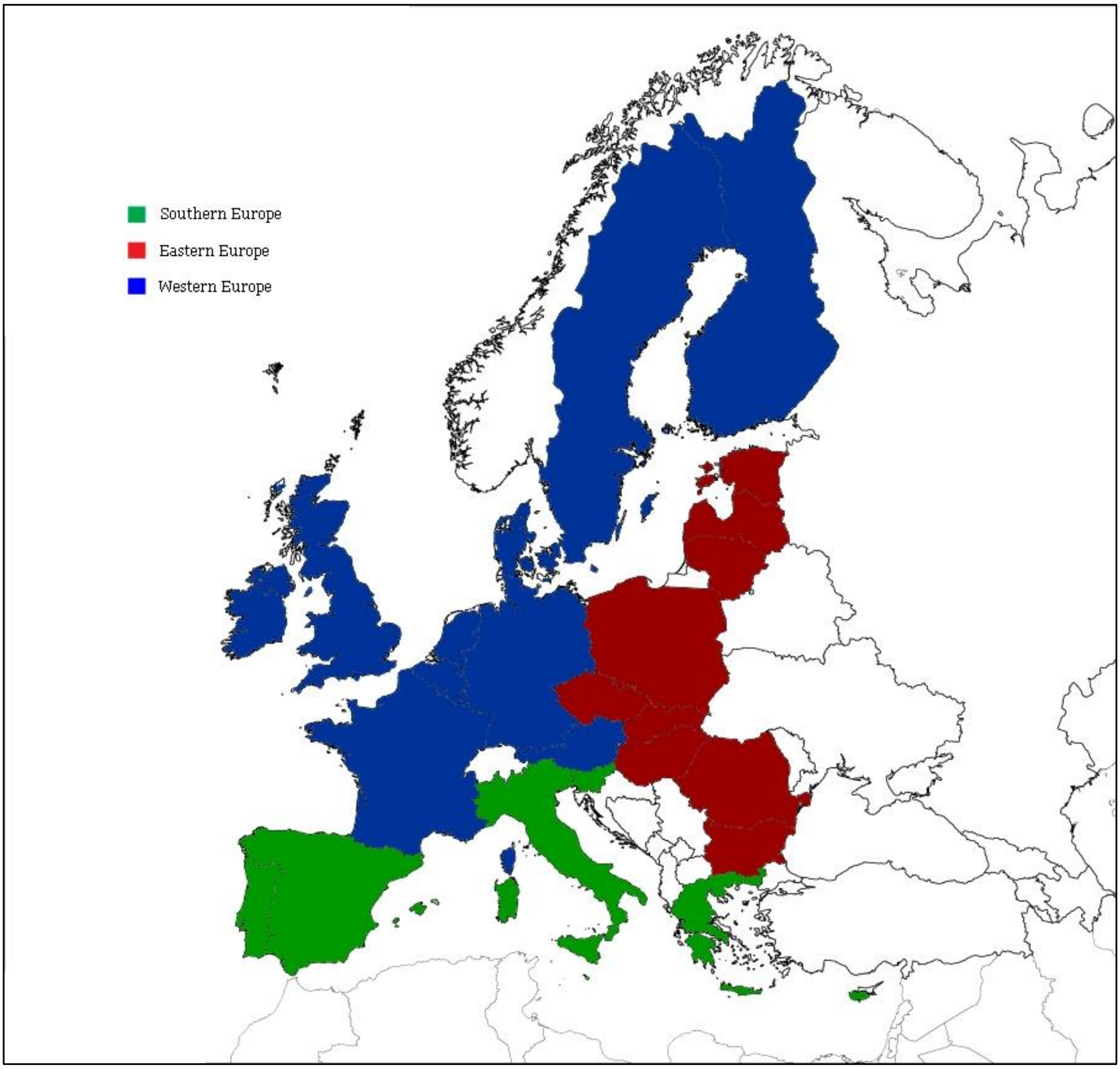
For reasons of confidentiality, we have aggregated the data into different geographical regions: Western Europe, Southern Europe and Eastern Europe. The countries in the different geographical regions are the following (see also Figure 10):

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

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

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

Figure 10. EU division in major geographical regions

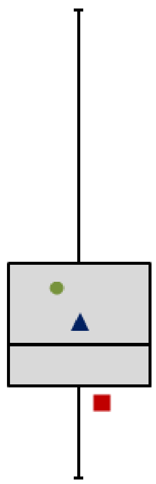


Source: Own illustration.

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

Box plots are furthermore presented in section 1.6 in order to display the cost ranges and to give an indication of the distribution among the units in the sample. An exemplary box plot is illustrated in Figure 11. The box itself is divided in two parts by a horizontal line. This line indicates the median of the sample, i.e. the numerical value separating the higher half of the data sample from the lower half. The lower border of the box represents the first (lower) quartile of the sample. It splits off the lowest 25% of the data sample from the highest 75%. Correspondingly, the upper border of the box indicates the third (upper) quartile of the sample, thus separating the highest 25% of data from the lowest 75%. Put differently, the box contains exactly the middle half of the data. The height of the box is also referred to as inter-quartile range (IQR). It is a robust way of showing the variability of a data sample without having to make an assumption on the underlying statistical distribution. The whiskers below and above the box represent the minimum and maximum value of the sample.

Figure 11. Exemplary box plot



Source: own illustration.

1.5.3 Calculation of indirect ETS costs

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

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

Indirect costs

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

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

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

Where:

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

Sources:

- Electricity intensity of production; this was acquired from interviews with and questionnaires answered by industry members.
- Carbon intensity of electricity generation: the maximum regional carbon intensity of electricity is utilised, provided by the Commission's Guidelines on State aid measures.[9] Note that these figures are not national. Member States who are highly interconnected or have electricity prices with very low divergences are regarded as being part of a wider electricity market and are deemed to have the same maximum intensity of generation (for example, Spain and Portugal).
- CO2 Price: Yearly averages of the daily settlement prices for Dec Future contracts for delivery in that year. The daily settlement prices were reported by the European Energy Exchange.

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

Year	2010	2011	2012
CO_2 Price	14.48	13.77	7.56

1.5.4 Validation of information

Data on capacity for float glass installations has proved difficult to obtain. All the individual companies involved in this study were asked for capacity data for all their plants. In parallel, capacity data was also obtained from an independent provider[10] on country and company level. This allowed validating the data on capacities for some of the individual companies that had one installation per country.

To our knowledge, and according to the Association, there are no independent data providers in the flat glass sector on energy costs[11]. This has made data validation difficult.

[9] 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)

[10] World Flat Glass, Freedonia.

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

Therefore, all the data on energy prices and energy consumption presented in the report was collected through the questionnaires to the individual installations in the sample.

Given this situation, the research team has tried to validate the data from the questionnaires by comparison of the different installations. This allowed indentifying outliers. When this was the case, follow-up interviews were carried out. Numbers were also compared with the other sub-sectors in this study (chemical sub-sectors and ceramics sub-sectors). Further checks were done with the help from other external sources[12].

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

The validation of production costs and margins for the float glass is complex. It is not possible to retrieve data from publicly available sources. Both production cost and margins of the EU float glass industry were validated through comparing the data submitted by the producers and verifying the plausibility of key indicators' evolution during the addressed period[13].

Please note that all the figures presented in section 1.6 and 1.7 include possible exemptions from taxes, levies or transmissions costs. The researchers asked the producers to communicate the prices they pay for energy carriers between 2010 and 2012. Therefore, their answers include exemptions/reductions if these are applicable. Note also that all the replies were submitted on a plant level.

1.6 Energy price trends

1.6.1 Introduction

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

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

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

[13] Verification was conducted through both data analysis and telephone interviews with the companies.

Table 10. Energy sources' cost share of total energy cost and total production cost. Averages for the sample and time period studied, 2010-2012[14]

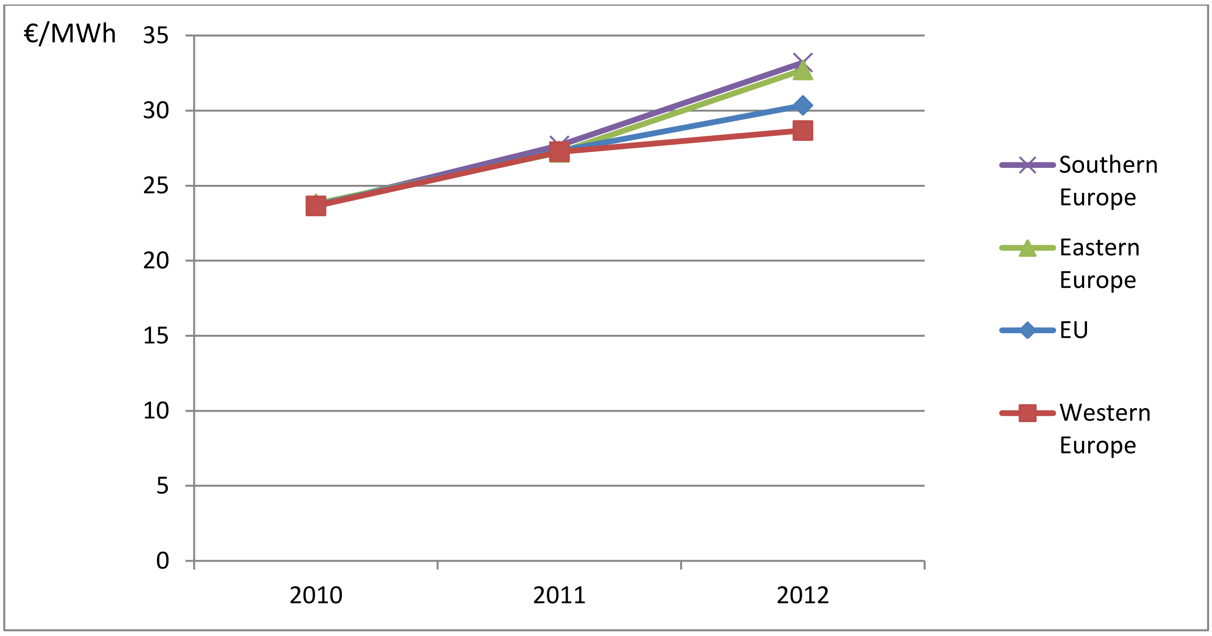
	Share in total energy cost, %	Share in total production cost, %
Natural gas	66.7 - 76.6%	21.0 - 28.1%
Electricity	14.6 - 15.5%	3.6 - 4.0%
Fuel oil	8.8 - 17.8%	6.0 - 10.9%
Energy Total	100%	35.1 - 39.1%

1.6.2 Natural gas

1.6.2.1 General trends

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

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



Source: Authors' own calculations based on questionnaires.

[14] The figures on the share of energy sources of total energy cost are averages for the full sample (ten plants) and the three-year period studied. The figures on the share of energy sources in total production cost present averages for the time period studied for the four plants that provided data on production cost and margins, such as EBITDA, to be consistent with section 1.10.

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

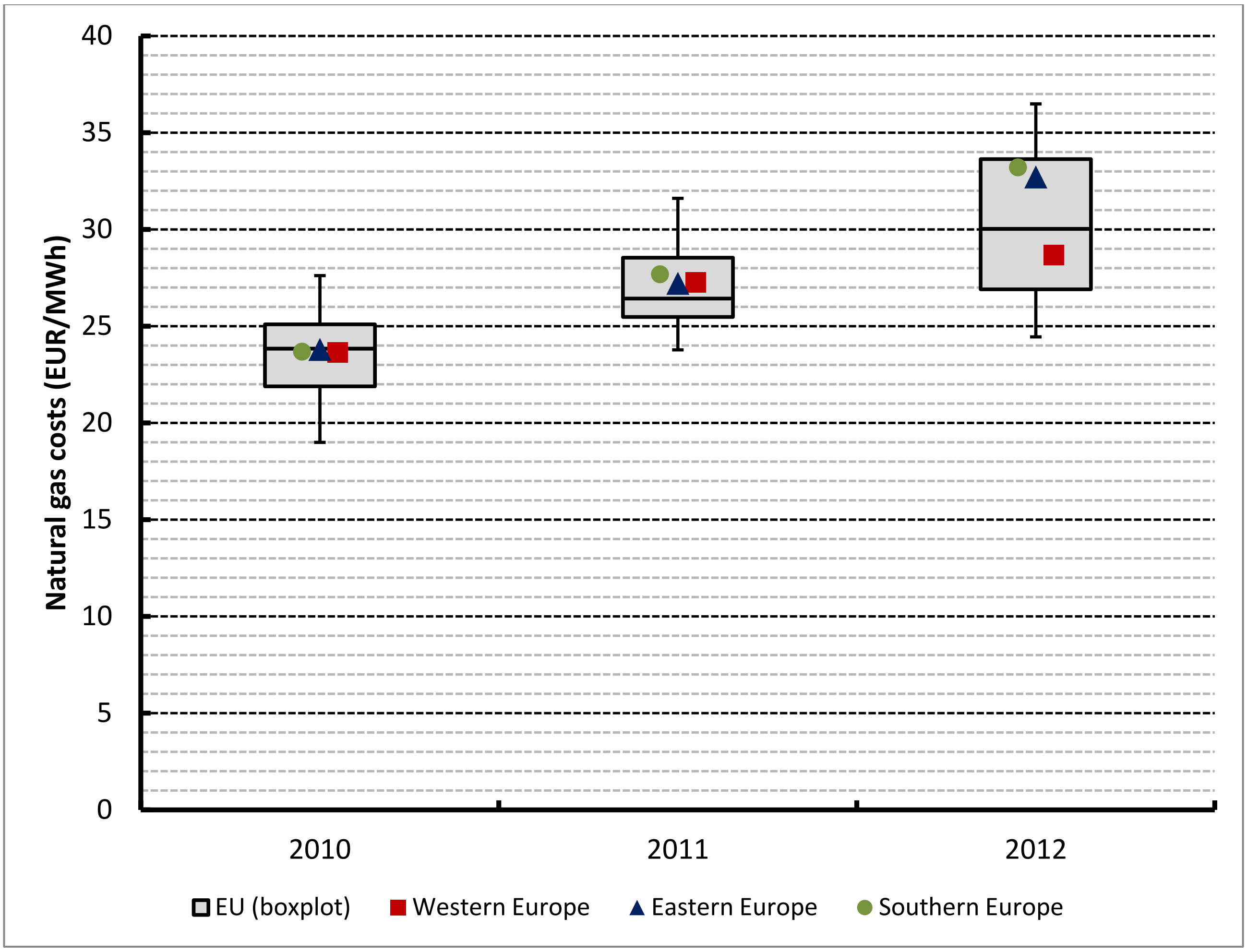
	2010	2011	2012
EU (average)	23.7	27.3	30.3
EU (median)	23.8	26.4	30.0
EU (IQR)	3.2	3.1	6.7
Western Europe (average)	23.6	27.3	28.7
Southern Europe (average)	23.7	27.7	33.2
Eastern Europe (average)	23.8	27.2	32.7
EU (max)	27.6	31.6	36.5
EU (min)	19.0	23.8	24.4

Source: Authors' own calculations based on questionnaires.

The trends in natural gas prices paid by EU float glass producers are also reflected in the box plots presented in Figure 13. The median price is increasing, and confirms that EU prices of natural gas are on the rise. In 2010 the median price was 23.8 €/MWh, while in 2012 it rose to 30.0 €/MWh (+26%). Additionally, the increasing inter-quartile range[15] (IQR) illustrates that the gap of prices paid by EU float glass producers is also growing. Figure 13 also describes maximum and minimum prices paid for different producers in the sample 2010-2012. The price gap between the maximum and minimum price has increased during the period from 9 €/MWh in 2010 to 12 €/MWh in 2012.

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

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



Source: Authors' own calculations based on questionnaires.

1.6.2.2 Regional differences

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

Western Europe

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

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

Southern Europe

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

Eastern Europe

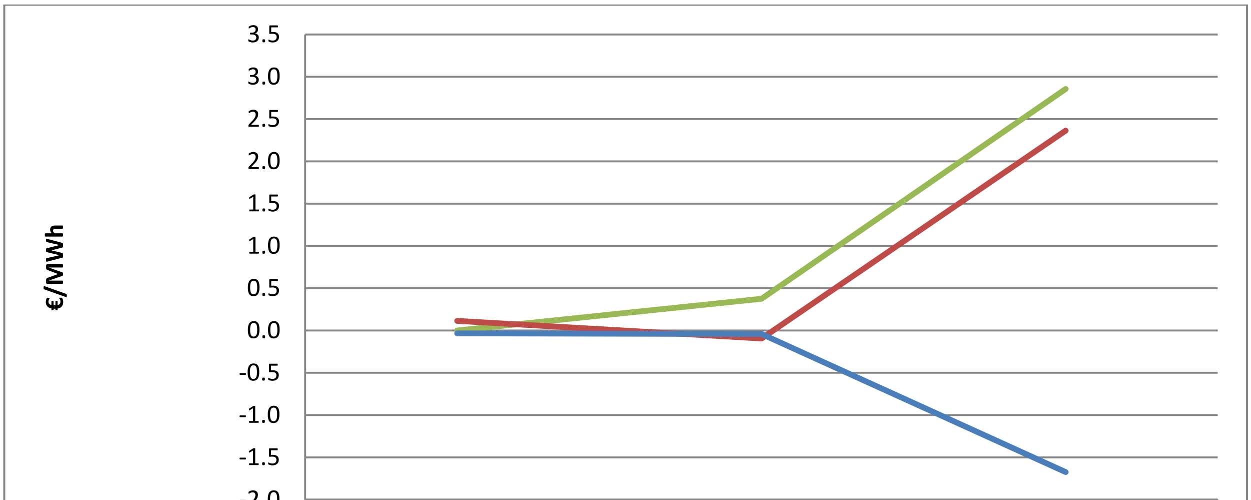
The average price on natural gas for Eastern European plants on average increased from 23.8 €/MWh in 2010 to 32.7 €/MWh in 2012 (+37%). The development is similar to the one in Southern Europe, with a fairly stable rate of increase, from 14% in 2010-2011 to 20% 2011-2012.

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

Regional gaps

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

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



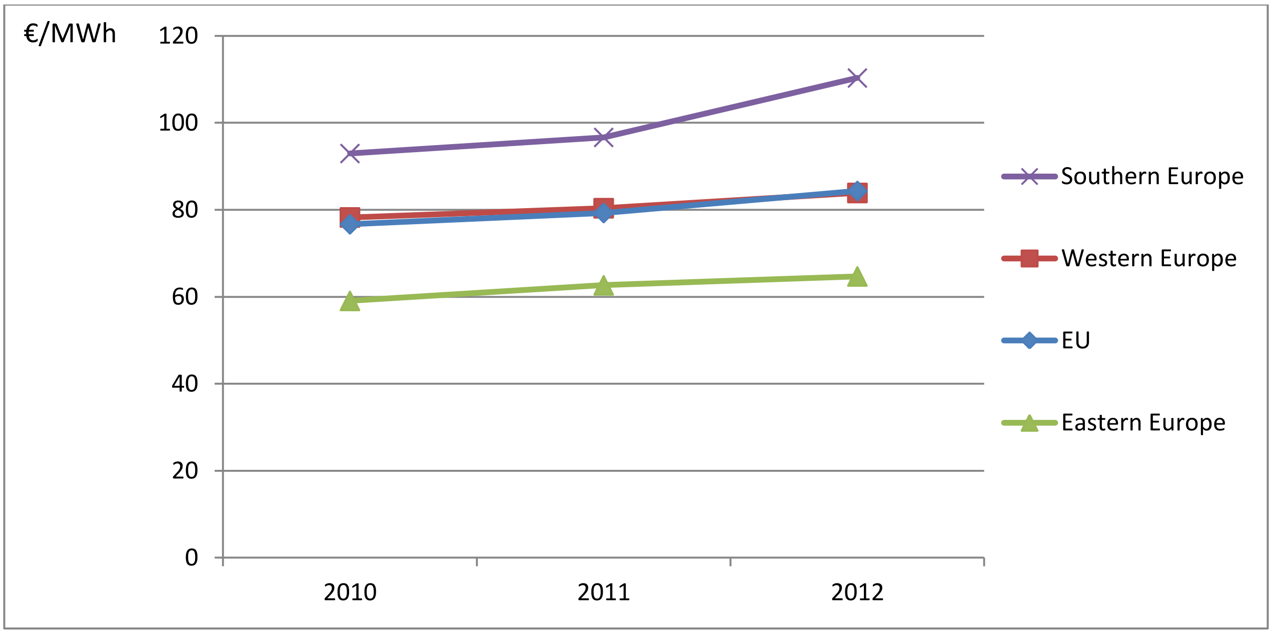
	2010	2011	2012
Southern Europe	0.0	0.4	2.9
Eastern Europe	0.1	-0.1	2.4
Western Europe	0.0	0.0	-1.7

1.6.3 Electricity

1.6.3.1 General trends

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

Figure 15. Weighted average price electricity, €/Mwh



Source: Authors' own calculations based on questionnaires.

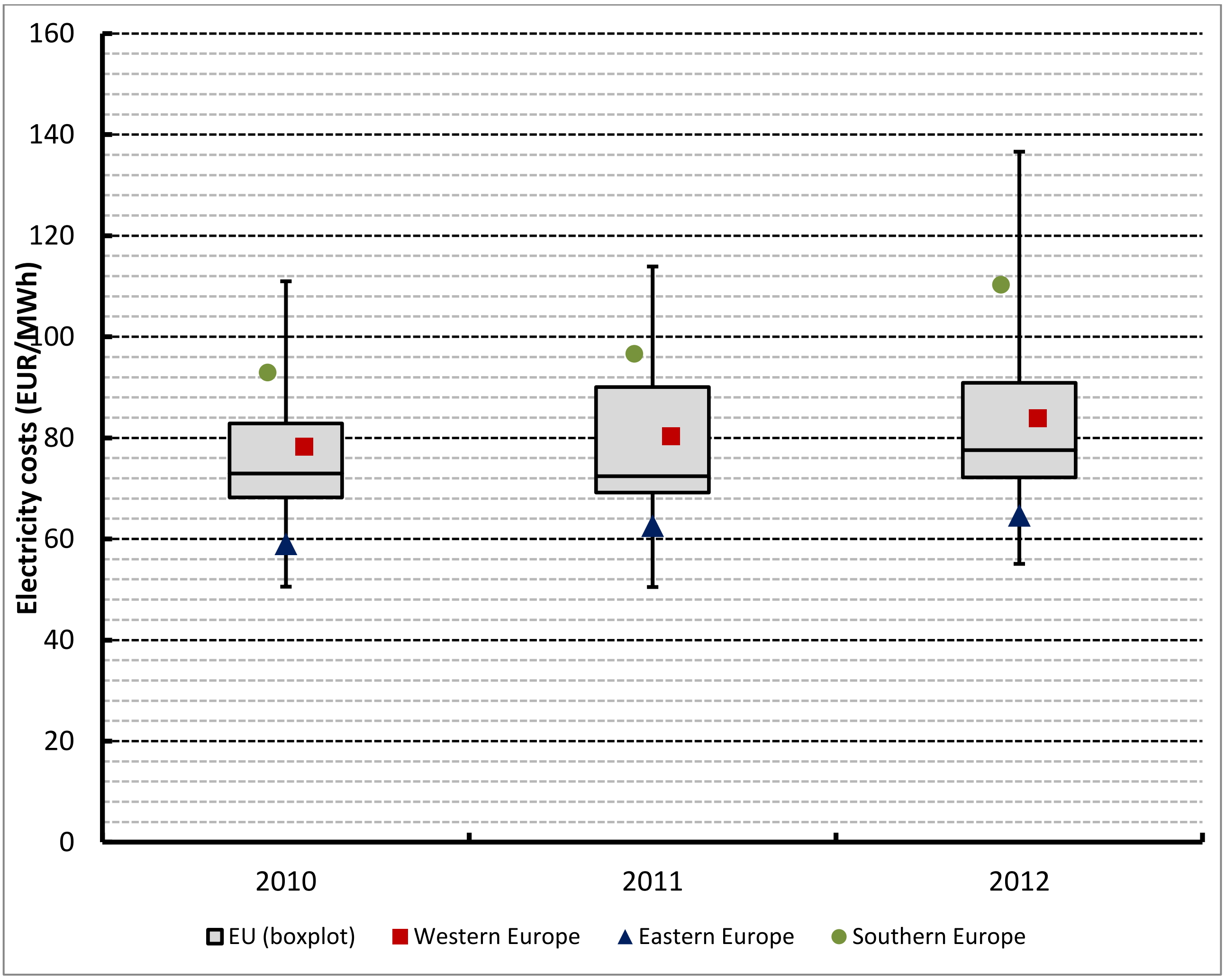
Table 12. Descriptive statistics for electricity prices paid by sampled EU float glass producers (€/MWh)

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

Source: Authors' own calculations based on questionnaires.

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

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



Source: Authors' own calculations based on questionnaires.

1.6.3.2 Regional differences

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

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

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

Western Europe

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

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

Southern Europe

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

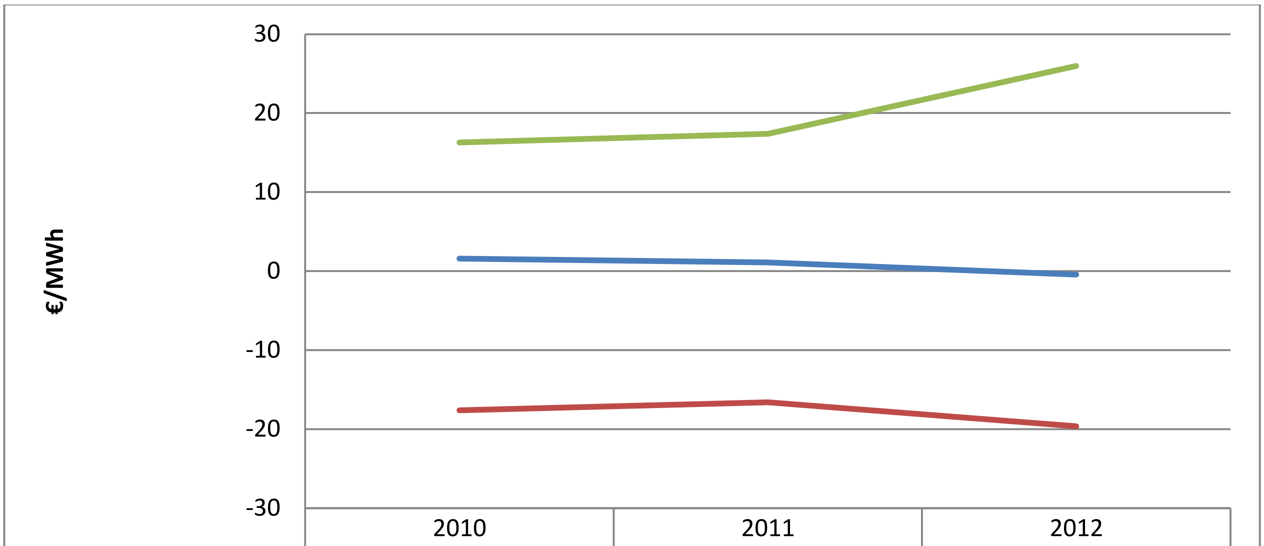
Eastern Europe

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

Regional gap

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

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



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

Source: Authors' own calculations based on questionnaires.

1.7 Analysis of the energy bills components

To better understand the price developments, the total costs for natural gas and electricity are broken into their components. For natural gas the components are grouped into: the energy component, grid fees and other levies and taxes (excluding VAT). For electricity, we include one additional component, the RES levy. Please note that the data presented in this section do not include all geographical regions. The sample in Southern Europe was too small to perform an analysis for this geographical region (see section 1.5.1).

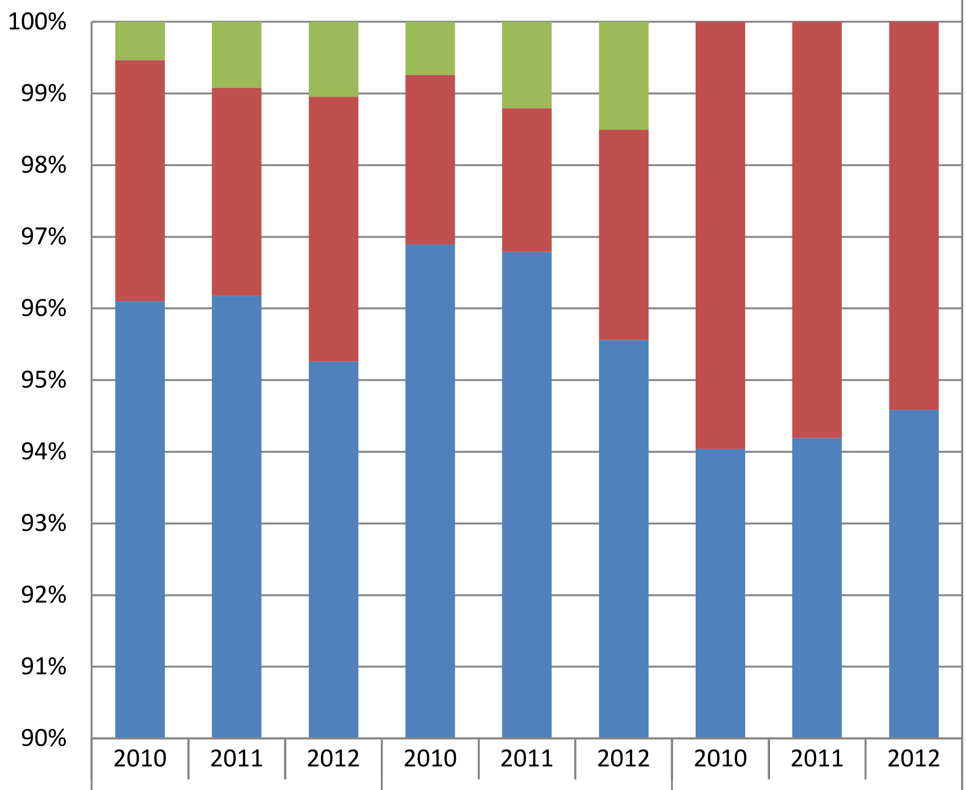
Moreover, all figures on energy costs in this section include possible exemptions from taxes, levies or transmissions costs.

1.7.1 Natural gas

1.7.1.1 General trends

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

Figure 18. Natural gas bill components, EU weighted average



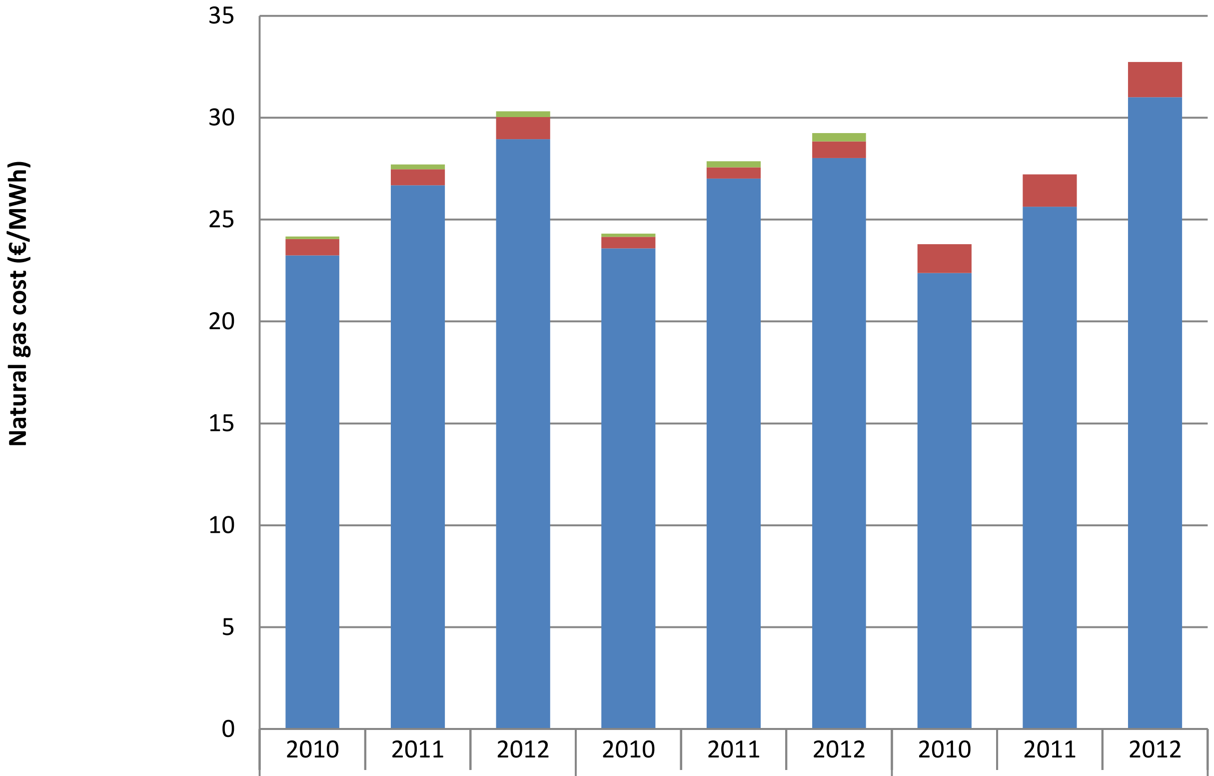
	EU 2010	EU 2011	EU 2012	Western Europe 2010	Western Europe 2011	Western Europe 2012	Eastern Europe 2010	Eastern Europe 2011	Eastern Europe 2012
Other (excl. VAT)	0.5%	0.9%	1.0%	0.7%	1.2%	1.5%	0.0%	0.0%	0.0%
Network cost	3.4%	2.9%	3.7%	2.4%	2.0%	2.9%	6.0%	5.8%	5.4%
Energy component	96.1%	96.2%	95.3%	96.9%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

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

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

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

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



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

Source: Authors' own calculations based on questionnaires.

1.7.1.2 Regional differences

Figure 18 and Figure 19 also show the breakdown of costs for Western Europe and Eastern Europe. The data presented in this section do not include Southern Europe since the data availability in this geographical region on the breakdown of costs was too limited (see section 1.5.1). On regional level, the following trends can be observed:

Western Europe

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

Eastern Europe

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

1.7.2 Electricity

1.7.2.1 General trends

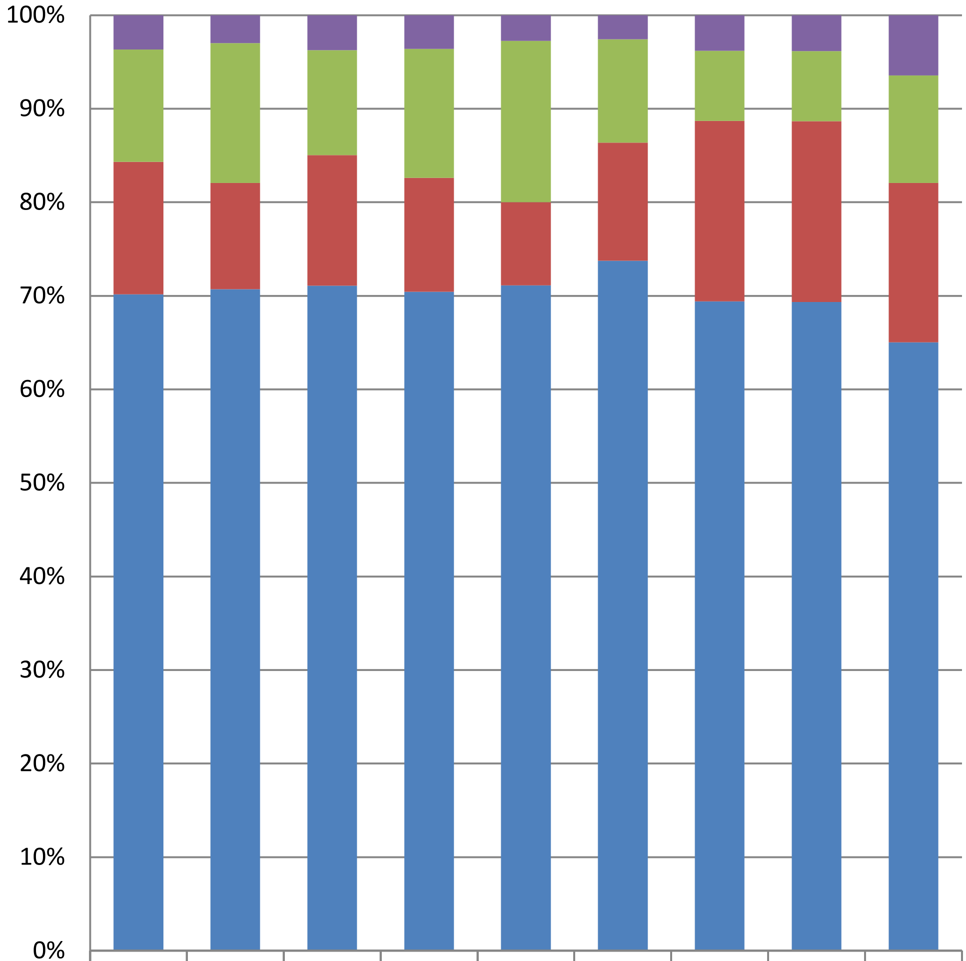
Similarly to natural gas, the energy component is the most significant component of the electricity prices paid by EU float glass plants (see Figure 20). In comparison to natural gas, however, this component is less dominant. In absolute terms, the energy component increased from around 50.5 €/MWh to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

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

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

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

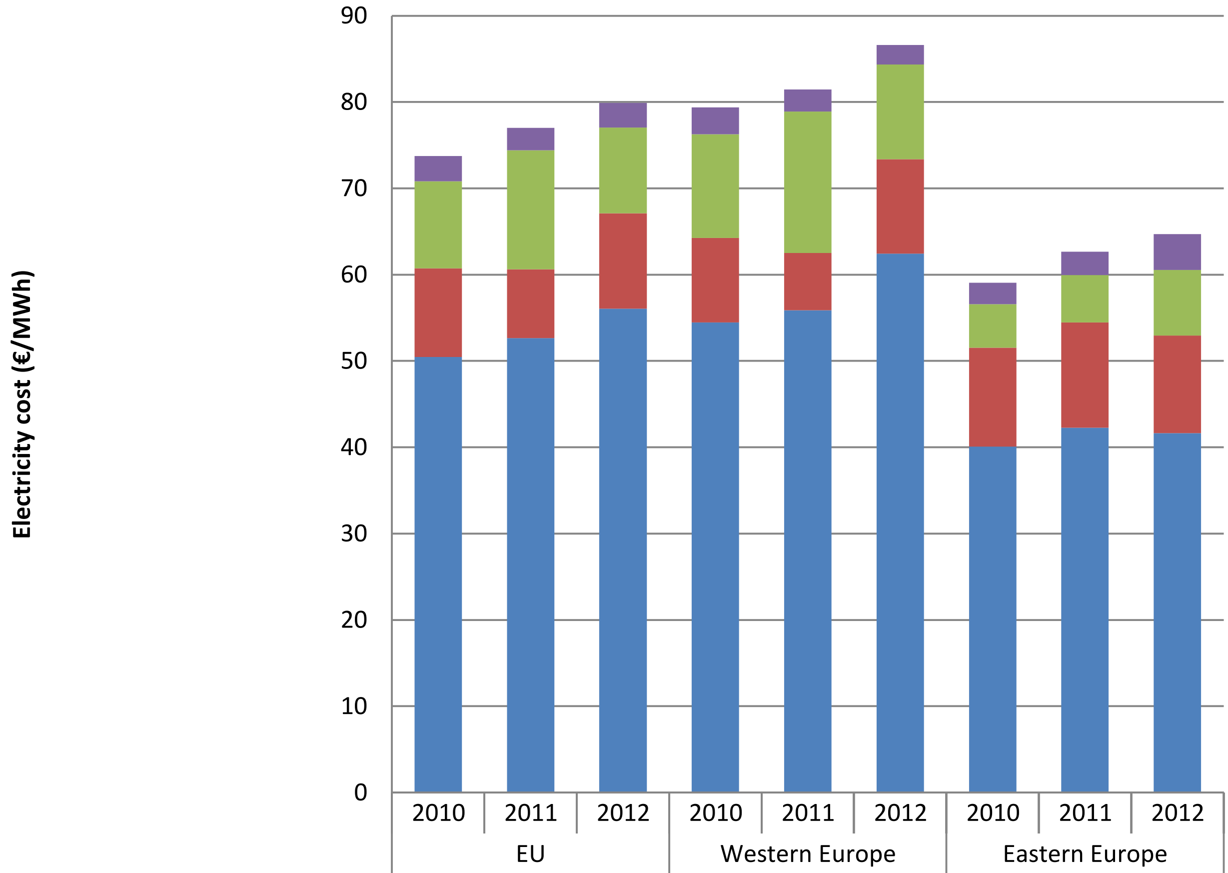
Figure 20. Electricity bill components, EU weighted average



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

Source: Authors' own calculations based on questionnaires.

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



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

Source: Authors' own calculations based on questionnaires.

1.7.2.2 Regional differences

Figure 20 and Figure 21 also show the breakdown of costs for Western Europe and Eastern Europe. The data presented in this section do not include Southern Europe since the data availability in this geographical region on the breakdown of costs was too limited (see section 1.5.1). On regional level, the following trends can be observed:

Western Europe

For Western Europe, the energy component has increased somewhat in importance (from 70% to 74%), which is above the EU average in 2012 (see Figure 20). It is also worth noting that some plants in Western Europe stand out with a share of the energy component above 80%, while one Western European plant had a share just under 60%. The grid fee was lower than the EU average and stable at around 12-13% as a share of the electricity bill when comparing 2010 and 2012. The large drop in the grid fee's share of the electricity bill in 2011 was mainly due to an increased share of the RES levies for that year.

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

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

Eastern Europe

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

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

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

1.8 Energy efficiency

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

1.8.1 General trends

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

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

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

1.8.1.1 Energy intensity (natural gas and fuel oil)

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

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

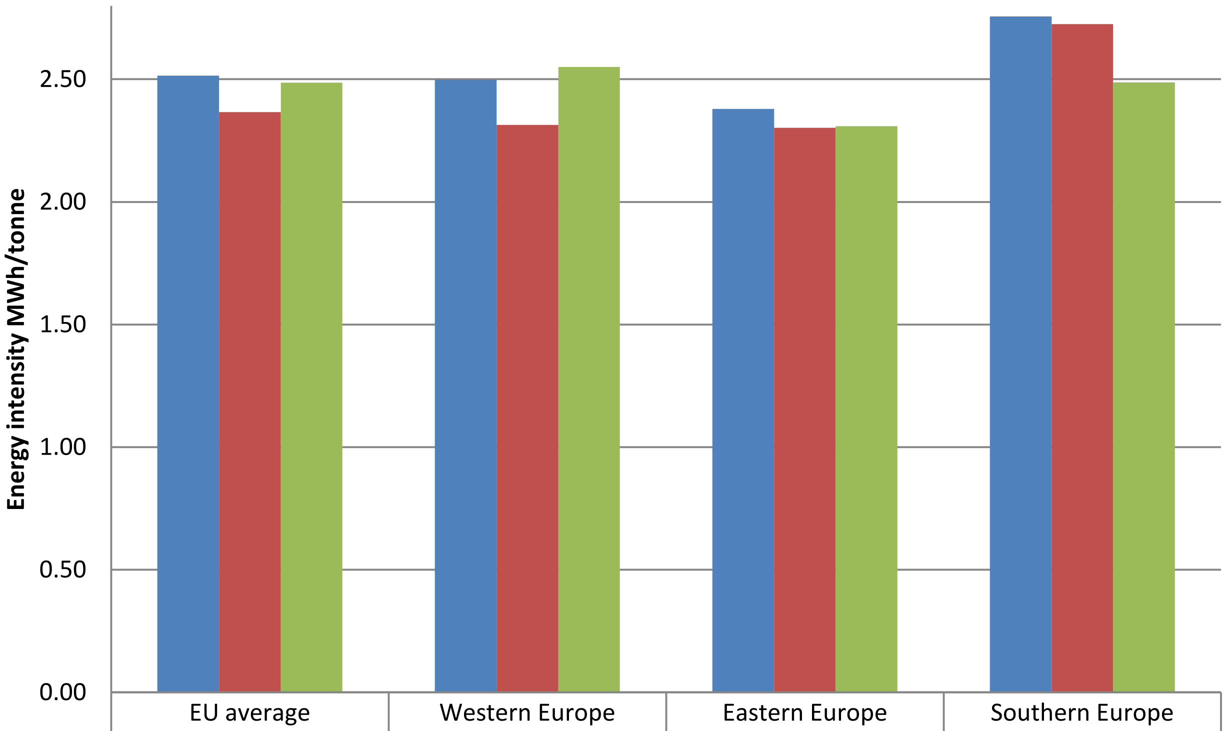
Figure 22 also illustrates regional differences in energy intensity.

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

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

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

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



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

1.8.1.2 Electricity intensity

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

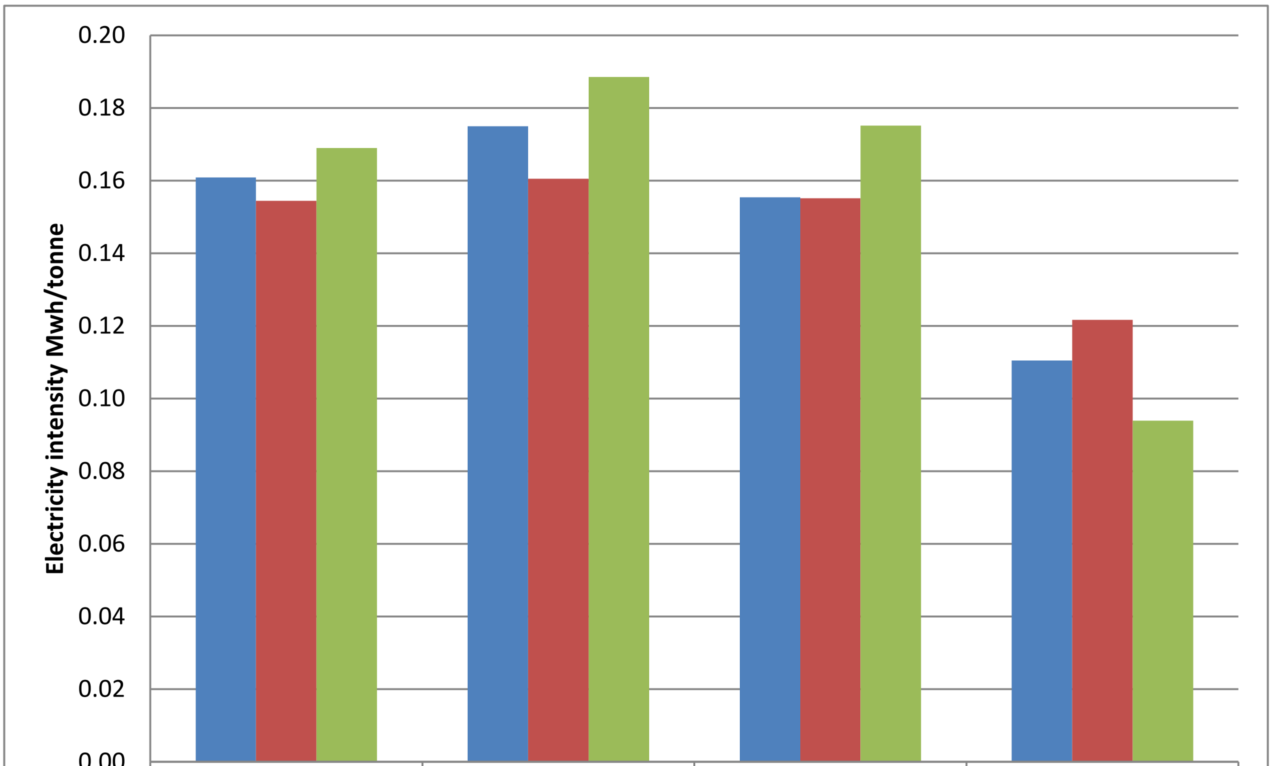
Figure 23 also illustrates geographical differences in electricity intensity.

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

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

Southern Europe had the lowest electricity intensity compared to the other regions. On average, electricity consumption during the time period decreased from 0.11 MWh/tonne in 2010 to 0.09 MWh/tonne in 2012 (-15%). It is also worth mentioning that this is the region with the highest electricity price (see Figure 15).

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



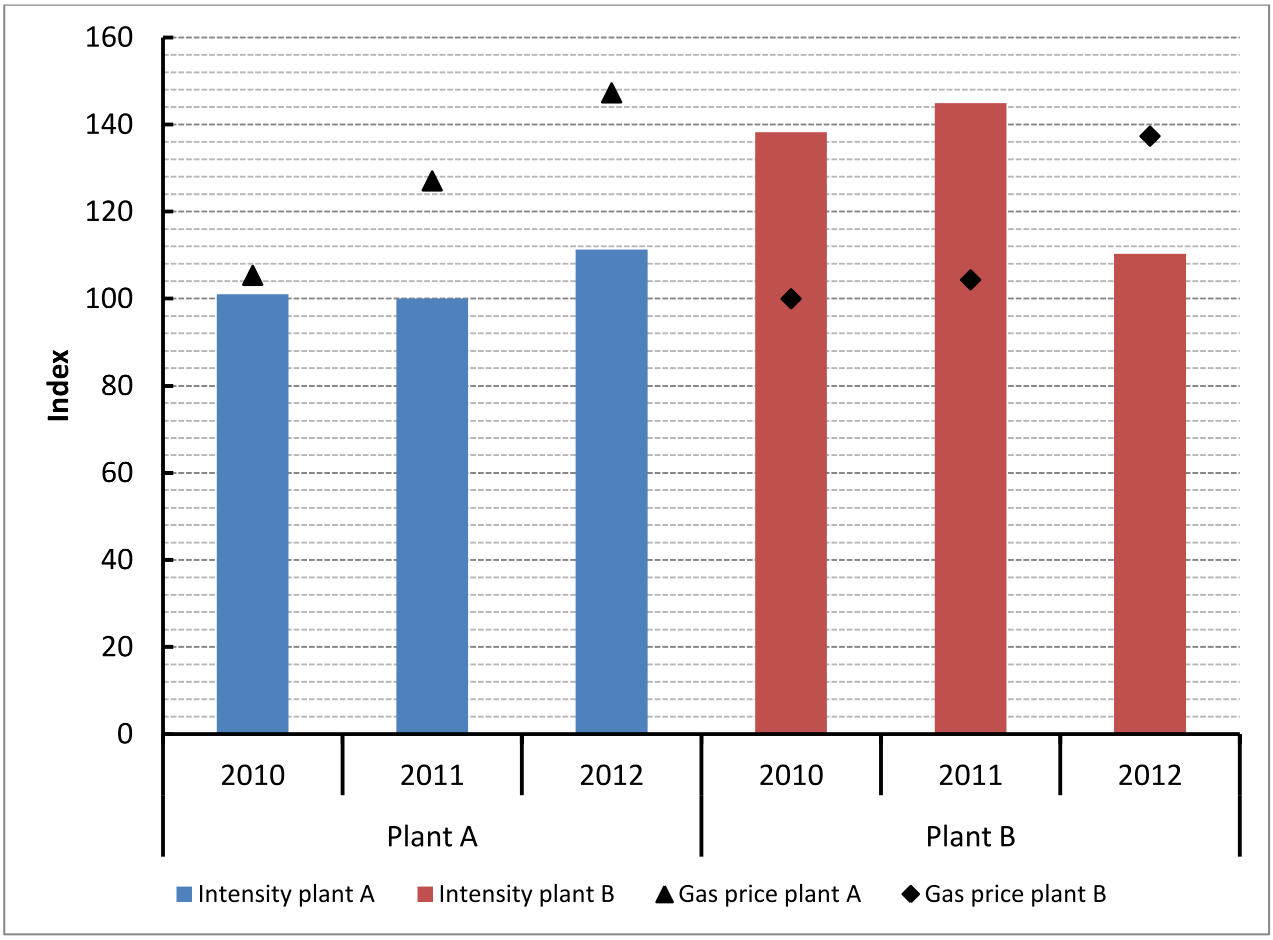
	EU average	Western Europe	Eastern Europe	Southern Europe
2010	0.16	0.17	0.16	0.11
2011	0.15	0.16	0.16	0.12
2012	0.17	0.19	0.18	0.09

1.8.2 Case studies

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

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

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



1.9 Indirect ETS costs for the Glass Sector

1.9.1 Sample

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

As described in section 1.5.3, the calculation of indirect ETS costs for the float glass industry was based on the electricity consumption figures provided by the sampled EU float glass producers as well as on the regional emission intensity of electricity generation and price of emission allowances. Tables 13, 14 and 15 summarise the indirect costs borne by EU float glass producers with different pass-on rates (0.6, 0.8 and 1.0).

1.9.2 Results

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

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

Pass-on rate: 0.6

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

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

Pass-on rate: 0.8

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

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

Pass-on rate: 1

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

There are large inter-regional differences in indirect costs, caused by two distinct factors. First the maximum regional CO_2 emissions factor[17], which is lowest in Southern Europe and highest in Eastern Europe.

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

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

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

1.9.3 Key findings

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

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

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

1.10 Production costs and margins

1.10.1 General figures

This section presents an analysis of the production costs and margins for EU producers of saleable float glass[18]. As already pointed out, 7 plants provided complete data on production costs and 4 plants provided data on financial indicators (e.g. EBITDA). To allow for a comparison between the various indicators, the research team proceeded with a reduced sample size of 4 plants. Validating the data provided by the producers was not possible.

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

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

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

- EBITDA,[19] i.e. the difference between plant market price and production costs, excluding capital costs;
- EBITDA over turnover (unit: %).

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

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

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

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

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

1.10.2 Impact of energy costs on production costs

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

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

Table 17. Impact of energy costs on production costs (melted and saleable float glass), 2010-2012[20]

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

Source: Authors' own elaboration.

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

1.11 General impressions

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

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

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

A number of plants in the sample stated that they were not entitled to any exemptions/reductions from network tariffs, taxes or levies. Some of the respondents described that they were entitled to certain reductions, without providing extensive details. A limited number of plants, however, gave a detailed description of the energy exemptions and reductions they were entitled to, for every year in the studied time period.

[20] The figures on energy costs on production cost is an average for the four plants that provided data on production costs and margins, such as EBITDA, as described in section 1.10.1.

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

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

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

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

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

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