Methodology for the free allocation of emission allowances in the EU ETS post 2012

Sector report for the glass industry

November 2009

Ecofys (project leader)
Fraunhofer Institute for Systems and Innovation Research
Öko-Institut

By order of the European Commission

Study Contract: 07.0307/2008/515770/ETU/C2
Ecofys project Number: PECSNL082164

Disclaimer and acknowledgements

Disclaimer

The views expressed in this study represent only the views of the authors and not those of the European Commission. The focus of this study is on preparing a first blueprint of an allocation methodology for free allocation of emission allowances under the EU Emission Trading Scheme for the period 2013 – 2020 for installations in the glass industry. The report should be read in conjunction with the report on the project approach and general issues. This sector report has been written by the Fraunhofer Institute for Systems and Innovation Research.

Acknowledgements

The authors would like to thank representatives from the glass industry for the in-depth discussions on possible benchmarking options for the glass industry during the execution of the project.

Table of content

1 Introduction

The glass industry can be subdivided into four subsectors namely hollow glass, flat glass, fibre glass and specialty glass. In terms of production volume, hollow glass and flat glass are by far the most important subsectors. The widest range of products can however be found in the category of specialty glass that covers also products like hand made glass jewellery or optical glasses.

In order to acquire information and data on the glass sector, the Fraunhofer Institute for Systems and Innovations Research (ISI) is in contact with CPIV, the Standing Committee of the European Glass Industries. CPIV is the umbrella association for national associations and the following glass federations:

- FEVE, the European Container Glass Federation
- GLASS FOR EUROPE, the European Flat Glass Federation
- APFE, the European Continuous Filament Glass Fibres Association
- ESGA, the European Special Glass Association
- EDG, the European Domestic Glass Association

In Annex I of the original and amended EU ETS Directive, *Manufacture of glass including glass fibre with a melting capacity exceeding 20 t per day* is listed. Table 1 gives an overview of the NACE classification of economic activities of this Annex I activity.

Table 1 Division of the glass industry according to Annex I of the amended Directive and corresponding activities in NACE Rev. 1.1 classification

Annex I activity	NACE code (Rev. 1.1)	Description (NACE Rev. 1.1)
Manufacture of glass including glass fibre with a melting capacity exceeding 20 t per day	26.11	Manufacture of flat glass
	26.12	Shaping and processing of flat glass[1]
	26.13	Manufacture of hollow glass
	26.14	Manufacture of glass fibres
	26.15	Manufacture and processing of other glass, including technical glassware

[1] Most of these installations with in this NACE sector are probably too small to be part of the ETS.

Information on the number of glass production installations in the EU 27 that are included in the ETS has been provided by (CPIV, 2009). An overview is given in Table 2.

Table 2 Overview of EU27 installations included in the ETS (CPIV, 2009)

Activity	**Number of ETS installations, EU27**
Manufacture of flat glass	60[1]
Manufacture of bottles & jars and flaconnage	170[2]
Manufacture of tableware	63
Manufacture of continuous filament fibre	16[3]
Manufacture of specialty glass products	?[4]

[1] 50 out of these 60 installations use the float process (58 float lines). The 10 remaining installations: rolling or casting process.
[2] Preliminary estimation. Of these around 20 may be flaconnage and another 20 jars.
[3] 16 installations, containing 33 furnaces; CPIV members only. CPIV members are estimated to include > 90% of EU27 filament fibre production. CPIV is aware of two more EU27 installations, one in Poland and one in Romania.
[4] No information available, since most of the specialty glass producing companies are not members of CPIV.

In terms of production volume, hollow glass and flat glass are with production volumes of 22.4 Mt hollow glass and 10.3 Mt flat glass in 2007 by far the most important products. Data on 2007 production volume, GHG emissions and power consumption has been provided by (CPIV, 2009). An overview of the direct GHG emissions of the sector is given in Table 3 and an overview of the sector's electricity consumption in Table 4. All data in the two tables are preliminary estimations and not definite.

Table 3 EU27 Production volume and GHG emissions of the year 2007 from the glass production chain (CPIV 2009; calculations by Fraunhofer ISI)

Activity	**Production volume EU27 (Mt)**	**Approx. specific emissions (kg CO_2/t product)[1]**	**Approx. direct emissions (Mt of CO_2-eq.)**
Manufacture of flat glass	10.26[2]	677	6.95[3]
Manufacture of bottles & jars and flaconnage	22.4[4]	518[5]	11.6[6]
Manufacture of tableware	?	?	
Manufacture of continuous filament fibre[7]	0.9	0.78	0.7
Manufacture of specialty glass products	?	?	?
Total	**?**	**?**	**?**

[1] Calculated from the production volume and the overall emissions
[2] 2007 data from Eurostat
[3] 2008 emissions data. Data from 2007 are expected to be slightly higher.
[4] Preliminary estimation.
[5] Calculated from emissions including tableware.
[6] Number is taken from CITL and displays an aggregated figure for the container glass, flaconnage and tableware sector.
[7] Preliminary results from NERA study and TNO study

Table 4 EU27 Production volume, and electricity consumption 2007 from the glass production chain (CPIV 2009; calculations by Fraunhofer ISI)

Activity	**Production volume EU27 (Mt)**	**Approx. specific power consumption (kWh/t product)**[1]	**Approx. power consumption (GWh)**
Manufacture of flat glass	10.26[2]	203	2083[3]
Manufacture of bottles & jars and flaconnage	22.4[4]	372[5]	8333[5,6]
Manufacture of tableware	?		
Manufacture of continuous filament fibre[7]	0.9	1110	999
Manufacture of specialty glass products	?	?	?
Total	**?**	**?**	**?**

[1] Calculated from the production volume and the overall emissions
[2] 2007 data from Eurostat
[3] Preliminary result calculated by NERA Economic Consulting; to be taken as an order of magnitude, rather than a precise figure.
[4] Preliminary estimation.
[5] Aggregated figure for the container glass, flaconnage and tableware sector
[6] Preliminary result calculated by LCA consulting; to be taken as an order of magnitude, rather than a precise figure
[7] Calculated from emissions including tableware

2 Production process and GHG emissions

2.1 Description of the production process

Glass production comprises the process steps ‘batch mixing and preparation’, ’melting’, ’homogenization and refining’, ’forming’ and eventually ’annealing’ and ’surface treatments’.

During the batch mixing and preparation step, silica (high quality sand), soda (Na_2CO_3) and potash are blent. Lime (CaO), magnesium oxide (MgO) and aluminium oxide (Al_2O_3) are added as stabilizers in order to reduce weathering of the glasses. Some refining agents like sodium, potassium and calcium sulphate or sodium and potassium nitrate help to remove the bubbles, arising during the melting step. Finally, small quantities of other additives are added in order to give to the individual glasses their desired characteristics.

Following the glass batch mixing and preparation step, the raw materials are transported to the furnace, where melting, homogenization and refining take place. Thereafter, the glass is formed. Forming of flat glass is usually practiced by the float or rolled glass process, while hollow glasses are formed by different blowing and pressing methods. Once the desired form is obtained, glass is usually annealed for the removal of stresses. Surface treatments, coatings or lamination may follow in order to improve the chemical durability, strength or optical properties.

Technologies for the Manufacturing of Glass

There is a wide range of melting techniques applied in the glass industry that vary from small electrically heated furnaces to large cross-fired regenerative furnaces e.g. in the flat glass manufacturing industry. The application of a specific technology depends on several influencing factors such as the required furnace capacity, chemical formulation of the glass, choice and prices of fuels, existing infrastructure and environmental performance (BREF Glass-draft, 2009, p. 43). The Reference Document on Best Available Techniques in the glass manufacturing industry (BREF Glass-draft, 2009) gives an estimation of the EU15 furnace types in 1997 (see Table 5, next page). The data given does however not allow differentiating amongst the different products of the glass industry.

Furnaces for the production of glass are usually constructed to continuously melt large volumes of glass. The uninterrupted operation period can last up to twelve years.

The output of furnaces has a wide range from 20 t of glass per day to more than 600 t per day. Generally, large installations with a capacity of more than 500 t/day use cross-fired regenerative furnaces. For medium-sized installations with a capacity in the range of 100 to 500 t/day end-fired recuperative unit melters are the most common choices but cross-fired regenerative, recuperative unit melters and in some cases oxy-fuel or electric melters may also be used.

Table 5 Estimates on the types of furnaces in the EU in 2005 (BREF Glass-draft, 2009, p. 43)

Type of furnace	**Number of units**	**Melting capacity (kt/y)**	**Average melting capacity (t/d)**
End-fired	225	16100	196
Cross-fired	145	20300	384
Electric	43	800	51
Oxygen	35	1600	125
Recuperative	120	3300	75
Others	60	900	41
Total	**628**	**43000**	**188**

Oxy-fuel melting is based on the combustion of fuels with mostly pure oxygen instead of regular combustion air. Although this technology requires an energy intensive production of pure oxygen it is still beneficial as it reduces the volume of waste gases by about two thirds and avoids the heating of the nitrogen contained in the air. Oxy-fuel melters do not apply heat recovery systems.

Electric furnaces are built as a box shaped container lined with refractory materials. Electrodes are inserted usually from the bottom of the furnace. Energy is provided through resistive heating as the current flows through the molten glass. Electric melting is used in smaller units as the thermal efficiency of fossil fuel fired furnaces decreases with unit size. According to the BREF Glass-draft (2009), p. 48, the thermal efficiency of electric furnaces is two to three times higher than that of fossil fuel fired furnaces. The choice of electric furnaces is economically and technically only appropriate under specific circumstances like low electricity prices, small furnaces, low electric resistance of the glass, etc.

Apart from these furnace types there are also furnaces with combined fossil fuel and electric melting, furnaces for discontinuous batch melting and furnaces with special melter design. The addition of electric boosting to fossil fuel fired furnaces is done to increase the output capacity and to meet fluctuating demand. Discontinuous batch melting and special designs are applied for smaller production volumes.

2.2 Direct emissions and heat recovery

Direct CO_2 emissions result from process emissions as well as from fossil fuel combustion. Process emissions occur due to the decarbonisation of the carbonate raw material in the process input, mainly sodium carbonate Na_2CO_3, limestone $CaCO_3$ and dolomite $CaMg(CO_3)_2$. An overview of the shares of process emissions on the one and emissions due to energy requirements on the other hand is given for different glass producing sectors in

Table 6 Shares of process emissions and emissions due to energy requirements from total direct emissions for different glass producing sectors (CPIV, 2009)

Sector	**Share of direct emissions due to energy requirements**	**Share of process emissions**
Flat glass[1]	73.5 %	26.4 %
Container glass[2]	85 - 90 %	10 - 15 %
Continuous filament fibre[3]	85 - 90 %	10 - 15 %

[1] Preliminary result calculated by NERA Economic Consulting
[2] Estimation of CPIV
[3] Preliminary result calculated by LCA consulting; to be taken as an order of magnitude, rather than a precise figure

The Reference Document on Best Available Techniques in the glass manufacturing industry (BREF Glass-draft, 2009, p. 87) indicate that in general the energy necessary for the melting step accounts for over 75 % of the total energy requirements of glass manufacture. For the manufacture of container glass, the typical energy distribution is given as follows: furnace 79 – 82 %, forehearth 6 %, compressed air 4 %, lehr[1] 2 %, and others 6 %. The energy distribution of continuous filament fibre production in comparison is very different as there is no lehr, but the fiberising operation and the drying / curing ovens also consume significant amounts of energy. According to CPIV[2], the average split for continuous filament fibre installations constitutes: furnace 48 %, forehearths 17 % and downstream processes 34 %.

Heat recovery is applied by regenerative and recuperative furnaces. According to the Reference Document on Best Available Techniques in the glass manufacturing industry (BREF Glass-draft, 2009, p.88), all of the float glass furnaces are of the cross-fired regenerative design, which allow preheat temperatures of up to 1,400 ° C and high thermal efficiencies. The preheat temperatures of recuperative furnaces, used for smaller production volumes, are usually limited to 800 °C as metallic heat exchangers do not allow higher temperatures. The lower recovery temperatures compared to regenerative furnaces lead to a lower heat recovery rate. This can, however, be compensated by further recovery systems on the waste gases for the preheating of input materials or for steam production.

[1] A lehr is used to slowly cool down glass products under controlled conditions. The operation may require additional heat energy in order to avoid a temperature drop taking place too fast.
[2] Personal communication – CPIV via e-mail, 3rd of July 2009

3 Benchmarking methodology

3.1 Background

The products of the glass sector are covered by a total of 34 PRODCOM codes. A list of all PRODCOM codes of the sector is attached to this report (see appendix A). Hollow glass, flat glass and continuous filament fibre are the main product categories. Each of the three categories comprises several products, of which an overview is given in the following.

Hollow Glass

Products of the hollow glass industry can further be divided into container glass (bottles & jars), flaconnage and tableware. Bottles & jars comprise bottles for beverages as well as wide neck jars for industrial purposes which are considered as commodities. Higher value containers for medicines and perfumes are categorised as flaconnage. Products of the tableware sector are domestic glass products and show a wide product variety.

Flat Glass

About 90 % of the world's flat glass is produced as float glass, going mainly into the building industry (75 % to 85 % of the output) and into the car manufacturing industry (15 to 25 % of the output). The majority of rolled glass is produced as patterned glass or wired glass. In addition, a new product "low iron glass for photovoltaic cell manufacture" has been emerging in the last years. A number of furnaces have been modified to produce this material of increasing importance.

Continuous Filament Fibre

Continuous filament fibres are especially used for the production of composite materials like fibre-reinforced plastics. Glass wool is usually categorized in another product group (see the sector report on mineral wool). Continuous filament fibre is generally manufactured from a glass melt in either cross-fired recuperative furnaces that are employing fossil fuels to supply the melting energy or oxy-fuel fired furnaces, generally using natural gas. In the year 2007, about 55 % of continuous filament fibre furnaces were oxy-fuel fired with some of them also applying electric boosting. As the production volume of continuous filament fibre is lower than that of the large bulk materials (hollow glass, flat glass), smaller furnaces are used. The use of regenerative furnaces is technically unfeasible. Most commonly, an E glass[3] formulation is employed for continuous filament fibre. With a low electrical conductivity of E glass, electrical melting is not seen as efficient process for continuous filament fibre production.

In the glass industry statistics, two types of data can be used. One is glass melted, which is the actual output coming directly from the glass furnace. The other is glass packed, which is always a lower amount than the glass melted due to losses in the post processing. Any process losses can normally be recycled as internal cullet in the flat and hollow glass subsectors.

[3] E glass has a chemical composition that is largely free of alkaline elements. The formulation is defined by Standard ASTM D578 and based on the following main oxides: Silica, calcium, alumina, boron and magnesium.

Applying a benchmark on the glass packed would put a higher emphasis on energy and emissions efficiency than applying a benchmark on melted glass, by taking into account the possibility to improve on the quality of the production process, which is in accordance with the approach to apply the benchmark to the final product. Basing benchmarks on the glass melted has the advantage that this amount is under rigorous monitoring from the manufacturers. However, although the practicability of a benchmark based on melted glass could be higher, we suggest using packed glass as activity indicator because of the higher emphasis on emission efficiency.

Cast/rolled glass on the one hand and float glass on the other hand can be considered as two distinct types of products, which are not necessarily interchangeable in their usage, since the majority of rolled glass is produced as patterned or wired glass. The two types of products are produced in different installations, not using the same processes and tools. Emission factors for these different manufacturing processes show that different energy intensities and direct GHG emissions are implied. On average, direct GHG emissions per t of rolled glass packed are more than 35% higher than for float glass (CPIV, 2009)[4].

Although uniformly belonging to the hollow glass sector, products from the categories bottles & jars, flaconnage and tableware can be considered as distinctly different. CO_2 emissions of the production of flaconnage products are higher in comparison to bottles and jars due to higher glass quality and more downstream activities (decorating with enamels, colouring, flame polishing, cutting and graving, sticking, painting). Due to the wide variety of tableware products it could even be considered, if accounting tableware products as specialty products would be a more sensible approach. A decision on this issue can however only be taken after separate data for bottles & jars, flaconnage and tableware will be made available. In case that jars, flaconnage and tableware are to be considered separately, the question is still to be raised whether there are enough installations to perform benchmarking.

The products from the continuous filament fibres sector comprise two subgroups, namely on the one hand chopped strands, rovings, yarns and staple fibre articles that are covered by PRODCOM codes 26.14.11.10 – 26.14.11.70 (accounting for roughly 85% of the overall production[5]) and on the other hand various types of mats and voiles or veil articles covered by PRODCOM codes 26.14.12.10 – 26.14.12.95. Those two categories are produced through the same initial process steps to obtain basic filament fibres (namely batch mixing, glass melting and refining, fiberising and sizing application) and differ in the downstream processes applied to obtain the final commercial articles. The downstream process to obtain “mat and voiles” articles consists of the application of a coating (wet application) on the formed mat followed by drying and curing (in gas fired ovens) and account for up to 40 % of the total direct emissions of the production process. The downstream processes applied in the first product category are however less direct CO_2 intensive and account for roughly 20 % of the overall emissions. Two distinct benchmarks for continuous filament fibre products could therefore be justified provided supporting statistical data can be obtained. In case of statistical limitations to have two distinct benchmarks, the default option would be to group all continuous filament fibre products into one single product category.

---

[4] Personal communication – CPIV via e-mail, 3rd of July 2009
[5] Personal communication – CPIV via e-mail, 17th of May 2009

CPIV proposes to establish the following ten benchmark groups for the glass industry.

Table 7 Benchmark categories as proposed by CPIV (2009) and corresponding PRODCOM codes

Benchmark group	Product	Corresponding PRODCOM codes
1	Cast / Rolled glass	26.11.11.13 26.11.11.15 26.11.11.30 26.11.11.50
2	Float glass	26.11.12.12 26.11.12.14 26.11.12.17 26.11.12.30 26.11.12.80
3	Bottles of colourless glass and glass containers	26.13.11.10 26.13.11.16 26.13.11.22 26.13.11.28 26.13.11.40
4	Bottles of coloured glass	26.13.11.34
5	Glass containers for pharmaceutical products	26.13.11.46
6	Flaconnage	26.13.11.52
7	Soda-lime drinking glasses	26.13.12.40 26.13.12.60
8	Tableware & Cookware (different glasses, excluding soda-lime drinking glasses)	26.13.12.80 26.13.13.30 26.13.13.50 26.13.13.60 26.13.13.90 26.13.14.00
9	Continuous filament fibres chopped stands, rovings, yarns and staple fibre articles	26.14.11.10 26.14.11.30 26.14.11.50 26.14.11.70
10	Continuous filament fibres mats and voiles articles	26.14.12.10 26.14.12.30 26.14.12.50
-	Drawn sheet or blown glass[1]	26.11.11.75 26.11.11.79

[1] No benchmark is necessary since there is only one installation in Europe and this installation is not part of the ETS

We will use this product differentiation as proposed by (CPIV, 2009) as a starting point. To the present we disagree, however, with a further sub-division of the three main product groups "hollow glass", "flat glass" and "continuous filament fibres", since significant differences in emission intensity of the product subgroups due to distinctly different product characteristics could not be proven with data.

3.2 Final proposal for products to be distinguished

We propose to determine benchmarks on the packed output of three product categories:

Table 8 Overview of the benchmark products of the glass sector and their corresponding PRODCOM codes

Benchmark group	Product	Corresponding PRODCOM codes
1	Flat glass (With possible further subdivision into “Cast/Rolled glass” , “Drawn sheet or blown glass” and “Float glass”)	26.11.11.13 26.11.11.15 26.11.11.30 26.11.11.50 26.11.11.75 26.11.11.79 26.11.12.12 26.11.12.14 26.11.12.17 26.11.12.30 26.11.12.80
2	Hollow glass (With possible further subdivision into “Bottles of colourless glass and glass containers”,” Bottles of coloured glass”, “Glass containers for pharmaceutical products”, “Flaconnage”, “Soda-lime drinking glasses”, “Tableware & Cookware (different glasses, excluding soda-lime drinking glasses)”	26.13.11.10 26.13.11.16 26.13.11.22 26.13.11.28 26.13.11.40 26.13.11.34 26.13.11.46 26.13.11.52 26.13.12.40 26.13.12.60 26.13.12.80 26.13.13.30 26.13.13.50 26.13.13.60 26.13.13.90 26.13.14.00
3	Continuous filament fibre (With possible further subdivision into “Continuous filament fibres chopped stands, rovings, yarns and staple fibre articles” and “Continuous filament fibres mats and voiles articles”)	26.14.11.10 26.14.11.30 26.14.11.50 26.14.11.70 26.14.12.10 26.14.12.30 26.14.12.50

The share of downstream processes (following the melting step) in energy consumption in the glass industry is significant and varies between roughly 20% for container glass and 40% for some special kinds of continuous filament fibre production. Downstream processes should therefore, as far as possible, be taken into account for the benchmarks. It will be essential for benchmarking purposes to define which downstream processes will be included in each of the benchmarks.

Because of the wide variety of products from the specialty glass sector, having distinctly different characteristics such as product form, size, and field of application, we do not consider a benchmark approach advisable for this product group. An overview of the PRODCOM codes of specialty glass products is given in Table 9.

Table 9 Overview of the products of the specialty glass sector and their corresponding PRODCOM codes

Description	**Corresponding PRODCOM codes**
Glass in sheets, bent, edge-worked, engraved, drilled, enamelled or otherwise worked, but not framed or mounted	26.12.11.50 26.12.11.90
Safety glass	26.12.12.15 26.12.12.19 26.12.12.30 26.12.12.53 26.12.12.55 26.12.12.70
Glass mirrors; multiple walled insulating units of glass	26.12.13.30 26.12.13.50 26.12.13.90
Glass in the mass, in balls (except microspheres), rods or tubes, unworked; waste and scrap of glass	26.15.11.10 26.15.11.30 26.15.11.50
Paving blocks... of glass, for building or construction purposes, n.e.c.	26.15.12.00
Open glass envelopes for electric lamps, cathode-ray tubes or the like	26.15.21.00
Clock or watch glasses, glasses for spectacles, not optically worked	26.15.22.00
Laboratory, hygienic or pharmaceutical glassware; ampoules of glass	26.15.23.30 26.15.23.50
Glass parts for lamps and lighting fittings, etc.	26.15.24.00
Electrical insulators of glass	26.15.25.00
Articles of glass n.e.c.	26.15.26.30 26.15.26.50 26.15.26.70 26.15.26.90

4 Benchmark values

4.1 Background and source of data

The use of cullet rather than mineral raw materials is an effective measure of reducing CO_2 emissions from glass manufacture since the energy demand for the endothermic chemical reactions of the glass formation is saved, the melting point of cullet is lower than that of mineral raw materials and the mass of feed per unit of output is 20% lower. It can be considered as a rough rule of thumb that a reduction by 2.5 to 3% of the furnace energy demand can be achieved per 10% of extra cullet input in the glass making process. Beyond the direct effect on energy demand and CO_2 emissions, a higher cullet use contributes to a reduced demand for raw materials, among which the most significant are carbonates such as soda ash, limestone and dolomite that decompose in the furnace releasing CO_2. Therefore, the addition of cullet reduces process emissions from these sources as well as the energy consumption during melting.

Cullet can be used to a higher degree in the manufacture of container glass than in the manufacture of flat glass and flaconnage. Flat glass and flaconnage products as well as extra-flint bottles require higher material qualities which can only be reached with a higher proportion of mineral raw materials. No cullet input at all is applied in the continuous filament fibres sector and in the production process of many special glass products for manufacturing process reasons (e.g. low alkali formulation for continuous filament fibres). Although the use of cullet constitutes a very efficient opportunity for emissions reduction (especially for container glass production), the collection rate of cullet is varying considerably across the European Union. The collection rates ranging from less than 10% to more than 90% clearly indicate that there is ample room for a higher use of cullet at least from the side of secondary material inputs. Availability of cullet is a crucial factor for individual plants that is strongly influenced by local and regional factors. Differences in existing Member State policies throughout the Community play a role. In the United Kingdom for example, obligations on recycling of packaging materials can be fulfilled by providing unsorted cullet to the construction industry as materials for road construction. This reduces the amount of available cullet for the glass manufacturing industry in the United Kingdom. Further, the quality requirements with respect to sorting of different glass colours implemented by the recycling policies are also influencing the availability of high quality cullet for the glass manufacturing industry. Furthermore, it has to be considered that installations producing glass of different colours cannot be compared in terms of cullet input. While for green glass, production cullet of almost any colour can be used, only white cullet input is possible for white glass production.

It could on the other hand be argued that with increasing market pull, induced by environmental policies and other mechanisms, a functional supra-regional cullet market will evolve also in those countries where it does not yet exist. Not accounting for cullet availability and colour will thus provide incentives for glass recycling and energy efficiency what is well in line with the purpose of the ETS.

Further differences in CO_2 emissions can be attributed to product quality, furnace capacity and choice of fuel. Natural gas is the predominant fuel for glass production, followed by oil products with an apparent growth of the share of natural gas in the recent years. Both fuels are interchangeable in the melting process. In discussions with glass industry representatives, technical advantages of using heavy fuel oil have however been claimed. As this fuel burns with a more luminous flame than natural gas, a deeper transmission of radiative heat into the mass of glass in the furnace could be reached. This, according to the stakeholders, leads to better results with respect to energy efficiency, but still to a worse performance regarding CO_2 emissions.

Since in the glass industry electric furnaces as well as fuel-based furnaces are operating, substitutability of electricity and fossil fuel might be an issue. Benchmark curves on direct emissions could therefore be dominated by the most electricity intensive instead of the most carbon efficient installations. Two solutions are possible for this problem (see Section 6.3 of the report on the project approach and general issues).

- Establishing a primary emissions benchmark curve that takes both direct emissions as well as the indirect emissions from electricity use in the melting furnace into account, using a uniform emission factor for electricity. In the allocation procedure, the resulting 'primary' benchmark needs to be multiplied with the plant-specific share of direct emissions to the total primary emissions. In order to avoid free allocation for electricity production, allocation should be limited to the level of historic direct emissions (Art. 10a (1) of the amended Directive.)
- Automatically using a fall-back approach (see Chapter 5 of the report on the project approach and general issues for products) where this problem occurs.

There is still a lack of data on the number of concerned electric furnaces in the different sectors of the glass industry. We recommend the primary emissions benchmark as the preferred choice. Alternatively (e.g. if the amount of emissions from electric furnaces is marginal), electric furnaces could be excluded from the benchmark curves and be covered by a fall-back approach (see Chapter 5 of the report on the project approach and general issues). Due to lack of data a decision on this issue could not yet be taken.

In how far product quality and the issue, whether further downstream activities are included in an installation or not, will cause larger spreads in the benchmark curves, could also not yet be investigated for lack of data.

Confidentiality is a major problem in the glass industry. In the flat glass industry for example, there are only four companies that control about 80% of the market for flat glass products (Pilkington, Saint-Gobain, Asahi with its European subsidiary AGC Flat Glass Europe and Guardian with its European subsidiaries). The high degree of industry concentration in the flat glass market leads to the effect that most of the relevant data on production volumes and input of energy carriers is publicly not available. Benchmark curves are therefore not accessible to CPIV; they are handled by an independent institute. The situation is similar for container glass and continuous filament fibres.

Stakeholders from the European flat glass association GLASS FOR EUROPE supposed nevertheless, that a benchmarking curve could eventually be made at the disposal of the project team following the signing of a confidentiality agreement and after an additional check by their competition lawyers. Today, GLASS FOR EUROPE can already provide some data that were collected by a third party fiduciary to guarantee that no single installation can be identified. An overview is given in Table 10.

For container glass, a questionnaire has been sent by an external consultant to companies across Europe in order to collect figures on greenhouse gas efficiency. Although those figures still have to be refined, average values for some products are given as a first indication in Table 10. Available data did however not allow distinguishing between “Glass containers for pharmaceutical products” and “Flaconnage” nor between “Soda-lime drinking glasses and Tableware & Cookware”. According to CPIV, the determination of the average of the 10% best performers can only be derived once clear indications about how to treat fuel mix, cullet level, outliers etc. will be known. No data on direct emission factors has been provided by stakeholders of the continuous filament fibres sector.

Table 10 CPIV data on the average of direct GHG emissions for the year 2008 (CPIV, 2009)

Product category	**No. of data installations**	**Average (kg CO_2/t product)**	**Range (kg CO_2/t product)**
Cast/Rolled glass	9[1]	952	740
Float glass	45[2]	697	681
Bottles of colourless glass and glass containers	56	500	480
Bottles of coloured glass	28	370	210
Glass containers for pharmaceutical products Flaconnage	16[3]	970	1210
Soda-lime drinking glasses Tableware & Cookware (different glasses, excluding soda-lime drinking glasses)	23[4]	1440	2610
Continuous filament fibre chopped strands, rovings, yarns and staple fibre articles	-	-	-
Continuous filament fibre mats and voiles articles	-	-	-

[1] Data from 9 installations out of an overall number of 10 installations in EU27
[2] Data from 45 installations out of an overall number of 50 installations in EU27
[3] Data is aggregated for ‘glass containers for pharmaceutical products’ and ‘flaconnage’. No separate data available.
[4] Data is aggregated for ‘soda-lime drinking glasses’ and ‘tableware & cookware’. No separate data available.

4.2 Final proposed benchmark values

With the data available to the present, the determination of benchmark values based on the average of the 10% most carbon efficient installations as prescribed by the amended Directive is not possible for any glass product. Indicative values based on Best Available Techniques will therefore be presented in this section. It has to be emphasised however that these values only represent orders of magnitude and shall give a rough idea of the actual final benchmark values.

Benchmark values for the glass sector based on Best Available Technique have been investigated by part of the consortium in a previous benchmark study in 2008 (Ecofys/Fraunhofer-ISI, 2009). The results are summarized in the following and an overview of the final derived benchmark values is given in Table 11.

- "The structure of the glass industry supports the formulation of three separate benchmarks for the hollow glass production, for the flat glass production and for the continuous filament fibre production and a fall-back approach (see Chapter 5 of the report on the project approach and general issues) for the specialty glass products not covered with these benchmarks.
- Natural gas is the dominant fuel followed by oil products with an apparent growth of the share of natural gas in the recent years.
- Specific data on the energy demand for most efficient technologies for glass making has not been found in the literature yet. Using examples of the most efficient technologies as found in literature results in a CO_2 emission benchmark for fuel combustion of 0.209 t CO_2/t melted hollow glass, of 0.336 t CO_2/t of melted flat glass and of 0.582 t CO_2/t melted continuous filament fibre.
- In addition to these fuel emissions, the best practice production of one t of melted hollow glass (with high share of cullet) results in process emissions of 0.016 t CO_2, and in 0.088 t CO_2 per t of melted flat glass and 0.120 t CO_2 per t of melted continuous filament fibre.
- The data for melted glass has to be corrected by the packed to melt ratio to result in benchmarks for the final product.
- The lack of verifiable data on emissions levels of most efficient technologies proves the need to further undertake investigations and examine the outcome of the revision process of the Reference document on Best Available Techniques in glass manufacturing.

Table 11 Overview of the final benchmark values based on BAT as derived in the 2008 benchmark study (Ecofys/Fraunhofer-ISI, 2009).

	Flat glass	**Hollow glass**	**Continuous filament glass fibre**
CO_2 emission benchmark for fuel combustion (t CO_2 / t melted glass)	0.336	0.209	0.582
CO_2 emission benchmark for process emissions (t CO_2 / t melted glass)	0.088	0.016	0.120
Total CO_2 emission benchmark (t CO_2 / t melted glass)	0.424	0.225	0.702
Assumed packed to melt ratio	70%	90%	70%
Total CO_2 emission benchmark (t CO_2 / t packed glass)	**0.606**	**0.250**	**1.003**

5 Additional steps required

In the chapters 3.1 and 4.1 several open issues have been mentioned on which to the present no decision could be taken due to lack of data.

1. For further work on a proposition of benchmark categories for the glass sector and for the determination of final benchmark values based on the average of the 10% most carbon efficient installations, benchmark curves for the individual subsectors will be required.

   In order to get a rough idea of the sector's performance, the information asked for in Table 12, i.e. information on the range of direct emissions for different product groups as well as on the spreads of the benchmark curves, could already help to investigate the number of benchmarks that are required for the glass industry.

Table 12 Overview of the factors reflecting the spread in the benchmarking curves for the different glass sectors

Product category	Range of direct emissions ($kg\ CO_2$/t of product)	Spread factor[1]
Cast/Rolled glass[2]	702 - 1450	2.1
Float glass[2]	511 - 1192	2.3
Bottles of colourless glass and glass containers	-	-
Bottles of coloured glass	-	-
Glass containers for pharmaceutical products	-	-
Flaconnage	-	-
Soda-lime drinking glasses	-	-
Tableware & Cookware (different glasses, excluding soda-lime drinking glasses)	-	-
Continuous filament fibre chopped strands, rovings, yarns and staple fibre articles	-	-
Continuous filament fibre mats and voiles articles	-	-
Specialty glasses	-	-

[1] Ratio between the highest and lowest value of the curve
[2] Data stems from 9 out of 10 EU27 installations. For confidentiality reasons, data from 2007 and 2008 were combined, which means that 18 data points instead of 9 were taken into account, counting each installation twice.

2. To allow for a consistent data collection it is furthermore essential for each of the proposed product categories to define which downstream processes are included in each of the benchmarks.

3. In order to make a decision on how to deal with direct emission related to downstream activities that are not included in the proposed benchmark categories, emissions data for these activities are required.

4. Finally, data on the number of electric furnaces as well as the shares of electricity versus fossil fuel used for each of the melting processes is necessary to allow for a decision on the treatment of electric furnaces and electrically boosted fossil fuel fired furnaces in the glass industry. A decision, if either a primary emissions benchmark or a fall-back option for electric furnaces shall be applied, can only then be taken.

6 Stakeholder comments

Comments on the interim report have been made by CPIV on the following issues (CPIV, 2009).

6.1 Choice of product groups to receive a benchmark

CPIV stresses that in the flat glass sector, float glass, rolled glass and low iron glass are clearly distinct types of products having unique applications. Being produced via distinct manufacturing processes, their energy intensities are not comparable. The hollow glass sector groups together bottles, flaconnage and tableware which differ considerably in terms of products, CO_2 emissions, production technology, quality demands, etc. Similarly, continuous glass fibres and glass wool are distinct products grouped together in the category “glass fibres” but with different manufacturing technologies.

PRODCOM codes offer a starting point to differentiate products and establish relevant benchmarks. However it must be noted that going beyond the codes may be necessary for certain new products. There is for instance no truly appropriate code for low-iron glass, which is a type of glass increasingly demanded as it has unique properties for use in photovoltaic cell manufacture. It also differs in specific energy consumption from standard clear glass.

For those product categories where too few installations are present to derive a representative benchmark, a fall back option should be left open. It will probably be the case for flaconnage, tableware and for all types of special glasses.

6.2 Different cullet shares in the production process

Glass producers are continually trying to maximize the amount of cullet they put into the furnace. However, the ability to use cullet depends on several factors.

1. The glass manufacturing industry can only use available post-consumer cullet

Cullet availability is not comparable in all Member States. While France and Germany for instance achieve high recycling rates, other Member States (e.g. Portugal) are lower for infrastructure reasons. As the collection and reprocessing infrastructure is largely independent of the glass industry it cannot be penalised for its suppliers not being able to meet even the existing demand for cullet. There are also many logistic issues concerning waste glass recycling that have not been addressed at all by the Ecofys report.

2. The glass manufacturing industry can only use cullet on an adequate quality

Even if cullet is available, the glass industry is reliant on its suppliers to meet basic quality specifications in order to be able to make saleable glass. Unfortunately the collection and reprocessing infrastructure is not always able to do this. This is a particular problem when post consumer glass is collected mixed with other recyclates (paper, plastic, metals, glass ceramics, ceramics) or when glass of different colours are collected mixed together. Material and colour separation at source is therefore crucial.

3. The quality requirements of the product must not be undermined

The specific quality requirements of several products limit the ability of the industry to use even high quality post consumer cullet. In some special cases, the technique for producing the glass is even such that no solid raw materials can be used. The possibilities of post-consumer cullet recycling in flaconnage, tableware, flat glass and special glass production are very limited for evident quality reasons. For these sub-sectors only internal cullet is recycled or, in the case of flat glass, perfectly treated post-consumer cullet.

CPIV is strongly opposed to the opinion expressed by the project team that regional cullet availability should not be taken into account for the benchmarks in order to provide incentives for cullet recycling. It is naive to assert that penalizing operators in those countries where cullet is not available in sufficient quantity will create the supply in a timely fashion. A supra-regional cullet market is a possibility, though the cost (and CO_2 penalty) of transportation against the energy saved will have a bearing on the commercial reality of the proposition. It is probable that affected companies could be damaged financially in the short term, perhaps terminally, before a solution is found. It is for the EU to resolve the issues that lead to the differences in cullet supply in the member states. Then, it may be possible to achieve what the consultants propose. Furthermore, passing on the CO_2 costs to the customer will not encourage the general public to recycle more. Other mechanisms need to be put in place.

The choice of cullet target percentage must reflect reality in each Member State and not an aspirational target. Different member states implement the Waste Packaging Directive in different ways. Anyhow, the ETS Directive should not interfere with the Waste Packaging Directive. To conclude, cullet availability at Member State level is most particularly a problem of trade balance. Countries exporting more of their empty or filled containers have less cullet available even if national collection rates conform to or are higher than those required by the Packaging and Packaging Waste Directive. If exporting countries are penalised by the benchmark system this later could be considered an impediment to free circulation of goods.

CPIV is of the opinion that a sound benchmark for the glass industry should be realistically achievable by all participants. It should take into account the cullet availability (including the technical requirements needed for reincorporation) across Europe as well as the actual capability that each glass sector has to effectively use recycled cullet. Colour of the glass is an important factor.

6.3 Forcing operators to switch to natural gas

In the glass industry, heavy fuel oil and natural gas are widely used and often interchangeable. While CPIV fully recognizes the need to curb CO_2 emissions, it is of the opinion that simply promoting gas (by prescribing it as the benchmark fuel) without taking into consideration other important issues is not a reasonable approach. The following factors should at least also be taken into account.

1. **Energy efficiency**
   Whilst gas-fired furnaces emit less CO_2 than oil-fired furnaces their energy efficiency is lower (about 4 to 7%) due to flame emissivity and flue gas heat contents. A balance has therefore to be struck between energy efficiency and greenhouse gas efficiency. In this respect, Article 10a (1) of the amended Directive states in that energy efficiency shall be taken into account: "for each sector and subsector, in principle, the benchmark shall be calculated for products rather than for inputs, in order to maximise greenhouse gas emissions reductions and energy efficiency saving throughout each production process".

2. **Security of supply**
   Forcing all operators to switch to gas makes Europe more dependent upon one energy source, and reduces the security of supply in all Member States. Furthermore when there is a gas shortage operators do not necessarily have the choice to refuse to switch to oil, not least because it is some Member states' energy policy to divert gas away from manufacturing to domestic consumption in case of shortage.

3. **Global CO_2 emissions**
   Heavy fuel oil is a residue of crude oil after gasoline and the distillate fuel oils are extracted through distillation. Its commercial uses are limited and the glass industry remains one of the few industries which can burn it. Forcing operators to switch to gas will limit the markets for this product, which will then probably be incinerated or shipped outside the EU, with no benefit to global CO_2 emissions. To reduce overall CO_2 it is necessary also to consider emissions to the environment as a whole from the adoption of a particular technology and not in isolation at installation level.

4. **Fuel switching**
   It should be noted that switching fuel is not necessarily as easy an option as it is presented in the report. This may sometimes impose changes in operating permits and adjustment to installations such as new burners and control systems.

5. **The fuel choice for the operator**
   The choice of fuel is a strategic decision. Today, operators can switch (for example) from heavy fuel to gas depending on the price of these fuels thus helping to maintain competitiveness; especially with competitors outside Europe.

Moreover, it is unfair to penalize operators in countries or regions where natural gas is simply not available. The consequences of causing closure of plant in those countries could be to wreck the recycling infrastructure in those regions and increase imports because the collected waste glass cannot be recycled anymore without glass production in these areas. It should be borne in mind that alternative glass recycling options, such as aggregates, are less carbon efficient.

CPIV therefore strongly recommends that an average fuel mix should be used instead of opting for natural gas only.

7 References

BREF Glass-draft (2009) *Draft Reference Document on Best Available Techniques in the Glass Manufacturing Industry* European Commission, Institute for Prospective Technological studies, Seville, July 2009.

CPIV (2009) *Personal e-mail communications with Fraunhofer ISI,* 15th of May, 17th of May, 25th of May, 3rd of July and 29th of July 2009 and *CPIV comments on the zero-order draft report,* 3rd of July 2009.

Ecofys / Fraunhofer-ISI (2009) *Developing benchmarking criteria for* CO_2 *emissions,* Ecofys Netherlands / Fraunhofer Institute for Systems and Innovation research, February 2009

Appendix A: PRODCOM codes of the glass sector

The products of the glass sector are covered by 34 PRODCOM codes. An overview is given in the following table. PRODCOM codes from the categories “Shaping and processing of flat glass” and “Manufacture and processing of other glass, including technical glassware” are not included in the table. These two categories cover about 25 more PRODCOM codes.

Table 13 PRODCOM codes of glass products in Annex I of the amended Directive

Product	PRODCOM Code
Non-wired sheets, of cast or rolled optical glass, whether or not coloured throughout the mass, opacified, flashed or having an absorbent or reflecting layer, but not otherwise worked	26.11.11.13
Non-wired sheets of cast or rolled glass, whether or not coloured throughout the mass, opacified, flashed or having absorbent or reflecting layer, not otherwise worked (excluding of optical glass)	26.11.11.15
Wired sheets of cast or rolled glass, whether or not coloured throughout the mass, opacified, flashed or having an absorbent or reflecting layer, but not otherwise worked	26.11.11.30
Profiles of cast or rolled glass, whether or not having an absorbent or reflecting layer, but not otherwise worked	26.11.11.50
Drawn or blown optical sheet glass, whether or not coloured throughout the mass, opacified, flashed or having an absorbent or reflecting layer, but not otherwise worked	26.11.11.75
Drawn or blown antique, horticultural and other glass	26.11.11.79
Non-wired sheets of float glass and surface ground or polished glass, having a non reflecting layer	26.11.12.12
Non-wired sheets of float glass and surface ground or polished glass, having an absorbent or reflective layer, of a thickness ≤ 3.5 mm	26.11.12.14
Non-wired sheets of float glass and surface ground or polished glass, having an absorbent or reflecting layer, not otherwise worked, thickness > 3.5 mm excluding horticultural sheet glass	26.11.12.17
Non-wired sheets of float glass and surface ground/polished glass, coloured throughout the mass, opacified, flashed or merely surface ground excluding horticultural sheet glass	26.11.12.30
Other sheets of float/ground/polished glass, n.e.c.	26.11.12.80
Glass preserving jars, stoppers, lids and other closures (including stoppers and closures of any material presented with the containers for which they are intended)	26.13.11.10
Containers made from tubing of glass (excluding preserving jars)	26.13.11.16
Glass containers of a nominal capacity ≥ 2.5 litres (excluding preserving jars)	26.13.11.22

Continuation Table 13

Product	PRODCOM Code
Bottles of colourless glass of a nominal capacity < 2.5 litres, for beverages and foodstuffs (excluding bottles covered with leather or composition leather, infant's feeding bottles)	26.13.11.28
Bottles of coloured glass of a nominal capacity < 2.5 litres, for beverages and foodstuffs (excluding bottles covered with leather or composition leather, infant's feeding bottles)	26.13.11.34
Glass containers for beverages and foodstuffs of a nominal capacity < 2.5 litres (excluding bottles, flasks covered with leather or composition leather, domestic glassware, vacuum flasks and vessels)	26.13.11.40
Glass containers for pharmaceutical products of a nominal capacity < 2.5 litres	26.13.11.46
Glass containers of a nominal capacity < 2.5 litres for the conveyance or packing of goods (excluding for beverages and foodstuffs, for pharmaceutical products, containers made from glass tubing)	26.13.11.52
Drinking glasses (including stemware drinking glasses), other than of glass ceramics, of lead crystal, gathered mechanically	26.13.12.40
Drinking glasses (excluding stemware drinking glasses and products of glass ceramics or lead crystal), of toughened glass	26.13.12.60
Other drinking glasses	26.13.12.80
Table or kitchen glassware of lead crystal gathered mechanically (excluding of glass ceramics, of toughened glass, drinking glasses)	26.13.13.30
Table/kitchen glassware with linear coefficient of expansion ≤5x10-6/K, temperature range of 0 °C to 300 °C excluding of glass-ceramics, lead crystal/toughened glass, drinking glasses	26.13.13.50
Glass-ceramic table, kitchen, toilet, office, indoor decoration or similar purpose glassware	26.13.13.60
Table/kitchen glassware (excluding drinking), toughened glass	26.13.13.90
Glass inners for vacuum flasks or for other vacuum vessels (including unfinished and finished)	26.13.14.00
Glass fibre threads cut into lengths of at least 3 mm but ≤ 50 mm (chopped strands)	26.14.11.10
Glass fibre filaments (including rovings)	26.14.11.30
Slivers; yarns and chopped strands of filaments of glass fibres (excluding glass fibre threads cut into lengths of at least 3 mm but ≤ 50 mm)	26.14.11.50
Staple glass fibre articles	26.14.11.70
Glass fibre mats (including of glass wool)	26.14.12.10
Glass fibre voiles (including of glass wool)	26.14.12.30
Nonwoven glass fibre webs; felts; mattresses and boards	26.14.12.50