Summary Report

Life Cycle Assessment
of Float Glass

PE INTERNATIONAL
EXPERTS IN SUSTAINABILITY

Title of the Study: Life Cycle Assessment of Float Glass

Client: Glass for Europe

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Acronyms

GfE	Glass for Europe
PEI	PE INTERNATIONAL
GABI	Ganzheitliche Bilanzierung (German holistic balancing)
LCI	Life Cycle Inventory
LCIA	Life Cycle Inventory Assessment
EPD	Environmental Product Declaration
PED	Primary Energy Demand
AP	Acidification Potential
EP	Eutrophication Potential
GWP	Global Warming Potential
POCP	Photochemical Ozone Creation Potential
ODP	Ozone Depletion Potential

1 Introduction

The following report was set-up in the context of a study developing an Environmental Product Declaration (EPD) for windows / transparent components commissioned by ift Rosenheim.

Glass for Europe (GfE) participated within this study by providing data describing the production of float glass used as part of a window.

This report provides a summary of the Life Cycle Inventory (LCI) of one kilogram of float glass as a final product. All other parts of the window (e.g. window frame) or further processing of the float glass (e.g. coating) remain excluded from this overview.

The gate-to-gate data (mass and energy flows) was provided by GfE as regional average across the European industry for float technology. The cradle-to-gate LCI results were modelled and calculated by PE INTERNATIONAL using the GaBi 4 database 2006[1] . Furthermore a Life Cycle Impact Assessment (LCIA) was performed.

This report is for Glass for Europe's use only and / or use approved by Glass for Europe. This interim report does not represent a complete Life Cycle Assessment according to ISO standard.

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[1] GaBi Software and data base for Life Cycle Engineering, PE International AG, www.gabi-software.com

2 System description

Although today, flat glass comes in many highly specialised forms intended for different products and applications (construction, automotive and solar-energy), the following study covers the data needed up to the production of float glass by way of the float process; the downstream processes needed to coat float glass are not included.

The study includes upstream processing and production of materials and energies that make up the production of the stated functional unit (one kg of float glass as a final product). Except for slag and glass cullet as no previous treatment was included before its recovery in the glass plants. The impact of the transport of materials to production sites was not included as a sensitivity analysis showed that the effect on the results is not relevant for the purpose of the study (below 1%). The decision was made considering that transport is a variable that needs further investigation taking into account more detailed information (transport mode and distances for each plant included in the average). Being a cradle-to-gate study the transport of the product to customers (use phase) and final destination (EoL phase) are not included in this overview and results evaluation.

Figure 1 shows a screenshot of the model built up in GaBi 4.4 software.

Figure 1: Cradle-to-gate system model of float glass

The primary data used in this study was collected and provided by GfE. All input/output data were provided in an aggregated form, therefore no detailed result graphs highlighting the main contributing production phases are provided. The following paragraphs, describing the float process, are based on the glass BREF[2] document and the information provided by GfE.

Float glass is primarily made of raw materials like sand, soda ash, dolomite, limestone, as well as glass cullet.

The batch materials and fuels go into the furnace to melt resulting in molten glass, which goes to a surface of an enclosed bath of molten tin. The molten glass floats then on top of the tin (giving the name to this technology) and as it flows along the surface of the tin bath away from the delivery canal it forms a ribbon of uniform thickness and cools down to be cut into standard sizes.

The float process produces glass sheets with a uniform thickness and perfectly smooth surfaces that need no further grinding or polishing. The resulting glass is then further treated in various ways to incorporate one or several of the advanced technologies applied to float glass today, depending on the final product and application for which it is destined.[3]

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[2] Glass Manufacturing Industry, Draft Reference Document on Best Available Techniques in Glass Manufacturing Industry, July 2009. European Commission, Joint Research Centre

http://eippcb.jrc.ec.europa.eu/reference/

[3] Glass for Europe http://www.glassforeurope.com/en/industry/float-process.php

3   Data quality

The primary data provided by GfE refer to the year 2005, the average values represent the annual production (of the participating sites) and are scaled to one kg of float glass. Data was provided from 25 sites, representing 3 companies as well as ~50% of the European market volume.

Within the DQC (Data Quality Check) PE INTERNATIONAL carried out benchmarking as well as plausibility checks. A comparison with the values reported in the BREF[4] document (gate-to-gate) and other available data sources (cradle-to-gate data from commercial databases and confidential sources) was done.

Where needed data was modified or completed in agreement with GfE.

GfE reported emissions of NO_2 as NOx. According to the mentioned BREF[3] document, glass industry emissions of NO_x should be considered as 95% NO and 5% NO_2. This split was applied to the data and has influence on the POCP category as can be seen in the result chapters. These emissions have different environmental impacts and therefore it is important to consider the split between the emissions, see BREF document for more explanation.

The emissions of sulphur oxides (SOx) include sulphur dioxide (SO_2) and sulphur trioxide (SO_3), and are reported as SOx equivalent. The two main sources of sulphur oxide emissions are the oxidation of sulphur in fuels and the decomposition/oxidation of sulphur compounds in batch materials. Based on information from the BREF[3] document the following split was applied: 95% SO_2 and 5% SO_3.

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[4] Glass Manufacturing Industry, Draft Reference Document on Best Available Techniques in Glass Manufacturing Industry, July 2009. European Commission, Joint Research Centre
http://eippcb.jrc.ec.europa.eu/reference/

4   Gate-to-Gate / Cradle-to-Gate Data

Table 1 provides an overview of the data used for the LCI modelling, the original questionnaire can be found in Annex I.

Inventory data from the GaBi databases have been applied for all input materials, for different energy sources (electricity / fuels) and for all transport processes, as shown in table 2 below (this is referred as "secondary data").

Table 1: Gate-to-gate input/output data per 1kg of float glass

Input flows per kg of float glass (gate-to-gate)		Amount	Unit
Materials	Sand	0.65	kg
	Soda (sodium carbonate)	0.20	kg
	Dolomite	0.17	kg
	Glass cullet (external)	0.04	kg
	Limestone	0.04	kg
	Sodium sulphate	0.01	kg
	Feldspar	4.38E-03	kg
	Nitrogen	0.09	kg
	Oxygen	0.01	kg
	Hydrogen	3.67E-04	kg
	Sodium chloride	5.40E-05	kg
	Slag	0.02	kg
	Coal	7.53E-5	kg
Energy	Natural gas	6.1	MJ
	Electricity from grid	0.80	MJ
	Heavy fuel oil	2.1	MJ
Water	Water [Water]	1.44	kg
Input flows per kg of float glass (gate-to-gate)		**Amount**	**Unit**
Product	Float glass	1	kg
Emissions to air	Carbon dioxide	0.70	kg
	Carbon monoxide	3.60E-04	kg
	Sulphur dioxide	2.60E-03	kg
	Sulphur trioxide	1.37E-04	kg
	Nitrogen dioxide	2.22E-04	kg
	Nitrogen oxides	4.21E-03	kg
	VOC (non CH4)	2.80E-06	kg
	Chromium (unspecified)	1.00E-07	kg
	Dust	3.00E-04	kg
	Hydrogen chloride	7.53E-05	kg
	Hydrogen fluoride	1.15E-05	kg
	Lead (+II)	3.00E-07	kg
	Nickel	4.00E-07	kg

Emissions to water (analytical measures)	Ammonia	3.50E-06	kg
	Solids (dissolved)	0.01	kg
	Solids (suspended)	3.48E-05	kg
	Chemical Oxygen Demand (COD)	8.70E-05	kg
	Biological oxygen demand (BOD)	1.63E-05	kg
	Total organic bounded carbon	8.30E-06	kg
	Metals (unspecified)	0.01	kg
	Chloride	2.93E-05	kg
	Fluorine	1.00E-07	kg
	Sulphate	1.70E-05	kg
	Phosphorus	7.00E-07	kg
	Nitrogen	5.20E-06	kg
	Nickel (+II)	1.00E-07	kg
	Waste water	0.77	kg
	Zinc (+II)	5.00E-07	kg
	Oil (unspecified)	3.00E-07	kg
Waste[5]	Disposed waste	4.74E-03	kg
	Waste for recovery	5.86E-03	kg
	Hazardous waste	1.11E-03	kg
	Non hazardous waste	9.67E-03	kg
	Land filled waste	3.70E-03	kg

Table 2: Secondary upstream data used in GaBi model

Feldspar	PE-GaBi	Germany
Sand	PE-GaBi	Europe
Dolomite	PE-GaBi	Europe
Sodium carbonate	PE-GaBi	Europe
Coal	ELCD/PE-GaBI	EU-25
Heavy fuel oil	ELCD/PE-GaBI	EU-15
Hydrogen	PE-GaBi	Europe
Limestone	PE-GaBi	Europe
Natural gas	ELCD/PE-GaBI	EU-25
Nitrogen	PE-GaBi	Germany
Oxygen	PE-GaBi	Germany
Sodium chloride	PE-GaBi	Europe
Sodium sulphate	PE-GaBi	Global
Power grid mix (electricity)	PE.GaBi	EU-25

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[5] In accordance with annex II-A of the Directive 2006/12/EC

5 Life Cycle Impact Assessment

The Life Cycle Inventory (LCI) data consists of the total inputs and outputs of the product system (e.g. carbon dioxide emissions); while the LCIA uses the LCI data to assess impacts such as Global Warming Potential (GWP).

The CML[6] Life Cycle Impact Assessment methodology was used for the LCIA part. The results of the study refer to the following impact categories: Primary Energy Demand, Global Warming Potential, Eutrophication Potential, Acidification Potential, and Photochemical Ozone Creation Potential. Further details on the impact categories can be found in Annex II: Description of Selected Inventories and Impact Categories.

5.1 Global warming potential

Global warming potential (GWP) is a measure of greenhouse gas emissions, such as carbon dioxide and methane. These emissions cause an increase in the absorption of radiation emitted by the earth, magnifying the natural greenhouse effect. GWP is measured in kilogram of Carbon dioxide equivalent on 100 years time span; see Annex II: Description of Selected Inventories and Impact Categories for details.

Figure 2 shows the total GWP value of 1.23 kg of CO2 equivalent per 1 kg of float glass, with a contribution of 16% from energy sources (energy upstream), 27% from batch materials production (materials upstream) and 57% from on-site production.
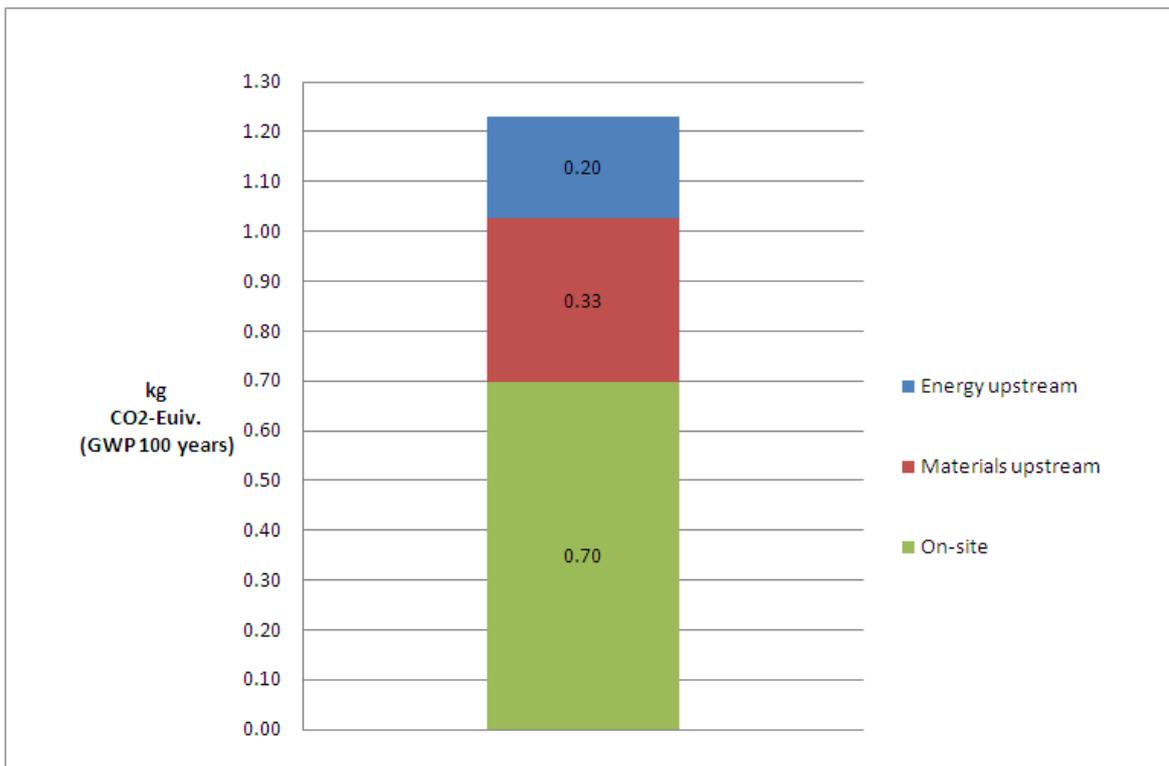
Figure 2: Total GWP for 1 kg float glass, cradle-to-gate

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[6] University of Leiden http://www.leidenuniv.nl/cml/ssp/index.html

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Figure 3 shows the main emissions to air contributing to GWP, where carbon dioxide is the main emission with 95% and the sum of all the other emissions with 5% of the total.
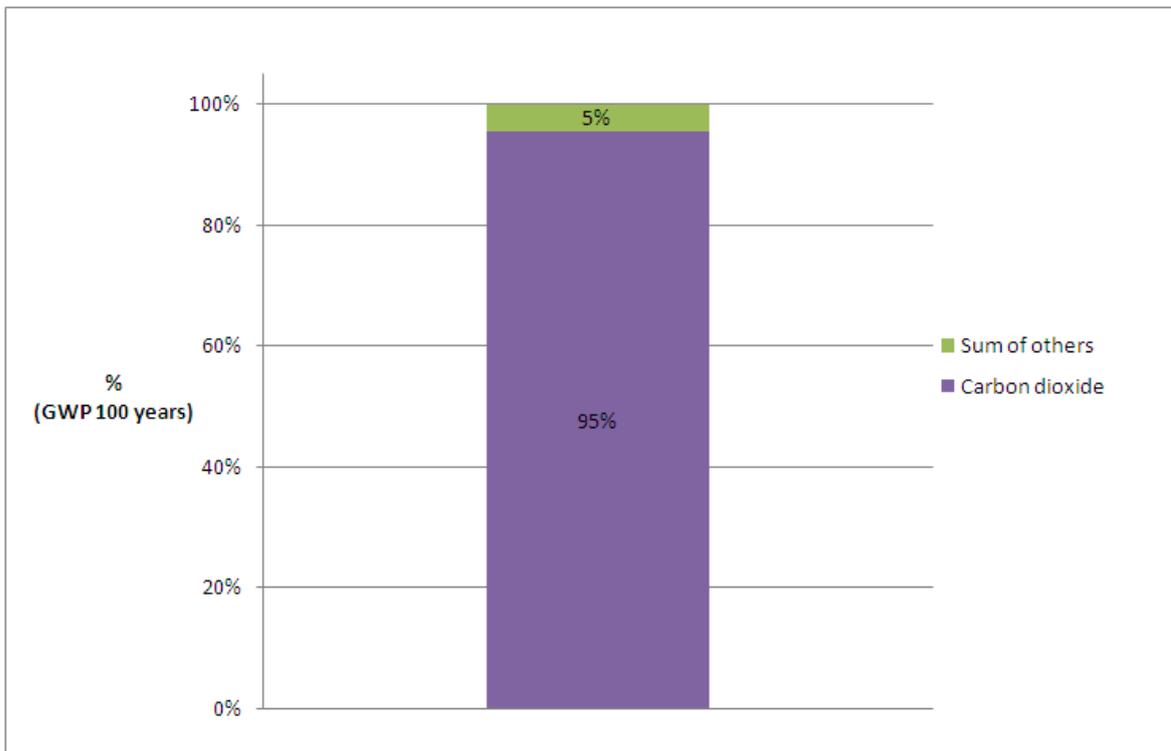
Figure 3: Total GWP main contributing emissions per 1 kg float glass, cradle-to-gate

Figure 4 below shows the GWP from the production of batch materials with a total of 0.33 kg of CO_2 equivalent; this is dominated by sodium carbonate with 87%, followed by sand with 7% and sum of other materials with 6% (nitrogen, oxygen, limestone, dolomite, hydrogen, sodium chloride and sodium sulphate).
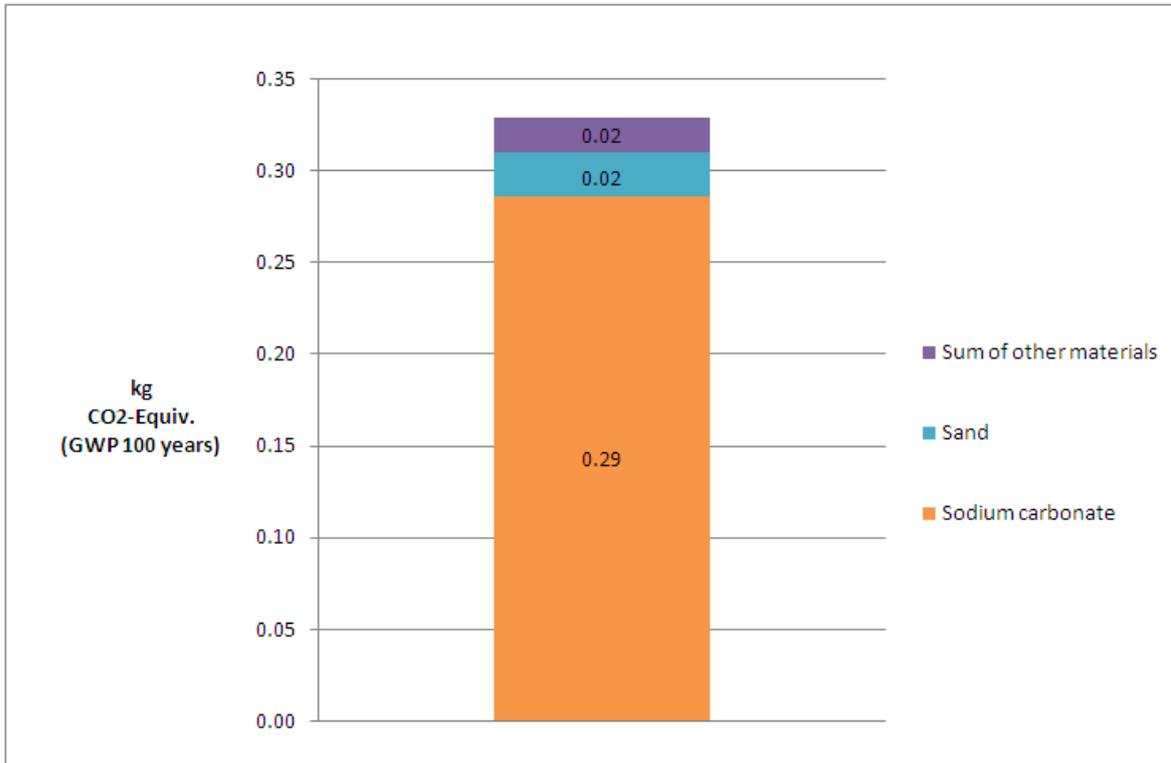
Figure 4: GWP from batch materials production per 1 kg float glass, cradle-to-gate

Figure 5 below shows the contribution of GWP coming from the energy sources production, where the main contributor is power (electricity) with 62%, followed by natural gas with 29% and heavy fuel oil with 9% of the total.
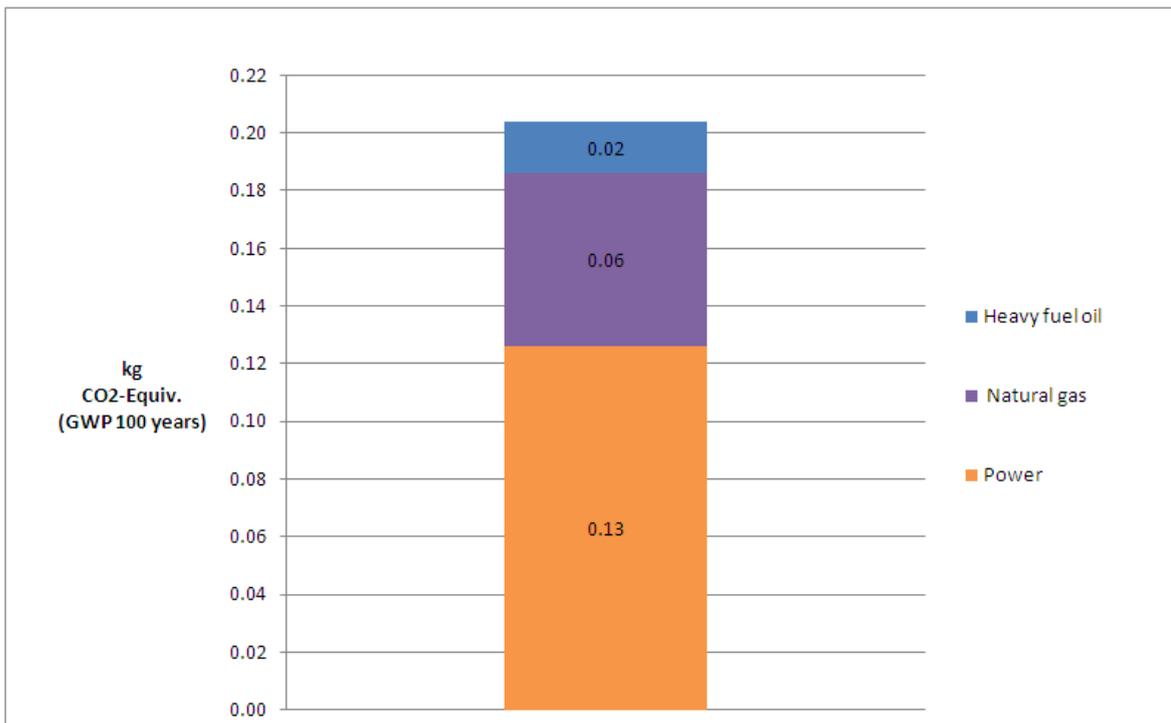
Figure 5: GWP from energy sources per 1 kg float glass, cradle-to-gate

5.2 Primary energy demand

Primary energy demand (PED) measures the total amount of primary energy directly withdraw from the hydrosphere, atmosphere or geosphere or energy source without any anthropogenic change, including both non-renewable and renewable resource. The Primary energy demand is expressed in Mega Joules (MJ) and as net caloric value; see Annex II: Description of Selected Inventories and Impact Categories for details.

The total PED value is 15.62 MJ (net calorific value) per kg of float glass. These PED value include both the renewable and non-renewable energy consumed, although the majority of PED is from non-renewable (fossil) energy. Of the total, 0.26 MJ is from renewable resources and 15.37 MJ is from non-renewable resources, with 2% and 98% respectively.

Figure 6 shows that 25% of the PED is required for the production of batch materials (materials upstream) and 75% is required for the energy sources (energy upstream).
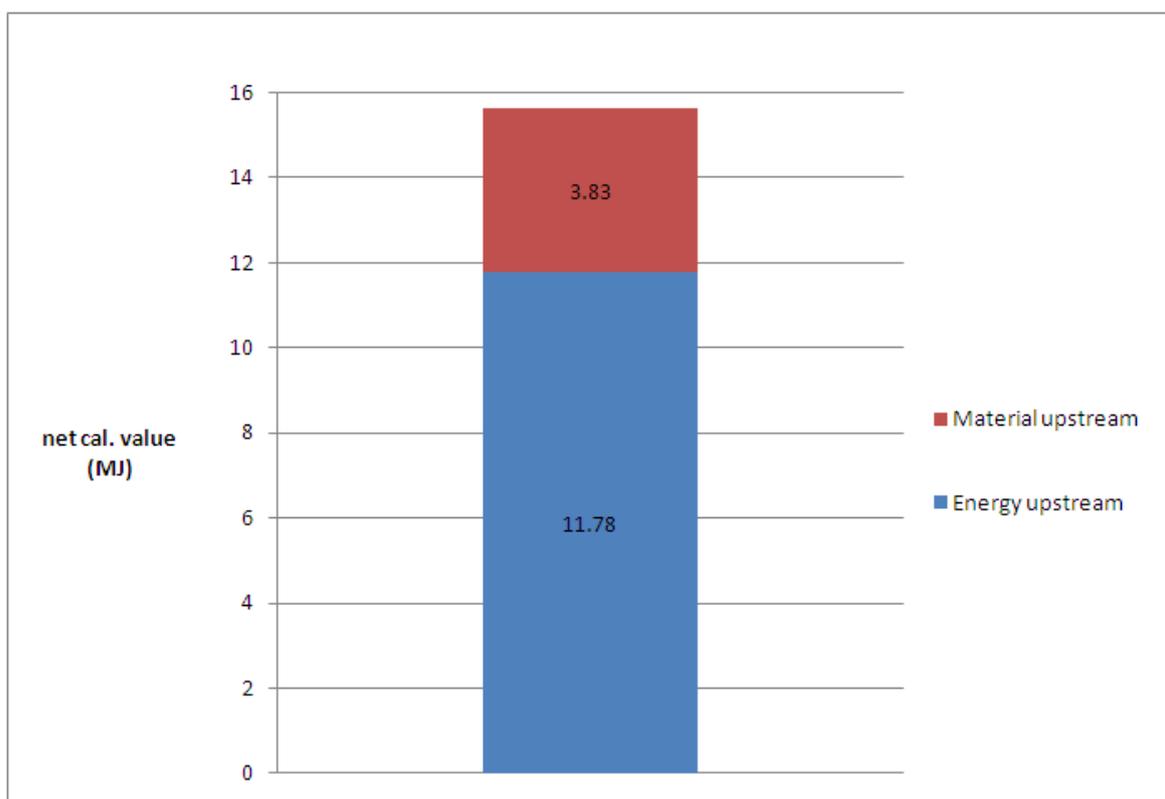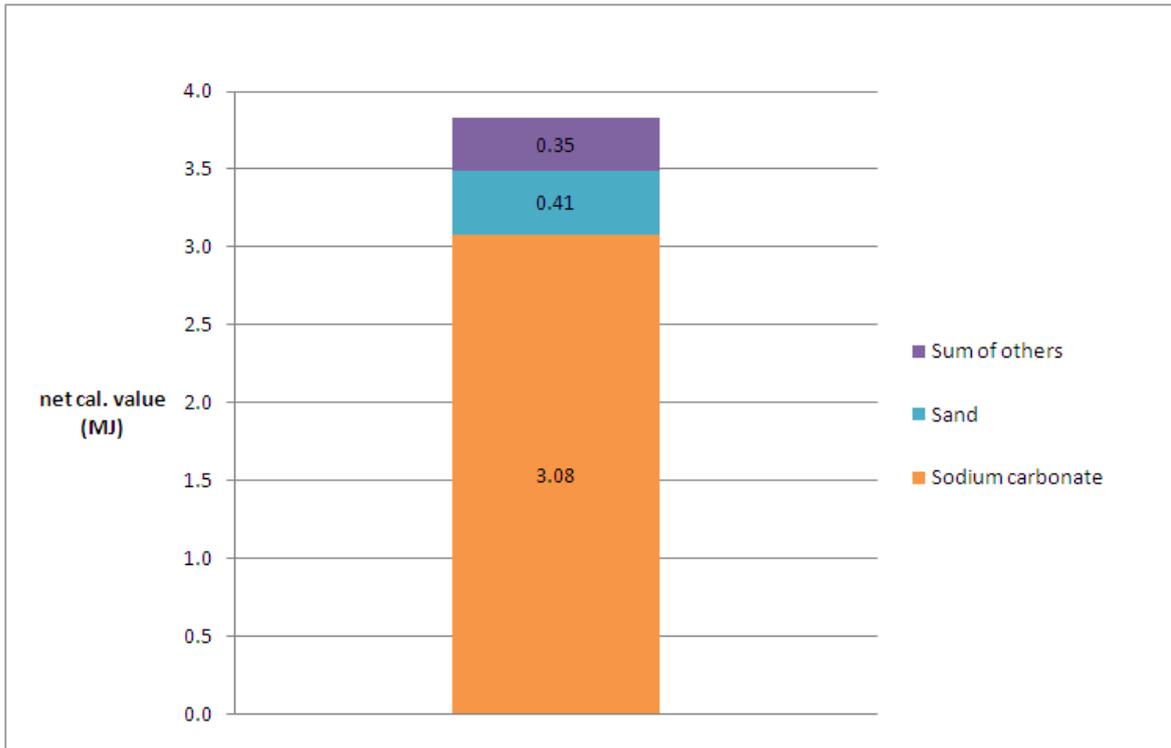

Figure 6: Total PED per 1 kg float glass, cradle-to-gate

Figure 7 shows that the PED from the production of batch materials is dominated by the production of sodium carbonate (80%), followed by production of sand (11%). Sum of the other materials (dolomite, hydrogen, nitrogen, limestone, sodium chloride, sodium sulphate and oxygen) accounts for 9% of the total.

Figure 7: PED from batch materials production per 1 kg float glass, cradle-to-gate

Figure 8 shows the PED from energy sources. The main contributor is the production of natural gas (58%), followed by the production of electricity (22%), and heavy fuel oil production with 20%.
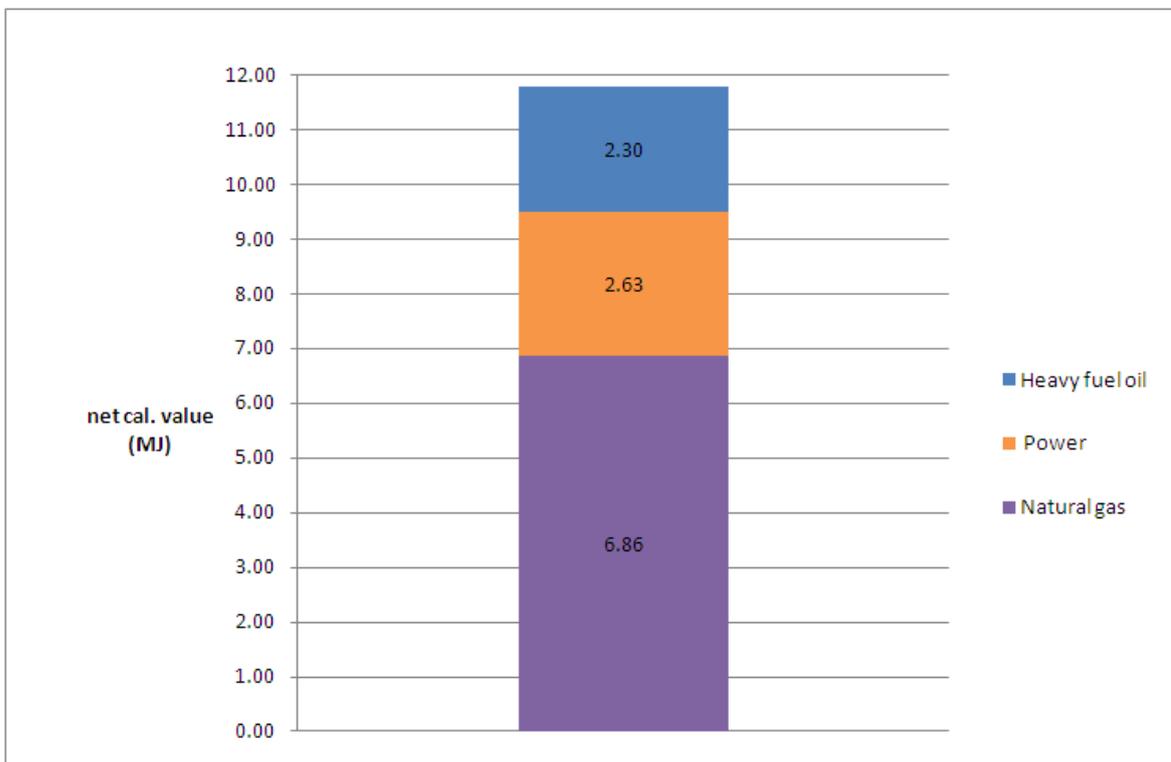
Figure 8: PED from energy sources per 1 kg float glass, cradle-to-gate

5.3   Eutrophication potential

Eutrophication potential (EP) is a measure of emissions that cause eutrophying effects (over nourishment) in the environment. Though the impact category employed is an indication of the impact for both terrestrial and aquatic systems, the eutrophication of an aquatic system, caused by excessive inputs of nitrogen and phosphorus, is of particular concern as this stimulates the growth of certain aquatic species to the detriment of the ecosystem, in particular through dissolved oxygen depletion. Eutrophication Potential is expressed as kilogram of Phosphate Equivalent; see Annex II: Description of Selected Inventories and Impact Categories for details.

The total EP value is 8.81E-04 kg Phosphate equivalent per kg of float glass. As shown in Figure 9, the on-site float glass production contributes with 67%. The remainder of the impact comes from the production of batch materials (28%) and energy sources (6%).
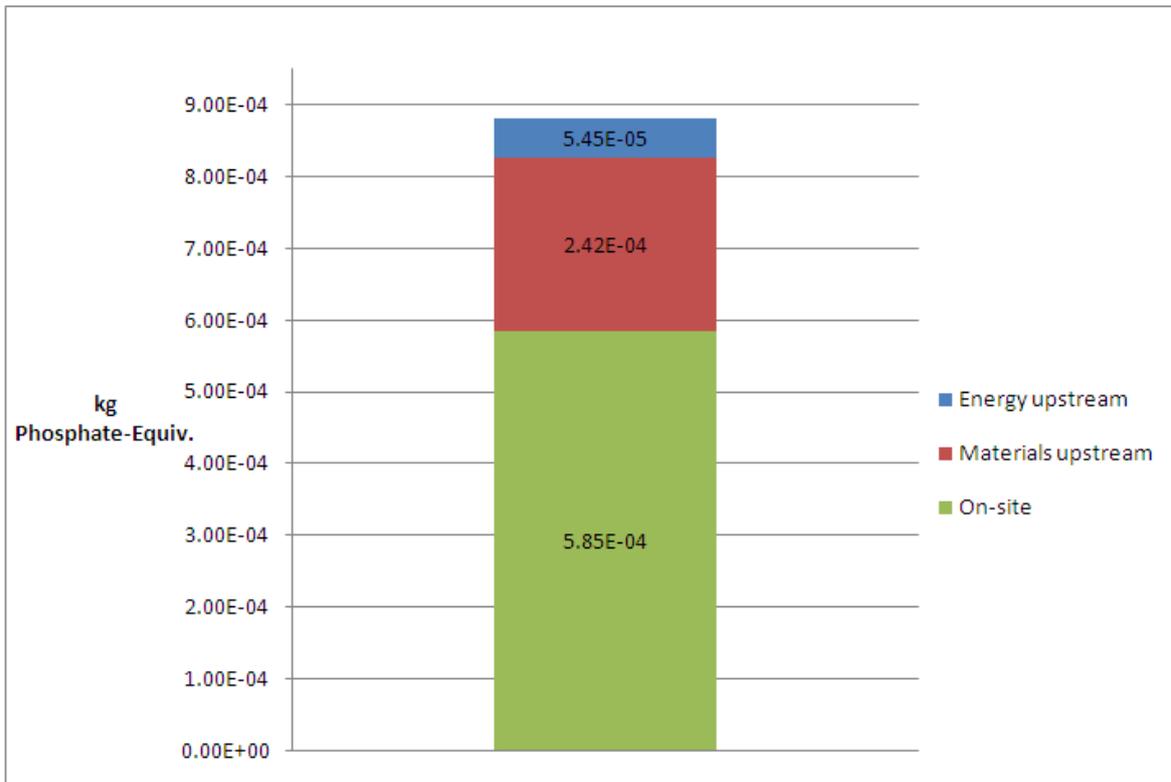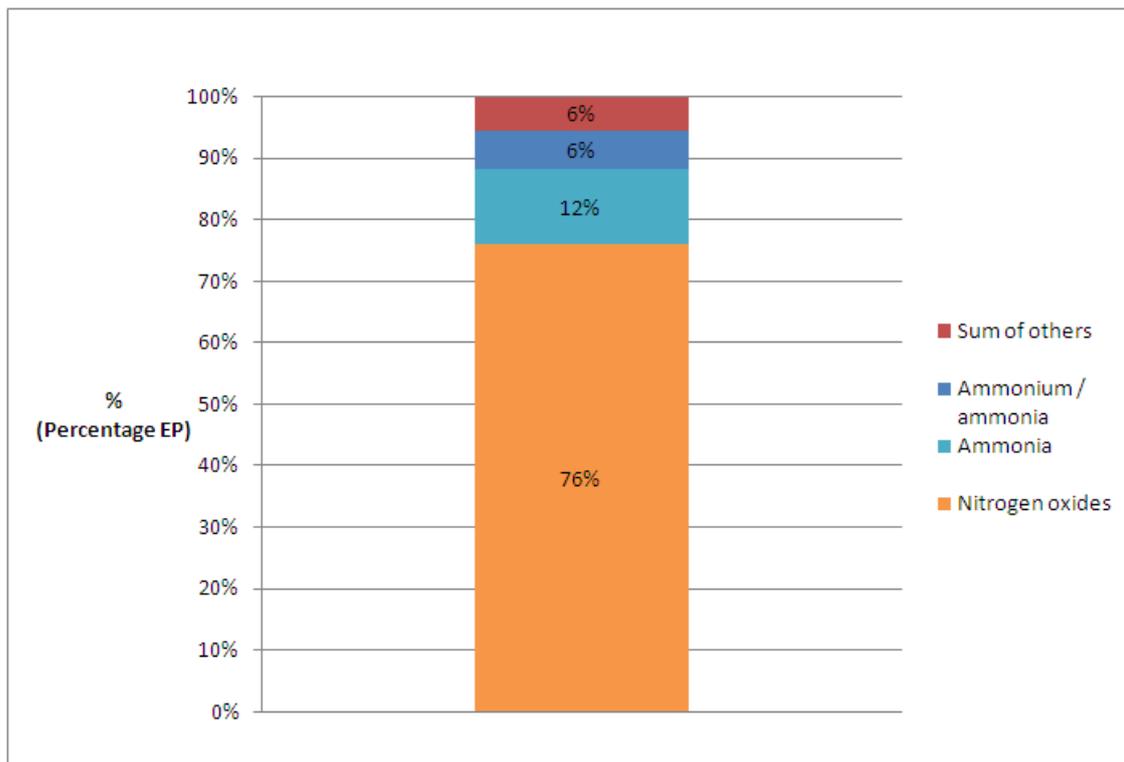

Figure 9: Total EP per 1 kg float glass, cradle-to-gate

Figure 10 gives an overview of the contribution of different emissions to EP, among these nitrogen oxides dominates with 76%, followed by ammonia with 12% and ammonium with 6%, while the sum of other emissions account for 6%.

Figure 10: Total EP main contributing emissions per 1 kg float glass, cradle-to-gate

Figure 11 shows the contribution from the different batch materials to EP. The main contributor is sodium carbonate with 94%, followed by sand (4%), and sum of other materials (2%).
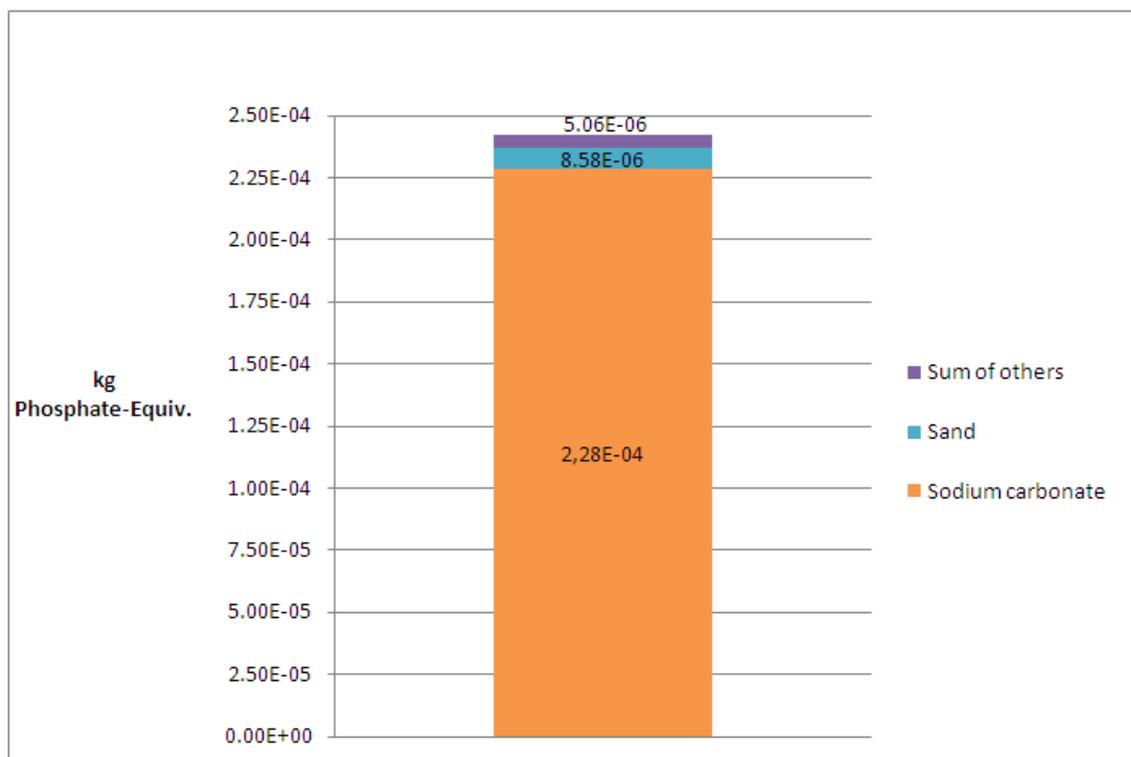
Figure 11: EP from batch materials production per 1 kg float glass, cradle-to-gate

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Figure 12 shows the contribution of the different energy sources to EP. This mainly comes from electricity generation (58%), followed by natural gas (28%), and heavy fuel oil (14%).
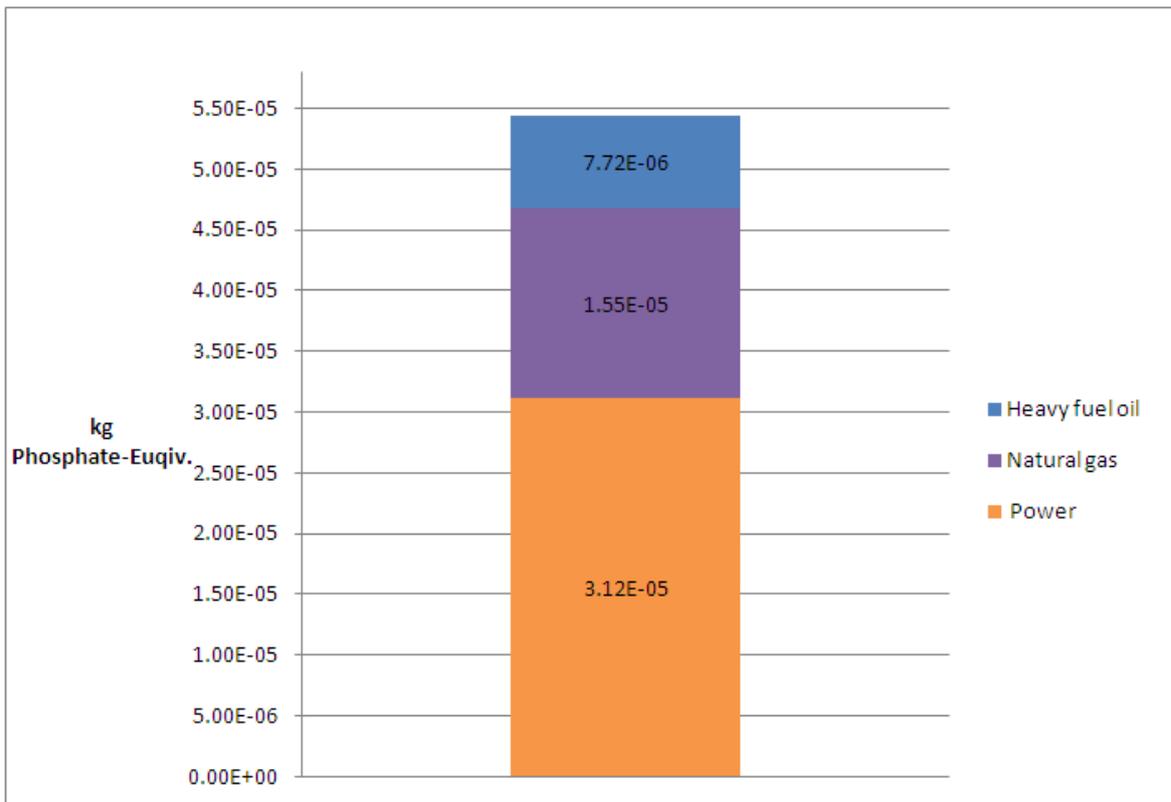

Figure 12: EP from energy sources per 1 kg float glass, cradle-to-gate

5.4 Acidification potential

Acidification potential (AP) as defined by the Dutch CML is a measure of emissions that cause acidifying effects to the environment, see Annex II: Description of Selected Inventories and Impact Categories for details.

Figure 13 shows the total AP value of 8.61E-03 kg of SO_2 equivalent per 1 kg of float glass. The on-site float production contributes with 69%, followed by the production of batch materials (materials upstream) with 18% and the energy sources (energy upstream) with 13%.
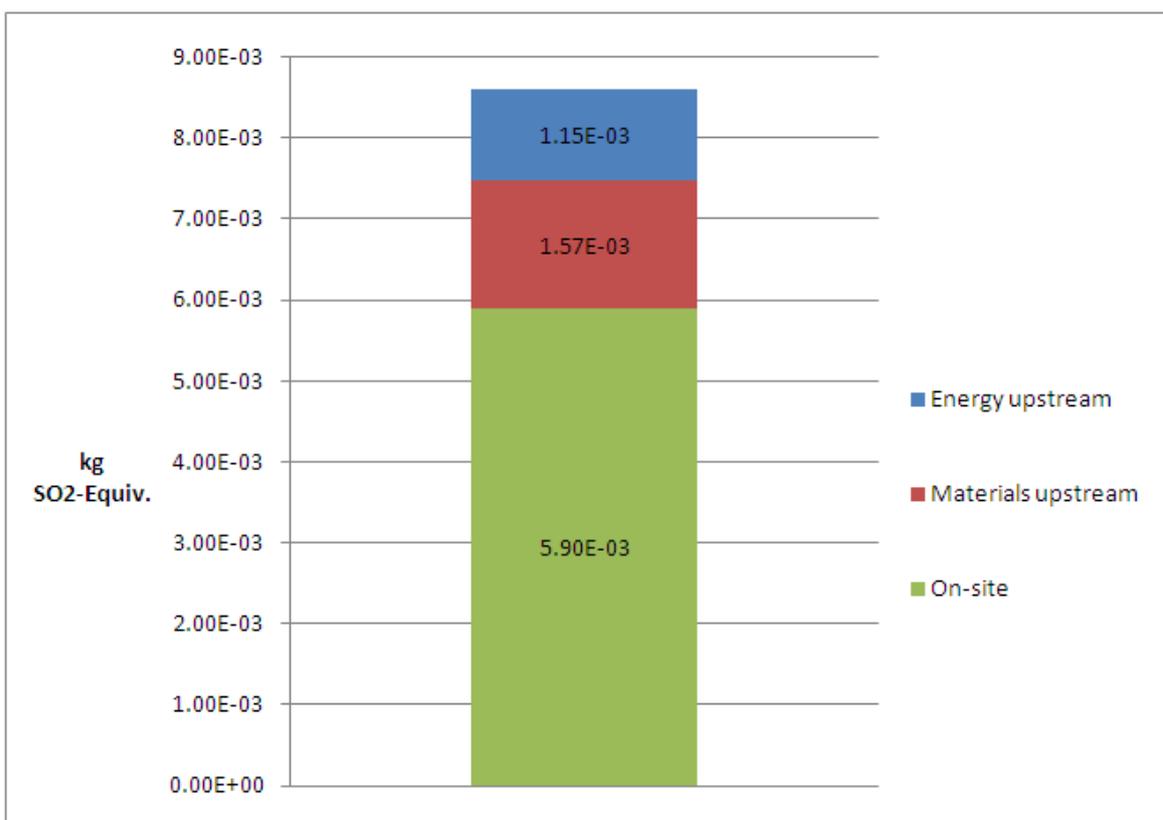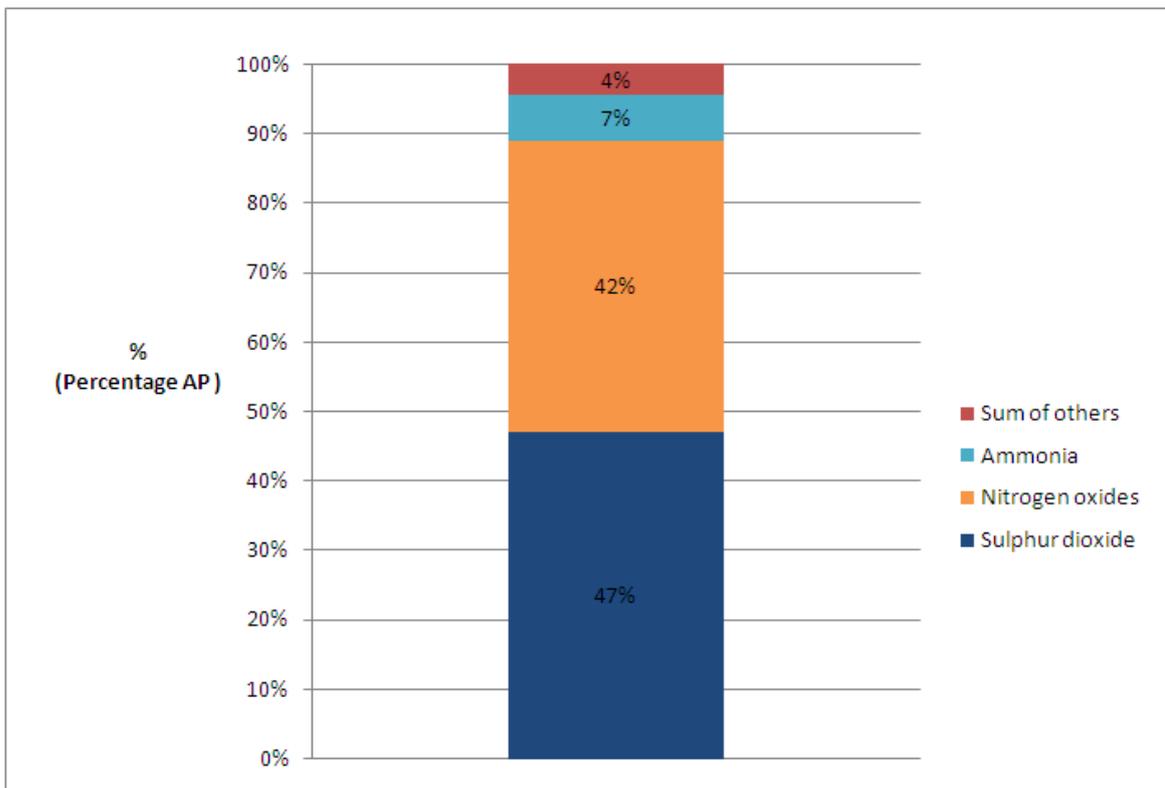

Figure 13: Total AP per 1 kg float glass, cradle-to-gate

Figure 14 gives an overview of the contribution to AP of different emissions, among these sulphur dioxide has a biggest contribution with 47%, followed by nitrogen oxides (42%), ammonia (7%) and sum of other (5%).

Figure 14: Total AP main contributing emissions per 1 kg float glass, cradle-to-gate

Figure 15 shows the AP related to batch materials production. As with the other inventory and impact categories, most of the acidification potential from batch materials production comes from the sodium carbonate with 92%. Sand contributes with 5% of the acidification potential and all the other materials contribute with 3%.
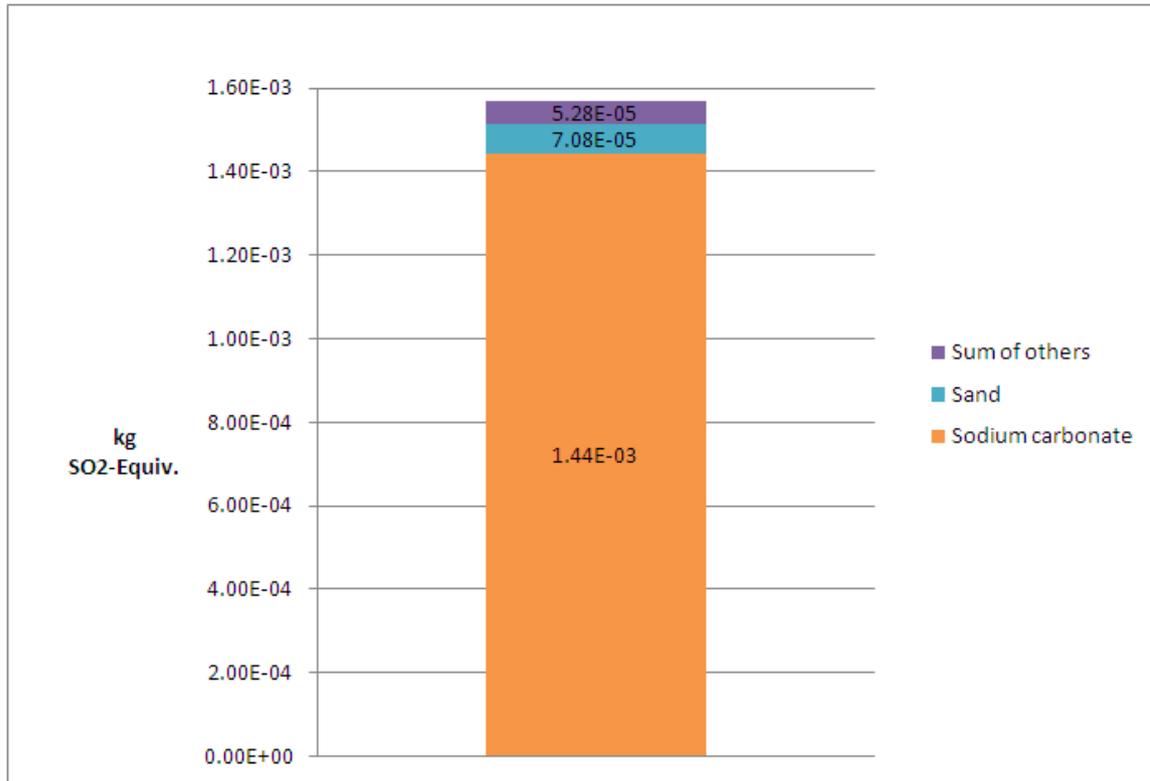
Figure 15: AP from batch materials production per 1 kg float glass, cradle-to-gate

Figure 16 shows the AP from the production of energy carriers. Where, electricity production contributes with 68%, followed by natural gas (22%), and heavy fuel oil (10%).
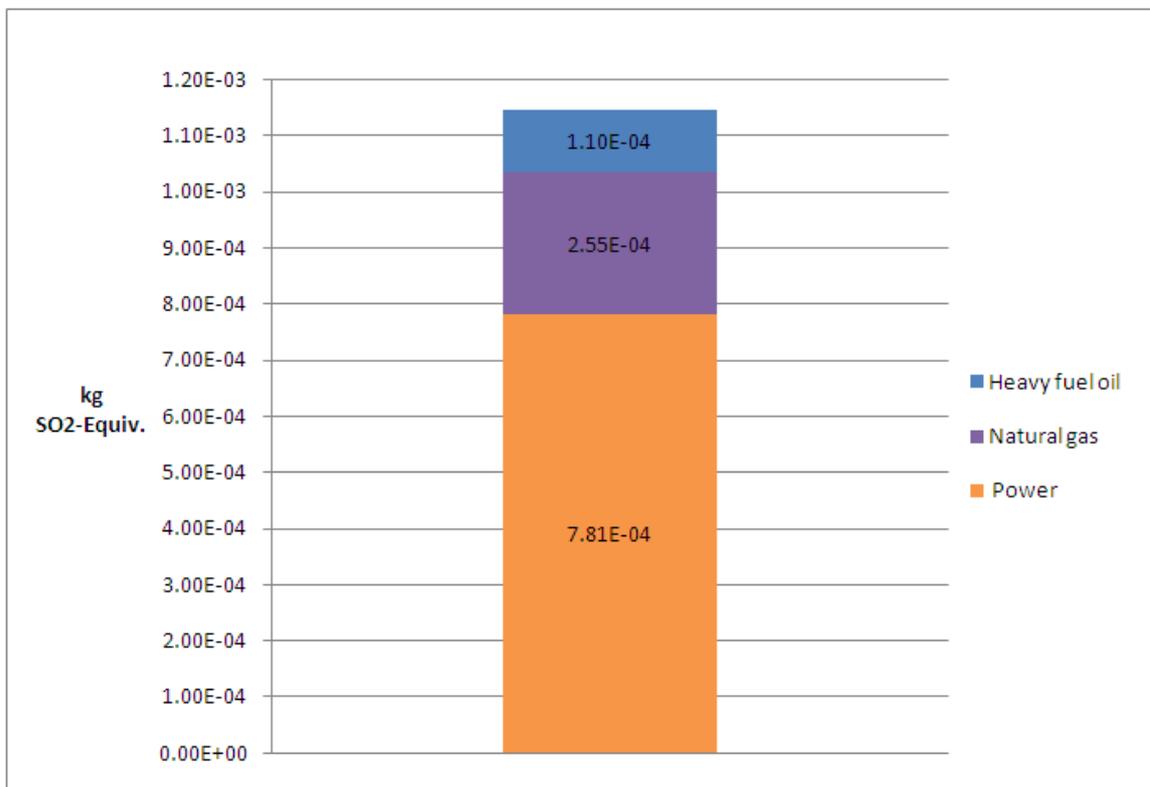
Figure 16: AP from energy sources per 1 kg float glass, cradle-to-gate

5.5 Photochemical ozone creation potential

Photochemical ozone creation potential (POCP) is a measure of emissions of precursors that contribute to ground level smog, produced by the reaction of nitrogen dioxide and volatile organic compounds (VOC) under the influence of ultra violet light. The photochemical ozone creation potential is expressed as kilogram Ethene equivalents, see Annex II: Description of Selected Inventories and Impact Categories for details.

Figure 17 shows the total POCP value, which is 4.65E-04 kg Ethene equivalent. From Figure 17 we can also see that float glass on-site production has the biggest contribution to POCP with a share of 56% and followed by energy sources (energy upstream) with 23% and batch materials production (material upstream) with a share of 21%.

Figure 17: Total POCP per 1 kg float glass, cradle-to-gate

Most of the POCP is coming from the SO_2 and NOx emissions with the share of 42% and 31% respectively, carbon monoxide (11%) and group NMVOC to air (11%). The sum of other contributes only 4% (see Figure 18).
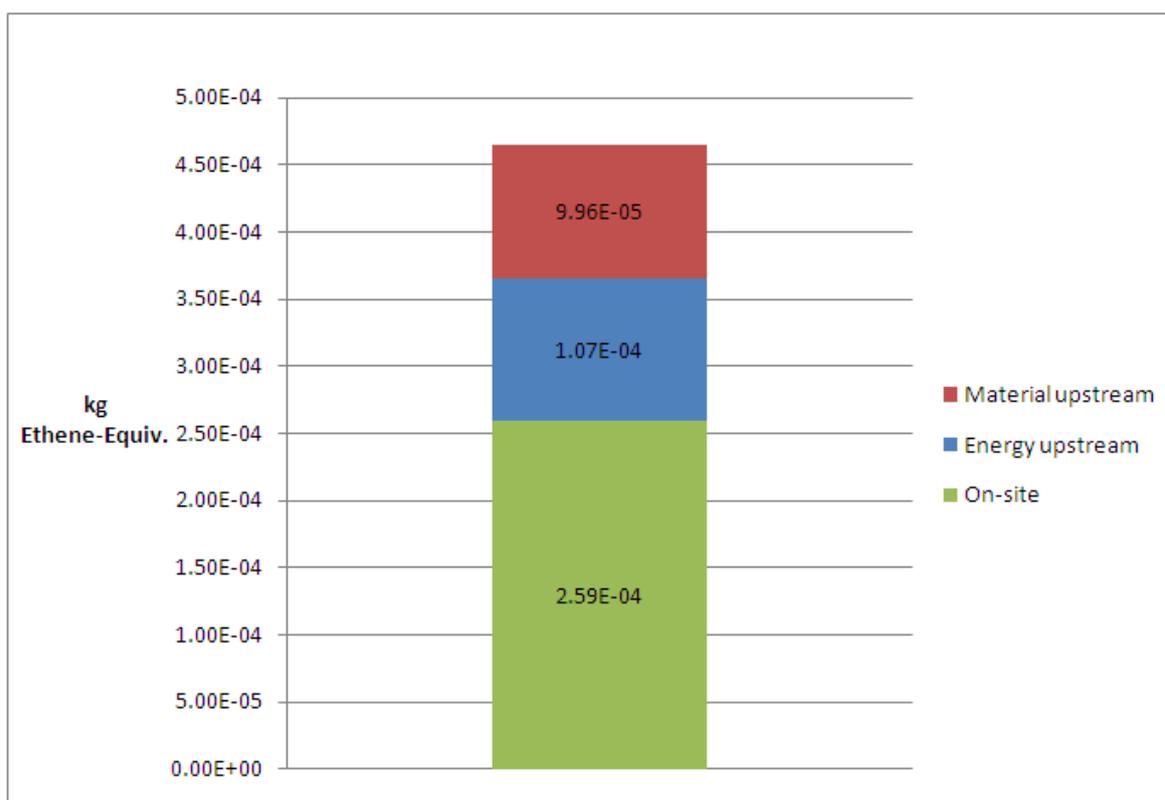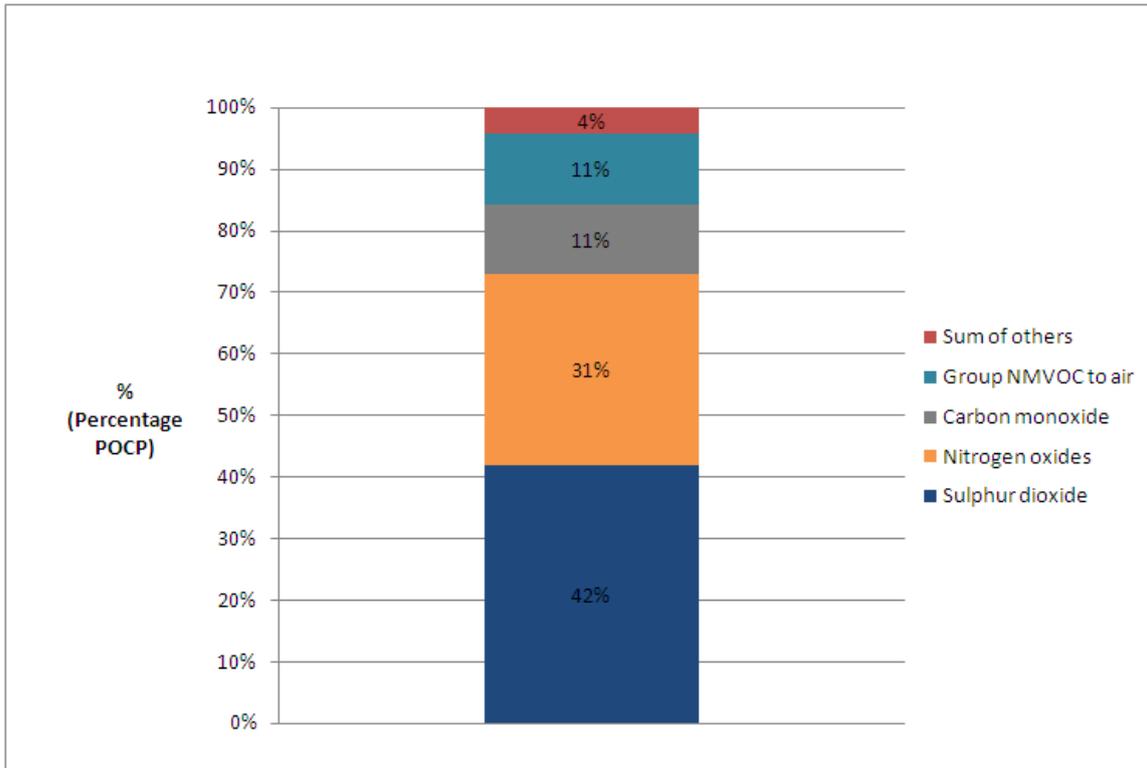
Figure 18: Total POCP main contributing emissions per 1 kg float glass, cradle-to-gate

Figure 19 shows the main contributors from the production of batch materials; as in other impact categories, sodium carbonate contributes the most with 89%, followed by sand (6%) and sum of other materials (5%).
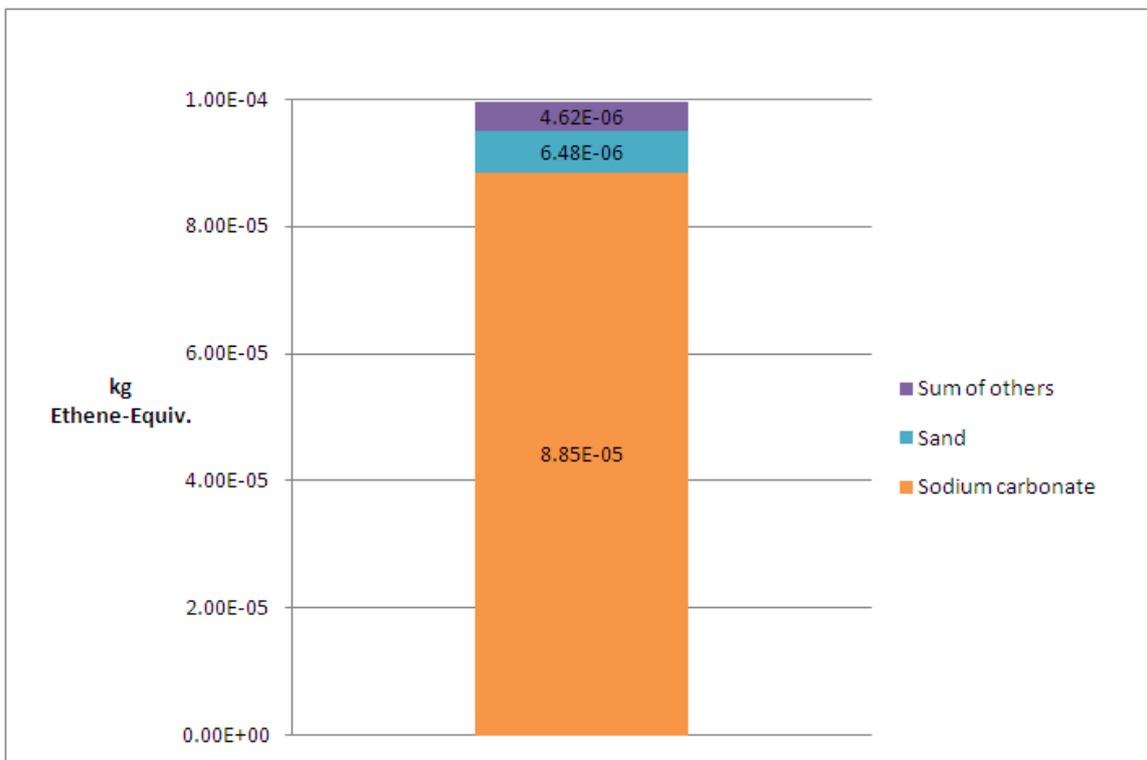
Figure 19: POCP from batch materials production per 1 kg float glass, cradle-to-gate

Figure 20 shows the detail of the contributions from energy sources; the contribution from electricity generation (power) is the highest with 44% of the total followed by the production of natural gas with 41% and production of heavy fuel oil with 15%.
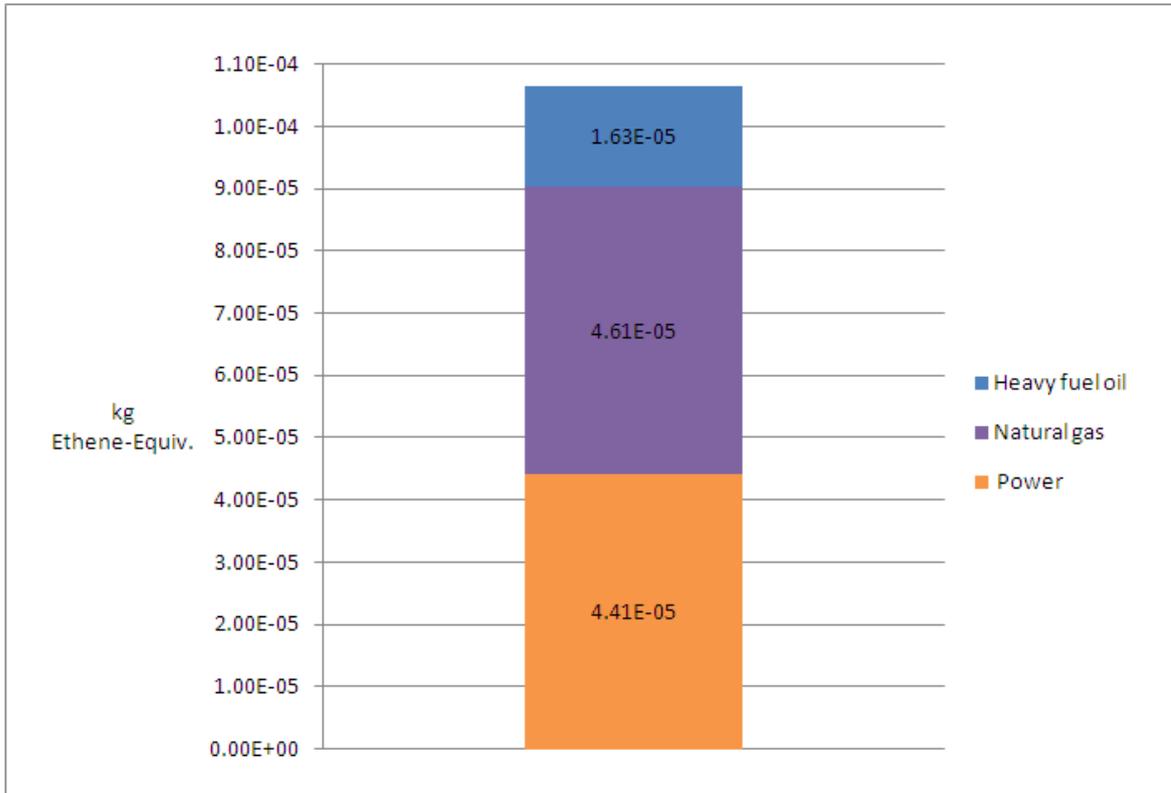

Figure 20: POCP from energy sources per 1 kg float glass, cradle-to-gate

ANNEX I: Primary data of float glass provided by GfE

	year: 2005	
Manufacturer:	**Glass for Europe**	
Number of float tanks considered	**25**	
Material:		
Source:		
Production: (Kg saleable glass)	**4409800250**	

Data per kg of saleable glass

Gross primary fuels and feedstocks	MJ/kg
Coal	0,0
Oil	2,1
Gas	6,1
Total Electricity from grid	0,8
Grid Electricity from renewable sources	0,1
Electricity from non grid renewable sources	0,0
Electricity from non grid CHP	0,0
Other renewable energy (e.g. biomass)	0,0
Hydrogen	0,0
Recovered energy	0,0
Light oil / Diesel / Gasoil	0,0
Propane	0,0
Other (please specify)	0,0
Total/MJ	9,1

Non energy resources	mg/kg	
(Raw materials)		natural resource
Sand	645868,8	yes/no
Limestone	35426,5	yes/no
Dolomite	165410,6	yes/no
Sodium carbonate	200143,2	yes/no
Coal	75,3	yes/no
Sodium sulphate	7853,5	yes/no
Feldspar/nepheline	4375,2	yes/no
Slag	18612,2	yes/no
NaCl	54,0	yes/no
Hydrogen	367,0	yes/no
Oxygen	5282,9	yes/no
Nitrogen	90148,6	yes/no
Recycled material (external cullet)	43694,3	yes/no
Water consumption	1435666,1	

Gross air emissions	mg/kg
Dust	300,0
CO	360,0
CO2	698447,1
CO2 from electricity and CHP	60409,2
CO2 from transportation (e.g. raw material)	0,0
SOx	2740,6
NOx	4434,3
VOC (NMVOC)	2,8
CH4	0,0
NH3	0,0
HF	11,5
HCl	75,3
N2O	
Pb	0,3
Ni	0,4
Cd	0,0
Cr	0,1
As	0,0

Gross water emissions	mg/kg
Dissolved solids	7331,8
NH4+	3,5
Suspended solids	34,8
COD	87,0
TOC	8,3
BOD	16,3
Metals (unspecified)	9740,4
Cl-	29,3
F-	0,1
(SO4)2-	17,0
P	0,7
N	5,2
Pb	0,0
Cd	0,0
Cr	0,0
Ni	0,1
Zn	0,5
As	0,0
oil	0,3
Waste water discharged	774744,1

Gross solid waste	mg/kg

'waste' shall mean any substance or object which the holder discards or intends or is required to discard (Directive 2006/12/EC). Material (e.g. cullet) recycled internally should not be included.

Hazardous waste (1)	1113,9
Non hazardous waste (1)	9674,4
Cullet recycled	271571,4
Disposed Waste (2)	4738,0
Recovered Waste(3)	5855,0
Landfilled Waste (4)	3702,9
Total Waste	11084,6

(1) without cullet internally recycled - hazardous wastes are c
(2) following european definition of annex II-A of directive 2(
(3) following european definition of annex II-B of directive 2006/12/EC
(4) Landfill is also included in Disposal

## ANNEX II: Description of Selected Inventories and Impact Categories

Acidification Potential

The acidification of soils and waters occurs predominantly through the transformation of air pollutants into acids. This leads to a decrease in the pH-value of rainwater and fog from 5.6 to 4 and below. Sulphur dioxide and nitrogen oxide and their respective acids (H2SO4 und HNO3) produce relevant contributions. This damages ecosystems, whereby forest dieback is the most well known impact.

Acidification has direct and indirect damaging effects (such as nutrients being washed out of soils or an increased solubility of metals into soils). However, even buildings and building materials can be damaged. Examples include metals and natural stones, which are corroded or disintegrated at an increased rate.

When analysing acidification, it should be considered that although it is a global problem, the regional effects of acidification could vary. Figure A 21 displays the primary impact pathways of acidification.

The acidification potential is given in sulphur dioxide equivalents (SO_2-Eq.). The acidification potential is described as the ability of certain substances to build and release H^+ - ions. Certain emissions can also be considered to have an acidification potential, if the given S-, N- and halogen atoms are set in proportion to the molecular mass of the emission. The reference substance is sulphur dioxide.
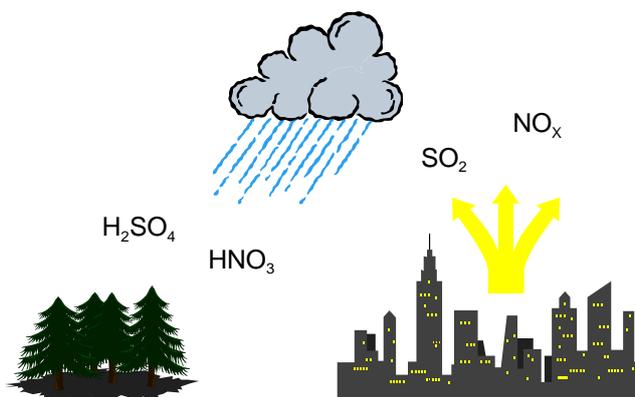
Figure A 21: Acidification Potential [Heijungs et al. 1992]

Eutrophication Potential

Eutrophication is the enrichment of nutrients in a certain place. Eutrophication can be aquatic or terrestrial. Air pollutants, wastewater and fertilization in agriculture all contribute to eutrophication.

The result in water is an accelerated algae growth, which in turn, prevents sunlight from reaching the lower depths. This leads to a decrease in photosynthesis and less oxygen production. In addition, oxygen is needed for the decomposition of dead algae. Both effects cause a decreased oxygen concentration in the water, which can eventually lead to fish dying and to anaerobic decomposition (decomposition without the presence of oxygen). Hydrogen sulphide and methane are thereby produced. This can lead, among

others, to the destruction of the eco-system.

On eutrophicated soils, an increased susceptibility of plants to diseases and pests is often observed, as is a degradation of plant stability. If the nutrification level exceeds the amounts of nitrogen necessary for a maximum harvest, it can lead to an enrichment of nitrate. This can cause, by means of leaching, increased nitrate content in groundwater. Nitrate also ends up in drinking water.

The causes of Eutrophication are displayed in Figure A 22. The Eutrophication potential is calculated in phosphate equivalents (PO4-Eq.). As with acidification potential, it's important to remember that the effects of Eutrophication potential differ regionally.
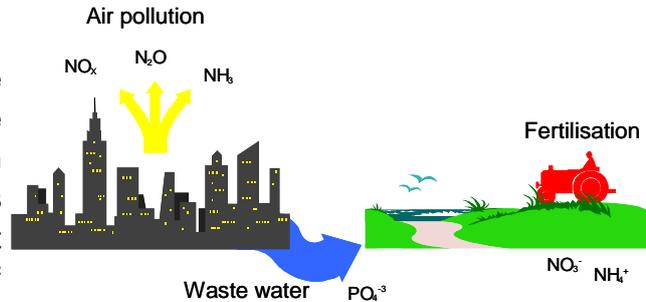
Figure A 22: Eutrophication Potential [Heijungs et al. 1992]

Global Warming Potential

The mechanism of the greenhouse effect can be observed on a small scale, as the name suggests, in a greenhouse. These effects are also occurring on a global scale. The occurring short-wave radiation from the sun comes into contact with the earth's surface and is partly absorbed (leading to direct warming) and partly reflected as infrared radiation. The reflected part is absorbed by so-called greenhouse gases in the troposphere and is re-radiated in all directions, including back to earth. This results in a warming effect at the earth's surface.

In addition to the natural mechanism, the greenhouse effect is enhanced by human activities. Greenhouse gases that are considered to be caused, or increased, anthropogenically are, for example, carbon dioxide, methane and CFCs. Figure A 23 shows the main processes of the anthropogenic greenhouse effect. An analysis of the greenhouse effect should consider the possible long term global effects.

The global warming potential is calculated in carbon dioxide equivalents (CO_2-Eq.). This means that the greenhouse potential of an emission is given in relation to CO_2. Since the residence time of the gases in the atmosphere is incorporated into the calculation, a time range for the assessment must also be specified. A period of 100 years is customary.
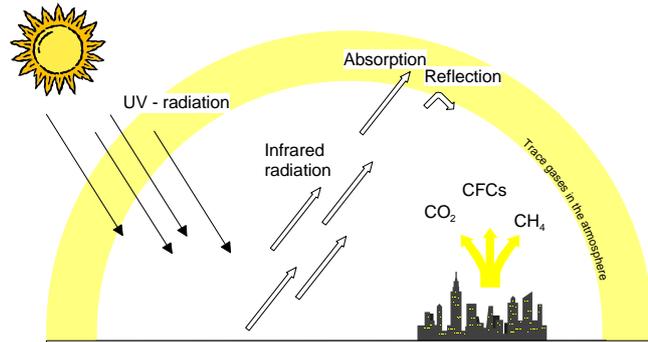
**Figure A 23:** Greenhouse effect [Heijungs et al. 1992]

Photochemical ozone creation potential

Despite playing a protective role in the stratosphere, at ground-level ozone is classified as a damaging trace gas. Photochemical ozone production in the troposphere, also known as summer smog, is suspected to damage vegetation and material. High concentrations of ozone are toxic to humans.

Radiation from the sun and the presence of nitrogen oxides and hydrocarbons incur complex chemical reactions, producing aggressive reaction products, one of which is ozone. Nitrogen oxides alone do not cause high ozone concentration levels.

Hydrocarbon emissions occur from incomplete combustion, in conjunction with petrol (storage, turnover, refuelling etc.) or from solvents. High concentrations of ozone arise when the temperature is high, humidity is low, when air is relatively static and when there are high concentrations of hydrocarbons. Because CO (mostly emitted from vehicles) reduces the accumulated ozone to CO_2 and O_2, high concentrations of ozone do not often occur near hydrocarbon emission sources. Higher ozone concentrations more commonly arise in areas of clean air, such as forests, where there is less CO (Figure A 24).

In Life Cycle Assessments, photochemical ozone creation potential (POCP) is referred to in ethylene-equivalents (C2H4-Eq.). When analysing, it's important to remember that the actual ozone concentration is strongly influenced by the weather and by the characteristics of the local conditions.
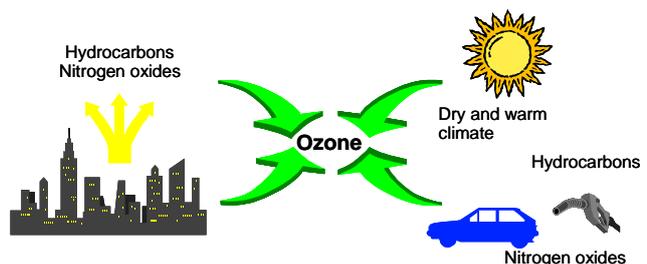
Figure A 24: Photochemical Ozone Creation Potential [Heijungs et al. 1992]

Primary energy demand

Primary energy demand is often difficult to determine due to the various types of energy source. Primary energy demand is the quantity of energy directly withdrawn from the hydrosphere, atmosphere or geosphere or energy source without any anthropogenic

change. For fossil fuels and uranium, this would be the amount of resource withdrawn expressed in its energy equivalent (i.e. the energy content of the raw material). For renewable resources, the energy-characterised amount of biomass consumed would be described. For hydropower, it would be based on the amount of energy that is gained from the change in the potential energy of the water (i.e. from the height difference). As aggregated values, the following primary energies are designated:

The total **"Primary energy from non renewable resources"**, given in MJ, essentially characterises the gain from the energy sources natural gas, crude oil, lignite, coal and uranium. Natural gas and crude oil will be used both for energy production and as material constituents e.g. in plastics. Coal will primarily be used for energy production. Uranium will only be used for electricity production in nuclear power stations.

The total **"Primary energy from renewable resources"**, given in MJ, is generally accounted separately and comprises hydropower, wind power, solar energy and biomass.

It is important that the end energy (e.g. 1 kWh of electricity) and the primary energy used are not miscalculated with each other; otherwise the efficiency for production or supply of the end energy will not be accounted for.

The energy content of the manufactured products will be considered as feedstock energy content. It will be characterized by the net calorific value of the product. It represents the still usable energy content.