

End-of-Waste Criteria (EoW)

for Glass Cullet:

Technical Proposals

October 2011

IPTS

Seville, Spain

DRAFT - WORK IN PROGRESS

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1 Introduction

According to Article 6 of the Waste Framework Directive 2008/98/EC (WFD), certain specified waste shall cease to be waste when it has undergone a recovery operation and complies with specific criteria to be developed in line with a number of legal conditions, in particular when there is an existing market or demand for the material and the use is lawful and will not lead to overall environmental or human health impacts. Such criteria should be set for specific materials by the Commission in comitology. This end-of-waste criteria mechanism was introduced to further encourage recycling in the EU by creating legal certainty and an equal level playing field and removing unnecessary administrative burdens.

A methodology guideline to develop end-of-waste criteria has been elaborated by the Joint Research Centre - Institute for Prospective Technological Studies (JRC-IPTS) and is documented in Chapter 1 of the JRC "End-of-Waste Criteria" report¹. The European Commission is preparing proposals for end-of-waste criteria for specific waste streams according to the legal conditions and following the JRC methodology guidelines.

1.1 Aim and objective

As part of the work on EoW, the JRC-IPTS has conducted the present study, which proposes end-of-waste criteria for glass cullet. The study also provides all necessary information to demonstrate conformity with Article 6 of the WFD.

The technical proposals on glass have been developed using the contributions of technical experts from member states and the stakeholders by means of a Technical Working Group (TWG). The technical experts have made their contribution in the form of written inputs and through participation in experts workshops organised by the JRC-IPTS.

Workshops were held on 6 July and 2 December 2010 at the JRC-IPTS, preceded by drafts of this report. The present report is a revision of the previous drafts, taking into account the discussions during the workshops, and the written inputs received by the technical working group after the workshops. The background data used in this report builds largely on an external study conducted for the IPTS by Ramboll/Ökopol (Ramboll/Ökopol, 2010).

1.2 Structure of this document

The first part (Chapter 2) of this report provides a comprehensive overview of waste glass recycling. It analyses waste glass sources, describes the waste glass recycling processes depending on the source of the material, and identifies the main health and environmental issues. It includes also a description of the economic and market aspects, the industry structure, glass cullet type specifications and standards used by industry, and related legislation and regulation.

The second part (Chapter 3) deals with the end-of-waste criteria as such. It presents the advantages of EoW criteria compared to the current situation. It then analyses if and how the basic general conditions for the end-of-waste criteria can be fulfilled and finally makes text proposals for the end-of-waste criteria.

The third part (Chapter 4) analyzes the potential environmental, economic and legal impacts of end-of-waste criteria on glass.

¹ <http://susproc.jrc.ec.europa.eu/activities/waste/documents/Endofwastecriteriafinal.pdf>.

2 Background information on waste glass reclamation and recycling

2.1 Glass and waste glass: terminology and characteristics

2.1.1 Identification and general description of glass

There is no exclusive definition of the term “glass”, a term describing a variety of inorganic materials with different mechanical and optical properties. What all glass materials have in common is a vitreous or amorphous state, originated by the relatively fast cooling and solidification of an initial molten state. The fast cooling prevents atoms, molecules or ions to organize into a more thermodynamically favourable crystalline structure. Therefore, glasses are not arranged in an orderly repeating pattern in all three dimensions like crystals but are characterised by an amorphous structure. As a consequence, glass does not melt at a certain temperature like other solids but softens slowly when heated up.

The most common type of glass is formed by melting a mixture of **silica** (SiO_2), **soda ash** (Na_2CO_3), and **lime** (CaCO_3) at high temperatures, followed by cooling during which solidification occurs without crystallization (Siddique, 2008). In the glass industry the term “glass” is predominantly used for silicate glasses, i.e. materials containing a high share of silica (SiO_2), formed under ambient cooling conditions from the molten state into an amorphous glass structure.

The main raw material for glass production is sand or quartz, which is the crystal form of silica (SiO_2). It consists of a continuous framework of SiO_4 silicon–oxygen tetrahedra, with each oxygen atom being shared between two tetrahedra. In amorphous glass structures, the bonds within each silica tetrahedron have a similar length as in the crystal form (same short-range order), but the three-dimensional distances between different tetrahedra are irregular (no long range order).

2.1.2 Chemical-physical properties of glass

In its simplest chemical form, glass can consist of pure silica, in which case it is called “*quartz glass*” or “*fused quartz*”. However, the production of amorphous glass from pure silica is highly energy intensive, requiring temperatures of around 1900°C . As such, quartz glass is only produced for applications requiring high chemical resistance and hence belongs to the special glass types (MGS, 2010).

In order to lower the energy requirements for glass production, most of the glass is composed of silica (SiO_2) plus other compounds. Silicon has the role of a so-called “network former”, and it is the main element used as network former. Alternative network formers are boron, or germanium. The network formers create a highly cross-linked network of chemical bonds.

Aside from network formers, glass contains also “network modifiers”, which are alkali-oxides added as fluxing agents for lowering the melting point of glass (sodium, potassium, lithium, etc.), alkaline earth metal oxides (calcium, magnesium, barium, strontium, etc.), and other metal oxides (i.e. aluminium oxide). The network modifiers change the bonding relationships and structural groupings, resulting in changes in the physical and chemical properties of the glass. The modifiers are usually present as ions, compensated by nearby non-bridging oxygen atoms, bound by one covalent bond to the glass network and holding one negative charge to compensate for the positive ion nearby.

Glass may also contain other added substances (e.g. lead, titanium, aluminium, zirconium, beryllium, magnesium, zinc), which may act both as network formers (e.g. Pb^{4+} replacing Si^{4+}) and as network modifiers, depending on the glass composition.

The main types of glass, according to physico-chemical composition, are:

1. Soda-lime glass
2. Lead crystal and crystal glass
3. Borosilicate glass
4. Electric glass, also called E glass

The first three categories account for more than 95% of all glass produced. The physico-chemical compositions of the most frequent glass types (soda-lime, lead crystal glass, borosilicate, and E glass) are summarized in Table 1, and are described more in detail below.

Table 1: Major components of soda-lime glass, lead crystal glass, borosilicate glass, and E glass (BREF 2009)

	Soda-lime glass	Lead crystal glass	Borosilicate glass	E glass
Siliceous dioxide (SiO_2)	71-75%	54-65%	70-80%	52-56%
Boron trioxide (B_2O_3)			7-15%	0-10%
Lead oxide (PbO)		25-30%		
Soda (Na_2O)	12-16%	13-15%	4-8%	0-2%
or Potassium oxide (K_2O)				
Lime (CaO)	10-15%			16-25%
Aluminium trioxide (Al_2O_3)			7%	12-16%

Soda-lime glass

Glass industry mainly produces “soda-lime” glass. It is composed of:

- 71-75% silicon dioxide (SiO_2 derived mainly from sand)
- 12-16% sodium oxide (Na_2O derived from soda ash – Na_2CO_3)
- 10-15% calcium oxide (lime, CaO , derived from limestone – CaCO_3)
- Low levels of other components

Sodium carbonate (Na_2CO_3 , “soda”) is added to lower the melting point of silica to about 1500 °C. However, soda addition leads to glass corrosion (Fearn *et al.*, 2006). To provide for a better chemical durability of the glass, calcium oxide (CaO , ‘lime’), magnesium oxide (MgO) and aluminium oxide (Al_2O_3) are added. Soda-lime glass is commonly used for the three major glass applications: container glass (packaging bottles, jars), flat glass (windows of buildings, automobiles) and domestic glass (drinkware, dishes).

Lead crystal and crystal glass

Lead crystal and crystal glass are types of glasses that contain varying amounts of lead oxides, as defined in the Council Directive 69/493/EEC of 15 December 1969 on the approximation of the laws of the member states relating to crystal glass.

The typical lead crystal composition is:

- 54-65% SiO_2
- 25-30% PbO (lead oxide can be partially or totally replaced by barium, zinc or potassium oxide in glasses known as crystal glass)
- 13-15% Na_2O or K_2O
- various other minor components

Lead oxides (PbO and Pb₃O₄) are used to improve the sonority and to increase the refractive index of the glass. This creates the high brilliance of domestic lead crystal and crystal glass products. Lead oxides ease the workability of handmade glass, because they lower the working temperature and the viscosity. Barium, zinc, and potassium oxide have similar properties as lead oxide, but they produce lower levels of brilliance and density, and therefore have disadvantages in the workability of handmade glass. As will be explained later, lead could be a source of environmental impact if it leached out of the glass material.

Borosilicate glass

A typical borosilicate glass composition is:

- 70-80% silicon dioxide SiO₂
- 7-15% B₂O₃
- 4-8% Na₂O or K₂O
- 7% Al₂O₃

If silicon is partly substituted by boron ("borosilicate glass") as a network former, superior durability and resistance against chemicals, water and heat are achieved. Boron changes the viscosity and liquidity to ease fiberisation. Borosilicate glass is used for laboratory equipment, as syringes, ampoules, vials and cartridges for pharmaceutical use, cookware, lighting (as bulbs for high-power lamps), windows for fire protection, and insulation mineral wool.

Electric glass, or E glass

Electric glass or E glass is a special type of borosilicate glass where part of the boron trioxide has been replaced by aluminium oxide, and is also characterized by a low alkali content (<2%). E glass has high electrical resistivity and it was developed for stand off insulators for electric wiring. E glass is mainly used for continuous filament glass fibre production (BREF, 2009).

2.1.3 Glass production and use

The European glass industry is very diverse and covers a variety of very different types of products and technologies, including bottles & jars, flat glass, continuous filament glass fibres (CFGF – not to be confused with insulation mineral wool), flaconnage, tableware, insulation mineral wool, optical fibres and special glass (cathode ray tubes, glass for televisions and monitors, lighting glass, optical glass, laboratory and technical glassware, borosilicate and glass ceramic cookware, etc). The specific products that the glass industry can produce are very diverse, ranging from tiny jewellery products to huge swathes of architectural flat glass for buildings. The common factor among these industries is that they all need glass melting furnaces to manufacture their products. The raw materials they need, the size and type of furnace, the amount of energy needed, the type of fuel used, the amount of cullet that can be used, the length of time needed to melt and produce a finished product vary considerably from one sector to another.

Glass can be applied for the production of various products. A typical classification is based on the six broad sectors of the glass manufacturing industry. Numbers in parentheses indicate their approximate shares of the total EU-27 production. For each sector, specific products or applications are listed below.

(1) Container glass or packaging glass (~56%): Bottles and other containers (for packaging of food, drinks, pharmaceuticals, cosmetics, etc.).

(2) Flat glass (~25%): Mainly windows in buildings and vehicles. The flat glass products can be roughly categorised into two types: float glass and rolled glass. Float glass is used for a huge number of applications including glazing for building and transportation, industrial applications, electronics, furniture, appliances, etc. Rolled glass is used principally in the manufacture of glass doors, partitions,

shower enclosures, and photovoltaic panels. Float and rolled glass are produced with different manufacturing processes. Rolled glass installations have much smaller furnaces than float glass, with lower load.

(3) Continuous filament glass fibres (~2%). Continuous filament glass fibres are produced and supplied in a variety of forms such as mat, chopped strand, roving, yarn, tissue or milled fibre. The main end use (approximately 75%) is the reinforcement for many polymer materials. The main markets for the resulting composite materials are the building industry, the automotive and transport sectors, and the electrical and electronics industry. Continuous-filament glass fibres are predominantly made of E glass.

(4) Domestic glass, also called tableware (~4%). Used for tableware, glassware, decorative glass, etc. Most important components are soda-lime, lead crystal, crystal glass, and opaque and glass ceramics.

(5) Insulation mineral wool (~10%). Insulation mineral wool is made of short fibres of glass (typically borosilicate glass or alkaline earth – alumina- silicate stonewool) and ceramic materials. It is used for insulation, filtering and firestop applications.

(6) Special glass (<3%)². The category of special glass covers a wide variety of glass, for example: optical/ophthalmic glass, glass in laboratory equipment (partly made of borosilicate glass), glass in tubing, glass ceramics, lighting glass, glass composing cathode-ray tubes (CRT) in computer monitors and TVs, as well as glass in other electronic equipment such as in TFT LCD screens (thin film transistor-liquid crystal display). There is no more production of CRT glass in the EU, but there is some recycling activity of CRTs (companies such as GRIAG and CRT Recycling Ltd).

Table 2: Sectors of the glass manufacturing industry, applications, types of glass they are made of, and approximate production volumes in the EU-27 in 2007 (data compiled from BREF, 2009)

Glass manufacturing sector	Application or use	Type of glass	Production in the EU-27 in 2007	Share of total production
Container glass or packaging glass	<ul style="list-style-type: none"> 75% beverage packaging 20% other food packaging 5% packaging cosmetics, pharmaceuticals and technical products 	Soda-lime glass	~21 Mt	~56%
Flat glass	<ul style="list-style-type: none"> 95% float glass: <ul style="list-style-type: none"> 75-85% buildings industry 15-25% automotive industry 5% rolled glass (wired or patterned) 	Soda-lime glass	~9.5 Mt	~25%
Continuous filament glass fibre	<ul style="list-style-type: none"> Roving, mat, chopped strand, textile, tissue, milled fibre (90% used for composite materials) 	E glass	~0.7 Mt	~2%
Domestic glass	<ul style="list-style-type: none"> Tableware, cookware, vases, ornaments 	Soda-lime glass, lead glass	~1.5 Mt	~4%
Mineral wool	<ul style="list-style-type: none"> Insulation material 	Borosilicate glass	~3.7 Mt	~10%
Special glass (CRT not produced in EU anymore)	<ul style="list-style-type: none"> 75% monitor glass 25% light bulbs/tubes, ceramic glass, high-temperature domestic glass 	Soda-lime, borosilicate glasses	~1 Mt	~3%
Total			~37.4 Mt	

² The production of special glass has dropped in the last few years, partly because of the downturn of CRT production (in particular, there is currently no CRT production left in the EU-27).

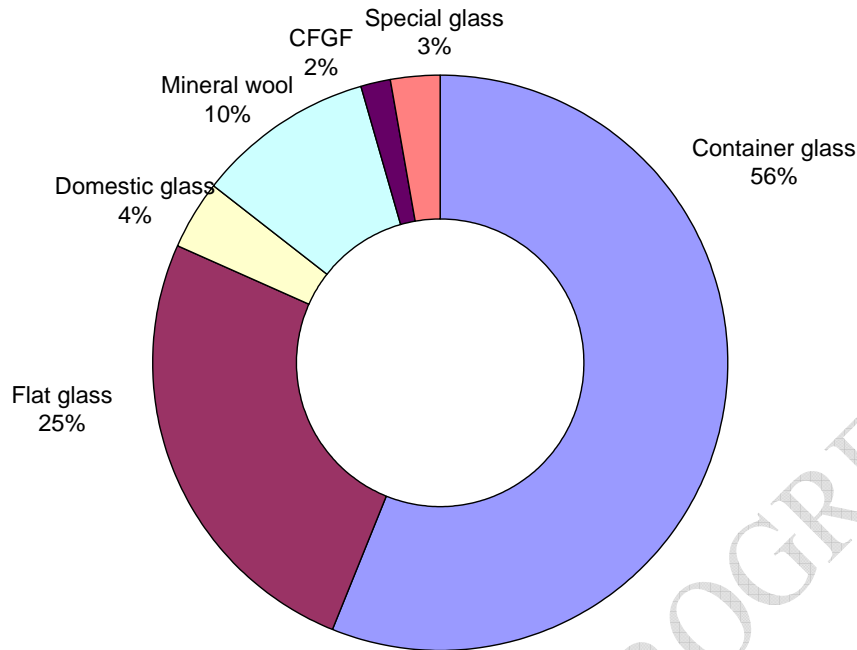


Figure 1: Sectors of the glass manufacturing industry, and their percentage contributions to the total production volume (2007)

2.1.4 Waste glass terminology: cullet

In general, the word cullet can be used to refer to either "broken glass" or to "waste glass". A distinction should be made regarding *internal* vs. *external* cullet: this distinction is important because internal cullet is not regarded as waste, while external cullet (which can be pre- or post-consumer) is classified as waste. When using the word "cullet" in the context of end-of-waste it will always refer to external cullet.

Internal cullet is composed of defective products detected and rejected by a quality control process during the industrial process of glass manufacturing, transition phases of product changes (such as thickness and colour changes) and production offcuts. The basis of the definition of internal cullet is the fact that these materials are immediately absorbed by the respective industrial process as a raw material for a new melting operation, not leaving the glass manufacturing plant. Internal cullet cannot be considered as waste as it was never a product.

External cullet is "waste glass that is collected and/or reprocessed with the purpose of recycling". External cullet can be of two types: (1) pre-consumer, also called post-industrial glass cullet, and (2) post-consumer glass cullet.

(1) Pre-consumer cullet is waste glass resulting from the manufacturing of products that contain glass as one of their components, and which leaves the specific facility where it was generated, becoming waste but not reaching the consumer market. An example of pre-consumer cullet is the glass cullet constituted by offcuts and pieces from defective manufacturing of e.g. the production of car windows from flat glass, which leave the car window manufacturing facility and are re-melted in the flat glass manufacturing facility.

(2) Post-consumer cullet is waste glass originated after the use of the glass products at the consumer market.

The majority of cullet is container glass and flat glass cullet. However, cullet can also come from insulating mineral wool, or from continuous-filament glass fibres. In these cases, especially for the case of High Temperature Insulation Wools (HTIW), the waste glass has a fibrous structure rather than the crushed-glass appearance that is usually associated with the word cullet.

The term **cullet** will be used in this document to refer to **reprocessed cullet**, that is, external cullet that conforms to a set of minimum quality criteria; and the objective of this project is to define the minimum quality criteria for reprocessed cullet to obtain the status of end-of-waste. Some types of reprocessed cullet may have reached a quality that is considered high enough that no additional sorting or cleaning steps are needed for its direct input into a glass furnace; in this case, some studies refer to the reprocessed as **furnace-ready cullet**.

The report sometimes will also make reference to **collected cullet**; in this case, it is a type of cullet that generally conforms to lower quality specifications than reprocessed cullet and may not be suitable as direct input for re-manufacturing into new glass products.

2.1.5 Waste glass: classification

There are two possible classifications of waste glass. On the one hand it can be classified according to its source, on the other hand according to the European Waste Catalogue.

Classification of waste glass according to its source: pre- and post-consumer waste glass

Pre-consumer waste is generated during manufacturing (before reaching the consumer), and has exclusively an industrial origin. It represents approx. 25% of waste glass generated in the EU³.

Post-consumer waste is generated after the manufactured products are used by the consumers. The approximate share of waste glass from this origin is approx. the remaining 75%. The main sources of post-consumer waste glass are:

- Municipal solid waste (from household and commercial waste collection)
- Industrial waste
- Construction and demolition waste (C&D)
- End-of-life vehicles (ELV)
- Waste from electric and electronic equipment (WEEE)

In general, pre-consumer glass is more homogeneous. Waste glass from post-consumer origins will almost always need different degrees of sorting, collection and treatment, while some pre-consumer streams may not need any treatment at all.

Classification of waste glass according to the European Waste Catalogue

An alternative classification of waste glass can be made following the European Waste Catalogue (EWC), which classifies waste glass according to five different sources:

- I. Mixed municipal solid waste and bulky waste (20%)
- II. Glass packaging and other waste glass from municipal, commercial or industrial sources (67%)
- III. Construction and Demolition (C&D) waste glass (5%)
- IV. Industrial sources (7%)
- V. End-of-life vehicles (ELV) waste glass (1%)

³ This figure has been estimated from data in (IPTS, 2009) and feedback received from experts (FERVER, FEVE)

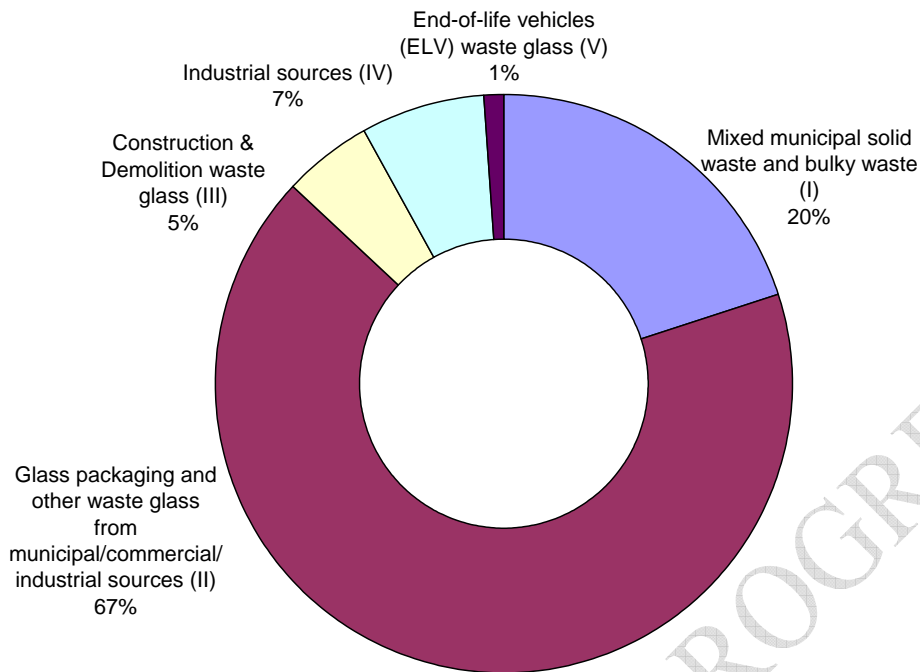


Figure 2: Source distribution of EU-27 waste glass generation according to the European Waste Catalogue

2.1.6 Glass cullet contaminants

Contaminants are materials present in glass cullet that are unwanted for its further use. Contaminants can be classified in two groups: non-glass material components, and glass material components that are detrimental for new glass manufacturing.

Non-glass material components

- Metals (ferro-magnetic and non-ferro-magnetic)
- Non-metal non-glass inorganics:
 - Ceramics, Stones and Porcelain (abbreviated in Europe as “CSP” or “KSP”)
 - Glass ceramics, also called pyro-ceramics or vitro-ceramics: These are heat-resistant non-glass ceramic materials
- Organics (food remains, strapping, plastic, wood, textiles)
- Hazards (hazardous materials contained in bottles and jars, medical or chemical refuse contained within needles and syringes)

Glass material components

Glass product quality is severely affected by the presence in glass cullet of glass types different from the main glass cullet type. For example:

- To manufacture flat glass, only flat glass cullet can be used (flat glass manufacture does not accept for example container glass cullet)
- To manufacture container glass (of soda-lime physico-chemical composition), it is not possible to use non-soda-lime glasses that are sometimes deposited by mistake in collection banks, such as: domestic lead-crystal glass or special borosilicate glasses coming for example from light bulbs and tubes (which present an undesirable higher melting point).
- To manufacture flint container glass, there is a limit on what percentage of green container glass cullet is used. Above that limit, the green glass cullet is adverse for new flint glass manufacturing.

Of all the non-glass contaminants listed above, one of the most problematic is the contamination with non-metal non-glass inorganics, including ceramics (CSP) and glass ceramics⁴. These inorganic contaminants have a higher melting point than glass components and they might not melt depending on their size, thereby creating unacceptable defects in the final glass products. An increased incorporation rate of cullet for glass melting requires high CSP qualities to minimise the risks of interruptions in the production and of inclusions in the final products. From the start of glass collection in the early 1970s until mid 1980s, manual sorting ("handpicking") was the only method to reduce CSP, achieving levels of about 400-500 g/tonne (i.e. 400-500 ppm, or 0.04-0.05%). Today automated optical sorting can achieve CSP levels of 25-50 g/tonne (i.e. 25-50 ppm, or 0.0025-0.0050%) (Van Santen and Beerkens, 2005). The contamination of glass by vitro-ceramics is a relatively new type of contamination. The recycling industry is concentrating on research towards sorting equipment for vitro-ceramics. These developments are rather new and immature. Therefore it is regarded as important to promote better collection schemes to minimize the inclusion of vitro-ceramic contaminants in the cullet.

The next problematic contaminants of glass cullet are metals. The effect of metal contaminants is that as they fall to the bottom of the glass furnace, they may cause damage to the furnace walls and bottom. Metals originate from caps or cans thrown into the waste glass collection banks. Table 3 presents the origin and effect of different types of metal contaminants in glass cullet.

Table 3: Type, origin and effect of metal contaminants in glass cullet (Van Santen and Beerkens, 2005)

Metal	Origin	Effect
Lead	Wine bottle caps (no longer used since the late eighties), reduction of lead oxide from domestic crystal glass	Furnace attack by furnace bottom damage caused by liquid metallic lead downward drilling (lead drops drilling into the refractory bottom of the tanks). Increased lead content in soda-lime container glass.
Aluminium	Cans or caps	Formation of silicon-inclusions by a reaction of the less noble aluminium with silica grains forming silicon metal spheres ($4 \text{ Al} + 3 \text{ SiO}_2 \rightarrow 3 \text{ Si} + 2 \text{ Al}_2\text{O}_3$)
Iron	Cans or caps	Less dangerous for the furnace or glass rigidity, although also causing inclusions and colour cords in the glass products from iron sulphides
Copper	Wires	Possible inclusions of copper or lead (present in some copper alloys) in the glass

Table 4 shows typical maximum permissible levels of major cullet contaminants for the use in container glass, flat glass, and insulation mineral wool production.

⁴ Glass ceramics are also referred to as pyro-ceramics, and they are also known as vitro-ceramics; these are heat-resisting inorganic materials. Amongst all types of inorganic contaminants, pyro-ceramics are considered by industry as one of the most difficult ones to detect and separate out because of their glass appearance. For their effective removal, specialized and innovative equipment is needed.

Table 4: Maximum permissible levels of typical contamination of cullet, for the production of container glass, flat glass, and insulation mineral wool (Glass for Europe, 2005; 2009; Eurima, private comm.)

Contamination	Particle weight/size	Container glass maximum (ppm)	Flat glass maximum (ppm)	Insulation mineral wool (ppm)
Ferrous metals	> 0.5 g	50	None (2 if < 0.5 g)	10
Non-ferrous metals	> 0.1 g	20	None (0.5 if < 0.1 g)	20
Inorganics	> 0.2 mm	20	None	25
Organics	> 2 g	3000	None (45 if < 2 g)	3000

Quality requirements for cullet use in the flat glass production are much stricter than for container glass. Cullet impurities for container glass production in the range of 20 - 50 g of metals and ceramics per tonne of glass (20-50 ppm) are usually acceptable. For flat glass, impurities of ceramics and non-ferrous metals are practically not acceptable. For instance, ferrous impurities have to be lower than 2 g per tonne of glass (2 ppm). Thus, most of the cullet used in the production of flat glass is internal cullet, and it amounts to about 10-15% of the input raw materials. However, most flat glass manufacturers (in particular, float glass) use external cullet, but its quantity is limited because of limited availability of external float glass cullet.

Colour

There are four colours of cullet mainly used in container glass production: (1) clear or flint; (2) green; (4) brown or amber, and (4) mixed cullet. Colour requirements are related to commercial, not environmental, requirements.

Maximum accepted levels of false colours in a given coloured cullet differ according to the desired product quality by the manufacturer. The strictest requirements apply for the manufacture of flint glass, whereas mixed glass (followed by green glass) has the highest tolerance for other colours.

Typical maximum limits of colour contamination for the manufacturing of a given colour of container glass are (BSI/WRAP, 2003):

- Flint glass: < 4% to < 6% (according to FERVER, even a lower tolerance, estimated at <2%)
- Brown glass: < 5% to < 15%
- Green glass: < 5% to < 30%

For container glass production, particle size in general is between 5 and 50 mm. Intentionally ground cullet (even to < 1 mm) is an increasing trend.

2.2 Waste glass management

2.2.1 Description of management options

Glass can for example be reused as returned bottles with deposit, in which case it is not defined as waste. Post-consumer waste glass can be recovered with the purpose of recycling in the glass

manufacturing industry, to make products such as container glass, flat glass or insulation mineral wool, and also for uses that do not imply re-melting, e.g.:

- Additive (fluxing agent) in brick and ceramics production
- Filter media (e.g. for water purification)
- Aggregate in civil works (loose fill, asphalt, backfill)
- Abrasive, e.g. for sandblasting
- Sports turf (rooting medium, top dressing)
- Decorative applications (tiles, flooring, synthetic marble).

The process of recycling consists of a series of steps to condition the waste glass for further use. Typical steps are collection, crushing, sorting, contaminant removal, transport, and final use. Some of these steps can, if appropriate, be by-passed. When no use is found for glass, it is stored or disposed of. The most frequent disposal options are landfilling and incineration. Incineration implies that glass is mixed with other materials in slag, which then can be either used (e.g. in civil works) or landfilled.

2.2.2 Waste glass generation

Overall mass balance

It is estimated (Ramboll/Ökopol, 2010) that the total amount of waste glass generated in the EU-27 in 2007 was 25.8 Mt. This resulted from a total production of glass in the EU-27 of 37.4 Mt in 2007. The extra-EU trade of manufactured glass represented only 5-10% of production. In addition, in 2007, extra-EU imports and exports of glass products approximately balanced each other, with a total imports volume of 3.6 Mt and total exports of 3.5 Mt (ECORYS, 2008).

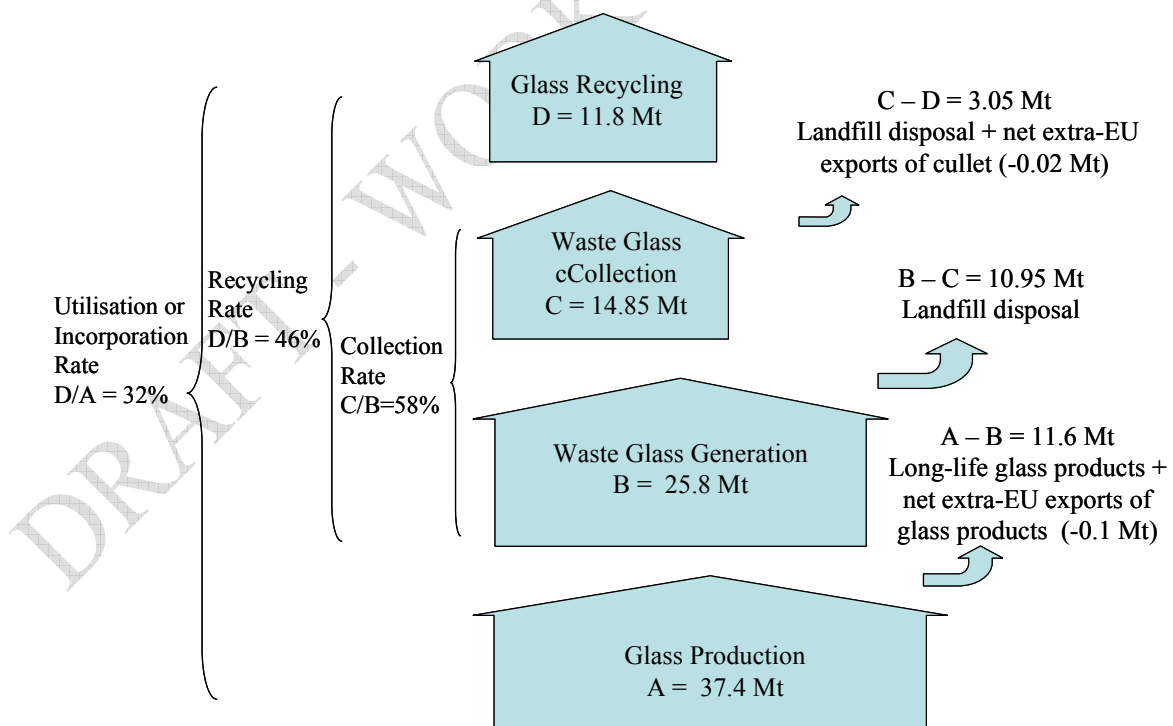


Figure 3: Mass balance of glass production, and consumption, and waste glass collection, recycling, traded, and disposed of (2007)

As can be seen in Figure 3, the difference between glass production (A) and waste glass generation (B) is $A - B = 11.6$ Mt. This difference is composed of long-life glass products, and the net extra-EU exports of glass products. In 2007, the net extra-EU exports of glass products was a small amount, representing only -0.1 Mt.

From the 25.8 Mt amount of waste glass generated, 14.85 Mt was collected for reuse/recovery/recycling. This gives a **collection rate of 58%**. Collection rates vary among member states, with collection rates higher than 80% in some countries.

Out of the total 14.85 Mt collected for reuse/recovery/recycling, around 11.8 Mt were actually recycled to replace raw materials in the manufacture of new glass products. This gives a **recycling rate of 46%** (of the total waste glass generated). As indicated in Figure 3, the difference between waste glass collected and recycled, $C - D = 3.05$ Mt, ends up disposed in landfills or results in a net extra-EU export of cullet. In 2007, the total extra-EU imports and exports of cullet were 0.21 Mt and 0.19 Mt, respectively. Therefore, the net extra-EU export of cullet was a small amount of -0.02 Mt.

Container waste glass is the largest part of the generated waste glass, with about 17 Mt.

Table 5 summarizes amounts of glass production, waste glass generation, waste glass collection with the purpose of recovery (mainly recycling), and waste glass recycled, for each of the six sectors of the glass manufacturing industry, whenever available. Data were collected from CPIV and FEVE statistics, as well as other references (ECORYS, 2008; Ramboll/Ökopol, 2010) and input from the TWG.

Table 5: Statistics on EU-27 glass production, and waste glass generation, collection, and recycling (2007)

Glass type (sector of manufacturing industry)	Production in the EU-27 in 2007 (A)	Waste glass generated in the EU-27 in 2007 (B)	Waste glass collected in the EU-27 in 2007 (C)	Waste glass recycled in the EU-27 in 2007 (D)
Container glass or packaging glass	~21 Mt	~17 Mt	~11 Mt	~8 Mt
Flat glass	~9.5 Mt	~5.1 Mt	~2.9 Mt	~2.9 Mt
Domestic glass (tableware)	~1.5 Mt	~0.8 Mt	~0.5 Mt	~0.5 Mt
Mineral wool	~3.7 Mt	~2.0 Mt	N/A	N/A
Continuous filament glass fibre	~0.7 Mt	~0.4 Mt	N/A	N/A
Special glass	~1 Mt	~0.5 Mt	~0.45 Mt	~0.40 Mt
Total	~37.4 Mt	~25.8 Mt	~14.85 Mt	~11.8 Mt

Notes regarding Table 5: Waste figures include both pre- and post-consumer waste glass. Total collection rate (C/B) is ~58%; total recycling rate (D/B) is ~46%. Data sources for the figures by glass type (sector of glass manufacturing industry) are given below:

- For container glass, statistics were mainly gathered from FEVE published data.
- For flat glass, most of the waste is pre-consumer. Estimates were derived from several sources, including glass manufacturers.

- For domestic glass, estimates were provided by the European Domestic Glass Association. However, as recycling in the domestic glass sector involves mainly spot operations with pre-consumer cullet, rather than a continuous flow of post-consumer cullet, there are no official data or reliable statistics. The figures provided should be regarded as estimates and subject to some degree of uncertainty.
- Regarding mineral wool, it is difficult to use mineral wool cullet for the manufacturing of new mineral wool production, because of its content of binding materials. However, Eurima reports that in the annual manufacturing of mineral wool in the EU (3.7 Mt), about 0.6 Mt of external cullet from container glass and flat glass sources were approximately incorporated. This means that the new mineral wool production incorporates about 16% of external cullet.
- According to GRIAG, the amount of special glass that was recycled in 2007 was around 0.40 Mt (a slightly higher amount was collected, with the difference being approx. the net extra-EU exports of special glass cullet). The amount recycled today is estimated as higher, around 1 Mt.
- In general there are no reliable available data on imports/exports of cullet per glass type but, given that the net trade of cullet for all types of glass combined is small compared to the total volume of waste glass generated, a similar trend is approximately expected when considering each type of glass individually. Because of cost considerations, cullet is generally not a material that is transported over long distances and therefore the imports and exports of cullet are small compared to the amounts recycled locally, near the point of waste glass collection.
- In Table 5, the difference between glass production (A) and waste glass generation (B) is composed of long-life glass products and net extra-EU exports of glass products for each of the glass sectors. As was the case with overall glass statistics (Fig. 3), the net extra-EU exports of glass products are significantly small. The difference between waste glass collection (C) and waste glass recycling (D) mainly goes to landfill disposal and net extra-EU exports of cullet (this last quantity is significantly small due to the mentioned high costs of transport).

Amounts of glass waste generation, collection, and recycling by sources

ELVs

In Europe, about 9 million end-of-life vehicles (ELV) arise each year. Assuming an average vehicle weight of 1000 kg, about 9 Mt of this waste are annually generated. Glass composes ~3% of the weight of a car, that is, about 30 kg, so that the total waste glass from ELVs is around 0.27 Mt per year in the EU-27.

The ELV Directive (2000/53/CE) aims at reducing the amount of vehicle waste to be landfilled. In particular, one of its goals is preventing environmental emissions of four heavy metals: lead, cadmium, mercury, and hexavalent chromium. The ELV Directive sets a reuse and recycling rate target of 80% by 2006 and 85% by 2015 (recycling rate is defined as weight of vehicle waste recovered for re-manufacturing into new products but excluding energy recovery, per weight of vehicle waste discarded).

Annex I of the ELV lists minimum technical requirements for treatment of ELV. The ELV directive encourages the dismantling and selective removal of components such as glass before shredding. Some experts of the TWG have mentioned that ELV glass cannot be recycled into re-melting applications once is shredded together with the metal scrap. If high recycling rates of 90% or higher are to be achieved, the ELV glass needs to be removed before shredding. Experts indicated furthermore that there is the technical capacity in Europe to perform the selective dismantling of ELVs and the recycling of their waste glass fractions with the purpose of re-melting into new glass products.

At present most of the discarded vehicles end up in dismantling facilities, which on the one hand carry out decontamination operations (removal of battery, tyres, fuel, oils, etc.) and on the other hand collect spare parts which can be sold for reuse. The decontaminated and selectively dismantled ELVs are sent to automotive shredder facilities, where the ELV are shredded to recover the ferrous and non-ferrous metals. Many references agree that in current shredding plants, about 75% of ELV is recovered.

The remaining 25%, which is called auto shredder residue (ASR) or auto fluff, is a complex heterogeneous waste which contains many different plastics (thermoplastics and thermosets), elastomers, foams, remaining metals, wood, glass, textiles, etc. Being a very heterogeneous stream, its recycling is neither technically nor economically feasible and therefore up to now ASR have been in their majority disposed in landfills.

Little information is available, but some experts of the TWG indicated that only the Netherlands was removing almost all the automotive glass from ELVs; other countries do it partly (e.g. Germany, France, Italy, Portugal, UK), and the remaining EU countries do it seldomly. Recent information (private communication from stakeholders) suggests that the producer's responsibility scheme in the Netherlands has decided to stop removing the car glass before shredding the vehicles, which is in contradiction with the goals stated in the ELV Directive. Experts from the TWG suggested that more effort should be directed to support the recovery/recycling of car glass, including the preference for dismantling of car windows prior to shredding.

WEEE

Waste from electrical and electronic (WEEE) equipment means equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents, such as computers, ovens, mobile phones, toys and hairdryers. Light bulbs, fluorescent tubes and low energy bulbs are also included in this category. In the collection systems for household waste, for example at apartment blocks, there is often a special place for electrical and electronic equipment, for example in the bulky waste room. Sometimes citizens can take WEEE to a recycling centre, or to hazardous waste collection points.

The WEEE directive (also discussed under legislation) puts the responsibility for reducing, reusing and recycling of WEEE on the producers, and requires removal of hazardous components.

WEEE consists, among other materials, of a mixture of metal, plastics and glass. Treatment may involve steps such as: shredding, granulating, magnetic separation, eddy current separation, density separation. Some manual separation can also be involved. Glass constitutes about 5% of WEEE on average⁵. The percentage of glass in certain types of WEEE materials such as CRT screens is significantly higher as reported by experts from the TWG.

Construction and Demolition (C&D)

According to Glass for Europe (2005) the total waste glass from C&D waste in the EU is about 1.2 Mt yearly. Out of ca 180 Mt of C&D waste, this represents ~0.66% in weight.

Environmental regulations promote selective demolition, considered as the most effective method for recycling the various types of waste streams in C&D wastes. However, mainly for reasons of cost of transport and the low value of most of the C&D recyclates except metals, C&D in the EU follows no standardised practice for the selective dismantling of materials in C&D waste, and the separate collection of glass.

2.2.3 Collection and transport techniques

Post-consumer dry recyclables are collected in two main different ways: *mono-material* collection (optionally with colour differentiation), or mixed with other dry recyclables (*multi-material* collection). Both options have advantages and disadvantages, frequently not affecting the same sectors of society.

⁵ European Environment Agency, "What is waste?", <http://scp.eionet.europa.eu/themes/waste>

Mono-material systems

Advantages:

- Normally results in higher quality. The amount of non-glass is significantly lower, making it easier to process and remove the lids, labels, foils, ceramics and any other impurities.
- Cullet has higher quality, and it is thus fit for a larger range of glass recycling uses. This is especially valid if there is colour separation.
- Increased added value over the recycling chain, also higher with colour separation.
- Lower costs of reject disposal (non-glass material fraction) or bad quality cullet batch disposal.
- In general, higher overall recycling rates (even though collection rates may not in all cases be higher)
- Better image to the public, as multi-material collection may result in the perception that glass is not being recycled
- Avoidance of gate fees for storage at material recovery facilities

Disadvantages:

- Requires existence of a reprocessor with adequate sorting technology within reasonable transport distance, otherwise it is likely that the material will be used for open loop recycling applications, such as aggregates, resulting in virtually no environmental benefits.
- The additional stage of colour sorting may have a significant cost impact and even become economically not viable.
- More demanding for consumers
- More costly in terms of collection than multi-material systems, especially if colour-separated

Multi-material systems

Advantages:

- Easier for households, as less sorting space is needed
- Cheaper collection

Disadvantages:

- Higher reprocessing costs to achieve the same quality as mono-material collection, if at all achievable.
- Lower recycling rates because of high contamination
- Higher glass loss during processing (typically 12-15% is wasted in material recovery facilities, compared to 1% for mono-material processing)
- Cullet frequently not suitable for further reprocessing with the aim of re-melting in glass manufacturing facilities. Experts reported that even in some cases the cullet is not suitable for use as aggregates because of its high organic contamination. As a consequence, the cullet from multi-material systems is sometimes rejected by aggregate companies.

It is currently a widespread opinion of the glass manufacturing industry that the best collection option for the long-term sustainability of the glass recycling industry is mono-material, if possible colour-separated. However, technologies for sorting continue to advance and in the near future it may be the case that multi-material collection may produce high-quality reprocessed cullet.

2.2.4 Reprocessing techniques

After collection and transport to the reprocessing facilities, waste glass is inspected visually, crushed and sorted, yielding cullet that is subsequently transported to a next step in the recycling chain.

Crushing and sorting of waste glass

The first phase of treatment upon arrival of waste glass at the reprocessing plant is visual inspection.

Visual inspection is undertaken by experienced staff with good knowledge of the processing technology of the plant. Lorries tip their load for visual inspection, to determine the processing needs. In some cases, the operator may decide that the contamination is too high for an economic treatment, and the load is disposed of without treatment.

If inspection results in acceptance, the material is crushed. Crushing reduces the glass piece size to the size suitable for further sorting or cleaning. Afterwards the organics may be dried at ambient air, or removed by washing, before the material passes sieves to reduce the organic content as well as magnetic separators and Eddy current separators to reduce the metal content. Highly contaminated materials may pass several times sieving as well as magnetic and Eddy current steps until they are clean enough to pass an optical sorting. In the different phases of the process, air suction removes lighter components such as paper and plastics.

Manual sorting can also be part of the sorting steps, removing by handpicking large pieces of foreign material such as plastics, paper, textiles, or ceramics/stone/porcelain. An increasing problem for container glass cleaning is the recent trend of using transparent thin foils attached to glass, instead of paper labels. Some adhesives of these foils lead to increased rates of waste because they cannot be separated from the glass (Pohl, 2010). Radio frequency identification (RFID) tags might also raise problems for recycling if their use will increase in the future, as suggested by members of the TWG.

The most complex process is optical sorting. Here, glass pieces are first sorted into different flows according to grain size. The flow passes through one or more optical sorting machines. Each sorting machine is equipped with cameras and sensors that use white light, laser light and infrared backlight. The opaque non-glass materials are detected. Different colours of glass can also be detected depending on how they transmit the different incident light beams. Detection triggers blowout commands. Blowout jets are used to eject target impurities at precisely the right moment. Regarding color impurities, this technique allows improving color separation, but not to the extent of a complete separation into single colour waste glass streams. In the last years, fast X-ray fluorescence detection systems combined with blow out techniques have become available as well. The X-ray system is able to sort out undesired glass fractions that cannot be detected with infrared technique, like lead glass, refractory glass and glass ceramic. Within milliseconds, material with defined characteristics is blown out of the cullet, independent from the size, shape, or colour of the particle (Mogensen, 2010; Pohl, 2010). Finally, automatic quality control is combined with manual quality control by qualified staff overseeing the final separation result. The outcome of these steps is cullet with a certain quality.

Pre-consumer glass waste, collected at a direct customer of the glass manufacturer, can spare some of the mentioned reprocessing steps. For example, a car manufacturing company buys flat glass from a glass manufacturer to be used in car windows. Some of the flat glass in the car manufacturing company ends up as waste during the production process of making car windows. This flat glass waste may be directly returned to the flat glass manufacturing company. It is a prerequisite for such direct return without processing that the waste glass has no contamination during its processing at the product manufacturing industry (in the example, the car manufacturing industry). Usually, this practice takes place in cases where long-term customer relations exist, e.g. within two steps of the glass supply chain that share ownership.

Transport of glass cullet to cullet users

Because of its relatively high density, low specific value, and frequent abundance of the raw materials that glass cullet substitutes, glass is mostly produced and consumed locally, and waste glass is collected and used locally. Transport takes place over relatively short distances, normally not more than 300 km. Still for certain types of glass cullet it is profitable to haul longer distances for collection or glass manufacturing.

2.2.5 Recycling techniques

The processed and transported cullet can be subject to a number of recycling techniques. However, a main issue here is compatibility, as only some cullet types may be suitable for the manufacturing of specific glass types.

Compatibility overview of cullet types

Not all cullet can be used for the production of any type of glass. Table 6 lists the origin of the cullet, and the types of glass that can or cannot be made from that cullet.

Table 6: Types of cullet that can and cannot be used in the manufacture of different types of glass

Origin of cullet	Types of glass that CAN be made with that cullet	Types of glass that CANNOT be made with that cullet
Container glass	<ul style="list-style-type: none"> Container glass Insulation mineral wool 	<ul style="list-style-type: none"> Flaconage Very high quality clear bottles Borosilicate-based glass Domestic glass
Flat glass	<ul style="list-style-type: none"> Container glass – (some types of flat glass cullet can be used to make container glass) Flat glass Insulation mineral wool 	
Continuous filament glass fibre	<ul style="list-style-type: none"> Continuous filament glass fibre 	
Domestic glass	<ul style="list-style-type: none"> Container glass (if the domestic glass cullet is lead-free), domestic glass, and insulation mineral wool (if the domestic glass cullet is pre-consumer) 	
Insulation mineral wool	<ul style="list-style-type: none"> Insulation mineral wool 	
Special glass: <ul style="list-style-type: none"> CRT Light bulbs, ceramic glass 	<ul style="list-style-type: none"> CRT and other glass products Light bulbs 	<ul style="list-style-type: none"> Container glass or flat glass

Container glass and flat glass cullet are the most versatile, as they can be used to manufacture a large proportion of all glass products. One of the exceptions is for ultra-clear domestic glass, as it must be free from any coloration. Since even clear container glass has some Fe and Cr which provides some colour, container glass cullet cannot be used to manufacture ultra-clear domestic glass. For ultra-clear tableware, the IWA 8:2009 establishes requirements according to their clarity and iron content. For other domestic glass with less strict clarity requirements, it is possible to produce and market glass tableware made from 100% recycled post-consumer glass⁶.

⁶ For example, there are specialized companies manufacturing or marketing tableware made with 100% post-consumer cullet, such as "La Mediterranea", <http://www.lamediterranea.com>, in Spain.

Within special glass, cullet from light bulbs can be used for the manufacture of new light bulbs. Also, cullet from fluorescent lamps and compact fluorescent lamps can be used for new fluorescent lamps and compact fluorescent lamps. The recovery of these types of products receives impulse from the implementation of the WEEE directive (Article 7 (2c)), which lays down a recovery rate of at least 70% for the average weight per appliance and the reuse and recycling rate of at least 50% per weight of appliance, in the EU.

Waste glass recycling techniques in the container glass industry

The use of external cullet (pre- and post-consumer) for container glass production started in the mid 1970s. Until 2008, within the EU the average use of post-consumer cullet in container glass production increased to approximately 50% of the total raw material input, with some installations utilising more than 80% cullet (BREF, 2009). Although the figures may not be representative for the EU-27, Table 7 shows different types of cullet used for the three major colours in container glass production in Germany in 2009, where the overall cullet use was 71.9 % (BV Glas, 2010).

Table 7: Percentages of pre- and post-consumer cullet used in the manufacture of flint, green and brown container glass, in Germany in 2009 (BV Glas, 2010)⁷

Glass type manufactured	Use of pre-consumer container-glass cullet	Use of post-consumer container-glass cullet	Use of flat glass cullet	Total use of cullet
Flint	15%	46%	8.4%	69.4%
Green	11%	63.5%	0.9%	75.4%
Brown	14.2%	55.1%	1.8%	71.1%

In the UK, 31% of container glass cullet and 3.3% of flat glass cullet are used on average for the manufacturing of container glass.

There are only a small number of container glass products, e.g. perfume and spirit containers, requiring a high degree of absence of colour. In such cases, no significant use of post-consumer glass cullet can be made due to colour impurities (BREF, 2009). In the opposite end of compatibility, green container glass can be made with up to over 90% cullet from a range of origins.

Waste glass recycling techniques in the flat glass industry

The use of cullet in flat glass manufacturing requires high cullet quality because the majority of products are colourless and do not allow impurities. Besides own production waste (internal cullet), flat glass industry uses external cullet, but nearly exclusively from processors of flat glass because this guarantees receiving specific cullet properties. It is estimated that about 95% of waste glass from flat glass processing is recycled (BREF, 2009).

The return of specific flat glass cullet quality from processing industries is eased by the fact that many processing companies (e.g. insulation glass producers) are owned by companies also producing flat glass. Although direct return from processing to melting is possible, flat glass producers prefer to contract waste glass treatment companies to be sure that contaminations are minimised, caused in particular by metals from spacer bars of insulation glass production or stones from waste storage and handling (Pohl, 2010).

About 3% of end-of-life vehicles (ELV) consist of glass (i.e. about 30 kg of glass for a 1 tonne car). The automotive glazing sector is actively involved in discussions on the treatment of ELV glass and provides advice and assistance to the economic operators involved. Cullet derived from ELV can often meet the quality requirements for the insulation mineral wool, container glass and the flat glass

⁷ According to FERVER, the total use of cullet in the manufacture of green container glass in the EU can even reach up to 95%.

industries (Glass for Europe, 2009). Currently, in the UK 4% flat glass cullet is used for the manufacturing of new flat glass.

Waste glass recycling techniques in the mineral wool industry

Insulation mineral wool (short glass fibre) is produced with organic binders, therefore the production waste as well as filter materials contain significant levels of organic substances. These can lead to problems in the production of new mineral wool and other glass types: reduced heat transfer, foaming, destabilisation of melting conditions, and alteration of the furnace chemistry. Furthermore, the organic content can make it necessary to add sodium or potassium nitrate as oxidising agent, which can significantly contribute to the production of nitrogen oxides emissions (BREF, 2009).

An additional issue of waste from the insulation mineral wool sector is that when fibre becomes waste, it is often in the form of a composite material, from which glass cannot be separated and is thus very difficult to recycle for the production of new glass products. Several manufacturers undertake internal recycling of fibrous production waste and of dust collected from the furnace waste gas. Before reutilization within the facility, pre-treatment is necessary due to the fibrous nature of the production waste. The material is pelletized or ground by milling.

Conversely, the production of high temperature insulation wool (HTIW) (aluminium silicate/calcium-magnesium silicate) uses no binders and therefore production waste can be re-fed into production without major difficulties.

However, the insulation mineral wool industry is increasingly using external cullet as raw material, in particular container glass and float glass cullets. As an example, insulation mineral wool in the UK uses up to ~30% of container glass external cullet and ~20% of flat glass external cullet. Experts from this industry reported a trend of increasing use of external cullet in mineral wool manufacture. Mineral wool manufacture sometimes can accept higher impurities of e.g. non-glass non-metal inorganics compared to other glass manufacturing sectors, especially if the cullet is finely ground prior to re-melting. The mineral wool industry therefore offers high potential for increasing incorporation of external cullet into its production, resulting in improved energy efficiency and environmental performance of this sector.

Waste glass recycling techniques in continuous filament glass fibre manufacturing

Continuous filament glass fibres are used in composite materials as a reinforcement component, which is valued because of its high strength to weight ratio. Some of the applications are in the construction, transportation, automotive and electrical and electronic sectors.

For the manufacturing of continuous filament glass fibre (CFGF), molten glass is drawn through a multi-hole heat-resistant tray with hundreds of 5-30 μm -diameter openings through which glass flows to form thin filaments. Afterwards, the filaments are treated by physico-chemical processes called "sizing", which promote the adherence of the fibres to different resins.

Because of the resin materials adhered to the glass fibres, the recycling of CFGF cullet in the CFGF manufacturing still presents difficulties. However, some limited internal re-melting of intermediate manufacturing residues has been started, and it contributes to minimize glass residues going to landfill (BREF, 2009). Because of special manufacturing requirements, the CFGF production sector uses virtually no external cullet of any type.

Waste glass recycling techniques for special glass

Cathode ray tube (CRT) glass for TV and computer monitors consists of a panel glass (lead-free glass screen) and a funnel glass (lead glass tube containing about 20% Pb). The panel glass contains substances like barium and strontium.

In general, there are no widespread recycling options for CRT, especially not in re-melting applications. There is however a small number of companies worldwide (a few in the EU) with technologies and processes for the recycling of CRT. Recycling companies separate panel glass from lead-containing funnel glass, commercialising cullet of these two fractions. Since there is no more CRT manufacturing in the EU, it is to be expected a rapid and steady decrease of CRT waste glass generated in the EU in the coming years.

The lead-free fraction (< 200 ppm) fulfils the requirements of the Packaging Directive (94/62/EC), amended by Commission Decisions 2001/171/EC and 2006/340/EC, of 250 ppm for Pb, Hg, Cd and Cr⁶⁺.

For the lead containing fractions, there are only a few niche options available. These include for instance the production of lead containing radiation shields, which protect against gamma radiation thanks to the presence of lead.

For other special glasses, for example light bulbs, the use of cullet is encouraged by the WEEE regulation (Article 7 (2c)), which sets a recovery rate of at least 70% for the average weight per appliance and the reuse and recycling rate of at least 50% per weight of appliance.

Waste glass recycling techniques in domestic glass manufacturing

Regarding the use of cullet in domestic glass manufacturing, a distinction has to be made between pre-consumer and post-consumer cullet. In general, post-consumer cullet does not meet the quality requirements for the manufacturing of domestic glass products, particularly to produce clear and ultra-clear tableware. For instance, the IWA 8:2009 requires iron level below 200 ppm for clear glass and 140 ppm for ultra-clear glass. However, there are also some specialised companies (for instance, "La Mediterranea" in Spain, <http://www.lamediterranea.com>) producing or marketing tableware made with 100% post-consumer cullet.

On the other hand, the pre-consumer cullet (coming directly from tableware production or via specialised intermediates) is well appreciated for recycling either in domestic glass or others sectors of the glass industry such as for container glass manufacturing, when the glass properties allow mixing (e.g. not allowed for lead crystal glass) (BREF, 2009). For example, pre-consumer cullet is used in cases where tableware and container glass are produced by two different companies on the same site (for instance in the Netherlands) or by the same company but in two different sites (Italy, Bulgaria).⁸

The recycling of lead crystal is a specific case, because this cullet can only be used for producing lead crystal. Quality considerations lead to higher rate of rejections and hence higher level of available cullet. Taking into consideration the high value of the raw materials, it is a common practice to sell/buy cullet between lead crystal manufacturers. This solution is considered much more preferable than landfilling.

Recycling in the domestic glass is estimated to represent currently around 0.5 Mt per year. Recycling of cullet in domestic glass manufacturing is considered to offer a large growth potential.⁹

⁸ European Domestic Glass Association, pers. comm. (2011)

⁹ Feedback from European Domestic Glass Association

Waste glass recovery techniques in non re-melting uses

There is a large number of secondary end market applications that can absorb cullet, although in terms of amounts, these do not absorb major flows. Frequently quoted uses are in ceramic sanitary ware production, as fluxing agent in brick manufacture, in sports turf and related applications (top dressing, root zone material, golf bunker sand), as water filtration media, as abrasive, or simply as filler material in civil works.

As in the EU such applications are currently limited, the details of the techniques used in these applications are not included in this report. In general, these outlet options do not require as strict quality criteria as in re-melting applications.

2.2.6 Industry structure

Glass production industry

The EU glass manufacturing industry represents ca. 1,200 companies and about 215,000 workers. The size of the glass companies range from small furnaces (SME) to big multinationals present in several countries (CPIV, 2010). In 2007, it produced 37.4 million tonnes of glass products.

The container glass manufacturers represent 56% of the industry in terms of production volumes. Flat glass volumes for the construction and automotive sectors represent ca. 25%. The remainder of the manufacturers produce mineral wool (10%), reinforcement fibres (2%), domestic glass (table- and cookware) (4%) and others (3%). The market is characterized by having a few, large manufacturers, particularly within the container glass, flat glass, and CFGF sectors (see Table 8).

Table 8: Structure of glass manufacturing industry in the EU-27 (data compiled from BREF, 2009)

Glass type	Number of companies	Number of large companies/groups	Number of installations	Number of member states where production takes place	Typical installation size
Container glass	70	6	175	22	300-600 t/day
Flat (float) glass	13	4	58	16	550-700 t/day
Domestic glass	Many	11	61 (> 20 t/day)	19	< 20 t/day
Mineral wool	> 5		62	21	80-160 t/day
Continuous filament glass fibre (CFGF)	7	4	17	11	50-100 t/day (avg.), wide range of installation sizes (equally distributed)
Special glass: glass tubes, bulbs, other	12		23	11	30-80 t/day

A number of organisations exist to represent the interests of the European industry.

FEVE is the association of European manufacturers of glass packaging containers and machine-made glass tableware. FEVE represents 59 member companies (21 groups), producing glass in 22 countries (EU, Switzerland & Turkey). The container glass industry is made up of three different sub-sectors that produce a diversity of products for different markets (bottles and jars for food packaging, glass packaging for cosmetic and pharmaceutical applications – also called *flaconnage*, or tableware for domestic glass).

Glass for Europe is the trade association for Europe's manufacturers of building, automotive, and transport glass, all derived from the basic material known as flat glass. This glass is used to make windcreens and windows for automobile and transports, and windows and façades for houses and

buildings. It is also used, in much smaller quantities, for many other applications like solar energy equipment, interior fittings and decoration, furniture, “street furniture” like bus stops for example, appliances and electronics, and others. Glass for Europe has four members: AGC Glass Europe, NSG-Pilkington, Saint-Gobain Glass, and Sisecam-Trakya Cam – and works in association with the company Guardian. Altogether, these five companies employ over 16 000 people across the EU and have an annual production capacity of around 11.5 Mt of float glass, representing nearly 90% of Europe’s flat glass production.

Other interest organizations at the European level representing the glass industry include: CPIV as the European umbrella organisation for all glass sectors; ESGA, the European Special Glass Association; EDG, European Domestic Glassware association; GlassFibreEurope, the European Glass Fibre Producers Association; and Eurima, the European Insulation Manufacturers Association.

Reprocessing industry

Reprocessing covers the stages of the life cycle chain of waste glass collection, sorting, pre-treatment, processing, transporting, and delivery for use (glass products, or other). Along this chain, the recovered waste stream gets clean to become secondary raw material for subsequent manufacturing of glass products.

FERVER is an international non-profit organization of waste glass reprocessing and recycling companies created in 2004, and currently encompassing more than 30 members coming from 12 European countries (10 EU member states plus Norway and Ukraine). In most of the EU countries there are a few (less than 5) cullet reprocessing companies, each of them with a number of reprocessing facilities across the country.

Some European Directives (for example the ELV or the WEEE) place the responsibility of collection and recovery of certain waste products on the glass producers. In a few countries, the government has set up a national organization (such as Eco-Emballages in France) that organizes the waste glass collection and establishes a single price for cullet, guaranteeing the purchase of the cullet at that price from the cullet reprocessors. In these cases, the cullet reprocessors do not own the cullet. In most of the EU countries, there is no organization setting a single price for the cullet, and instead there is a free market where the cullet is owned by the reprocessors until it is sold to the manufacturers.

In Spain, the glass packaging manufacturers have set up Ecovidrio, an organization in compliance with the Packaging Directive, which needs to be authorized in each autonomous region. Ecovidrio organizes the waste glass management, including collection and reprocessing. The cullet is owned by the organization Ecovidrio, and the organization sells it to glass manufacturers at market price, ensuring complete recycling.

Overall in the EU, it is not uncommon that cullet reprocessing companies are associated or owned by the glass manufacturers, being co-located or at close distance from the manufacturer. This structure provides producers with high confidence in the quality of the cullet, reducing transportation costs and the likelihood of cullet contamination during transport.

2.3 Economic and market aspects of waste glass recycling

2.3.1 Markets and international trade of glass cullet

Intra-EU trade refers to imports and exports within EU countries, where the total import volume should be equal to the total export volume. Extra-EU trade refers to imports by EU member states from other countries outside of the union, and exports by the EU to other countries outside of the Union.

Data on the glass cullet traded among member states, as well as imports and exports to and from the EU-27 have been estimated using Eurostat's external trade database, COMEXT. The dataset is "CN8 70010010 Cullet and other waste and scrap of glass".

Figure 4 presents the temporal variation of intra-EU trade, where the plot of "imports" and "exports" should be identical, but it is slightly different because of differences and errors in data reporting. The trade (as represented by either imports or exports) grew steadily since 2000 until 2006, when it reached a value of around 1.5 million tonnes (Mt), and it then made a jump by 30% to the current level of around 2 Mt of intra-EU trade. In 2009 the trade of cullet fell slightly, possibly as a consequence of the economic crisis.

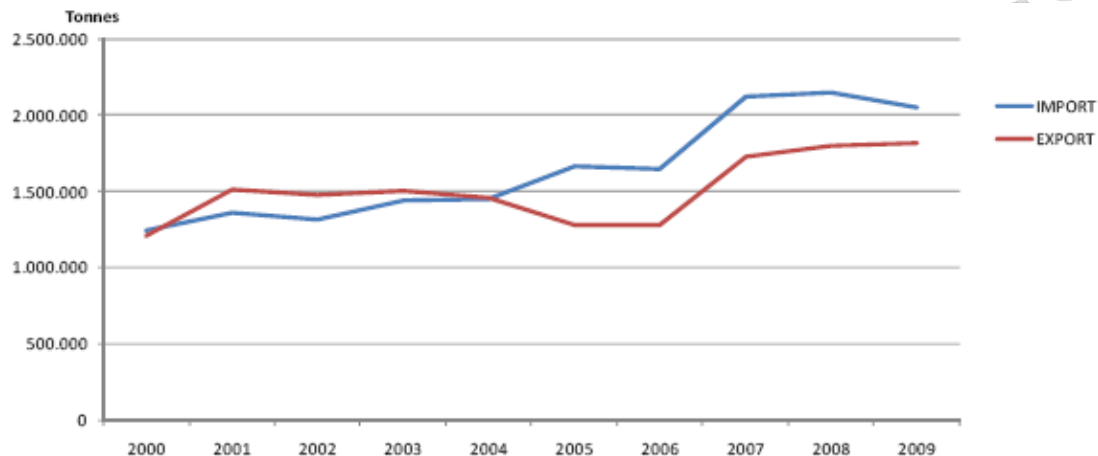


Figure 4: Intra EU-27 Trade of cullet and other waste and scrap of glass (Eurostat, 2010b)

The trade volume with non-EU countries (Figure 5) is about a tenth of the intra EU trade. Figure 5 represents the temporal trend of total imports from and exports to the EU-27. In this figure, it can be appreciated that imports outweigh exports, although both magnitudes have grown from 2000 to 2009. Since 2000 until 2007, the total exports from EU to non-EU countries have tripled from 50 000 to 150 000 tonnes, reducing the difference between total imports and total exports. In 2007, the import surplus was reduced to 17 000 tonnes, but since then until 2009 the import surplus is growing again as exports from EU to non-EU countries are in a downward trend during the past couple of years.

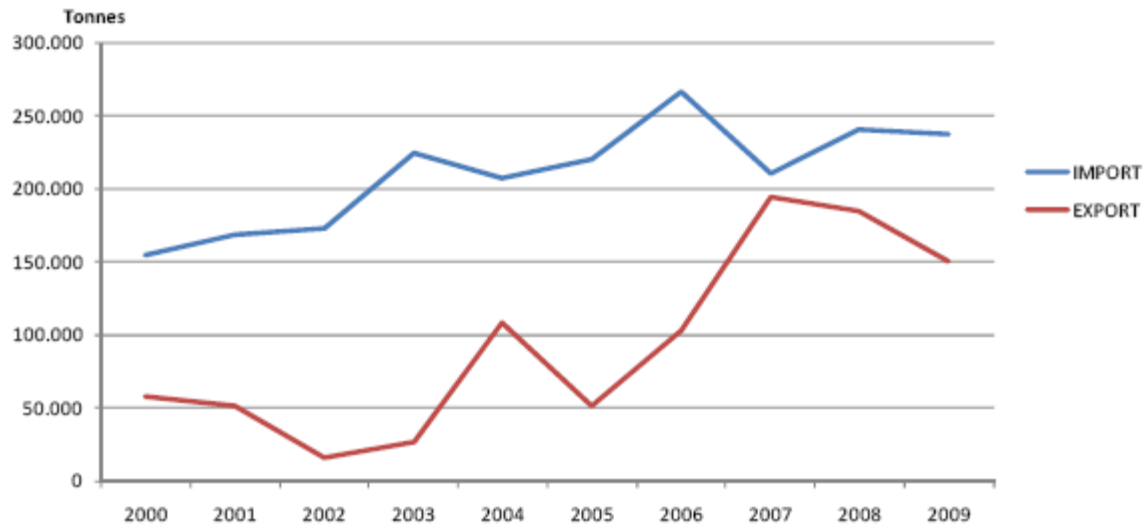


Figure 5: Extra EU-27 Trade of cullet and other waste and scrap of glass: temporal variation of total imports and exports from and to EU-27, from 2000 to 2009 (Eurostat, 2010b)

The main exporter of cullet to the EU is a neighbour of the EU countries: Switzerland, from where around 80% of cullet is imported.

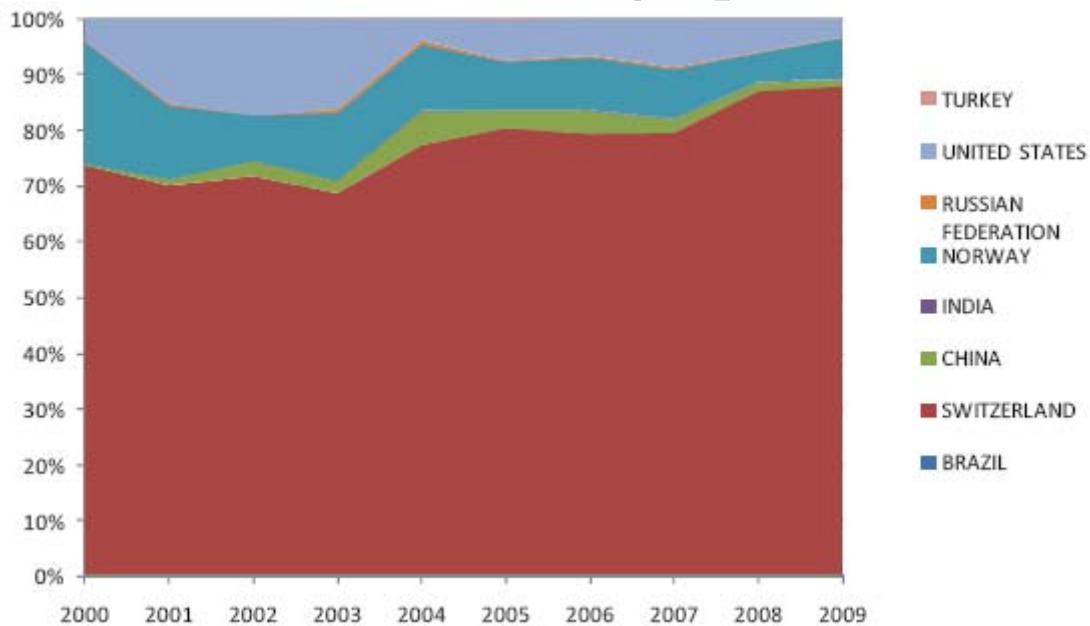


Figure 6: Extra EU-27 Import of cullet and other waste and scrap of glass: Distribution of imported cullet volumes, regarding country of origin of the traded cullet (Eurostat, 2010b)

The extra-EU export of cullet shows a variety of trading partners (Fig. 7). The export to Switzerland has decreased since 2000 until 2004 and is now stable. The export to India is on the increase. The export to Brazil, Russian and Canada increased for some years but is now low.

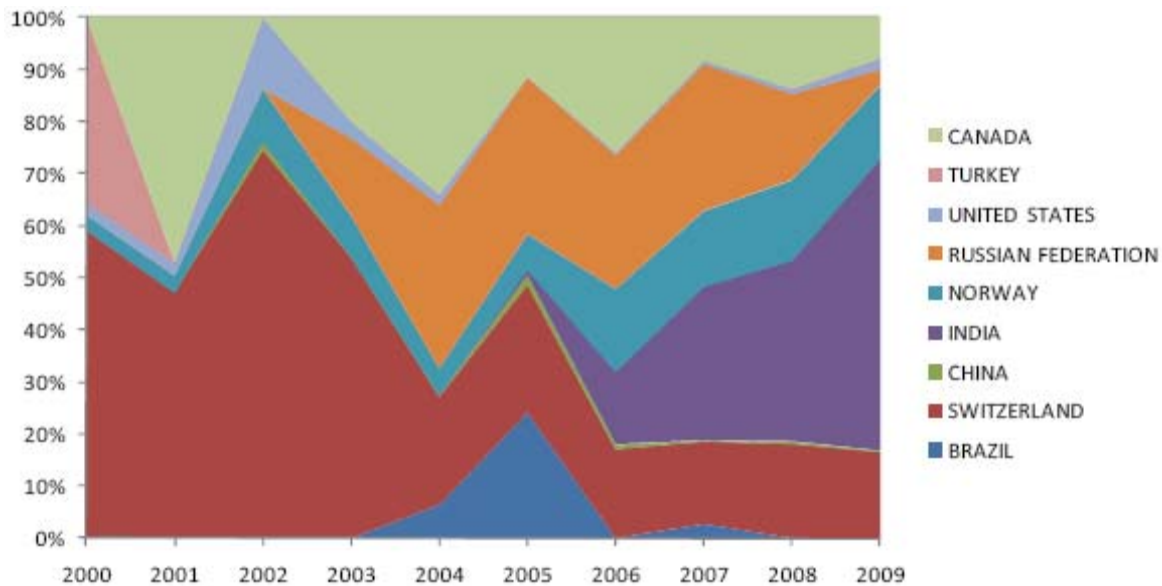


Figure 7: Extra EU-27 Export of cullet and other waste and scrap of glass: Distribution of exported cullet volumes, regarding country of destination of the traded cullet (Eurostat, 2010b)

2.3.2 Cost of waste glass recycling

The cost of waste glass recycling involves costs for collection, sorting, treatment and re-melt, and waste disposal.

Collection and sorting costs: Collection of container glass from households

The average cost of separate collection of recyclable materials from household waste in France has been estimated at 139-144 EUR/tonne¹⁰. Only a share of this relates to glass.

Additional colour separation in existing mono-material kerbside collection could add 10-15% to the operating costs of a collection scheme, and cost 17 – 24 EUR per input tonne more than collecting mixed glass in a single compartment (WRAP, 2007).

Multi-material collections are estimated to be 10-20% cheaper than collecting glass in a separate compartment, including MRF gate fees (WRAP, 2007).

Collection and sorting costs: Dismantling of end-of-life vehicles (ELV) components

Experience from the UK shows costs of dismantling at 122 – 467 EUR per tonne.

The French ADEME has estimated removal costs of 40-50 EUR/tonne for the windshield and 10-20 EUR/tonne for the side windows.

Some studies suggest that, once dismantled, mixed automotive glass has a negative value of approximately 30 EUR/tonne (GHK and BIOIS, 2006)

Separating integrated heating elements and radio antennae in the windscreens from the waste glass comes at a cost of 50 – 120 EUR per tonne of glass to ensure a better quality product. The resulting

¹⁰ Data from ADEME, France, <http://www2.ademe.fr/servlet/getDoc?id=11433&m=3&cid=96>

waste glass quality does not allow for recycling waste glass back into flat glass but is suited for less demanding uses (Envirowise, 2008).

Collection and sorting costs: Construction and demolition (C&D) waste glass

Crushing of glass together with concrete costed around 11 EUR/tonne in 1997, (DEMEX, 1997)¹¹. Separate removal of flat glass (windows) at demolition sites is rather costly, at 430 – 1675 EUR per tonne (DEMEX, 1997).

Costs of re-melt and treatment

British Glass has estimated the distribution of manufacturing costs for container glass. Energy is the largest share with 27%, followed by raw material input costs of ca. 16% (WRAP, 2008). Since every mass unit of cullet substitutes 1.2 mass units of raw material, and re-melting cullet is less energy intensive than re-melting raw material, both energy and material costs will be proportionally lower as higher rates of cullet are incorporated in glass manufacturing.

2.3.3 Prices

Prices of glass cullet may vary significantly from one country to another in the EU. Information on prices from some individual member states (UK, France, Denmark) are presented here to give an indication of the order of magnitude of prices, as data was easily available in those countries, but well aware that these figures might not be fully representative of the remaining EU-27 countries.

The market prices for glass cullet largely depend on the price of primary raw materials that cullet substitute, and on energy prices. Raw materials and energy prices are determined by demand and supply. According to data from Eurostat (Price index on secondary materials), the average, annual market prices for glass cullet have shown an upward trend since 2000. Prices have risen from around 35 EUR/tonne to 50 EUR/tonne in 2008. Between 2003 and 2004 alone the glass cullet price rose by 10 EUR/tonne. The price development is presented in Figure 8, Figure 9 and Figure 10.

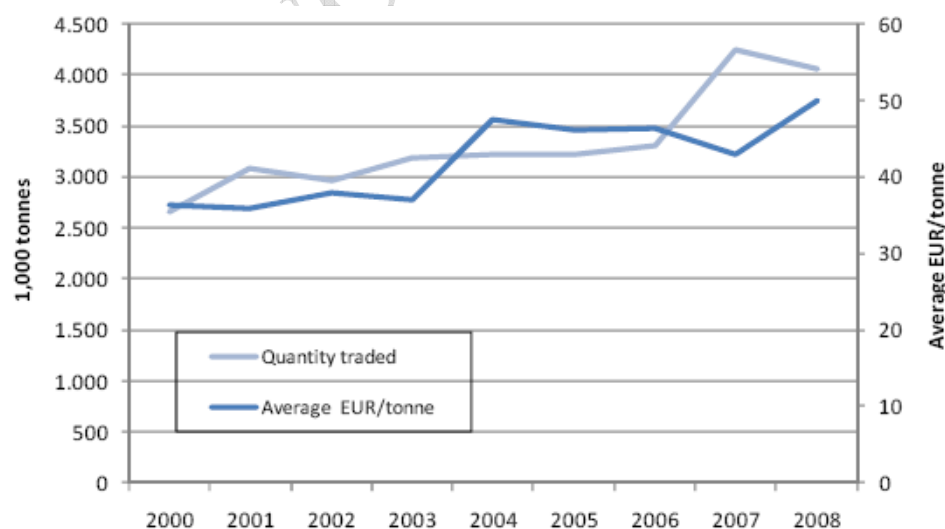


Figure 8: Market prices for glass cullet and traded volumes, annual average prices 2000-2008 (Eurostat, 2010a)

¹¹ The approximate exchange rate is 1 DKK = 0.134 EUR

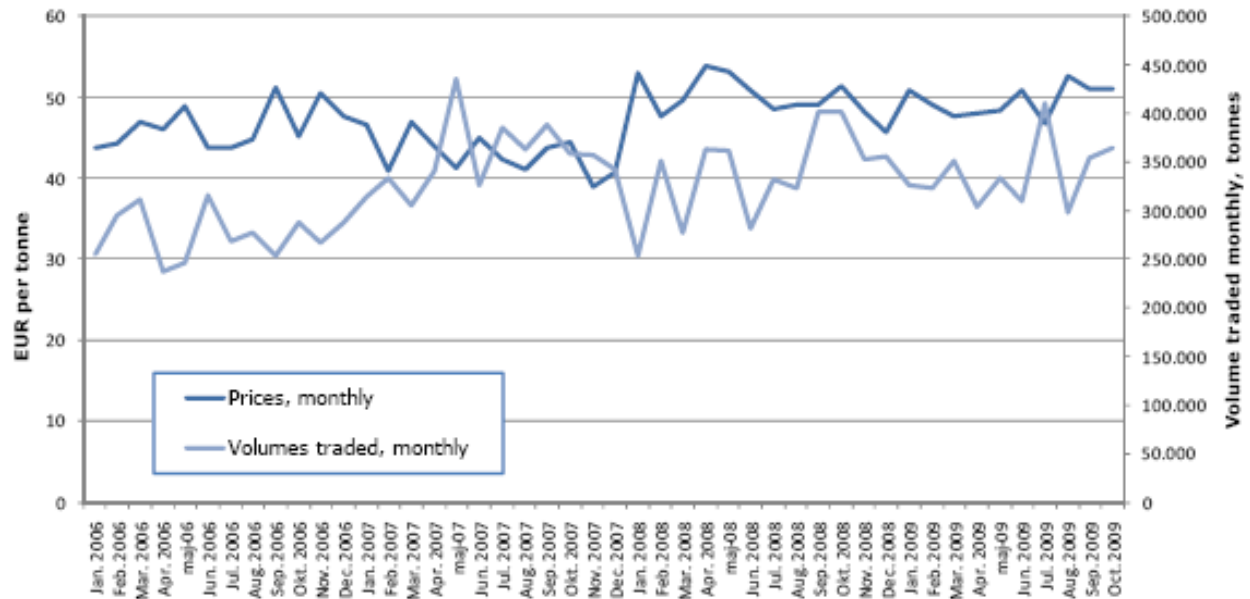


Figure 9: Market prices for glass cullet and traded volumes, January 2006 to October 2009 (Eurostat, 2010a)

Case example: UK

Figure 10 represents prices for container glass delivered to a cullet collector who will clean and sort the glass ready for use, or for further checking, by a glassmaker (LetsRecycle, 2010). The prices correspond to 2006 (Jan – Dec) and the period January 2009 – April 2010. For each colour, the maximum and minimum price is displayed. The price paid for glass cullet tends to be relatively stable because the glass industry is not dependent on the export market and there is also a strong domestic market for glass.

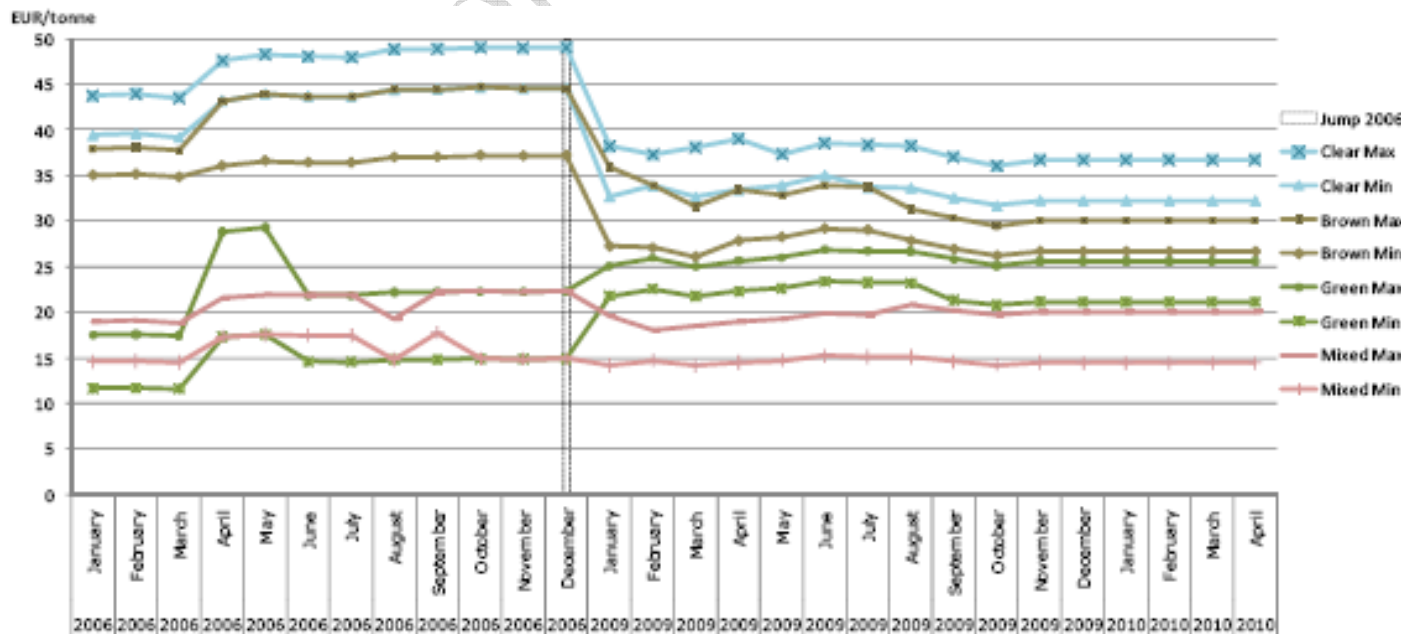


Figure 10: UK market prices (minimum and maximum) for bottles and jars in two time periods : Jan-Dec 2006 (left half of the graph), and Jan-2009 to Apr-2010. Prices in EUR/tonne (Monthly exchange rates have been used to convert GBP into EUR) (LetsRecycle, 2010)

The prices for clear and brown cullet fell about 10 EUR/tonne from 2006 to 2009. Green cullet prices rose a little whereas the mixed cullet price remained at a constant price of 15 EUR/tonne.

Case example: Denmark

The cullet prices in Denmark show a downward trend since 1989. The clear and coloured cullet follow the same trend, but for cullet of lower quality, such as mixed cullet and cullet of flat glass and lamps, the fall in prices is more pronounced. Today's price for medium quality is ca. nil (delivered at the gate), and poor quality cullet comes actually at a cost of 46-53 EUR/tonne (Ramboll/Ökopol, 2010).

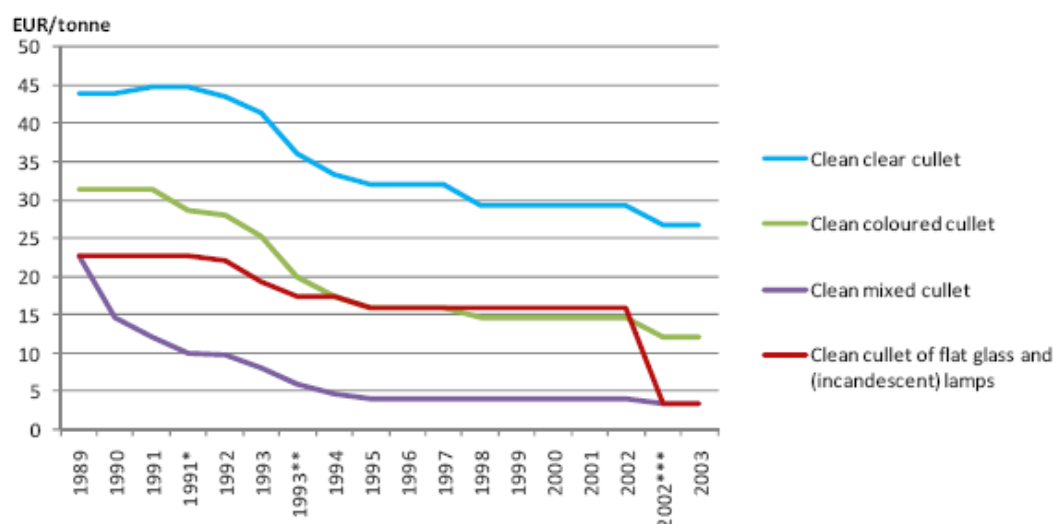


Figure 11: Price development on the Danish market for cullet, 1989-2002 (EUR/tonne) Note: *: Revised prices 1 March 1991 – 31 Dec 1991. **: Revised prices 1 March 1993 – 31 December 1993. ***) Revised prices 1 August 2002 – 31 December 2002. As of 1 October 2002 the transport refund was reduced to 6.7 EUR per tonne. Source: Kaysen (2004) and Kaysen (2001)

Case example: France

The French glass manufacturers have guarantee contracts with local authorities ensuring the purchase of all glass cullet collected at a price per tonne agreed in advance. The price is set for one year, and in 2009 it was ca. EUR 20 per tonne (Verre Avenir, 2010).

In the context of this take-back guarantee to local authorities, Eco-emballages and Adelphe Recyclage have published a reference price for container cullet in Europe. In 2007-2008 PriceWaterhouseCoopers (2009) conducted a survey among 45 plants located in 11 EU member states. The reference price is based on data from 35 plants. A similar survey was made for 2004- 2006. The survey shows that the price for container cullet was almost stable in 2004-2006. Over the period, the price rose by 17.4%.

Table 9: Reference index for container cullet price in Europe (France excluded) Note: Container cullet includes household glass from local authorities, industrial glass (bottle plants) and other sources (e.g. restaurants and commercial catering). Cost prices apply to ready-to-use cullet delivered to the plant (PriceWaterhouseCoopers, 2007; 2009).

	2004	2005	2006	2007	2008
Reference index	100	100.1	101.0	104.2	117.4

Prices apply to ready-to-use cullet delivered to the plant. They include the following costs and subsidies:

- Purchase of raw glass;
- Transportation of the raw cullet from the collection point to the treatment centre;
- Treatment of the glass;
- Transportation of the processed cullet from the treatment centre to the plant;
- Any supplier discounts or grants awarded to the glass manufacturers through any domestic system in place (this can include, for example in Italy: transport grants, year-end discounts, subsidies for target overshoots, or raw glass purchase grants)
- Where applicable, amounts paid by glass industrials to finance the administrative expenses of the organization of the recycling of household glass from local communities.

The French glass manufacturers use mixed colour cullet from selective collection of unsorted raw glass PriceWaterhouseCoopers (2009).

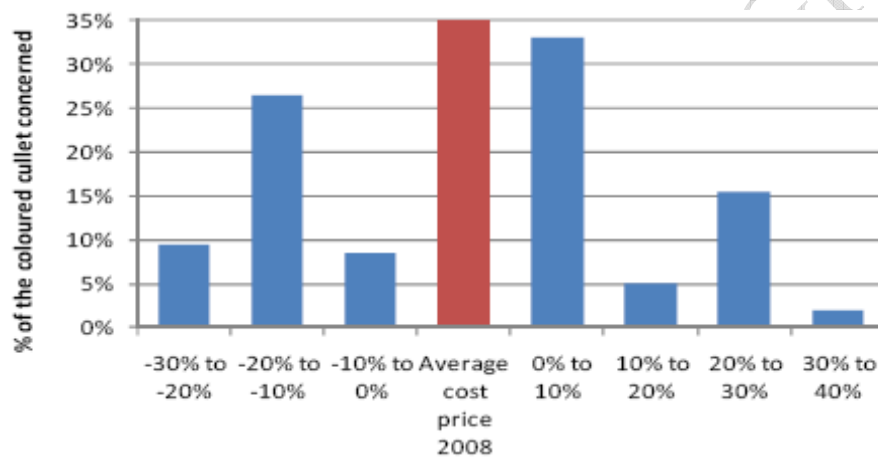


Figure 12: Dispersion of the cost price compared to average cost for coloured cullet\

EU-wide outlook

Some of the elements that influence the development of the cullet market are:

- The supply and demand of cullet
- The development of the energy market (the higher the energy costs the more cullet will be used)
- The CO₂ taxes
- The availability of virgin raw materials
- The technological development of glass processing
- The development in collection systems
- The ability of the market to use the collected and processed quantities that will substantially be increasing in those countries where collection rates today are low.
- The development of international trade imbalances, e.g. surplus of green cullet in the UK vs net export of flint products.

2.4 Technical specifications and standards

2.4.1 Overview of existing standards

Technical specifications and standards are needed and widely used in the industry to create references for price-setting, for classification, and for quality control.

Technical specifications and standards for glass cullet may refer to one or more of the following properties of the glass cullet material:

- Physico-chemical composition
- Content of impurities
- Physical size and shape
- Homogeneity, i.e. the variation within the given specification

A specification may include safety requirements. They may establish maximum limits of given impurities, and may also exclude certain components. Impurities include non-glass components, and glass components that are detrimental for new glass manufacturing.

There are a number of technical specifications developed by industrial or recyclers organizations (FERVER, BSI/WRAP), or independent consultant groups, and which are applied in certain member states and in individual market transactions on a case-by-case basis.

Additionally, member states in some cases have developed technical standards for glass cullet. Feedback from the TWG pointed out that these standards may vary significantly from country to country. These national standards are usually strictly linked to the quality of the collected cullet, to the technical structures of local glass industries and to the national commercial situation.

FERVER technical specifications

In the glass recycling and manufacturing industries, common specifications exist, as drafted by FERVER for so-called “furnace-ready cullet”. After consultation among its members, FERVER has put together a set of technical specifications to characterize cullet of sufficient quality that could eventually be declared as end-of-waste, and as a possible guideline for end-of-waste criteria (FERVER, 2007), as follows:

Table 10: Maximum limits for non-glass contaminants, from FERVER specifications for end-of-waste cullet

Contaminant	Limit (ppm)	Limit (wt%)
Ceramics (CSP)	100	0.01
Ferrous Metals	10	0.001
Non-ferrous Aluminium	25	0.0025
Non-ferrous Lead	35	0.0035
Synthetics	200	0.02
Opal	500	0.05
Organics	2000	0.2

In addition to maximum limits for the listed non-glass contaminants, FERVER specifications include requirements on colour, cullet size, and moisture content, as follows:

Colour requirement: The colour composition can vary from mixed-coloured to mono-coloured (such as flint, green, amber, etc.), depending on the specifications of the user.

Cullet size: 100% of the cullet particles should be of <100 mm size.

Moisture: Should be less than 5%

CEN guidelines for packaging waste glass

CEN has developed a standard guideline: "Packaging - Material recycling - Report on requirements for substances and materials to prevent a sustained impediment to recycling" (CEN/TR 13688:2008). These guidelines include a set of contamination limits for packaging waste glass to be consistent with the requirements of the European Packaging and Packaging Waste Directive 94/62/EC (EC, 1994).

The guidelines include also a list of glass types which should not be intentionally collected together with the glass packaging waste, such as: screen glass (TV, computers, etc.), lead crystal tableware, wired glass, glass ceramics, lamp glass, borosilicate glass, etc.

The maximum contamination limits for non-glass components in cullet listed are:

- Ferrous metals: 5 ppm
- Non-ferrous metals: 5 ppm
- Non-glass inorganics (CSP): 50 ppm
- Organics: 500 ppm
- Plastics: 100 ppm

BSI PAS 101 - Specification for collected container glass cullet

In 2003, the British Standard Institute (BSI) published the "publicly available specification" (PAS 101): "Recovered container glass - Specification for quality and guidance for good practice in collection". PAS 101 was elaborated in consultation with the Waste & Resources Action Programme (WRAP) and several other organisations like British glass recycling and manufacturing industries (BSI/WRAP, 2003). PAS 101 introduces a four tier grading system for "collected cullet" quality - grades A to D - according to the degree of colour separation, contamination and particle size. The quality standards for "collected cullet" are significantly less strict than other quality standards for "reprocessed cullet", that is, a cullet that has undergone a more thorough cleaning, treatment and processing procedure.

In summary, the BSI/WRAP PAS 101 specifications for collected cullet for grades A to D are as follows:

- **Colour contamination requirements:** Colour contamination is not an environmental issue but a limit is necessary so that the cullet has a minimum economical value
 - 4% to 6% for clear container cullet
 - 5% to 15% for brown container cullet
 - 5% to 30% for green container cullet
- **Contamination limits**
 - 0.5% to **1% organic** (grades A to D)
 - 0.1% to **0.2% ferrous** (grades A to D)
 - 0.2% to **0.4% non-ferrous** (grades A to D)
 - Percentage to be determined between seller and buyer for non-glass inorganics (ceramics, etc.)
 - No more than 3% of surface area is organic, inorganic, ferrous or non-ferrous
- **Particle size**
 - Containers are not intentionally crushed or broken (large pieces are easier for colour separation at later cullet processing stages)
 - Particle size should be subject to agreement between the collector and the processor
- **No medical, toxic, or hazardous materials**

Table 11: Specifications for four container glass cullet grades by BSI/WRAP PAS 101 (BSI/WRAP 2003). These standards correspond to "collected cullet".

Grade A			
Cullet type	White flint (clear)	Amber (brown)	Green
Permitted contaminant	Other colours 4%	Other colours 5%	Other colours 5%
Contamination: No more than 0.5% organic, 0.1% ferrous and 0.2% non-ferrous.			
Grade B			
Cullet type	White flint (clear)	Amber (brown)	Green
Permitted contaminant	Amber (brown) 6%	Other colours 15%	Other colours 30%
Contamination: No more than 0.5% organic, 0.1% ferrous and 0.2% non-ferrous.			
Grade C			
Cullet type	White flint (clear)	Amber (brown)	Green
Permitted contaminant	Amber (brown) >6%	Other colours >15%	Other colours >30%
Contamination: Up to 1.0% organic, 0.2% ferrous and 0.4% non-ferrous.			
Grade D			
Cullet type	White flint (clear)	Amber (brown)	Green
Permitted contaminant	Amber (brown) >6%	Other colours >15%	Other colours >30%
Contamination: Up to 3% organic, inorganic, ferrous and non-ferrous.			

BSI PAS 102 - Specifications for processed glass for selected secondary end markets

In 2004, the British Standards Institute (BSI) published a publicly available specification, PAS 102, for processed glass for selected secondary end markets, developed in consultation with WRAP and several other organisations.

The motivation for developing this specification was to analyze alternatives for the excess green container cullet generated in the UK. One of the options was its export for re-melting abroad, and the option analyzed here was its use in a diversity of secondary end applications such as:

- Use in ceramic sanitary ware production
- Use as a fluxing agent in brick manufacture
- Use in sports turf and related applications (for example, as top dressing, root zone material or golf bunker sand)
- Use as water filtration media (for example, for potable water treatment, or waste water treatment.
- Use as an abrasive

The PAS 102 provides test methods for the determination of: particle size distribution, etc. The requirements for cullet to be used in the following secondary end markets are summarized in Table 15.

Table 12: Summary of PAS 102 quality requirements for container cullet to be used in secondary end markets.

	Use in ceramic sanitary ware production	Use as a fluxing agent in brick manufacture	Use in sports turf and related applications	Use as water filtration media	Use as an abrasive
Total contaminant (organic, inorganic, ferrous/non-ferrous metals)	1%	1%	Subject to agreement between processor and end user	Free from organic contaminants. Specific contaminant limits subject to agreement between processor and end user.	500 ppm organics 50 ppm inorganics 50 ppm Fe metals 20 ppm non-Fe metals
Particle size distribution	<0.1% 106 µm <1% 75-106 µm Balance < 75 µm	100% pass. 150 µm 90% pass. 75 µm 50% pass. 45 µm	95-100% pass. 2-8 mm 65-100% pass. 0.5-2 mm	0.5-2 mm for treating potable water < 4.5 mm for waste water	Fine (0.2-5 mm) to coarse (1-3 mm)
Colour requirement	None	None	None	(a) Entirely brown glass, with colour contamination not exceeding 5% total (b) Entirely green glass, with colour contamination not exceeding 5% total	Subject to agreement between processor and end user.
Remarks				Cullet shall not contain: medical or chemical refuse, hazardous/toxic material, plate glass, light bulbs, fluorescent lighting tubes	Should be free from corrosive constituents and adhesion-impairing contaminants

Colour contamination means all other colours except the one mentioned. For brown glass: all other colours are green, clear and blue. For green glass, all other colours are brown, clear and blue.

WRAP – Quality Protocol for Flat Glass

In January 2008, WRAP published a "Quality Protocol for flat glass" (WRAP/EA, 2008). This Quality Protocol – developed with the aim of increasing customer confidence – sets out criteria for when the material is no longer classified as waste and is suitable as input material in the manufacture of new glass products. In general, impurity quality standards for cullet to be used in the manufacture of flat glass are around 20 times stricter than those for the manufacture of container glass.

The protocol underlines the similarity of purpose with Article 6 of the Waste Framework Directive: "Compliance with these criteria is considered sufficient to ensure that the fully recovered product may be used without harm to human health or the environment and therefore without the need for waste

management controls. In addition, the Quality Protocol indicates how compliance may be demonstrated and points to best practice for the use of the fully recovered product" (WRAP/EA, 2008).

According to the quality protocol, the following criteria must be met in order to produce a processed cullet "that will normally be regarded as having been fully recovered and to have ceased to be waste when dispatched to the customer" (WRAP/EA, 2008):

Input controls:

- The cullet must be produced using only those input materials specified in:
 - a. The approved standard relevant to the market into which the cullet will be sold, and
 - b. A number of relevant good practice guides
- To ensure that only the appropriate types of waste flat glass are accepted, the producer must have, and maintain, procedures in the form of acceptance criteria.

Requirements of an approved standard to be observed:

- The producer must comply with all the requirements of an approved standard applicable to the designated market into which the processed cullet will be sold.
- In order to achieve one of the approved standards, waste flat glass must undergo sufficient processing. In some cases, the approved standard dictates the level of processing that must be undertaken. Where processing levels are not detailed, it is expected that, as a minimum, a number of listed processing steps will be undertaken to enable physical contamination to be removed. These steps will vary depending on the source of the input material (Appendix D).
- Tools and machinery containing nickel should not be used for the processing and transport of cullet. Nickel contamination will produce defects within the glass which are impossible to detect on the production line but can cause critical failure of products later in the products life.
- If the sampling indicates that the material does not meet the approved standard, the load must be rejected or, if appropriate, put back through the production process.
- Producers should be aware that any standard may be subject to regular review and they must ensure they comply with the latest revision.

Designated market sectors:

- Processed cullet must be destined for appropriate use within one of the designated market sectors: bricks and ceramics, abrasives, flat glass.
- This Quality Protocol does not include the use of processed cullet as an aggregate as this falls within the scope of the Quality Protocol for the production of aggregates from inert waste.
- This Quality Protocol does not apply to container glass, glass bead, foam glass, paint filler and fibre glass as publicly available specifications for these end uses are not currently available.

Under "requirements", the quality protocol refers to "Appendix B", listing standards that apply to processed cullet for various end uses at the time of publishing. Among these standards is the draft "Specification for Flat Glass Cullet used in Flat Glass Manufacture", produced by Glass Technology Services in 2007 (GTS, 2007) and summarized below.

GTS – Specifications for Flat Glass Cullet used in Flat Glass Manufacture

The "Specification for Flat Glass Cullet used in Flat Glass Manufacture" was produced by Glass Technology Services in 2007 (GTS, 2007), and it contains the following requirements:

Composition:

All cullet supplied for use in flat glass manufacture shall be of known origin.

It shall consist of the following glass types only:

- Clear soda lime silica window glass.
- Less than 5% lightly tinted flat glass (bronze, green, blue and grey).

- Flat glass with highly transparent thermal insulating coatings (eg. ClimaGuard, K glass and Planitherm)

The following glass types are not permitted in any quantity:

- Mirrored glass (some manufacturers may accept low levels of <0.8%)
- Wired glass (any type)
- Laminated glass
- Fire resistant laminates (e.g. Pyrodur, Pyrostop, Pyroguard)
- Container glass
- Lead glass
- Borosilicate glass (e.g. Pyrex, Borofloat, Pyran, labware, cookware)
- Glass ceramics (e.g. Robax, Ceran)
- Windscreens or antenna glass
- Glass printed with ceramic inks
- Dark tinted glass

Particle size:

The particle size of the cullet load has implications for material handling at the glass manufacturing site. It is important to keep the fine fraction to a minimum as this can cause airborne dust problems, whilst the larger pieces can cause blockages in the cullet transfer system.

Upon analysis of a representative sample the particle size shall be within the limits set out below:

- No more than 5% <4 mm
- No more than 15% < 6mm
- Maximum fragment area: 100 cm²

Where loads are routinely inspected on delivery to the glass manufacturer's site, the particle size shall be as large as possible so that contamination can be more readily identified.

Contamination:

All cullet shall be "free from contamination". Contaminants which cause problems, their typical sources, and proposed maximum allowable concentrations are listed in Table 13. Even very low levels of contamination will cause glass defects.

It is not possible to detect contamination at these low levels, it is therefore essential that the cullet quality is controlled at source. For advice on prevention of contamination please refer to the "Good Practice Guide" associated with this specification (GTS, 2007).

Table 13: Exemplary accepted level of contaminants for flat glass cullet by Glass Technology Services (GTS, 2007).

Contaminant	Typical source	Limit
Ferrous metals	Cutting blades	Particles > 0.5g: none Particles < 0.5g: 2g/t maximum
Non-ferrous metals	Spacer bars, drink cans and leaded glass	Particles > 0.1g: none Particles < 0.1g: 0.5 g/t maximum
Nickel-containing steels or alloys	Grinding equipment	No particles
Inorganic material	Porcelain, aggregate, silicon carbide, cutting wheels	No particles > 0.2 mm
Organic material	Plastics (PVB, PVC), wood, cardboard, paper, rubber gasket, foam spacers, floppy disks	Particles > 2g: none Particles < 2g: 45 g/to maximum

2.5 Legislation and regulation

In order to clarify the legal basis for trade of recycled material, it is necessary to analyse both the legislation currently controlling the recovered glass cullet as waste, and the legislation that would cover the glass cullet if it no longer was waste. The question to be answered is: how would product legislation regulate and control the environmental risks associated with recovered material disposal/recovery once it ceases to be waste?

In the EU, the management and trade of recovered glass cullet are regulated under waste law:

- The Waste Framework Directive (WFD) and the EU Waste Shipment Regulation. Collection industries usually operate under a permit for waste treatment, although the details of their permits vary among member states.
- The production of materials and treatment of recovered materials on site are subject to the IPPC Directive.
- Some waste materials may also be regulated under the Packaging Directive (Packaging and Packaging Waste Directive, 94/62/EC of 20 December 1994).
- REACH.
- By-product definition under the WFD.
- The Waste Electric and Electronic Equipment (WEEE) directive: It establishes minimum mandatory standards for recycling and treatment of WEEE wastes.
- The End-of-Life Vehicles (ELV) Directive: It establishes minimum technical requirements for the treatment of ELV wastes.

2.5.1 The IPPC Directive and Consequences for Waste Glass

General information on IPPC requirements related to waste glass

The aim of the IPPC Directive 2008/1/EC (recast version of Directive 96/61/EC) is to achieve integrated prevention and control of pollution arising from the activities listed in its Annex I. It lays out measures designed to prevent or, where that is not practicable, to reduce emissions in the air, water and land from the abovementioned activities, including measures concerning waste, in order to achieve a high level of protection of the environment taken as a whole.

At present, the Directive is merged with 6 other directives aiming at industrial emissions control, and they have been replaced by a new Industrial Emissions Directive (IED) (2010/75/EU). The IED is expected to strengthen the role of the Best Available Techniques (BAT) and the related measures described in '*Best Available Techniques Reference Documents*' (BREFs). However, the IPPC permits issued under the IPPC Directive are still valid during a transition period.

IPPC requirements for primary glass and EoW waste glass

Waste glass is mainly processed in treatment plants not falling under the scope of the IPPC Directive because according to Annex 1 no. 5 of the directive, only hazardous waste treatment with a capacity exceeding 10 tonnes per day is covered by the IPPC Directive.

On the other hand, the final destination of waste glass and potential future end-of-waste glass are glass manufacturing processes covered by the IPPC Directive and the future Industrial Emissions Directive

¹² European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste, http://europa.eu/legislation_summaries/environment/waste_management/l21207_en.htm

(IED) under number 3.3 of Annex 1: "Installations for the manufacture of glass including glass fibre with a melting capacity exceeding 20 tonnes per day" (IPPC, 2008).

For this kind of installation, best available techniques and associated emission levels are described in the Glass BREF (2001) which is currently being revised (2009) (BREF, 2009).

The IPPC directive (now IED directive) permits ensure that emissions are measured and remain below accepted levels. The IPPC directive does not make any distinction whether the input is raw material, cullet, or end-of-waste cullet. Therefore, EoW criteria are not expected to have an impact on air emissions.

2.5.2 Waste Shipment Regulations and Consequences for Waste Glass

There is a series of international regulatory instruments, recommendations, compliance guides and guidelines to be considered regarding the monitoring and control of shipment of waste to other countries.

The following regulations are of particular importance in for waste glass:

1. Basel Convention of 22 March 1989 on the Control of Transboundary Movement of Hazardous Wastes and their Disposal (Basel Convention, 1989).
2. OECD Council Decision C(2001)107/Final of the OECD Council concerning the revision of Decision C(92)39/Final on the Control of Transboundary Movement of Wastes Destined for Recovery Operations (OECD, 2001).
3. Regulation (EC) No. 1013/2006 on shipments of waste (EC, 2006).
4. Commission Regulation (EC) No. 1418/2007 concerning the export for recovery of certain waste listed in Annex III or IIIA to Regulation (EC) No. 1013/2006 of the European Parliament and of the Council to certain countries to which the OECD Decision on the control of transboundary movements of wastes does not apply (EC, 2007).
5. Directive 2002/96/EC on Waste Electrical and Electronic Equipment, or WEEE Directive (EC, 2002).
6. Correspondents' Guidelines No 4 - Classification of waste electrical and electronic equipment according to Annex IV part I note (c) of Regulation (EC) No 1013/2006 on shipments of waste (UBA Guidelines WEEE) (UBA, 2006)¹³
7. Correspondents' Guidelines No 7 on Classification of glass waste originating from cathode ray tubes (CRT) under entries B2020 or A2010 (UBA Guidelines CRT) (UBA, 2009)¹³

The most important international regulations are the Basel Convention and the OECD Council Decision.

¹³ The Correspondents' Guidelines were prepared by the Waste Shipment Correspondents of the EU Member states, <http://ec.europa.eu/environment/waste/shipments/guidance.htm>

2.5.3 Waste Shipment Regulations: The Basel Convention

The **Basel Convention** is a global control system for transboundary shipment of **hazardous waste**. An export ban on hazardous wastes from OECD member countries to OECD non-member economies was formally incorporated into the Convention with Decision III/1. However, due to a lack of ratification by a sufficient number of Parties to the Convention, this export prohibition has not yet entered into force internationally; however, it has been transposed by the EU, resulting in an export ban on hazardous glass waste to OECD non-member economies.

The **Basel Convention** contains lists of wastes in two annexes (Annex VIII and Annex IX).

The wastes listed in Annex VIII are hazardous wastes. The entries concerning waste glass are:

A2010: Glass waste from cathode-ray tubes and other activated glasses

A1180: Waste electrical and electronic assemblies or scrap containing components such as [...] glass from cathode-ray tubes and other activated glass [...] or contaminated with Annex I constituents (e.g., cadmium, mercury, lead, polychlorinated biphenyl) to an extent that they possess any of the characteristics contained in Annex III (note the related entry on list B B1110).¹⁴

The wastes listed in Annex IX are not covered by the relevant article of the Basel Convention as they are considered to be not hazardous. The entries concerning waste glass in Annex IX are:

GE020: Glass waste in non-dispersible form: Glass fibre waste

B2020: Glass waste in non-dispersible form: Cullet and other waste and scrap of glass except for glass from cathode-ray tubes and other activated glasses

B2040: Other wastes containing principally inorganic constituents: Lithium-Tantalum and Lithium-Niobium containing glass scraps.

2.5.4 Waste Shipment Regulations: The OECD Council Decision

The **OECD Council Decision** (OECD, 2001) is a controlling system for the import and export of **wastes destined for recycling**, in order to allow their tradability within the OECD member countries.

Wastes regulated in the **OECD Decision** are grouped into two lists according to risk categories:

- Green List
- Amber List

Green Listed wastes are not subject to any waste-law control and are treated as goods. Amber Listed wastes are subject to a control procedure; they require notification (application) and the consent of the applicable authorities. Additionally, legally binding contracts are required from the parties involved in the exporting of wastes, respectively those having legal control of the wastes and those running the recycling plants (Ramboll/Ökopol, 2010).

The waste lists of the Basel Convention have been integrated into the OECD lists in such a way that the “Green Procedure” applies to Annex IX of the Basel Convention and the “Amber Procedure” applies to the wastes listed in Annex VIII of the Basel Convention.

¹⁴ B1110 is not valid in EU law (see Annex III, part I, (d)). The OECD entries GC01022 and GC02022 apply instead, which do not relate to waste glass but mainly to scrap.

2.5.5 Waste Shipment Regulations: The EC Waste Shipment Regulation

Regulation 1013/2006/EC on shipments of waste (EC, 2006) is the European transposition of the international regulations on shipments of waste. This European regulation implements the international obligations of the Basel Convention and of the OECD Decision, and includes the internationally agreed objective that wastes shall be disposed of in an environmentally sound manner. It also forbids the shipment of hazardous wastes, in particular (see Annex V of the Regulation) from EU to non-OECD countries¹⁵.

The Regulation includes the following waste lists:

Annex III for Green Listed wastes¹⁶,

- Annex III A for mixtures of Green Listed wastes,
- Annex IV for Amber Listed wastes, and
- Annex V, which covers wastes subject to the export prohibition.

All annexes comprise the corresponding lists/annexes of the Basel Convention and the OECD Decision, or of the European List of Waste according to Decision 2000/532/EC.

Annexes III and IV list the wastes that may be exported according to the Green or Amber control procedure. Prohibition of export to non-OECD countries applies to wastes listed in Annex V Part 1 List A and to the hazardous ones listed according to Annex V Part 2.

Table 14 provides an overview of the scope of Regulation 1013/2006/EC on shipments of waste out of the EU (Ramboll/Ökopol, 2010).

Table 14: Overview of the scope of Regulation 1013/2006 on shipments of waste out of the EU¹⁷

Transboundary Shipment	Export out of the EU into countries to which the OECD Decision applies; Art. 18, 34, 35 and 38	Export out of the EU into countries to which the OECD Decision does not apply; Art. 18, 36 and 37
Wastes for recycling Annex III, III A	Duty to notify within the EU: Art. 18; Art. 38	Duty to notify within the EU: Art. 18; however individual case regulations according to Art. 37
Wastes for recycling Annex IV, IV A	Permissible, notification in accordance with Art. 38	Not applicable
Hazardous wastes for recycling according to Annex V	Not applicable	Prohibited
Waste for disposal	Prohibited, with exceptions, notification in accordance with Art. 35	Prohibited

The three glass wastes GE020, B2020 and B2040 are green listed wastes and appear in Annex III either directly (GE 020) or through a link to the Basel Convention (B2020 and B2040). As being green listed they are allowed to be exported into OECD countries when following Article 18 of EC Regulation on Shipments of Waste. Article 18 requires that the form of Annex VII of the regulation has to accompany the waste shipment.

¹⁵ This ban is not yet in force worldwide.

¹⁶ Annex IIIB can still be worked out in a committee procedure. This regards Green wastes not listed at the Basel/OECD level, but which can be shipped between EU Member states without notification.

¹⁷ Articles or annexes specified in the Table are articles or annexes from Regulation 1013/2006.

When exporting wastes of Annexes III and IIIA, i.e. non-hazardous wastes for recovery, to a country to which the OECD Decision does not apply, various control procedures according to Article 37 of 1013/2006 apply. The procedure required for specific countries of destination and for specific types of waste is defined in the EC Waste Export Regulation 1418/2007/EC (EC, 2007). It defines, in tabular form, whether:

- the export of wastes listed in Annex III to Regulation 1013/2006 to the respective country of destination is prohibited or
- a waste may only be shipped to the respective country of destination with prior written notification and approval or
- a waste may be shipped without notification under consideration of the general duties to notify of Art. 18 of Regulation 1013/2006¹⁸ (Ramboll/Ökopol, 2010)

In case of non OECD countries the requirements change depending on the country. For example GE020 (Glass waste in non-dispersible form, Glass fibre waste) is not to be exported to Egypt, has to be notified and approved by the respective authorities when exported to the Ivory Coast and can be shipped to Brazil when respecting the duties according to Article 18. A simplified overview of the regulations of these three bodies of regulations is provided in Figure 13.

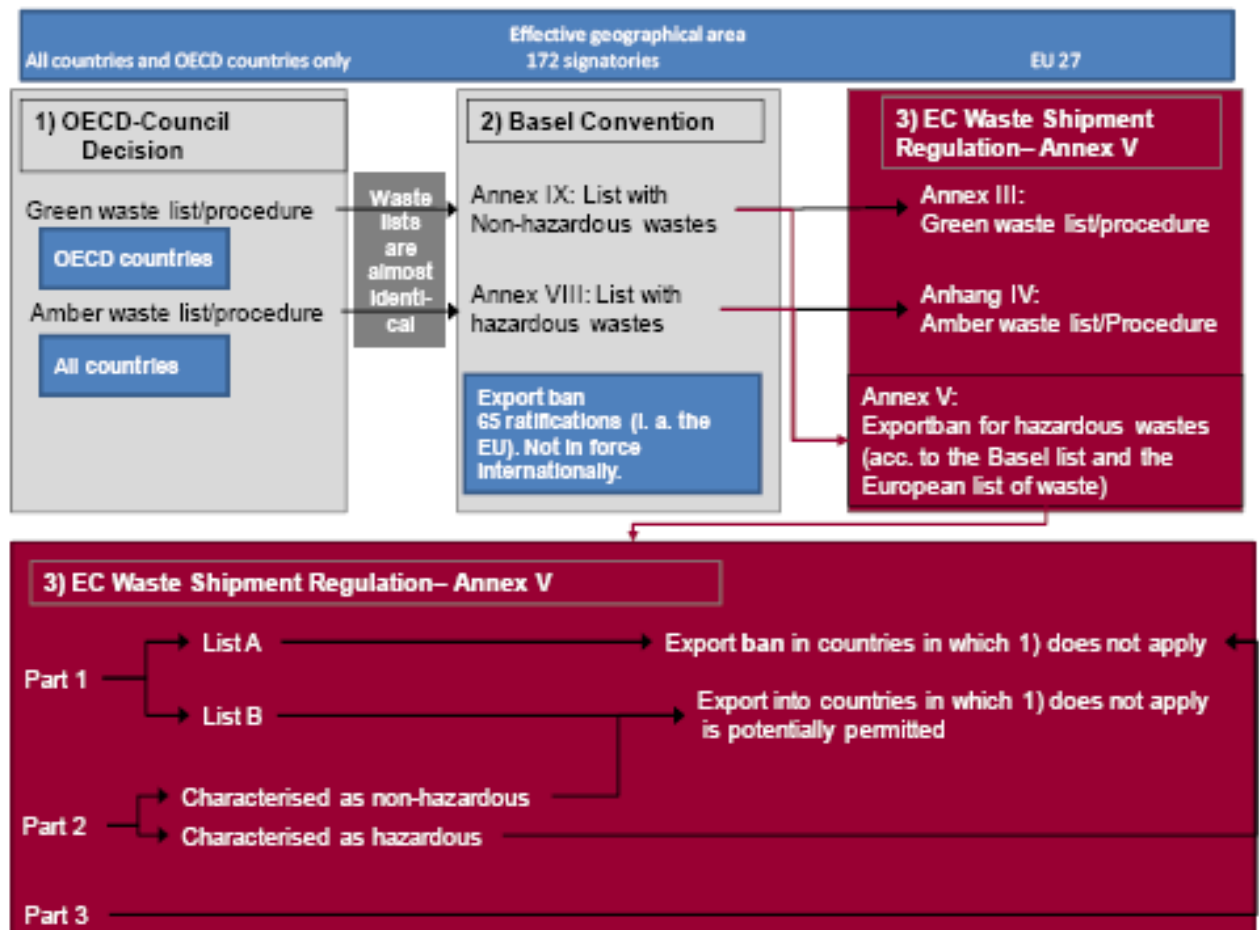


Figure 13: Overview of regulations on shipment of waste

¹⁸ The procedure according to Art. 37 par. 2 of 1013/2006 applies to unlisted countries of destination.

Transitional agreements

For certain glass wastes, among other wastes, transitional agreements for New EU member states are provided by Article 63 of Regulation 1013/2006/EC, for example:

1. Until 31 December 2010, all shipments to **Latvia** of waste for recovery listed in Annexes III and IV and shipments of waste for recovery not listed in those Annexes shall be subject to the procedure of prior written notification and consent in accordance with Title II.

By way of derogation from Article 12, the competent authorities shall object to shipments of waste for recovery listed in Annexes III and IV and shipments of waste for recovery not listed in those Annexes destined for a facility benefiting from a temporary derogation from certain provisions of Directive 96/61/EC during the period in which the temporary derogation is applied to the facility of destination.

2. Until 31 December 2012, all shipments to **Poland** of waste for recovery listed in Annex III shall be subject to the procedure of prior written notification and consent in accordance with Title II.

By way of derogation from Article 12, until 31 December 2007, the competent authorities may raise objections to shipments to Poland for recovery of the following waste listed in Annexes III and IV in conformity with the grounds for objection laid down in Article 11:

B2020 and GE020 (glass waste), [...]

With the exception of glass waste, paper waste and waste pneumatic tyres, this period may be extended until no later than 31 December 2012 in accordance with the procedure referred to in Article 18(3) of Directive 2006/12/EC.

By way of derogation from Article 12, until 31 December 2012, the competent authorities may raise objections in conformity with the grounds for objection laid down in Article 11 to shipments to Poland of: [...] (b) waste for recovery not listed in the Annexes.

3. Until 31 December 2011, all shipments to **Slovakia** of waste for recovery listed in Annexes III and IV and shipments of waste for recovery not listed in those Annexes shall be subject to the procedure of prior written notification and consent in accordance with Title II. [...]

4. Until 31 December 2014, all shipments to **Bulgaria** of waste for recovery listed in Annex III shall be subject to the procedure of prior written notification and consent in accordance with Title II. [...]

5. Until 31 December 2015, all shipments to **Romania** of waste for recovery listed in Annex III shall be subject to the procedure of prior written notification and consent in accordance with Title II. [...]

Currently, the requirements lead to administrative effort for companies applying for waste shipment. Glass waste classified as EoW glass would not fall under these restriction when export shall be undertaken.

In summary, it is generally not prohibited to export recovered waste glass from a EU Member State to recycling in a third country out of the EU, provided the waste is not hazardous (for hazardous waste, its transboundary movement is regulated by the Basel Convention¹⁹) (Basel Convention, 1989). In the

¹⁹ The Basel Convention,

http://europa.eu/legislation_summaries/environment/waste_management/l28043_en.htm

context of the Waste Shipment Regulation (WSR)²⁰, and depending on the destination country, 'green list' controls or notification controls apply (List B of Part 1 of Annex V of the WSR).

Green list controls do not apply within OECD countries except completion of an Annex VII form. For recycling in non-OECD countries, the Regulation requires the Commission to obtain a new declaration from the receiving country as to whether it will accept each kind of waste; it may also require pre-notification. In List B, the possibly affected ones are some recovered waste glass types.

In any case, the Waste Shipment Regulation allows exports from the Community only if the facility that receives the waste is operated in accordance with human health and environmental standards that are broadly equivalent to standards established in Community legislation. The waste must be dealt with in an environmentally sound manner while it is being moved and recovered. The recovery facility must be capable of recovering the waste glass in an environmentally sound manner without causing health risks. Generally, the recovery facility should be licensed or permitted in some way by the relevant local regulatory authorities.

The end-of-waste would affect recovered waste glass that has fulfilled the criteria and become product/secondary material in the way that the trading will be not under waste shipment regime.

"Green list' controls include:

- The waste can be moved legally without obtaining permission from the regulators.
- The waste must be accompanied by a completed and signed "Annex VII form".
- Specified contracts for recovering the waste between the person sending the waste and the person receiving the waste must be in place.
- When the person receives the waste, he must sign the accompanying form.
- Copies of the form relating to the waste movement must be kept for three years.
- The regulatory authorities can ask for copies of the documents relating to the movements already made or ask for information from those documents.

The OECD (2009) reports that traders encounter problems related to the "Annex VII form" requirements. The traders mention that the form adds administrative burden, which they do not feel is necessary, but the main concern is about providing information on the origin and the final destination of the shipment, which in some cases is perceived as confidential for commercial reasons. This confidentiality is no longer guaranteed if the recycler and the generator of the waste get this information via the Annex VII form.

The procedures laid out in OECD Decision C(2001)107/Final concerning the control of transboundary movements of waste destined for recovery indicate that the materials may be traded for recycling using normal commercial controls within the OECD. This implies that the standard customs controls for goods are applied to these materials, without additional procedures. According to OECD (2009), the US and Japan apply the OECD Decision in this way. Conversely, the EU follows the WSR and applies the 'green list controls'.

2.5.6 Directive on Waste Electrical and Electronic Equipment (WEEE Directive)

The Directive applies to the following categories of electrical and electronic equipment:

- Large household appliances;
- Small household appliances;
- IT and telecommunications equipment;

²⁰ Regulation (EC) No. 1013/2006 of the European Parliament and the Council of 14 June 2006 on shipments of waste (Waste Shipment Regulation),

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32006R1013:EN:NOT>

- Consumer electronics equipment;
- Lighting equipment;
- Electrical and electronic tools, with the exception of large-scale stationary industrial tools;
- Toys, leisure and sports equipment;
- Medical devices, with the exception of all implanted and infectious products
- Monitoring and control instruments;
- Automatic dispensers.

Alongside provisions that require separate collection and acceptance, the directive also specifies that the best available treatment, recovery and recycling techniques must be used. Under consideration of Regulation 1013/2006/EC, such treatment may also be performed outside the European Union.

Nevertheless, in the case of treatment outside the EU, the obligations and targets of the directive are only considered as fulfilled if the exporter can prove that the treatment takes place under conditions that are equivalent to the requirements of the Directive.

Waste glass may occur as part of waste electric and electronic equipment, in particular cathode ray tubes and computer monitors as described under Correspondents' Guidelines No 7 above.

Correspondents' Guidelines No 4 - Subject: Classification of waste electrical and electronic equipment and fly ash from coal-fired power plants²¹

The Correspondents' Guidelines No 4 - Classification of waste electrical and electronic equipment and fly ash from coal-fired power plants according to Annex IV part I note (c) of Regulation (EC) No 1013/2006 on shipments of waste was developed by the German EPA 'Umweltbundesamt' for competent authorities implementing Regulation 1013/2006/EC.

Regarding waste glass contained in WEEE, the guideline proposes the following classification:

A1180 Waste electrical and electronic assemblies or scrap (Footnote 1) containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or contaminated with Annex I constituents (e.g. cadmium, mercury, lead, polychlorinated biphenyl) to an extent that they possess any of the characteristics contained in Annex III (note the related entry on list B, B1110). (Footnote 2)

Footnote 1: This entry does not include scrap assemblies from electric power generation

Footnote 2: PCBs are at a concentration level of 50 mg/kg or more.

Correspondents' Guidelines No 7 - Subject: Classification of glass waste originating from cathode ray tubes (CRT) under entries B2020 or A2010²²

The guidelines have been elaborated by German EPA "Umweltbundesamt". They are directed towards competent authorities responsible for the implementation of Regulation 1013/2006/EC, and discussion of the subject of shipments of waste glass. The guidelines are intended primarily as a support for enforcement. Correspondents' Guidelines No 7 specifies which types of treated cathode ray tubes (CRT) glass can be considered as hazardous waste and which type as being non-hazardous.

a) Generally, panel glass²³ that has been properly separated and from which activated coatings, frit and other contaminants have been removed may be classified under entry B2020, provided that the

²¹ http://ec.europa.eu/environment/waste/shipments/pdf/correspondents_guidelines4_en.pdf

²² http://ec.europa.eu/environment/waste/shipments/pdf/correspondents_guidelines7_en.pdf

²³ These correspondents' guidelines do not reflect any agreement by Correspondents on the appropriate classification of funnel glass that had been similarly treated.

remaining heavy metals are enshrined in the glass, that there is no risk of dispersion and that all the heavy metals or the glass itself can be recycled;

b) Untreated²⁴ funnel glass (and mixed CRT glass) with coating or contaminated by lead frit or phosphors should be classified under entry A2010;

c) Front panels cut from the CRT, where either the phosphors have not been removed or there is contamination by coatings or lead frit, should normally be classified under entry A2010.

2.5.7 The Packaging Directive

The European "Packaging and Packaging Waste Directive" (EC, 1994) sets maximum levels for certain substances when glass is recycled. The Directive also requires the determination of national recycling rates. Determining end-of-waste criteria for glass needs to make sure that these requirements can still be fulfilled.

This Directive is intended to harmonize national legislations with the goal of preventing or reducing the environmental impact of packaging and packaging waste. Its provisions address the prevention of packaging waste, the reuse of packaging materials, and their recovery and recycling. As part of the Directive's provisions, the following commitments and targets for packaging waste recovery and recycling are set:

Article 6.1 (a) "no later than five years from the date by which this Directive must be implemented in national law, between 50% as a minimum and 65% as a maximum by weight of the packaging waste will be recovered" (by 30 June 2001)

Article 6.1 (b) "within this general target, and with the same time limit, between 25% as a minimum and 45% as a maximum by weight of the totality of packaging materials contained in packaging waste will be recycled with a minimum of 15% by weight for each packaging material" (by 30 June 2001)

Article 6.1 (c) "no later than 10 years from the date by which this Directive must be implemented in national law, a percentage of packaging waste will be recovered and recycled, which will have to be determined by the Council in accordance with paragraph 3 (b) with a view to substantially increasing the targets mentioned in paragraphs (a) and (b)" (by 30 June 2006)

The Packaging Directive (EC, 1994) also sets maximum levels for certain substances when container glass is produced. These limit values can be regarded as the only European-wide quality standards, although they are indirect standards because they refer to the final product, not to the cullet. The European Packaging Directive (EC, 1994) requires in **Article 11** to produce packaging without exceeding the concentration levels of four heavy metals:

1. Member states shall ensure that the sum of concentration levels of lead, cadmium, mercury and hexavalent chromium present in packaging or packaging components shall not exceed the following:

- 600 ppm by weight two years after the date referred to in Article 22 (1); (by 30 June 1998)
- 250 ppm by weight three years after the date referred to in Article 22 (1); (by 30 June 1999)
- 100 ppm by weight five years after the date referred to in Article 22 (1). (by 30 June 2001)

(i) OJ No L 326, 29.12.1969, p. 36²⁵

²⁴ With regard to treated funnel glass see previous footnote.

²⁵ Article 22(1) of the Packaging Directive establishes that member states should bring into force the laws, regulations and administrative provisions necessary to comply with this Directive before 30 June 1996.

2. The concentration levels referred to in paragraph 1 shall not apply to packaging entirely made of lead crystal glass as defined in Directive 69/493/EEC (1). (EC, 1994)

The heavy metal concentration limit of **100 ppm** in waste glass was waived by a derogation available under Commission Decision 2006/340/EC (extending derogation under Commission Decision 2001/171/EC). Through this derogation, glass packaging may exceed the heavy metal concentration limit of 100 ppm – there is no deadline by which this derogation will expire. In addition, the text of Commission Decision 2001/171/EC specifies that: "Where the average heavy metals concentration levels on any twelve consecutive monthly controls made from the production of each individual glass furnace, representative of normal and regular production activity, exceeds the **200 ppm** limit, the manufacturer shall submit a report to the competent authorities in the member states. This report shall include: measures values, description of measurement methods employed, suspected sources for the presence of heavy metals concentration levels, and detailed description of the measures taken to reduce the heavy metals concentration levels." The 200 ppm limit for heavy metals is not an obligation, but a threshold above which concentrations need to be reported to the competent authorities. Some individual member states may establish limits on heavy metal content in glass, for example 250 ppm in Germany (UBA, 2010).

2.5.8 REACH Regulation and Consequences for Glass

REACH is the European Community Regulation on chemicals and their safe use (EC 1907/2006)²⁶. It deals with the Registration, Evaluation, Authorisation and Restriction of Chemical substances. The new law entered into force on 1 June 2007. The aim of REACH is to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances.

As quoted from Article 1.1: "The purpose of this Regulation is to ensure a high level of protection of human health and the environment, including the promotion of alternative methods for assessment of hazards of substances, as well as the free circulation of substances on the internal market while enhancing competitiveness and innovation".

The following paragraphs explain how REACH applies to glass, depending on whether it is **primary glass**, **waste glass**, or **end-of-waste glass**²⁷.

Primary glass under REACH: Exemptions from registration

Primary glass is regarded as a substance under REACH. It is currently included in the European Inventory of Existing Substances (EINECS)²⁸ by various entries. It is a "Substance of Unknown or Variable Composition, Complex Reaction products or Biological materials" (UVCB substance) which is defined by its starting materials and processing conditions, in accordance with the ECHA guidance on substance identification²⁹.

Hence, glass is in principle to be registered as substance under REACH. As glass is covered by EINECS entries, manufacturers had the possibility to pre-register and hence benefit of the "phase – in scheme" under REACH³⁰.

²⁶ REACH, http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm

²⁷ These terms are included here to try to better explain how REACH applies to glass. These terms cover the full life cycle of glass. Primary glass should be understood as glass produced in a glass manufacturing facility and that is put into the market

²⁸ <http://ecb.jrc.ec.europa.eu/esis/index.php?PGM=ein>

²⁹ http://guidance.echa.europa.eu/docs/guidance_document/substance_id_en.pdf

³⁰ The phase-in scheme under REACH provides for staggered registration deadlines (c.f. REACH Art. 23): by December 2010, the following substances are to be registered: all substances in volumes above 1000 t/a, all

However, most types of primary glass can be exempted from registration because registration is deemed inappropriate or unnecessary and their exemption from Titles II (registration), V and VI does not prejudice the objectives of REACH (Article 2.7 (b), which refers to Annex V.11).

Annex V.11 states: "The following substances unless they meet the criteria for classification as dangerous according to Directive 67/548/EEC and provided that they do not contain constituents meeting the criteria as dangerous in accordance with Directive 67/548/EEC present in concentrations above the lowest of the applicable concentration limits set out in Directive 1999/45/EC or concentration limits set out in Annex I to Directive 67/548/EEC, unless conclusive scientific experimental data show that these constituents are not available throughout the lifecycle of the substance and those data have been ascertained to be adequate and reliable: Glass, ceramic frits."

Hence, glass is exempted from registration if:

- 1) it is not classified as dangerous and
- 2a) does not contain classified constituents in amount above defined threshold values or
- 2b) contains classified constituents above the threshold values, but for which it can be demonstrated that they are not available³¹ during the lifecycle.

Regarding point 1 (glass is exempted from registration if it is not classified as dangerous), most of glass is not classified as "dangerous" or "hazardous" and its cullet is managed as waste, but not hazardous waste. An exception is for example cathode-ray tube waste glass, which is managed as hazardous waste. Classification of glass as hazardous is not only triggered by components, but it may also be triggered by other reasons such as physical properties: for example, some fibrous waste glass is classified as hazardous due to its physical properties: i.e. certain small glass fibres are classified as hazardous because due to their physical properties they may be inhaled and cause harm.

Point 2 of the exemption from registration for glass focuses on the constituents of the glass. The above requirements for the exemption from registration refer to the "dangerous constituents" of glass. According to the guidance on substance identification, a constituent is characterized by a unique chemical identity. Due to the matrix structure and the vitreous nature of glass, no unique chemical identities can be distinguished. Therefore, currently a dangerous constituent is understood by the glass industry as "elements meeting the criteria for classification as dangerous in all their chemical forms according to Directive 67/548/EEC".³²

Most of the metallic dangerous constituents which are most frequently found in glass have been classified at EU level and are hence included in Annex I of directive 67/548/EEC. The presence of these metallic constituents does not render the glass hazardous, as they are incorporated into the glass matrix. Whereas some metal compounds have a separate harmonized classification, when referring to constituents of glass, the group entries should be used. The applicable group entries are quoted from Annex I of Directive 67/548/EEC³³ in the following:

substances in volumes above 100 t/a with a classification of R50/53 and all substances in volumes above 1 t/a which meet the criteria for classification as carcinogen, mutagen or reprotoxic (CMR) of categories 1 and 2. By June 2010 all substances in volumes above 100 t/a are to be registered and the last deadline of June 2018 applies to all substances in volumes above 1 t/a. Registrants can only benefit from these staggered registration deadlines, if their substances have already been on the EU-market (so called "Phase – in substances").

³¹ Currently "not available" is interpreted as "practically not released" and "not resulting in significant exposures of humans or the environment". A respective guidance document is currently under development (this guidance is currently on hold).

³² Prof. Helmut Greim, Prof. Helmut Schaeffer, Dr. Nicola Favaro: Exemption from registration for glass under REACH Regulation no. 1907/2006/EC, Brussels, 12. November 2009.

³³ Annex I of Directive 67/548/EEC has been taken over into the GHS-regulation (1272/2008), which will eventually replace Directive 67/548/EEC

- antimony compounds, with the exception of the tetroxide (Sb_2O_4), pentoxide (Sb_2O_5), trisulphide (Sb_2S_3), pentasulphide (Sb_2S_5) and those specified elsewhere in this Annex³⁴
- arsenic compounds, with the exception of those specified elsewhere in this Annex
- cadmium compounds, with the exception of sulphoselenide (xCdS.yCdSe) reaction mass of cadmium sulphide with zinc sulphide (xCdS.yZnS), reaction mass of cadmium sulphide with mercury sulphide (xCdS.yHgS), and those specified elsewhere in this Annex
- chromium (VI) compounds, with the exception of barium chromate and of compounds specified elsewhere in this Annex
- lead compounds with the exception of those specified elsewhere in this Annex
- selenium compounds except cadmium sulphoselenide

Regarding potential hazards posed by boron compounds, it is to be noted that several boron compounds, in particular boron trioxide, B_2O_3 (also called boric oxide), are used as starting material for the manufacture of glass, e.g. borosilicate glass, which is regarded as one of the most inert glasses and the reason why it is used for pharmaceutical and laboratory uses. On the other hand, several (but not all) compounds of boron are classified as dangerous, and e.g. boric acid has been added to the "substances of very high concern" (SVHC) list. However, the term "dangerous constituent" cannot be applied to the substance glass, as explained above. Whereas metal and their compounds are regarded as dangerous constituents because they would e.g. leach as ions and could form various compounds once emitted from the glass matrix, boron oxide is besides silicon oxide the main glass former and is hence not expected to leach. Possible dangerous effects of boron compounds on human health are irrelevant in this context, since borosilicate glass is one of the most inert glasses. In summary, even though boric oxide is hazardous, borosilicate glass is not hazardous because the boric oxide is embedded as part of the glass matrix as one of the forming materials and it does not leach out, therefore it is not available in the environment, not posing human or health hazard concerns (the no availability of boric oxide is one of the conditions to exempt glass containing boric oxide from REACH registration).

Having identified this list of hazardous constituents that may be present in some types of glass, it should be demonstrated that these constituents are not available during the lifecycle to comply with the requirements of the exemption.

Due to this, glass used as food contact material and most types of glass (except e.g. some types of special glass) are likely to be exempted from registration under REACH. Certain special glasses may not fulfil the requirements and hence should be registered.

Waste glass under REACH

Provision is made in REACH for exemptions of waste glass from some or all of its requirements, under certain conditions. These are possible because either regulatory regimes in other legislation (e.g. waste) are considered to be equivalent or more stringent than REACH in terms of substance information provision and controls, or certain substances or categories of substances are already known to pose little or no risk to health or the environment, or their registration is not considered appropriate.

Article 2.2 of the REACH Regulation³⁵ specifies that waste is not a substance, mixture or article within the meaning of Article 3 of this Regulation. As long as waste glass has the status of waste it is therefore not a substance, mixture or article for REACH, and most obligations under the REACH Regulation do not apply. In other words, if waste glass has still the status of waste, it is covered by waste law, not by REACH.

³⁴ "This Annex" is a reference within Annex I of Directive 67/548/EEC and aims to ensure that the specific entries for specific metal compounds are used, when available.

³⁵ EC 1907/2006

End-of-waste glass under REACH: Exemptions from registration

Once a substance has undergone one or more recovery operations and ceases to be waste, it is regarded as a recovered substance and falls under the scope of REACH. According to the ECHA guidance³⁶ on waste and recovered substances, any recovery operation, including manual sorting, is considered to be a manufacturing process if such recovery operation results in the generation of one or several substances as such or in a mixture or in an article that have ceased to be waste (e.g. produces EoW glass). Hence, recovered glass (or this case EoW glass) would fall under the REACH regulation, if the EoW criteria are fulfilled and the operator of the recovery process declares his product as EoW.

When waste glass ceases to be waste according to Article 6 of the WFD, the REACH exemption under Article 2.2 does not apply anymore, and end-of-waste glass may in principle be subject to REACH, unless it qualifies for certain exemptions as explained below.

Thus, many types of recovered glass are exempted from most REACH obligations (e.g. registration and evaluation obligations, but not downstream safety information communication) because of two possible reasons:

- 1) Because the nature of cullet as a **recovered substance**, by **Article 2.7(d)**
- 2) Because registration for recovered glass (being a substance) is deemed inappropriate or unnecessary, by Article **Article 2.7(b) (Annex V.11)**

Any operator of recovery processes intending to declare his product as EoW glass is to consider that rightful placing on the market is only possible, if he can claim either that the conditions of:

- Article 2.7(d) are fulfilled (exemption for recovered substances) and the substance is already registered, or
- Article 2.7(d) are fulfilled: the recovery operator has pre-registered the substance and the volume of the recovered substance does not require registration before that of the primary producers³⁷, or
- Annex V.11 are fulfilled (exemption from registration for glass)

If the substance glass that is being recovered as EoW glass is not yet registered and is not exempted according to Annex V.11, the recovery operator either must have pre-registered the substance (and the registration deadline has not yet passed) or the recovered EoW glass is regarded as a “non-phase in substance”³⁸, which is to be registered **before** manufacturing and placing on the market.

³⁶ ECHA, Guidance on waste and recovered substances, version 2, May 2010, ECHA-10-G-07-EN, available at the ECHA website under http://guidance.echa.europa.eu/docs/guidance_document/waste_recovered_en.pdf

³⁷ In the case of glass, it most likely that all primary producers register glass in volumes above 1000 t/a or claim the exemption in accordance with Annex V. Therefore, if the operator of a recovery process has preregistered his substance, he could either refer to existing registrations (which must be at least as early as his own) or to the exemption.

³⁸ “Non-phase-in substances” are all substances, which are not “phase-in substances”, i.e. in principle all substances which are **not** contained in the European Inventory of Existing Chemical Substances (EINECS) and/or which have been manufactured before 1992 but not been placed on the EU market and / or which have not been notified as no-longer polymer. In case of glass, any glass, which could not be assigned to the entries of glass in EINECS, e.g. due to different starting materials or processing conditions, have to be regarded as non-phase-in substance.

The 2008 update of Annex V of REACH (EC/987/2008) and in particular Annex V.11, exempts *glass* and *ceramic frits* from the mentioned obligations, unless:

"they meet the criteria for classification as dangerous according to Directive 67/548/EEC and provided that they do not contain constituents meeting the criteria as dangerous in accordance with Directive 67/548/EEC present in concentrations above the lowest of the applicable concentration limits set out in Directive 1999/45/EC or concentration limits set out in Annex I to Directive 67/548/EEC, unless conclusive scientific experimental data show that these constituents are not available throughout the lifecycle of the substance and those data have been ascertained to be adequate and reliable"

The document "Guidance on waste and recovered substances"³⁹ issued by the European Chemicals Agency (ECHA) provides clarification on the application of **Article 2.7 (d)** of REACH. It describes under which conditions legal entities recovering substances from waste can benefit from the exemption laid down in Article 2.7 (d) of REACH and elaborates on the obligation to share information in the supply chain, as put forward in Title IV of REACH, which is not contained in the exemption.

Substances which are recovered in the Community can be exempted from registration, if the conditions of Article 2.7(d) of REACH are fulfilled:

- (i) the substance that results from the recovery process is the same as the substance that has been registered in accordance with Title II; and
- (ii) the information required by Articles 31 or 32 relating to the substance that has been registered in accordance with Title II is available to the establishment undertaking the recovery.

Hence, the operator of the recovery process aiming to market EoW glass must, in order to benefit from the exemption, document that the substance has already been registered by showing "sameness" with a registered glass. For glass, it is most likely that showing "sameness" by the same IUPAC name is sufficient, as due to the nature of glass, impurities in EoW glass are rather limited and, in most cases would not change the hazardous properties to an extent that a "new" substance would have to be defined.

Substances recovered from waste may contain foreign materials, which are not removed during the recovery steps. If these materials do not exceed a concentration of 20% (w/w), they can be regarded as impurities and hence belong to the substance "as manufactured/recovered". In the case of glass, these materials could be materials used as labels (paper, plastics), coatings or items attached to the glass (e.g. metal part of light bulbs). If the concentration of any of these substances exceeds 20% w/w of the substance glass, they have to be regarded as separate substances and the recovered material is a mixture.⁴⁰

The second condition requires that relevant safety information (Safety Data Sheet (SDS) or other corresponding information) are available. Any SDS or information according to Article 32 may be used that the recovery operator has rightful access to.

The registrant of a substance is required to assess exposures and risks from the waste stage of the substance, if the substance meets the criteria for classification as dangerous according to Directive

³⁹ "Guidance on waste and recovered substances", Version 2, May 2010 (ECHA),

http://guidance.echa.europa.eu/docs/guidance_document/waste_recovered_en.pdf

⁴⁰ The ECHA guidance on waste and recovered substances, http://guidance.echa.europa.eu/docs/guidance_document/waste_recovered_en.pdf (May 2010), provides detailed guidance on how recovered substances are to be defined. It also provides some guidance on when components of substances can or cannot be regarded as impurities.

67/548/EEC and is registered in amounts exceeding 10 tonnes per year. Relevant information from the exposure assessment and risk characterization of the waste stage (including recommended recovery and recycling operations and risk management measures to be applied) are to be forwarded to the downstream users of the substance, who should ensure safe waste treatment based on the respective recommendations. However, in practice this information on safe handling of a substance in wastes does normally not reach an actor of the waste treatment sector and if it would it is not binding for a waste treatment activity.

It is to be noted that waste glass would only obtain the status of EoW glass if the operator of the recovery process determines that the end-of-waste criteria are fulfilled and actively decides to declare the recovered material as EoW glass. If that declaration of EoW is not made, the material continues to be waste and continues to be regulated under the waste legislation.

In summary, the same REACH requirements apply to EoW glass as to primary glass, except that EoW glass can also be exempted from registration according to Article 2.7(d), in addition to the exemption according to Article 2.7(b).

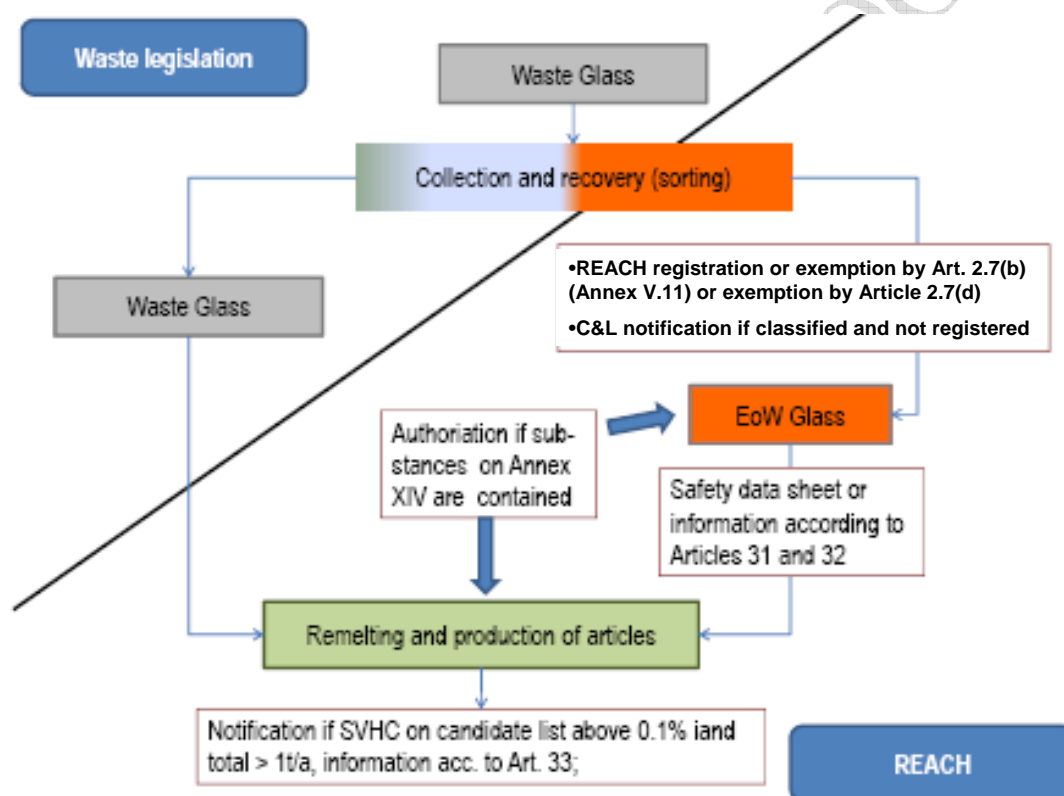


Figure 14: Requirements imposed by REACH on "end-of-waste glass", regarded as a substance

Only if none of the exemptions above apply, the recovery operator would either have to submit an immediate registration dossier (prior to any primary producer) or has to decide to further trade his glass under the waste regime⁴¹.

In summary, the registration requirements always include the identification of

⁴¹ It might be the case that some glass has been pre-registered but the registration deadline has not been reached because the tonnage is below 1000 t/a

- the registered substance,
- the annual amount produced and
- the identified uses.

Depending on the registered amount, different testing requirements have to be fulfilled (REACH Annexes VI to XI). For substances registered in amounts exceeding 10t/a, a chemical safety report must be compiled and, if the substance is classified as dangerous according to Directive 67/548/EEC, an exposure assessment and risk characterization is required. More information on registration requirements can be found in the ECHA web site (<http://echa.europa.eu/>).

Regardless of whether or not glass is registered under REACH, certain requirements always apply. In particular, notification of classification and labelling (C&L) is in principle required by CLP. A brief description of the requirements is outlined in the following paragraphs.

Notification of classification and labelling information: According to the CLP Regulation⁴² substances which are classified as dangerous are to be notified to the European Chemicals Agency (ECHA), if they are placed on the EU – market as such or in preparations, if contained above the cutoff limits of the Preparations Directive (99/45/EC).

End-of-waste glass is recovered glass cullet that is put in the market **as a substance**. As was reviewed in the above paragraphs, most end-of-waste cullet types are not classified as hazardous. Some hazardous components in glass are present as an integral part of the glass substance (example, boron compounds in some types of special glass or in borosilicate glass) but are virtually not released. However, as EoW glass is a substance, then the CLP Regulation is applicable.

Safety data sheets or other information according to Article 32: If the EoW glass were to meet the criteria for classification as dangerous, a safety data sheet should have been provided to the customers. If it contains constituents, for which community occupational exposure limits exist or which could pose a risk to man and the environment, the recipient of the EoW glass has the right to request an SDS as well. If risk management measures are necessary to ensure safe handling of glass, information according to Article 32 must be applied. This could e.g. relate to any abrasive processing of glass (dust formation).

Regarding this point on safety data sheets, the majority of experts expressed that glass – being a substance as such – does not contain any SVHC, so that no safety data sheets are required.

Authorization of manufacturing and use: If substances are included in Annex XIV⁴³ of REACH, any manufacturing and use of those substances must be covered by an authorization. Authorisation applies to the manufacturing and use of substances, or to their placing on the market for a certain use. A company needs an authorisation to manufacture or place on the market a substance for a use, or to use it, if the substance has been included in Annex XIV. However, for the time being, no glass is included in Annex XIV and thus no authorisation is needed. Therefore, in the EoW discussion context,

⁴² REGULATION (EC) No 1272/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006

⁴³ Annex XIV is the so called “list of substances subject to authorization”. This list is filled over time by formal processes involving the proposal for inclusion of a substance by a Member State or ECHA, a public consultation procedure and a formal adaptation of the Annex. Annex XIV currently contains 6 substances; the first inclusion of substances took place in February 2011

the REACH authorization process might be relevant only once a certain glass type is included in Annex XIV.

Notification of SVHC on the candidate list and information according to REACH Article 33: If substances of very high concern (SVHC) on the candidate list for authorization are included in articles in concentrations above 0.1% w/w, a notification is to be submitted to ECHA if the total amount of that SVHC in the articles exceeds 1 t/a per article produced. This applies to articles manufactured from primary raw materials or from EoW glass; Article 33 does not apply to substances/mixtures⁴⁴. If EoW glass is re-melted this is an indication that the chemical composition is more important than the physical form and it is to be regarded as a substance. Consequently, if the user of EoW glass re-melts it to produce articles, he is to notify any SVHC on the candidate list if the respective conditions are fulfilled. If the EoW glass is directly reused, the operator of the recovery operation is required to make a respective notification. In either case, Article 33 requires to forward information together with the article. The type of information is to include as a minimum the identity of the SVHC and in addition information on safe handling, use and disposal of the article.

Feedback was received from the TWG regarding the "notification of SVHC on the candidate list and information according to REACH Article 33". Experts emphasized again that glass, being a substance as such, it does not contain any SVHC. Additional feedback was related to the mentioned information requirements under Article 33. According to the document it was not clear whether the **information requirements** also cover SVHCs on the candidate list, which are contained in glass as constituents. Experts also stated that glass has been included in annex V (11) REACH and is regarded as a substance under REACH, and further that the articles of the glass industry consist of the substance glass only.

In response to expert comments, there needs to be a clear distinction between the requirements of: notification of SVHC according to Article 33, and the information requirements (IR) related to registration. It is important to make clear that IR are related to registration and not to Article 33. Therefore, only substances required to be registered under REACH are subject to information requirements; in this case, manufacturers or importers of substances required to be registered should provide to ECHA the information required by REACH (depending on tonnage and hazardousness). In contrast, Article 33 is about the duty to communicate information on SVHC substances in articles in the supply chain and also to the consumer.

The table below summarizes requirements and exceptions for cullet as either EoW or waste, from either REACH or waste legislation:

	Cullet as waste	Cullet as EoW
Requirements from waste legislation	Full scope of waste legislation is applicable until recycling of glass in new glass manufacturing.	No requirements from waste legislation when EoW criteria are fulfilled and EoW status of glass is declared by the operator of the recovery process
Requirements for exemption from REACH according to Article 2.7(b) (Annex V.11)	REACH does not apply	Demonstration that substance glass is not dangerous and does not contain dangerous constituents above cutoff limits, or Contains dangerous constituents above cutoff limits which are however not available during the lifecycle

Requirements for exemption from REACH for cullet as a recovered substance according to Article 2.7 (d)	REACH does not apply	<p>Substance is already registered</p> <p>Identification of chemical identity of substance glass to demonstrate sameness</p> <p>Availability of information according to Article 31 and 32 at the recovery operator</p> <p>If no pre-registration exists, substance must be registered before EoW is declared</p>
Registration requirements under REACH, if exemptions don't apply	No requirements from REACH, except assessment of the lifecycle stage waste in case glass which is classified as dangerous is registered in amounts exceeding 10 t/a ⁴⁵	<p>The exemptions above – Art. 2.7(b) and (d) – are very often applied. Registration is only required in specific cases where those exemptions do not apply. In the case that registration is required:</p> <p>Registration dossier requires chemical identification of substance (eco-)toxicity testing depending on registered amount and dangerousness</p> <p>Exposure assessment and risk characterization if registration volume > 10 t/a and classification as dangerous</p> <p>If no pre-registration exists, substance must be registered before EoW is declared</p>
Notification of classification to C&L inventory under CLP-Regulation	CLP regulation does not apply	CLP applies but notification would be necessary if substance is dangerous and not registered by the recovery operator
Forwarding of information to customers	Waste documentation	<p>SDS for glass classified as dangerous</p> <p>In these cases where SDS is not required, the article 32 information is required if handling, use and/or disposal require specific risk management</p>
Authorisation	REACH does not apply	Only applicable to substances included in Annex XIV of REACH
Information on SVHC on the candidate list	Information could support operators in waste treatment installations to control substance specific risks. However, no legal requirements	In principle, no information requirements for operator of recovery process

⁴⁵ For dangerous substances registered in amounts exceeding 10 t/a, a chemical safety report is to be included in the registration dossier, which is to contain an assessment of risks from the entire lifecycle of a substance. This is not described here in further detail, as it does not influence or relate to the context of EoW criteria.

Summary on REACH requirements and exceptions for EoW cullet

Article 2.2 of the REACH Regulation specifies that waste is not a substance, mixture or article within the meaning of Article 3 of this Regulation. If waste glass or cullet has still the status of waste, it is covered by waste law, not by REACH. When waste glass ceases to be waste according to Article 6 of the WFD, the exemption under Article 2.2 of the REACH regulation no longer applies, and glass is subject to REACH.

Many types of recovered glass are, however, exempted from most REACH obligations (e.g. registration and evaluation obligations, but not downstream safety information communication) because of two possible reasons:

- 1) Because the nature of cullet as a **recovered substance**, by **Article 2.7(d)**
- 2) Because registration for recovered glass (being a substance) is deemed inappropriate or unnecessary, by **Article 2.7(b) (Annex V.11)**

The 2008 update of Annex V of REACH (EC/987/2008) and in particular Annex V.11, exempts *glass* and *ceramic frits* from the mentioned obligations, unless:

"they meet the criteria for classification as dangerous according to Directive 67/548/EEC and provided that they do not contain constituents meeting the criteria as dangerous in accordance with Directive 67/548/EEC present in concentrations above the lowest of the applicable concentration limits set out in Directive 1999/45/EC or concentration limits set out in Annex I to Directive 67/548/EEC, unless conclusive scientific experimental data show that these constituents are not available throughout the lifecycle of the substance and those data have been ascertained to be adequate and reliable"

ECHA (2010) has provided guidance on the interpretation of these exceptions. Only those types of glass and ceramic frits are exempted which do not have any significant hazard properties.

2.5.9 By-products

If a certain recovered waste component were regarded as being a by-product, and not being waste, in the sense of Article 5 of the WFD, then the case end-of-waste criteria would not apply unless the by-product becomes waste at a later phase.

Article 5 of the WFD on by-product reads as follows:

"1. A substance or object, resulting from a production process, the primary aim of which is not the production of that item, may be regarded as not being waste referred to in point (1) of Article 3 but as being a by product only if the following conditions are met:

- (a) further use of the substance or object is certain;
- (b) the substance or object can be used directly without any further processing other than normal industrial practice;
- (c) the substance or object is produced as an integral part of a production process; and

(d) further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts.

2. On the basis of the conditions laid down in paragraph 1, measures may be adopted to determine the criteria to be met for specific substances or objects to be regarded as a by-product and not as waste referred to in point (1) of Article 3. Those measures, designed to amend non-essential elements of this Directive by supplementing it, shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 39(2)."

It is noticeable that Article 5 of the WFD says "...may be regarded...", which appears to leave a certain freedom of choice even if the four conditions of Article 5 are met, at least as long as measures under Article 5.2 have not been adopted.

By-products are not waste and therefore cannot become end-of-waste.

2.6 Environmental and health issues

2.6.1 Introduction

For the purpose of determination of end-of-waste criteria, the interest as regards environment and health is to ensure the fulfillment of condition (d) of Art. 6 in the WFD, that is, that by changing the condition of recovered waste stream from waste to non-waste, *'the use of the substance or object will not lead to overall adverse environmental or human health impacts'*. The question is therefore to analyse which are the direct and indirect environmental impacts of this change on waste collection, treatment and recycling.

Glass products are used for many purposes. In some applications glass material competes with other materials, e.g. packaging can also be delivered in other materials such as plastics, metals (aluminium, steel, etc.), or with composites consisting of paper fibres in combination with aluminium and/or plastic foils. Conversely, no alternative material has been found to compete with most flat glass applications.

The major environmental and health benefit of glass is its theoretical endless recyclability without loss of quality. Glass is also an inert material with very low rates of leaching of its constituent substances into liquids in contact with the glass, therefore a low risk of migration of substances into the food.

Glass manufacture is a high-temperature energy-intensive process. It is well known from several LCA analyses that compare the recycling and disposal of waste glass that recycling has environmental benefits in all cases, greater in recycling uses involving re-melting, and lower in other recycling uses, cf. Figure 15 below.

The environmental impacts of waste collection, treatment and recycling, including storage and transport of recovered/recycled materials can be listed as:

- Energy uses
- Resource uses
- Air emissions: CO₂, and other greenhouse gases
- Other air emissions (toxic and/or environmentally harmful substances and dust)
- Leaching or leakage of liquid components to the underground
- Fire hazards
- Accidents at work (by e.g. glass shards)

The largest potential environmental impacts of the life cycle of glass, excluding the use phase, relate to the melting activities:

- The products from burning of fossil fuels and the high-temperature oxidation of nitrogen in the combustion atmosphere
- Particulate matter arising mainly from the volatilisation and subsequent condensation of volatile batch materials
- Gases emitted from the raw materials and melt during the melting processes.

2.6.2 Energy uses

The total energy consumptions by the European glass industry are distributed between energy sources as follows: 15 % as electricity (coal is the common European marginal for electricity), 30 % as fuel oil and 55 % as natural gas. (Ramboll/Ökopol, 2010).

In general, over 75 % of the energy used in the glass manufacturing is used for melting the glass. An exception is the mineral wool sector, where the fiberising operation and the curing oven are also major energy consuming processes.

The actual energy requirements experienced in the various sectors vary widely from about 3.3 to over 40 GJ/tonne. The majority of glass is produced in large furnaces and the energy requirement for melting is generally below 8 GJ per tonne of melted glass. The *theoretical* energy requirement to produce soda lime glass from virgin raw materials is approximately $E_{RM} = 2.671$ GJ/tonne. The energy requirements to melt 100% glass cullet (crushed recovered glass) are about $E_{cul} = 1.886$ GJ/tonne. It is observed that the use of 10% of cullet in the glass manufacturing process contributes to energy savings between 2 and 3%, i.e. a theoretical maximum potential of 30% energy saving can be obtained by replacing all virgin material by cullet.

2.6.3 Resource uses

The production of one tonne of glass will typically require:

- 700 kg of silica sand
- 192 kg of limestone or dolomite
- 207 kg of soda ash
- 71 kg of other minerals

This gives a total of 1.17 tonnes of raw materials and the 170 kg difference is due to the loss of CO₂ from the decomposition of soda ash, limestone and dolomite. Hence the use of cullet instead of virgin raw materials will lead to saving of roughly 120 % of raw materials expressed on the basis of final glass product.

Finally, it should be noted that the quality of glass is not degraded in the recycling process, as long as the cullet is appropriately sorted by colour.

2.6.4 Air emissions: CO₂, and other greenhouse gases

Enviros Consulting (2003) calculated the CO₂ life cycle emissions in the UK at 843 kg per tonne container glass manufactured from raw materials and 529 kg per tonne container glass manufactured from cullet, indicating a saving of 314 kg CO₂ equivalents per tonne glass produced. In turn, an LCA study published by FEVE⁴⁶ has shown that on a cradle-to-cradle basis, each time 1 tonne of cullet is incorporated in a glass furnace for manufacturing container glass, 670 kg of CO₂ are saved.

⁴⁶ LCA study by FEVE, http://www.feve.org/index.php?option=com_content&view=article&id=16&Itemid=18

When using cullet for other applications, the net energy and CO₂ emission saving potential decreases. For cullet exported from the UK (by sea transport) and used by foreign glass manufacturers, the savings have been estimated as 290 kg CO₂ equivalents per tonne glass produced. For container glass production, the transportation of raw material accounts for less than 4% of the total CO₂ emissions.

Cullet used for the production of glass fibres yields a saving of 275 kg CO₂ equivalents per tonne glass fibre produced.

Other uses of glass cullet include brick and tile manufacturing, use as sandblasting material, use as filtration media or aggregate replacement. All these yield much lower CO₂ savings, which might even be negative in some cases. Figure 15 summarizes the potential CO₂ savings for cullet use in different applications.

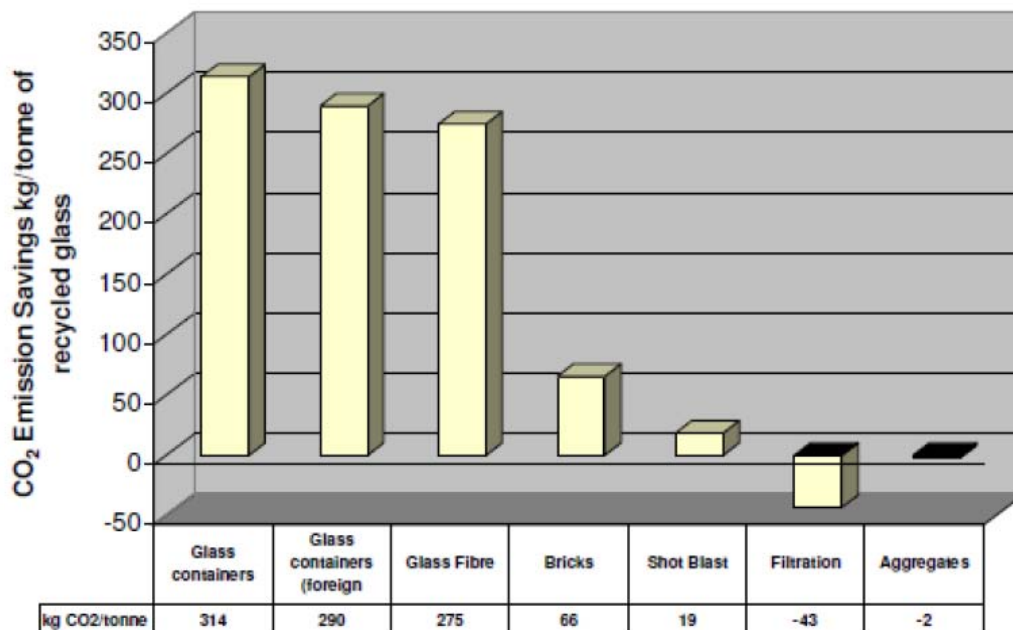


Figure 15: CO₂ emission savings for cullet applications (Enviros Consulting, 2003)

The CO₂ emissions for collecting waste glass were at approx. 3 kg CO₂/tonne of glass collected. Furthermore, for bulk haulage of collected glass to the reprocessors, 12 kg CO₂/tonne of glass is added. Finally, the transport from reprocessor to glass factory is estimated to induce another 0.61 kg CO₂/tonne.

2.6.5 Other air emissions

During melting activities with the aim of producing glass, several particulate and gaseous emissions may occur. Table 15 summarizes these.

Table 15: Summary of emissions to atmosphere arising from melting activities (Ramboll/Ökopol, 2010)

Emission	Source / Comments
Particulate matter	Condensation of volatile batch components. Carryover of fine material in the batch. Product of combustion of some fossil fuels.
Oxides of nitrogen	Thermal NO _x due to high melting temperatures. Decomposition of nitrogen compounds in the batch materials. Oxidation of nitrogen contained in inlet air for combustion.
Oxides of sulphur	Sulphur in fuel. Decomposition of sulphur compounds in the batch materials. Oxidation of hydrogen sulphide in hot blast cupola operations.
Chlorides/HCl	Present as an impurity in some raw materials, particularly synthetic sodium carbonates and external cullet. NaCl used as a raw material in some special glasses.
Fluorides/HF	Present as a minor impurity in some raw materials, including external cullet. Added as a raw material in the production of enamel frit to add certain properties in the finished product. Added as a raw material in the continuous filament glass fibre sector, and in some glass batches to improve melting, or to produce certain properties in the glass e.g. opalescence. Where fluorides are added to the batch, typically as fluorspar, uncontrolled releases can be very high.
Heavy metals (e.g. V, Ni, Cr, Se, Pb, Co, Sb, As, Cd)	Present as minor impurities in some raw materials, post-consumer cullet, and fuels. Used in fluxes and colouring agents in the frit sector, in particular for enamel frits (predominantly lead and cadmium). Used in some special glass formulations (e.g. lead crystal and some coloured glasses). Selenium is used as a colourant (bronze glass), or as a decolourising agent in some clear glasses.
Carbon dioxide	Combustion product from combustion of fossil fuels. Emitted after decomposition of carbonates in the batch materials (e.g. soda ash, limestone).
Carbon monoxide	Product of incomplete combustion, particularly in hot blast cupolas.
Hydrogen sulphide	Formed from raw material or fuel sulphur in hot blast cupolas due to the reducing conditions found in parts of the furnace.

Furthermore, air emissions will also be associated with the combustion of fuel oil, natural gas and coal used directly or indirectly to generate heat and electricity in the melting process. Dust emissions can be generated in the context of glass production, use and recycling, specifically:

Any dust emissions to ambient air may cause impacts on human health and the environment if consisting of very fine particles. The feedback from the TWG indicated that glass recycling reduces all emissions including dust, with the only possible and well-documented exception of lead. No adverse health effects have been recorded in populations living in the vicinity of glassworks. If EoW criteria will contain limitations to the input of lead-containing materials, then the use of cullet in glass manufacturing is not expected to result in increased lead-containing dust emissions.

2.6.6 Heavy metal accumulation in the glass cycle

Apart from dust emissions, heavy metals may be a concern related to the glass cycle.

In glass production, metals originate from:

- Impurities in raw materials, including cullet
- Impurities in fuels
- Additives to achieve special colours (Table 20)
- Lead for the production of crystal glass
- Selenium for decolourisation of some clear glasses (BREF, 2009)

Table 16 summarizes the major metals used for glass colouration.

Table 16: Metals used in glass to achieve different optical properties (BREF, 2009)

Antimony	Sb3+	White, yellow (lead with antimony)
Copper	Cu2+	Light blue, red
Chromium	Cr3+	Green
	Cr6+	Yellow
Cobalt	Co2+	Intense blue, but pink in borate glasses
	Co3+	Green
Gold	AU3+	Ruby red
Iron	Fe3+	Yellowish-brown
	Fe2+	Bluish-green
Manganese	Mn3+	Violet
Neodymium	Nd3+	Reddish-violet
Nickel	Ni2+	Greyish-brown, yellow, green, blue to violet (depending on the glass matrix)
Praseodymium	Pr3+	Light green
Selenium	Se0	Reds, pink (also Se2+, Se4+, Se6+, depending on glass type)
Tin	Sn2+	Copper ruby
	Sn4+	White
Titanium	Ti3+	Violet (melting under reducing conditions)
Uranium	U4+	Black, yellow green (no longer used)
Vanadium	V3+	Green in silicate glass; brown in borate glass

In addition to the metals listed, lead is a major metal used in the production of certain glass.

Although direct ingestion of heavy metals from glass or intake of metals from leaching are extremely unlikely, lead, silica and low solubility particles such as barium can pose risks to human health through inhalation of dust.

Reprocessing of glass may have an impact on dust emissions and heavy metals. Crushing of glass into cullet will generate dust and the desired particle size affects dust generation. A possible effect of using cullet is a likely increase the use of selenium as decolorizing agent in the glass manufacturing, which could lead to an increase in emissions. Also, lead emissions could increase due to carryover of lead in cullet over the years.

2.6.7 Leaching of substances to the underground

Glass is considered inert, and is in fact used for the encapsulation (vitrification) of wastes, for example radioactive waste. In the context of packaging, there have been a number of studies showing that any heavy metals contained in glass will remain in the glass.

According to a study conducted on behalf of the Food Standards Agency in the UK, glass has been found to be a material of high chemical inertness under accelerated migration testing conditions (<http://www.food.gov.uk/science/research/contaminantsresearch/contactmaterials/a03prog/a03projlist/a03029proj/>)

Water pollution is in most known cases not a major issue for installations within the glass manufacturing industry (Ramboll/Ökopol, 2010).

3 End-of-waste criteria

3.1 *Rationale for end-of-waste criteria*

The end-of-waste criteria should be such that the material has waste status if – and only if – regulatory controls under waste legislation are needed to protect the environment and human health; otherwise the material should have end-of-waste status to facilitate recycling. The criteria should be developed in compliance with the legal conditions, be operational, and do not create new disproportionate burdens, taking into consideration that recovered waste glass recycling is a well-functioning industrial practice today.

Criteria should be ambitious in providing benefits to as many waste glass flows as possible, but must also address with priority the main and largest represented flows in the EU. Criteria cannot fail to target these priority flows by trying to encompass all existing waste glass flows, and all special cases and national singularities.

It has been reported that the current waste status of glass cullet creates in some cases a number of administrative and economic burdens, especially related to storage, transport and trade, and creates legal uncertainty by keeping under waste legislation a material that in practice is often perceived and treated as a product. In those cases, the end-of-waste status of the glass cullet would result in a reduction of those administrative and economic costs.

The following main types of benefits can be expected when EU-wide end-of-waste criteria for glass cullet are introduced:

- Clearer differentiation between high quality and low quality recovered glass cullet. Only high quality recovered glass cullet will cease to be waste.
- Improved functioning of the internal market (simplified and harmonised rules across countries, increased legal certainty, increased transparency and reliability of quality-assured shipment of materials).
- Reduction of administrative and economic burdens, especially related to transport, shipment and trade, which are redundant for environmentally safe materials.

EoW criteria have to be clear, concise and enforceable. They have to be robust and controllable through spot checks, and minimise non-compliance that may undermine their credibility.

The definition of the criteria has been guided by the principles of simplicity and proportionality. Criteria have been proposed in the less intrusive form possible, yet ensuring fulfilment of the conditions of Art.6 of the WFD. Proportionality has been used in the prioritisation of the target glass cullet groups, addressing first the largest flows.

A majority of responses from the TWG were in support of developing end-of-waste criteria for glass cullet, provided that the criteria are practical and enforceable, promote the efficient use of resources, facilitate meeting recycling targets, and result in reduced administrative and other costs. The development of end-of-waste criteria is seen as a reflection of the cultural shift from waste disposal to resource conservation and recycling. A general comment from industry (cullet reproprocessors, glass manufacturers) is also that end-of-waste criteria should not interfere with innovation and flexibility in the glass industry.

3.2 Scope and conditions for end-of-waste criteria

3.2.1. Scope of end-of-waste criteria

The scope of end-of-waste criteria can be summarized in two points:

End-of-waste criteria are relevant only for recovered glass cullet, i.e. glass cullet that has undergone a recovery operation. This means they will usually only apply to so-called *external* cullet, i.e. cullet that has become waste, as opposed to *internal* cullet consisting of manufacturing process rejects that are immediately absorbed by the respective industrial process as a raw material, which do not leave the glass manufacturing plant and are usually not registered as waste. External cullet can be of industrial origin (pre-consumer) or be post-consumer.

The scope of the proposal of end-of-waste criteria for glass cullet presented in this document is only to glass cullet processed for recycling in a process that involves re-melting in a glass furnace. The use of glass cullet in non-recycling, non re-melting operations, i.e. filling material, filter material, or abrasive are not part of the scope of the end-of-waste criteria here presented.

A detailed explanation of the rationale for this limitation of scope to recovered glass cullet aimed at re-melting in a glass furnace is provided in the following.

Firstly, the only currently common specific purpose identified in the EU that drives the recycling of glass cullet is recycling in re-melting processes. Remaining uses that are not based on re-melting seem driven by an excess of supply, and the availability of inexpensive, lower quality glass cullet fractions.

As presented in the background information section, more than 90% of the market of glass cullet for recycling is for re-melting applications. Thus, the largest current market in the EU is for these applications.

Secondly, most life-cycle based assessments indicate that re-melting uses result in considerably higher energy savings than non re-melting uses. Thus, it makes sense to prioritise the support of EoW status for the recycling that provides the largest environmental gains. This is also in line with the hierarchy principles of the Waste Framework Directive.

Low-quality glass cullet fractions for one-use recovery (water filtering, aggregate, landscaping), imply a downgrading of the material that render it unfit for further recycling.

Lastly, non re-melting applications would generally require end-of-waste criteria of a very different technical nature than the quality criteria required for re-melting uses. It does thus not make technical sense to overburden or oversimplify the end-of-waste criteria for re-melting uses with those of the non re-melting uses, just for the purpose of having an all-encompassing set of criteria.

With the evolution of markets and technology, one must not exclude that in the future, clear, strong markets and demand are identified for EoW for glass cullet destined to one-use recycling applications (open loop recycling). In such case, the proposed criteria could be complemented with a separate set of EoW criteria on glass cullet for these specific non re-melting purposes. If appropriate, such additional criteria could be proposed as part of EoW focusing on the use, e.g. as part of "aggregates EoW criteria".

In order to ensure a correct application of the limited scope of EoW proposed, the EoW criteria should minimise the risk that glass cullet that has ceased to be waste is diverted to uses different from re-melting. This issue is discussed further on in this chapter.

The proposed scope is in general supported by the experts of the TWG. While the majority of experts have agreed to limit the scope to glass cullet processed for recycling in a process that involves re-melting in a furnace, a number of experts have instead defended the idea of opening the scope of EoW to any application, not only re-melting. The main argument in favour of this idea is that alternative applications, e.g. the use of cullet in aggregates, should not be discouraged. However, current practice under waste law can continue. Some experts were of the opinion that if applications of cullet cannot achieve EoW status, the industry may decide to landfill rather than use the cullet in open-loop recycling applications such as aggregates.

As suggested by some experts, separate sets of end-of-waste criteria for different uses of the cullet may be prepared at a later stage. However, at this stage it is not possible to set EoW criteria for open-loop recycling. More research is needed, especially regarding material behaviour in direct contact with the environment (e.g. in aggregates applications). Meanwhile, for non re-melting uses, the legal status would remain as it is today.

3.2.2. Conditions for end-of-waste criteria

According to Article 6 of the Waste Framework Directive, "certain specified waste shall cease to be waste within the meaning of point (1) of Article 3 when it has undergone a recovery operation and complies with specific criteria to be developed in accordance with the following conditions:

- a) The substance or object is commonly used for a specific purpose;
- b) A market or demand exists for such a substance or object;
- c) The substance or object fulfils the technical requirements for the specific purpose referred to in (a) and meets the existing legislation and standards applicable to products; and
- d) The use of the substance or object will not lead to overall adverse environmental or human health impacts."

Regarding conditions (a) and (b), there is substantial evidence (as was described in Chapter 2) that a structured market and a demand exist for at least two types of cullet: container glass and flat glass cullet. In terms of production volumes, container glass and flat glass manufacturing together represent ~85% of the total glass market in the EU-27.

These two types of cullet can be re-melted to manufacture not only new container glass and flat glass, but also can be re-melted into glasses belonging to other manufacturing sectors, e.g. insulation mineral wool. In contrast, cullet from other glass sectors typically can only be used to manufacture strictly the same type of glass. On the other hand, in some cases, e. g. in the continuous filament glass fibre (CFGF) manufacturing, there are still difficulties to use cullet of any type as input, including CFGF cullet.

Regarding condition (c), there is no common international standard or specification for glass cullet. There are other standards that are commonly used in different regions in Europe such as FERVER's for furnace-ready cullet, or BSI PAS101 for collected container glass cullet (c.f. Section 2.4), and there are also many case-by-case technical specifications that established in private commercial agreements. For example, for a cullet reprocessing company, the quality requirements for the cullet might be determined by a specific customer, e. g. container glass manufacturer in need of very specific bottle quality requirements. Those standards are business-to-business specifications agreed through a contract between the cullet reprocessor and the glass manufacturer.

The third condition (c) implies that end-of-waste criteria need to ensure that, at the point of ceasing to be waste, any technical requirements related to the use are fulfilled and the recycled material should comply with applicable legislation and standards as product. In the case of glass cullet, this means that at the moment of end-of-waste, the recovered glass cullet should fulfil specifications that material producers use for the recovered material that they buy. The consequence for such material is that, by

fulfilling the specifications, its quality is such that it will actually be used for manufacturing new material, even if it is exported or imported outside waste regulatory controls. This is also true in the case of exports outside the EU, including to non-OECD countries. Recovered glass cullet is commonly used as a feedstock for the production of new material, at least for glass cullet coming from certain sectors of the glass manufacturing industry. Any use other than for the production of new material is highly unlikely.

Regarding the fourth condition (d), from a life cycle point of view, glass cullet recycling as such has overall environment benefits, and therefore if EoW promotes recycling, a net environmental benefit can be expected. The use of recovered material in the glass furnace is regulated as far as emissions are concerned by the IPPC Directive regardless of whether the material is a waste or not.

The main areas where the waste status of this material can potentially make a difference for the environmental and health impacts are transport (waste shipment) and trade. If the material has EoW status it can in principle be transported by any transport undertaking and not only those that are permitted to transport waste. However, since EoW glass is in general very clean of impurities (max 0.5%), this shall not pose any major health or environmental concerns. Regarding transport and shipment, it is important that only material without waste-specific hazardous properties ceases to be waste and that it can be expected that the use of the material outside the EU would not lead to higher environmental or health impacts.

3.3 Outline of end-of-waste criteria

According to the JRC methodology guidelines, the ultimate aim of end-of-waste criteria is to ensure product quality. End-of-waste criteria will therefore usually include direct product quality requirements. In addition, a set of end-of-waste criteria may include elements that check product quality indirectly, in particular requirements on input materials and requirements on processes and techniques. Usually, there will also be supportive requirements on quality management and regarding the provision of information (e.g. on product properties). The following are the main types of end-of-waste criteria:

- (1) Product quality requirements
- (2) Requirements on input materials
- (3) Requirements on treatment processes and techniques
- (4) Requirements on the provision of information
- (5) Requirements on quality management

This approach to define a set of end-of-waste criteria combining several levers of action corresponds well to current good industrial practice of ensuring the product quality of glass cullet. Accordingly, glass cullet ceases to be waste when it is placed on a market where it has a demand because it fulfils certain product quality requirements, has a clearly identified origin and has been processed according to the required treatment processes. Compliance with all these requirements has to be ensured by applying industrial practice of quality control.

It is desirable to keep the criteria clear, as simple as possible, and enforceable. It would also be desirable to rely as much as possible on the direct product quality requirements, in particular to provide criteria that are useful in the case of spot checks of traded material and which would allow demonstrating non-compliance with the end-of-waste criteria directly. These possible elements of the end-of-waste criteria are presented below, including a summary of comments received from the technical working group, and proposals for modification of earlier proposals of the end-of-waste criteria.

The five sections on end-of-waste criteria are presented individually below. Each section starts by an overview of the context of each of the criteria, followed by a description of the discussion and feedback received during workshops and written inputs, and a conclusion and final proposal of each of the criteria.

3.4 Criteria on product quality

Product quality criteria are needed to check for: (1) direct environmental and health risks, and (2) if the product is suitable as direct input to the final use of recycled glass cullet, to ensure that a market for the recovered glass cullet exists.

In practice, product quality criteria should also allow deciding if the material in the glass cullet is sufficiently pure and has been separated effectively from other types of materials.

Criterion 1.1. Requirements on meeting a customer specification, an industry specification or a standard

Compliance with a technical specification or standard is needed to demonstrate that the recovered glass cullet fulfils the technical requirements for a specific purpose implying re-melting and it also indicates that there will be a market and a demand.

The technical specifications may be of an agreed nature across the glass industry at large, a glass manufacturing sector, or be defined on a case-by-case basis between individual businesses.

It could be considered proportionate and useful to demand compliance with a specification and standard that can be freely chosen as long as the specification or standard is one that is actually used by a user to define the needs for glass cullet input materials. For each consignment of recovered glass cullet the supplier should provide information regarding the specification or standard. The identification of the specification should be sufficiently clear so that it will be possible for the competent authorities, in the case of an inspection, to verify, by own investigation, that the specification corresponds to authentic user requirements. The key elements of the specifications should be summarised in the documentation (provision of information).

From the feedback received from the technical working group, there is a general agreement that the glass cullet should comply with a standard or specification. To the best knowledge there is only one CEN standard relevant for cullet (CEN/TR 13688:2008, "Standards for glass packaging to be considered recyclable in the context of the waste packaging directive"). The most common types of specifications used in trading are individual case-by-case business specifications. There is no international or EN standard for glass cullet that would include a list of grades of glass cullet to be used in trading. Therefore, Criterion 1.1 has been proposed in a generic form, to require **compliance** (not grading) with a customer specification, an industry specification, or a standard.

Criterion 1.1 is therefore proposed as:

Criteria	Self-monitoring requirements
1. Quality of cullet resulting from recovery operation	
1.1 The glass cullet shall comply with a customer specification, an industry specification or a standard for direct use in the production of glass substances or objects by re-melting in glass manufacturing facilities.	Qualified staff ⁴⁷ shall verify that each consignment complies with the appropriate specification.

Criterion 1.2. Requirements on content limits for non-glass components⁴⁸

The end-of-waste criteria should include limit values for the content of "non-glass components" in order to check directly on the material if the separate collection and/or treatment of the waste have been effective to produce a separated glass cullet which is sufficiently pure. Such limit values would also restrict the possibilities of having other wastes mixed into the glass cullet. The strictness of the limit values reduces the possibility that the cullet will be used in applications other than re-melting.

Limit values on non-glass components can be used in compliance testing by the producer of end-of-waste material (at the site of the processor) as well as in "on-the-spot" checks for example by regulatory authorities.

It is important to keep in mind that the potential introduction of quantitative limit values has to be done with care, and be limited to the extent possible, in any case responding to currently existing practice. Introducing novel limit values would result in additional burdens to the glass chain, which is against the overall aim of EoW of simplifying the administrative requirements of the shipment of recyclables, as compared to the situation under waste law.

For the sake of clarity and simplicity the same limit values should apply to all types of recovered glass cullet for re-melting applications. Stricter requirements in specifications, standards and commercial agreements for specific types of recovered glass cullet will in any case be possible, in parallel to the EoW requirements.

The proposed limit values should be mainly based on existing standards or specifications for container glass, flat glass and tableware glass cullets, which are used in the main applications of cullet in the market: container glass, flat glass, domestic glass, and insulation mineral wool production. **Table 17** provides a summary of contamination limits for "recovered cullet" proposed in existing specifications and standards, depending on final uses of cullet.

Finally it is important to clarify that compliance demonstration with stricter product quality specifications (i.e. stricter limits for non-glass components) shall also be regarded as compliance with EoW criteria, to ensure that EoW will not introduce additional burdens or "double-checking".

⁴⁷ Qualified staff is defined as: staff who are qualified by experience or training to monitor and assess the properties of cullet.

⁴⁸ In this document, the terms "non-glass components" or "impurities" are used to refer to all components of the cullet which are not glass. In particular, "non-glass components" are classified in four exclusive groups: ferrous metals, non-ferrous metals, non-metal non-glass inorganic materials (for example: ceramics, porcelain, stones, pyro-ceramics), and organic materials (for example: paper, rubber, plastic, fabrics, wood).

Table 17: Summary of contamination limits for existing specifications and standards, relative to final use of the "processed cullet"⁴⁹

Final uses of cullet	Fe (ppm)	Non-Fe (ppm)	Inorganic (ppm)	Organic (ppm)	Total limit (ppm, %)	Colour requirement	Remarks
Container glass (Glass for Europe)	50	20	20	3000	3090 ppm, 0.309 %	(a) For green glass < 5% contamination (b) For brown glass < 5% contamination (c) For flint glass < 4% contamination	
Container glass (FERVER)	10	60	100	2000	2170 ppm, 0.217%	Subject to agreement between buyer and seller	Moisture should be less than 5% Cullet size should be < 50 mm, no excessive fines to avoid dust
Flat glass (Glass for Europe)	2	0.5	None	45	47.5 ppm, 0.00475 %		
Insulation mineral wool (Eurima)	10	20	25	3000	3055 ppm, 0.3055%	None	
Ceramic sanitary ware (BSI/WRAP, 2004)					1%	None	
Fluxing agent in brick manufac. (BSI/WRAP, 2004)					1%	None	
Sports turf and related applications (BSI/WRAP, 2004)					Subject to agreement between processor and end user	None	
Water filtration media (BSI/WRAP, 2004)				None	Specific contaminant limits subject to agreement between processor and end user.	(a) Entirely brown glass, with colour contamination not exceeding 5% total (b) Entirely green glass, with colour contamination not exceeding 5% total	Cullet shall not contain: medical or chemical refuse, hazardous/toxic material, plate glass, light bulbs, fluorescent lighting tubes
Use as an abrasive (BSI/WRAP, 2004)	50	20	50	500	620 ppm, 0.062%	Subject to agreement between processor and end user	Should be free from corrosive constituents and adhesion-impairing contaminants

⁴⁹ In this table, CSP includes glass ceramics, also called vitro-ceramics. The sources of the data are indicated in parentheses on the first column.

The technical working group expressed support for the rationale of end-of-waste criteria, as being essentially based on ensuring: (1) protection of the environment and (2) the existence of a market for the end-of-waste material.

It was recognized that there is always a commercial relation between customer and supplier establishing specifications which may differ from the end-of-waste criteria, and that the end-of-waste product quality criteria should not be used for commercial purposes; instead, they should reflect the environmental status and the existence of a market for a product. In this sense, the end-of-waste criteria should represent a minimum quality benchmark specifying when the cullet ceases to be waste and becomes a secondary raw material, ready for recycling in re-melting. In addition, end-of-waste criteria should not interfere with business-to-business specifications between cullet reprocessors and glass manufacturers.

There was also a general understanding that the end-of-waste specification should be set with the aim of ensuring that the material is processed to a level where it can be considered fully recovered, even if the end user subsequently requires higher specification material. The general feedback received was that the end-of-waste product quality limit should represent a fair balance, being not too flexible but also not overly strict, in order to accommodate existing differences between EU member states. Too restrictive requirements on cullet could put in difficulty some countries compared to others. The current situation is that of large differences in technical, legislative and social contexts for glass cullet across the EU-27, and therefore a gradual harmonization is mentioned as being preferable than a sudden change, which could result in negative effects on the internal market.

Only one member of the TWG expressed disagreement with the need to set EoW product quality criteria. Concerns were expressed that if the EoW product quality criteria are too wide they will be meaningless, and if too tough then the glass manufacturers would have to pay a higher price for a cullet quality that they do not need. Instead of establishing product quality criteria, it is proposed that the mere existence of a commercial contract between cullet processor and glass manufacturer shall be sufficient for the cullet to attain EoW status, together with a statement guaranteeing that the cullet will only be used for re-melting into new glass products.

A few observations can be made to address this alternative proposal. First, EoW product quality criteria will hardly be stricter than the commercial criteria, therefore there is no risk that manufacturers will have to pay a higher price for EoW cullet than what they pay today for cullet as waste. In addition, if the parameters in EoW criteria are not detected in the specific glass cullet type traded, then the statistics-based sampling plan will tell that very sparse measurements will be needed for the given parameter, constituting a low additional burden. Second, requiring the existence of a commercial contract may unnecessarily pose confidentiality concerns. In addition, commercial contracts may refer to technical characteristics of the final product, and not to the protection of health and the environment, as EoW do. EoW product quality requirements are considered necessary to guarantee no adverse environmental or health risks, including if the cullet would be used in applications other than recycling. Finally, EoW criteria are meant to be applicable to any glass cullet satisfying certain product quality requirements upon transfer from the producer to another holder, that guarantee existence of a market and no adverse environmental impacts, regardless there is an actual purchasing contract between cullet reprocessor and glass manufacturer or not.

Limits on non-glass components: the FERVER proposal

Regarding the quantitative values for the product quality criteria, there was broad support from the TWG for a specification such as the one developed by FERVER, and that this specification should be suitable (with possible modifications) as a basis to define end-of-waste criteria. The arguments in support of FERVER specifications were based on the fact that these specifications are already in operation and used in practice between cullet reprocessors and glass manufacturers in Europe, and that they represent best industry practice. The TWG showed strong support for establishing limits for **four non-glass components**, based on FERVER specifications, with limits listed as follows:

Ferrous metals: 10 ppm

Non-ferrous metals: 60 ppm

Non-metal non-glass inorganics: 100 ppm

Organics: 2000 ppm

These four parameters indeed correspond to materials that are typically found in collected cullet for recycling, and therefore constitute an appropriate basis for EoW criteria. They are individually analyzed below, addressing their potential environmental and health effects, and how the proposed concentrations guarantee the existence of a market.

It should also be clarified that even though meant to define *furnace-ready* cullet, meeting the FERVER limits does not automatically mean that the cullet can be directly used in all types of furnaces or in all specific cases. However, this type of limits is considered suitable as a basis to make a distinction between waste and non-waste. The suitability of the cullet for use in specific glass furnaces should be the object of the bilateral contract between cullet processors and glass manufacturers.

Limits on non-glass components: proposals other than FERVER

One of the experts of the TWG proposed that the EoW criteria should be set at the level of flat glass (stricter than FERVER), e.g. similar to the specifications of WRAP/EA (2008), included on Table 17 (under "flat glass"). However, several other experts explicitly mentioned that flat glass criteria are too stringent and would leave most packaging glass out of EoW condition.

Another member of the working group has proposed a more detailed and stricter set of limits. This recommendation was developed by the glass cullet reprocessing sector and the glass manufacturing sector in cooperation from one Member State. The limits proposed are as follows:

- Ferrous metals: 5 ppm
- Non-ferrous metals: 5 ppm
- Non-metal non-glass inorganics: 40 ppm
- Organics: 400 ppm
- Other glass (labware, vacuum glass, light bulb): 10 ppm
- Pyroceramic (a glass ceramic): 30 ppm
- Refractory, metal carbide, nitrates, zirconium, corundum, chrome bearing materials: 0
- Heavy metal content (lead PbO, cadmium, mercury, and hexavalent chromium): 100 ppm
- Size of particles: < 80 mm

The limits proposed were developed on the basis of commercial requirements of the glass manufacturing companies in the Member State and the neighbouring countries, and were considered needed to guarantee a market for cullet in the region.

In addition, a number of experts have also mentioned the non-glass contaminant limits listed in CEN/TR 13688:2008 (standards for glass packaging to be considered recyclable in the context of the waste packaging directive), as follows:

- Ferrous metals: 5 ppm
- Non-ferrous metals: 5 ppm
- Non-metal non-glass inorganics: 50 ppm
- Organics: 500 ppm
- Plastics: 100 ppm

It is to be noted that all these alternative proposals are stricter than FERVER specifications.

Limit on ferrous metals

A review of technical specifications for cullet intended for re-melting into new glass products and consultation with experts indicates that a limit on ferrous metals content is needed in order to guarantee that the cullet has undergone appropriate and sufficient separation of ferrous metals to a level that does not adversely impact its re-manufacturing by re-melting.

Ferrous metals constitute a type of non-glass impurity that causes unwanted coloration in the final glass products. If its concentration in the cullet is above a certain limit, it will not be usable by glass manufacturers because it would adversely affect the colour properties of the mix of cullet and raw materials that are used as input in furnaces, and therefore it will be rejected.

FERVER specifications establish a limit of 10 ppm in order to meet manufacturing technical limitations. This concentration of ferrous metals contained in the cullet will not result in any adverse health and/or environmental impact if the cullet is used for re-melting applications.

Feedback received from experts from the manufacturing and cullet reprocessing industries suggests that the limit could be increased from 10 to 50 ppm, based on evidence that the 10 ppm limit is seen as too strict for a significant fraction of glass producers and therefore not deemed reasonable as EoW criterion. Experts have pointed out that the 50 ppm limit is often seen in commercial contracts and therefore suggested as a more reasonable limit to guarantee the existence of a market for EoW cullet. This ferrous metal content (50 ppm) is also not considered to be an environmental nor a health issue.

Therefore, in order not to exclude significant cullet flows suitable for re-melting applications from attaining EoW status, a 50 ppm limit can be considered preferable to 10 ppm.

Limit on non-ferrous metals

A review of technical specifications for cullet intended for re-melting into new glass products and feedback from experts indicates that a limit on non-ferrous metals content is needed in order to guarantee that the cullet has undergone sufficient separation of non-ferrous metals to a level that does not adversely impact its re-manufacturing by re-melting. Non-ferrous metals are found to attack and cause defects in the walls and bottom of the glass furnaces, leading to shortened furnace life. Therefore, cullet containing non-ferrous metals above specified limits is consistently rejected by glass manufacturers, and therefore a market for that cullet would not be guaranteed.

The non-ferrous metal limit of 60 ppm contained in FERVER specifications is widely accepted by experts as a reasonable EoW limit. As for the case of ferrous metals, this low concentration of non-ferrous metals contained within the cullet glass matrix will not pose any health or environmental hazard, and therefore the 60 ppm limit can be seen as a reasonable EoW criterion.

A possibility of adding the ferrous and non-ferrous metals together in one single limit was also considered. However, the experts explained that ferrous and non-ferrous metal contaminants produce different effects in glass manufacturing: while ferrous metals cause undesirable coloration in the final glass products, non-ferrous metals cause damage to the furnaces. Given the different nature of the two contaminants, it is proposed to keep two separate limits.

Limit on non-metal non-glass inorganics

For non-metal non-glass inorganic materials (e.g. ceramics, porcelain, stones, and pyro-ceramics), a review of technical specifications for cullet intended for re-melting into new glass products and feedback from experts indicates that a limit is very much needed in order to guarantee that the cullet has undergone sufficient separation of inorganic contaminants to a level that does not adversely impact its re-manufacturing by re-melting. Non-metal non-glass inorganics are considered the non-glass contaminants of most concern because they are difficult to sort out. In addition, because they are materials of high melting point, they are unwanted for glass manufacturing because they cause fatal defects in the final manufactured glass products, which may even lead to health hazards for the

consumers if the product breaks when used. Therefore, cullet containing inorganic contaminants above specified limits is consistently rejected by glass manufacturers, and therefore a market for that cullet would not be guaranteed.

The limit of 100 ppm contained in FERVER specifications is generally accepted by experts as a reasonable EoW criterion.

However, it was pointed out by experts (glass manufacturing industry and cullet reprocessing associations) that several glass manufacturing processes including container glass and insulation mineral wool are able to accept cullet containing concentrations higher than 100 ppm of inorganic contaminants, as long as the cullet is finely crushed to less than 1 mm, and provided the metal contaminants are removed from the cullet prior to its crushing below 1 mm. The reason for the need to remove the metal fractions before crushing is that, once finely crushed, it is considered very difficult or impossible to remove contaminants from the cullet.

Based on this consideration, the following inorganics EoW criterion is proposed:

- Non-metal non-glass inorganics:
 - 100 ppm for cullet size > 1mm
 - 1500 ppm for cullet size ≤ 1 mm

Regarding the fines which come naturally with the coarse fraction (i.e. not intentionally ground), experts expressed that they should respect the limits of the coarse fraction, i.e. the limit of 100 ppm inorganic content.

Further consultation regarding how often manufacturers today accept finely ground cullet at the higher inorganics concentration (~1500 ppm for ≤ 1mm particle size cullet) suggested that this practice is still marginal today, representing approximately 3 to 5% of the cullet input to glass furnaces for re-melting. The experts indicate though that this practice is increasing and is expected to increase further in the coming years.

Aside from adversely impacting the usefulness of the cullet in the market for re-melting, inorganics concentrations up to 1500 ppm are not known to cause any adverse environmental or health impacts, and therefore the proposed limits are reasonable as EoW criteria as long as they satisfy the usefulness of the cullet in the glass manufacturing market.

After compiling the evidence from the existing specifications and the expert feedback, it is proposed to set the inorganics limits at 100 ppm concentration for cullet size > 1mm, and allow for 1500 ppm inorganics concentration for cullet size ≤ 1 mm. Despite the additional complexity, this dual criterion does not compromise safety or the environment or introduces a loophole in this regard, and accommodates the likely increasing trend of using finely ground cullet in re-melting applications, promoting a higher recycling rate and allowing for innovation in recycling processes.

An additional comment was received regarding cullet used in the manufacturing of foam glass. Compared to the FERVER proposed limit of 100 ppm, the manufacturing of foam glass is able to accept cullets with up to 1-3% inorganic content (i.e. 10,000 – 30,000 ppm), much higher than the FERVER recommendation or the 1500 ppm limit suggested for finely ground cullet. However, given that the quantities of cullet used by the foam glass industry are much smaller than for the other glass sectors and that the allowed inorganic contamination is much higher than for most of glass manufacturing sectors, it does not seem reasonable to introduce a less stringent inorganics requirement, which would render the cullet unusable by the mayor glass manufacturing sectors such as container glass or insulation mineral wool.

Limit on organics

A review of technical specifications for cullet intended for re-melting into new glass products and consultation with experts indicates that a limit on organics content is needed in order to guarantee that the cullet has undergone appropriate and sufficient separation to a level that does not adversely impact its re-manufacturing by re-melting. Organics, which include combustible organic-based materials (e.g. paper, rubber, plastics – sometimes referred to as synthetics- fabrics, and wood), are undesirable for new glass manufacturing because they produce unwanted colour in the final product.

The wide majority of experts have shown support for the FERVER limit of 2000 ppm organics in cullet. This organic concentration in the cullet implies it does not pose adverse environmental or health impacts.

Considerations regarding cullet size

In principle, cullet size does not seem to be a requirement of end-of-waste, because it does not have any associated environmental impact and does not seem to affect the existence of a market for the cullet.

Small cullet particle size could result in dust. A minimum cullet size is also usually set to allow for efficient sorting at the reprocessing facilities. Maximum cullet size is required to technically allow its input into the furnaces for re-melting. The size will depend on the furnace and the sorting technology used. Therefore, cullet size is always a part of the business-to-business specifications that consider the specific technologies of the buyer and processor, and shall be part of commercial requirements, and are not related to health/environmental impacts.

Most experts agreed that cullet size does not need to be a part of the end-of-waste criteria. In support of this position it was expressed that cullet size specifications should be allowed to evolve according to new technological developments. For example, it was noted that the use of powder cullet is increasing in the container glass industry because it provides specific properties, different than those of coarse cullet.

For certain contaminants such as inorganics, a smaller cullet size in intentionally ground cullet would allow a higher maximum inorganic content limit. As explained above, this does not compromise safety or the environment, and therefore it is not to be regarded as a loophole, but an additional element of the criteria to be dealt with in commercial agreements.

Some stakeholders suggested the possibility of setting a maximum grain size of 80-100 mm. However, a detailed grain size restriction is not advisable as it would constrain the use of EoW only to the manufacture of certain glass products and not others.

In summary, given that cullet size does not seem to pose health/environmental impacts, that there are different market requirements regarding grain size (packaging, flat, insulation), and that it is not desirable to exclude potentially recyclable glass cullet streams because of particle size requirements, it is not proposed to include cullet size as part of the end-of-waste product quality criteria.

Considerations regarding moisture content

Moisture content does not seem to be a requirement needed in end-of-waste criteria, because of absence of associated environmental impacts. All stakeholders agreed that moisture content should not be part of the EoW criteria. The evidence of the little technical concern of this parameter is that most of the cullet reprocessors and glass producers do not store the cullet in dry or canopied conditions.

Considerations regarding colour

No EoW colour requirements are proposed, as there seems to always be a market for any mixed colour input as long as non-glass contaminants are kept below certain product quality limits. For example,

mixed-colour container cullet is used to manufacture new container glass or insulation mineral wool. Mixtures of colours obviously do not pose any threat to the environment or health. This is considered a commercial parameter to be defined in business-to-business specifications.

Criterion 1.2. Self-monitoring requirements, including industry practices regarding sampling, testing and monitoring of product quality

The questions regarding monitoring discussed were:

- What are the qualitative/quantitative methods for monitoring that are performed in practice? Where/how is monitoring performed? (waste material separation, recovery, recycling)
- Which are the sampling methods? Is it manual or automated checking? Which technologies are applied? Which are the frequencies of sampling?
- Are there any key reference documents (by industry, trade associations, other sources) containing guidelines and standards for monitoring? Shall reference to any of these be made in the EoW criteria?

General monitoring practice in industry

Monitoring of cullet quality is mainly a responsibility of the cullet reprocessors. The monitoring is a combination of visual inspection, sampling, and sample analysis. The feedback received from the TWG suggests that most manufacturers rely on the reprocessors to ensure that the material meets the specifications and how that is achieved is not their concern. Certificates of conformity are provided by reprocessors in many cases. Reprocessors have documented quality systems, and some are registered to ISO9001. Some manufacturers may in addition choose to further sample the material, and this is usually random sampling followed by analysis in laboratory conditions or through manual analysis.

According to information from a container glass manufacturer, monitoring is always performed by the supplier of reprocessed cullet (the end-of-waste cullet), at the supplier side, in order to test their reprocessed cullet and thus guarantee the delivering of the appropriate quality. Since there are many suppliers in Europe, producing cullet of different commercial specifications, monitoring methodologies can vary from supplier to supplier. However, what is common to all the monitoring procedures is that their objective is essentially to guarantee that contaminations are within agreed specifications between the supplier of the cullet and the buyer (the glass manufacturer).

The glass manufacturer then possibly applies also an incoming monitoring procedure. The extent to which the glass manufacturer performs more or less extensive monitoring also depends on the degree of trust in the supplier of the cullet. For highly reliable suppliers and especially for pre-consumer cullet, the glass manufacturing industry will accept the suppliers' monitoring data, and may perform more limited and less frequent additional monitoring.

Visual inspection

Visual inspection involves at least separation of non-glass components by the trained eye of an operator and measurement of the quantities found.

Sampling and sample analysis

For sampling, experts have suggested using available sampling plans drafted in international standards. In particular, a number of experts have suggested following Standard EN 14899, Characterization of waste - Sampling of waste materials. The framework for the preparation and application of a sampling plan should be implemented as the material is waste as long as there is no proof that the quality requirements for end-of-waste (heavy metals, impurities etc) are met. This standard proposes very generic methodologies that are laid out to guarantee representativeness and randomness of the sampling.

The mentioned EN 14899 makes reference to a few other guidance documents, such as:

PD CEN/TR 15310-1:2006 Characterization of waste – Sampling of waste materials – Part 1: Guidance on selection and application of criteria for sampling under various conditions

PD CEN/TR 15310-2:2006 Characterization of waste – Sampling of waste materials – Part 2: Guidance on sampling techniques

PD CEN/TR 15310-3:2006 Characterization of waste – Sampling of waste materials – Part 3: Guidance on procedures for sub-sampling in the field

PD CEN/TR 15310-4:2006 Characterization of waste – Sampling of waste materials – Part 4: Guidance on procedures for sample packaging, storage, preservation, transport and delivery

PD CEN/TR 15310-5:2006 Characterization of waste – Sampling of waste materials – Guidance on the process of defining the sampling plan

BS EN 932-1:1997 Tests for general properties of aggregates Part 1. Methods for sampling

According to FERVER, the control procedure to check whether reprocessed cullet corresponds to the end-of-waste criteria for glass should be defined in a well-specified procedure. The sampling procedure should be realistic, feasible with limited manpower and adequate equipment, being representative in relation to the lot it concerns. FERVER has submitted a proposal for a “sampling and quality check procedure”.

This procedure must be executed together with a representative of the recycler (meaning in this case, the glass manufacturer). The proposal is divided in three parts: (a) Quality check on contamination, (b) Quality check on cullet size, and (c) Evaluation. FERVER members sign an Ethical Code of Good Practice based on the three parts of the quality management methodology:

(a) Quality check on contamination

- Sample size:
 - 0.1% of the lot size, with a minimum of 100 kg (depending on lot size with minimum quantity for small lots, to emphasize representativeness)
- Sampling: random
 - 50 % taken all over the surface of the lot
 - 50 % taken from the inside of the lot
- Samples: separate samples are taken by filling buckets with a content of ± 15 kg glass per bucket
- Real sample size: addition of the weight of all buckets taken
- Buckets are emptied on a table
- Manual sorting of contamination such as:
 - CSP (ceramics, stones and porcelain)
 - Ferrous metals
 - Nonferrous metals Al
 - Nonferrous metals Pb
 - Synthetics
 - Opal
 - Organics
- Removed contaminations are weighted and calculated in grams/ton

(b) Quality check on cullet size

- Sample size: 10 kg

- Sampling:
 - The quality-checked sample is made homogeneous by mixing it several times
 - Randomly small samples are taken till the maximum of 10 kg is reached
- Sieves/meshes: hand sieves with the following square mesh size are used to screen the sample:
 - 100 mm
- Sieving:
 - With this hand sieve the sample of 10 kg is screened and every fraction is weighed
 - The weights per fraction are calculated in percentages
 - Fractions :
 - < 100 mm
 - > 100 mm
- Separated fractions are weight and calculated in %

(c) Evaluation

Based on the results of all those tests, the cullet will be defined as:

- End-of-waste cullet, if it complies with the end-of-waste criteria
- Waste, if it does not comply with the end-of-waste criteria

Regarding the FERVER proposal Part (a) (quality check on contamination), one of the experts suggested that the minimum sample size requirement of 100 kg might be unnecessarily high for e.g. very clean pre-consumer glass cullet. If the FERVER monitoring procedure is adopted as EoW monitoring procedure, this expert proposes 50 kg as a more reasonable quantity, constituting a good optimum between practicability and representativeness.

FERVER's position, however, is that a sample of less than 100 kg is not representative. For example, the glass cullet input to cullet reprocessing facilities may contain some large pieces of e.g. inorganics (for example large stones). Although these large pieces are easy to detect they are sometimes difficult to blow out by the sorting equipment. The presence of these large-size contaminants are deemed to cause unacceptable measuring errors in samples such as 50 kg. This is the reason why FERVER defends 100 kg as the minimum sample size, after analysis based on scientific statistical sampling methods.

In some member states such as in the UK, there is work in progress to develop national end-of-waste quality protocols, where the environment agency works with industry in order to develop sampling plans which are produced in compliance with recognised standards. By producing sampling plans which are specific to the size and nature of the producers operations, the type of sampling and its frequency is proportionate to the volume and variability of waste-derived product manufactured.

Feedback received from the TWG regarding monitoring of product quality

During the course of this study, experts have submitted feedback regarding the proposed monitoring procedure, contrasted with how they conduct monitoring in practice at their facilities. According to experts, the responsibility for cullet quality monitoring lies clearly with the cullet processor and although the glass manufacturer will generally make spot checks on the quality of cullet delivered these can not be as comprehensive or as frequent as those required to be made by the supplier.

Experts inform that, in practice, representative samples constituting between around 0.2 and 1% of the reprocessed cullet are taken and submitted to a visual inspection by trained staff. The sampling data are registered on the production data sheets. The visual inspection of the samples controls the content of the four mentioned types of non-glass components, colour composition, and grain size including

finest estimation (approx. < 2 mm cullet particles). In addition, a sub-set of samples are taken to analyze their chemical composition. In parallel there is a regular visual check of cullet storages and possible pollutions.

Comments in support of a generic monitoring approach

- In general, a generic approach is considered to be more appropriate for a kind of legislative text such as EoW, which intends to avoid adding burdens. Of course, additional requirements can be set in a bilateral contract between the cullet processor and the glass manufacturer if required.
- For some experts, while the definition of EoW should reasonably require demonstration of conformity to a specification, it is not necessary to be prescriptive in any testing requirements placed on either the reprocessor or the manufacturer.
- Different cullet reprocessors and glass manufacturers implement different monitoring systems, partly depending on the specific quality requirements of the cullet for a given application. Less frequent monitoring is also established for highly trusted suppliers, and especially for pre-consumer cullet.
- The specific requirements on minimum sample size and percent of consignment monitored are seen by some glass manufacturing industry that regularly use pre-consumer cullet as too burdensome and not needed when the pre-consumer cullet properties are well-known and with little variability.

Comments in support of a more specific monitoring approach

- A number of experts supported the specific monitoring approach, because it is considered the most reliable means to guarantee that EoW cullet meets the required product quality requirements. For these experts, the monitoring approach should be unique, clearly laid out, and avoiding misinterpretations. However, the same experts also pointed out that the procedures for monitoring should be easily applicable in the field, easy to implement, and be performed fast (without delaying e.g. freight carriers), with a minimum of equipment.
- One of the experts agreed with the specific monitoring approach, but suggested two modifications: removing the requirement for a minimum sample sizes of 100 kg, and removing the requirement for the individual sub-samples to be ~15 kg each.
- Some experts believe that 100 kg minimum sample size is unnecessarily strict criterion, and it is not always feasible to implement. Sometimes it is not even necessary to implement, in the opinion of experts, e.g. when monitoring pre-consumer cullet purchased by glass manufacturers from well-known and trusted sources, with low variability. The specific monitoring requirement, especially for pre-consumer cullet, would add additional unnecessary burden to an already well-functioning recycling activity.

Conclusion

There is general agreement from the TWG that EoW criteria should include monitoring requirements in order to guarantee that the product quality limits are met. The experts suggest that monitoring is to be left to the reprocessors, and that glass manufacturers do not really mind the monitoring procedures implemented as long as the product quality is guaranteed. Evidence suggests also that there is a wide variety of monitoring methods implemented, and a large fraction of experts referred to generic international standards for monitoring. At the same time, it is agreed that EoW criteria should not add further burdens to existing procedures, and that monitoring is less frequent for highly trusted suppliers and for pre-consumer cullet.

In summary, it is concluded that a generic approach for monitoring is appropriate for EoW. In addition, the monitoring criteria specifically state that less frequent monitoring may be needed for pre-consumer cullet, while more frequent monitoring may be necessary for glass cullet from multi-material collection. The proposal for Criterion 1.2 including self-monitoring requirements is laid out below.

Criterion 1.2

Criteria	Self-monitoring requirements
1. Quality of cullet resulting from recovery operation	
<p>1.2 The content of non-glass components shall be limited to the following thresholds:</p> <ul style="list-style-type: none"> ▪ Ferrous metals: ≤ 50 ppm; ▪ Non-ferrous metals: ≤ 60 ppm; ▪ Non-metal non-glass inorganics: <ul style="list-style-type: none"> ○ ≤ 100 ppm for cullet size > 1 mm ○ ≤ 1500 ppm for cullet size ≤ 1 mm ▪ Organics: ≤ 2000 ppm <p>Examples of non-metal non-glass inorganics are: ceramics, stones, porcelain, pyro-ceramics.</p> <p>Examples of organics are: paper, rubber, plastic, fabrics, wood.</p>	<p>Qualified staff shall carry out a visual inspection⁵⁰ of each consignment.</p> <p>At appropriate intervals, representative samples of glass cullet shall be analysed gravimetrically to measure the total non-glass content. The non-glass content shall be analysed by weighing after mechanical or manual (as appropriate) separation of materials under careful visual inspection.</p> <p>The appropriate frequencies of monitoring by sampling shall be established taking into account the following factors:</p> <ol style="list-style-type: none"> (1) The expected pattern of variability (for example as shown by historical results). (2) The inherent risk of variability in the quality of waste glass used as input for the recovery operation and any subsequent processing. Pre-consumer waste glass with a highly predictable composition needs less frequent monitoring. Waste glass from multi-material collection may need more frequent monitoring. (3) The inherent precision of the monitoring method. (4) The proximity of results to the limitation of the non-glass contents to the limits indicated above. <p>The process of determining monitoring frequencies should be documented as part of the quality management system and should be available for auditing.</p>

⁵⁰ Visual inspection is defined as: Inspection of cullet consignment using either or all human senses such as vision, touch and smell and any non-specialised equipment. Visual inspection shall be carried out in such a way that all parts of a consignment are covered.

Criterion 1.3. Requirements on hazardous properties

Condition (d) of Article 6 WFD demands that end-of-waste criteria need to ensure that the use (understood here as including also transport, handling, trade) of recovered glass cullet shall not lead to overall adverse environmental or human health impact.

This implies that the recovered glass cullet should not obtain end-of-waste status if it has any of the hazardous properties included in Annex III of the Directive 2008/98/EC on waste (properties of waste which render it hazardous).

The reason is that in this case general waste regulatory controls as well as the specific provisions of the WFD on hazardous waste (in particular Articles 17-19 regarding control, ban on the mixing and labelling of hazardous waste) are needed to protect the environment and human health.

Comprehensive direct monitoring of the "product" regarding all of the possible hazardous properties by specific tests is, however, not a feasible approach. The best approach to exclude hazardous properties of the product is to rely on a combination of requirements on input materials and quality management.

Nevertheless, it is suggested to include also in the product quality requirement a clause that clearly establishes that recovered glass cullet with hazardous properties does not cease to be waste. This is needed not only to establish clarity in principle but has also a practical value in cases when certain types of possible hazardous properties are detected as part of visual inspection.

During the discussions with the TWG, an important point was raised as to whether the end-of-waste criteria should include the lead limit of the Packaging Directive of 200 ppm, in order to prevent negative environmental impacts of lead leaching from glass into the environment (EC Packaging Directive and Commission Decision No. 2006/340/EC amending Decision 2001/171/EC for the purpose of prolonging the validity of the conditions for a derogation for glass packaging in relation to the heavy metal concentration levels established in Directive 94/62/EC).

However, it is important to stress that the 200 ppm value in the Packaging Directive concerns the finished products, not cullet, and is determined on the basis of 12 consecutive monthly analyses per furnace. In addition, it is not a limit value as such but a trigger point for the manufacturer concerned to produce a report for the authorities on corrective actions.

The arguments brought forward by the experts in favour and against the introduction of this limit are detailed below, followed by a conclusion.

In favour of introducing a lead limit

- One of the arguments in defense of the inclusion of a limit for lead content as part of the end-of-waste criteria is that, while the Packaging Directive makes a reference to the content of heavy metals (cadmium, lead, mercury, and hexavalent chromium) in container glass, there is no similar requirement for flat glass or for other types of glass. Introducing the requirement of lead testing as part of the end-of-waste criteria would help consistently guarantee the protection of public health and the environment as regards the impacts of lead.
- Information was also provided regarding the existence of fraudulent recovery operations in certain European regions, such as the use of lead glass cullet as drainage material in landfills, as abrasive (to replace sand paper), in the ceramic industry, as additive for concrete, for manufacturing foam glass, or for the production of lead glass beads for road marking paints. All these applications are mentioned as potentially leading to the leaching of lead oxide from the glass matrix and its dispersion into the environment.

- Another expert welcomed a limit of heavy metals, but suggested that the limit should indeed be for heavy metals: lead, cadmium, mercury and hexavalent chromium as listed in the Packaging Directive, instead of only for lead. In addition, the expert proposed that the limit be lowered to 100 ppm at the request of glass manufacturers of one Member State based on the argument that it would not only help them avoid reporting procedures stipulated by the Packaging Directive and the related Commission Decision (Directive 94/62/EC, Commission Decision 2001/171/EC), but that it would also be important for flat glass manufacturers since excessive heavy metal content decreases the quality of their products.

Against introducing a lead limit

- Based on leaching studies, heavy metals in glass do not make the glass hazardous, because there is no leaching of heavy metals from the glass, meaning that glass containing heavy metals does not pose any harm whether in products used by consumers or in the open environment. Lead incorporated into glass containers is considered far less dangerous to the environment and human health than lead in natural sites (e.g. many raw materials contain impurities of lead). Due to its inert character, glass is to experts' knowledge never classified as hazardous based on its chemical composition. Experts pointed to several pieces of legislation providing evidence of the inert nature of glass:
 - According to Council Decision 2003/33/EC glass is accepted at landfills without further testing.
 - Under the REACH Regulation (EC 1907/2006), glass is regarded as a substance and does not contain any other substances. Although all substances would normally need to be registered, most glasses, and in particular, soda-lime glass (the glass used for almost all container applications), due to their inertness, have been exempt from this obligation of REACH (COMMISSION REGULATION (EC) No 987/2008 of 8 October 2008 amending Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards Annexes IV and V). Glass is not classified in Annex I of Directive 67/548/EEC on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances.
 - Glass is not listed in a priority list, as foreseen under Council Regulation (EEC) No 793/93 on the evaluation and control of the risks of existing substances.
 - Commission decision 2001/171/EC sets the conditions for derogation for glass packaging in relation to the heavy metal concentration levels established in Directive 94/62/EC on packaging and packaging waste. Subsequently the Commission decision 2006/340/EC of 8 May 2006 extended indefinitely the validity of these conditions.
- Cullet containing more than 200 ppm lead and below 5000 ppm has none of the properties which render it hazardous according Annex III to directive 2008/98 EC.
- The packaging directive is relevant for container glass only. Therefore, some experts expressed that there is no need to use these limits for flat glass as well, and no reason to extend to others sectors a constraint specifically linked by the packaging directive. Furthermore, the concentration limits in the packaging directive apply to the final product, and are not considered reasonable for cullet.
- The criterion on lead content is not seen as relevant for flat glass cullet, as flat glass does not contain lead. Today, the greatest majority of the flat glass cullet recycled in flat glass furnaces comes from pre-consumer cullet. This type of cullet comes from the glass processors who produce final products for building, automotive, and industry (e.g. double glazing units, automotive glazing, solar panels, etc.). The cullet comes essentially from offcuts and consist of clean flat glass exempt from any other pollutant. This type of cullet, if sorted properly in the processor premises, fulfils the cullet specifications of the flat glass manufacturers and can be directly sent back to the furnace without additional treatment and after monitoring by visual inspection only. Today, it is

considered as a waste because the glass processor is an independent legal entity different from the flat glass manufacturer and thus falls within the definition of waste according to the Waste Framework Directive 2008/98/EC. If this type of pre-consumer cullet benefits from the EoW criteria, its direct recycling will be greatly facilitated.

Some comments against introducing a lead limit were specifically related to difficulties in monitoring:

- The current practice in monitoring hazardous properties is the combination of visual inspection plus appropriate testing upon suspicion of hazardous properties. Not all batches of cullet are tested for all hazardous properties, because there is a combination of information such as the knowledge about the origin of the input material, and because of costs associated with the chemical analysis. Experts expressed that the EoW procedure should not be stricter than the type of monitoring applied by hazardous waste monitoring. In practice, as chemical analysis is not considered feasible nor cost effective, the approach is thus based on the physical identification of pieces of lead glass. It was pointed out that, up until now, it has been quite difficult in practice to identify on a routine basis the pieces of lead glass among the pieces of container glass cullet, in particular by “visual inspection” and more generally optical sorting. X-ray sorting devices are becoming available and there are thus perspectives for routine monitoring of lead glass content. However, these techniques are not yet sufficiently mature to be the basis for an acceptance criterion for cullet.
- Monitoring of the lead content would be costly and create a burden for the recycling, particularly for pre-consumer cullet. Monitoring of a heavy metal's content would also be technically challenging because of difficulties in taking representative samples.
- Regarding costs of monitoring, for the reasons given above it is considered inappropriate to consider introducing an average heavy metal content limit as part of the EoW criteria for container glass cullet.
- According to industry representatives from e.g. UK, cullet processors and glass manufacturers do not routinely analyse cullet for the presence of heavy metals.
- Other experts expressed that the most effective way to minimize the presence of heavy metals in glass is to impose controls on the input materials (at the source, i.e., rely on prevention).

Conclusion

Taking into account the above arguments in favor and against lead monitoring, the following points can be concluded:

- There is clear evidence, from leaching studies and expert feedback, that glass containing varying amounts of heavy metals (including lead), even at concentrations higher than 200 ppm, do not pose hazards to the environment and/or human health for either the consumer using the product or open in the environment.
- The 200 ppm heavy metal limit of the packaging directive refers to container glass products, not the cullet, and is intended to be a threshold limit only for reporting heavy metal concentrations to authorities.
- The recycling industry today does not perform monitoring of heavy metals by chemical analysis, and monitoring would be at present technically and economically unfeasible. If the EoW criteria would include a 200 ppm lead limit and the need for its monitoring, it would impose unreasonable burdens to a well-functioning recycling industry today.

- Finally, if a lead limit would be part of the EoW criteria, and given the economic and technical burdens that this would entail as explained above, it is possible that the industry would refrain from applying for EoW status for cullet that otherwise would meet EoW criteria, therefore possibly hindering the environmental benefits that recycling of cullet in re-melting applications would bring.

As a conclusion, it is proposed that the EoW criteria will not include a 200 ppm limit on lead content. Finally it is to be noted that control on hazardous materials is further accomplished by EoW criteria on input materials and quality management.

Criteria	Self-monitoring requirements
1. Quality of cullet resulting from recovery operation	
1.3 The glass cullet shall not display any of the hazardous properties listed in Annex III to Directive 2008/98/EC. The glass cullet shall comply with the concentration limits laid down in Commission Decision 2000/532/EC ⁵¹ , and not exceed the concentration limits laid down in Annex IV of Regulation 850/2004/EC ⁵² .	<p>Qualified staff shall carry out a visual inspection of each consignment. Where visual inspection raises any suspicion of possible hazardous properties, further appropriate monitoring measures shall be taken, such as sampling and testing where appropriate.</p> <p>The staff shall be trained on potential hazardous properties that may be associated with cullet and on material components or features that allow recognising the hazardous properties.</p> <p>The procedure of recognising hazardous materials shall be documented under the quality management system.</p>

3.5 Criteria on input materials

The purpose of criteria on input materials is to check indirectly product quality.

The end-of-waste criteria should allow as input only waste types for which it is practical to obtain cullet in compliance with the product quality requirements. This implies that a waste can only be allowed if it contains material that can be recovered for the production of new glass products and, after appropriate treatment, can be used without overall adverse environmental or human health impacts.

At the same time the criteria should not be unnecessarily restrictive, and all types of waste glass that contain recoverable material and for which treatments exist to obtain material with the required product quality should be allowed as input.

It is important to understand to what extent the different types of cullet are present in the recycling market. As mentioned earlier, in the glass manufacturing sector, two types of glass (container glass and flat glass) together represent ~85% of the total glass market. These two types of cullet are the most versatile and can be used to manufacture new container glass, flat glass and/or insulation mineral wool, among others, while waste glass from other sectors has more restricted applications in the re-melting industry.

⁵¹ OJ L 226, 6.9.2000, p.3.

⁵² OJ L L 229, 30.4.2004, p. 1.

Another important factor is whether there are certain types of waste glass that are commonly not acceptable as suitable input because their particular physico-chemical composition might render them detrimental to glass production. In this regard, the CEN guidelines on waste glass (CEN/TR 13688:2008) proposes as part of the quality standards a list of waste glass types that "should not be intentionally used as input for recycling operations", including: screen glass (TV, computers, etc.), lead crystal tableware, wired glass, glass ceramics, lamp glass, borosilicate glass, among others. Other specifications such as FERVER's and the UK quality protocol for flat glass also include lists of glass types that should not be intentionally used as input materials.

In proposing the end-of-waste criteria on input materials, several options were in principle analyzed. One option is to allow all types of input materials, assuming that the remaining end-of-waste criteria (on product quality, on quality management, etc.) would be sufficient to guarantee a high-quality cullet. A second option is to allow a number of input materials except for a list of excluded types. The risk of this second option is that the list of excluded types might not be exhaustive, resulting in the situation where undesirable waste types could then be allowed as input because they are not explicitly excluded in the criterion ("negative list"). The final option is to specify those glass types that are explicitly allowed as input ("positive list").

Criterion 2.1 on allowed input waste glass types

During the discussion with the expert group, the first approach suggested was to restrict input materials to cullet from container glass and flat glass. Firstly, there seems to be a general understanding that container glass and flat glass cullet vastly dominate the range of cullet types that are used in manufacturing new glass products. A substantial group of experts, from the cullet reprocessing and glass manufacturing industries, agreed with this initial formulation. There was a common understanding among these experts that there are a number of glass types that should be excluded as candidates to become end-of-waste, in particular: CRT glass, continuous-filament glass fibre, foam glass, and insulation mineral wool.

However, feedback was also received suggesting alternative formulations for a criterion on input materials:

- A number of experts expressed that the criteria on input materials are secondary to criteria on product quality. Therefore they propose to remove a restriction of input, and to allow all types if input glass as long as they comply with product quality criteria. Some experts would also agree to allow glass defined as hazardous: in this case, it would be up to the treatment processes/techniques to make sure that either hazardous components are removed or that the glass is chemically intact and that it has an EoW application where its properties are needed and accepted according to legislation and standards.
- Some experts would avoid a too inclusive criterion. Even if container glass and flat glass cullet dominate the range of cullet types used in manufacturing new glass products, there is no reason why cullet from different sectors (e.g. special glass, fibre glass, domestic glass) should not be used as well, if they fulfil the end-of-waste criteria. Instead of the source of the cullet, compliance with the limit values for end-of-waste cullet should be used. Some experts argue that even heavily contaminated glass cullet may be processed with appropriate process technology at the cullet reprocessing plants to fulfill EoW product quality criteria, but others argue that while this is technically possible, it would not be practical in real life.
- The broad principles by which end-of-waste criteria are set should be applicable to all waste glass streams, so that when end markets are available, appropriate criteria may be set.
- A criterion restricting input to packaging and flat glass is seen by some experts as potentially excluding bottle banks which collect post-consumer waste glass. If the criterion explicitly allows only container glass and flat glass as input materials, the waste glass collected at bottle banks would be excluded because it contains unintentionally-added quantities of other glass types.

- Waste glasses from all glass sectors have been mentioned by at least one or a few of the experts as suitable input material. For example, some experts stated that there are new developments in recycling within glass manufacturing sectors such as the continuous-filament glass fibre, and that the EoW criteria for input materials should not restrict the input to only container glass and flat glass, but also be open to other materials such as: continuous-filament glass fibre, special glass if it is lead-free, domestic glass if it is lead-free, and insulation mineral wool.
- Lead-free tableware may be possible as input material, in the view of a number of experts. A Criterion was suggested as: "Only waste containing recoverable container glass, lead-free tableware glass or flat glass may be used as input. Lead-containing glass shall not be intentionally used as input". However, it was also remarked that the collection of such material may be problematic as it is not obvious to the consumer what lead-free glass exactly is.
- Regarding whether CRT glass should or not be allowed as input, there was a variety of opinions in favour and against being allowed as suitable input.

In summary, from the comments received, the most often cited arguments regard the possibility to include lead-free tableware and CRT cullet, and ensure that bottle bank content is suitable input. Arguments in favour and against these two waste streams as suitable inputs are summarized below.

Arguments in favour of including lead-free tableware as suitable input:

- Lead-free tableware is the sector where the potential for growth is considered the highest.
- Lead-free tableware glass is a soda-lime glass, regarded as of excellent quality, and can be recycled into container glass products. Experts do not see an environmental justification why this material should not stop being a waste at the same point as packaging glass and flat glass according to the same product quality criteria
- It is common practice that significant flows of domestic lead-free glass (tableware), especially if pre-consumer, can be used as input material on the production of furnace ready cullet.

Arguments against including lead-free tableware as suitable input:

- In practice, for post-consumer lead-free tableware, it may not be obvious to the consumer what is or not lead free.

Arguments in favour of allowing CRT as suitable input:

- In the view of some experts, no glass flow should be excluded just because it represents a small part of the total glass industry or because it is classified as hazardous waste. CRT belongs to the group of "special glass" because it is needed for special applications with unique properties, where using either the front glass or the cone glass is normal practice (CRT glass manufacturing, foam glass manufacturing, lead production, other special uses in glass manufacturing and the construction industry). The CRT recycling business in the EU has already done this recycling process for its funnel and panel glass, and these materials have been exported to Asia for instance. In the opinion of the CRT recycling industry, as a result of the treatment processes the CRT glass effectively ends to be waste and becomes a product.
- For other stakeholders, only part of the CRT waste glass should be allowed as input, namely only the almost lead-free Barium and Strontium glass, which has been separated from the lead glass fractions from CRTs and purified according to the state of the art (removal of phosphor coatings). It was however noted that, although the treated CRT glass has reduced lead levels, it would not normally be suitable for container glass use or in food grade applications.
- The reprocessing of CRT glass is regulated by hazardous waste legislation, and the expert reprocessing and use of CRT glass has not shown evidence of adverse effects on human health and the environment. Due to the specific properties of CRT as hazardous input, experts proposed developing a separate set of EoW criteria for CRT input.

Arguments against allowing CRT as suitable input:

- Some experts expressed that, although in principle CRT material could be allowed as input if it could be freed from hazardous contents via approved treatment, however the industry is not able to do this at present to a level where the cullet would be suitable for re-melting applications.
- For some experts, at the moment it is too complex to allow input materials other than container glass or flat glass cullet. However in a later stage, EoW criteria could be developed for other types of cullet.
- If materials such as WEEE glass, and in particular CRT glass, were allowed as input, the end-of-waste criteria may have to be more complicated than those designed for re-melting applications.

Conclusions

The points below summarize the feedback received and conclude the main elements to be part of a Criterion 2.1 on input waste glass materials:

- Experts agree that the vast majority of waste glass flows correspond to container glass and flat glass, and a majority of experts support restricting input materials to only container glass and flat glass
- Recognizing that bottle banks may contain unintentionally added quantities of other waste glasses, Criterion 2.1 includes a statement reflecting that: "the collected waste glass may unintentionally contain minor amounts of other glass types", so as not to exclude the bottle banks as suitable input, which would severely decrease the volumes of cullet suitable to achieve EoW status.
- Lead-free tableware is a high quality input material that is increasingly being recycled. This opinion is supported by a substantial part of experts. It is therefore deemed reasonable to allow it as suitable input.
- CRT glass contains, aside from lead, other hazardous components, which would require additional EoW criteria on specific treatment processes and techniques. As explained in the section on quality criteria, it is to be noted that EoW criteria will not contain a prescription for monitoring heavy metal content in cullet, because of technical and economic limitations. Regarding the control of potential hazardous content in cullet, it was also supported by experts that the most practical approach is to prevent the introduction of hazardous materials by the control of input materials. As a conclusion, it is considered necessary to place stricter controls on input materials and it is proposed to exclude CRT glass as suitable input for the currently proposed EoW criteria. In addition, the flows of CRT glass are on the decrease and new CRT glass is not manufactured in Europe any longer.

In conclusion, for the arguments just summarized, and after a balance of advantages and disadvantages of different proposals for input materials, it is proposed to limit the input materials to container glass, flat glass, and lead-free tableware cullet as the end-of-waste criterion, while ensuring that separately collected glass (bottle banks) is suitable input if not unreasonably contaminated. Finally, it is important to point out that the criterion on input materials has been drafted in relation to how strict or not other criteria are, and that all criteria are necessarily inter-related.

Criteria	Self-monitoring requirements
2. Waste used as input for the recovery operation	
2.1 Only waste from the collection of recoverable container glass, flat glass or lead-free tableware may be used as input. The collected waste glass may unintentionally contain minor amounts of other glass types.	Acceptance control of all glass-containing waste received by visual inspection and of the accompanying documentation shall be carried out by qualified staff who are trained on how to recognise glass-containing waste that does not meet the criteria set out in this Section.

Criterion 2.2 on excluded input waste glass types

Criterion 2.2 is intended to exclude glass-containing waste from mixed municipal solid waste or health care waste as input. An important rationale in support of Criterion 2.2 is that a number of available cullet specifications explicitly exclude as valid inputs the following glass-containing wastes: mixed municipal solid waste, health care waste, and hazardous wastes.

The experts from the TWG have generally agreed with Criterion 2.2. One of the experts however provided an argument against excluding waste glass from municipal solid waste as input material, based on the existence of companies undertaking separation of mixed municipal solid waste. In addition it was argued that, if the cullet complies with the other EoW criteria, there would not be grounds to exclude such input. EoW criteria could additionally require that input from mixed municipal solid waste undergoes specific treatment such as washing. However, feedback received from numerous experts expressed that cullet is very rarely washed. Based on these considerations, it does not seem appropriate to allow cullet from mixed municipal solid waste.

Additional comments expressed by the TWG are summarized below:

- Criterion 2.2 excluding glass-containing waste from mixed municipal solid waste and health care waste as input is seen as appropriate today, because the recycling of cullet from those sources is not currently practiced. As sorting technologies are likely to be developed over the coming years (e.g. the removal of municipal solid waste from the cullet at material recovery facilities), this criterion could be revised in the future in order to adequately take future technical and process advances into consideration.
- A few experts still defend that there is no reason to set any criteria restricting input materials. It is argued that, depending on the used process technology, even heavily contaminated waste glass can be processed into furnace-ready cullet fulfilling the EOW criteria. The glass waste can be heavily contaminated but should not be toxic.
- An expert suggested there is no need to exclude health care waste as input, provided that the cullet supplier is able to prove that the cullet is not hazardous (e.g. that glass tubes, empty bottles, medicine bottles, etc. are all empty and washed).

Conclusion

Health care waste, and to a more limited extent mixed municipal solid waste, presents a significant probability of being contaminated with hazardous materials. It has been expressed by experts that cullet reprocessing facilities are under normal practice not allowed to accept hazardous waste as input, as they do not have a license to handle hazardous wastes. In addition, the CEN international standard for cullet explicitly excludes hazardous wastes as suitable input.

While some experts suggested that mixed municipal solid waste and health care waste could be accepted as input as long as they were cleaned and washed, the majority of experts explained that cullet is virtually never washed at cullet reprocessing facilities. Therefore, the need for washing cullet coming from the mentioned sources would only impose additional burdens to the cullet recycling businesses. It thus seems reasonable to require that these types of input materials are not allowed. The proposed formulation for Criterion 2.2 is presented below.

Criteria	Self-monitoring requirements
2. Waste used as input for the recovery operation	
2.2 Glass-containing waste from mixed municipal solid waste or health care waste shall not be used as an input.	Acceptance control of all glass-containing waste received by visual inspection and of the accompanying documentation shall be carried out by qualified staff who are trained on how to recognise glass-containing waste that does not meet the criteria set out in this Section.

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Criterion 2.3: Exclusion of hazardous waste input

This Criterion 2.3 is intended to exclude hazardous waste as input. The wide majority of experts have agreed on the need for this criterion.

The Criterion on excluding hazardous waste as input is based on a number of arguments:

- Generally, cullet reprocessing facilities are not allowed to accept hazardous waste as input because they do not hold hazardous waste licenses.
- A number of existing cullet specifications explicitly exclude hazardous wastes as valid inputs.
- Since the EoW product quality criteria rely on visual inspection of hazardous properties but do not include the quantitative monitoring of hazardous content in cullet, one needs to limit hazardous materials at the input.
- The quantitative monitoring and testing of product quality is not a workable approach to ensure that the resulting product does not have any hazardous properties, as sufficient confidence can only be obtained with disproportionate testing efforts. Instead, monitoring of the input is considered a more proportionate approach.

Arguments against excluding hazardous waste as input:

A few experts defended including hazardous waste as input, as long as the other criteria guaranteed that the reprocessed cullet would meet product quality criteria. The arguments and suggestions are summarized below:

- In the view of some of the experts, the inclusion of this criterion will mean that hazardous waste glass such as lead glass resulting from CRT pre-treatment (cone glass or mixed glass) will not be allowed to obtain the end-of-waste status.
- If discarded equipment containing cathode-ray tubes is considered a hazardous waste only due to its content of lead, it could potentially be rendered non-hazardous by removing this substance in a controlled process that could be specifically required as part of a criterion on treatment processes and techniques.
- A number of experts proposed that hazardous waste could be allowed as input if there are appropriate and effective treatment options for removing the hazardous contaminants.

In addition, a few experts suggested adding a specific limit on lead content of the input material, specifically that glass waste containing more than 0.5% (= 5000 ppm) lead shall not be used as input. This limit comes from Commission Decision 2000/532/EC, which defines limits for wastes to be classified as hazardous.

Arguments in favour of introducing 5000 ppm limit to lead content of input:

- According to the feedback received, not all EU member states classify lead glass as hazardous waste/material, arguing that the lead oxide is enshrined in the glass. Therefore, the addition of the 5000 ppm limit of lead could help provide guidance

Arguments against introducing 5000 ppm limit to lead content of input:

- Some experts reject the concept that glass with a lead content greater than 5000 ppm should be classified as being hazardous. Glass is considered to be essentially inert so there is no pathway to the environment. Lead glasses should not be used as input, but in the present state of the art and in the context of the existing legal framework (Packaging and packaging waste Directive) this should not be a criterion for end-of-waste.
- Glass is a substance and does not contain any other substance. Therefore, directive 2000/532/EC does not apply as it refers to substances contained in waste. So any reference to the 5000 ppm is not considered relevant. Some waste glasses may be classified as hazardous but this is linked to the presence of non-glass contaminants and not to the chemical composition of glass.

Regarding self-monitoring requirements, it was pointed out that:

- The exclusion of hazardous waste as input is controllable not only by visual inspection, but also supported by chemical analysis. The absence of hazardous waste as input is sometimes also ensured because the input material flows are well-known and trusted.

Conclusion

Despite some of the arguments that were offered against excluding hazardous wastes as input, it seems that there are still technical and economic limitations in the monitoring of reprocessed cullet for hazardous contaminants. Even though some experts are concerned that recycling of hazardous waste glass will be hindered if not allowed to obtain EoW status, it is to be noted that these hazardous materials could still undergo recycling under the waste regime, as is done today. The waste regime is considered necessary to prevent environmental and/or health risks. In addition, a majority of experts defended the exclusion of hazardous wastes as input. It is therefore proposed to include Criterion 2.3 as follows:

Criteria	Self-monitoring requirements
2. Waste used as input for the recovery operation	
2.3 Hazardous waste shall not be used as an input.	Acceptance control of all glass-containing waste received by visual inspection and of the accompanying documentation shall be carried out by qualified staff who are trained on how to recognise glass-containing waste that does not meet the criteria set out in this Section.

Mono-material vs. multi-material origin

In previous versions of this report, it has been discussed whether glass-containing waste from single stream collection is the only suitable input, or if glass-containing waste from comingled collection shall also be allowed.

Opinions received from industry and member states coincide in that single-stream collection of glass and colour separation at source are the best choice for the re-melting into new glass products. Colour-mixed collection only offers small efficiency increases in the collection of the material. Significant resources in energy, infrastructure, capital investment, and labour are required to colour-sort the glass following the colour-mixed collection. In opinion of some industry experts, end-of-waste criteria should prioritize inputs from single-stream and colour-separated collections. The market demands high quality cullet, according to industry, and this is seen as the key to sustainable glass recycling.

Regarding multi-material collection (comingled collection), a majority of experts (both from the reprocessing and the manufacturing sides) agree that currently the quality of cullet from multi-material collection is very low, and generally not economical to reprocess to re-melt standard but instead used in secondary end markets. Glass is quite difficult to separate from a comingled stream of materials and it is usually the last material to be sorted out from the mixed stream, so that it ends up being significantly contaminated with for example ceramics. Because of this, several countries conducting multi-material collection do not include glass as one of the permissible materials to be collected in the mixture of dry recyclables, and many cullet reprocessors are currently not accepting cullet from multi-material collection.

Despite the agreement on the low quality of cullet from multi-material collection, experts do not generally support that end-of-waste criteria should explicitly exclude cullet obtained from multi-material collection as suitable input, mainly because this exclusion might result in a halt to

technological innovation and the development of improved techniques for cullet sorting. The same experts also expressed that, as long as the cullet meets the product quality criteria as currently proposed, end-of-waste should not impose restrictions on how the cullet was collected prior to achieving the mentioned product quality criteria. It was also expressed that the market should regulate itself, and if there are companies undertaking the proper separation of comingled material, cullet from that source should not be prevented from becoming end-of-waste.

As a conclusion, we observed a general agreement that both the current quality of the cullet from multi-material collection is low and not suitable for re-melting applications, but also that multi-material collection should not be stopped as long as it keeps developing so that eventually it might be able to produce a cullet with high enough quality to meet end-of-waste status. An additional argument in support of allowing waste glass from multi-material collection is that the product quality criteria contain strict limit values for non-glass components: an insufficiently treated multi-material input will therefore be excluded if not able to comply with these limit values.

Following from the above considerations, and from the feedback received during workshop discussions and written inputs, it is proposed not to include a criterion that restricts waste glass input obtained from multi-material collection.

3.6 Criteria on treatment processes and techniques

The purpose of criteria on treatment processes and techniques is to check product quality indirectly.

When reaching end-of-waste status, the material must have gone through all necessary treatment processes that make it suitable as direct input material for the final users of recovered glass cullet and allow transporting, handling, trading and using the recovered glass cullet without increased environmental and health impact or risks.

The required treatment processes to achieve this differ depending on the waste types from which the recovered glass cullet has originally been obtained. Some details on the treatment processes and techniques for different types of waste were described in Section 2.2.

Criteria on processes and techniques can include:

- Basic general process requirements that apply in all cases (for all types of waste);
- Specific process requirements for specific types of waste (including for all allowed hazardous waste types).

Previous end-of-waste discussions for other waste streams have concluded that for non-hazardous waste there is a preference for generic requirements that do not prescribe a specific technology. The reason is that industry should not be prevented from adjusting processes to specific circumstances and from innovation in general. Specific process requirements may, however, be needed for the treatment of hazardous wastes and certain special cases of input materials (such as WEEE or ELV) in order to complement the direct product quality requirements.

The purpose of the general process requirements is to clarify the minimum treatment required and where in the treatment chain the point of end-of-waste is reached. The criteria on treatment processes and techniques proposed are:

3.1 The glass-containing waste shall have been collected, separated and processed, and from that moment shall permanently have been kept separate from any other waste.

3.2 All treatments (sorting, crushing, separating, cleaning) needed to prepare the cullet for direct input to glass manufactured products shall have been completed.

The feedback received from the TWG generally supports Criteria 3.1 and 3.2.

Regarding Criterion 3.2, there is a general agreement that the end-of-waste criteria should not include specific treatment equipment or technology. Several comments in support of 3.2 are summarized below:

- One of the arguments offered in support of Criterion 3.2 is that it will be very difficult to decide upon the specific necessary technology that would be a common denominator across glass sectors and European regions. In addition, if specific treatment processes and techniques were to be specified, this could potentially slow down innovation, and provide competitive advantage to individual companies. Therefore, it seems preferable to focus on the quality of the product and not on the process followed to achieve that quality. Experts considered that setting output standards which are challenging but achievable will drive technology development.
- According to other experts, in order to transform waste glass into EoW cullet, a full range of processing equipment is necessary. The criteria should be given to the product itself and not to a recycling process. Detailed process specifications and criteria might lead to a limitation of the further process research and development activities in the glass recycling sector. It would not facilitate further product quality improvements. The trends and behavior of the consumer are rather dynamic, as is the composition of his waste. Therefore, the glass recycling industries need to be ready to adapt to changes and be innovative.

Some concerns regarding 3.2 were also raised by experts:

- In particular, it was mentioned that pre-consumer cullet usually requires a much lesser degree of treatment processes and techniques compared to post-consumer cullet, and that the EoW criteria should not impose additional burdens to the recycling of cullet from pre-consumer sources in industries such as the manufacture of flat glass or domestic glass. It was specifically expressed that waste glass processing and treatment steps needed in order to prepare cullet for direct input to glass manufactured products should not be mandatory; in the case of pre-consumer cullet, it is usually ready to reuse after collection and sorting.

Experts were also asked whether it would be necessary to require specific treatment processes and techniques for waste glass from multi-material collection. Most of the answers coincided that there should not be a specific treatment process or technique required in this case.

Finally, regarding treatment processes listed in 3.2, these are only examples and none of them specifically required. In addition, experts confirmed that washing is very rarely a part of the treatment processes for cullet, because washing would produce liquid waste with high chemical oxygen demand which would require treatment and disposal, creating potential environmental risks and increased costs that would reduce the amount of material recycled. It was confirmed that the whole cullet sorting and reprocessing process is a dry process.

Conclusion:

From the feedback received it was concluded that treatment processes and techniques should be required as part of the EoW criteria but the specifics should not be prescribed, in order to promote innovation in the recycling industry and to not add additional burdens. The treatment processes listed in 3.2 are only examples of possible processes.

Table 18: Proposed end-of-waste criteria regarding processes and techniques.

Criteria	Self-monitoring requirements
3. Treatment processes and techniques	
3.1 The glass-containing waste shall have been collected, separated and processed, and from that moment shall permanently have been kept separate from any other waste.	
3.2 All treatments such as: crushing, sorting, separating, or cleaning, needed to prepare the cullet for direct use in the production of glass substances or objects shall have been completed.	

3.7 Criteria on quality management

Quality management is needed to create confidence in the end-of-waste status. The owner of the material applying the end-of-waste status will have to rely on a quality management system to be able to demonstrate compliance with all the end-of-waste criteria for the material to cease to be waste. Moreover, a signal of confidence in the quality management system is sent to the buyers when the system is audited by an external verifier.

A quality management system must be in place and cover the key areas of operation where compliance with end-of-waste criteria will have to be demonstrated.

While the implementation of an internationally recognised quality management such as ISO 9001 would be suitable, it is not considered appropriate for end-of-waste criteria to specify a particular quality management system which must be implemented.

It is considered appropriate and proportional for end-of-waste criteria to require that a quality management system is implemented and externally verified. Such verification should assess if the quality management system is suitable for the purpose of demonstrating compliance with the end-of-waste criteria applicable to the case in question.

For the competent waste authority, it must be able to commission an independent second party audit of the implemented quality management system to satisfy itself that the system is suitable for the purpose of demonstrating compliance with end-of-waste criteria.

The details on the verification, auditing or inspection of the quality management system can follow the different national approaches.

The acceptance of input materials, all treatment steps and product quality checks (including any sampling and testing or visual inspections) according to the end-of-waste criteria must have been carried out under a fully implemented and externally verified quality management system.

The owner of the material that invokes the end-of-waste status must provide information about the product to characterise the product technically, identify the external verifier of the quality management system, and certify that all end-of-waste criteria have been met and accepted by buyers and competent authorities. Such information may also be provided electronically.

Summary of feedback received regarding quality management

From the feedback received, there was an agreement that there shall be a quality management system implemented, which is essential in order to assure the end-of-waste status of the cullet. It is also clear that visual inspection needs to be complemented by sampling and measuring. The EoW status should be determined before the cullet leaves the cullet reprocessor, and this should be guaranteed by a quality management in place. Aside from that, it was mentioned that most glass packaging producers are ISO 9001 (or equivalent) compliant, and also most cullet reprocessors have an internal quality system with online monitoring of the processes and products.

Regarding the need or not to require an ISO-type procedure, there was a broad agreement that the end-of-waste criteria should not require a specific ISO procedure, based on the arguments outlined as follows:

- Not all the companies in the glass reprocessing or manufacturing industries hold registered ISO-type quality systems.
- Requiring an ISO procedure as part of the end-of-waste criteria might lead to potential cost increases
- However, as many glass companies are multinational or even multi-continental, it could be preferable to align with international standards such as the ISO standard (or similar) rather than any other local procedures.
- An ISO procedure is recommended although not essential. Only companies without ISO 9001 may use a different quality management system.
- One of the experts expressed that it would be preferable if the producer had a third-party assessment of his quality system to a recognised standard, e.g. ISO 9001. In practice, according to experts, while cullet processors may have a quality system in place, they are sometimes not accredited due to the cost and expense of maintaining the system to a recognized standard, and in this case the quality system is provided by the glass manufacturer auditing his supplier to ensure that adequate systems are in place. The mandatory imposition of this requirement is seen as possibly leading to increased costs. Some experts therefore propose that the assessment of the quality management system could be performed either by a third-party or, alternately, audited by the glass manufacturer.

One of the experts disagreed with the majority of opinions and expressed that end-of-waste criteria should not introduce quality management criteria for glass after the waste has been processed in the treatment plant. The reason supporting this position is that commercial criteria negotiated between the glass reprocessor and the glass manufacturing company already include a procedure for quality management, and there would therefore be a risk that the end-of-waste criteria might add complexity to the existing system, and possibly lead to price increases.

A number of experts pointed out that the reprocessing of cullet leading to the EoW glass may involve a number of companies conducting different treatment steps, but that the quality management system should only be required from the last company in the chain, the one producing EoW glass. In the expert's opinion, it is the producer's responsibility to produce cullet which meets all the EoW criteria, to have a quality management system in place, and to certify all that by issuing the statement of conformity. It was suggested that requiring other operators up the recycling chain to implement the same quality management system would not be proportional and would make the whole process more expensive. It was mentioned that this point would be particularly important for member states with lower recycling rates and far from meeting recycling targets of the Packaging Directive so that the collection and the first steps of treatment are not hampered by unnecessary burdens. In particular, it was suggested that Part 3 of the quality management text, containing a requirement on previous holders as originally drafted, should be removed.

Other experts suggested that an environmental (independent) verifier (with specific knowledge in the field of sampling, testing and assessment on quality management systems) accredited by an Accreditation Body should verify the compliance of the cullet and the quality management system.

Experts were also questioned whether there shall be any additional requirement on quality management for the transport or storage of end-of-waste cullet to avoid contamination. Most experts expressed that yes, there should be quality management implemented for the transport or storage of EoW cullet, but this should be covered only by bilateral commercial contracts. In addition, storage facilities and logistic means used have to be properly cleaned before being used and kept as such. These properly cleaned conditions are already regularly checked by the cullet reprocessors.

Finally, some concerns were raised by industries using pre-consumer cullet, that the quality management system might be too onerous or non-applicable in a closed-loop business-to-business situation.

Conclusion:

From the feedback received, there was wide support for the EoW criteria to contain a requirement on quality management and a general agreement with the original formulation. The proposal for a quality management requirement is presented below:

QUALITY MANAGEMENT

1. The producer shall implement a quality management system suitable to demonstrate compliance with the EoW criteria.
2. The quality management system shall include a set of documented procedures concerning each of the following aspects:
 - a. acceptance control of waste used as input for the recovery operation;
 - b. monitoring of the treatment processes and techniques;
 - c. monitoring of the quality of glass cullet resulting from the recovery operation (including sampling and analysis);
 - d. feedback from customers concerning compliance with glass cullet quality;
 - e. record keeping of the results of monitoring conducted under points (a) to (d);
 - f. review and improvement of the quality management system;
 - g. training of staff.
3. The quality management system shall also prescribe the specific monitoring requirements set out in the end-of-waste criteria for each criterion.
4. A conformity assessment body as defined in Regulation (EC) No 765/2008, which has obtained accreditation in accordance with that Regulation, or any other environmental verifier as defined in Art 2 (20) (b) of Regulation (EC) No 1221/2009 shall verify that the quality management system complies with these quality management requirements. The verification should be carried out every three years.
5. The importer shall require his suppliers to implement a quality management system which complies with these quality management requirements.
6. The producer shall give competent authorities access to the quality management system upon request.

3.8 Criteria on provision of information

Requirements on the provision of information are a complementary element of end-of-waste criteria. The criteria have to minimise any onerous administrative load, recognising when current practice is competent in providing a valuable material for recycling, respecting existing legislation, and protecting health and the environment.

Criteria on e.g. labelling of a consignment are only needed in specific cases. One such specific case is to support the limitation of scope of application of the criteria to a specific purpose, pursuing fulfilment of condition (a) of Art 6. in the WFD ("(a) the substance or object is commonly used for a specific purpose"). In the case of glass cullet, and as explained in the scope definition, the scope of EoW status is restricted cullet for the direct use in the production of glass substances and objects by re-melting in glass manufacturing facilities.

In order to ensure a correct application of the limited scope of use of glass cullet, the EoW criteria will include a requirement on provision of information, with the aim of minimizing the risk that EoW glass is diverted to uses different from the production of glass substances and objects by re-melting in glass manufacturing facilities, be it within or outside the EU.

Different options are possible for implementing the requirement on provision of information. One of the options discussed is that producers provide evidence that glass cullet is destined directly to the manufacturing of glass, e.g. through a contract with a glass manufacturer. However, some experts argued that such documentation makes EoW paperwork equivalent to the current requirements under Green List waste shipments.

Another option discussed, and here proposed, is to require labelling that is compulsory for the producer of EoW cullet, stating that the consignment has passed all EoW requirements and its exclusive intended use is the manufacture of glass. Labelling is not meant as a physical attachment to the consignments, but could be issued also in electronic form.

The requirement on labelling does not directly ensure that glass cullet is destined to the manufacturing of glass, but no other of the requirements proposed would provide a warranty on this, as all of them can be misused if this is the intention. However, ignoring the labelling is ignoring the scope of the Regulation, which could also be included in its enacting provisions.

If glass cullet labelled as EoW is deviated from glassmaking it becomes waste, and if not declared accordingly, the consignment becomes an illegal shipment of waste.

It is therefore proposed that a statement of conformity shall be issued for each consignment of cullet comprising the following requirements:

- **The producer or the importer shall transmit the statement of conformity to the next holder of the cullet consignment. The producer or the importer shall retain a copy of the statement of conformity for at least one year after its date of issue and shall make it available to competent authorities upon request.**
- **The statement of conformity may be issued as an electronic document.**

The statement of conformity must include the following information (Table 19)

Table 19: Possible format for the state of conformity

1.	<p>Producer/importer of the glass cullet:</p> <p>Name:</p> <p>Address:</p> <p>Contact person:</p> <p>Tel.:</p> <p>Fax:</p> <p>E-mail:</p>
2.	<p>a) The name or code of the glass cullet category in accordance with an industry specification or standard:</p> <p>b) The main technical provisions of the industry specification or standard, including compliance with EoW product quality requirements for non-glass components, i.e. ferrous metals, non-ferrous metals, non-metal non-glass inorganics, and organics:</p>
3.	The glass cullet consignment complies with the industry specification or standard referred to in point 2.
4.	Quantity of the consignment in tonnes:
5.	The producer of the glass cullet applies a quality management system (as defined in Section 3.7 Criteria on quality management) which has been verified by an accredited verifier or, where glass cullet which has ceased to be waste is imported into the customs territory of the Union, by an independent verifier.
6.	The glass cullet consignment meets the criteria referred to in Sections 3.4, 3.5 and 3.6 (criteria on product quality, criteria on input materials, and criteria on treatment processes and techniques).
7.	The material in this consignment is intended exclusively for direct use in the production of glass substances or objects in re-melting processes.
8.	<p>Declaration of the producer/importer of the glass cullet: I certify that the above information is complete and correct to my best knowledge:</p> <p>Name:</p> <p>Date:</p> <p>Signature:</p>

Comments in support of the statement of conformity and additional suggestions:

The feedback received regarding the statement of conformity showed general support for the points drafted above. Specific comments are summarized below:

Provision of information on EoW status is seen as something that should be part of the consignment documentation. It was expressed that the current practice at cullet reprocessor sites is that, even if the cullet does not leave an area and it is just temporarily stored, it is always identified. The view is that the largest part of the information requested in the proposed statement of conformity is already part of the usual procedure, and the EoW requirements for the statement of conformity are not expected to add significant administrative burden to the current practice.

In line with the previous comment, other experts suggested that a possible format for the statement of conformity could be the same as used in existing freight documents, wherein the statement of conformity can be easily mentioned. This is seen as a way to reduce the administrative burden.

According to experts, the output of a glass recovery facility will either be waste glass (with the necessary waste documents, e.g. Annex VII or notification in line with EU-WSR 1013/2006) or an EoW-glass (with statement of conformity). The experts insist on an obligation that the statement of conformity (or similar document which refers to the obtained EoW status of the material) shall accompany each shipment. This is the only possibility for environmental inspectors to have an indication that every consignment is in line with the EoW requirements. Without this statement of conformity, the control inspectors could assume that the consignment needs to be considered as waste and could imply that the transporter needs to act according to the EU-WSR No 1013/2006. The importance of avoiding the risk of shipments of low-quality material (inside or outside the EU) was highlighted as especially important. It is equally important that the EoW regulation does not impose additional burden to current practice. In order to minimize possible burden by the EoW regulation, experts proposed that the statement of conformity is fulfilled by adding the necessary information to the existing and commonly used CMR-document (document accompanying shipments, according to the Convention on the Contract for the International Carriage of Goods by Road).

Some concerns regarding the statement of conformity:

- Other experts, while supporting the use of a statement of conformity, have nevertheless expressed concerns about how effective this will be. Materials such as glass cullet often form part of complex commercial transactions where the material may exchange hands (through brokers, and without physical movement of the product) several times before reaching the final customer. If the statement of conformity only stays with the product for the first transfer of ownership, it will be impossible to determine whether or not the material is waste at a later stage. There would be a potential risk of operators deliberately transferring ownership in order to mask a consignment's waste status. It was suggested that this risk could be reduced by requiring that the statement of conformity follows the consignment down the supply chain and that it forms part of the consignment paperwork for any overseas shipment.

Additional comments and suggestions were:

- The provision of information should be simple, swift, effective, and most important: efficient. The required information should be part of the existing consignment documentation (the majority is already there in current practice). The EoW criteria should not create administrative burden and duplicate controls.
- Provided that testing and certification required by EoW are in line with current reporting and that there is no imposition of heavy metals testing, then the burden of proof does not seem to lead to increased administrative requirements.
- A declaration of the contracting glass industry that the material will be used as raw material instead of virgin raw material is necessary.

- A substantial number of experts pointed out that the electronic filing of information is preferred because it is less costly and involves less administrative burden.
- Some of the requirements regarding the statement of conformity are seen as very onerous or non-applicable in closed-loop recycling using pre-consumer cullet.
- A number of experts proposed removing Point 2b), seen as an unnecessary administrative burden. It was argued that there is no need to cite the technical details of the specification, as these are already covered by the commercial specification put in place when the commercial contract is agreed. It would then be sufficient to state that the producer has a suitable quality system in place. The documentation described should be integrated with the usual supply documentation, i.e. the “delivery note”

Experts were asked what kind of liability they think would apply to an EoW producer or holder of a labelled consignment if the consignment was not used for the intended purpose:

- The answer is seen as dependent on how the legislation is implemented in each country. The producer or holder of the cullet must be aware of legislation and how irregular situations are handled.
- This will depend on how the WFD is implemented in the various EU member states. For example, in the UK the range of offences has yet to be detailed in an amendment to the enabling orders imposing civil sanctions. However, it is likely that the regulator will have powers to impose a fixed monetary penalty (up to £100 for an individual or £300 for a body corporate), a variable monetary penalty (up to £250,000) or a compliance notice depending on how offences are graded in the orders. Criminal proceedings may be instituted for non-payment.

Conclusions

Experts showed strong support for the requirement on provision of information. Provision of the information by the producer of EoW glass by labelling the consignment through a statement of conformity has been judged acceptable by experts, not seen to impose additional burden – in particular if in electronic form –, and deemed proportional to the risk of infringement in light of the strictness of the rest of criteria. The specific provision of information in Part 2b) was not seen by most experts as introducing increased burdens and is kept in the original form. The non-glass component threshold proposed is only achievable for glass cullet that was directly of high quality or has gone through sorting, restricting the market for the end-of-waste glass to buyers willing to pay for this quality of glass. EoW glass of this quality poses no environmental or health risk. The risk that EoW glass was diverted for other purposes is low. If the EoW glass was still diverted for other purposes, the (EU) holder that uses EoW glass for other purposes without declaring it would be made liable of infringement of the Regulation.

3.9 Application of end-of-waste criteria

For the application of end-of-waste criteria laid out above it is understood that a consignment of recovered glass cullet ceases to be waste when the producer of the cullet certifies to the next holder that all of the end-of-waste criteria have been met.

It is understood that recovered glass cullet that does not meet the end-of-waste criteria still can be used for the production of new products. In this case, the recycling is completed when the recovered glass cullet is introduced in the manufacturing process (i.e. re-melted in a furnace) and new material has been produced.

Experts from the TWG remarked the importance of ensuring that pre-consumer cullet returned to glass melting factories has become a secondary raw material before or when it gets through the gate and

hence prior to storing this secondary raw material on site and re-introducing it into the furnace. This is to avoid that glass factories and furnaces become waste storage and treatment facilities.

Finally, experts commented on estimates as to what percentage of the total current reprocessed glass cullet could pass EoW criteria as proposed. The following comments were conveyed:

- Estimating these percentages is difficult. A concern was expressed that if an unnecessary heavy metal limit was imposed as originally proposed, then this could potentially exclude significant amounts of cullet from achieving EoW status, which otherwise would be perfectly suitable for new glass manufacturing respecting e.g. the requirements of the Packaging Directive. Since the EoW criteria does not include a requirement on heavy metal limit, these potential concerns will not be an issue.
- Experts estimated that, from all the packaging and flat that is collected, more than ~80% corresponds to EoW criteria after proper sorting and treatment with the purpose of re-melting into newly manufactured glass products.
- The limit of non-metal non-glass inorganics are seen as potentially the most challenging to comply with. However, as the latest draft the EoW product quality criteria consider the possibility of raising the inorganics limit for intentionally ground cullet, these concerns would be diminished.
- For other experts, more important than quantities able to pass EoW criteria, they see the potential for easing the burdensome procedures currently in place. While the quantities of cullet ready for re-melting will probably not change substantially, there is the potential for cost decreases in recycling, and a lowering of prices of high-quality cullet.
- The overall impacts of the EoW criteria are difficult to foresee. Generally, too strict conditions would reduce the amount of cullet on the market and increase the price. Too light conditions would increase the amount of cullet on the market reducing the price but increasing the difficulties to obtain a high-quality product with the purpose of re-melting into new glass products.

4 Description of impacts

The establishment of end-of-waste criteria is expected to support recycling markets by creating legal certainty and a level playing field, as well as by removing unnecessary administrative burdens. This section outlines key impact issues of the implementation of end-of-waste criteria on the environment, markets, and the application of existing legislation. Impacts have been outlined based on the final draft of EoW criteria proposed in this document.

EoW criteria have been proposed with the aim of encompassing the largest possible flows of glass cullet currently used and perceived by the industry as a valuable raw material, while respecting the conditions of Art. 6 of the WFD, and maintaining strictness in its quality. In the absence of a unique solution that fits all demands, the proposed criteria are the result of a compromise and the principle of proportionality, addressing with priority the major flows (packaging glass, flat glass, and lead-free tableware glass) with a scope restricted to manufacture of glass products by re-melting in glass manufacturing facilities. As such, some applications such as aggregates are outside of the scope of EoW but these represent low percentages of the total applications of cullet in the EU. No use different from re-melting has been found that requires high quality glass cullet, and therefore EoW shall in principle not affect the current availability of glass cullet for these other markets, which can remain under waste legislation.

4.1 *Environmental and health impacts*

Air emissions, odours, leaching, dust, noise, fire risks, health impacts

The treatment of glass cullet in cullet reprocessing facilities will remain regulated by waste law, as for any facility that handles waste input. Thus, the specific emissions, dust or noise generated during the treatment of waste containing glass will not be changed by the implementation of end-of-waste criteria.

The environmental and health impacts of glass manufacturing are described under IPPC permits⁵³. IPPC permits do not take into account whether the input to the manufacturing plant is cullet as waste or as end-of-waste; i.e. emission limits are established with independence of the input being waste or not. Therefore again the EoW regulation will not have an impact on emissions and other health impacts from glass manufacturing facilities.

For glass manufacturing facilities using cullet as part of the input, and whether the cullet is waste or EoW, glass manufacturing facilities are industrial production sites and will continue to generate waste of different types, the handling of which needs waste management permits. Because of the need to fulfil the EoW criteria, when the EoW regulation is implemented, EoW material will on average be similar or of higher quality than generic waste glass. Therefore, as EoW material may have a lower impurity content than generic waste glass, some changes may occur in the amount and composition of the rejects from cullet reprocessing and from glass manufacturing facilities. It is likely that a higher quality of EoW glass will result in a decrease of the rejects generated by glass manufacturers and an increase in the amount of rejects by cullet reprocessors (the rejects will be composed of non-glass components: metals, non-metal inorganics, and organics). As the rejects are waste streams needing management, EoW may have an influence on waste management activities at the cullet reprocessors and the glass manufacturers, but this impact is likely to be marginal.

⁵³ The IPPC Directive has been replaced by the Industrial Emissions Directive (IED) (2010/75/EU); however, the IPPC permits are still valid during a transition period.

Risks related to transport and storage

Storage and transport of end-of-waste glass will no longer be covered by waste regulatory controls. Theoretically, this could imply an increased risk of impact to the environment in case end-of-waste glass had properties needing control only provided by waste regulation. However, normal good practice of transport and storage seem to be appropriate to control the type of risks of end-of-waste glass storage, mainly related to leaching, biodegradation of organic residuals, and control of dust and nuisance of material blown away with the wind. These impacts are currently controlled in many reprocessing plants by the design of storage areas, with separation screens and walls, and regular cleaning. In practice it can be expected that end-of-waste glass will, as a product, be stored in most cases under the same conditions as it used to as waste.

Theoretically, the only potentially higher risk to the environment from end-of-waste glass would be that, because of the facilitated cross-boundary movement, more glass is diverted from recycling. However, this seems unlikely, as there is no rational reason for not using high quality material, on the top end of the price scale of waste glass, for uses that do not demands such quality.

Impacts outside the EU

It is unlikely that facilitated export of end-of-waste glass outside the EU would have any substantial effects on increased emissions outside the EU. It may be of concern that emissions (air, water, waste generation) of glass production outside the EU may be larger than in the EU, but if changing, these emissions would decrease and not increase, as the content of non-glass components will likely be lower in end-of-waste glass than in waste glass.

End-of-waste will likely imply a shift of reject waste disposal over borders: by more systematically controlling sorting and cleaning to meet EoW material quality criteria in reprocessing, there would be a reduced export of non-glass components in waste glass, as exported end-of-waste glass will be on average less polluted than waste glass exported today for production outside the EU. This would imply additionally the avoidance of cases of camouflaged waste export, export for cheap labour sorting purposes, and the avoidance of the disposal of the non-glass fraction in the destination country. Marginal energy savings may also result by not unnecessarily transporting for long distances the unusable materials in glass.

Impacts on accumulation of substances in the recycling loops

Since EoW criteria restrict input materials to virtually lead-free glasses (container glass, flat glass and lead-free tableware), and prohibits that hazardous waste is used as input, these requirements may result in a long-term reduction of the accumulation of these substances in the glass cycle. This requires obviously that glass manufacturers of the glass type affected by the intrusion of the substance shift their input to EoW.

Impacts on recycling

EoW will be an additional element in the set of available regulatory mechanisms that promote the most environmentally favourable options for waste management. EoW will facilitate the recycling of glass of high quality, and thereby be an incentive for choosing this option when feasible. As recycling has in most cases the largest environmental benefits (especially for re-melting uses), this would be fully in line with the goals of the waste hierarchy. There is not significant impact expected for the remaining non re-melting uses. The EoW regulation would be neutral to them, as they could continue their current practice under the umbrella of waste law, using as input either waste glass or end-of-waste glass.

4.2 Market impacts

In general, the introduction of end-of-waste criteria is expected to support recycling markets by creating legal certainty and a level playing field, as well as removing unnecessary administrative

burdens. The feedback received from experts indicates that a strong motivation to pursue the development of end-of-waste for glass cullet is to help European companies remain competitive in an increasingly globalized world, even though the background data presented (c.f. Chapter 2) indicate that glass cullet is not a resource that is shipped long distances to overseas destinations, and most of the trade out of the EU takes place with neighboring countries. This concern has in any case been addressed by an effort to understand the impacts on trade of the introduction of the end-of-waste criteria for glass cullet. Trade effects of EoW are however likely to be significant only at regional and intra-EU level, and much less at a global level.

The following potential economic and market impacts may be expected:

- internal market benefits;
- avoidance of costs related to shipment of waste;
- avoidance of costs of handling the glass cullet in terms of permits and licenses;
- price adjustments;
- impacts on coexistence and share of markets;
- impacts on recycling markets in individual member states in Europe.

Internal market benefits

EoW criteria will facilitate trade in general, by creating a common definition of glass end-of-waste. Since cullet is mostly traded within the EU, EoW is expected to contribute to a smoother functioning of the internal EU market.

Costs related to shipment of waste

The waste status of glass cullet affects its exportability and importability by increasing the administrative and economic burdens. The total costs related to international shipment are related to the following factors:

- If sent overseas, requirement to obtain certain information from non-EU reproducers to satisfy 'broad equivalence' obligations set out in the Packaging Directive, and Waste Shipments Regulation. With 'end-of-waste' status, it would be possible to produce the necessary evidence based on the end-of-waste criteria concept.
- Notification and insurance costs on financial guarantees for waste shipments sent to countries where pre-notification is required (including certain 'green list' shipments) under the Waste Shipments Regulation. Each notification requires a financial guarantee, except to countries under treaty of accession arrangements. This is covered by financial institutions at certain costs, and also means a less liquidity for the glass cullet operators. Because of this there is a limit to the number of notifications a company can handle or absorb. In other words, there is an artificial (trade) barrier and companies cannot sell to all potential customers after their financial limit has been reached.
- The shipment of Green Listed waste to EU member States in a transitional period does not require a financial guarantee (insurance). However, administrative fees for notification might be high and vary from country to country. End-of-waste would facilitate free trade of glass cullet that meets the set end-of-waste criteria in Latvia up to 31 December 2010; Poland up to 31 December 2012; Slovakia up to 31 December 2011; Bulgaria up to 31 December 2014; and Romania up to 31 December 2015.
- Administration costs for maintaining Annex VII Waste Shipments Regulation tracking forms and domestic waste movement forms. In addition to the direct administration costs associated with form filling, there is an issue of having to supply commercially sensitive data. Customers outside the EU jurisdiction are not willing to have their commercial transactions recorded and made available to public authorities. Therefore they turn to non-EU suppliers.

- Loss of business where customers fail to provide appropriate information.

Costs of handling the glass cullet in terms of permits and licenses

The situation for waste collectors and reprocessors regarding permits or licenses will not change. Some traders may decide to trade only glass cullet which has ceased to be waste, as a market niche, and would not need any waste license.

As part of an authorisation to treat waste, a glass cullet company may have to complete the following administration paperwork every year:

- An annual report (company-specific reporting of all transactions and EWC code-specific reporting of all transactions)
- Monthly reports of incoming and outgoing materials
- Record books
- Special activity license for the plant, for transport for processing. The costs of the reports are substantial.
- Environmental impacts assessment of the waste glass reprocessing plant activity if handling over 5 tonnes/day
- Environmental responsibility insurance
- Waste transport authorization

These requirements would be relieved if only dealing with end-of-waste. However, EoW does not mean absence of control: it will result in some paperwork of a different nature. The main difference is that EoW paperwork is essentially related to the certification of quality, a task already existing in both reprocessors and glass manufacturers, but which with the implementation of EoW may be re-distributed along the glass cullet supply chain.

No significant market impacts are expected for the non re-melting uses. As mentioned above, an EoW regulation would be neutral to them, as these uses could continue their current practice under the umbrella of waste law, using as input either waste glass or end-of-waste glass. In case EoW material has marginally higher prices, the use of EoW material for these uses that do not need such quality would be lower. On the other hand, the availability of EoW material of high quality may stimulate the use in emerging glass markets (e.g. solar panels, laboratory and optical equipment) in partial substitution of other raw materials.

Price

It is likely that EoW can only have a small or no impact on prices. Better conditions for movement of glass cullet consignments could lead to more investments in reprocessing, such as:

- Build more protected storage areas to avoid loss of quality.
- Build more monitoring and sorting equipment at reprocessing plants. Some of this equipment may increase the use of energy and manpower at reprocessing plants. However, this may lead to a subsequent reduced need of non-glass component separation at glass manufacturers, due to the more systematically checked quality, sorting and characterisation of the input materials received.

With such effects, the supply of high quality glass cullet would be stimulated. This may lead to an increase in recycling rates and an image improvement of glass as a highly recyclable material, both stimulating collection and recycling. This may also affect the positioning of glass in its competition with other alternative packaging materials such as plastic, metals, or cartons. EoW may also push administrations to further move towards mono-material source collection, even colour-sorting at source.

One of the potential side effects in the medium and long term could be marginally higher prices of glass cullet that has ceased to be waste, compared to waste glass. As argued above, this scenario is doubtful, as glass manufacturers will probably not be willing to pay a higher price for end-of-waste material, once they already have the technology to handle the more affordable glass cullet. If materialised, higher prices may reduce the accessibility of EoW glass for recovery purposes not demanding high quality.

In any cases, price evolution will likely be different in the different member states because of the differences in industry structure and ownership, and the fact that glass cullet is not exported in large amounts and is mostly managed regionally due to the economics of transport. In some member states, reprocessors are independent from manufacturers and there is a free market for cullet. In other member states, reprocessors are owned by manufacturers, or manufacturers own the glass and not the companies providing the service of reprocessing. In other Member States, the government has set up a national organization to collect cullet from local authorities and has set a single price and therefore there is no free market for cullet. Price evolution will probably be different depending on the mentioned different market situations in different member states. A few experts expressed concerns regarding the possibility of increasing prices for EoW cullet. It is difficult to estimate the overall impact of EoW as it may also lead to increase cullet availability, which would also have an impact on prices. EoW may also contribute to avoiding artificial prices resulting from situations where there is no free market for cullet.

Coexistence and share of markets

The entering into force of an EoW criteria Regulation will likely result in a new option within the market of glass cullet. Waste status could remain for the lower quality market segment of glass cullet. Firstly, as explained in detail in the scope definition, it is proposed that many uses of glass cullet will remain under waste legislation, until a decision is made on the appropriateness of preparing additional EoW criteria for other uses. Secondly, the glass cullet market for glassmaking will have a new option, both within the EU and outside the EU. EoW glass, because of its demonstrated quality, will in its own right acquire the benefits of a product in terms of trade and image. Glass cullet that remains waste will continue to be a valuable material for glassmaking (and for other uses). Both market options will find an equilibrium point and coexist. The exact point of equilibrium and uptake of the new option cannot be predicted. Decisions will have to be made by individual reprocessors and manufacturers, weighting the advantages and disadvantages for them of both options.

Coexistence will also be observed on trade. On the one hand, glass that has ceased to be waste will be easier to export within and out of the EU (this will mostly affect trade with neighbour countries, which absorb of 80% of this trade). On the other hand, the EU demand of glass that has ceased to be waste will also be higher, as higher quality material is more demanded in an area like the EU where the costs for glass manufacturers of disposal of rejects are higher. It is difficult to forecast the share of EoW material in the domestic market and in exports outside the EU when equilibrium is reached.

Impact on recycling markets in individual member states in Europe

Some exceptional cases exist in Europe where an individual member state has a national system in place to organize the recycling of glass, the most relevant case being France. In France, the government has set up a national organization, EcoEmballages, which organizes the collection of cullet with the aim of re-melting, and which guarantees to local authorities that collected cullet will be purchased by EcoEmballages, no matter the distance from collection to glass manufacturing facilities, at a single price set up by EcoEmballages, as long as the collected cullet has an impurity of less than about 2%. In this sense, there is no free market for cullet in France. Since EoW regulation is based on promoting a free market for cullet, this is seen by some member states as a potential disruption in member states where cullet is not a free market, and potentially causing: (a) A "delocalization" of recycling, by reducing incentives for local authorities to collect waste glass, and possibly reduced recycling rates, (b) reduced cullet availability for the glass industry, or (c) possible price increase of the cullet.

However, EoW is expected to be fully compatible with current specific recycling structures in the mentioned member states, and EoW will not affect the ownership of the cullet. Regarding possible effects of EoW on cullet prices, if the free market were to lead to higher cullet prices, this might also have a positive impact for municipalities as they might obtain a greater profit for their collected waste glass, having to spend less in waste management services. In individual cases where distances from collection to glass manufacturing might not make collection economically sound, EoW might result in reduced collection rates in certain geographical areas, but overall, EoW is expected to lead to increased cullet recycling rates on average in the EU.

4.3 Legal impacts

End-of-waste is in line with existing overarching EU legislation (e.g. other articles of the WFD, or Packaging Directive and its targets), and therefore marginal impacts can be expected. Larger differences on impacts can be expected on national legislation, or European legislation that gives national freedom, e.g. application of VAT, national systems for collection of glass such as green-dot/take-back, or current systems of waste licensing. The overall aim of EoW is to create the most simple, yet operational proposal.

The most important impacts related to legislation that have been detected are, apart from the release from any obligation under waste legislation (see comments on the Waste Shipments Regulation above), the introduction of product legislation, most notably VAT and REACH. From the perspective of both companies and authorities, one of the elements of concern besides compliance is the possible economic impacts of implementation of new legislation.

VAT

Concerns were raised in the technical working group that the end-of-waste status of glass cullet may in certain countries affect the applicability of reverse VAT charges, which is an instrument used in some member states to avoid tax evasion.

Member states have the authority for deciding whether glass cullet that has ceased to be waste is subject to value-added taxation. Member states may request different VAT rates on glass cullet once it ceases to be waste.

It should be noted that the end-of-waste criteria are not intended to change the way in which VAT is payable in each Member State. It would therefore be preferable that any provisions on glass cullet in national VAT law are formulated in a way that makes them independent on the status as waste or not (end-of-waste). However, it is not within the remit of waste legislation (herewith EoW) to prescribe the VAT rate or regime that any Member State decides to apply to glass cullet.

Experts agreed that fiscal policy is a matter of each individual member state and which has nothing to do with the status of a substance: waste or non-waste. It was suggested as preferable that end-of-waste glass would not be subject to any additional tax in the future due to its end-of-waste status, as that would be seen as creating distortions on the playing field. Other experts pointed out that furnace-ready cullet today is exempted from VAT since it is a recycling product.

REACH

Article 2.2 of the REACH Regulation specifies that waste is not a substance, mixture or article within the meaning of Article 3 of this Regulation. If glass cullet has still the status of waste, it is covered by waste law, not by REACH. When glass cullet ceases to be waste according to Article 6 of the WFD, the exemption under Article 2.2 of the REACH regulation no longer applies, and glass is subject to REACH.

Many types of recovered glass cullet are, however, exempted from most REACH obligations (e.g. registration and evaluation obligations, but not downstream safety information communication) because of two possible reasons:

- 1) Because the nature of cullet as a **recovered substance**, by **Article 2.7(d)**
- 2) Because registration for recovered glass (being a substance) is deemed inappropriate or unnecessary, by Article **Article 2.7(b) (Annex V.11)**

The 2008 update of Annex V of REACH (EC/987/2008) and in particular Annex V.11, exempts *glass* and *ceramic frits* from the mentioned obligations, unless:

"they meet the criteria for classification as dangerous according to Directive 67/548/EEC and provided that they do not contain constituents meeting the criteria as dangerous in accordance with Directive 67/548/EEC present in concentrations above the lowest of the applicable concentration limits set out in Directive 1999/45/EC or concentration limits set out in Annex I to Directive 67/548/EEC, unless conclusive scientific experimental data show that these constituents are not available throughout the lifecycle of the substance and those data have been ascertained to be adequate and reliable"

ECHA (2010) has provided guidance on the interpretation of these exceptions. Only those types of glass and ceramic frits are exempted which do not have any significant hazard properties:

"Firstly, glass or ceramic frits are only to be exempted if they (as substances as such) do not meet the criteria for classification as dangerous according to Directive 67/548/EEC. There are two possibilities to assess this criterion: look at the glass or frit itself or look at the starting materials.

Secondly, they are not exempted if the substance contains constituents meeting the criteria as dangerous in accordance with Directive 67/548/EEC that are present in concentrations above the lowest of the applicable concentration limits set out in Directive 1999/45/EC or concentration limit set out in Annex I to Directive 67/548/EEC, unless conclusive scientific experimental data show that these constituents are not available throughout the life-cycle of the substance and those data have been ascertained to be adequate and reliable. In this case, industry has to look at the constituents after the production of the glass (constituents could be different than the starting materials) to see if they meet the criteria as dangerous in accordance with Directive 67/548/EEC and are present above the relevant concentration limit. If this is the case then they are not exempted unless the constituent is not available throughout the life-cycle of the substance.

It is the responsibility of manufacturers or importers to assess and document the conclusive scientific data to demonstrate their substance(s) fulfil these criteria.

Man Made Vitreous Fibres (MMVF) included in Annex I to Directive 67/548/EEC are not covered by this exemption as they meet the criteria in Annex VI of that Directive. In addition, MMVF, which are not listed in Annex I to Directive 67/548/EEC, but that meet the criteria for classification as dangerous according to Annex VI of Directive 67/548/EEC are also not to be exempted."

Interactions with the Packaging and Packaging Waste Directive (PWD)

While supporting the principle that end-of-waste should be at the cullet reprocessing stage (subject to a suitable specification being in place), experts expressed the need to take into account the connections

between EoW and the wording of the Packaging and Packaging Waste Directive (PWD), especially regarding the definitions of recycling and recycling targets.

Article 3.7 of the PWD defines recycling as: “‘recycling’ shall mean the reprocessing in a production process of the waste materials for the original purpose or for other purposes including organic recycling but excluding energy recovery;”

For example, it was expressed that current UK legislation transposing the PWD incorporates a system that allows accredited reprocessors to issue Packaging Waste Recovery Notes (PRNs) as evidence of delivery of packaging waste to them by producers or registered schemes. Registration as an accredited reprocessor is conditional upon handling and recycling packaging **waste**.

Finally, it is important to emphasize that the development of EoW criteria is independent of any interpretation regarding recycling or recycling targets in the PWD or any legislative instruments derived from it.

Connection with the EU-ETS directive 2009/29/EC

Some experts expressed possible connections between EoW and CO₂ emissions from glass manufacturing in the context of compliance with the EU-ETS directive. In particular, a potential decrease in cullet availability is seen as a factor that could possibly push the glass manufacturing industry to increase the number of CO₂ allowances to buy on the carbon market. This in turn is seen as possibly leading to higher prices for these allowances and difficulties for the glass producers to achieve CO₂ reduction targets.

However, in general it is expected that EoW will lead on average in the EU to higher cullet availability. It could be the case that some individual glass manufacturing companies in certain regions or member states might have to purchase extra CO₂ allowances if located in geographical regions with lower cullet availability. But overall, EoW is expected to yield positive effects regarding reductions in CO₂ emissions on average in the EU. It will be important to keep monitoring the evolution of cullet prices and availability in the EU in the following years, to better and more accurately evaluate the impacts of EoW.

4.4 Summary of identified potential impacts of EoW on glass cullet

Environmental and health impacts

- EoW supports the image of glass cullet as a recyclable resource.
- EoW will likely stimulate more collection and recycling of waste glass in the EU, especially in those countries that currently have lower collection rates.
- EoW will likely stimulate better quality control, and increased recycling of glass of high quality. The high quality of EoW cullet will especially promote re-melting applications, the recycling options with greatest associated environmental benefits. EoW is not expected to have a significant impact on non re-melting applications, which may continue their current practice under waste law, i.e. EoW is expected to be neutral to the non re-melting uses.
- Theoretically, the only potentially higher risk to the environment from end-of-waste glass would be that, because of the facilitated cross-boundary movement, more glass is diverted from recycling. However, this seems unlikely because of the high product quality characteristics of end-of-waste glass.
- EoW will be an additional element in the set of available regulatory mechanisms that promote the most environmentally favourable options for waste management. EoW will facilitate the recycling of glass of high quality, and thereby be an incentive for choosing this option when feasible. As recycling has in most cases the largest environmental benefits (especially for re-melting uses), this would be fully in line with the goals of the waste hierarchy.

Market impacts

- Improved functioning of the internal and external market to the EU: transparency, level playing field, and removal of unnecessary administrative burdens.
- The additional image push of glass as a recyclable resource will likely translate into higher value of this material and its recycling chain, especially the EoW material generated in the EU.
- Avoidance of administrative costs related to shipment of waste (permits, licenses, uncertainty).
- Additional sorting and quality control will require changes in current practices, which in the short term may result in costs. In the long term, these costs should be lower and be compensated by the benefits of EoW.

Legal impacts

- Improved functioning of the internal and external market to the EU: legal certainty, harmonised rules, etc.
- Decrease of unnecessary control related to the Waste Shipment Regulation
- Each Member State must check the extent of impact to national law, e.g. countries that use reverse VAT or taxation of natural resources in national law. End-of-waste criteria do not intend to change the way in which VAT is payable in each Member State.
- When glass cullet ceases to be waste and becomes end-of-waste, it is in principle subject to REACH. However, many types of recovered glass are exempted from REACH obligations for registration and evaluation. End-of-waste glass is however generally subject to obligations on downstream safety information communication according to REACH.

5 Glossary

CFGF: Continuous filament glass fibre.

Collection: The gathering of waste glass, including the preliminary sorting and preliminary storage of waste glass for the purposes of transport to a waste treatment facility (following the definition of the Waste Framework Directive (2008/98/EC)).

Collection rate: Percentage of waste glass collection (with the purpose of recovery/recycling) compared to the total waste glass generation. Waste glass collected in a country but exported for recycling in another country is included. Waste glass imported from other countries and recycled in the country in question is not included.

Consignment: A batch of cullet which is destined for delivery from a producer to another holder; one consignment might be contained in several transport units such as containers.

CSP: Ceramics, stones, and porcelain (non-glass non-metal inorganic components present in cullet).

Cullet: The word cullet can be used to refer to either "broken glass" or to "waste glass". A distinction should be made regarding *internal* vs. *external* cullet. This distinction is important because internal cullet is not regarded as waste, while external cullet (which can be pre- or post-consumer) is classified as waste. When using the word "cullet" in the context of end-of-waste it will always refer to external cullet (see definitions of **internal cullet** and **external cullet**). The term **cullet** will be used in this document mainly to refer to **reprocessed cullet**, that is, external cullet that conforms to a set of minimum quality criteria. The report sometimes makes reference to **collected cullet**; in this case, it is a type of cullet that generally conforms to lower quality specifications than reprocessed cullet and may not be suitable as direct input for re-manufacturing into new glass products.

Cullet, internal: Internal cullet is composed of defective products detected and rejected by a quality control process during the industrial process of glass manufacturing, transition phases of product changes (such as thickness and colour changes) and production offcuts. The basis of the definition of internal cullet is the fact that these materials are immediately absorbed by the respective industrial process as a raw material for a new melting operation, not leaving the glass manufacturing plant. Internal cullet cannot be considered as waste as it was never a product.

Cullet, external: External cullet is "waste glass that is collected and/or reprocessed with the purpose of recycling". External cullet can be of two types: (1) pre-consumer, also called post-industrial glass cullet, and (2) post-consumer glass cullet.

(1) Pre-consumer cullet is waste glass resulting from the manufacturing of products that contain glass as one of their components, and which leaves the specific facility where it was generated, becoming waste but not reaching the consumer market. An example of pre-consumer cullet is the glass cullet constituted by offcuts and pieces from defective manufacturing of e.g. the production of car windows from flat glass, which leave the car window manufacturing facility and are re-melted in the flat glass manufacturing facility.

(2) Post-consumer cullet is waste glass originated after the use of the glass products at the consumer market.

Disposal: Any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy. Annex I of the Directive sets out a non-exhaustive list of disposal operations (following the definition of the Waste Framework Directive (2008/98/EC)).

Flint cullet: Colourless cullet

Glass: Generic term referring to a material of an amorphous structure, composed essentially of silicates.

Glass consumption: Glass that is purchased and consumed in the market within a country or group of countries, plus imports from the outside, minus exports to the outside.

Glass detrimental to production: This definition encompasses types of glass not matching the quality definition for the manufacture of a given type of glass. For example, in the manufacture of flint glass, there is a maximum limit (percentage) of coloured (green and amber) glass permitted. Or for example, container glass cullet may not be suitable for the manufacture of flat glass.

Glass production: Glass that is manufactured by a country or group of countries. Some of it is unsold, some of it is sold in the market within the list of countries, and some of it is exported.

Health care waste: Waste from human or animal health care and/or related research (except kitchen and restaurant wastes not arising from immediate health care), including all its subcategories as detailed in Code 18 of Commission Decision 2000/352/EC of 3 May 2000 (List of Wastes).

Holder: The natural or legal person who is in possession of cullet.

HTIW: High temperature insulation wool.

Importer: Any natural or legal person established within the European Union who introduces cullet which has ceased to be waste into the customs territory of the EU.

Impurities: Also called "non-glass content", or "non-glass components" (see non-glass components)

Manufacturer: Glass manufacturer

Mono-material collection, also called separate collection: A system for collection of recyclables where each of the materials is collected as separate streams. The system can be for pick-up by waste trucks from door to door (also called "kerbside collection"), or in containers or banks distributed in inhabited areas, and where waste producers bring and deposit their waste (also called "bring systems"). In the context of waste glass, the mono-material collection can be further colour-separated or colour-mixed.

Multi-material collection, also called comingled collection: A system for collection of two or more recyclable materials together. The system can be for pick-up by waste trucks from door to door (also called "kerbside collection"), or in containers or banks distributed in inhabited areas, and where waste producers bring and deposit their waste (also called "bring systems"). The materials are normally paper, plastics, metals, and sometimes also glass. In some cases, the only allowed plastic, metal and glass is as packaging.

MSW: Municipal solid waste. Means non-sorted, mixed waste from households and commerce, collected together. This waste flow excludes the flows of recyclables collected and kept separately, be it mono-material flows or multi-material (comingled) flows.

Mt: Million tonnes

Non-glass components: Also known as contraries or impurities, are non-glass materials that result of imperfect sorting, such as ferrous and non-ferrous metals, organic materials (paper, plastic, wood) or inorganic material objects or residuals (ceramics, stones and porcelain).

Producer: The holder who transfers cullet to another holder for the first time as cullet which has ceased to be waste.

Qualified staff: Staff who are qualified by experience or training to monitor and assess the properties of cullet.

Recovery: Any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy (following the definition of the Waste Framework Directive (2008/98/EC)). Annex II of the Directive sets out a non-exhaustive list of recovery operations. Recovery includes recycling and energy recovery. Energy recovery means "the use of combustible wastes as a means to generate energy through direct incineration with or without other waste but with recovery of the heat".

Recovery rate: See collection rate above.

Recycled glass: A broad term, generally applied to any type of glass product containing to some degree secondary raw material from waste glass, which is used as input substituting raw materials used to manufacture glass.

Recycling: Any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes (following the definition of the Waste Framework Directive (2008/98/EC)). It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations.

Recycling rate: Amount of collected waste glass that is re-melted for making new glass, compared to the total waste glass generated, in percentage terms.

Reprocessing plant: Broad term used to define any of the intermediate actors in the waste glass chain between the end-users and the glass manufacturing plants. It encompasses companies or institutions undertaking activities such as collection, sorting, grading, classification, cleaning, crushing, compacting, trading, storing, or transporting. The input material to these plants is waste glass. The output is glass that may either be waste or non-waste.

Reprocessor: Operator of a cullet reprocessing plant (see above).

Separate collection: The collection where a waste stream is kept separately by type and nature so as to facilitate a specific treatment (following the definition of the Waste Framework Directive (2008/98/EC)).

Treatment: Recovery or disposal operations, including preparation prior to recovery or disposal (following the definition of the Waste Framework Directive (2008/98/EC)).

Utilisation rate: Amount of collected waste glass that is re-melted for making new glass, compared to the total glass production, in percentage terms.

Visual inspection: Inspection of cullet consignment using either or all human senses such as vision, touch and smell and any non-specialised equipment. Visual inspection shall be carried out in such a way that all parts of a consignment are covered.

WFD: Waste Framework Directive (Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives).

6 References

- ABAG GmbH (2004), *Guidance on classification of waste according to EWC-Stat categories Statistics on generation of waste*, Annex to the Manual on Waste Statistics, Eurostat E 5, ABAG GmbH
<http://epp.eurostat.ec.europa.eu/portal/page/portal/waste/documents/GUIDANCE%20DOC.PDF>
- Basel Convention (1989), Basel Convention of 22 March 1989 on the control of transboundary movements of hazardous wastes and their disposal, amended by Decisions on 22 September 1995 and 27 February 1998, from 9 to 13 December 2003 and from 25 to 29 October 2005, http://europa.eu/legislation_summaries/environment/waste_management/l28043_en.htm
- BIS/DEFRA (2010), Department for Business Innovation and Skills (BIS) and Department for Environment, Food and Rural Affairs (Defra), *“Less is more”: Business Opportunities in Waste & Resource Management*, Department for Environment, Food and Rural Affairs, March 2010, <http://www.defra.gov.uk/environment/waste/documents/opportunities-waste-manage.pdf>
- BREF (2009), Glass BREF, Integrated Pollution Prevention and Control - Draft Reference Document on Best Available Techniques in the Glass Manufacturing Industry, Institute for Prospective Technological Studies, Joint Research Centre, European Commission, Seville, July 2009, ftp://ftp.jrc.es/pub/eippcb/doc/gls_d2_07-2009.pdf
- BSI/WRAP (2003), PAS 101: Recovered container glass – Specification for quality and guidance for good practice in collection, London/UK, http://www.wrap.org.uk/recycling_industry/information_by_material/glass/pas101_recovered.html
- BSI/WRAP (2004), PAS 102: Specification for processed glass for selected secondary end markets, London/UK, http://www.wrap.org.uk/recycling_industry/information_by_material/glass/glass.html
- BV Glas (2010), "Cullet use in container glass production in Germany in 2009", Bundesverband Glas (BV Glas), Ms. Aldenhoff, Email to Ökopool, 13 April 2010.
- CEN (2008), CEN/TR 13688:2008 "Packaging - Material recycling - Report on requirements for substances and materials to prevent a sustained impediment to recycling", July 2008.
- CoReVe (2008), "Risultati 2008: Raccolta e riciclo del vetro", http://www.coreve.it/pdfdownload/download_pdf_995227979.pdf
- CPIV (2004), CPIV REACH position paper, http://www.glassonline.com/infoserv/Glass_recycle_reuse/CPIV_REACHPositionPaper.pdf
- CPIV (2010), CPIV position paper on the design of CO2 benchmarks and fall back options under the EPS for the glass sector, [http://www.cpivglass.be/publications/CPIV%20Proposal%20for%20benchmarking%20\(january%202010\).pdf](http://www.cpivglass.be/publications/CPIV%20Proposal%20for%20benchmarking%20(january%202010).pdf)
- Czech Statistical Office, http://www.czso.cz/csu/2007edicniplan.nsf/engpubl/2001-07-in_the_cr_in_2006
- DEMEX (1997), "Genanvendelse af planglas", DEMEX Rådgivende Ingeniører A/S., Arbejdsrapport fra Miljøstyrelsen nr. 88/1997, Miljøstyrelsen (Danish EPA), 1997
- Douglas (1972), "A history of glassmaking", R.W. Douglas, G.T. Foulis & Co Ltd, Henley-on-Thames/UK.
- EBRC (2006), "Occupational dermal and inhalation exposure to diantimony trioxide during the production of crystal glass - Extrapolation from data on exposure to lead oxides", Final report, EBRC
- EC (1969), Council Directive of 15 December 1969 on the approximation of the laws of the Member States relating to crystal glass (69/493/EEC)
- EC (1994), "Packaging Directive", European Parliament and Council Directive 94/62/EC of 20 December 1994 on Packaging and Packaging Waste, http://europa.eu/legislation_summaries/environment/waste_management/l21207_en.htm

- EC (2000a), EC Waste List, Commission Decision of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste, Brussels, 2000, as amended.
- EC (2000b), Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end of life vehicles, <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:269:0034:0042:EN:PDF>
- EC (2002), WEEE Directive, Directive 2002/96/EC of the European Parliament and of the Council of 27/01/2003 on waste electrical and electronic equipment, OJ L 37 from 13/02/2003, p. 24, as amended, <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0096:en:HTML>
- EC (2006), Regulation (EC) No. 1013/2006 of the European Parliament and the Council of 14 June 2006 on shipments of waste (Waste Shipment Regulation), <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32006R1013:EN:NOT>
- EC (2007), Waste Export Regulation, Commission Regulation (EC) No. 1418/2007 concerning the export for recovery of certain waste listed in Annex III or IIIA to Regulation (EC) No. 1013/2006 of the European Parliament and of the Council to certain countries to which the OECD Decision on the control of transboundary movements of wastes does not apply, Brussels, 2007.
- EC (2008), "The new Waste Framework Directive", Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, Official Journal of the European Union, 22 November 2008, <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0003:EN:PDF>
- ECHA (2010a), "Guidance on waste and recovered substances", May 2010, http://guidance.echa.europa.eu/docs/guidance_document/waste_recovered_en.pdf
- ECHA (2010b), "Guidance for Annex V. Exemptions from the obligation to register", European Chemicals Agency. Helsinki, Finland, http://guidance.echa.europa.eu/docs/guidance_document/annex_v_en.pdf
- ECORYS SCS Group (2008), "FWC Sector Competitiveness Studies - Competitiveness of the Glass Sector. Within the Framework Contract of Sectoral Competitiveness Studies, Final report, Directorate-General Enterprise & Industry, 14 October 2008, http://ec.europa.eu/enterprise/newsroom/cf/document.cfm?action=display&doc_id=4044&user_service_id=1
- End-of-waste documents from the JRC-IPTS are available from <http://susproc.jrc.ec.europa.eu/activities/waste/>
- Enviros Consulting Ltd. (2003), "Glass recycling – Life cycle carbon dioxide emissions", http://www.britglass.org.uk/Files/Enviros_LCA.pdf
- Envirowise (2008), "UK Glass Manufacture, A Mass Balance Study", http://www.britglass.org.uk/Files/Mass_Balance_Final.pdf
- European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste. Latest amended by Regulation (EC) No 219/2009 of the European Parliament and of the Council of 11 March 2009, http://europa.eu/legislation_summaries/environment/waste_management/l21207_en.htm
- Eurostat (2010a), "Price index on secondary materials", Environmental Data Centre on Waste <http://epp.eurostat.ec.europa.eu/portal/page/portal/waste/data/wastemanagement/recycling>
- Eurostat (2010b), External trade (ComExt)
- Eurostat (2010c), Manufactured goods (Prodcom)
- N. Favaro and F. Van Houte (2009), "The glass industry in Italy and Europe: a survey", Stazione Sperimentale del Vetro (SSV) and Standing Committee of the European Glass Industries (CPIV), <http://www.glassonweb.com/articles/article/575/>
- Fearn et al. (2006), "Sodium and hydrogen analysis of room temperature glass corrosion using low energy Cs SIMS", S. Fearn/D.S. McPhail (Department of Materials, Imperial College, London/UK), R.J.H. Morris/ M.G. Dowsett (Department of Physics, Warwick University, Gibbet Hill Rd., Coventry/UK), Applied Surface Science 252 (2006) 7070–7073.

- FERVER (2007), "Guideline specifications for the product status of furnace ready cullet", Statement from 5 September 2007
- GHK and BIOIS (2006), "A study to examine the benefits of the End of Life Vehicles Directive and the costs and benefits of a revision of the 2015 targets for recycling, re-use and recovery under the ELV Directive", GHK and BIOIS, May 2006, European Commission
- Glass for Europe (2005), "Recycling of glass from construction and demolition waste", position paper, February 2005.
- Glass for Europe (2009), "Recycling end-of-life vehicle glazing", position paper, January 2009.
- Glass International (2009), "French glass industry: Review and projections", Glassmann Europe, Glass International
- GRIAG (2009), "High Potential for Increased Recycling of CRT glass in Europe", Press release, GRIAG Glasrecycling AG, Werder/Germany, 12.6.2009
- GTS (2007), "Specification for Flat Glass Cullet used in Flat Glass Manufacture – Draft", Glass Technology Services (GTS), Sheffield/UK, 2007
- Helmenstine (2010), "Colored Glass Chemistry", A.M.Helmenstine, About Chemistry, Web information, <http://chemistry.about.com/cs/inorganic/a/aa032503a.htm>
- INFU/Prognos (2007), "Study of waste streams and secondary materials in the EU", <http://www.waste-stream.eu/>
- IPPC (2008), Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control – codified version, 2008.
- IPTS (2008). "End-of-Waste Criteria Final Report", European Commission, Joint Research Centre, Institute for Prospective Technological Studies, <http://susproc.jrc.ec.europa.eu/documents/Endofwastecriteriafinal.pdf>
- IPTS (2009). "Study on the Selection of Waste Streams for End-of-Waste Assessment – Final Report", European Commission, Joint Research Centre, Institute for Prospective Technological Studies, http://susproc.jrc.ec.europa.eu/documents/SelectionofwastestreamsforEoW-FinalReport13_02_2009.pdf
- Kaysen (2001), "Statistik for glasemballage 1999", Miljøprojekt, 601, Miljøstyrelsen, 2001, Denmark
- Kaysen (2004), "Statistik for glasemballage 2002", Miljøprojekt Nr. 935, Miljøstyrelsen, 2004, Denmark
- KEMI (2008), "European Union Risk Assessment Report: Diantimony trioxide – Risk assessment", Swedish Chemicals Agency, Swedish Chemicals Inspectorate, Sundbyberg/Sweden, http://ecb.jrc.ec.europa.eu/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/datreport415.pdf
- Letsrecycle (2010), "Glass prices UK container glass", web information, <http://www.letsrecycle.com>, London, 2010.
- MGS (2010), "Fused quartz production", Machined Glass Specialists, Inc., Ohio/USA, 2010, <http://www.mgsquartz.com>
- Mogensen (2010), "Screening and sorting technology", Mogensen KG, web information, Wedel/Germany, <http://www.mogensen.de>
- OECD (2001), OECD Council Decision C(2001)107/Final concerning the revision of Decision C(92)39/Final on the control of transboundary movements of wastes destined for recovery operations, last amended 26 October 2005 with Decision C(2005)141
- OECD (2009), Joint Working Party on Trade and Environment: Reducing barriers to international trade in non-hazardous recyclable materials: exploring the environmental and economic benefits, Part 1: A synthesis report
- Oxford (2008), "Compact Oxford English Dictionary", 3rd Edition, Oxford University Press, Oxford/UK, <http://www.askoxford.com>
- Pohl (2010), Pohl, Reiling AG, Personal communication with Ökopöl, 22.3.2010.
- PricewaterhouseCoopers (2007), Détermination d'un indice de référence du prix de revient du calcin en Europe hors France - Années 2005 et 2006, PricewaterhouseCoopers, Eco-emballages and adelphe, September 2007
- PricewaterhouseCoopers (2009), Setting a reference index for cullet cost price in Europe (France excluded) - years 2007 and 2008, PricewaterhouseCoopers, Eco-emballages and adelphe, October 2009

- Ramboll/Ökopol (2010), "Study on Recyclable Waste Glass in the context of the development of end-of-waste criteria for the EU Waste Framework Directive", Interim report, 21 April 2010.
- REACH, http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm
- Siddique (2008), "Waste Glass", Chapter 5 in: "Waste Materials and By-Products in Concrete", Springer, 2008
- UBA (2006), Guidelines on WEEE, Correspondents' Guidelines No 4 on the Classification of waste electrical and electronic equipment and fly ash from coal-fired power plants according to Annex IV part I note (c) of Regulation (EC) No 1013/2006 on shipments of waste, Umweltbundesamt, Dessau, 2006, <http://www.umweltbundesamt.de/abfallwirtschaft-e/gav/leitlinien.htm>
- UBA (2009), Guidelines on CRT, German EPA - Correspondents' Guidelines No 7 - Subject: Classification of glass waste originating from cathode ray tubes (CRT) under entries B2020 or A2010, Umweltbundesamt, Dessau, 2009 <http://www.umweltbundesamt.de/abfallwirtschaft-e/gav/leitlinien.htm>
- UBA (2010), Sandra Leuthold, Umweltbundesamt (Federal Environmental Agency), Dessau/DE, personal communication with Ökopol, 19.1.2010.
- Van Santen/Beerkens (2005), "Recycling in container glass production: present problems in European glass industry", Engelbert van Santen (Glass Consultant)/Ruud Beerkens (TNO Glass Group), The Netherlands, 2005.
- Verre Avenir (2010) Enjeu économique, www.verre-avenir.fr
- WRAP (2004), Materials recovery from waste cathode ray tubes (CRTs). Prepared by ICER (Industry Council for Electronic Equipment Recycling), Banbury, WRAP, March 2004, <http://www.icer.org.uk/IcerMaterialsRecoveryFromCRTs.pdf>
- WRAP (2007), "Assessment of the International Trading Markets for Recycled Container Glass and their Environmental Implications", Final Report, July 2007, http://www.wrap.org.uk/downloads/MSG007_Final_v2_no_fibre_glass.1e19b9c4.3950.pdf
- WRAP (2008), "Market Situation Report – September 2008, Realising the value of recovered glass: An update", http://www.wrap.org.uk/downloads/Glass_MSR_update_online.1f94d7c0.6009.pdf
- WRAP (2009a), Assessing the demand for glass containers with maximum recycled content, WRAP Project TYR009-19. Report prepared by Kirk N., Sutherland, E., Westerman, S., Gardner, P. and Andrews, L., Banbury, WRAP, 2006, http://www.wrap.org.uk/downloads/Maximum_Recycled_Content_Report.6f11600d.7955.pdf
- WRAP (2009b), WRAP and Environment Agency, *Flat Glass Collection*, Banbury, WRAP, 2009, http://www.wrap.org.uk/downloads/Flat_Glass_Benefits_Brochure_Final.d58ceeal.6784.pdf
- WRAP (2010), Can you recycle your flat glass waste? The potential for recycling flat glass waste in the domestic replacement window sector, Banbury, WRAP, <http://www.wrap.org.uk/downloads/FlatGlassWaste1.c48b676f.55.pdf>
- WRAP/EA (2008), "The quality protocol for the production of processed cullet from waste flat glass", WRAP/Environmental Agency, London/UK, http://www.environment-agency.gov.uk/static/documents/Business/Quality_protocol_for_flat_glass.pdf, <http://www.environment-agency.gov.uk/business/topics/waste/114412.aspx>

Other sources of information

- CPIV - Standing Committee of the European Glass Industries (Comité Permanent des Industries du Verre Européennes), or European Glass Federation, www.cпивglass.be, Members:
 - APFE, European Glass Fiber Producers Association, www.glassfibreeurope.eu/
 - FEVE, the European Container Glass Federation, www.feve.org
 - EDG, European Domestic Glass Committee
 - ICF, International Crystal Federation
 - ESGA, European Special Glass Association

- Glass for Europe, www.glassforeurope.com
- FERVER, Fédération Européenne des Recycleurs de Verre, www.ferver.be, an International Non Profit Association of the European glass recycling industries, 25 members from 10 EU-member states.
- Eurima - European Insulation Manufacturers Association (Mineral Wool), Statistics available at www.eurima.org
- European Environmental Bureau (EEB), <http://www.eeb.org/Index.html>, an environmental NGO
- Glass Technology Services, Ltd (UK), <http://www.glass-ts.com/home/home.html>, a subsidiary of British Glass. They help industry develop glass products (the technical arms of British Glass), they have capabilities to perform testing of glass products.
- "Recycled Glass Market Study & Standards Review - 2004 Update", written by ENVIROS and published by *The Waste & Resource Action Programm*, Oxon, UK (2006)
- "UK Glass Manufacture – a mass balance study", *British Glass Manufacturer' Confederation* (2004) available at <http://www.britglass.org.uk/Files/UKGlassManufactureAMassBalance.pdf>
- *Chambre Syndicale des Verreries Mécaniques de France*, information on prices of collecting and sorting recycling glass, available at <http://www.verre-avenir.fr/index.php/le-recyclage-du-verre/enjeu-economique>
- www.glassonline.com
- www.glassonweb.com

Some European/National Associations of Glass Manufacturers, Recyclers, and Waste Management related to Glass:

- FEAD: European Federation of Waste Management and Environmental Services
- Germany: Bundesverband Glasindustrie e.V.
- Austria: GLAS RECYCLING GMBH
- Belgium: FEBEM-FEGE (Belgian Federation of Waste Management Companies)
- Spain: ANFEVI, www.anfevi.com
- Finland: Environment Packaging Register
- France: Verre Avenir
- Ireland: Irish Glass
- Italy: CO.RE.VE.
- Norway: Norsk Glassgjenvinnig AS
- Netherlands: Maltha Holding
- Netherlands: Sitch Promotie Glasbak
- Portugal: Portuguese Container Glass Association (AIVE)
- UK: British Glass, www.britglass.org.uk, glass industry trade federation in the UK
- UK: Glass Packaging Industry
- Sweden: Svensk GlasÅtervinning
- Switzerland: Vetro Recycling AG

7 Annex I. Criteria

This Annex presents a compact version of the proposed end-of-waste criteria for glass cullet.

Criteria	Self-monitoring requirements
1. Quality of cullet resulting from the recovery operation	
<p>1.1 The glass cullet shall comply with a customer specification, an industry specification or a standard for direct use in the production of glass substances or objects by re-melting in glass manufacturing facilities.</p>	<p>Qualified staff⁵⁴ shall verify that each consignment complies with the appropriate specification.</p>
<p>1.2 The content of non-glass components shall be limited to the following thresholds:</p> <ul style="list-style-type: none"> ▪ Ferrous metals: ≤ 50 ppm; ▪ Non-ferrous metals: ≤ 60 ppm; ▪ Non-metal non-glass inorganics: <ul style="list-style-type: none"> ○ ≤ 100 ppm for cullet size > 1 mm ○ ≤ 1500 ppm for cullet size ≤ 1 mm ▪ Organics: ≤ 2000 ppm <p>Examples of non-metal non-glass inorganics are: ceramics, stones, porcelain, pyro-ceramics.</p> <p>Examples of organics are: paper, rubber, plastic, fabrics, wood.</p>	<p>Qualified staff shall carry out a visual inspection⁵⁵ of each consignment.</p> <p>At appropriate intervals, representative samples of glass cullet shall be analysed gravimetrically to measure the total non-glass content. The non-glass content shall be analysed by weighing after mechanical or manual (as appropriate) separation of materials under careful visual inspection.</p> <p>The appropriate frequencies of monitoring by sampling shall be established taking into account the following factors:</p> <ol style="list-style-type: none"> (1) The expected pattern of variability (for example as shown by historical results). (2) The inherent risk of variability in the quality of waste glass used as input for the recovery operation and any subsequent processing. Pre-consumer waste glass with a highly predictable composition needs less frequent monitoring. Waste glass from multi-material collection may need more frequent monitoring. (3) The inherent precision of the monitoring method.

⁵⁴ Qualified staff is defined as: staff who are qualified by experience or training to monitor and assess the properties of cullet.

⁵⁵ Visual inspection is defined as: Inspection of cullet consignment using either or all human senses such as vision, touch and smell and any non-specialised equipment. Visual inspection shall be carried out in such a way that all parts of a consignment are covered.

	<p>(4) The proximity of results to the limitation of the non-glass contents to the limits indicated above.</p> <p>The process of determining monitoring frequencies should be documented as part of the quality management system and should be available for auditing.</p>
<p>1.3 The glass cullet shall not display any of the hazardous properties listed in Annex III to Directive 2008/98/EC. The glass cullet shall comply with the concentration limits laid down in Commission Decision 2000/532/EC⁵⁶, and not exceed the concentration limits laid down in Annex IV of Regulation 850/2004/EC⁵⁷.</p>	<p>Qualified staff shall carry out a visual inspection of each consignment. Where visual inspection raises any suspicion of possible hazardous properties, further appropriate monitoring measures shall be taken, such as sampling and testing where appropriate.</p> <p>The staff shall be trained on potential hazardous properties that may be associated with glass cullet and on material components or features that allow recognising the hazardous properties.</p> <p>The procedure of recognising hazardous materials shall be documented under the quality management system.</p>
<p>2. Waste used as input for the recovery operation</p>	
<p>2.1 Only waste from the collection of recoverable container glass, flat glass or lead-free tableware may be used as input. The collected waste glass may unintentionally contain minor amounts of other glass types.</p>	<p>Acceptance control of all glass-containing waste received by visual inspection and of the accompanying documentation shall be carried out by qualified staff who are trained on how to recognise glass-containing waste that does not meet the criteria set out in this Section.</p>
<p>2.2 Glass-containing waste from mixed municipal solid waste or health care waste shall not be used as an input.</p>	<p>Acceptance control of all glass-containing waste received (by visual inspection) and of the accompanying documentation shall be carried out by qualified staff who are trained on how to recognise glass-containing waste that does not meet the criteria set out in this Section.</p>
<p>2.3 Hazardous waste shall not be used as an input.</p>	<p>Acceptance control of all glass-containing waste received by visual inspection and of the accompanying documentation shall be carried out by qualified staff who are trained on how to recognise glass-containing waste that does not meet the criteria set out in this Section.</p>

⁵⁶ OJ L 226, 6.9.2000, p.3.

⁵⁷ OJ L L 229, 30.4.2004, p. 1.

3. Treatment processes and techniques

3.1 The glass-containing waste shall have been collected, separated and processed, and from that moment shall permanently have been kept separate from any other waste.

3.2 All treatments such as: crushing, sorting, separating, or cleaning, needed to prepare the glass cullet for direct use in the production of glass substances or objects shall have been completed.

QUALITY MANAGEMENT

1. The producer shall implement a quality management system suitable to demonstrate compliance with the EoW criteria.

2. The quality management system shall include a set of documented procedures concerning each of the following aspects:

- a. acceptance control of waste used as input for the recovery operation;
- b. monitoring of the treatment processes and techniques;
- c. monitoring of the quality of glass cullet resulting from the recovery operation (including sampling and analysis);
- d. feedback from customers concerning compliance with glass cullet quality;
- e. record keeping of the results of monitoring conducted under points (a) to (d);
- f. review and improvement of the quality management system;
- g. training of staff.

3. The quality management system shall also prescribe the specific monitoring requirements set out in the end-of-waste criteria for each criterion.

4. A conformity assessment body as defined in Regulation (EC) No 765/2008, which has obtained accreditation in accordance with that Regulation, or any other environmental verifier as defined in Art 2 (20) (b) of Regulation (EC) No 1221/2009 shall verify that the quality management system complies with these quality management requirements. The verification should be carried out every three years.

5. The importer shall require his suppliers to implement a quality management system which complies with these quality management requirements.

6. The producer shall give competent authorities access to the quality management system upon request.

The producer or the importer shall issue, for each consignment of glass cullet, a statement of conformity as set out below. The producer or the importer shall transmit the statement of conformity to the next holder of the consignment. They shall retain a copy of the statement of conformity for at least one year after its date of issue and shall make it available to competent authorities upon request. The statement of conformity may be issued as an electronic document.

1.	<p>Producer/importer of the glass cullet:</p> <p>Name:</p> <p>Address:</p> <p>Contact person:</p> <p>Tel.:</p> <p>Fax:</p> <p>E-mail:</p>
2.	<p>a) The name or code of the glass cullet category in accordance with an industry specification or standard:</p> <p>b) The main technical provisions of the industry specification or standard, including compliance with EoW product quality requirements for non-glass components, i.e. ferrous metals, non-ferrous metals, non-metal non-glass inorganics, and organics:</p>
3.	The glass cullet consignment complies with the industry specification or standard referred to in point 2.
4.	Quantity of the consignment in tonnes:
5.	The producer of the glass cullet applies a quality management system (as defined in Section 3.7 Criteria on quality management) which has been verified by an accredited verifier or, where glass cullet which has ceased to be waste is imported into the customs territory of the Union, by an independent verifier.
6.	The glass cullet consignment meets the criteria referred to in Sections 3.4, 3.5 and 3.6 (criteria on product quality, criteria on input materials, and criteria on treatment processes and techniques).
7.	The material in this consignment is intended exclusively for direct use in the production of glass substances or objects in re-melting processes.
8.	<p>Declaration of the producer/importer of the glass cullet:</p> <p>I certify that the above information is complete and correct to my best knowledge:</p> <p>Name:</p> <p>Date:</p> <p>Signature:</p>