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# FEVE paper on how to calculate the Recycled Content and the Post-Consumer Recycled Content (PCR) of glass containers.

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## 1 Contents

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## 2 Background

Glass exhibits outstanding properties as packaging material:

- it is endlessly recyclable in a closed loop no matter how many times it is recycled
- it is virtually inert: no substance will be transferred from glass to the product it contains
- it preserves the original properties of the product packed in it (being organoleptic, olfactory, medical,..)
- it is highly impermeable to gases

Re-melting glass into a glass furnace brings many environmental benefits. Each time 1 tonne of glass is recycled in a glass furnace:

- it avoids the extraction of 1.2 tonnes of virgin raw materials
- it reduces the CO2 emissions by 580 kg on a Life Cycle basis[1]
- it reduces the energy consumption of the furnace (as a rule-of-thumb for large furnaces, every 10% increase of cullet will reduce the energy consumption of the furnace by ~2.5% but this can vary depending of furnace size)[2]

On top of those benefits, glass has an additional advantage when it comes to recycling, namely it is a **permanent material**[3]. This means that glass has the potential to be recycled over and over again, without any loss of its main intrinsic properties. Permanent materials are perfect to maintain a true circular material loop. Due to the strength of their chemical bonds, permanent materials are indeed not damaged by the recycling process and can stay in the recycling loop as long as they are properly collected, treated and re-melted.

In this context, as there is a need to unambiguously define the recycled content of glass containers, the container glass industry makes recommendations in this paper on **how to calculate two different ratios:**

- **the Recycled Content of glass containers**
- **and the Post-Consumer Recycled content (PCR) of glass containers**

[1] Based on a FEVE LCA study from December 2016
[2] See page 314 of Glass BREF - https://publications.jrc.ec.europa.eu/repository/bitstream/JRC78091/lfna25786enn.pdf
[3] See the report by Stazione Sperimentale del Vetro: https://feve.org/wp-content/uploads/2016/09/SSV-Report-on-Glass-as-Permanent-Material.pdf

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# 3 Recycling rate versus recycled content

Although this paper focuses mainly on the concept of recycled/post-consumer content, it seems relevant in this section to explain the difference between **recycling rate** and **recycled content** and what exactly these two rates measure.

- The **recycling rate** is a measure of the proportion of materials/articles put on the market in a specific geographical area by fillers and importers which, after consumer use, is collected for recycling. The recycling rate of glass containers in the EU reached 76% in 2017. This means that 76% of the glass bottles put on the EU market were collected to be recycled.
- The **recycled content** is a measure of the proportion of recycled material contained in a specific product. It is of course product dependent. The average recycled content of glass containers in the EU was assessed during the last FEVE Life Cycle Assessment in 2012 and reached 52%.

The difference between the recycling rate and the recycled content can be explained by different factors:

- A difference in scope: the recycling rate is linked with the efficiency of the collection system in the Member states (which is the ratio between the quantities collected for recycling and the quantities put on the market), while the recycled content is linked with the quantity of recycled glass put in the glass furnaces.
- The balance between imports and exports of empty and filled bottles is influencing the amount of recycled glass available to be recycled in the EU.
- The recycling rate is currently measured at the entrance of the glass recycling plant (in fact what is collected) which is composed of other packaging materials (loose contaminants like plastic bottles or plastic bags as well as metal caps and paper / plastic labels on the bottles) in addition to food residues and water which need to be removed during the recycling step.
- Some glass containers collected for recycling are in fact recycled in industries other than the container glass (e.g. insulation wool, cellular glass, road filling,…). They are therefore included in the recycling rate, not in the recycled content of glass containers.
- Sometimes, pre-consumer recycled glass (i.e. glass from breakages from a filling line or a decoration process) is not captured by the recycling rate but is included in the recycled content.
- Some non-glass materials (like calumite from the steel industry) can be recycled in a glass furnace. They are not included in the glass recycling rate, but well in the recycled content (this represents however a very small fraction, typically 0.5% at EU level)

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**The container glass industry considers that the recycling rate is a better indicator than the recycled content to measure the circularity of glass containers, for one simple reason: there is not enough recycled glass on the market !**

Therefore, if one glass producer increases its recycled content, automatically another glass producer will see its recycled content decreasing. Recycled content is therefore more adapted to materials for which, contrary to glass, the supply is bigger than the demand.

For glass, as the demand for recycled glass is higher than the supply, the recycling rate is more adapted than the recycled content, as it is necessary to focus on increasing collection and recycling rather than playing a zero-sum game where the increase in recycled content for one manufacturer means de facto a reduction for another.

**Despite the preference of the container glass industry to speak in terms of recycling rate, they also have to address the requests of some customers to measure recycled content. This is the reason for this paper**.

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# 4 Internal and external cullet in the glass industry

Cullet is a synonym for "broken glass".

The source of cullet used in the glass manufacturing process is twofold:

1) it can originate from rejects from the glass process itself, and is called internal cullet
2) or it can originate from pre-consumer collection (e.g. breakages on the filling or decoration lines or flat glass coming from processing activities) or from post-consumer collection schemes (e.g. glass collected in bottle banks or flat glass collected after the end-of-life of cars or buildings) and is then called external cullet.

The internal cullet rate measures somehow the rejection rate on a glass production line. The articles not matching the technical specifications (in terms of defects, seeds, light transmittance,…) are indeed discarded and generally put back in the furnace to be remelted. The higher the rejection rate and the lower the line efficiency, the higher becomes the average internal recycling rate. Glass being a permanent material (it can be recycled infinitely without any degradation of its intrinsic properties), all rejects from the production line are re-melted into a glass furnace. Doing this means that there is no waste generated and landfilling is avoided.

The **external cullet rate** measures the amount of cullet coming from outside the plant (pre-consumer or post-consumer) integrated by the glass plant in its production. Colour and transport distances are important parameters which influence where the cullet is going to be re-melted. The recycled content of glass containers is equal to this external cullet rate + any other recycled material incorporated in the batch.

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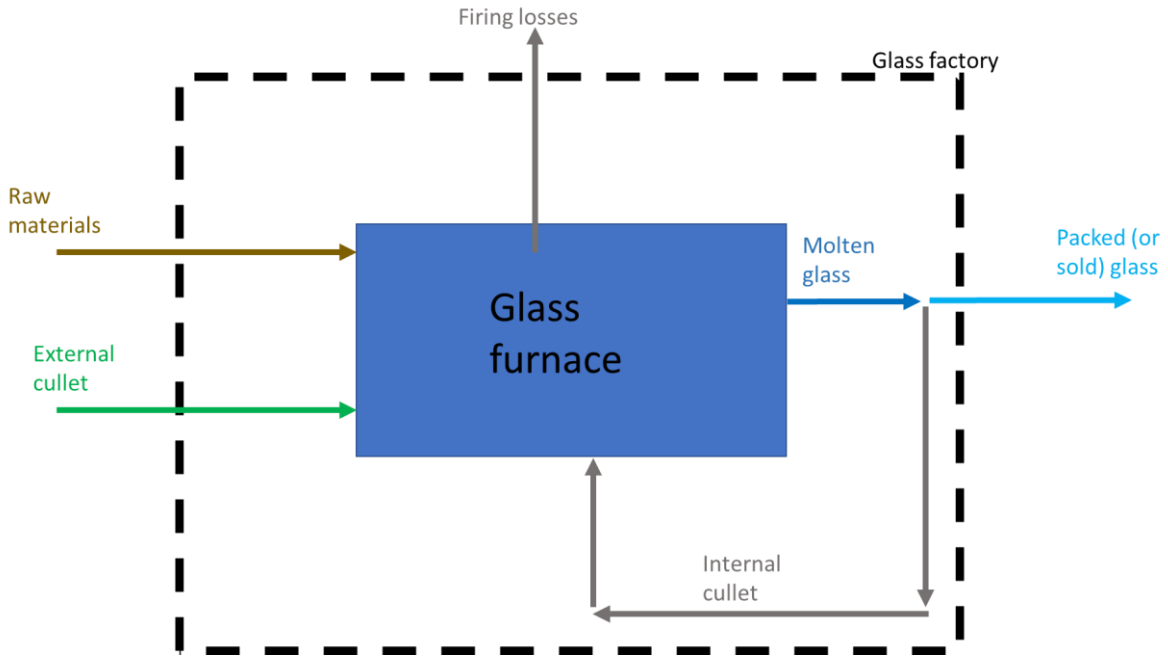
# 5 Mass flows of a glass factory

This difference between internal and external cullet is shown in the graphic below, illustrating a glass factory (dashed line) with the glass furnace:

- The **inputs** are:
  - The external cullet which is coming from outside and therefore crosses the perimeter of the glass factory
  - The virgin raw materials which are typically sand, soda ash and carbonates
- The **outputs** are:
  - The firing losses which are the gases coming from the decomposition of the raw materials (CO2, Sox,…)
  - The packed glass is the glass sent outside the factory
- The **internal flows** are:
  - The molten glass which is the glass coming out of the furnace
  - The internal cullet is circling within the glass factory without crossing its perimeter. It corresponds to the difference between the molten glass and the packed glass (rejects not meeting the quality requirements).



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# 6 The ISO standard 14021 on Environmental labels and declarations

A **definition of recycled content** is given in the ISO 14021:2016 "*Environmental labels and declarations — Self-declared environmental claims (Type II environmental labelling*)".

The definition includes pre-consumer material and post-consumer material but excludes recycled glass generated in the glass process and capable of being reclaimed within this process:

***Definition of recycled content according to ISO 14021:***

*Recycled content = Proportion, by mass, of recycled material in a product or packaging. Only pre-consumer and post-consumer materials shall be considered as recycled content, consistent with the following usage of terms:*

> *1) Pre-consumer material*
>
> *Material diverted from the waste stream during a manufacturing process. Excluded is reutilization of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it.*
>
> *2) Post-consumer material*
>
> *Material generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product which can no longer be used for its intended purpose. This includes returns of material from the distribution chain.*

# 7 Boundaries of the glass process in the sense of ISO 14021

As the ISO 14021 excludes cullet generated in the glass process and capable of being reclaimed in it, **it is necessary to define accurately the boundaries of the glass process**.

To this end, the manufacturing process of glass containers consists generally of the following steps:

- Selection and control of raw materials.
- Preparation of raw materials: essentially weighing and mixing materials to a set batch recipe.
- Melting: the raw materials undergo fusion at high temperature (1,300 to 1,550°C) in a furnace.
- Forming: the molten glass is shaped and allowed to solidify.
- Annealing: internal stresses in the container are removed by reheating the bottle and cooling it slowly.
- Finishing: finishing includes in particular internal quality control.

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- Further sorting (being internal or external) to meet specific customers requirements is also considered as being part of the glass manufacturing process.

**Any piece of glass generated during these manufacturing steps and re-injected in the furnace is to be considered as internal cullet and cannot be included in the recycled content calculation**. This also includes off-site quality control rejects and rejects generated during these manufacturing steps but in another glass furnace (belonging or not to the same company).

Once the glass containers are packed after the quality control, they can be sent to another process (like filling operations, decoration operations,…). Filling and decoration are not part of the glass manufacturing process. Cullet generated in these processes (resulting mainly from breakages) and sent back to the glass furnace can be included in the calculation of the recycled content.

The distinction between internal and external (being pre-consumer or post-consumer) cullet presented in this section is illustrated in Annex I "Glass value chain and definition of pre-consumer and post-consumer recycled content".

# 8 Formulas for the calculation of recycled content and content in post-consumer recycled glass

Talking into account the discussion from the previous sections, **two glass recycling indicators can be defined**.

## 8.1 FORMULA TO CALCULATE THE RECYCLED CONTENT OF A GLASS CONTAINER

$$\textbf{Recycled content} = \frac{Total\ tonnes\ of\ \textbf{external}\ cullet + other\ recycled\ material}{total\ tonnes\ \textbf{packed}\ glass}$$

**The packed glass is here to be understood as packed after sorting operations (see Annex I).**

**The external cullet is the sum of post-consumer glass and pre-consumer glass as defined in the ISO 14021 but excludes internal cullet as defined in section 6 of this document**. The numerator contains also non-glass recycled materials like calumite (a waste material from iron production used in glass production).

Internal cullet is not included in the recycled content figure to ensure that recycled content:

- correlates with a reduction in the use of virgin raw materials
- is not artificially inflated by variations in the manufacturing process

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This is common practise and is in line with the ISO standard ISO 14021 Environmental labels and declarations – self declared environmental claims (Type II environmental labelling) in its definition of recycled content (section "*7.8 Recycled content*").

## 8.2 FORMULA TO CALCULATE THE POST-CONSUMER RECYCLED CONTENT (PCR) OF A GLASS CONTAINER

In some cases, customers (or end-consumers) may be interested in knowing not the total recycled content of a glass container but rather the proportion in a container of recycled glass used by end-consumers and recycled into a container. **In this case, the following formula should be used (and this indicator should not be called "recycled content" to avoid confusion with the ISO 14021):**

$$\textbf{\textit{Post-consumer recycled content (PCR)}} = \frac{\textit{Total tonnes of } \textbf{\textit{post consumer recycled glass}}}{\textit{total tonnes } \textbf{\textit{packed}} \textit{ glass}}$$

In this case, the pre-consumer and the other non-glass recycled materials have been excluded from the numerator.

**The packed glass is here to be understood as packed after sorting operations (see Annex I).**

A minimum reference period of 6 months of production data is recommended for these calculations to avoid the effect of short campaigns.

With this post-consumer recycled content indicator, a problem can arise when a production site has multiple furnaces producing the same type of glass. For this calculation to be applied a manufacturer must guarantee that the whole cullet produced on a given PCR consuming furnace is recycled ONLY in this furnace. If this is not possible or desirable then the total amount of PCR used must be divided by the total packed ware of all furnaces that receive cullet from the PCR consuming furnace (ware produced on the original furnace and all the others combined).

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# 9 Summary

Technically, glass bottles can be produced with up to 100% recycled glass, and so endlessly. Glass is a very simple material that can be endlessly and easily recycled into new glass applications, and without any degradation of its quality. It always remains safe even when recycled.

This is one of the reasons why glass is used to produce packaging solutions for consumer food and beverages, perfumery and cosmetics, and pharmacy goods. Post-consumer recycled glass is the most important ingredient we use to produce new glass packaging solutions.

Two different indicators can be used to quantify the amount of recycled materials in a glass containers:

- The recycled content, which is defined in an ISO standard and measures all the recycled material in a glass bottle
- And the post-consumer recycled content (PCR) which quantifies only the post-consumer glass present in a glass container.

**Both indicators have usefulness but should not be confused. The correct name should be used in all communication messages related with glass containers**. In particular, the second indicator should not be called Recycled Content.

These two indicators are calculated as follows:

$$\textbf{Recycled content} = \frac{Total\ tonnes\ of\ \textbf{external}\ cullet + other\ recycled\ material}{total\ tonnes\ \textbf{packed}\ glass}$$

**The external cullet is the sum of post-consumer glass and pre-consumer glass as defined in the ISO 14021 but excludes internal cullet as defined in section 6 of this document.**

$$\textbf{Post-consumer recycled content (PCR)} = \frac{Total\ tonnes\ of\ \textbf{post consumer recycled glass}}{total\ tonnes\ \textbf{packed}\ glass}$$

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# 10 Annex I - Glass value chain and definition of internal cullet and pre-consumer and post-consumer recycled content