
XIII Convegno della Rete Italiana LCA
VIII Convegno dell'Associazione Rete Italiana LCA

**Il Life Cycle Thinking a supporto
delle strategie di mitigazione e
adattamento ai cambiamenti climatici**

**Università degli Studi Roma Tre,
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Erika Mancuso, Marina Mistretta, Chiara Montauti, Simona Scalbi**



Agenzia nazionale per le nuove tecnologie,
l'energia e lo sviluppo economico sostenibile



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Enhancing the environmental performance in the hollow glass production. A case study

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Abstract

In Italy the production of hollow glass represents more than 82% of the total glass production and recycled glass is one of the most important materials, as it allows to obtain great environmental benefits as well as a reduction in energy consumption. The present paper has carried out an LCA study. The goal of the analysis has been to analyse the environmental performance within the whole life cycle system of the hollow glass production to identify possible alternative scenario for reducing the environmental impacts, in particular the global warming potential emissions. The scenario has considered the hypothesis to increase cullet post consumer use in the current production system from regional supply.

1. Introduction

In Italy the production of hollow glass represents more than 82% of the total glass production, which is equal to over 5,000,000 t (Assovetro, 2018); commodities from the hollow glass include bottles, glasses, containers, which are uses in many sectors as the food, pharmaceutical and cosmetic ones. In the analysis of the Italian hollow glass market, fig. 1, the trend of production over the years has been constant over time.

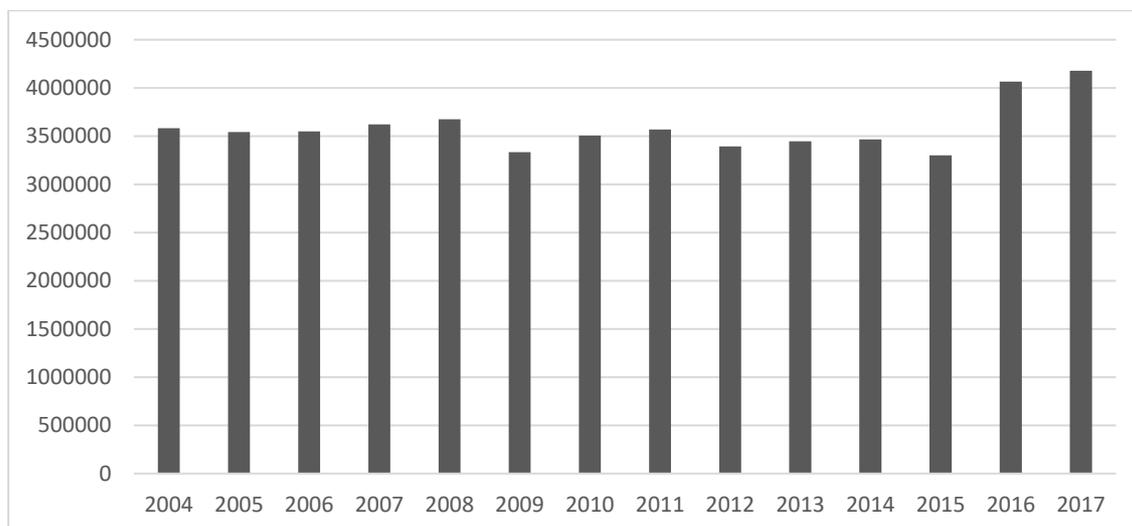


Figure 1: Hollow Glass Production in Italy (t).

Source: Personal elaboration by Author on Feve, 2015 and Assovetro, 2018

To better understand this market, it is necessary to focus attention also on the consumption of this sector in Italy. Analyzing fig.2, it is possible to highlight how the consumption of hollow glass, which have shown a slow but significant increase in the decade 2007-2017, increased hollow glass consumption of 12.70%.

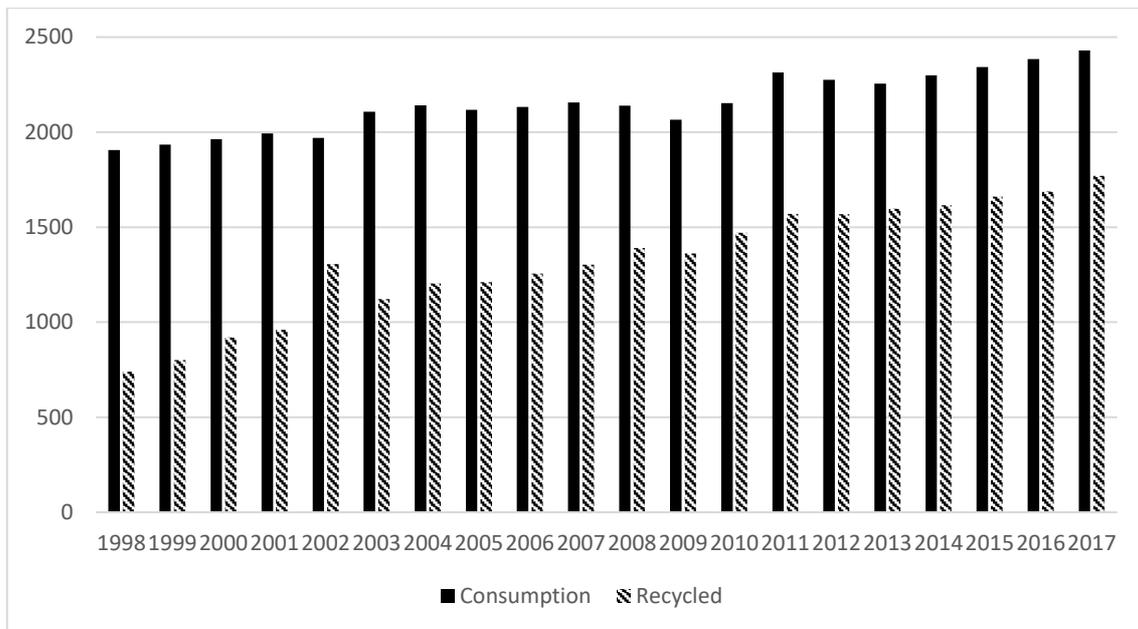


Figure 2: Historical Series of consumption and recycling of glass packaging in Italy (kt)
 Source: Grisan, 2018 and Feve, 2015

With the increasing use of glass, it was necessary to increase the recycling of this material guaranteeing a reduction in the use of virgin raw materials. It is important to highlight how over the years the recycling of this material has increased, going from 740 kt in 1998 to 1,769 kt in 2017, which is 72.80% of the glass consumption and over 42% of the hollow glass production. In Europe, the average recycling rate for glass packaging is steady at 74%. This figure is in line with Italian performance, but significantly lower than countries such as Belgium, Switzerland, Finland or Sweden, where this rate is around 95%. Currently, recycled glass is one of the most important materials, as it allows to obtain great environmental benefits as well as a reduction in energy consumption. The relevance of container glass sector, which could increase its importance in replacement of some plastic by single use together with its environmental impacts, suggests studies and analysis for enhancing the technical, environmental, economic, performances of this industry.

The present LCA study has been twofold: a) to analyze the environmental performance within the life cycle system of the hollow glass production from a plant and b) to identify a possible alternative scenario for reducing the environmental impacts, and the global warming potential emissions. The scenario has considered the hypothesis to increase cullet post consumer use from regional supply within the current production system.

2. Materials and Methods

Data and relative documents come from Vetrerie Meridionali (VeMe) S.p.a. plant located in Castellana Grotte (BA) Italy. This company, which is the object of the LCA study, has been working in the automatic hollow glass sector for over 40 years. Its annual production is equal to 130,000 - 140,000 tons with a workforce of 210 units.

An LCA was performed based on current production cycle of the company, concerning the container glass for beverage and food. Based on the analysis of the worst environmental performance of the stages within the entire cycle, best practices were applied to improve the performance. Finally, a comparison of environmental impacts has been made between the current situation and a better performance based on an increasing rate of cullet from its regional supply.

1.1. LCA

The LCA study has been elaborated according to the ISO 14040:2006 and 14044:2018, to the PCR basic module CPC 37 “glass and glass products and other non-metallic products n.e.c. v 3.0” (Environdec, 2018). Software used is GaBi thinkstep AG version 8.7.0.18 ecoinvent integrated 3.3 database. All the data used in the present analysis are “primary data” or “site specific data” that are data collected within the production plant where the specific product processes are performed and data from other parts of the cycle of life brought back to the specific product system under examination, for example materials or electricity supplied by a contractual supplier who is able to provide data for the services actually delivered. No allocations or parameterizations have been made.

The functional unit was identified in 1 kg of finished hollow glass. The energy data used refers to the domestic energy mix. The method used to assess the environmental impact is the latest available version of CML 2001 (January 2016 version).

2.1.2. Life cycle impact assessment

The calculated impact categories are as follows:

- Greenhouse gas emissions (expressed as the sum of global warming potential, GWP, 100 years), in carbon dioxide equivalents (CO₂).
- Emission of acidifying gases (expressed as the sum of the acidification potential, AP) in sulfur dioxide (SO₂) equivalent.
- Gas emissions that contribute to the creation of tropospheric ozone (expressed as the sum of potential ozonation, POCP), in C₂H₄ (ethylene) equivalent.
- Emission of substances in water that contribute to the reduction of oxygen (expressed as a sum of potential eutrophication, EP), in phosphate (PO₄) equivalent.
- Abiotic depletion potential is calculated and displayed as two separate indicators. The first is Abiotic Depletion Potential – Elements (ADP-Elements), which includes all non-renewable material resources, in kg Sb equivalent.
- The second is Abiotic Depletion Potential – Fossil fuels, (ADP-fossil fuels) including all fossil resources, in MJ (net calorific value).
- Water depletion (WD), which is equal to water use (only water input flows are considered), in m³.

2. LCA inventory

2.1. System boundaries

The analysis concerns the “from cradle to grave” methodology, excluding the final consumption phase are divided into three phases called UPSTREAM, CORE and DOWNSTREAM. The system boundaries are those identified by the CPC 37 PCR and by other typologies of studies (Vinci et al, 2019; Auer et al, 2017; Avery, et al. 2017).

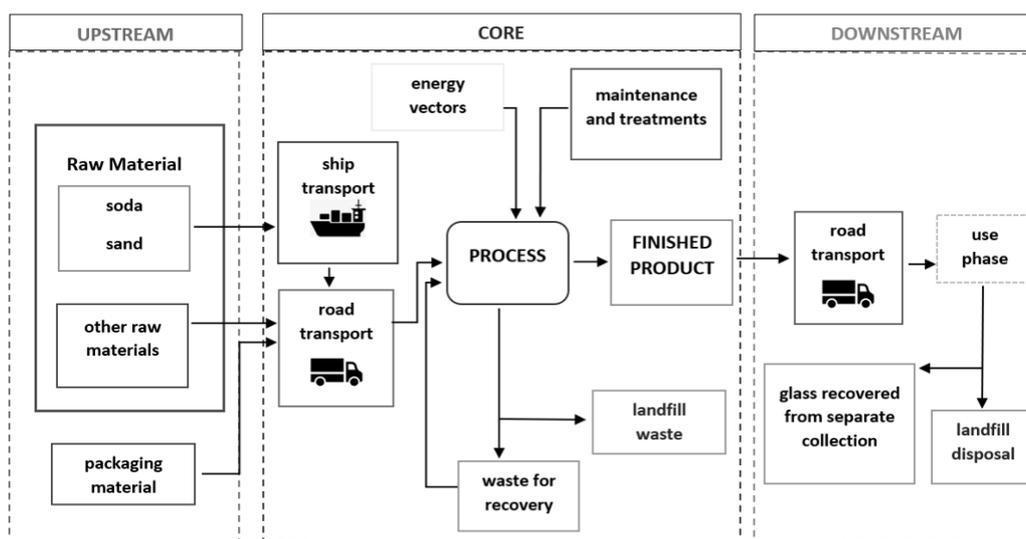


Figure 3: The life cycle stage

2.2. Inventory

It was decided to carry out a cut-off of 1% in relation to the masses of incoming and outgoing flows (raw materials, primary packaging, waste products and substances for maintenance and treatment). It was also verified that the flows excluded for cut-off participated in less than 1% of the environmental impacts calculated as required in the reference PCR.

Table 2 shows data concerning the waste generated during the core, upstream and downstream phases. The most important waste categories are emulsions, steel and iron waste: these two categories together represent more than 40% of the total amount of produced waste. Among the categories identified, another important consideration is characterised by rainwater, representing 10% of the total waste produced.

Table 1: Quantity of the main raw material used per year and their percentage

Raw material	kg	%
Cullet	57,536,013.11	32
Sands	60,479,030.70	34
Soda	20,813,685.60	12
Calcium carbonate	14,747,711.18	8
Dolomite	10,198,933.70	6
Yellow sands	15,289,920.50	8
Total	179,773,043	100

Table 2.: The main categories of waste

Waste	kg	%
Emulsions	120,700	21%
Iron and Steel	119,441	21%
Plastic	81,421	14%
Rainwater	58,400	10%
Others	201,948	35%
Total	581,910	100%

2.3. Transport carriers

The other data entered in the process flow concerns: transport of raw material (sand and soda) on a ship transport packaging, energy carriers used in the production process, finished product, transport of waste to landfills, finished product transport to customer companies, raw material transport. The transport values are the following: ship transport: 1.610 ton/km; road transport: 0.047 tons/km; Packaging transport: 0.001 ton/km; Waste transport value to landfill: 0.00104 ton/km; Finished product transport to the customer companies: 0.00007 ton/km. The waste transported to the landfill are of two types: those deriving from the production process and those extrapolated by the EUROSTAT data in which the data of glass taken to landfill and not recovered has a value equal to 23.1%.

The data related to diesel consumption comes from the meter placed at the service of the supply tank. The data measured by the meter is expressed in liters; the conversion factor defined by ENEA with reference to Legislative Decree 102/2014 and equal to 0.833 kg / liter was used for the conversion into kg.

2.4. The life cycle stage

The main process includes the three main phases, UPSTREAM, CORE and DOWNSTREAM. The CORE input and output flows are the VeMe materials (raw material and primary packaging material) and the hollow finished glass respectively.

UPSTREAM PHASE

The UPSTREAM phase includes the procurement of raw materials and material for the primary packaging, all contributing to making up the material entering the production process inserted in the CORE phase.

CORE PHASE

The CORE phase includes the consumption of energy carriers (electricity, natural gas and diesel) according to the domestic energy mix, the consumption of substances for maintenance and treatments, the transport of the incoming raw material the waste produced for recovery and the waste produced. sent to the landfill.

DOWNSTREAM PHASE

The DOWNSTREAM phase includes the transport of the finished product to the customer companies and the recycling and unloading phase of the glass, following its use, once thrown into the recycling bins or into undifferentiated bins, the percentage used to calculate the value of waste-recycled glass.

3. Results and Discussion

Figure 4 shows the results of the environmental performance splitting the main environmental indicators between PRE phase and POST phase. PRE phase refers to the LCA of the whole current production process; POST phase refers to the scenario with the increasing of 50% of cullet post consumer from regional supply. This means that from 57,536,013,11 kg (as reported in table 1) of cullet current used in the production activity it has gone to 115,072,027,40 equal to 64% of the total of raw materials. The other raw materials have been reduced in proportion with the average composition of the raw material used by the company. From technological point of view this scenario is plausible given that the furnace can be fed with more than 70 % of cullet (personal communication by the plant manager of the VeMe company). This hypothesis is valid considering that are over 84,000 t of post-consumer cullet is available in the Apulia region from the separate collection. This is equal to 21 kg/per person of cullet yearly collected in this region.

For the GWP environmental indicator, the greater weight of the impact is represented almost equally using energy vectors (CORE phase) and by the supply of the raw material calcium carbonate (UPSTREAM phase), followed by the supply of soda always relative to the UPSTREAM phase.

These results can be useful for a pre-revamping analysis to implement some technological innovations. As above underlined, on the basis on our hypothesis (increasing share of cullet to more than 60%), the environmental impacts have been calculated for comparison with the current data.

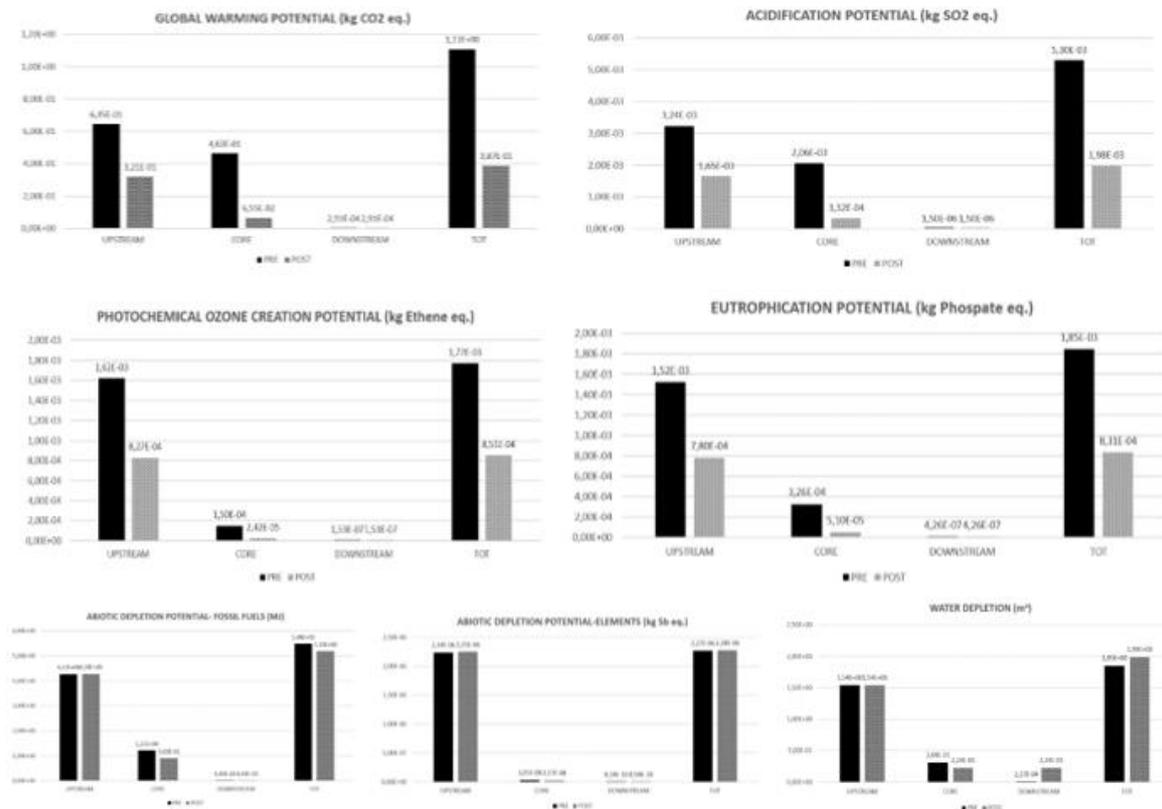


Figure 4: LCA comparison between scenario PRE (current production system) and POST (scenario with the increasing of 50% of cullet post consumer from regional supply)

It emerges a GWP reduction, due to a decrease of raw materials and road transport and to the energy requirements for glass melting (Blengini et al, 2012), above all in the upstream and core phases, as figure 4 shows. The results related to energy savings are in line with other studies, which illustrated that every 10% replacement of the sand mixture, soda and some oxides with glass cullet saves 2.5% of the energy needed for the chemical transformation that takes place in the melting furnace (Gallego-Schmid et. al, 2018; Vellini et al, 2009).

It must be stressed as the improvement of the separated collection rate can useful affect the regional supply of the glass cullet. So, the challenge will be to implement the circular economy cluster at regional or provincial level, where the urban waste become the inputs of the production cycles.

4. Conclusions

The carried-out analyses show that the use of glass cullet instead of raw materials enhances the main environmental performance indicators, above all if cullet is recovered in the regional territory. Furthermore, the reduced use of soda (sodium carbonate), calcium carbonate and dolomite (calcium carbonate and magnesium) thanks to the proportional increasing of the cullets materials saves the amount of “indirect” energy required for preparation of the vitrifiable mixture. Other important aspect is related to reduction of the transport of raw material (sand and soda) by the ship. The advantage of the cullet from regional supply reduces dramatically the ratio tons/km with important benefits on the environment. The main disadvantage of cullet procurement is the associated with the quality of the product. It is important to select cullet without contamination avoiding glass from solar panels or flat glass because if not removed could affect negatively the batch stream.

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