# Analysis of the life cycle of Cork, Aluminium and Plastic Wine Closures

CORTICEIRA AMORIM, SGPS, SA

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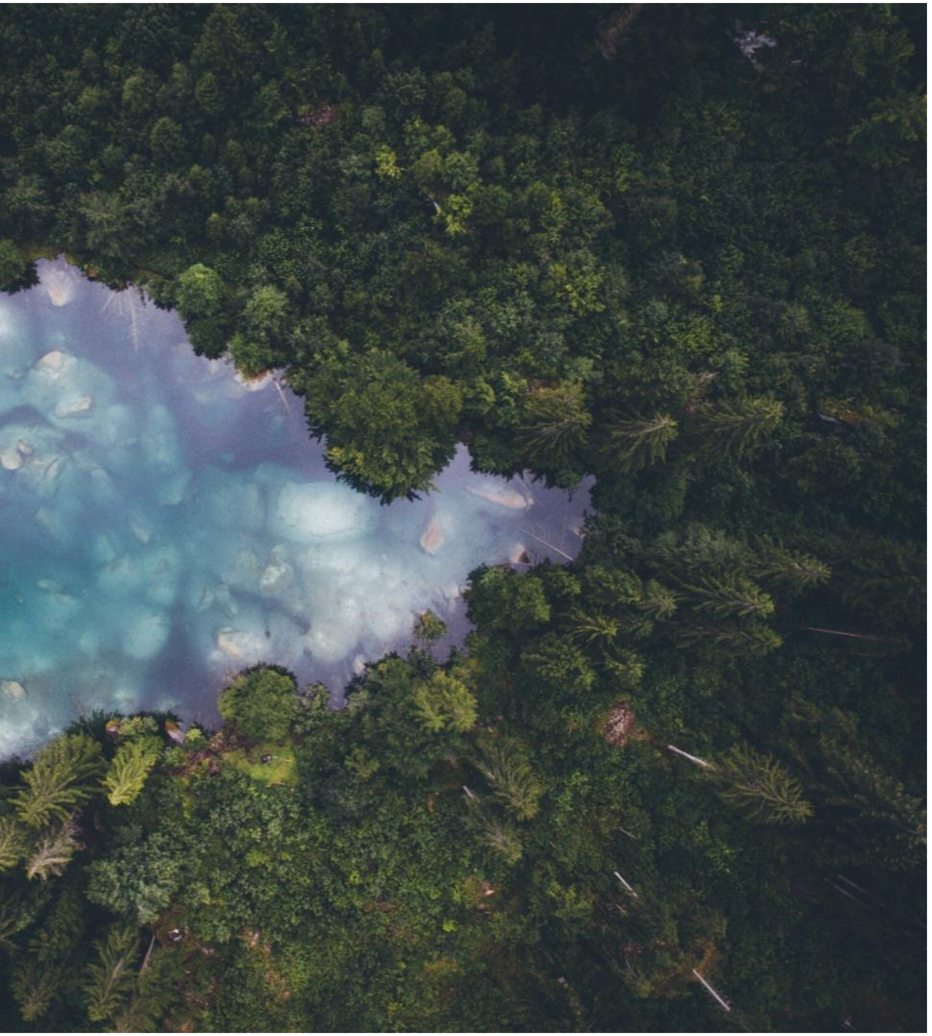
pwc

# Contents





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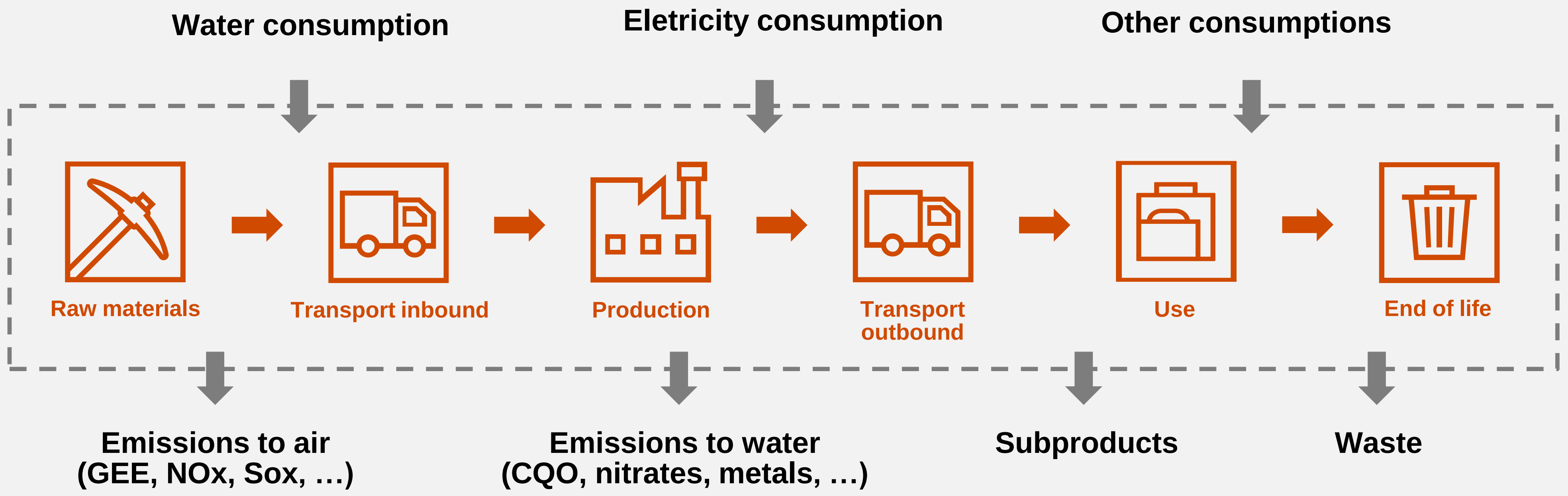
We would remind you that this survey is based solely on the facts, circumstances and hypotheses submitted to us and which are specified in the report. If these facts, circumstances or hypotheses differ, our conclusions are liable to change.
In addition, the results of the survey should be considered in their entirety in respect of the hypotheses, and not taken in isolation.

# 1 Introduction

# Introduction

## What is an LCA

- LCA is  a method for assessing the environmental aspects and potential impacts associated with a product system throughout its life cycle.
- Life cycle thinking: compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product.
- The LCA tool is an ally of the **Circular Economy (CE)**, so in addition to quantifying and interpreting, it allows you to compare the solutions and the most viable path with the aim of maximizing environmental and financial performance.



# Introduction

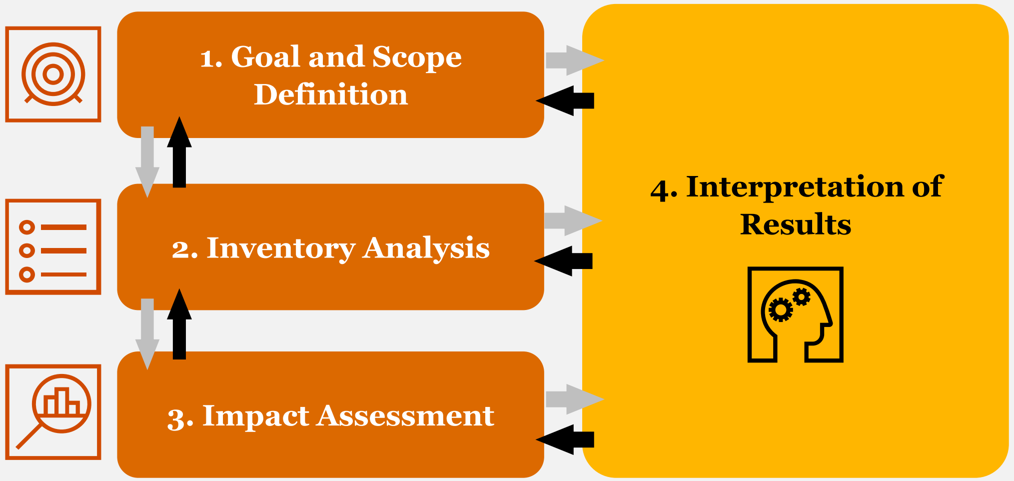
## LCA: Methodology

The practice of LCA follows a set of international procedural guidelines established in ISO standards and other standards, which describe the options for developing a life cycle analysis, with their use guaranteeing the credibility of this type of studies.

**ISO 14040:2006**
Principles and Methodology

**ISO 14044:2006**
Requirements and Guidelines

- Definition of the objective and scope of the LCA
- Life Cycle Inventory Analysis (ICV) Phase
- Life Cycle Impact Assessment (LCIA) Phase
- Life cycle interpretation phase
- LCA Report and Critical Review
- Limitations of LCA
- Relationship between LCA phases
- Conditions for using value choices and optional elements.



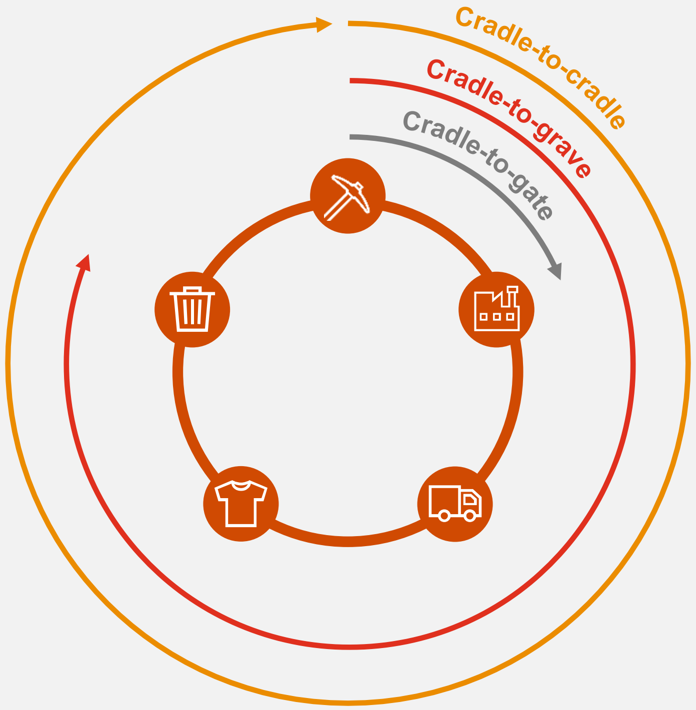

These phases are iterative, as each stage utilizes the outcomes of the other stages.

**Critical review:** process of ensuring consistency between an LCA and the principles and the requirements of the International Standards on life cycle assessment. According to ISO 14040 guidelines, this study was submitted to a critical review by an independent committee.

# Introduction

## LCA: Approach

### Approach




**Cradle-to-gate** → Cradle-to-gate evaluates a product until it leaves the factory gates before being transported to the consumer, that is, it does not take into account the use and end-of-life phases. This analysis can significantly reduce the complexity of an LCA and thus create insights more quickly, especially about internal processes, and are often used for environmental product declarations (EPD).

**Cradle-to-grave** → Cradle-to-grave is the most adopted methodology and addresses the entire product life cycle, including the downstream transport phase, use phase and end-of-life phase of the product.

**Cradle-to-cradle** → Cradle-to-cradle is a concept often referred to in EC. It is a variation of cradle-to-grave, exchanging the waste stage for a recycling process that makes it reusable for another product, resulting in “closing the cycle”. It is also called closed-loop recycling.

# Introduction

## Context of the survey

**Corticeira Amorim** is the largest cork processing group in the world and the largest **producer**, supplier and distributor of cork stoppers worldwide.

For centuries, cork stoppers have been the closures of wine bottles. In the XXth century, synthetic products emerged and aluminium and plastic closures were the newcomers to the market of wine bottle closures.

- In 2008, Corticeira Amorim has requested the aid of **PwC/Ecobilan** to quantify and compare the environmental impacts of cork stoppers versus aluminium and plastic closures on the UK market of wine. This study aims to update the previous study and natural stopper's environmental impact taking in to consideration that the natural cork stopper has undergone changes in manufacturing process:
  - inclusion of new processes like TCA (trichloroanisole) treatment and detection
  - automatic sorting
  - refrigeration of the cork storage stage
  - automatic slicing and drilling
  - vaporization and humidification of industrial areas

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# LCA Study

# LCA Study

## Objectives

### Study Goal

**Evaluation of the environmental impacts of Cork Stoppers versus Aluminium and Plastic Closures:**

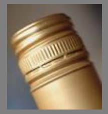
- Identify opportunities to improve the environmental performance of cork stoppers.
- Provide additional information to the wine industry, namely to wineries that want to have a responsible and environmentally friendlier choice.
- Prepare a firm and quantified argument on which Corticeira Amorim can call when comparing cork stoppers with alternative materials.

### Study Scope

- The functional unit considered on this survey is sealing a standard bottle of wine bottled sold on the UK market. The results are presented using one thousand wine closures as the reference flow.
- Three wine closures were studied in this LCA:
  - Natural cork stopper produced by Corticeira Amorim;
  - A typical aluminium closure;
  - A typical plastic closure.
- This is a Cradle-to-grave study.

# LCA Study

## Products studied

| | Closure | | |
|---|---|---|---|
| |  Cork Stopper |  Typical Aluminium Closure (same as in 2088 study) |  Typical Plastic Closure (same as in 2088 study)* |
| **Name** | Natural cork | - | - |
| **Producer** | Amorim Cork | - | - |
| **Place of production** | Portugal - Santa Maria de Lamas | France (East of France) | Belgium |
| **Dimensions (mm x mm)** | 45 x 24 | 60 x 30 | 43 x 22 |
| **Weight (g)** | 3.87 | 4.6 | 6.2 |
| **Composition** | 100% Cork | 89.9% Aluminium<br>7% Expanded PET –2% TIN<br>0.5% Kraft<br>0.6% PVDC | 68% Low Density Polyethylene (LDPE)<br>16% High Density Polyethylene (HDPE)<br>16% Polypropylene (PP) |

* Plastic closures include interior foam (LDPE) and an external layer, composed by a mixture of HDPE and PP. Information on the precise composition of the external layer of the closure was not available, since the patent of the closure refers the inclusion of High Density Polyethylene and Polypropylene, but not the corresponding percentages. In this study it has been considered that this layer is a compound of 50% High Density Polyethylene and 50% Polypropylene.

# LCA Study

**Boundaries of systems studied**

The life cycle systems for each wine closure considered (cork, aluminum and plastic) were divided according to a common structure for all closures, composed of the following subsystems:

1. Production of raw materials;
2. Transport of raw materials
3. Production of closures;
4. Transport of closures;
5. Bottling;
6. Use of closures;
7. End-of-life.

Energy consumption associated to bottling activities was not considered for any of the types of closures considered, due to lack of information.

The life cycle phase corresponding to the use of the closures by the consumers was not considered for any of the studied closures, since it is not associated to significant environmental impacts and is expected to be very similar for the three materials.

Ageing of wine was not taken into account in this study, a normal conservation time before consumption was considered. As mentioned, it was also considered that all closure systems have the same level of performance regarding TCA or other quality problem (oxygenation for example).

# LCA Study

## Peer Review

According to ISO 14040 guidelines, the study was submitted to a critical review by an independent committee including the following external experts:

- An independent life cycle analysis (LCA) expert (Mr. Guy Castelan)
- An independent packaging and recycling expert (Mr, Carlos de Los Llanos)
- An independent cork forestry expert (Mr. Filipe Costa e Silva, from Instituto Superior de Agronomia of Universidade Técnica de Lisboa);

The results of the critical review of the LCA report were considered at the final version of the report and included in the LCA report, together with answers from PwC.

# LCA Study

## Environmental indicators

To evaluate the potential impacts of natural and synthetic wine closures on the environment, the survey included the analysis of seven indicators:

- Non-renewable energy consumption
- Emission of greenhouse gases
- Water consumption
- Production of solid waste
- Contribution to the formation of photochemical oxidants
- Contribution to atmospheric acidification*
- Contribution to the eutrophication of surface water

**Indicators were chosen taking into consideration the following:**

- They represent the most typical and well-known indicators for LCA;
- They evaluate the most important environment impacts for the stoppers production activity;
- Indicators that were selected by similar studies done (e.g., Life Cycle Assessment of a single-piece natural cork stopper for oenological use, described in the previous 2008 survey).

* The LCA impact indicator method for atmospheric acidification was updated when comparing with 2008 analysis, namely ir was previously expressed in g. eq. H+ and is currently expressed in g. eq. SO2, according to current best practices

# LCA Study

## Wine closures model

| | CORK CLOSURE | PLSTIC CLOSURE | ALUMINIUM CLOSURE |
|---|---|---|---|
| **Production** | raw materials, stopper production, finishing | raw materials production | raw materials production, |
| **Transport** | all the transportation into the production process to the bottling centers | transport from stoppers producer to the bottling centers | transport from stoppers producer to the bottling centers |
| **Bottling** | PVC cover | PVC cover | Not considered |
| **End of life** | 1.2% recycled<br>98.8% landfill | 19% recycled<br>81% landfilled | 28% recycled<br>72% landfilled |

# LCA Study

## Methodology

**SOFTWARE**

- The TEAM™ software was used to model the systems and calculate ACV inventories and environmental impacts.

**INFORMATION**

- In this survey, was not used information supplied by the producers of aluminium and plastic closures.
- Regarding cork stoppers, most of the data was obtained using actual data from Corticeira Amorim's industrial units and TEAM™ database, and, if not available, internet research was the method used for collecting information.

**ASSUMPTIONS**

- The biogenic carbon associated to cork stoppers was considered, since this is directly related and integrated into Corticeira Amorim's products.
- The worst case scenario approach for cork stoppers was considered; this remark is mainly applicable for the comparison of cork and the environmental performances of aluminum and plastic closures.
- It was considered a scenario of plastic recycling, meaning that there is a beneficial impact related to avoiding the production of virgin plastic granules.
- In the case of aluminium, this beneficial impact is included in the model through the introduction of recycled aluminium as a secondary material for food packaging products.

# LCA Study

## List of excluded life stages

### Due to lack of information In the public domain

- Paints used in PVC covers for cork and plastic closures.
- Energy consumption in bottling activities, for all types of closures.
- For aluminium and plastic, production of closures was not included. This survey only includes the production of the necessary intermediate and raw materials.

### Due to methodological reasons

- Final destination and transportation of wastes.
- Transport after the bottling site since this will be the same for the three kinds of closures.

### Due to having negligible impacts

- The construction of buildings on industrial sites and fabrication of tools and machines.
- The transport of workers related to the extraction of raw materials, for all types of closures considered.
- Energy consumption in administrative areas and laboratory, for all types of closures studied.

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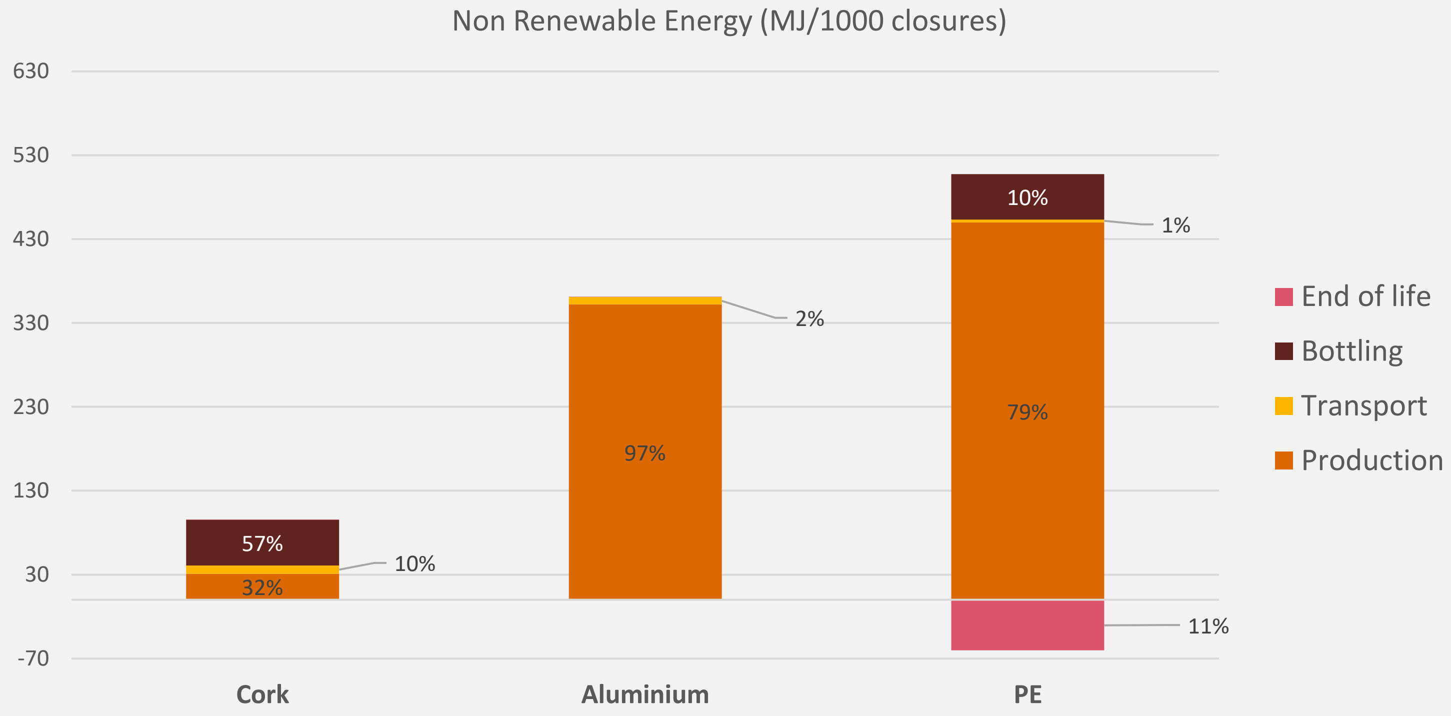
# Results

# Results

## Non-renewable energy consumption

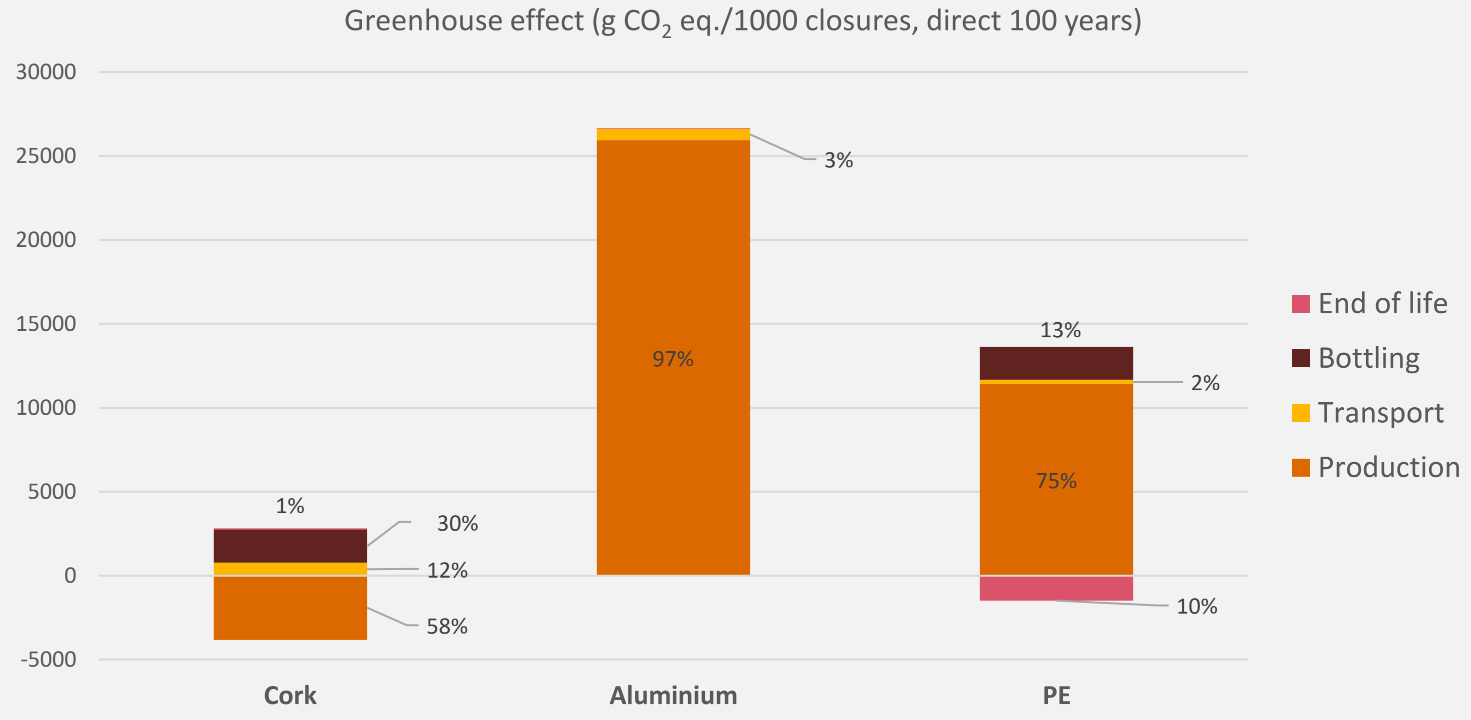



The beneficial impact in terms of non-renewable energy consumption associated to plastic closures is due to the fact that in this survey we are considering a scenario of plastic recycling, meaning that there is a beneficial impact related to avoiding the production of virgin plastic granules (more than 10%).

- Aluminium and plastic closures have significantly higher non-renewable energy consumption, when compared with cork stoppers. This is mainly due to energy consumed for the production of raw materials (aluminium and different types of plastic) used by aluminium and plastic closures.
- Bottling represents for cork stoppers the major part of the energy consumed (57%).

# Results

## Emission of greenhouse effect gases



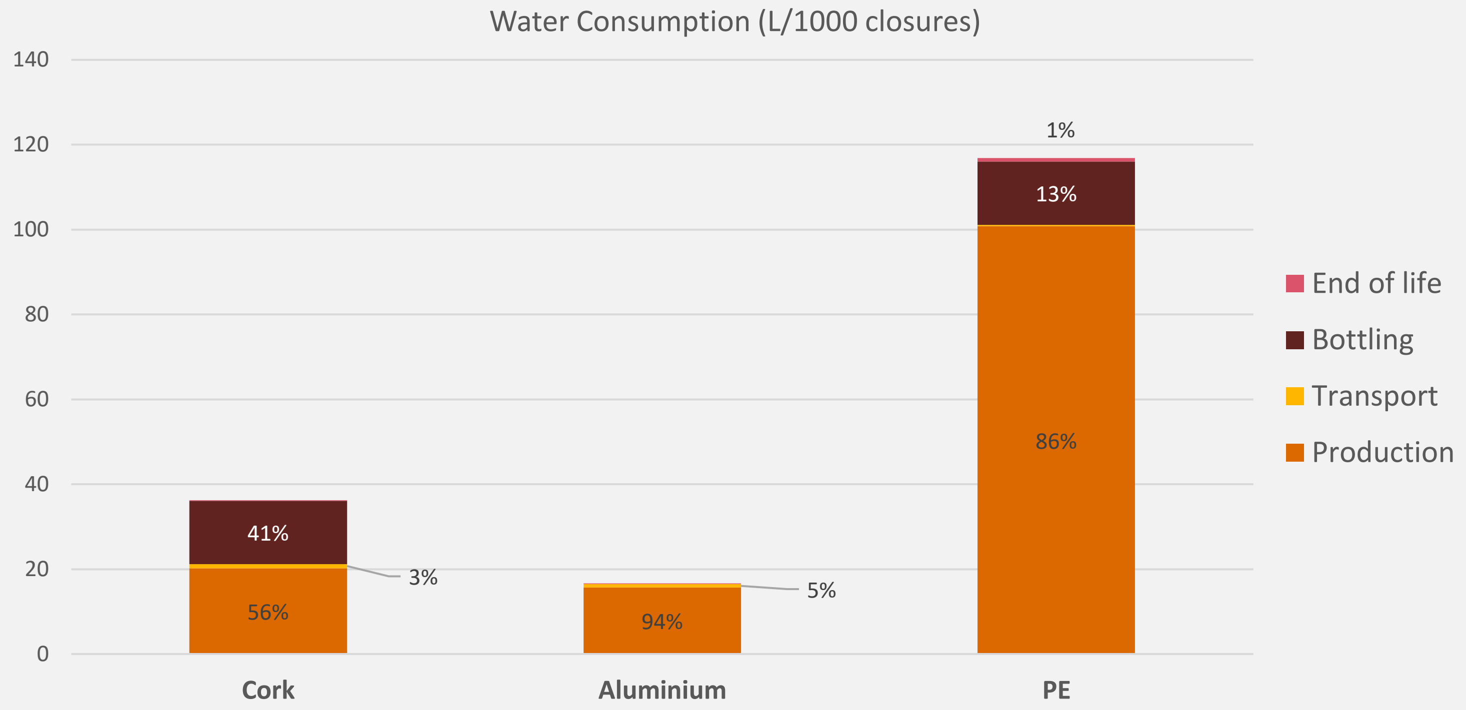

The beneficial impact in terms of emission of greenhouse effect gases associated to plastic closures is due to the avoidance of production of virgin plastic as a consequence of plastic recycling (around 10%).

The beneficial impact in terms of emission of greenhouse effect gases associated to cork stoppers is due to the carbon intake during cork growth (58%).

- Aluminium closures are associated to the highest greenhouse effect gases emissions, followed by plastic closures. Emissions associated to cork stoppers are significantly lower.
- Bottling represents for cork stoppers a major part of the greenhouse effect gases emissions (70%, regarding the total negative impacts).

# Results

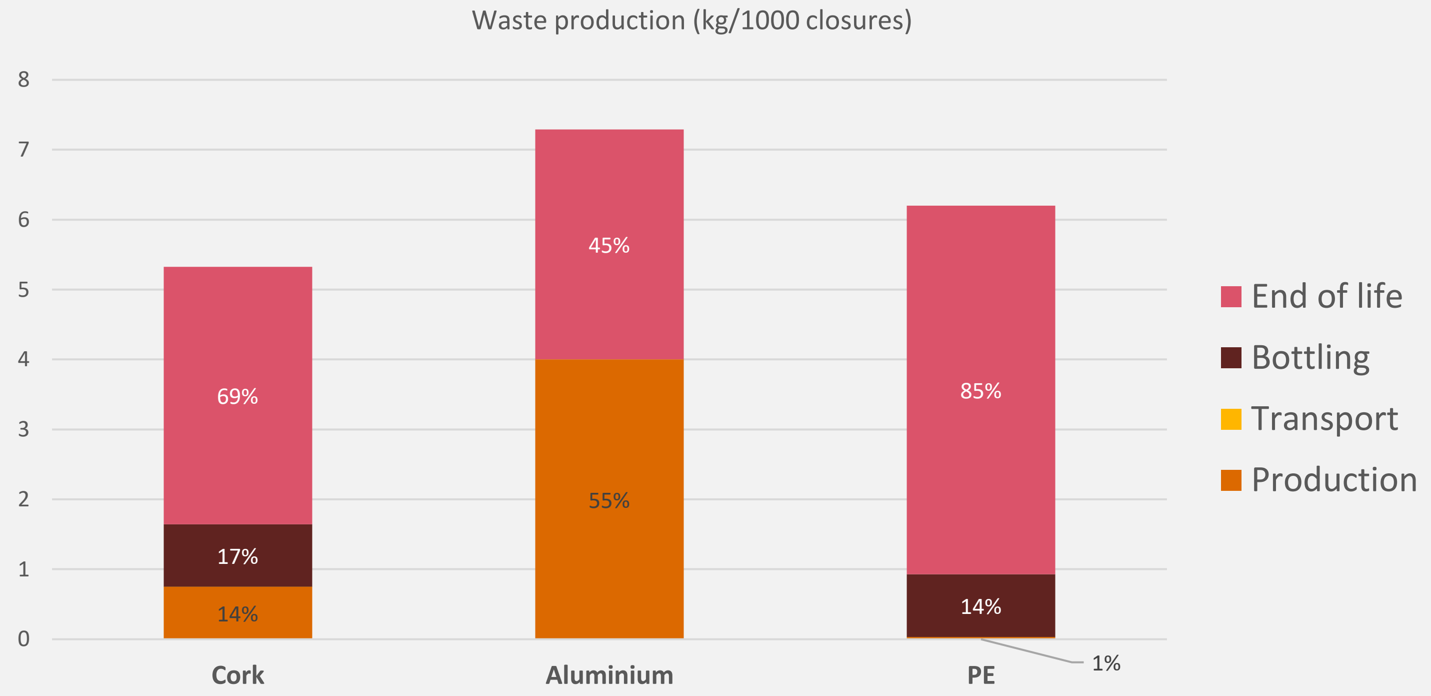
## Water consumption




- Plastic closures show the biggest water consumption of all three closures. Water consumption in production phases is similar for cork and aluminium closures, and significantly higher for plastic closures.
- Water consumption associated to bottling in the case of cork and plastic closures results from high water consumption associated to the production of PVC (around 14 litres for 1kg of PVC) that is used for the PVC cover at the bottling stage.

# Results

## Production of solid waste

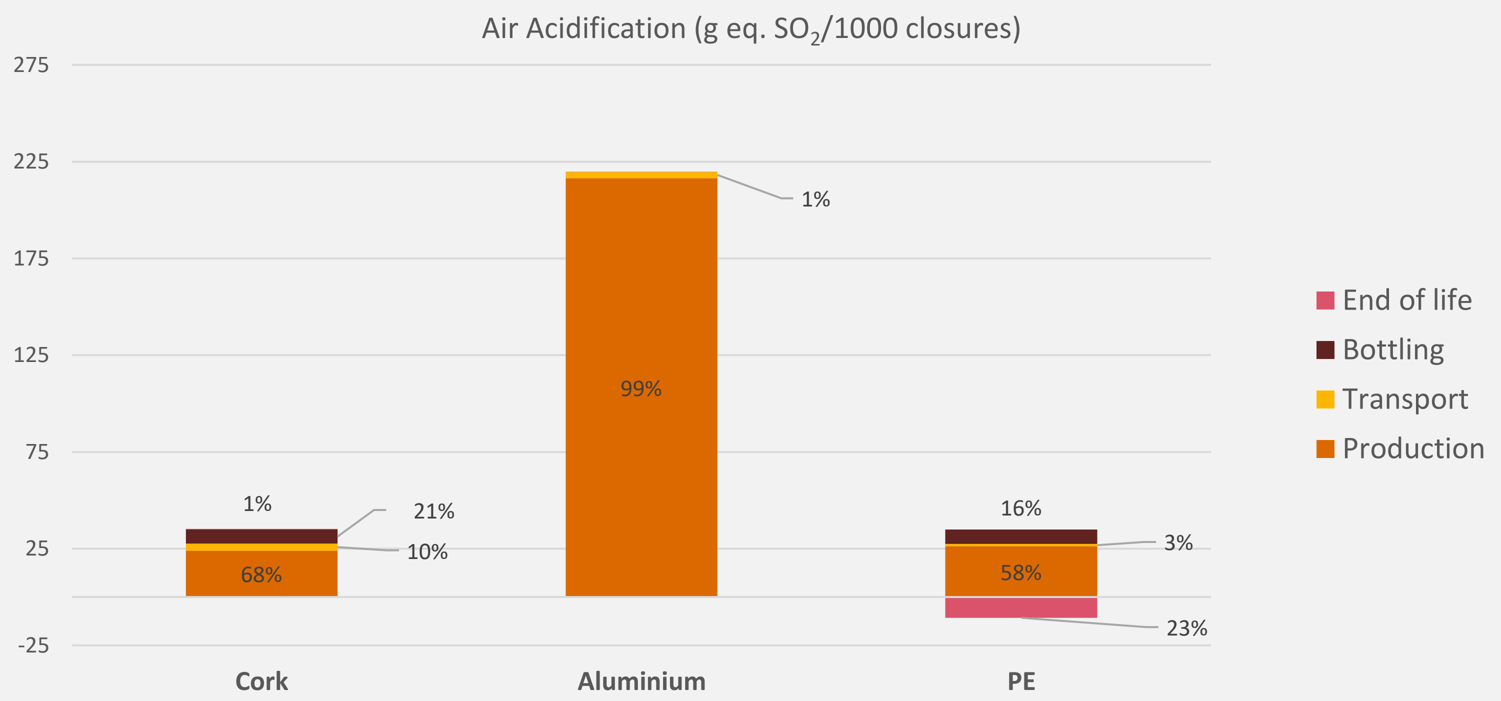



Regarding cork and plastic closures, post-consumer end-of-life phase is the most relevant in term of production of solid waste, whilst the rest of the phases are less relevant, representing only 31% and 15% of cork and plastic closures total waste produced, respectively.

- Aluminium closures are the biggest producers of solid waste, followed by plastic and cork closures.
- In the case of aluminium closures, production phase and end-of-life are the phases responsible for the major production of solid waste. When compared with cork and plastic closures, production of waste at the production phase in the case of aluminium is significantly higher.

# Results

## Contribution to atmospheric acidification *



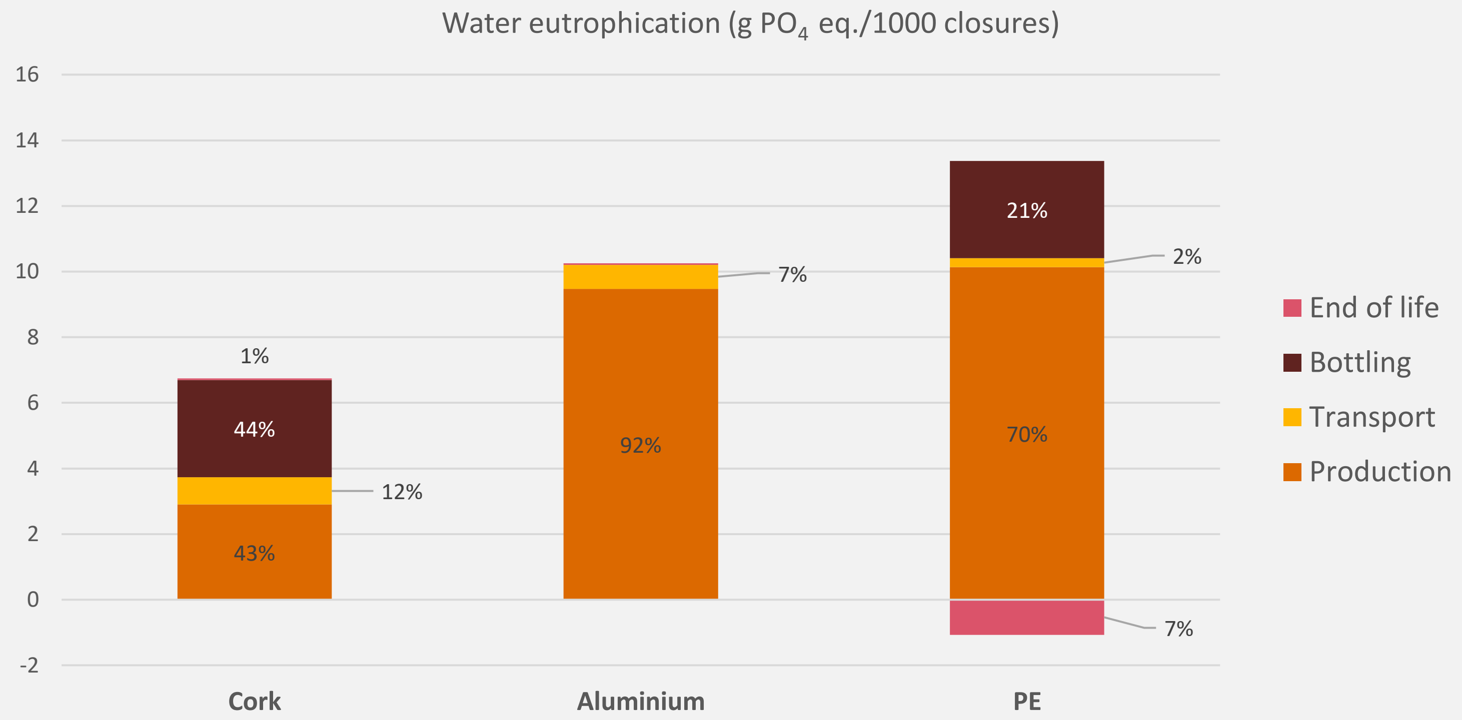

The beneficial impact in terms of atmospheric acidification associated to plastic closures is due to the avoidance of production of virgin plastic as a consequence of plastic recycling (23%).

* The impact indicator method for atmospheric acidification was updated when comparing with 2008 analysis, namely ir was previously expressed in g. eq. H+ and is currently expressed in g. eq. SO2, according to current best practices

- From the analysed materials, aluminium closures are the biggest contributors to atmospheric acidification, followed by cork stoppers and by plastic closures.
- Production represents, for cork stoppers, the major part of contribution to atmospheric acidification (68%).
- The plastic closure impact on air acidification has significantly decreased as a result of improvements related to impact modules related to gas treatment and fossil fuel extraction.

# Results

## Contribution to the eutrophication of surface water

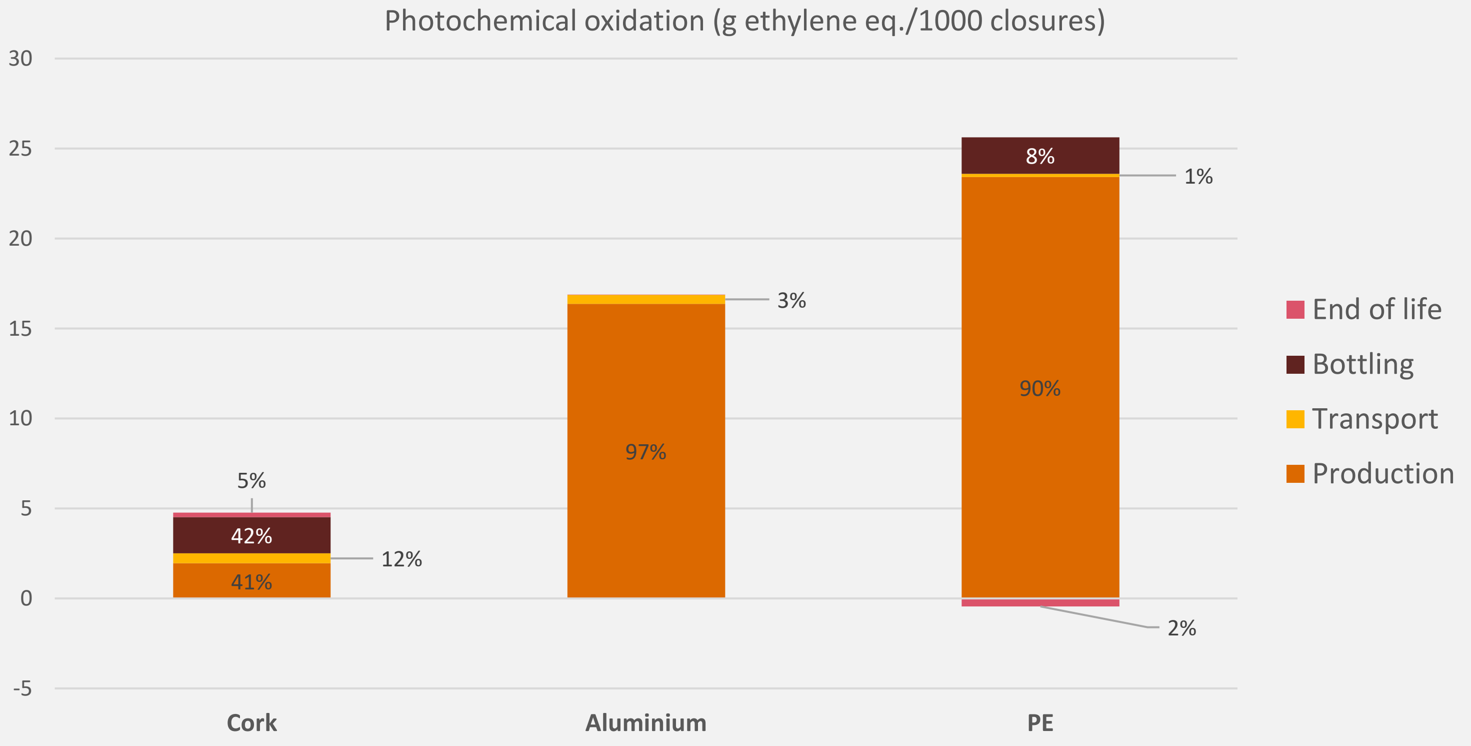



The beneficial impact in terms of eutrophication of surface water associated to plastic closures is due to the avoidance of production of virgin plastic as a consequence of plastic recycling (around 7%).

- Plastic closures are the biggest contributors to water eutrophication, followed by plastic and cork closures.
- Production phase is for the aluminium closures the most relevant in term of contribution to the eutrophication of water (representing 92%).
- Bottling phase is for the cork the most relevant in term of contribution to the eutrophication of water, representing 44%, followed by the production phase with a total of 43%.

# Results

## Contribution to the formation of photochemical oxidants




The beneficial impact in terms of formation of photochemical oxidants associated to plastic closures is due to the avoidance of production of virgin plastic as a consequence of plastic recycling, which is not that significant (2%).

- From the analysed materials, plastic closures are the biggest contributors to the formation of photochemical oxidants, followed by aluminium closures and by cork stoppers.
- Bottling represents, for cork stoppers, a major part of the contribution to the formation of photochemical oxidants (42%).

# Results

## Sumary of Results

| Environmental Indicator | Type of stopper | | |
|---|---|---|---|
| | Cork Stopper | Aluminium closure | Plastic closure |
| **Non-renewable energy consumption (MJ/1000 closures)** | 95.73 | 361.15 | 447.31 |
| **Water consumption ($m^3$ / 1000 closures)** | 36.28 | 16.65 | 116.84 |
| **Production of solid waste (kg / 1000 closures)** | 5.33 | 7.29 | 6.20 |
| **Contribution to atmospheric acidification (g $SO_2$ eq. / 1000 closures)** | 35.19 | 219.78 | 24.15 |
| **Contribution to the formation of photochemical oxidants (g ethylene eq. / 1000 closures)** | 4.77 | 16.88 | 25.18 |
| **Contribution to the eutrophication of surface water (g phosphates eq. / 1000 closures)** | 6.75 | 10.25 | 12.30 |
| **Emission of greenhouse gases (g $CO_2$ eq. / 1000 closures)** | -961 | 26642 | 12132 |

Best Performance
Performance poorer by less than 20% in relation to best performance
Performance poorer by at least 20% in relation to best performance

# Results

## Summary of the relative performances of the closures

| Environmental Indicator | Type of stopper | | |
|---|---|---|---|
| | Cork Stopper | Aluminium closure | Plastic closure |
| **Non-renewable energy consumption** | 1.00 | 3.77 | 4.67 |
| **Water consumption** | 2.18 | 1.00 | 7.02 |
| **Production of solid waste** | 1.00 | 1.37 | 1.16 |
| **Contribution to atmospheric acidification** | 1.46 | 9.10 | 1.00 |
| **Contribution to the formation of photochemical oxidants** | 1.00 | 3.54 | 5.28 |
| **Contribution to the eutrophication of surface water** | 1.00 | 1.52 | 1.82 |
| **Emission of greenhouse gases** | 1.00 (-961 g $CO_2$ eq. / 1000 closures) | +∞ (26642 g $CO_2$ eq. / 1000 closures) | +∞ (18132 g $CO_2$ eq. / 1000 closures) |

Best Performance (green)
Performance poorer by less than 20% in relation to best performance (orange)
Performance poorer by at least 20% in relation to best performance (red)

Cell colours: Non-renewable energy consumption – Cork green, Aluminium red, Plastic red; Water consumption – Cork red, Aluminium green, Plastic red; Production of solid waste – Cork green, Aluminium red, Plastic orange; Contribution to atmospheric acidification – Cork red, Aluminium red, Plastic green; Contribution to the formation of photochemical oxidants, Contribution to the eutrophication of surface water and Emission of greenhouse gases – Cork green, Aluminium red, Plastic red.

# 4 Conclusions

# Results

## Industrial stages and environmental performance

- The production phase predominates for all the indicators considered (except for solid waste production, where end of life phase predominates).
- Environmental impact associated to the production phase is significantly higher for **aluminium** and **plastic** than for cork closures, for almost all the environmental impact categories studied. This is due to the high impact of production of aluminium and plastic, when compared with cork stoppers.
- Bottling has similar impact for cork and plastic closures, since the bottling processes are identical. In the case of cork stoppers, this phase of the life cycle has a high environmental impact, specially in water eutrophication and greenhouse effect, mainly associated to the PVC cover. The utilization of a capsule over a cork stopper or plastic stopper is optional, depending on client requirements.
- Transport has a minor impact in the total emissions for the three type of closures, when comparing with other phases.
- Regarding recycling rates, in the case of cork stoppers the recycling rate is marginal. Corticeira Amorim is reinforcing and expanding existent collection programs, with the aim of increasing this rate, which represents an opportunity for improvement of cork stoppers performance.
- In conclusion, for the market and packaging application considered, the cork stopper is the best alternative in terms of non-renewable energy consumption, emission of greenhouse effect gases, contribution to the formation of photochemical oxidants, contribution to the eutrophication of surface water and total production of solid waste.