COMPARATIVE ASSESSMENT OF THE LIFE CYCLES OF BLISTER PACKS AND ALTERNATIVES

REPORT Final version of 20/06/2025

COMMISSIONER OF THE LCA STUDY:

Chloé SABATHIER - Packaging R&D Manager
chloe.sabathier@citeo.com

Marie LEMOINE - Eco-design engineer
marie.lemoine@citeo.com

EVEA CONTACTS:

Mathieu SOUHIL - LCA and eco-design project manager
m.souhil@evea-conseil.com

Robin SALES - Senior LCA and Eco-design Consultant
r.sales@evea-conseil.com

Axel MARQUES - Junior LCA and eco-design consultant
a.marques@evea-conseil.com

*LCA in accordance with international standards ISO 14040, ISO 14044 and ISO 14071
Document finalised and approved by the critical review panel on 20/06/2025

1

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

READING GUIDE

READING:

In the following report, 2.53E-06 should be read as .$2,53 \times 10^{-6}$

ABBREVIATIONS:

CFP	Call For Projects
LCA	Life Cycle Assessment
SA	Sensitivity Analysis
CFF	Circular Footprint Formula
NMVOCs	Non-methane Volatile Organic Compounds
CTUh	Comparative Toxic Unit for humans
EF	Environmental Footprint
ICP	Industrial and Commercial Packaging (secondary and tertiary packaging)
LCIA	Life Cycle Impact Assessment
EOL	End Of Life
SF	Secondary Function
IPCC	Intergovernmental Panel on Climate Change
LCI	Life Cycle Inventory
ILCD	International Reference Life Cycle Data System
JRC	Joint Research Centre
LHV	Lower Heating Value
WMO	World Meteorological Organisation
LDPE	Low-Density Polyethylene
HDPE	High-Density Polyethylene
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint; Category Rules
PET	Polyethylene Terephthalate
PP	Polypropylene
PPWR	Packaging and Packaging Waste Regulation
PU	Polyurethane
EPR	Extended Producer Responsibility
FU	Functional Unit
CSU	Consumer Sales Unit

1 INTRODUCTION

1.1 GENERAL ASPECTS

CITEO is a private, not-for-profit company specialising in the recycling of household packaging and graphic paper under the concept of "Extended Producer Responsibility" (EPR). This allows companies in the sector to delegate this obligation to a government-approved eco-organisation, in this case CITEO. CITEO's activity is therefore regulated by State approval. Its main mission is to reduce the potential environmental impact associated with packaging by offering recycling, sorting and reuse solutions to the players involved, and by supporting them in their eco-design initiatives.

In anticipation of the forthcoming PPWR (Packaging and Packaging Waste Regulation) deadlines, which aim not only to improve the recyclability of packaging but also to ban non-recyclable packaging by 2030, CITEO wishes to identify alternatives to **PET/cardboard blister packaging**. This packaging, which is widely used for stationery, toothbrushes and DIY items, will probably not be recyclable by 2030 (according to PPWR criteria). At present, there is still uncertainty surrounding the definition of packaging that will be considered recyclable. This definition will be given definitively by 2028, but in the meantime, it is possible to identify the most relevant alternatives that could replace cardboard/PET blisters. This is why it is essential to study and **compare the environmental performance of the alternatives that could replace these blisters**. These alternatives must be recyclable and have a lower environmental impact than the reference blister pack.

CITEO commissioned EVEA to carry out a comparative life cycle analysis (LCA), subject to critical review, between the PET/cardboard blister pack and its potential alternatives already on the market or under development. One of the aims of this project is to highlight the environmental impact of the various solutions to CITEO's customers and, ultimately, to consumers.

The objectives of this LCA are:

1) *Quantify the environmental impact of PET/cardboard blister packaging and the alternatives studied, considering the stages in the complete life cycle of each system studied, using an overall analysis by packaging category (also known as a helicopter analysis), rather than packaging by packaging without distinguishing between categories.*
2) *Compare these impacts to identify the solution(s) offering improved environmental performance and recyclability in line with legislation that applies (or may apply) between now and 2030. This comparison considers the primary function of this type of packaging, but the interpretations and conclusions also consider the nuances provided by the secondary functions in relation to the sector's issues. These secondary functions will be developed later in the report, but the presentation of the results (no graphs and detailed interpretations in this section) provides all the information readers need to make the comparisons in their own specific case.*
3) *The results, interpretations and conclusions of this study can be communicated to the public by* CITEO, *according to 2 targeted audiences detailed in* *Section 1.2.2.*

CITEO is actively involved in encouraging marketers to reduce the impact of packaging on issues such as climate change and resource consumption.

The PET/cardboard blister packs and alternatives analysed in this study are therefore different types of packaging with varying compositions, used to contain and protect small and medium-sized items sold in supermarkets, such as mainly non-food stationery, oral hygiene products, hardware items, etc...

This LCA study was conducted in anticipation of the **PPWR's ban on marketing non-recyclable packaging by 2030**. One of the PPWR's notable obligations is the requirement for packaging to be designed for recyclability and for the minimum threshold for material recovery through recycling to be increased to 70%. PET/cardboard blister packs may not meet these minimum requirements, which could result in them being banned from the market in 2030.

CITEO therefore wishes to assess the potential environmental impact of the alternatives and then launch a call for projects based in part on the results of the LCA. The aim of this call for projects will be to help marketers of products - who are CITEO's direct customers - that use PET/cardboard blister packs to redesign their blister packs or to use the alternative packaging presented here, while considering changes in the PPWR. **However, as of Q2 2025, the methodology for defining a level of recyclability according to the PPWR is not yet known. It will not be known until 2028.**

One of the key issues in this study is the volume packed, since it is on this parameter that the functional unit is based and drives the results. The FU is discussed in more detail in Section. 2.2.1

In this study, some of the packaging studied is already on the market, while others are only at the prototype stage: 2.2, 3.4, 6.1, 8.2 (seeTable 3). However, these are not prototypes at the R&D stage, but packaging that has been developed and is ready for sale. On the latter, only the graphic finishing elements are missing, which have nevertheless been modelled.

CITEO therefore wishes to compare the PET/cardboard blister pack with 9 types of alternative packaging, the general characteristics of which are presented inTable 1 below. In addition, several types of packaging are studied by type (or by "family" or "category"), where possible, to identify trends by packaging family and not in relation to a particular sample. In the first column, N represents a natural number and allows each sample to be identified by a numerically. For example, for the first family, there are 5 samples, all numbered from 1 to 5 so that they can be clearly identified. The penultimate column gives information on the theoretical suitability for recycling of the packaging proposed.

Nomenclature	Type of packaging (family)	Composition details	Mass (g)	Packaged volume (cm3)	Recyclability of packaging in 2030	Packaging illustration (non-contractual)
1.N $N \in [\![1;5]\!]$	**PET/cardboard blister pack**	PET shell Flat cardboard base	17 à 102	25,1 à 352,0	No (with a few exceptions)	

Nomenclature	Type of packaging (family)	Composition details	Mass (g)	Packaged volume (cm3)	Recyclability of packaging in 2030	Packaging illustration (non-contractual)
2.N $N \in [\![1;6]\!]$	**Reverse blister pack**	Flat cardboard shell and base	18 à 89	56,0 à 436,6	Yes	
3.N $N \in [\![1;5]\!]$	**Cardboard case**	Folded flat cardboard	25 à 129	85,4 à 902,7	Yes	
4.1	**Card + strap**	Flat cardboard base Nylon tie (clamp)	49	105,5	Yes	
5.1	**Moulded cellulose**	Cellulose shell PET lid	45	146,5	Yes	
6.1	**Opaque flexible paper flowpack[1]**	Paper HDPE film PU glue	19	149,0	Yes	

[1] The 6.1 pack contains 80% paper and 20% plastic, which complies with the PPWR minimum of 70% paper for this type of pack.

Nomenclature	Type of packaging (family)	Composition details	Mass (g)	Packaged volume (cm3)	Recyclability of packaging in 2030	Packaging illustration (non-contractual)
7.1	**Transparent flexible paper flowpack** [2]	Paper PP Film PU glue	19	126,0	Yes	
8.N $N \in [\![1;4]\!]$	**PP flexible flowpack**	PP Film PU glue	18 à 71	85,4 à 700,0	Yes	
9.N $N \in [\![1;2]\!]$	**Bulk without display**	Flat cardboard box for transport,	41 and 114	500.0 and 1120.0	Yes	
10.1	**Bulk with display**	Flat cardboard box for transport and display	144	1365,0	Yes	

Table 1 General characteristics of the different types of packaging studied

NB: the photos are illustrations only and are not the actual products used in the study.

This LCA only studied single-use packaging, not re-use solutions. The main reason for this exclusion is that the study focuses on assessing the environmental impact of potential replacements for the cardboard/PET blister pack, which is already widely used for packaging. Reuse solutions for this type of product (DIY products, stationery, etc.) are not yet used by marketers, which partly explains their absence from this study. Furthermore, reuse does not appear to be relevant for this type of product. These products are purchased less frequently than food products. Therefore, consumers are less likely to return these reusable packaging systems. *EVEA is positioning itself as a proactive supporter of new reusable packaging systems and can provide advanced life cycle assessments (LCAs) on these systems, as well as offering specialised LCA and eco-design tools for these new challenges.*

The aim of this study is therefore to measure the environmental performance of this packaging against a PET/cardboard blister pack reference scenario. This will enable us to identify the environmental impact of each packaging type/family, communicate the LCA results regarding different packaging functions and characteristics, and inform marketers' choices. Recommendations on the most suitable eco-design approaches for each packaging family will also be made.

[2] The same applies to the 7.1 packaging, which contains 75% paper and 25% plastic.

There is also an alternative to the PET/cardboard blister pack, which is a pack sold as an "all-PET blister pack". During the mapping of alternative solutions and data collection phase, this solution was not favoured by marketers/industrialists and we were therefore unable to collect data on this type of packaging. In addition, it should be noted that "plastic clamshell" packaging is generally made from PVC or PETg (often mixed with PET), two plastic materials which currently have no recycling pathway in Europe (and which interfere with the recycling of other resins, such as PET).

1.2 OBJECTIVE OF THE STUDY

1.2.1 THE REASONS FOR CARRYING OUT THE STUDY

CITEO commissioned EVEA to carry out this comparative LCA.

The study consists of a comparative analysis of the life cycle of different types of packaging, the main characteristics of which are presented in Table 1

The aim is to quantify the environmental impact of each packaging, at identical perimeter, for the same service provided (see functional unit), with a view to identifying the best compromise between the different functions of a packaging and its associated environmental impact.

The final objective of the study is also to enable CITEO to communicate the results of the LCA to its clients, who are the marketers using PET/cardboard blister packaging, as well as the manufacturers of these blisters and the public.

To communicate with the public, **it is necessary to draw up a full comparative LCA report, together with a procedure for critically reviewing this LCA.** The group of experts who carried out the critical review is explained in Section 2.10.

Some of CITEO's clients and market players, particularly in France, are involved in this study to guarantee the relevance of the input data, the packaging studied and the results. The information provided by these clients is anonymous and cannot be explained in this report (for example, the name of the client, the packaging reference, the brand, etc.).

1.2.2 THE APPLICATION AND THE TARGET AUDIENCE

1.2.2.1 COMMUNICATION OBJECTIVES

The aim of this study is to use the results of the potential environmental impact for external communication:

Externally, CITEO will use this report to communicate the potential environmental benefits of the best packaging typology identified compared to others. The main audience for this LCA is the product (and therefore packaging) marketers who are CITEO's clients. They will therefore be able to identify the most environmentally efficient alternatives to modify their practices and turn to the best types of packaging, considering the constraints linked to the primary and secondary functions intrinsic to each type of packaging and the content/container pairing. In addition, following this study, CITEO intends to issue a call for projects with a view to giving its customers and their packaging converters/suppliers the space and resources to achieve these objectives. In addition, this study has identified packaging converters/suppliers as a secondary audience who will benefit from the identification of eco-design strategies and levers, with a view to improving their packaging.

The proposed external communication is based on comparative statements concerning the potential main impact reductions linked to the design of the best type of packaging identified.

1.2.2.2 DETAILS OF HOW THE REDUCTION OF ENVIRONMENTAL IMPACT WILL BE COMMUNICATED

Each manufactured product has an impact on its environment, and therefore environmental impacts that may vary depending on the production zones considered. Some designs will have a lower impact than others, which may result in a lower overall environmental impact than other solutions. The reduction in impact compared with other packaging is thus identified (in % in particular) and represents what we will call the ***potential relative reduction in environmental impact compared with another system***.

The reduction in impact between the different packaging solutions (compared one by one), if expressed as a %, will be all the greater if certain stages that are identical for all the solutions have been excluded (use phase, packaging, etc.). The life cycle stages considered in this study are detailed in Section 2.

As a reminder, as with the communication elements, if the entire life cycle had been modelled, the reduction in the impact gap would necessarily have been less in relative terms, as more elements would have been included in the study and therefore the absolute impact values would have been greater.

Based on our experience, the relative difference between two solutions (for an indicator or for the single score) may be significant from 3% upwards in some cases and may not be significant from 10% upwards. In fact, depending on the products studied, the scope established, the details of the data collection, the flows modelled, and the uncertainties linked to the impact quantification methodologies, the interpretation of the relative differences in impacts must be seen on a case-by-case basis.

In other words, it is not possible to define a % deviation from which we can validate significance without carrying out in-depth analyses of uncertainties, the subject of which is developed in Section 2.8.2.8.

It is important to remember that the differences can be interpreted more simply for the same elementary flow, and that these differences (of a few % points) are significant if they are based on the quantity of the same elementary flow.

It is important to note that, to date, there is no scientific consensus on a minimum significant difference (on an indicator or on a single score) that would allow us to say that one product is more virtuous than another on a particular indicator.

In addition, for the freshwater ecotoxicity indicator, the difference between the absolute values of 2 products or substances must be greater than 10^4. If this criterion is not met, the conclusions are neither reliable nor relevant for this impact indicator. The 10^4 factors in the USETox[i] report applies to the comparison of two substances, but less so to life cycle assessment (because this threshold applies to an absolute comparison and not a relative one). This is why EVEA is arbitrarily proposing not to focus on this indicator. If values are presented in the report, this will be for information purposes only.

It should be borne in mind that the indicators in the impact categories do not have the same level of robustness according to the European Commission[v] . For example, freshwater ecotoxicity, use of non-fossil resources, water use, and land use are the indicators with the lowest level of robustness in the panel of selected indicators. The robustness of the indicators can be found in Table 4 below.

It should also be borne in mind that for land and water use indicators, a specific limitation needs to be explained to better interpret these indicators. These indicators are subject to uncertainties, as the study did not regionalise the flows on a local scale but took global values of world flows. Consequently, as the flows have not been regionalised, the study cannot show greater impacts if the water used or the land used in a local area has impact (for example, in a desert area with little land and access to water).

2 SCOPE OF THE STUDY

2.1 PRODUCT SYSTEMS TO BE STUDIED

The products studied in this LCA are primary packaging for small and medium-sized items. All these types of packaging share the same functions, which are detailed in the next section.

The technical descriptions of each solution are detailed in Section 3.

It is important to note that a section dedicated to industrial and commercial packaging (ICP), which is the secondary and tertiary packaging for each of the products protected by primary packaging, is presented below, as it is considered within the scope of this study. ICPs are described and studied in more detail in Section 3.2.

The environmental impacts of each packaging are modelled according to the functional unit described in the next section.

2.2 PRODUCT SYSTEM AND FUNCTIONAL UNIT FUNCTIONS

2.2.1 FUNCTIONAL UNITS - PRIMARY AND SECONDARY

As the aim of this study is to compare different types of packaging, a reference unit must be defined. This is the functional unit, which enables products to be compared, based on the same service provided.

As part of this study, many packages (27), divided into 10 packaging families, with a packaged product capacity ranging from 25 cm^3 to 1365 cm^3, and packaging different types of products (stationery, toothbrushes, DIY, hardware, etc.), including "bulk" solutions, were compared with each other. Because of this wide variety of packaging configurations, it is necessary to define the minimum service provided by each package, to have a basis for comparison based on the same service provided; **this service provided will therefore be the main function. A main functional unit will then be defined to quantify the main function.** This is the **reference unit** to which all the flows in this LCA study will be related.

Secondly, it is necessary to define secondary functions, for which certain packaging families can respond, and others not. **This will give the readers of this study the keys to making the** most relevant comparisons according to their constraints, which will allow the results, interpretations and conclusions to be qualified according to these secondary functions. To illustrate this point in a fictitious way, consider the following example:

- *A packaging family X has a lower environmental impact than a packaging family Y on the main functional unit.*
- *However, packaging family X only fulfils secondary functions such as "a tamper-evident system" or "a space on the packaging for communication and marketing". In this case, packaging family Y fulfils these secondary functions and would therefore be preferred by the marketer*.

The main function, to which all primary packaging responds, is as follows:
“To transport and enable the shelving of stationery, DIY products, toothbrushes, and non-food items at a retail location”

It's worth noting that there are inequalities between packaging families in terms of mechanical function. For example, the **8. flexible PP** family does not offer the same mechanical performance as the **1. blister** family. It is therefore unrealistic to consider that all packaging is comparable in all cases, since in some cases mechanical properties are paramount and each product has specific packaging needs, linked to its properties and the requirements of the sector. This parameter will be recalled at the end of the presentation of the results to provide some nuance to the interpretations/conclusions of the study.

The main functional unit, which incorporates the volume dimension of the packaging, is as follows:
“To transport and enable the shelving of 1 cm^3 of stationery, DIY products, toothbrushes and non-food items at a retail location.”

The definition of each term in the main functional unit is given below:

- **Stationery products**: Article relating to the use of paper.
- **Do-it-yourself (DIY) products**: Items related to construction, design and gardening. These products are diverse and varied, ranging from screws and bolts to bathroom seals.
- **Toothbrush:** Utensil used to clean the teeth of humans or animals**.**
- **Non-food item:** Any good intended for marketing but not for human or animal ingestion**.**
- **Transported:** Moved from one place to another, a good or a person. In this case, we are talking about goods**.**
- **Shelving:** Arrangement of an item so that it can be offered for sale in a shop or self-service system.
- **Retail location:** Place organised to receive the public with a view to selling goods and/or services. Example: supermarket, DIY shop, etc.

Note: this functional unit was chosen without considering the term "protect", because the bulk solutions studied do not "protect" products that are presented in bulk, so the service provided is not the same as for the other packaging studied.

The reference flows represent the quantity of product required to fill the functional unit. In this study, each package is modelled by means of a form calling up all the flows characterising it (raw material, transport, shaping, end of life, etc.). The volume of the packaging characterises the output flow of this file. In the final modelling stage, all the incoming flows are reduced to 1 cm^3 of packaging. As a result, there is only one reference flow in this study: a complete packaging system, including all the stages of its VDC scaled to its packed volume. The reference flow is therefore as follows:

$$Reference\ flow = \frac{Complete\ packaging\ system\ (g)}{Primary\ packaging\ volume\ (cm^3)}$$

Packaging volume data for all scenarios are detailed Table 8
The reference flows (quantity of primary, secondary and tertiary packaging, per package, per 1cm3) are detailed in Figure 5

The various secondary functions chosen in this study are then detailed in the following section. Table 2 shows, for each packaging family, whether that family generally tends to fulfil a secondary function. Here is an example to illustrate:

- *Bulk solutions do not generally fulfil the function of a "tamper-evident system", a system that prevents consumers from indirectly "stealing" the product contained in the primary packaging.*

The approach was based on families rather than the individual packaging studied, as this method of presentation and interpretation is more consistent with the objectives of the study, the aim not being to compare packaging 1 by 1, but families of packaging. This also means that, in the table, when a family does not generally fulfil a function, this does not necessarily apply to all the packaging in the family. Using the previous example to illustrate:

- *However, the bulk solutions mentioned can meet this "tamper-evident system" criterion, in a particular case where these bulk packs would be located behind a counter and a salesperson would need to have control over the contents of the bulk.*

The Secondary Functions (SF), to which some primary packaging families respond, and others do not, are as follows:

- **SF/1: "and to see the packaged product contained in the packaging".**
- **SF/2: "and to allow communication and marketing elements to be placed on the packaging".**
- **SF/3: "and to help combat fraud".**

The definition of each term in the secondary functions is given below:

- **See the packaged product:** That the consumer can perceive the article with their own eyes
- **Content:** What is contained in a container
- **Packaging:** Object designed to contain and protect goods to facilitate handling, transport and display**.**
- **Communication elements**: Allowing the different visual, graphic or textual elements to be arranged and organised on the surfaces of the packaging visible to the consumer.
- **Marketing elements:** All visual components (text and/or graphics) used to promote a product and influence consumer behaviour.
- **Combating fraud:** Preventing or deterring product theft by various technical means. The aim of these strategies is to dissuade consumers from attempting to steal the goods contained in the packaging.

Note: these secondary functions are not exhaustive, but they are characteristic of the functions and constraints of the sectors of activity linked to this packaging and are therefore coherent and relevant to the objectives of this LCA.

N°	Scenario	SF No. 1: Transparency	SF No. 2: Marketing	SF No. 3: Combating fraud	Comment
1	Cardboard blister + PET	Yes	Yes	Yes	The packaged item is fully visible to the consumer
2	Reverse blister pack	To be qualified	Yes	Yes	The notion of transparency for reverse cardboard blisters can be respected using windows or over-transparent graphics. However, this function is not as well fulfilled as in the reference scenario.
3	Cardboard case	To be qualified	Yes	To be qualified	The same applies to reverse blisters for transparency. These packaging systems can easily be opened in shop if they do not have "easy-open" labels.
4	Cardboard + straps	Yes	Yes	To be qualified	The packaged item is fully visible to the consumer The ties are generally strong (this is the case for the model chosen) and require equipment to detach the product from its packaging. This depends on the strength of the tie chosen by the manufacturer.
5	Moulded cellulose	Yes	To be qualified	Yes	It is partly possible to print a label (or film) that is stuck onto the PET lid for marketing purposes, but this reduces the notion of transparency depending on the size of the label.
6	Transp flexible paper.PP	To be qualified	Yes	Yes	This type of material is not as transparent as PET. It is possible to see through it, but the consumer's perception of the product is not the same as with the reference scenario.
7	Opaque flexible paper.PE	No	Yes	Yes	The material is too opaque to see the product. It is possible to print a visual of the product on the packaging.
8	Flexible PP	Yes	Yes	Yes	The packaged item is fully visible to the consumer
9	Bulk without display	Yes	To be qualified	No	It is possible to print marketing communication elements on the cardboard surfaces available. However, you need to know the purpose of the packaging: on the shelf or simply as a transport IBC. Bulk packaging does not help to combat fraud, as the accessibility of products in bulk can indirectly encourage consumers to steal them, which is not the case with all other packaging.
10	Bulk with display	Yes	Yes	No	The same as for bulk without display, but here the display is designed to display communication and marketing elements.

Table 2 Analysis of secondary functions by packaging type

2.3 METHODOLOGY USED

This study was carried out in accordance with the principles and frameworks defined by ISO 14040 (AFNOR, 2006)[ii] and ISO 14044 (AFNOR, 2006)[iii] , which set out the requirements for carrying out a product life cycle assessment.

The following chapter on life cycle assessment was written by the European Commission (EUROPEAN COMMISION, 2019) [iv]

The life cycle assessment methodology is divided into **four distinct but interdependent phases,** since frequent feedback is required throughout the study, making the overall approach iterative. Its practice is now standardised by the ISO 14040 series.

- **PHASE 1** - Definition of objectives and scope of application

In the **objectives and scope** definition phase, the objectives of the study are defined, i.e. the intended application, the reasons for carrying out the study and the target audience. The main methodological choices are made at this stage, particularly the exact definition of the functional unit, the identification of system boundaries, the identification of procedures, the impact categories studied, and the Life Cycle Impact Assessment (LCIA) models used, as well as the identification of data quality requirements.

- **PHASE 2** - Life cycle inventory (LCI) analysis

The **life cycle inventory (LCI)** phase comprises the data collection and calculation procedure for quantifying the inputs and outputs of the system under study. Inputs and outputs include energy, raw materials and other physical inputs, products and co-products and waste, emissions to air/water/soil and other environmental aspects. The data collected relates to foreground processes (e.g. for a consumer good, the manufacture and packaging of a product) and background processes (e.g. for a consumer good, the production of electricity and purchased materials). The data is validated and linked to the process units and functional units.

- **PHASE 3** - Life Cycle Impact Assessment (LCIA)

In the **life cycle impact assessment (LCIA**) phase, the results of the LCI are associated with environmental impact categories and indicators. This is done using life cycle impact assessment methods that, firstly, classify emissions into impact categories and, secondly, characterise them using common units to enable comparison.

- **PHASE 4** - Interpretation

Finally, during the interpretation phase, the LCI and LCIA results are analysed in line with the defined objective and scope. This stage involves checks on completeness, sensitivity and consistency. Any uncertainty or imprecision in the obtained results is also addressed at this stage.

Two concepts are essential to meeting these standards. LCA is based on:

- The multi-stage approach, which allows several stages of the life cycle defined in Phase 1 to be considered. The life cycle stages considered are described in Section 3.3.1, 'Delimitation of system boundaries'.
- The multi-criteria approach, characterised by a panel of environmental impacts selected in Phase 1 to holistically account for the environmental impacts of the studied system.

2.4 THE LIMITS OF THE SYSTEM

2.4.1 DEFINING SYSTEM BOUNDARIES

The study is called "cradle-to-grave": it considers the stages in the life cycle of the various products studied, from the extraction of raw materials to their end-of-life.

The main life cycle stages studied in this LCA are as follows:

- Raw materials
- Manufacture
- Distribution
- Use/Phase of use
- End of life

For a better understanding, Figure 1 presents the main stages of the life cycle considered in this study:

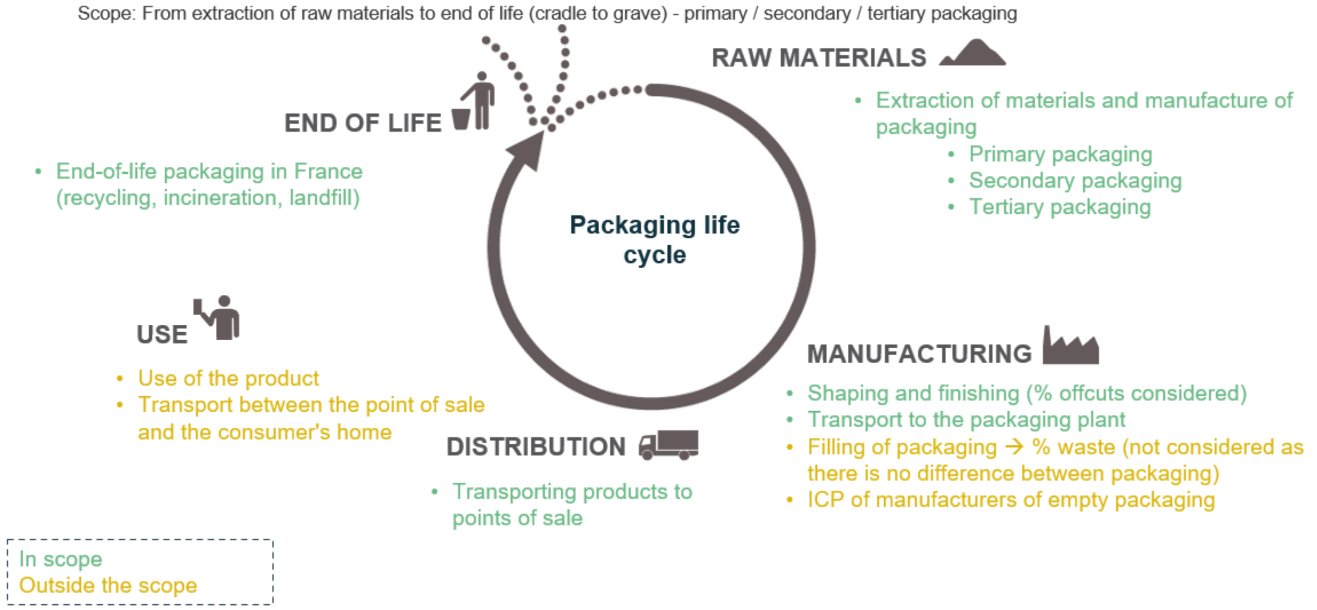


Figure 1 Simplified life cycle diagram (EVEA, 2025)

The life cycle of the items contained in the packaging, as well as the packaging itself, is not considered, as the study focuses on primary packaging and ICPs and not on the production of the contents. In addition, no sensitivity analysis was carried out on the rate of loss of contained products. As each product contained is different and non-specific in this study, it would not be possible to carry out this sensitivity analysis. The failure to take account of this loss (which depends on the type of product contained) is a limitation of the study.

The use phase, which includes the storage and shelving sub-steps and transport from the consumer to their home, is not considered. Storage and display do not have any impact. The transport of the packaging and the product contained by the consumer between the point of sale and their home is not taken into account because the mass and volume of the packaging and products are very small compared with the useful volume of a private vehicle, and are also assumed to be relatively identical for each package, and finally, are not directly linked to the objectives of the study.

The ICPs of manufacturers of packaging components are not considered during the production phase. Similarly, the transportation of empty secondary and tertiary packaging has not been considered, as this would make the study too complex. This would require going back up the entire chain of suppliers and collecting very specific information from many stakeholders. The study focuses on the design of primary packaging and not on different practices throughout the packaging creation value chain.

As far as end-of-life is concerned, the parameters selected for the end-of-life of scrap and packaging waste are adapted according to the geographical areas where the waste was generated, in the case of this study, in France (apart from sensitivity analysis, Asian production scenario). In this report, the term "scrap" refers to industrial waste produced during the manufacture of various components. For example, during the injection moulding of plastics, parts that do not comply with quality requirements are considered as rejected parts, also known as scrap. As explained in Section 3, scrap has been applied to all types of materials (Section 3.1.2).

All other assumptions and additional comments are detailed in the LCI in Section 3.

The year of validity of the data is 2025. The data was collected at the end of 2024/beginning of 2025 and is foreground data.

The results of this study are consistent and relevant over an arbitrary period of 6 years, up to 2030, and as long as the design of the different packaging put on the market remains faithful and identical to the packaging defined in this study and over the given period.

TheFigure 2 below illustrates all the life cycle stages included in the system definition.

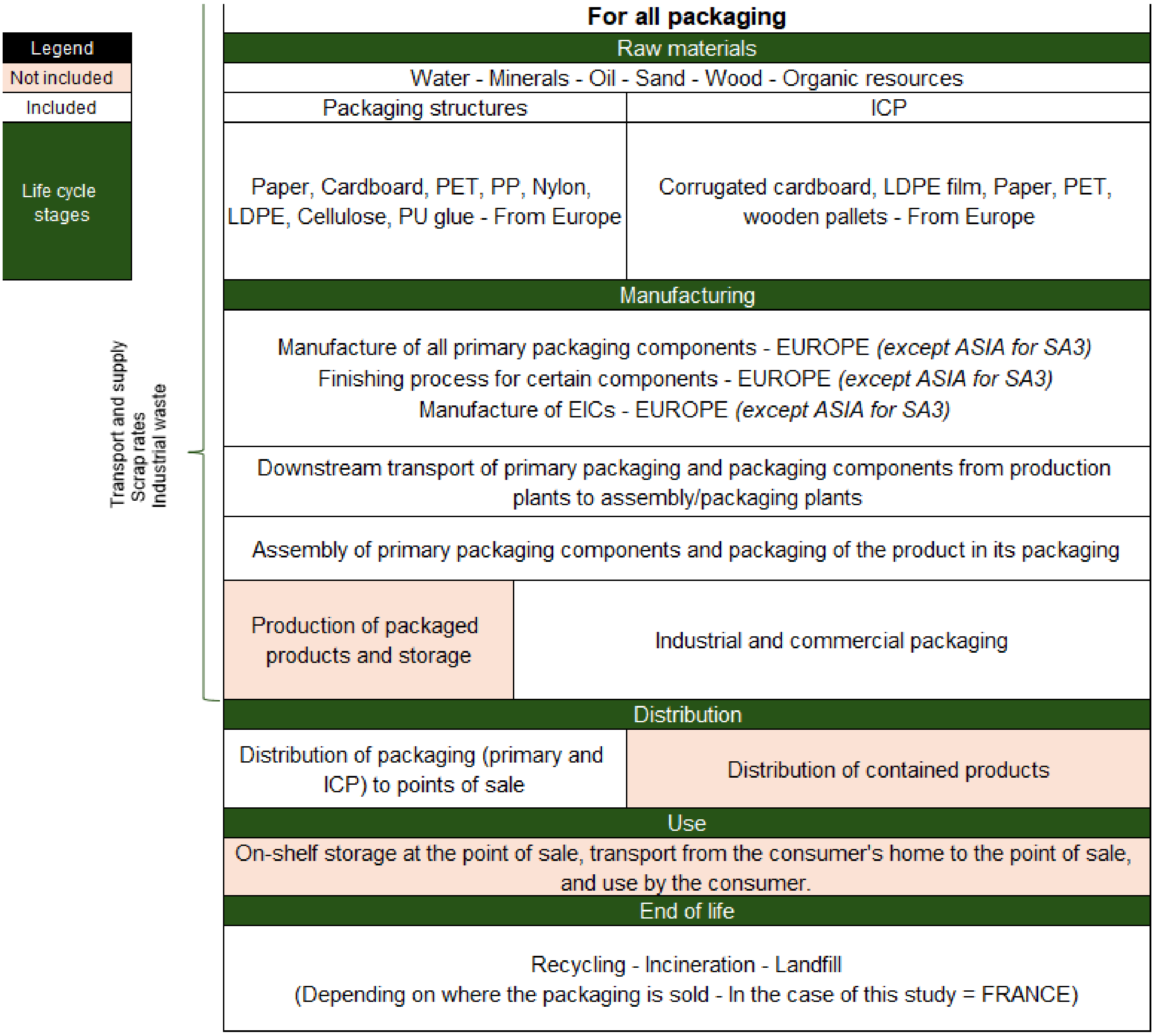


Figure 2 Detailed life cycle of different types of packaging

Regarding the limits of the geographical system, all packaging components, whether for primary packaging or for industrial and commercial packaging (secondary and tertiary packaging), are manufactured in EUROPE (except for the Asian SA scenario).

The data was collected via CITEO, which organised the data collection with its clients, marketers of non-food items.

2.4.2 EXCLUSION CRITERIA

The cut-off criteria are calculated to make the exclusion of certain elements from the boundaries of the system transparent. The exclusion of certain elements must be assessed against at least three criteria: the mass criterion, the energy criterion and the environmental impact criterion.

Nevertheless, in this study, no cut-off criteria were calculated, but the exclusion criteria used within the system boundaries are detailed inTable 3. Nevertheless, the cut-off procedure is applied in the background processes from the ecoinvent database.

The ecosystem model used is "Allocation, cut-off by classification". This cut-off system model is based on the recycled content, or cut-off, approach. In this model, waste is the responsibility of the producer ("polluter pays"), and there is an incentive to use recycled products, which are available without "charge" or impacts (cut-off). Further information is available on the ecoinvent website (ECOINVENT, 2022) v.

However, the Circular Footprint Formula explained in Section 2.5 is used in the case of recycling and materials containing recycled material. To sum up, there is no cut-off for the end-of-life part because the CFF is used (including recycling, incineration and landfill).

Table 3 below illustrates the exclusion criteria within the boundaries of the system. The second column lists the impacts that are not considered quantitatively, with a qualitative description of these impacts. The third column explains the reasons for excluding criteria.

OUTSIDE THE PERIMETER	IMPACT OF EXCLUSION ON THE STUDY	JUSTIFICATION
Manufacture of the products contained in the packaging	The production of goods contained in packaging. Taking this scope into account would have entailed high consumption of inputs of various kinds, the impacts of which are not considered in this study. **(Low impact)**	The aim of the study is to carry out an LCA of the primary packaging, considering the ICPs and not the products contained.
Loss of products depending on packaging	Product loss through damage or theft due to the specific design of the packaging has not been considered. Depending on the product packaged, considering product loss can result in very significant impacts that may exceed the impact of the primary packaging alone. **(Medium impact)**	Each product contained is different and non-specific in this study, which makes it impossible to take this element into account in a quantitative way.
Product development, samples and promotional items	The impacts of product development, prototypes, samples and promotional items, which include the consumption of materials and energy, are not considered in this study. **(Low impact)**	Product packaging is the only subject of the study. These elements do not make the difference between the different solutions studied.

Recycling flexible PP	CITEO shares the information that flexible PP will be chemically recycled by 2030. In the study, the recycling of flexible PP was modelled based on mechanical recycling. It is assumed that chemical recycling would have had a greater impact than mechanical recycling, due to the greater use of energy, electricity and consumables, particularly solvents. Qualifications to this assumption are given in the 3.7.3.2 section. **(Low to medium impact depending on the technology)**	Data on the chemical recycling process, particularly for flexible PP, is not yet available.
Energy and water consumption Warehouses and sales outlets	N/A	These buildings are not specific to the sale of stationery or DIY products, so their impact is spread across all the products stored there, regardless of product type or brand. Similarly, these elements do not differentiate between the two designs.
Manufacture and transport of ICPs used to transport empty primary packaging from their production site to the product packaging plant.	Considering this additional packaging and transport would have led to an increase in the consumption of cardboard, pallet wood and LDPE. In addition, it would have increased the overall amount of transport, which would have had a greater impact on the climate change indicator. **(Low impact)**	The packaging of raw materials (before processing) and their transport are already considered in the ecoinvent database. As a result, the transport of ICPs from their production site to the product packaging site is not specifically modelled. However, these stages are considered for primary packaging. However, the ICPs used to transport "empty" primary packaging (or primary packaging components) from their production site to the product packaging site have not been considered. The 2 reasons are as follows: - It was not possible to go back up the value chain when collecting the data, as there are n-4 contacts between EVEA and the manufacturers who would have this type of information. It would not have been possible to collect data in a uniform and robust way at this stage. - This stage is more concerned with industry practices than with the eco-design of final packaging and integrating this stage does not directly meet the objectives of this LCA.
Use phase of the packaged product and primary packaging	Taking this scope into account would have meant considering losses at the point of sale due to the behaviour of certain consumers who unwrap a product on the shelf, rendering it unsaleable, or losses due to handling errors during shelf placement, for example. Taking these factors into account would have increased the intensity of all the flows involved in this study. **(Medium impact)**	To take these various losses into account, it would have been necessary to carry out a study on a specific product, to study not only consumer purchasing behaviour, but also the practices of each retailer, particularly in terms of shelf management. These considerations are not feasible in the context of this study, which covers 27 packages (27 different products). Nevertheless, even if this aspect is not addressed in this LCA, it is important, as good practice for packaging manufacturers, to optimise the factors mentioned to avoid transferring impacts.

Transport between the consumer's home and the point of sale	Taking this specific transport into account would have increased the amount of transport required to meet the FU. As a result, the share of transport in the results is minimised, which is a limitation of this study. **(Medium impact)**	It is possible to take this transport into account by making an allocation in relation to the volume of the product, as the PEF suggests (source: [ix] ; Section "7.14.1.3 Consumer transport"). However, here the total volume of the product and packaging is not known, which makes this attribution less relevant. Although the packaged volume is known, this is not the case for the actual volume occupied by the product and its packaging. As this volume is greater than the packaged volume, the allocation would therefore be underestimated. It has therefore been decided not to take this transport into account. In addition, the transport cocktail (proportion of various means of transport combined to make a given journey) used by consumers to make this type of purchase is not clearly identified due to the wide variety of products that can be packaged within this study.
Bulk self-service/consumer refill	In the bulk packaging family (with and without display), systems used to sell liquid products or bulk food are not considered. In this LCA, this packaging is used both for transport and, in some cases, as a display unit (secondary packaging with marketing functions). These sales systems, in which it is possible to fill a single sachet (with the desired number of products) from a dispenser, are more sophisticated and complex than simple cardboard packaging. This consideration therefore 'favours' bulk packaging in the context of this study. **(Medium impact)**	Bulk sales for the type of article studied in this study are not sufficiently developed and widespread to consider a system closer to what is done in the food sector, for example.

Table 3 Exclusion criteria within system boundaries

All the specific details and assumptions made for the inventory have been detailed in Section 3.

2.5 ALLOCATION PROCEDURES

Sometimes the processes in a product's life cycle generate multiple products or co-products. Recycling processes may also be implemented, generating secondary raw materials. In this case, the rules for allocating co-products and recycling need to be determined.

Baseline data was used for processes involving co-products (chemical manufacturing, pulp and paper manufacturing, oil refining, etc.). For these processes, the ecoinvent 3.10 Allocation, Cut-off (ecoinvent, 2024)[Erreur ! Signet non défini.] database was used, so the allocation rules in this database are applied to these processes. The allocation is mainly economic. The cut-off procedure makes it possible to define the allocations for the environmental impacts generated by recycling processes (all the environmental impacts generated during the recycling process are allocated to the secondary raw material) and energy recovery processes (the production of heat or electricity is not considered in incineration processes). However, the following paragraph explains the changes made to the modelling of recycling and energy recovery that do not follow the ecoinvent allocation.

Recycling, recycled materials and energy recovery for incineration:

Recycling is a multifunctional process that enables waste to be treated and secondary raw materials to be produced.

The ecoinvent 3.10 data has been adapted to comply with the PEF recommendations. For example, the circular footprint formula (2013)[v] (CFF) has been used for primary packaging, secondary packaging and the end-of-life of tertiary packaging.

The CFF is a method recommended by the European Commission for defining allocations for the environmental impacts generated by recycling and energy recovery processes.

CFF's equation is as follows:

$$(1-R_1)\times E_v + R_1 \times \left(A \times E_{Recycled} + (1-A)\times \frac{Q_{Sin}}{Q_p}\times E_v\right) + R_2 \times (1-A)\times\left(E_{RecycledEoL} - \frac{Q_{Sout}}{Q_p}\times E_v^*\right) + R_3 \times (1 - B)\times\left(E_{ER} - LHV \times X_{ER,heat}\times E_{SE,heat} - LHV \times X_{ER,elec}\times E_{SE,elec}\right) + (1-R_2-R_3)\times E_D$$

Parameters:

- R_1 This is the proportion of materials entering production that have been recycled from a previous system.
- R_2 This is the proportion of materials contained in the product that will be recycled (or reused) in a subsequent system. R2 must therefore consider the inefficiencies of the collection and recycling (or reuse) processes. R2 is measured at the output of the recycling plant.
- R_3 This is the proportion of the product's material that is used for energy recovery at the end of its life.
- $X_{ER,heat}$ and $X_{ER,elec}$ the efficiency of the energy recovery process for heat and electricity.
- LHV The lower calorific value (LCV) of the material contained in the product and used for energy recovery.
- Q_{Sin} the quality of the incoming secondary material, i.e. the quality of the recycled material at the point of substitution (between 0 and 1).
- Q_{Sout} quality of outgoing secondary materials, i.e. the quality of recycled materials at the point of substitution (between 0 and 1).
- Q_p quality of the raw material, i.e. quality of the virgin material (between 0 and 1).

Allocation factors:

- A The factor by which charges and credits are shared between the supplier and the user of recycled materials.
- B Allocation factor for energy recovery processes applies to both costs and credits.

Inventories:

- $E_{Recycled}$ The specific emissions and resources consumed (per functional unit) resulting from the process of recycling recycled (reused) materials, including the collection, sorting and transport processes.
- $E_{RecycledEoL}$ Specific emissions and resources consumed (per functional unit) resulting from the end-of-life recycling process, including collection, sorting and transport.
- E_v Specific emissions and resources consumed (per functional unit) resulting from the acquisition and pre-treatment of virgin materials.
- E_v^* The specific emissions and resources consumed (per functional unit) resulting from the acquisition and pre-treatment of virgin materials that are supposed to be replaced by recycled materials.
- E_{ER} Specific emissions and resources consumed (per functional unit) resulting from the energy recovery process (e.g. incineration with energy recovery, landfill with energy recovery, etc.).
- $E_{SE,heat}$ and $E_{SE,elec}$: specific emissions and resources consumed (per functional unit) that would have been generated by the specific substitute energy source, heat and electricity respectively.
- E_D specific emissions and resources consumed (per functional unit) resulting from the disposal of waste at the end of the life of the product analysed, without energy recovery

2.6 IMPACT CATEGORIES AND RELATED METHODOLOGY

2.6.1 SET OF IMPACT CATEGORIES

The choice of life cycle impact assessment method was made in consultation between EVEA and CITEO, to best meet the objectives of the study, i.e.:

- Reflect the issues representative of the system studied: energy consumption to produce primary, secondary and tertiary packaging, the impact on air, water and soil of the packaging manufacturing and finishing processes, the impact of transport and end-of-life processes.
- To ensure readability (reduced number of impact indicators as only the most relevant will be selected for this study, in this case climate change as a priority, followed by eutrophication in freshwater, and water consumption)
- Accessibility for experts (impact indicators) and non-experts (inventory indicators and translation of $CO_{2(eq)}$ impact indicators in particular).

The **Environmental Footprint 3.1** (EF 3.1) method (EUROPEAN COMMISSION, 2019)[v] was chosen as it is recommended by the European Commission's Joint Research Center (JRC).

TheTable 4 below presents the 16 indicators of the reference method as well as their original methods and their robustness derived from a mix of science and citizens. The potential impact indicators, explanations and references come from the PEF Guide (Manfredi & et al, 2012)[vi] and can be consulted there, the recommended default LCIA methods come from the Supporting information to the characterization factors of recommended EF Life Cycle Impact Assessment method report (Fazio & et al., 2018)[vii] and the robustness of the indicators comes from the ILCD Handbook (Pant & et al., 2011) .[viii]

Indicators	Indicators	Units	Explanations	Recommended default LCIA method	Robustness (I for the most robust categories, III for the least robust)
Climate change	Climate Change	Kg CO2 eq.	It relates to the capacity to influence changes in the global average surface-air temperature and subsequent change in various climate parameters and their effects, such as storm frequency and intensity, rainfall intensity and frequency of flooding, etc. due to human activities, including the use of fossil fuels.	Baseline model of 100 years of the IPCC (based on IPCC 2013)	I
Depletion of the ozone layer	Ozone depletion	Kg CFC11 eq.	EF impact category that accounts for the degradation of stratospheric ozone due to emissions of ozone-depleting substances, for example long-lived chlorine and bromine containing gases (e.g. CFCs, HCFCs, Halons).	Steady-state ODPs as in (WMO 1999)	I
Ionising radiation	Ionising radiation	kBq U-235 eq.	EF impact category that accounts for the adverse health effects on human health caused by radioactive releases.	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)	II

Photochemical ozone formation	Photochemical ozone formation	kg NMVOC eq.	EF impact category that accounts for the formation of ozone at the ground level of the troposphere caused by photochemical oxidation of Volatile Organic Compounds (VOCs) and carbon monoxide (CO) in the presence of nitrogen oxides (NOx) and sunlight. High concentrations of ground-level tropospheric ozone damage vegetation, human respiratory tracts and manmade materials through reaction with organic materials.	LOTOS-EUROS (Van Zelm et al, 2008) as applied in ReCiPe 2008	II
Particles	Particulate matter	kg PM2.5 eq.	EF impact category that accounts for the adverse health effects on human health caused by emissions of Particulate Matter (PM) and its precursors (NOx, SOx, NH3)	PM model recommended by UNEP (UNEP 2016)	I
Human toxicity, non-cancerous	Human toxicity, non-cancer	CTUh	EF impact category that accounts for the adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin insofar as they are related to cancer.	USEtox model (Rosenbaum et al, 2008)	II/III
Human toxicity, cancer	Human toxicity, cancer	CTUh	EF impact category that accounts for the adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin insofar as they are related to non-cancer effects that are not caused by particulate matter/respiratory inorganics or ionising radiation.	USEtox model (Rosenbaum et al, 2008)	II/III
Acidification	Acidification	molc H+ eq.	EF impact category that addresses impacts due to acidifying substances in the environment. Emissions of NOx, NH3 and SOx lead to releases of hydrogen ions (H+) when the gases are mineralised. The protons contribute to the acidification of soils and water when they are released in areas where the buffering capacity is low, resulting in forest decline and lake acidification.	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	II
Eutrophication of fresh water	Eutrophication, freshwater	kg P eq.	Nutrients (phosphorus) from sewage outfalls accelerate the growth of algae and other vegetation in water. The degradation of organic material consumes oxygen resulting in oxygen deficiency and, in some cases, fish death. Eutrophication translates the quantity of substances emitted into a common measure expressed as the oxygen required for the degradation of dead biomass.	EUTREND model (Struijs et al, 2009) as implemented in ReCiPe	II
Marine eutrophication	Eutrophication, marine	kg N eq.	Nutrients (phosphorus) from sewage outfalls accelerate the growth of algae and other vegetation in water. The degradation of organic material consumes oxygen resulting in oxygen deficiency and, in some cases, fish death. Eutrophication translates the quantity of substances emitted into a common measure expressed as the oxygen required for the degradation of dead biomass.	EUTREND model (Struijs et al, 2009) as implemented in ReCiPe	II
Eutrophication on land	Eutrophication, terrestrial	mol N eq.	Fertilised farmland accelerates the growth of algae and other vegetation in water. The degradation of organic material consumes oxygen resulting in oxygen deficiency and, in some cases, fish death. Eutrophication translates the quantity of substances emitted into a common measure expressed as the oxygen required for the degradation of dead biomass.	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	II
Ecotoxicity, fresh water	Ecotoxicity, freshwater	CTUe	EF impact category that addresses the toxic impacts on an ecosystem, which damage individual species and change the packaging and function of the ecosystem. Ecotoxicity is a result of a variety of different toxicological mechanisms caused by the release of substances with a direct effect on the health of the ecosystem. **Warning**: To be significant, the difference between 2 products must be more than 10^4 on this indicator (USETOX, 2018)	USEtox model, (Rosenbaum et al, 2008)	II/III

Land use	Land use	Pt	EF impact category related to use (occupation) and conversion (transformation) of land area by activities such as agriculture, roads, housing, mining, etc. Land occupation considers the effects of the land use, the amount of area involved and the duration of its occupation (changes in quality multiplied by area and duration). Land transformation considers the extent of changes in land properties and the area affected (changes in quality multiplied by the area).	Soil quality index based on LANCA (Beck et al. 2010 and Bos et al. 2016)	III
Use of water	Water use	m3 depriv.	EF impact category that addresses use of water. The availability of water resources is a key issue, a source of economic and geopolitical tension in many parts of the world. Most water consumption comes from watersheds that are already under extreme water stress.	Available WAter REmaining (AWARE) in UNEP, 2016	III
Use of resources, minerals and metals	Resource use, minerals and metals	kg Sb eq.	EF impact category that addresses use of minerals and metals. The pressure on these resources such as minerals, metals, rare earths... is increasing, and the decrease in reserves is creating economic and geopolitical tensions. The use of these resources can lead to a decrease in available reserves.	ADP for mineral and metal resources, based on van Oers et al. 2002 as implemented in CML, v. 4.8 (2016).	III
Use of fossil resources	Resource use, fossils	MJ	EF impact category that addresses use of energy. The production and distribution of energy, whatever its form (electricity, gas, coal or other), uses energy resources, generates emissions and requires means of transport and distribution. Energy consumption is therefore responsible for environmental impacts.	ADP for energy carriers, based on van Oers et al. 2002 as implemented in CML, v. 4.8 (2016).	III

Table 4 List of impact category indicators selected for evaluation

For this report, only the most relevant indicators for the products studied will be selected and analysed in detail; the results of all the indicators will be available in the Appendices (Section7). The indicator selection method suggested by the PEFCR[ix] is based on indicators that cumulatively contribute to at least 80% of the single score. However, this method cannot be applied in the context of this project, as to achieve 80% of the single score for the 27 packages, 13 of the 16 indicators would have to be selected. Analysing the results with such many indicators does not seem relevant and makes interpretation much more complex, which would reduce the educational, communication and popularisation scope of this LCA study.

As a result, in consultation with the critical review panel, it was decided to restrict itself to the 5 indicators that contribute most to the single score, with the addition of freshwater eutrophication, which CITEO would like to see. This covers between 68% and 72% of the contribution to the single score for all packaging. The 6 indicators selected are as follows:

- Climate change
- Eutrophication; freshwater
- Land use
- Water use
- Resource use; fossils
- Resource use; minerals and metals

Details of the impacts of each system studied according to the indicators chosen are described in the LCIA (Section 4). The methodology for grouping into a single score is presented in Section 2.6.3 below.

2.6.2 BIOGENIC CARBON AND BIOGENIC METHANE FOR CARDBOARD AND PAPER

ecoinvent considers the flow of biogenic carbon dioxide with the specific substance "biogenic carbon dioxide" for the EF 3.1 method on climate change as a characterisation factor of 0 for this substance. The substance "carbon dioxide" has a characterisation factor of 1.

ecoinvent considers the flow of biogenic carbon dioxide with the specific substance "methane, biogenic" for the EF 3.1 method on climate change with a characterisation factor of 27 for this substance. The substance "methane" has a characterisation factor of 29.8.

In other words, it is assumed that no absorption of biogenic CO2 is considered as an emission of biogenic carbon at the end of life. A neutral balance is therefore assumed: the elimination and emission of CO2 are not considered, and characterisation factors (0:0) are used for biogenic CO2.

2.6.3 GROUPING OF IMPACT CATEGORIES

The Environmental Footprint 3.1 (EF 3.1) method recommended by the PEF is used for harmonised LCAs. It is made up of 16 impact indicators, as detailed above.
Modelling a system using life cycle analysis enables an inventory to be made of the substances absorbed and emitted by the system. The impact assessment method translates these flows into impacts using indicators and characterisation. For a more in-depth approach, with the need for a global view of environmental impacts, normalization and weighting factors can be applied to the impact category indicators.

CHARACTERISATION:
In the EF 3.1 method, each indicator is defined by a list of substance flows contributing to the impact it characterises, while each flow is associated with a characterisation factor, making it possible to translate the flow into the unit in which the indicator is expressed. For example, one kilogram of methane is equivalent to 29.8 kg of CO2 for the Climate Change indicator, which is its characterisation factor: 1kg of CH4 = 29.8 kg CO2 eq.

NORMALIZATION:
In the EF3.1 method, the results per impact indicator can be normalised, i.e. brought back to a common reference by dividing the results of the characterisation by the emissions of an average inhabitant of the world over one year (seeTable 5). Standardised results are therefore unitless.

WEIGHTING:
In the EF3.1 method, the standardised impact scores are multiplied by a weighting factor associated with the indicator to obtain a single score combining the impact indicators. This single score is expressed in points (Pt), one point being equivalent to the average annual impact of one person in the world.

These weights are calculated using two combined methods with equal weight:
- The opinion of a panel of citizens and a panel of LCA experts who responded to a questionnaire in which they were asked to assign points to different impact categories.
- A hybrid approach based on the robustness of impact indicators and expert judgement.

SINGLE SCORE:
To obtain a single score, the results for each of the 16 impact categories are standardised and then weighted.

Normalisation involves dividing the results characterised by normalisation factors (corresponding to the impact of an average person in the world over one year). The normalised results are multiplied by the weighting factors to obtain a single score, given in Points (Pt.).

It is important to bear in mind that the construction of reliable factors relies on biases and methodologies specific to the EF3.1 method, multiplying the uncertainties on the result of a single score. **Thus, the result of a single score comparison only shows a trend**. One of its main objectives is to help decision-making by providing a global view of impacts via a single indicator. **The other indicators need to be considered when analysing the results. The single score is not intended for external communication.**

IMPACT INDICATORS	UNITS	NORMALIZATION FACTORS (equivalent to 1/"impact of one person in the world per year)	WEIGHTING FACTORS
Climate change	kg CO2 eq	1,32^{E}-04	21,60%
Depletion of the ozone layer	kg CFC-11 eq	1,91^{E}+01	6,31%
Human toxicity, cancer	CTUh	5,78^{E}+04	4,78%
Human toxicity, non-cancerous	CTUh	7,75^{E}+03	5,01%
Fine particles	Deas inc.	1,68^{E}+03	8,96%
Ionising radiation	kBq U235 eq	2,37^{E}-04	2,13%
Photochemical ozone formation	kg NMVOC eq.	2,44^{E}-02	1,84%
Acidification	mol H+ eq	1,80^{E}-02	6,20%
Eutrophication on land	mol N eq	5,65^{E}-03	2,96%
Eutrophication of fresh water	kg P eq	6,21^{E}-01	3,71%
Marine eutrophication	kg N eq	5,1^{E}-02	2,80%
Land use	Pt	1,22^{E}-06	1,92%
Ecotoxicity, fresh water	CTUe	1,76^{E}-05	7,94%
Use of water	m3 water eq	8,70^{E}-05	8,51%
Use of fossil resources	MJ	1,54^{E}-05	7,55%
Use of resources, minerals and metals	kg Sb eq	1,57^{E}+01	8,32%

Table 5 Normalization and weighting factors for the 16 impact category indicators for calculating the single EFP score, using the EF3.1 method

2.7 LIMITATIONS OF THE STUDY

It is important to note that this study has several limitations. These stem from the limitations of the system defined, the data used, the assumptions made and the intrinsic LCA methodology.

System limitations

Several processes have been excluded from the system limits. Among these processes, we would like to draw attention to some of them:

- The loss of the product contained in the packaging has been excluded from the limits of the system because each product contained is different and non-specific in this study, which makes it impossible/irrelevant at the scale of this study to take this element into account. In other words, the packaging covered by the study packs different types of products, which therefore have very different impacts. However, taking account of product losses can have a significant impact on the product life cycle, even more so than the impact of the packaging. What's more, certain packaging designs are robust and can lead to greater product losses through theft or deterioration of the product. Packaging marketers can refer to the 2.2.1 section, which details the secondary functional units and in particular the FUS/3 (to help combat fraud), for further information on this limit and the packaging to use for loss-sensitive products.
- The individual's home/sales journey has been excluded from the limits of the system, since it is not necessarily specific to the purchase of that product. However, it would be possible with a volume allocation (packed volume/trunk volume), to allocate part of the transport to this specific purchase. However, the packed volume is less than the actual volume of the product, which would make this allocation less relevant and representative of reality. In addition, the transport cocktail used by consumers to make these purchases is not known and is an essential piece of data missing from the study. This stage was therefore not considered.
- The use phase is also excluded from the scope, and is one of the limitations of the study, insofar as the nature of the packaged product varies greatly from one package to another. In addition, some packaging does not have the same level of protection as the PET/cardboard blister pack, which can lead to a rate of rejects when the product is put on the shelf by employees, or at the time of purchase if some consumers easily open the product and put it back on the shelf, making it less attractive or even unsaleable.

The 4.1 pack has a particularity inherent in its design which means that its environmental impact cannot be interpreted with the same degree of certainty. It does not have a packaged volume as such, since the product is not actually contained in the packaging but is attached to it with a nylon drawstring. As a result, the concept of packed volume is less suited to this type of design, making the resulting interpretation more delicate, which is a limitation of this study. Nevertheless, this family of packaging is present on the market and constitutes a real alternative to the reference packaging. This is why it is essential to consider it as such and include it in the study.

Since the system used to display bulk packaging on shelves without a display is excluded from this study, this partly "benefits" this family. As a result, the analysis of this type of packaging is less robust than the rest of the categories, which is a limitation of this study. Nevertheless, a sensitivity analysis of this issue is discussed in the section below 4.3.4.

Data limitations

In addition to using generic data from ecoinvent, which can be assimilated to averages for materials and for the various manufacturing, transport and end-of-life processes, several assumptions have been made to model the unit processes that make up the life cycle of the various types of packaging. All these assumptions are referenced in the LCI in Section 3. Uncertainties may remain concerning certain specific data (finishing surfaces, recycling rates, composition of raw materials, transport distances for supply or distribution, end-of-life of products, for example).

Where no data was available in the ecoinvent database, proxies were used, which may be an additional limitation to the study. The use of this type of data is described in detail in the 3.1.1 section.

The robustness of the data used for each package is specified in Section 3.

Limit on scrap rates:

- During the manufacture of packaging, industrial processes are imperfect, so some of the raw material processed does not end up in the final packaging. This part of the material, known as waste, is quantified by a rate specific to each material, process and packaging. As manufacturers do not always provide this information at the time of collection, it is either estimated empirically or taken directly into account in the ecoinvent database.
- Flat cardboard scraps resulting from the cutting of the latter are estimated by taking the ratio of the surface area of cardboard present in the final packaging to the maximum surface area of cardboard that would be needed to produce the final pattern. This maximum surface area considers the cardboard punching zones, the tabs and the shape of the unfolded pattern. A conservative approach is applied to these measurements. To illustrate this, Figure 3 shows schematically the different areas measured, used to calculate the ratio leading to the estimated percentage loss. Here, the blue area represents the surface area of cardboard present in the packaging that the consumer will have in his hands, while the orange area represents the maximum area that the packaging manufacturer would need to achieve the final pattern. The ratio of blue area to orange area is calculated to measure the percentage of scraps.

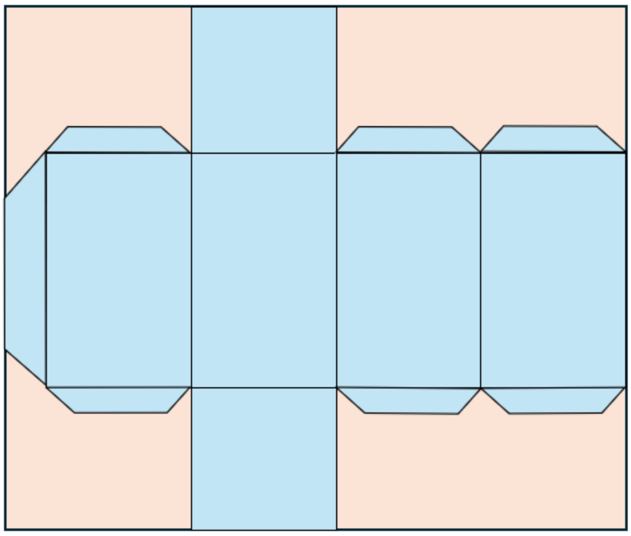


Figure 3 Diagram illustrating the method for measuring cardboard scraps

The scraps rates calculated in this way do not consider any optimisations used by manufacturers to minimise waste. In fact, cardboard pattern die-cuts are certainly placed in such a way as to minimise the scraps associated with the die-cutting process. Here, scraps are maximised and therefore certainly overestimated.

Furthermore, in this study, each sample studied is associated with a single pack produced by a given supplier for a particular packaged product. Data collection is therefore specific to a particular packaging. Since certain packaging families are represented by a single sample, it is important to specify that the results obtained from these samples must be qualified and put into perspective with their representativeness within the market.

Intrinsic limits

The numerical impact values are potential impact values and not actual values. They make it possible to assess the relative potential impact of the different designs to be compared, but do not reflect threshold exceedances, safety margins or risks.

Modelling limits

During the critical review process, a modelling error was identified by the expert panel. Currently, the SBBs modelled call for 1kg of recycled raw material (from a recycling process); a process that contains material losses between collection, sorting and recycling. To model the end-of-life recycling of a packaging, we need to model 1kg of waste to be recycled (input), and not 1kg of raw material recycled after the recycling process (output). This error will be considered when interpreting the results (see Section 4.2.1.8) and in the conclusions.

Note: By carrying out the exercise of modifying the CFF on 1 packaging (the N°8.1 entirely in plastic); this leads to an evolution of the single score and climate change of 0.5%, which should not fundamentally modify the conclusions and interpretations of the study. In conclusion on this limitation, EVEA agrees with the panel's comment and on this error, however EVEA is very confident (via internal tests) that this will not change the results and conclusions of the study.

2.8 DATA AND DATA QUALITY REQUIREMENTS

2.8.1 DATA REQUIREMENTS

2.8.1.1 Foreground data

Foreground data are specific to the system under study. They directly concern the activities under the control of CITEO or its clients.

Examples:

- Quantity of raw material used,
- Energy consumed for a specific manufacturing stage,
- Emissions measured on site.

This data is generally collected in the field, via internal surveys, interviews or actual measurements. For this project, the methodology used to select the primary data consisted of collecting the data directly via CITEO, which then collected the data from its customers: firstly, thanks to a general interview, and then in detail via a collection file completed by the customers. The masses of data on activity, raw materials, manufacturing processes, finishing processes, palletisation plans, and waste are supplied by CITEO via its customers. The primary data sources used in the study are detailed in section 2.8.2.1, and the primary data used for primary packaging and ICPs are detailed in Table 8 and Table 11, for the other elements of the system studied the primary data is described in section 3.

2.8.1.2 Background data

Background data are generic data that represent processes not specific to the study, outside the direct control of CITEO or CITEO's customers.

Examples:

- Electricity generation in each country (national electricity mix).
- Steel or plastic manufacturing (average data taken from a database of several manufacturers).
- International shipping, fuel production, etc.

The background data for this project comes from the generic ecoinvent 3.10 cut-off database.

2.8.1.3 Missing data

For missing data, a bibliographical search was first carried out. Hypotheses were formulated if no information was found in the bibliography.

2.8.2 DATA QUALITY REQUIREMENTS

2.8.2.1 Reliability of the source

For each stage of the life cycle, the specification of the data sources used is shown below. As specified in the previous section2.8.1, ***foreground data*** is data provided by CITEO and CITEO's customers via specific data collection; ***semi-specific*** data ***(or also called proxy data)*** is data extrapolated from data provided by CITEO and customers or from bibliographic research; ***background data*** is data from the ecoinvent database.

RAW MATERIALS → MANUFACTURING:

Primary packaging; and industrial and commercial packaging (secondary and tertiary):

- *Foreground data*
    - Weights and types of materials used
    - Manufacturing, finishing and packaging facilities
    - Scenarios for manufacturing, finishing and packaging processes
    - Finishing surfaces
    - Types of supply transport and distances between manufacturing plants and packaging sites
    - Waste from manufacturing, finishing and packaging processes
- *Semi-specific data (data adapted from specific hypotheses or bibliographic research) or background data:*
    - Raw materials inventories
    - Inventories of manufacturing, finishing and packaging processes
    - Transport inventories

DISTRIBUTION:

- *Foreground data:*
    - Types of transport used by the market
    - Mass fill rates of lorries for parameterised transport
    - Average distances by zone within the perimeter
- *Semi-specific data (data adapted from specific hypotheses or bibliographic research) or background data:*
    - Packaging materials inventory
    - Transport inventories
    - Tertiary packaging weights

END OF LIFE:

- *Semi-specific data (data adapted from specific hypotheses or bibliographic research) or background data:*

- Recycling, landfill and incineration rates, based on bibliographic sources or market research via CITEO.
- Recycling, landfill and incineration inventories

2.8.2.2 Geographical representation

The foreground data relating to the manufacture and finishing of primary packaging was collected in the EUROPE zone by CITEO and its customers and dates to 2024. In addition, data associated with the manufacture and finishing of secondary and tertiary packaging (ICP) was collected in the EUROPE zone. In the same way, these key data were collected by CITEO and its customers: materials, weights and palletisation plans. Both can be considered as representative of reality. The details are specified in the LCI in the section 3. There is no data on the origin of tertiary packaging suppliers for supply and distribution, so global assumptions have been made, as detailed in Section 3.

The data is consistent with the scope of the system as defined in Section 2.4.

The alignment between foreground and background data was carried out using this procedure:

- Where the foreground data collected is geographically representative of EUROPE, it has been combined with basic background geographic data {RER} in the modelling. If not available, {GLO} data has been used. If not available, {RoW} data was used.

The choice of {GLO} or {RoW} data has a wider geographical scope and is therefore less suited to the foreground data used.

2.8.2.3 Temporal representativeness

All foreground data collected from CITEO, and its members/suppliers are from the year 2024. The ecoinvent 3.10 database used for background data was published in November 2023. The temporal representativeness of the ecoinvent 3.10 database varies from one dataset to another: some date back to the 1990s, while others are updated to 2023. This heterogeneity is explained by the diversity of sources, sectors and regions covered: the data is updated progressively according to priorities and the availability of information.

2.8.2.4 Technological representativeness

The foreground data collected for individual packs may not be fully representative of all solutions in the market under consideration. The data collected for a package comes from a single supplier for each package, and not from an average for the market under consideration, over an adequate period which would have been necessary to compensate for normal fluctuations. Foreground data are collected by CITEO customers who produce or will produce the products studied in this LCA.

The background data used for the processes is generic data from the ecoinvent 3.10 database. Details are given in the LCI in Section 3.

2.8.2.5 Summary of data quality requirements under the EFP

The Table 6 below summarises the assessment of data quality according to the PEF[ix] criteria explained in the four previous sections (accuracy, temporal, geographical, temporal and technological representativeness) with a score from 1 (Very good quality - meets the criterion to a very high degree, with no need for improvement) to 5 (Very poor - does not meet the criterion, substantial improvement is required).

Lifecycle stage	Accuracy (reliability of source)	Geographical representation	Temporal representativeness	Technological representativeness
Raw materials	**2** Assessed by CITEO customers, not verified	**1** Specific information	**1** Collected in 2024	**1** Information specific to packaging and their respective ICPs
Primary packaging production	**2** Assessed by CITEO customers, not verified	**1** Specific information	**1** Collected in 2024	**2** Data relating to the plant that not only produces the specific packaging studied
ICP production	**2** Assessed by CITEO customers, not verified	**1** Specific information	**1** Collected in 2024	**2** Data relating to the plant that not only produces the specific packaging studied
Distribution	**2** Generic distribution by truck over 500 km	**1** Specific information	**1** Collected in 2024	**3** Generic information
End-of-life of primary packaging and ICP	**3** Based on the literature	**2** Adapted geographical scope	**2** Rate in 2030 *See Section3.7 for sources*	**2** Statistics for municipal solid waste not specific to the product studied

Table 6 Description of data quality assessment

2.8.2.6 Completeness

The system is not complete because some stages have been excluded from the limits, but it is still sufficiently representative. The excluded stages are detailed in Section 2.4.

2.8.2.7 Levels of reliability of assumptions and trade-offs made on modelling data

In the event of missing data from CITEO's customers, literature searches were carried out to support the assumptions. Four levels of reliability were identified to assess the accuracy of the assumptions made for the life cycle inventory.

Table 7 below describes the levels of reliability used to assess the assumptions or trade-offs on the data formulated in Section 3 . For the sake of readability, the acronyms VR, R, LR and UR are used.

Trade-offs are specific hypotheses that relate (in this report) solely to the choice of primary packaging data.
Data trade-offs are made between the choice of data from specific information from a direct stakeholder in the project or from precise measurements carried out on the products. These trade-offs are very reliable (VR) when the LCA producer can choose the data used for modelling from several sources. On the other hand, if the LCA producer only has access to one source (supplier or measurement), then there is no trade-off, and the level of reliability is considered reliable (R).

	Level of reliability	Description

1	Very reliable - VR	The assumptions are based on highly reliable sources, such as previous projects or robust bibliographical research. Trade-offs between two or more sources of data from suppliers or actual measurements are considered highly reliable.
2	Reliable - R	Assumptions are based on approximate data: the assumptions are maximising/disadvantaging to avoid underestimating the impacts. No arbitration because only one source of data is available (supplier or measurement)
3	Low reliability - LR	The assumptions are based on approximate data: the effects that these data have on the impacts are not known and no means have been put in place to prevent them.
4	Unreliable - UR	Assumptions are based on unreliable or unrecognised data, unverified assumptions or estimates: the level of reliability is insufficient to meet requirements.

Table 7 Description of the reliability levels of the assumptions/arbitrages for the LCI

In Section 3 the level of reliability of each hypothesis or data trade-off has been detailed at the end of the description.

2.8.2.8 Uncertainties in this Comparative LCA

Uncertainties in LCA come from several sources. It is essential to distinguish between uncertainties arising from foreground data (linked to inventories specific to the study, such as packaging weights) and those from background data (from databases such as ecoinvent). Uncertainties in the foreground data are under the control of CITEO and its clients via the data collected, and of the study's producer via the assumptions and trade-offs made. They may arise, for example, from the uncertainty associated with a measurement or the choice of a reference year. Background data can vary according to geographical, temporal and technological representativeness. These two types of data contribute differently to the overall uncertainty of the results. The higher the quality of the project data, the lower the uncertainty. The quality of the project data has been estimated in Table 6

For this reason, it is common practice to carry out an uncertainty analysis using different methodologies, to measure the impact of uncertainties in the input data on the results and thus reinforce the robustness of the conclusions.

The Monte Carlo method is commonly used for uncertainty analysis. However, it is complex to implement in the context of this project, given the number of packages studied and the number of input variables. Sensitivity analyses presented in this report (section 2.9) are used to quantitatively measure the robustness of the conclusions reached on certain influential parameters of the study. These sensitivity analyses are not uncertainty analyses, but they do enable us to check that the conclusions of the study remain the same with different primary inventory data. The modified input data are targeted in advance by the person conducting the LCA study. The same foreground inventory data would also be modified as part of the uncertainty analysis, in a non-targeted manner, and all the other foreground or background data in the study would be modified. The sensitivity analyses presented in this report therefore provide a partial response to the uncertainty issues, but do not replace an uncertainty analysis.

In addition, methodological uncertainties (such as the choice of allocation method or impact calculation method) can also affect the results.
Below is a paragraph giving a qualitative breakdown of the uncertainties associated with the calculation of each of the indicators selected in this comparative LCA (the level of robustness of these calculation methods can be found in Table 4):

1. Climate Change - Baseline model of 100 years of the IPCC (based on IPCC 2013)

- The IPCC's climate models, while advanced, are based on future emissions scenarios, which are themselves subject to socio-economic and political uncertainties. The complexity of the climate system introduces natural variabilities that are difficult to predict accurately. Climate feedback, such as the release of methane from permafrost, are additional sources of uncertainty. Results may vary depending on the models used and the assumptions made. Finally, the time scale of 100 years can mask significant short-term variations.

2. Eutrophication in freshwater - EUTREND model (Struijs et al, 2009)

- The EUTREND model assesses eutrophication on a regional scale, which can mask significant local variations. Data on nutrient emissions, particularly nitrogen and phosphorus, are often incomplete or imprecise. The complexity of biogeochemical processes in aquatic ecosystems makes it difficult to model eutrophication accurately. Seasonal variations and extreme events, such as flooding, can have a significant impact on the results. The influence of human activities, such as agriculture and urbanisation, adds a further layer of complexity.

3. Soil use and transformation - Soil quality index based on LANCA (Beck et al. 2010 and Bos et al. 2016)

- The soil quality index based on LANCA depends on soil and land use data, which can vary considerably from region to region. The complexity of the interactions between the physical, chemical and biological properties of soils makes an exhaustive assessment difficult. Agricultural and forestry practices, as well as climate change, can significantly alter soil quality. Data on soil organic carbon stocks, a key indicator of soil quality, is often incomplete. Soil quality prediction models can be influenced by local factors that are not considered.

4. Consumption of water resources; water stress - Available WAter REmaining (AWARE) in UNEP, 2016

The AWARE indicator is sensitive to water consumption and availability data, which are often incomplete or inaccurate, particularly in developing regions. Seasonal and inter-annual variations in water availability can be difficult to incorporate into models. Groundwater abstraction, which is often poorly quantified, can have a significant impact on water stress. Climate change, by altering rainfall and evaporation patterns, adds a further layer of uncertainty. The water needs of ecosystems, which are often neglected, are difficult to assess accurately.

5. Consumption of non-renewable resources; Fossils - ADP for mineral and metal resources, based on van Oers et al. 2002 as implemented in CML, v. 4.8 (2016).

- The ADP indicator for fossil resources is based on estimates of reserves and extraction rates, which are subject to revision in the light of discoveries and technological advances. Fossil resource data may be influenced by economic and political factors, such as commodity prices and energy policies. Uncertainties related to the extraction and transformation of fossil resources may impact results. Greenhouse gas emissions associated with the extraction and combustion of fossil fuels are considered separately in the climate change indicator. The depletion of fossil fuels is a complex process, influenced by geological, technological and economic factors.

6. Consumption of non-renewable resources; Minerals and Metals - ADP for mineral and metal resources, based on van Oers et al. 2002 as implemented in CML, v. 4.8 (2016).

- The ADP indicator for mineral and metal resources is like that for fossil resources, with uncertainties related to reserve estimates and extraction rates. The complexity of the geology of mineral and metal deposits makes it difficult to assess available resources accurately. Technological advances in extraction and recycling may alter reserve estimates. Data on mineral and metal resources may be influenced by geopolitical factors, such as conflicts and embargoes. The environmental impact of the extraction and processing of mineral and metal resources, such as soil and water pollution, is not directly considered in this indicator.

2.9 SENSITIVITY ANALYSIS

Sensitivity analyses have been carried out on the calculations, either to consolidate the results and check that variations in certain input data do not lead to different conclusions, to partially meet the requirements of the ISO standard on uncertainties, or to assess potential levers for reducing environmental impact. In addition, some sensitivity analyses are carried out in response to a specific request from the CITEO customer (SA1 and SA2).

The following sensitivity analyses were carried out for packaging:

- SA1: Variation in the rate of recycled and incorporated material for certain materials
- SA2: Asian origin of primary packaging
- SA3: Increased pack volume for the PET/Cardboard blister family, without hugging the product

These analyses are presented in Section 4

2.10 TYPE OF CRITICAL REVIEW

To comply with the recommendations of ISO 14040, ISO 14044 and ISO 14071, and in view of the above-mentioned communication objectives, the LCA of packaging is subject to an external critical review by an examiner.
CITEO commissioned QUANTIS to carry out the critical review:

- Panel Chairman: Colin JURY - QUANTIS - jury.colin@quantis.com
- Packaging expert: Christophe MORIN - PACK AGILE - c.morin@packagile.fr
- LCA expert: Gonzalo HUAROC - POLE ECO-CONCEPTION - France gonzalo.huaroc@eco-conception.fr

The conclusion of the critical review is detailed in Section 6

The critical review process for an ISO 14040 and 14044 product life cycle assessment (LCA) report involves a full evaluation of the report by an independent expert to ensure that the study meets the standards set by ISO. The review process assesses the overall quality of the report, including the completeness of the data, the methodology used and the validity of the conclusions. The reviewer also assesses the transparency and objectivity of the report and ensures that the study complies with the guidelines set out in ISO standards 14040 and 14044.
A first report (called V1) was submitted to the reviewer, who read it and then compiled the remarks and comments in a report available in the appendix. The editors of this report took these comments into account and made the necessary changes to propose a second version of the report (called V2), which will be reread one last time before being submitted to the reviewer, who will then issue a final critical review opinion, available at the end of the report.

3 LIFE CYCLE INVENTORY

The following section describes the packaging systems studied and all the data and assumptions used to model them.

All the data included in the system's boundaries have been processed: the following LCIs make it possible to consider each piece of data required to model the system under study in a specific or generic way (in addition to assumptions if necessary).

The colour legend below has been used in the tables in this section to make them easier to understand:

- In ***bold orange***, data has been created by EVEA in previous projects or based on bibliography. The life cycle inventories (LCIs) for these specific data are reported in Section 3.3.

The recycled content and end-of-life of primary, industrial and commercial (secondary and tertiary) packaging are considered using the Circular Footprint Formula (CFF) (see Section 2.5).

The following sections contain descriptions of the following components and packaging materials:

- Primary packaging,
- Their ICPs between the packaging plant and the point of sale,
- Inventories of materials, manufacturing and finishing processes specific to the project,
- The transport scenarios considered,
- End-of-life (recycling, incineration, landfill) of primary packaging, ICPs and production offcuts.

3.1 - PRIMARY PACKAGING COMPONENTS AND MATERIALS BY PACKAGING SYSTEM

3.1.1 GENERAL HYPOTHESES

For the sake of readability and clarity, the assumptions applying to each of the packaging systems are explained once below to lighten the reading of the following tables and to focus on the assumptions specific to each of the packaging systems. Where assumptions are specific to certain packaging systems, these are discussed in the next Section 3.1.2 for an overall view.

Sample	N°	Scenario [7] [8]	Product number	Material [1] [6]	Component weight (g) [2]	Percentage of recycled material (%) [5] [10]	Percentage scrap in production (%) [2] [3]	Manufacturing process [6]	Finishing process [6] [4]	Finishing surface (cm^2)	Total mass (g)	Volume (cm3) [9]	Total mass / volume (g/cm3)

[1] For raw materials, "market for" background data was used, which includes an average supply transport for the geography under consideration as well as an average of raw material production data that reflects the industrial reality of the market. For the geography under consideration, "RER" data was used because in the case of CITEO's customers who market packaging in France, the origin of raw materials is generally European. A sensitivity analysis was carried out to study an Asian origin of raw materials. If "RER" data is not available, "GLO" data has been selected. For manufacturing processes, only "RER" data were selected unless contraindicated for a particular packaging system *(VR).*

[2] The quantity of material included in the "Component mass (g)" column does not include the quantity of scrap, which is added separately with the specific ratio in the "Percentage of production scrap" column. *(VR)*

[3] Not all customers have provided scrap rates for their various manufacturing processes. This parameter is important for several types of packaging, particularly those made from cardboard with a rectangular shape, or which are perforated in places. These scrap rates are specific to packaging design and apply to all die-cut parts of flat cardboard or plastic film used in primary packaging. The following approach has therefore been adopted:

a. Customer-specific scrap rates were used when this information was provided and deemed consistent after cross-referencing with the physical samples received by EVEA *(VR)*,

b. If the customer did not provide a specific scrap rate, EVEA estimated the scrap rate based on the packaging samples received. The "surface area" approach was adopted, i.e. the surface area covered by the maximum dimensions of the packaging in two orthogonal directions was subtracted from the actual surface area occupied by the packaging to obtain the scrap surface area and therefore the maximum production scrap rate *(R)*, *(EVEA assumption).*

c. In addition to the scrap rates specific to the design, scrap rates specific to the manufacturing processes were applied. These generic scrap rates were used from the transformation inventory data in ecoinvent.

- For the plastic injection process, the scrap rate applied is taken from the ecoinvent database, i.e. 0.6%. *(VR)*
- For the extrusion process, the scrap rate applied is taken from the ecoinvent database, i.e. 2.4%. *(VR)*
- For the thermoforming process, the scrap rate applied is taken from the ecoinvent database, i.e. 6%. *(VR)*
- For the flowpacking process, the scrap rate applied has been estimated at 2% by EVEA. *(R)*
- For cellulose, a scrap rate of 1% has been applied (value shared by a confidential manufacturer) but these "material" scraps are reintegrated into the following cycle. No material scrapes are therefore considered, but electrical and water losses are *(R)*

[4] Assumptions have been made concerning the finishing data:

a. Not all customers have provided surfaces for the various finishing processes. These surfaces are specific to packaging design. The following approach was therefore adopted:

- Customer specific surface finishes have been used where this information has been provided and found to be consistent after cross-referencing with physical samples received by EVEA. *(VR)*
- If the customer does not provide a specific scrap rate, EVEA has estimated the scrap rate based on the packaging samples received. *(VR) (EVEA assumption)*
- For all scenarios, a coverage rate of 100% of the finishing processe was considered (maximum EVEA assumption). *(VR)*

b. Two printing technologies are used: offset printing and flexographic printing. As life cycle inventories are not available in the ecoinvent database, EVEA has generated specific inventories for these data. These specific data are reported in Section3.3. *(VR)*

c. Heat-sealing varnish: The cardboard/PET blisters (reference packs) use heat-sealing varnish to bond the PET blister to the cardboard card. No customer was able to provide specific data on the composition of a heat-sealing varnish. The proxy "Polyurethane adhesive {GLO}| market for polyurethane adhesive | Cut-off, S" was therefore used for all the scenarios because commercial products[x,xi] of water-based heat-sealing varnish, specifically designed for heat-sealing PET or PVC to cardboard, are formulated on a polyurethane basis. Not all customers were able to collect the mass of heat-sealing varnish used, but this mass was estimated at 3% relative to the mass of cardboard for one customer (6 g/m² minimum according to one varnish manufacturer[xii] for a 200 g/m² cardboard). The conservative assumption of applying a mass of 10 g/m², i.e. a rate of 5%, to all PET/cardboard blisters was made. *(R)*

d. Gloss varnish: no customer was able to provide specific data on the composition of a gloss varnish. The proxy "Acrylic varnish, with water, in 53% solution state {RER}| market for acrylic varnish, with water, in 53% solution state | Cut-off, S" was therefore used for all scenarios. *(R)*

[5] Integration of recycled material: the R1 factor is explained in the CFF, see Section 2.5.

Note: All R1s are set at 0% in the base case so as not to favour the specific choices of each customer and to compare the intrinsic designs for each scenario on an equal footing. R1 recycling rates will be arbitrarily set at 50% in a dedicated sensitivity analysis. *(VR)*

[6] The material data, process data and finish data are the ecoinvent data called up for the component. ***Some data may be data that has been created by EVEA.*** Details of the background data used in this project are given in Table 10. *(VR)*

[7] The same transport scenario is considered for all the scenarios between the packaging plant and the point of sale of the product, i.e. 500 km by lorry according to the data "Transport, freight, lorry >32 metric ton, EURO6 {RER}| transport, freight, lorry >32 metric ton, EURO6 | Cut-off, S". This process is therefore called up for each package, for 500km and for the mass of the packaging system concerned (including primary, secondary and tertiary packaging). [xiii] *(VR)*

[8] The same transport scenario is considered for all scenarios between the production plant and the packaging plant, i.e. 300 km by lorry (recommendation in section 7.14.2 of the PEF[ix]) according to the data "Transport, freight, lorry >32 metric ton, EURO6 {RER}| transport, freight, lorry >32 metric ton, EURO6 | Cut-off, S". This process is therefore called up for each package, for 300km and for the mass of the packaging system concerned (including primary packaging only). *(VR)*

[9] The data associated with packaged volume is either collected by CITEO's customers or by EVEA via the packaging samples supplied. Table 9 details how the information is collected for packaged volume. Where EVEA collects packaged volume, different methods are used depending on the type of packaging.

a. Parallelepiped packaging: this is the simplest case, as all you must do is measure the length, width and height, then multiply these quantities together to obtain the packaged volume.

b. Complex shape packaging

- Impermeable: if the packaging is made of a material that can hold water, then the volume is calculated by measuring the mass of water it can hold, and the volume is then obtained using the density of the water.

- Permeable: if the packaging is not water-resistant, then a similar method is used, except that here the packaging is filled with powdered sugar. In the same way, the mass of sugar that can be accommodated is measured. Then, using the density of the powdered sugar, the packaged volume is determined.

[10] Recyclability of components: the R2 factor is explained in the CFF, see Section 2.5, and is detailed in Table 13. For all packaging, single-material packaging was considered recyclable at the rates in force in France, see Table 15. In the case of multi-material packaging, the main component was considered recyclable and the secondary components non-recyclable unless they were easily separable and effectively separated. The "PET/cardboard blister pack" reference packaging is not considered recyclable if the mass of cardboard is less than 70% of the total mass of the packaging. The value of 70% is the one envisaged in the PPWR update, which was adopted in 2025. If the mass of cardboard represents more than 70% of the total

mass, then the cardboard part is considered recyclable, but the PET shell is not considered recyclable. The recyclability of each packaging component considered in this study is detailed Table 13

For each of the packaging systems studied, here is the source of the data and additional description:

- All components, material data, manufacturing and finishing processes are derived from data provided by CITEO's customers.
  Note: Most customers were able to provide samples to EVEA. Based on these samples, EVEA was able to verify the data collected by the customers and collect any additional data that the customer had not been able to collect. *(VR)*

3.1.2 SPECIFIC HYPOTHESES

Where there are assumptions specific to certain packages, these are discussed in this section.

- The data associated with the process of shaping a flexible polymer, « flowpackage »:
  - It is assumed that both sides of the packaging undergo this treatment (welding). For some packs, only one side is welded. Consequently, 50% of this shaping is applied so that the model is representative of the packaging in question. *(R)*
  - A production scrap rate of 2% has been arbitrarily applied for this process. *(R)*
- For packaging family 5, moulded cellulose trays, shaping (thermoforming) is included in the specific data collected. *(VR)*

3.1.3 FOREGROUND DATA FOR PRIMARY PACKAGING

To give an overall view of the differences between the primary packaging and the masses involved, Table 8 below shows the composition and masses of each primary packaging. A colour code has been used to reflect the reliability of the data collected. The legend of this colour code is detailed Table 9

1326

Sample	N°	Scenario	Product number	Material	Component weight (g)	Percentage of recycled material (%)	Percentage scrap in production (%)	Manufacturing process	Finishing process	Finishing surface (cm^2)	Total mass (g)	Volume (cm3)	Total mass / volume (g/cm3)
Yes	1	**Cardboard blister + PET**	1.1	Flat cardboard	3,3	100%	11%	Cardboard cutting	Heat-seal varnish + Offset printing	234	7,0	95,3	0,073
				aPET	3,7	100%	6%	Thermoforming					
Yes			1.2	Flat cardboard	3,9	100%	1%	Cardboard cutting	Heat-seal varnish + Offset printing	236	5,9	50,0	0,118
				aPET	2,0	0%	6%	Thermoforming					
Yes			1.3	Flat cardboard	3,1	0%	3%	Cardboard cutting	Heat-seal varnish + Offset printing	180	4,4	25,1	0,176
				aPET	1,3	70%	6%	Thermoforming					
Yes			1.4	Flat cardboard	8,5	0%	1%	Cardboard cutting	Heat-seal varnish + Offset printing	674	18,8	168,6	0,111
				aPET	10,3	0%	6%	Thermoforming					
Yes			1.5	Flat cardboard	8,5	0%	1%	Cardboard cutting	Heat-seal varnish + Offset printing	674	23,0	352,0	0,065
				aPET	14,5	0%	6%	Thermoforming					
No	2	**Reverse blister pack**	2.1	Flat cardboard	8,0	48%	15%	Cardboard cutting	Offset printing	230	8,0	88,7	0,090
Yes			2.2	Flat cardboard	7,5	95%	17%	Cardboard cutting	Offset printing	512	7,5	56,0	0,134
Yes			2.3	Flat cardboard	7,8	100%	34%	Cardboard cutting	Offset printing	206	7,8	85,4	0,091
No			2.4	Flat cardboard	18,4	100%	6%	Cardboard cutting	Offset printing	494	18,4	436,6	0,042
No			2.5	Flat cardboard	12,0	88%	7%	Cardboard cutting	Offset printing	242	12,1	167,4	0,073
				PP	0,1	0%	20%	Extrusion		-			
Yes			2.6	Flat cardboard	8,1	88%	3%	Cardboard cutting	Offset printing	298	8,1	106,1	0,077
Yes	3	**Cardboard case**	3.1	Flat cardboard	12,1	100%	26%	Cardboard cutting	Offset printing	636	12,1	382,5	0,032
No			3.2	Flat cardboard	36,8	30%	34%	Cardboard cutting	Offset printing	661	56,9	902,7	0,063
No				Corrugated cardboard	20,1	100%	2%	Cardboard cutting		-			
Yes			3.3	Flat cardboard	9,9	95%	24%	Cardboard cutting	Offset printing	506	9,9	130,0	0,076
Yes			3.4	Flat cardboard	8,8	100%	45%	Cardboard cutting	Offset printing	245	8,8	85,4	0,103
Yes			3.5	Flat cardboard	20,3	0%	12%	Cardboard cutting	Offset printing	793	20,3	255,0	0,080
No	4	**Cardboard + straps**	4.1	Flat cardboard	21,7	0%	5%	Cardboard cutting	Offset printing	340	25,2	105,5	0,239
				Nylon	2,0	0%	5%	Injection	-	-			

				LDPE	1,5	0%	5%	Extrusion	-	-			
No	5	**Moulded cellulose**	5.1	Cellulose	8,0	100%	1%	Cellulose thermoforming	-	-	8,3	146,5	0,057
				aPET	0,3	0%	2,40%	Extrusion	Flexo printing	96			
Yes	6	**Flexible paper.PP transp**	6.1	Paper	1,5	0%	1%	Lamination	Offset printing	240	2,0	149,0	0,013
				PP	0,4	0%		Extrusion + lamination	Gloss varnish	240			
				Pu glue	0,1	0%		-	-	-			
Yes	7	**Flexible paper.PE opaque**	7.1	Paper	1,8	0%	1%	Flowpackage	Offset printing	240	2,4	126,0	0,019
				LDPE film	0,6	0%	2,40%	Extrusion	-	-			
Yes	8	**Flexible PP**	8.1	PP	5,4	0%	1%	Extrusion + flowpackage (1 side)	Flexo printing	315	5,8	414,1	0,014
				Paper	0,4	0%	18%	-	-				
Yes			8.2	PP	1,2	0%	1%	Extrusion + flowpackage	Offset printing	240	1,3	85,4	0,015
				PU glue	0,1	0%	1%	-					
Yes			8.3	PP	3,8	0%	0%	Extrusion + flowpackage	-	-	13,8	700,0	0,020
				Flat cardboard	10,0	0%	6%	Cardboard cutting	Offset printing	306			
Yes			8.4	PP	1,1	0%	1%	Extrusion + flowpackage	Offset printing	240	1,2	86,6	0,013
				Pu glue	0,1	0%	1%	-	Gloss varnish	-			
No	9	**Bulk without display**	9.1	Flat cardboard	43,0	80%	5%	Cardboard cutting	Offset printing	700	43,0 [1]	1120,0	0,038
No			9.2	Flat cardboard	15,0	0%	5%	Cardboard cutting	Offset printing	467	15,0 [1]	500,0	0,030
Yes	10	**Bulk with display**	10.1	Flat cardboard	40,7	100%	44%	Cardboard cutting	Offset printing	1076	43,1 [1]	1365,0	0,032
				Paper	0,1	0%	5%	Cardboard cutting	Offset printing	17			
				LDPE	2,3	0%	2%	Extrusion	-	-			

Table 8 Summary table of primary packaging data

[1] The notion of primary or secondary packaging for non-display bulk packaging is subtle. Primary packaging for this impact category is not necessarily present on the shelves (although some may be). On the other hand, this packaging is in direct contact with the product and can also be considered as primary packaging. In this study, the decision was made to consider this packaging as primary packaging, to facilitate comparison with other packaging (and to present all the elements more easily in the same Table 8), even though this consideration may be open to debate.

The Table 8 , brings together all the key data associated with each primary packaging: material, percentage of recycled material, percentage of production waste, etc. The various data come not only from the collection files filled in by CITEO's customers but also from the samples supplied to EVEA and then measured. The various items of information come not only from the collection files completed by CITEO's customers but also from samples supplied to EVEA and then measured. These two sources of information are invaluable for the collection of data specific to each packaging and make it possible to differentiate a two-level scale on the reliability of the arbitrations carried out on the data: very reliable (VR) and reliable (R). In the case where the customer has completed the data collection file and EVEA has analysed the sample, the information collected is robust. This situation leads to two cases:

- The value collected by the customer and by EVEA is identical or close, the value collected by the customer is retained. This is the case leading to the most robust information and is identified by the **green** colour code in Table 9. *(VR)*
- If the value collected by the customer and by EVEA are not identical or close enough, the value collected by EVEA is used. This leads to robust information and is identified by the **light green** colour code in Table 9. *(VR)*

In cases where the supplier has not collected the information and EVEA has been provided with a sample to study. This makes it possible to reliably measure the essential information, which is represented by the **light-yellow** colour in Table 9. This situation leads to a robust level of information *(R)*

Finally, if the supplier has collected the information and communicated it via the collection file and no sample has been provided to EVEA for verification purposes, this results in a level of information reliability considered to be the least robust in Table 9. However, the reliability of this type of data is sufficient to carry out an LCA (the data collected is not always verified using samples). This situation is represented by the **light orange** colour code *(R)*.

Legend
Collected by the supplier and measured by EVEA from the samples, **supplier value used**
Collected by the supplier and measured by EVEA from the samples, **EVEA value retained**
Not collected by supplier and measured/estimated by EVEA from samples, **EVEA value used**
Collected by the supplier, **supplier value retained**, EVEA was unable to verify

Generic ecoinvent rate applied

Table 9 Legend for the source of information associated with Table 8

3.1.4 BACKGROUND DATA FOR PRIMARY PACKAGING

Table 10 represents the background data used for raw materials, processes and finishes. These data were either taken directly from ecoinvent or were created by EVEA (shown in ***bold orange***) in previous projects or based on bibliography. The data created by EVEA is detailed in the 3.3 section.

Data name	R1 (% recycled content)	Background data used in modelling	Transport data (market)
Raw materials			
aPET	0%	Polyethylene terephthalate, granulate, amorphous {RER}| polyethylene terephthalate production, granulate, amorphous | Cut-off, S	Same transport scenario as in "Polyethylene terephthalate, granulate, amorphous {GLO}| market for polyethylene terephthalate, granulate, amorphous | Cut-off, U".
aPET	50%	**Polyethylene terephthalate amorphous recycled 50% {RER}| market | EVEA CFF - v3.10**	Same transport scenario as in "Polyethylene terephthalate, granulate, amorphous {GLO}| market for polyethylene terephthalate, granulate, amorphous | Cut-off, U".
Corrugated cardboard	0%	**Corrugated cardboard recycled 0% {RER}| market | EVEA CFF - v3.10**	Same transport scenario as in "Corrugated board box {RER}| market for corrugated board box | Cut-off, U".
Corrugated cardboard	50%	**Corrugated cardboard recycled 50% {RER}| market | EVEA CFF - v3.10**	Same transport scenario as in "Corrugated board box {RER}| market for corrugated board box | Cut-off, U".
Flat cardboard	0%	Solid bleached and unbleached board carton {RER}| solid bleached and unbleached board carton production | Cut-off, S	Same transport scenario as in "Solid bleached and unbleached board carton {RER}| market for solid bleached and unbleached board carton | Cut-off, U".
Flat cardboard	50%	**Flat cardboard recycled 50% {RER}| market | EVEA CFF - v3.10**	Same transport scenario as in "Solid bleached and unbleached board carton {RER}| market for solid bleached and unbleached board carton | Cut-off, U".
Cellulose	0%	**Cellulose R1=0% EVEA**	Same transport scenario as in "Sulfate pulp, unbleached {RER}| market for sulfate pulp, unbleached | Cut-off, U".
Cellulose	50%	**Cellulose R1=50% EVEA**	Same transport scenario as in "Sulfate pulp, unbleached {RER}| market for sulfate pulp, unbleached | Cut-off, U".
PU glue	0%	Polyurethane adhesive {GLO}| market for polyurethane adhesive | Cut-off, S	N/A
LDPE	0%	Polyethylene, low density, granulate {RER}| polyethylene production, low density, granulate | Cut-off, S	Same transport scenario as in "Polyethylene, low density, granulate {GLO}| market for polyethylene, low density, granulate | Cut-off, U".
LDPE	50%	**Polyethylene low density recycled 50% {RER}| market | EVEA CFF - v3.10**	Same transport scenario as in "Polyethylene, low density, granulate {GLO}| market for polyethylene, low density, granulate | Cut-off, U".
Nylon	0%	Nylon 6-6 {RER}| market for nylon 6-6 | Cut-off, S	N/A
Paper	0%	Kraft paper {RER}| kraft paper production | Cut-off, S	Same transport scenario as in "Kraft paper {RER}| market for kraft paper | Cut-off, U
Paper	50%	**Kraft paper recycled 50% {RER}| market | EVEA CFF - v3.10**	Same transport scenario as in "Kraft paper {RER}| market for kraft paper | Cut-off, U".
PP	0%	Polypropylene, granulate {RER}| polypropylene production, granulate | Cut-off, S	Same transport scenario as in "Polypropylene, granulate {GLO}| market for polypropylene, granulate | Cut-off, U".
PP	50%	**Polypropylene recycled 50% {RER}| market | EVEA CFF - v3.10**	Same transport scenario as in "Polypropylene, granulate {GLO}| market for polypropylene, granulate | Cut-off, U".
ICP raw materials			
aPET	0%	Polyethylene terephthalate, granulate, amorphous {RER}| polyethylene terephthalate production, granulate, amorphous | Cut-off, S	Same transport scenario as in "Polyethylene terephthalate, granulate, amorphous {GLO}| market for polyethylene terephthalate, granulate, amorphous | Cut-off, U".

LDPE film	0%	Polyethylene, low density, granulate {RER}| polyethylene production, low density, granulate | Cut-off, S	Same transport scenario as in "Polyethylene, low density, granulate {GLO}| market for polyethylene, low density, granulate | Cut-off, U".
Corrugated cardboard	0%	**Corrugated cardboard recycled 0% {RER}| market | EVEA CFF - v3.10**	Same transport scenario as in "Corrugated board box {RER}| market for corrugated board box | Cut-off, U".
Pallet	0%	EUR-flat pallet {RER}| market for EUR-flat pallet | Cut-off, S	N/A
Paper	0%	Kraft paper {RER}| kraft paper production | Cut-off, S	Same transport scenario as in "Kraft paper {RER}| market for kraft paper | Cut-off, U
Manufacturing processes			
Cardboard cutting	N/A	Already included in material data	N/A
Extrusion	N/A	Extrusion, plastic film {RER}| extrusion, plastic film | Cut-off, S	N/A
Flowpackage	N/A	**Flowpackage {RER} EVEA**	N/A
Injection	N/A	Injection moulding {RER}| injection moulding | Cut-off, S	N/A
Lamination	N/A	**Lamination {RER} (without binder) EVEA**	N/A
Thermoforming	N/A	Thermoforming of plastic sheets {GLO}| market for thermoforming of plastic sheets | Cut-off, S	N/A
Cellulose thermoforming	N/A	Already included in material data	N/A
Finishing processes			
Offset printing	N/A	**Offset printing RER EVEA**	N/A
Flexo printing	N/A	**Flexographic printing {GLO} EVEA**	N/A
Gloss varnish	0%	Acrylic varnish, with water, in 53% solution state {RER}| market for acrylic varnish, with water, in 53% solution state | Cut-off, S	N/A
Heat-sealing varnish	0%	Acrylic varnish, with water, in 53% solution state {RER}| market for acrylic varnish, with water, in 53% solution state | Cut-off, S	N/A

1368 **Table 10 Background data used in modelling for raw materials, manufacturing process and**
1369 **finishes**

1370 3.1.5 WEIGHT OF PACKAGING SYSTEMS (PRIMARY + ICP)

1371 Figure 4 shows the mass of primary packaging as a function of its composition for one CSU (in the
1372 specific case of bulk, the CSU is the entire bulk pack, which may contain several products).

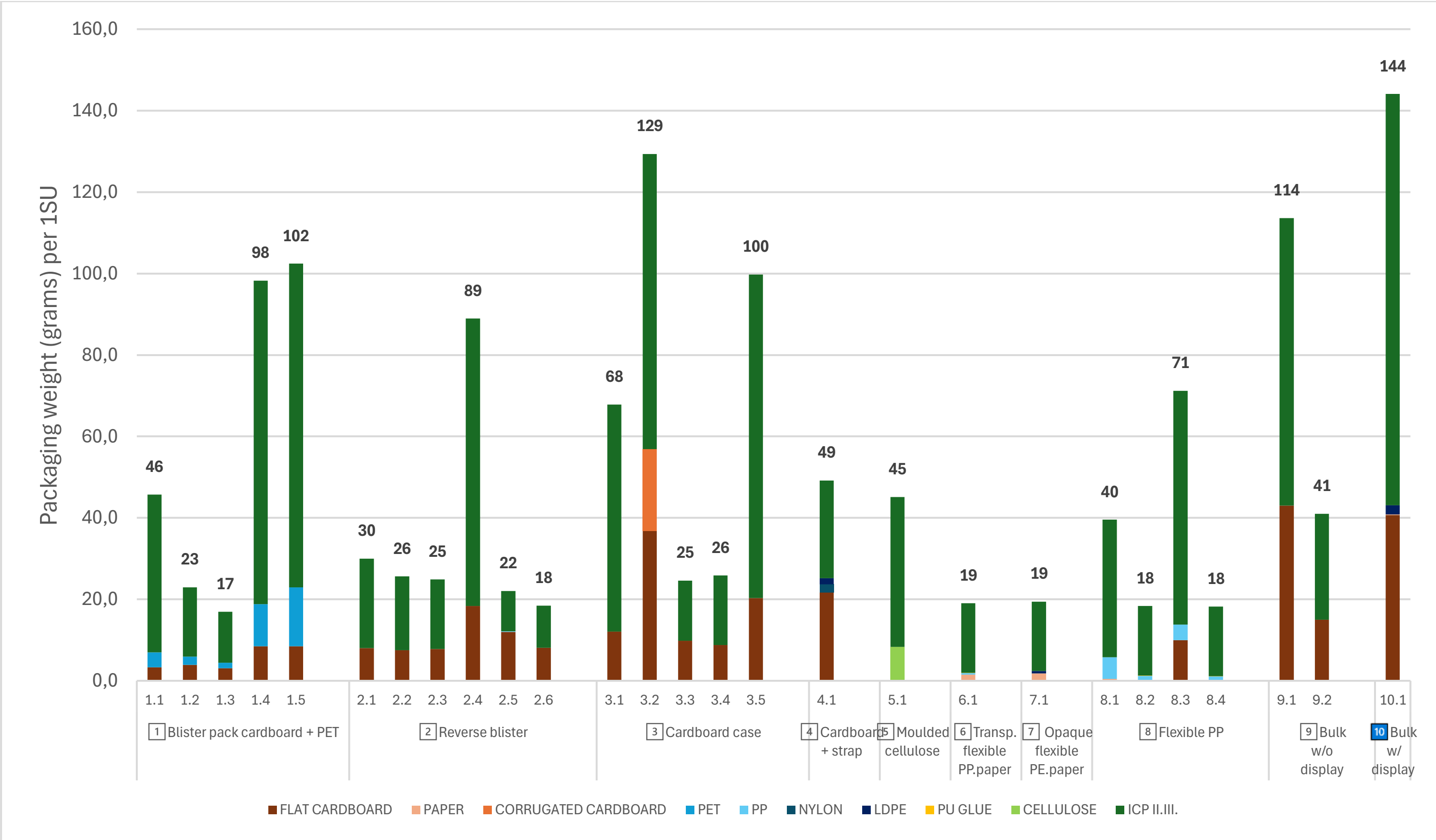


Figure 4 Pack weights for 1 CSU (in g)

The graphFigure 4 does not allow us to highlight generalities or trends by packaging type, especially as the UVCs presented here are not comparable with each other (not the same products, so different dimensions). However, the mass of ICP is much greater than the mass of primary packaging for all scenarios.

To get a better idea of a potential trend, the same graph is shown for the FU considered in this study at Figure 5

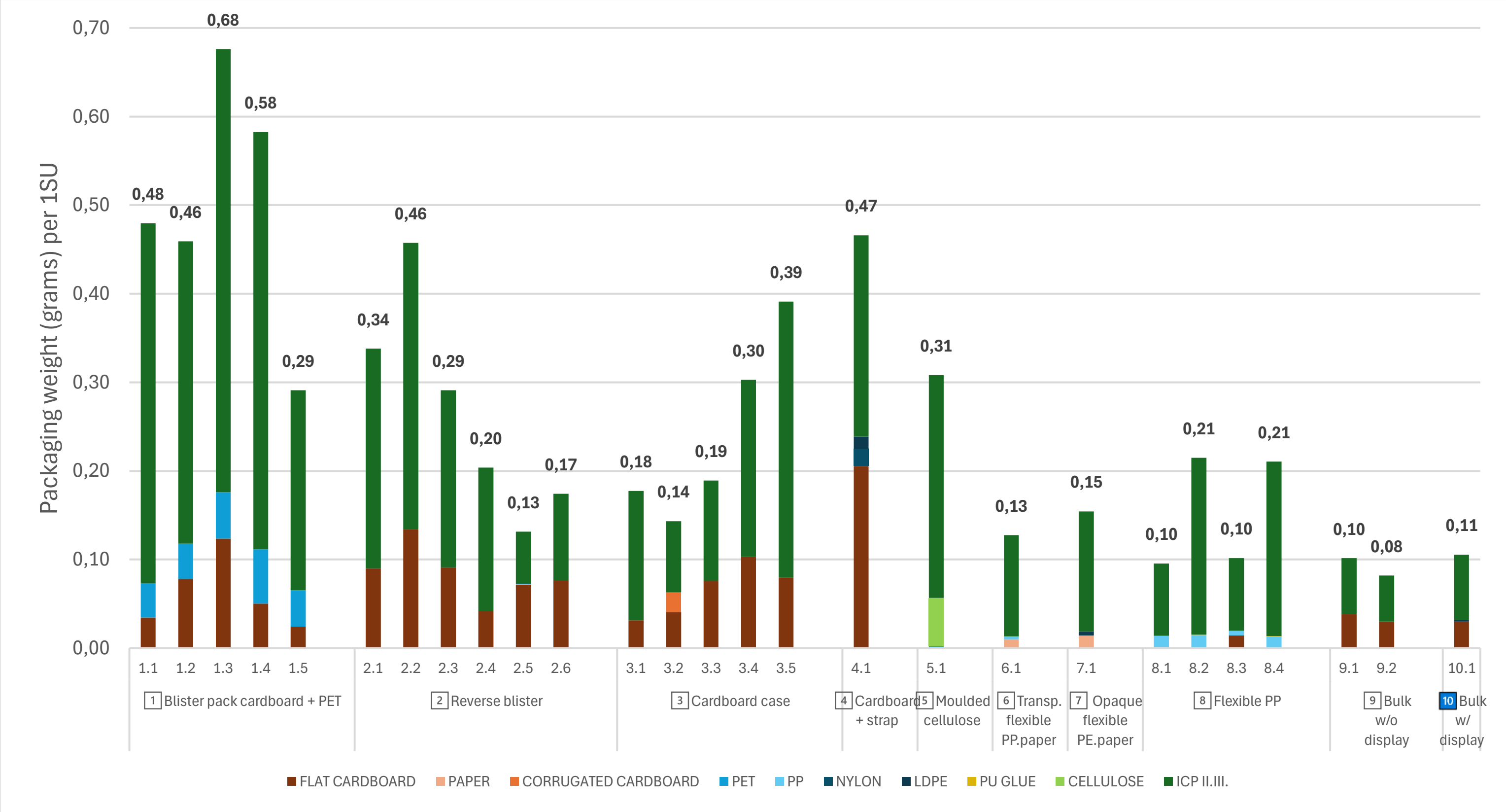


Figure 5 Weight of packaging per 1 cm3 packed (in g)

Figure 5 , shows significant trends in packaging mass by type. The **PET/cardboard blister** reference scenario has the highest overall ratio of packaging mass to packed volume (0.50 g/cm^{3}packed on average), followed by family 2: **reverse blisters** (0.32 g/cm^3 packed on average), then **cardboard cases** (family 3) with an average of 0.24 g of packaging per cm^3 packed.

In addition**, families 8 and bulk (9 and 10 together)** appear to offer the best "pack mass/packed volume" performance. These families respectively have an average ratio of 0.16 and 0.10 g per cm^{3}packed.

Families 4, 5, 6 and 7 have an intermediate ratio and are represented by only one sample, so it is not possible to establish a relevant average. However, family 4 has a very high ratio (0.47 g/cm^{3}packed), which is because this packaging does not really have a packed volume (volume of the product). The ratio for family 5 (0.31 g/cm^{3}packed) is close to the average for families 2 and 3: cardboard packaging families. Families 6 and 7 (0.13 and 0.15 g/cm^3 packed) have a ratio very close to the average for family 8: flexible PP packaging.

Nonetheless, there is considerable variability in the number of samples representing each family, which needs to be considered when analysing the average ratios.

3.2 COMPONENTS AND MATERIALS FOR INDUSTRIAL AND COMMERCIAL PACKAGING PER PACKAGE

3.2.1 GENERAL HYPOTHESES

For the sake of readability and clarity, the assumptions that apply to each packaging system are explained below only once, to lighten the reading of the following tables and focus on the assumptions specific to each packaging system.

N°	Scenario	Product number	Category	Material + process [1] [3] [4]	No. of packs I in pack II and/or III	Packing weight II or III (g) [2] [6]	Total mass of packaging II and III per I (g)

[1] For raw materials, "market for" data has been used, which includes an average supply transport for the geography under consideration as well as an average of raw material production data which reflects the industrial reality of the market. For the geography under consideration, "RER" data was used because the raw materials suppliers are in Europe. If "RER" data is not available, "GLO" data has been selected. *(VR)*

[2] The quantity of material included in the "Mass of packaging II or III (g)" column does not include the quantity of waste, which is considered directly in the ecoinvent data used (cardboard materials) or added for converted materials: 2.4% for LDPE film extrusion and 6% for PET tray thermoforming. *(VR)*

[3] Integration of recycled material: the R1 factor is explained in the CFF, see Section 2.5. Note: All R1s are set at 0% so as not to favour the specific choices of each customer and to compare the intrinsic designs for each scenario on an equal footing *(VR)*.

[4] Recyclability of components: the R2 factor is explained in the CFF, see Section 2.5. All ICP components are considered recyclable without exception, in line with the rates in force in France (see Table 15).

[5] The material data is the ecoinvent or EVEA data called up for the component. The background data is detailed in Table 10. Note that the shaping processes for ICP materials are directly included in the material data:

a. aPET thermoformed corresponds to PET material that has been shaped using a thermoforming process. Scraps are considered.

b. LDPE film corresponds to LDPE material with a film extrusion process, with associated scraps rate *(VR)*.

[6] The quantity of LDPE film required per pallet is the same for all types of packaging. This is an average of all the LDPE masses supplied during data collection. This choice is in line with the objectives of the study, since the aim here is to consider the ICPs without penalising a primary packaging due to poor palletising practices. In the same way, all pallets are 25kg (Europe format pallet) and used 25 times on average (source: [ix]). *(VR)*

3.2.2 SUMMARY TABLE OF ICP

To give an overview of the differences between the ICP systems, and in particular the masses involved and the optimisation of palletisation associated with a primary packaging design, the following Table 11 shows the composition and masses of each ICP.

N°	Scenario	Product number	Category	Material + process	No. of packs I in pack II or III	Packing weight II or III (g) [3]	Total mass of packaging II and III per I (g) [3]
1	**Cardboard blister + PET**	1.1	II	Corrugated cardboard	6	70	38,7
			III	LDPE film	936	300	
			III	Pallet	936	25000	
		1.2	II	Corrugated cardboard	160	604	17,1
			II	Corrugated cardboard	20	68	
			III	LDPE film	2560	300	

			III	Pallet	2560	25000	
		1.3	II	thermoformed aPET	12	12	12,5
			II	Corrugated cardboard	12	71	
			III	LDPE film	4512	300	
			III	Pallet	4512	25000	
		1.4	II	Corrugated cardboard	4	74	79,4
			II	Corrugated cardboard	24	409	
			III	LDPE film	576	300	
			III	Pallet	576	25000	
		1.5 [1]	II	Corrugated cardboard	4	74	79,4
			II	Corrugated cardboard	24	409	
			III	LDPE film	576	300	
			III	Pallet	576	25000	
2	**Reverse blister pack**	2.1	II	Corrugated cardboard	12	89	22,0
			II	Corrugated cardboard	840	600	
			III	Corrugated cardboard	315	1200	
			III	LDPE film	2520	300	
			III	Pallet	2520	25000	
		2.2	II	Corrugated cardboard	10	80	18,1
			III	LDPE film	2500	300	
			III	Pallet	2500	25000	
		2.3	II	Corrugated cardboard	160	604	17,1
			II	Corrugated cardboard	20	68	
			III	LDPE film	2560	300	
			III	Pallet	2560	25000	
		2.4	II	Corrugated cardboard	4	120	70,5
			III	LDPE film	624	300	
			III	Pallet	624	25000	
		2.5	II	Corrugated cardboard	22	112	9,9
			II	Paper	5544	1200	
			III	LDPE film	5544	300	
			III	Pallet	5544	25000	
		2.6	II	Corrugated cardboard	18	108	10,4
			II	Paper	6048	1200	
			III	LDPE film	6048	300	
			III	Pallet	6048	25000	
3	**Cardboard case**	3.1	II	Corrugated cardboard	4	90	55,8
			III	LDPE film	760	300	
			III	Pallet	760	25000	
		3.2	II	Corrugated cardboard	48	356	72,5
			II	Corrugated cardboard	432	2800	
			III	LDPE film	432	300	
			III	Palette	432	25000	
		3.3	II	Corrugated cardboard	10	63	14,7
			III	LDPE film	3000	300	
			III	Pallet	3000	25000	
		3.4	II	Corrugated cardboard	160	604	17,1
			II	Corrugated cardboard	20	68	
			III	LDPE film	2560	300	

			III	Pallet	2560	25000	
		3.5	II	Corrugated cardboard	4	74	79,4
			II	Corrugated cardboard	24	409	
			III	LDPE film	576	300	
			III	Pallet	576	25000	
4	**Cardboard + straps**	4.1 [2]	II	Corrugated cardboard	11	89	24,0
			II	Corrugated cardboard	770	600	
			II	Corrugated cardboard	289	1200	
			III	LDPE film	2310	300	
			III	Pallet	2310	25000	
5	**Moulded cellulose**	5.1	II	Corrugated cardboard	4	63	36,8
			III	LDPE film	1200	300	
			III	Pallet	1200	25000	
6	**Transp flexible paper.PP**	6.1	II	Corrugated cardboard	160	604	17,1
			II	Corrugated cardboard	20	68	
			III	LDPE film	2560	300	
			III	Pallet	2560	25000	
7	**Opaque flexible paper.PE**	7.1	II	Corrugated cardboard	160	604	17,1
			II	Corrugated cardboard	20	68	
			III	LDPE film	2560	300	
			III	Pallet	2560	25000	
8	**Flexible PP**	8.1	II	Corrugated cardboard	25	211	33,7
			III	LDPE film	1000	300	
			III	Pallet	1000	25000	
		8.2	II	Corrugated cardboard	160	604	17,1
			II	Corrugated cardboard	20	68	
			III	LDPE film	2560	300	
			III	Pallet	2560	25000	
		8.3	II	Corrugated cardboard	6	110	57,4
			III	LDPE film	648	300	
			III	Pallet	648	25000	
		8.4	II	Corrugated cardboard	160	604	17,1
			II	Corrugated cardboard	20	68	
			III	LDPE film	2560	300	
			III	Pallet	2560	25000	
9	**Bulk without display**	9.1	II	Corrugated cardboard	3	80	70,6
			III	LDPE film	576	300	
			III	Pallet	576	25000	
		9.2	II	Corrugated cardboard	50	364	26,0
			III	LDPE film	1350	300	
			III	Pallet	1350	25000	
10	**Bulk with display**	10.1	II	Corrugated cardboard	18	552	100,9
			III	LDPE film	360	300	
			III	Pallet	360	25000	

Table 11 Summary table of information relating to ICPs

[1] In the case of packaging 1.5, as the pelletising plan was not provided, it is identical to packaging 1.4. This consideration is consistent since the two products have very similar packaging in terms

of size, are produced by the same manufacturer and package two products of the same brand *(VR)*.

[2] For the "4.1 cardboard + straps" packaging, the palletising plan was not provided at the time of data collection. As a result, it is approximated by the layout of the ICPs for product 2.1. These two items are produced by the same manufacturer, which implies consistent palletising practices. As the products have different dimensions, a ratio between the maximum volume of the two products is applied so that a consistent number of "4.1 cardboard + straps" packages fit into a grouping box designed for the 2.1 package. Similarly, the same number of grouping boxes are placed on the pallet.

[3] The masses presented in the column "Packaging II or III mass (g)" correspond to the masses used in the LCI for all secondary and tertiary packaging, except for pallets, which are used 25 times and therefore have a mass divided by 25 in the LCI. On the other hand, the calculation in the column "Total mass of packaging II and III per I (g)" considers the mass of the entire pallet and corresponds to the mass of secondary and tertiary packaging transported.

3.3 SPECIFIC MATERIALS, MANUFACTURING PROCESSES AND FINISHING PROCESSES

The data created by EVEA for materials, finishing and manufacturing processes are listed below. Some data will be used later in the report (for the end-of-life of certain materials) but are nevertheless presented here. To ensure that the report is easy to read, an explanation of how each item of data was obtained has been appended. Readers can use the cross-references below to consult the inventory used to generate each datum.

Raw materials:

- **Polyethylene terephthalate amorphous recycled 50% {RER}| market | EVEA CFF - v3.10** → *see Appendix 7.2.1*
- **Corrugated cardboard recycled 0% {RER}| market | EVEA CFF - v3.10** → *see Appendix 7.2.2*
- **Corrugated cardboard recycled 50% {RER}| market | EVEA CFF - v3.10** → *see Appendix 7.2.2*
- **Flat cardboard recycled 50% {RER}| market | EVEA CFF - v3.10** → *see Appendix 7.2.3*
- **Cellulose R1=0%** → *see Appendix 7.2.4*
- **Cellulose R1=50%** → *see Appendix 7.2.4*
- **Polyethylene low density recycled 50% {RER}| market | EVEA CFF - v3.10** → *see Appendix 7.2.5*
- **Kraft paper recycled 50% {RER}| market | EVEA CFF - v3.10** → *see Appendix 7.2.6*
- **Polypropylene recycled 50% {RER}| market | EVEA CFF - v3.10** → *see Appendix 7.2.7*

Manufacturing processes:

- **Flowpackage {RER} EVEA** → *see Appendix 7.2.8*
- **Lamination {RER} (without binder) EVEA** → *see Appendix 7.2.9*

Finishes:

- **Offset printing RER EVEA** → *see Appendix 7.2.10*
- **Flexographic printing {GLO} EVEA** → *Appendix 7.2.11*

Electricity:

- **Electricity, medium voltage {EN}| market for electricity, medium voltage - Scenario 2030 - EVEA** → *see Appendix 7.2.12*

3.4 UPSTREAM TRANSPORT OF RAW MATERIALS TO PACKAGING AND/OR MANUFACTURING PLANTS

All the raw materials used in this project were modelled using ecoinvent "market for" data or modified to correspond to market data (see Table 10). Market for" data includes the average transport of the material to the point of consumption for a given geographical area. Packaging components may be transported several times before arriving at the packaging site. As the number of transfers between the various subcontractors and conversion sites and the transport distances depend on the choice and the technical and economic constraints of each marketer and, to a lesser extent, on the design of the packaging, the assumption has been made not to consider the impact of transport specific to this stage, considering that the transport included in the "market for" data already covers this aspect. *(R)*

3.5 DOWNSTREAM TRANSPORT OF PACKAGING FROM PRODUCTION PLANTS TO PACKAGING PLANTS

Once the various primary packaging components have been produced, they are shipped to the place where the product is packaged. All packaging is transported by lorry over 300 km (described aboveTable 12). The mass transported corresponds to the mass of the packaging system reduced to one CSU (primary packaging one CSU).

As mentioned in the exclusion criteria Table 3 , ICPs used to transport "empty" primary packaging (or primary packaging components) from their production site to the product packaging site have not been taken into account for two reasons:

- It was not possible to go back up the value chain when collecting the data, as there are n-4 contacts between EVEA and the manufacturers who would have this type of information. It would not have been possible to have a homogeneous and robust data collection at this stage.
- This stage is more concerned with industry practices than with the eco-design of final packaging and integrating this stage does not directly meet the objectives of this LCA.

In addition, the packaging and packaging components are at this stage in a form optimised for transport, thus reducing the quantity of ICP required. For example, cardboards are packaged flat, PET blisters are not yet thermoformed and are packaged flat or are already thermoformed and can therefore be stacked, and the same applies to cellulose blisters.

3.6 DOWNSTREAM TRANSPORT OF PACKAGING FROM PACKAGING PLANTS TO POINTS OF SALE

Once the products (of various types here) have been packed in the primary packaging, they are packed in ICPs (see Table 11) for shipping to the points of sale. All packaging is transported by lorry over 500 km (described below Table 12). The mass transported corresponds to the mass of the packaging system per CSU (primary packaging + ICP for one CSU).

Truck (>32 T)	Transport, freight, lorry >32 metric ton, EURO6 {RER}| transport, freight, lorry >32 metric ton, EURO6 | Cut-off, S

Table 12 Transport data between packaging plant and point of sale

3.7 END OF LIFE

Primary, secondary and tertiary packaging, as well as supply and distribution packaging, are considered to end up in the household packaging waste stream, where they can be sorted for recycling or sent for final treatment (landfill or incineration).

The recyclability of primary packaging components is described in Table 13 . The end-of-life associated with these recyclable components will therefore be recycling at the recyclability rates described in Table 15 , and a residual end-of-life corresponding to the remaining residual rate, which will be shared with the incineration and landfill rate projected for 2030. Non-recyclable components have an end-of-life that will be shared only between the incineration and landfill rates projected for 2030. The abbreviations used in the "Justification" column of Table 13 are described in Table 14

N°	Scenario	Product number	Material	Recyclable (yes/no)	Justification
1	Cardboard blister + PET	1.1	Flat cardboard	no	m<70%
			PET	no	NS
		1.2	Flat cardboard	no	m<70%
			PET	no	NS
		1.3	Flat cardboard	yes	m>70%
			PET	no	NS
		1.4	Flat cardboard	no	m<70%
			PET	no	NS
		1.5	Flat cardboard	no	m<70%
			PET	no	NS
2	Reverse blister pack	2.1	Flat cardboard	yes	M
		2.2	Flat cardboard	yes	M
		2.3	Flat cardboard	yes	M
		2.4	Flat cardboard	yes	M
		2.5	Flat cardboard	yes	M
			PP	no	NS
		2.6	Flat cardboard	yes	M
3	Cardboard case	3.1	Flat cardboard	yes	M
		3.2	Flat cardboard	yes	M
			Corrugated cardboard	yes	S=M

		3.3	Flat cardboard	yes	M
		3.4	Flat cardboard	yes	M
		3.5	Flat cardboard	yes	M
4	Cardboard + straps	4.1	Flat cardboard	yes	M
			Nylon	no	NS
			LDPE (bubble bag)	yes	SS
5	Moulded cellulose	5.1	Cellulose	yes	M
			PET lid	no	NS
6	Transp flexible paper.PP	6.1	Paper	yes	M
			PP	no	NS
			Pu glue	no	NS
7	Opaque flexible paper.PE	7.1	Paper	yes	M
			LDPE film	no	NS
8	Flexible PP	8.1	PP	yes	M
			Paper	no	NS
		8.2	PP	yes	M
			PU glue	no	NS
		8.3	PP	yes	M
			Flat cardboard	yes	SS
		8.4	PP	yes	M
			Pu glue	no	NS
9	Bulk without display	9.1	Flat cardboard	yes	M
		9.2	Flat cardboard	yes	M
10	Bulk with display	10.1	Flat cardboard	yes	M
			Paper	no	NS
			LDPE	yes	SS

Table 13 Primary packaging components considered recyclable in 2030

[1] Packaging elements are considered "recyclable" here if the element can join a recycling channel that has been set up on the scale and in practice. Recyclability calculated by software such as CITEO's TREE may differ, particularly for complete packaging.

Legend	
m<70%	cardboard mass < 70% total packaging mass
m>70%	cardboard mass > 70% total packaging mass
NS	non-separable or non-separated element in reality
M	main component of recyclable packaging
S=M	secondary packaging component made of the same material as the main component
SS	secondary element separable and separate from the main element

Table 14 Legend for abbreviations used in the "Justification" column ofTable 13

For all **primary packaging**, in the case of single-material packaging made from a recyclable material, this was considered recyclable at the rates in force in France (see Table 15). In the case of multi-material packaging, the main component was considered recyclable and the secondary components non-recyclable unless they were easily separable and effectively separated. The "PET/cardboard blister pack" reference packaging is not considered recyclable if the mass of cardboard is less than 70% of the total mass of the packaging. If the mass of cardboard represents more than 70% of the total mass, then the cardboard part is considered recyclable but the PET blister is not considered recyclable (see the remark on the previous paragraph in Section 1.1).

ICPs are considered recycled because:

- Single-material cardboard boxes and paper dividers can easily follow the paperboard recycling flows.
- LDPE films, which are collected by manufacturers as part of the value chain, are considered recyclable and recycled at the same rate as PE - the flexible sector projected for 2030.
- PET trays can follow the rigid PET stream.
- Wooden pallets are reused and then sent to wood waste streams.

3.7.1 END-OF-LIFE SCENARIO

Data source and additional description:

- It has been assumed that all packaging and their respective ICPs end their life in the target market, i.e. the French market. *(VR)*
- All end-of-life data for 2030, data from the report "Household packaging: What trajectories for 2030? Press briefing - 15 May 2023" by CITEO[xiv] . *(R)*
- Residual incineration and landfill rates in France are projected at 29% for landfill and 71% for incineration by 2030, according to the FNADE (Fédération Nationale des Activités de la Dépollution et de l'Environnement)[xv]. These figures are obtained by calculating the ratio of disposal or energy recovery to total materials not recovered.

3.7.2 OVERVIEW OF END OF LIFE

Table 15 below shows the end-of-life percentage data for France. The first two lines consider the incineration (energy recovery) and landfill rates, where a material is not recycled. For materials, a recycling rate is applied, and the residual rate remaining unrecycled is shared with the incineration and landfill rates.

Material	% end of life	France
Non-recyclable material (2030)	**% energy recovery (incineration)**	71%
	% landfill	29%
Paper	**recycling rate**	85%
	% energy recovery (incineration)	11%
	% landfill	4%
Flat cardboard	**recycling rate**	85%
	% energy recovery (incineration)	11%
	% landfill	4%
Corrugated cardboard	**recycling rate**	85%
	% energy recovery (incineration)	11%
	% landfill	4%
Pallet wood	**recycling rate**	30%
	% energy recovery (incineration)	50%
	% landfill	20%
PP Flexible	**recycling rate**	55%

Material	% end of life	France
	% energy recovery (incineration)	32%
	% landfill	13%
LDPE (household)	recycling rate	55%
	% energy recovery (incineration)	32%
	% landfill	13%
PET	recycling rate	55%
	% energy recovery (incineration)	32%
	% landfill	13%
Adhesives, Coating, Finishes	recycling rate	0%
	% energy recovery (incineration)	71%
	% landfill	29%

Table 15 End-of-life data by type of material in France in 2030 (source: CITEO[xvi]).

For the % LDPE recycling rate for pallet film, the LDPE (household) rate was applied, i.e. 55%. The observed specific recycling rate for LDPE pallet film seems to be higher than 40% (approaching 90%) but no specific rate could be applied due to a lack of reliable statistics. The explanation for this specific recycling rate of 90% lies in the fact that manufacturers who assemble and dismantle pallets have infrastructures dedicated to sorting their ICP waste. So, the current recycling rate for plastic packaging (32% according to CITEO) and even that for 2030 (55% CITEO target) is certainly an underestimate compared with what happens in industry. The truth about the recycling rate for LDPE plastic pallet film therefore lies between these two values: 55% and 90%. Since the rate used for modelling is 55%, the impacts associated with the end-of-life of plastic films are certainly overestimated. As this consideration is identical for all the packaging in the study, the order between the different alternatives compared will remain the same whatever the value considered. However, if the order between two alternatives is maintained, the difference between the two alternatives could be affected upwards or downwards.

3.7.3 END-OF-LIFE IN FRANCE: RECYCLING

3.7.3.1 CFF data

Table 16 below shows the data used to implement the CFF by material. These values are taken from Appendix C of the European Commission's EF method[xvii].

Material	A	Qsout/Qp
Plastics	0,5	0,9
Paper/Cardboard	0,2	0,85
Wood	0,8	1

Table 16 CFF data for the fraction of materials with recycled content

The Qsout/Qp ratio for wood is not given in Appendix C. We take 1 by default.

3.7.3.2 Recycling oh finished product

Table 17 below presents the life cycle inventory of the recycling process for the materials included in primary packaging and their corresponding ICPs. For each material, the recycling process data is explained.

Material	France
Paper	Graphic paper, 100% recycled {RER}| graphic paper production, 100% recycled | Cut-off, S
Flat cardboard	White lined chipboard carton {RER}| white lined chipboard carton production | Cut-off, S
Corrugated cardboard	**Corrugated box {RER}| production | Cut-off, U 100% recycled [3]**

Material	France
Pallet wood	Wood chips, from post-consumer wood, measured as dry mass {RER}| market for wood chips, from post-consumer wood, measured as dry mass | Cut-off, S
PP Flexible	Polyethylene, high density, granulate, recycled {CH}| polyethylene production, high density, granulate, recycled | Cut-off, S [2]
Flexible LDPE	Polyethylene, high density, granulate, recycled {CH}| polyethylene production, high density, granulate, recycled | Cut-off, S [2]
PET	Polyethylene terephthalate, granulate, amorphous, recycled {Europe without Switzerland}| polyethylene terephthalate production, granulate, amorphous, recycled | Cut-off, S
Adhesives, Coating, Finishes, other plastics [4]	N/A

Table 17 Inventory of recycling processes for primary, secondary and tertiary packaging

Assumptions:

[2] As there are no specific data for the mechanical recycling of flexible PP and flexible PE (film) within ecoinvent, an assumption has been made about this recycling process being like the data on recycled polyethylene. *(R)*

Similarly, CITEO indicates that the future recycling stream for flexible PP will be a stream recycled by a chemical recycling process. As this type of process does not exist on an industrial scale and is therefore not included in ecoinvent, an approximation using mechanical recycling has been made. (*LR*). This approximation may lead to an underestimation of the end-of-life impact of the flexible solution, as chemical recycling will certainly have a greater impact and require more energy than mechanical recycling. On the other hand, chemical recycling could increase the Qsout/Qp ratio from 0.9 to 1, which would increase the benefits of recycling. In fact, chemical recycling makes it possible to return directly to the monomer. As a result, it is possible to produce a polymer of equivalent quality afterwards (Qsout/Qp=1), which is not the case with mechanical recycling. These questions and assumptions clearly show that there is a need for new specific LCAs linked to the challenges of polymer recycling processes to refine the results of this type of LCA.

[3] The cardboard recycling process is not included in the ecoinvent database. EVEA has created new cardboard recycling processes by adapting the ecoinvent data. Details of these changes are available in the3.3 section. *(R)*

[4] These components are not intended for recycling, and are considered to be incinerated and/or landfilled in accordance with the tables in Sections3.7.4 and .3.7.5 *(R)*

TheTable 18 below shows the life cycle inventory of virgin materials avoided by recycling for the materials included in primary packaging and their corresponding ICPs.

Material	France
Paper	Kraft paper {RER}| kraft paper production | Cut-off, S
Flat cardboard	Solid bleached and unbleached board carton {RER}| solid bleached and unbleached board carton production | Cut-off, S
Corrugated cardboard	**Corrugated cardboard box {RER}| Virgin production | Cut-off, U**
Pallet wood	Sawnwood, softwood, raw, dried (u=20%) {Europe without Switzerland}| sawnwood production, softwood, raw, dried (u=20%) | Cut-off, S
PP Flexible	Polypropylene, granulate {RER}| polypropylene production, granulate | Cut-off, S
Flexible LDPE	Polyethylene, low density, granulate {RER}| polyethylene production, low density, granulate | Cut-off, S
PET	Polyethylene terephthalate, granulate, amorphous {RER}| polyethylene terephthalate production, granulate, amorphous | Cut-off, S
Adhesives, coatings, finishes, other plastics [4]	N/A

Table 18 Inventory of virgin materials avoided by recycling primary, secondary and tertiary packaging

3.7.4 END-OF-LIFE IN FRANCE: ENERGY RECOVERY

3.7.4.1 Energy recovery

The Table 19 below shows the data used for energy recovery in France. The projected French electricity mix in 2030 is detailed in Section 3.3.

	Energy recovery
Type of energy	**France**
Electricity 2030	**Electricity, medium voltage {EN}| market for electricity, medium voltage - Scenario 2030 - EVEA**
Heat	Heat, central or small-scale, natural gas {RER}| market group for heat, central or small-scale, natural gas | Cut-off, S

Table 19 Energy recovery inventories

Assumptions:

- During incineration with energy recovery, electricity and thermal energy can be recovered. The quantities recovered depend on the efficiency of the incinerator.
  - To evaluate the energy recovered, we apply the following formula given by the Circular Footprint Formula (CFF) recommended by the European Commission *(VR)*:
    - $Electricity\ recovered = Part\ of\ material\ incinerated * LHV * X_{ER,elec}$
    - $Heat\ recovered = Part\ of\ material\ incinerated * LHV * X_{ER,heat}$
      - LHV: Lower calorific value (MJ/kg)
      - $XER_{,elec}$: efficiency of the energy recovery process on the incineration site to produce electricity
      - $XER_{,heat}$: efficiency of the energy recovery process on the incineration site for heat.
  - Losses occurring in the use of heat (e.g. heat network losses) or electricity (e.g. load or transformation losses) generated by the recovery are not considered *(R)*.
- 100% of the material incinerated is recovered and 100% of the benefits of incineration are allocated to the material (B=0), as recommended in Appendix C of the PEF. *(VR)*

Table 20 below shows the energy recovery efficiency data used to generate heat and electricity from waste in France, and the lower calorific value considered for each material.

		Efficiency of energy recovery in France [1]	
	LHV (MJ/kg)	**XER, elec**	**XER, heat**
Paper	14,12	0,11	0,268
Flat cardboard	15,92	0,11	0,268
Corrugated cardboard	15,92	0,11	0,268
Pallet wood	14,0	0,11	0,268
PP Flexible	32,6	0,11	0,268
Flexible LDPE	39,01	0,11	0,268
PET	22,95	0,11	0,268
Adhesives, Coating, Finishes, other plastics	30,79	0,11	0,268

Table 20 Net energy production data used for energy recovery by region

Assumption:

[1] The ADEME guidelines for the comparative LCA of packaging[xviii] give a value for $XER_{,elec}$ and $XER_{,heat}$ specific to France. These two values have been adopted for France and Europe. *(VR)*

[2] The LHVs are indicated in the documentation of the incineration process in the ecoinvent database. See Section 3.7.4.2 for details of selected incineration processes. (*VR*)

3.7.4.2 Energy recovery from the final product

General assumptions:

The percentages of waste entering the energy recovery stream are detailed in Section 3.7.2. These R3 rates for 2030 are calculated by this formula: "tx_inc*(1-R2)" with tx_inc the incineration rate of 71% for the scenario projected for France in 2030.

Table 21 below shows the life cycle inventory of the various processes for recovering energy from materials in France.

Material	France
Paper	Waste graphical paper {CH}| treatment of waste graphical paper, municipal incineration FAE | Cut-off, S
Flat cardboard	Waste paperboard {CH}| treatment of waste paperboard, municipal incineration FAE | Cut-off, S
Corrugated cardboard	Waste paperboard {CH}| treatment of waste paperboard, municipal incineration FAE | Cut-off, S
Pallet wood	Waste wood, untreated {CH}| treatment of waste wood, untreated, municipal incineration FAE | Cut-off, S
PP Flexible	Waste polypropylene {CH}| treatment of waste polypropylene, municipal incineration FAE | Cut-off, S
Flexible LDPE	Waste polyethylene {CH}| treatment of waste polyethylene, municipal incineration FAE | Cut-off, S
PET	Waste polyethylene terephthalate {CH}| treatment of waste polyethylene terephthalate, municipal incineration FAE | Cut-off, S
Adhesives, Coating, Finishes, other plastics	Waste plastic, mixture {CH}| treatment of waste plastic, mixture, municipal incineration FAE | Cut-off, S

Table 21 Inventory of energy recovery processes in France

3.7.5 END OF LIFE IN FRANCE: LANDFILL

General assumptions:

- The percentages of waste destined for landfill are detailed in Section 3.7.2. They correspond to the percentage of waste that has not been recycled or recovered for energy purposes.

Table 22 below shows the life cycle inventory of the various materials landfilled in France, considered in the landfill scenario.

Material	France
Paper	Waste graphical paper {CH}| treatment of waste graphical paper, sanitary landfill | Cut-off, S
Flat cardboard	Waste paperboard {CH}| treatment of waste paperboard, sanitary landfill | Cut-off, S
Corrugated cardboard	Waste paperboard {CH}| treatment of waste paperboard, sanitary landfill | Cut-off, S
Pallet wood	Waste wood, untreated {CH}| treatment of waste wood, untreated, sanitary landfill | Cut-off, S
PP Flexible	Waste polypropylene {CH}| treatment of waste polypropylene, sanitary landfill | Cut-off, S
Flexible LDPE	Waste polyethylene {CH}| treatment of waste polyethylene, sanitary landfill | Cut-off, S
PET	Waste polyethylene terephthalate {CH}| treatment of waste polyethylene terephthalate, sanitary landfill | Cut-off, S
Adhesives, Coating, Finishes, Non-recyclable PET	Waste plastic, mixture {CH}| treatment of waste plastic, mixture, sanitary landfill | Cut-off, S

Table 22 Inventory of landfill processes in France

3.7.6 END-OF-LIFE OF SCRAPS

- Percentages of scraps/production waste were considered for all materials. These percentages are given in Table 8 (column "Production scrap percentage (%)"). The percentages of production waste are specific to the product design (given by the customer or by EVEA) or come from general information in the ecoinvent data. These scraps production are recycled with a recycling rate of 100% for single-material components and 0% for multi-material components or packaging. *(R)*

- No scrap or production waste related to the packaging of the products in the packs has been considered. The impact of packaging is outside the scope of the study as it depends on the product to be packaged, and no specific data has been collected on this subject. *(VR)*

4 LIFE CYCLE IMPACT ASSESSMENT & INTERPRETATIONS

Environmental impacts are assessed using the calculation method presented in Section 2.6. The following section presents and compares the life cycle impacts of packaging.

This section is divided into the following parts:

- 4.1 Selected impact categories
  - Climate change
  - Eutrophication in freshwater
  - Land use and transformation
  - Consumption of water resources; water stress
  - Consumption of non-renewable resources; Fossils
  - Consumption of non-renewable resources; Minerals and Metals
  - PEF Single Score
- 4.2 Comparison of packaging families:
  - 4.2.1: According to the Main FU, over the entire Life Cycle, by life cycle stage, for the 6 impact categories selected + Single Score in addition
  - 4.2.2: According to Secondary FUs, over the entire Life Cycle, with a qualitative approach
  - 4.2.3: According to the Main FU, on the LC stages corresponding to primary packaging, on the 6 impact categories selected + Single Score in addition
  - 4.2.4: According to the Main FU, with a focus on packaged volume ("volume classes", between small, medium and large volumes)
- 4.3 Focus on 3 stages in the life cycle for primary packaging
  - Raw materials, manufacturing and end-of-life
- 4.4 Sensitivity analyses (*climate change only, other indicators in appendix*):
  - SA1: Variation in the rate of recycled and incorporated material for certain materials
  - SA2: Asian origin of primary packaging
  - SA3: Increased pack volume for the PET/Cardboard blister family, without hugging the product
  - Other SA prospects

For the sake of readability, only the graphs are presented in the report. The tables and data used to construct the graphs are presented in tables appended to the report (Section 7.3). Some tables are nevertheless presented in the body of the report when deemed relevant.

4.1 SELECTED IMPACT CATEGORIES

For this study, the impact indicators were selected from those in the EF method, recommended by the European Commission's Joint Research Centre (JRC). The 16 indicators proposed by this method are described in Section 2.6.

Given the results obtained using the EF 3.1 method (single score, see Table 23 below), the impact indicators contributing to more than 80% of the cumulative impact on the single score could have been chosen. This method of choosing impact indicators (80% of the cumulative impact on the single score) is described in the PEFCR guidance document proposed by the European Commission (Fazio & et al., 2018)[vii].

However, the top 80% of SU contributors for all the scenarios represent 8 of the 16 indicators: the results are therefore presented according to 5 indicators representing the main issues, then an additional indicator chosen because it is specifically monitored by CITEO (Eutrophication in fresh water). The values for the other 10 indicators are presented in the appendix (Section 7.4). The single score is presented for each moment, however no communication to the public can be made on this indicator.

Impact category	Unit	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	2.6	3.1	3.2	3.3	3.4	3.5	4.1	5.1	6.1	7.1	8.1	8.2	8.3	8.4	9.1	9.2	10.1
Total - Single score (nPt)	%	100 %	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Climate change	%	30,0 %	29,2%	30,2%	30,1%	30,6%	28,3%	28,3%	28,5%	28,3%	28,6%	28,2%	28,3%	28,5%	28,5%	28,6%	28,3%	31,3%	28,6%	28,0%	28,4%	29,9%	29,1%	29,1%	29,1%	28,4%	28,6%	28,8%
Depletion of the ozone layer	%	1,9%	1,5%	1,7%	1,9%	2,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Ionising radiation	%	0,8%	1,0%	1,1%	0,8%	0,8%	1,6%	1,8%	1,8%	1,5%	1,9%	1,9%	1,6%	1,8%	1,9%	2,0%	1,6%	1,4%	2,8%	1,2%	1,3%	0,8%	0,9%	1,2%	0,9%	1,8%	2,1%	1,9%
Photochemical ozone formation	%	4,7%	4,7%	4,6%	4,6%	4,6%	4,6%	4,7%	4,5%	4,6%	4,6%	4,8%	4,8%	4,6%	4,7%	4,6%	4,8%	4,4%	4,3%	4,8%	4,9%	5,9%	6,2%	5,2%	6,4%	4,6%	4,7%	4,6%
Fine particles	%	7,5%	7,7%	7,3%	7,3%	7,2%	7,9%	8,1%	8,2%	8,0%	8,5%	8,1%	8,0%	8,2%	8,3%	8,2%	7,9%	7,8%	5,6%	6,9%	6,7%	5,7%	6,3%	7,1%	6,4%	8,4%	9,0%	8,1%
Human toxicity. non-carcinogenic	%	1,7%	1,7%	1,7%	1,7%	1,7%	1,8%	1,7%	1,6%	1,8%	1,6%	1,7%	1,7%	1,6%	1,6%	1,6%	1,8%	1,3%	1,6%	1,8%	1,8%	1,4%	1,7%	1,6%	1,7%	1,6%	1,4%	1,5%
Human toxicity. cancer	%	4,2%	4,1%	4,0%	4,1%	4,0%	4,3%	4,1%	4,1%	4,4%	4,1%	4,0%	4,3%	4,1%	4,0%	4,0%	4,3%	3,2%	3,8%	4,6%	4,3%	4,6%	4,7%	4,5%	4,5%	4,2%	4,1%	4,1%
Acidification	%	4,7%	4,8%	4,8%	4,7%	4,7%	4,6%	4,8%	4,6%	4,6%	4,6%	4,9%	4,8%	4,7%	4,8%	4,7%	4,8%	4,9%	4,8%	4,7%	4,6%	3,8%	4,2%	4,2%	4,2%	4,6%	4,7%	4,5%
Eutrophication. freshwater	%	6,2%	6,2%	6,4%	6,4%	6,0%	7,7%	7,5%	7,1%	7,7%	6,7%	7,5%	7,7%	7,1%	7,1%	7,0%	7,8%	5,6%	10,1%	8,7%	8,7%	5,9%	7,1%	6,7%	7,3%	7,0%	5,9%	6,7%
Marine eutrophication	%	1,9%	2,0%	1,9%	2,0%	1,9%	2,2%	2,1%	2,1%	2,3%	1,9%	2,1%	2,2%	2,0%	2,0%	2,0%	2,2%	2,2%	2,0%	2,3%	2,2%	1,7%	2,1%	2,0%	2,1%	2,1%	1,7%	1,9%
Terrestrial eutrophication	%	2,1%	2,2%	2,1%	2,2%	2,1%	2,5%	2,4%	2,4%	2,5%	2,3%	2,4%	2,5%	2,4%	2,3%	2,3%	2,5%	2,2%	2,3%	2,5%	2,5%	1,9%	2,2%	2,2%	2,3%	2,4%	2,1%	2,3%
Ecotoxicity. freshwater	%	2,1%	2,1%	2,0%	2,1%	2,0%	2,5%	2,3%	2,2%	2,5%	2,0%	2,3%	2,4%	2,2%	2,1%	2,1%	2,5%	1,7%	2,1%	2,9%	2,4%	2,0%	3,0%	2,3%	2,7%	2,2%	1,8%	2,0%
Land use	%	4,0%	5,4%	3,0%	3,9%	3,4%	6,1%	5,7%	6,2%	6,0%	6,4%	5,7%	5,4%	6,1%	6,0%	6,0%	5,6%	4,6%	4,4%	4,6%	4,6%	2,7%	3,5%	4,8%	3,7%	6,6%	6,6%	6,0%
Use of water resources	%	2,3%	2,4%	2,2%	2,3%	2,2%	2,8%	2,6%	2,6%	2,8%	2,5%	2,6%	2,7%	2,6%	2,5%	2,5%	2,8%	4,7%	2,6%	3,4%	3,9%	3,8%	3,3%	3,2%	3,3%	2,6%	2,3%	2,8%
Use of energy resources	%	19,0 %	18,1%	20,1%	18,9%	19,4%	18,5%	18,9%	19,3%	18,3%	19,6%	18,9%	18,6%	19,3%	19,4%	19,7%	18,4%	20,9%	21,0%	18,1%	18,5%	23,3%	19,9%	20,5%	19,9%	19,1%	20,2%	20,2%
Depletion of resources, minerals and metals	%	6,9%	6,7%	6,8%	6,9%	7,3%	4,6%	4,9%	4,6%	4,6%	4,6%	4,9%	4,9%	4,7%	4,8%	4,7%	4,8%	3,8%	3,8%	5,3%	5,1%	6,4%	5,7%	5,2%	5,5%	4,6%	4,7%	4,7%
Total in % for the 6 selected indicators	**%**	**68%**	**68%**	**69%**	**68%**	**69%**	**68%**	**68%**	**68%**	**68%**	**68%**	**68%**	**68%**	**68%**	**68%**	**68%**	**68%**	**71%**	**71%**	**68%**	**69%**	**72%**	**69%**	**70%**	**69%**	**68%**	**68%**	**69%**

Table 23 Contribution of each impact indicator to the single score for each packaging system

The cells coloured green/jade represent the indicators **that contribute most to the unique score of the different packs.**

A word of caution when reading this table: packaging is not intended to be compared with other packaging. The importance (or contribution) of each indicator to the single score is shown here for each package.

The selected indicators (highlighted in green in the 1st column of the table), in order of contribution, are as follows:

- Climate change,
- Resource use; fossils,
- Eutrophication; freshwater,
- Resource use; minerals and metals,
- Land use,
- Water use,

NB: the "fine particles" indicator is a major contributor to the impact and ranks third for many packaging systems. It was decided not to include this indicator in the in-depth analyses of this report because it is not one of the priority issues for CITEO and the packaging industry in general**.**

These major contributors add up to between 68% and 72% of the single score. In the following, these indicators will be analysed as a priority in the body of the report, but all the information on the other indicators will be available in the appendix.

All the contributions of the indicators to the single score for each packaging system are presented in the appendix Section 7.4, via Table 40

4.2 COMPARATIVE EVALUATION

4.2.1 COMPARISON BESED ON THE MAIN FUNCTIONAL UNIT, OVER THE ENTIRE LIFE CYCLE AND BY LIFE CYCLE STAGE

To determine which packaging system generates the least environmental impact of the various alternatives to cardboard/PET blisters studied, each scenario will be compared on the basis of the functional unit (1 cm^3 capacity), taking into account all the stages of the life cycle (see Section 2.2.1).

It should be remembered that all the packaging families compared here, via their capacity reduced to 1cm^3, must be qualified and adapted to the specific needs of each packaged product. The interpretations made in this section are based solely on this packed volume and do not consider the mechanical properties of each family. Flexible packaging does not necessarily allow similar products to be packaged as rigid packaging. This consideration, which is one of the limitations of the study, must be considered and adapted to the needs of each manufacturer and marketer. In addition, the results associated with each type of packaging are based on a specific collection from a single supplier. So, behind each pack, there is only one supplier/brand. It is therefore essential to consider this parameter when interpreting the results, and to consider the number of packages per family to qualify the conclusions.

In this section, the life-cycle impact is presented by life-cycle stage only for the indicators selected (see Section 4.1). The life-cycle impact of the various packaging systems studied, according to **all** the indicators, is presented in Table 41 and Table 42

The life cycle stages considered are detailed in Figure 2. The following paragraph details the vocabulary and scope associated with the colour code used in the following results graphs:

Raw materials: Includes the extraction and first production/processing of raw materials (plastics, cardboard, etc.).

Manufacturing: Includes the processes involved in transforming materials into components (e.g. injection moulding, extrusion).

Finishing: Includes the component finishing processes (printing, varnishing for example).

RM PACK I.: **Raw materials** for **primary packaging** components (including additional raw materials that end up as **scraps production**) and their **supply to processing sites** (market for average)**.**

TRANSFO+SCRAP I.: Includes the **processes involved in transforming** materials into components (injection, extrusion) as well as the **end-of-life of scraps** when there are any.

FINISHES I.: Includes **finishing processes** for packaging components (e.g. printing, varnishing).

ICP II.III. + EOL: This covers the **raw materials**, **procurement, manufacture and end-of-life** of ICPs (split between recycling, incineration and landfill) used to transport packaging between the packaging plant and the point of sale.

TRP DISTRIB: Includes the transport of **primary** packaging and their ICPs from the packaging site to the point of sale.

EOL PACK.I: This refers to the end-of-life of primary packaging, split between recycling, incineration and landfill.

4.2.1.1 Climate change indicator

Figure 6 shows the contribution of each stage in the packaging life cycle, according to the "climate change" indicator. The vocabulary and scope associated with the colour code used in the results graphs is presented in Section 4.2.1. In addition to the graphs shown, Table 43 details the impact of each life cycle stage for all packaging systems on the "climate change" indicator and is available in the appendix.

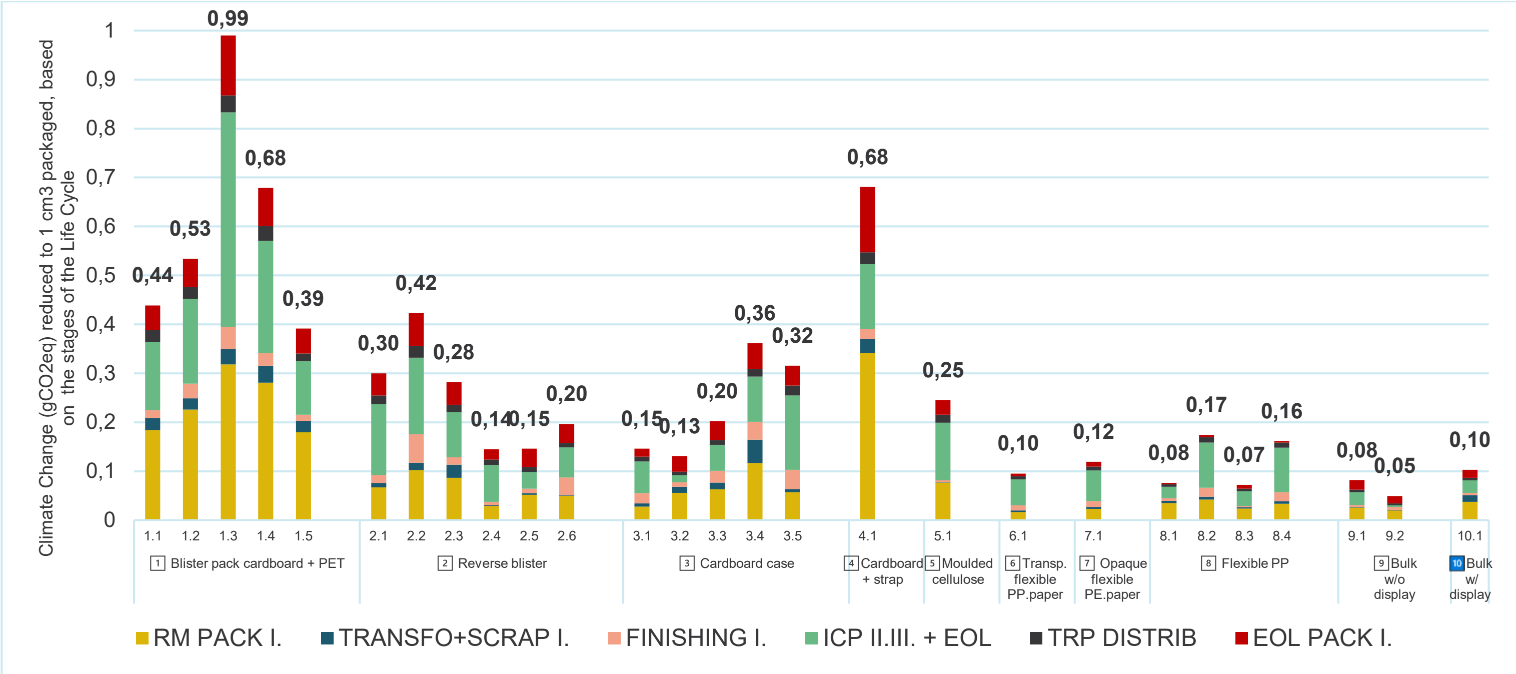


Figure 6 Comparison of packaging systems, by life cycle stage, according to the climate change indicator (FU = 1cm^3 packed)

Interpretation of the impact on this indicator:

Overall, in terms of climate change, the alternatives studied have a lower impact than the '1. PET/Cardboard blister' reference. More specifically, we can observe that:

- **Flexible** packaging categories **6 (transparent paper), 7 (opaque paper), 8 (PP) and bulk packaging categories 9 and 10** have a significantly lower impact than the benchmark. The reduction in impact observed is at least -56% (packaging 1.5 compared with 8.2) to -95% (packaging 1.3 compared with 9.2). These packs are also the most efficient in terms of mass used per volume packed (see Figure 5), which explains their low impact.
- The individual packaging categories based on cardboard **2. cardboard (reverse blister), 3. (cardboard case), and 5. (moulded cellulose)** are generally better than the reference, but certain designs generate a limited environmental gain (2.1, 2.2, 3.4 and 3.5) because of their low packed volume. The worst packaging (2.2) generates an impact 8% higher than the best reference (1.5) but the reduction in impact in these categories can be as much as 87%.
- Category **4 (cardboard + straps)** has an impact comparable to or even greater than the reference, but it is difficult to draw any conclusions due to the irrelevance of this packaging, which is represented only by a design and does not protect a defined volume (packaged volume = volume of the object, which may be indirectly underestimated).

Interpretation by life cycle stage:

- Of all the scenarios studied, the stages that contribute most to the impact of climate change are **raw materials** and **ICPs**.
  - **ICPs** are the most represented elements in terms of mass for most of the packaging systems studied (see Figure 5). However, they have a lower overall mass impact than **raw materials** because they generate less scraps, are made from less impactful materials and can be reused (pallets).

    - For **flexible** packaging (6 to 8) and for certain **blister**, **reverse blister** and **carton** designs, the **ICPs** are the components that contribute most to the system's impact. These components should not be neglected in the eco-design of new alternatives.
    - Packaging category **4, cardboard + straps**, is penalised using flat cardboard that is too solid, generating a significant impact on **raw materials**. This cardboard is necessary because the packaged object is heavy, and the cardboard must be thick to guarantee the rigidity of the packaging. For other applications, the mass/volume ratio of this type of packaging can be improved.
- The **finishing** stage has a significant impact on climate change, particularly for individual cardboard-based solutions (**blisters 1. and 2., cases 3**.). These types of packaging tend to have a larger printed surface area.
- The **end-of-life** stage is a major contributor for **cardboard-based** packaging and a minor one for **plastic-based** packaging. The justification is as follows:
    - Modelling the end-of-life of cardboard using the CFF involves a cardboard recycling process that has a greater impact than virgin material, so the avoided impacts associated with recycling are doubly reduced (recycling process with a high impact and low avoided impact). This is due to the use of co-waste/co-products from the forestry industry, black liquor, which is used as a source of heat and avoids the use of non-renewable resources.
    - Conversely, in the case of recycled plastics, the recycling process has less impact than the virgin material, so the avoided impacts (benefits) associated with recycling are significant on two levels (low-impact recycling process and high avoided impact).
- The **raw materials processing** stages (except for designs involving a high rate of production waste, such as packaging 3.4 with 45% of waste linked to cardboard cutting) and **transport** make a small contribution to the impact.

4.2.1.2 Resource use; fossil indicator

Figure 7 shows the contribution of each stage in the packaging life cycle, according to the "Resources use; fossil" indicator. The vocabulary and scope associated with the colour code used in the results graphs is presented in Section 4.2.1. In addition to the graphs shown, Table 44 details the impact of each life cycle stage for all packaging systems on the "Resources use; fossil" indicator and is available in the appendix.

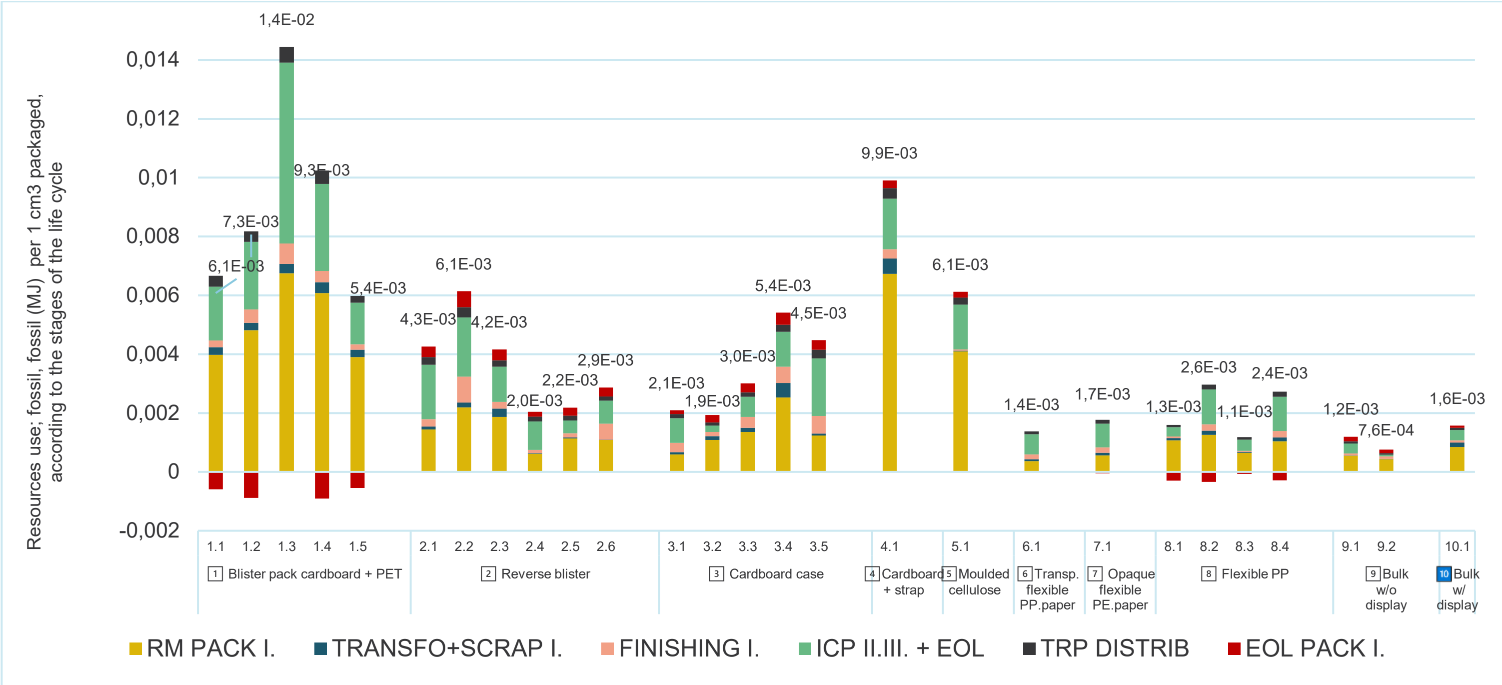


Figure 7 Comparison of packaging systems, by life cycle stage, according to the fossil resource use indicator (FU = 1cm³ packed)

Interpretation of the impact on this indicator:

Overall, regarding the use of fossil resources, the interpretations that can be made of the results are close to those made for the climate change indicator (the use of fossil resources often leads to the emission of greenhouse gases responsible for climate change), so the alternatives studied are also less impactful than the "1. PET/Cardboard blister" reference. More specifically, we can see that:

- **Flexible** packaging categories **6 (transparent paper), 7 (opaque paper), 8 (PP) and bulk 9 and 10** have a significantly lower impact than the benchmark. The reduction in impact observed is at least -52% (packaging 1.5 compared with 8.2) to -95% (packaging 1.3 compared with 9.2). The **8. flexible PP** category is penalised more than other flexible packaging on this indicator because it uses more plastic derived from fossil resources (oil). This packaging is also the most efficient in terms of mass used per volume packed (see Figure 5), which explains its low impact.
- The individual packaging categories based on **cardboard 2 (reverse blister), 3 (case) and 5 (moulded cellulose)** are also better than the reference, but some designs have a greater impact than the best-performing reference blisters (1.1 and 1.5), such as the 2.2 and 3.4 packages, because of their low pack volume. For the other packaging options, the reduction in impact across these categories ranges from 22% to 86% for **reverse blister packs (2.)**, from 18% to 87% for **cardboard cases (3.)** and from 13% to 58% for **moulded cellulose (5.)**.
- The impact of category **4 cardboard + straps** is comparable or even greater than the reference.

Interpretation by life cycle stage:

- Of all the scenarios studied, the stages that contribute most to the impact in terms of the use of fossil resources are raw materials and ICPs.
  - ICPs are the most represented elements in terms of mass for most of the packaging systems studied (see Figure 5). However, they have a lower overall impact by mass than raw materials because they generate less scraps, are made from less impactful materials and can be reused (pallets).

    - For **flexible** products (6 to 8) and for certain **blister**, **reverse blister** and **case** designs, the **ICPs** are the components that contribute most to the impact of the system. These components should not be neglected in the eco-design of new alternatives.
    - Packaging category **4, cardboard + straps**, is penalised using flat cardboard that is too solid, generating a significant impact on **raw materials**. This cardboard is necessary because the packaged object is heavy, and the cardboard must be thick to guarantee the rigidity of the packaging. For other applications, the weight/volume ratio of this type of packaging can be improved.
- The **finishing** stage has a non-negligible impact on the use of energy resources, particularly for individual cardboard-based solutions (**blisters 1. and 2., cases 3**.). These types of packaging tend to have a larger printed surface.
- The **end-of-life** stage is a significant contributor for **cardboard-based** packaging and a negative contributor (beneficial for the environment) for **plastic-based** packaging. The justification is as follows:
    - The modelling of the end-of-life of cardboard in CFF involves a cardboard recycling process that has a greater impact than virgin material, so the avoided impacts associated with recycling are doubly reduced (impacting recycling process and low avoided impact). This is due to the use of co-waste/co-products from the forestry industry, black liquor, which is used as a source of heat and avoids the use of non-renewable resources.
    - Conversely, in the case of recycled plastics, the recycling process has less impact than virgin material, so the avoided impacts (benefits) associated with recycling are significant on two levels (the recycling process requires few energy resources and makes it possible to avoid virgin material, which uses a lot of resources, generating a high avoided impact).
- The **raw materials processing** stages (except for designs involving a high rate of production waste, such as packaging 3.4 with 45% scrap rate linked to cardboard cutting) and **transport** make a small contribution to the impact.

4.2.1.3 Eutrophication; freshwater indicator

Figure 8 shows the contribution of each stage in the packaging life cycle, according to the "Eutrophication; freshwater" indicator, a priority indicator for CITEO. The vocabulary and scope associated with the colour code used in the results graphs is presented in Section 4.2.1. In addition to the graph presented, Table 45 details the impact of each life cycle stage for all packaging systems on the "Eutrophication; freshwater" indicator and is available in the appendix.

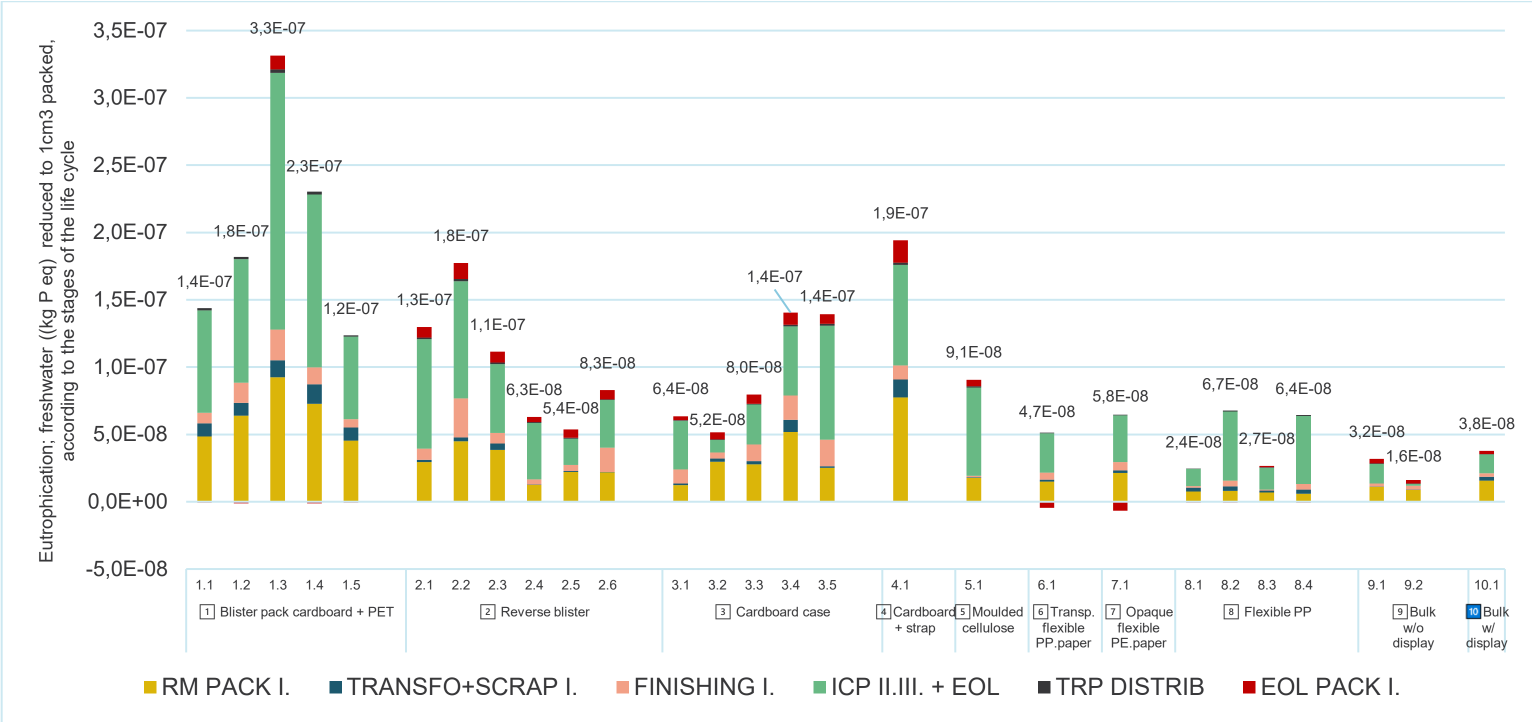


Figure 8 Comparison of packaging systems, by life cycle stage, according to the freshwater eutrophication indicator (FU = 1cm³ packaged)

Interpretation of the impact on this indicator:

Overall, in terms of eutrophication in freshwater, the alternatives studied have less impact than the "1. PET/Cardboard blister" reference. More specifically, we note that:

- **Flexible** packaging categories **6 (transparent paper), 7 (opaque paper), 8 (PP) and bulk 9 and 10** have a significantly lower impact than the benchmark. The reduction in impact observed is at least -44% (packaging 1.5 compared with 8.2) to -95% (packaging 1.3 compared with 9.2). These packs are also the most efficient in terms of mass used per volume packed (see Figure 5), which explains their low impact.
- The individual packaging categories based on **cardboard 2 (reverse blister)** and **3 (case)** are better overall than the reference, but some designs generate limited environmental gains (2.1, 2.2, 2.3, 3.4 and 3.5) because of their low pack volume. The worst packaging (2.2) generates an impact 44% higher than the best reference (1.5), but the reduction in impact in these categories can be as much as 84%.
- **Categories 5 (moulded cellulose)** and **4 (cardboard + straps)** have an impact comparable to or even greater than the reference blisters.

Interpretation by life cycle stage:

- Of all the scenarios studied, the stages that contribute most to the impact of eutrophication in freshwater are **raw materials** and **ICPs**.
    - For most packaging systems, **ICPs** are the components that contribute most to the system's impact. This contribution is mainly due to the corrugated cardboard used in **ICPs**. Converting wood into paper pulp generates effluents rich in biodegradable organic matter, nitrogen compounds and phosphates, particularly from ash treatment, which can be released into surface water if wastewater treatment is inadequate. These components must not be overlooked in the eco-design of new alternatives.

    - Flat cardboard and paper, which are massively used in the **raw materials** for the packaging studied here, also have an impact on freshwater eutrophication. However, they generate half the impact per kg of corrugated cardboard because they generate less ash (preferential use of electrical energy) and do not use glue or starch.
    - plastic **raw materials** have less impact on eutrophication than paper/cardboard-based materials, which is an advantage for **flexible** packaging.
- The **finishing** stage has a non-negligible impact on eutrophication in freshwater, particularly for individual cardboard-based solutions (**blisters 1. and 2., cases 3**.). These types of packaging tend to have a larger printed surface.
- As in the previous section and for the same reasons, the **end-of-life** stage makes a significant contribution to the impact of cardboard-based packaging and a negative one for plastic packaging. In fact, cardboard recycling has a greater impact than virgin material on this indicator, mainly because of the use of coal in both the recycling process and the electricity in the average European mix considered for this material. Since the virgin material substituted has less impact, it does not offset the impact of recycling.
- **The raw materials processing** and **transport** stages make a small contribution to the impact of the Group's activities.

4.2.1.4 Resource use; minerals and metals, indicator

Figure 9 shows the contribution of each stage in the packaging life cycle, according to the "Resource use; minerals and metals" indicator. The vocabulary and scope associated with the colour code used in the results graphs is presented in Section 4.2.1. In addition to the graph presented, Table 46 details the impact of each life cycle stage for all packaging systems on the "Resource use; minerals and metals" indicator and is available in the appendix.

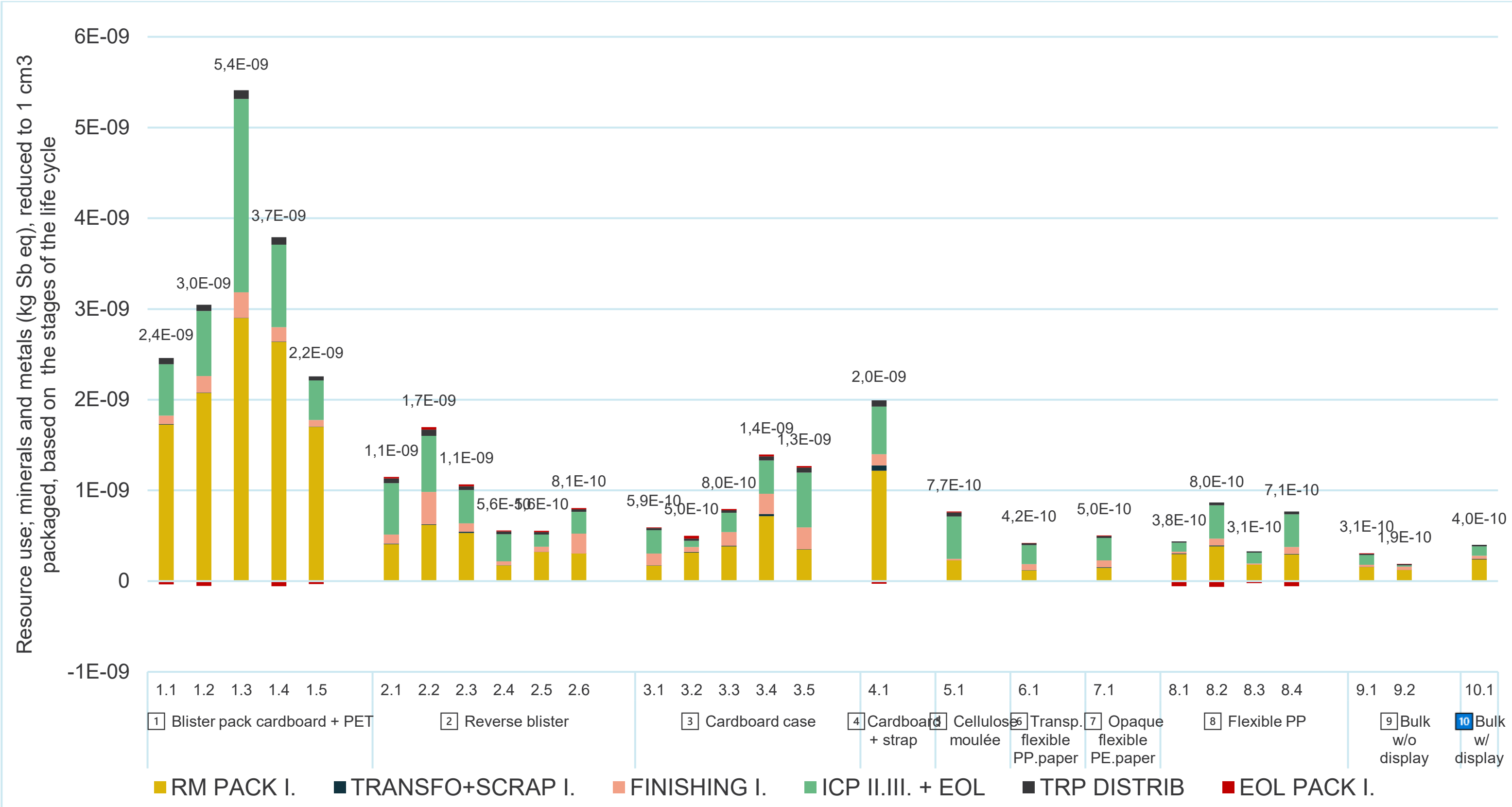


Figure 9 Comparison of packaging systems, by life cycle stage, according to the depletion of resources, minerals and metals indicator (FU = 1cm^3 packed)

Interpretation of the impact on this indicator:

In terms of the depletion of mineral and metal resources indicator, the alternatives studied all have less impact than the "1. PET/Cardboard blister pack" references.

More specifically, we observe that:

- **Flexible** packaging categories **6 (transparent paper), 7 (opaque paper), 8 (PP) and bulk 9 and 10** have a much lower impact than the benchmark. The reduction in impact observed is at least -64% (packaging 1.5 compared with 8.2) to -96% (packaging 1.3 compared with 9.2). These packs are also the most efficient in terms of mass used per volume packed (see Figure 5), which explains their low impact.
- The individual packaging categories, based on **cardboard 2 (reverse blister)** and **3 (case),** are better than the reference, even though some designs generate a more limited environmental gain (2.1, 2.2, 2.3, 3.4 and 3.5) because of their low packed volume. The worst packaging (2.2) generates an impact 23% lower than the best reference (1.5), which is a significant gain in environmental performance, and the reduction in impact in these categories can be as much as 91% (3.2 versus 1.3).
- **Categories 5 (cellulose)** and **4 (cardboard + straps)** have a better overall impact than the reference blister packs. However, the best reference packaging (1.5) has an environmental performance comparable to 4.1. The number of samples representing families 4 and 5 limits interpretations for these families.

Interpretation by life cycle stage:

- Of all the scenarios studied, the stages that contribute most to the impact in terms of depletion of mineral and metal resources are raw materials and ICPs.

- **Raw materials** contribute more than **ICPs** in proportion. Blister reference has a high impact due to **raw materials**, which is explained using PET for the shell. This PET uses terephthalic acid (PTA) as a precursor. Cobalt, a rare metallic element, is used to catalyse the synthesis of PTA, which explains the significant impact of PET-based packaging on this indicator.
- The remaining impacts attributed to **raw materials** and **ICP** are due to the use of metals in industrial facilities.

- The finishing stage has a significant impact on the depletion of mineral and metal resources, particularly for individual cardboard-based solutions (**blisters 1. and 2., cases 3.**). These types of packaging tend to have a larger printed surface.
- The **end-of-life**, **raw materials processing** and **transport** stages make a small contribution to the impact of our products.

4.2.1.5 Indicator land use

Figure 10 shows the contribution of each stage in the packaging life cycle, according to the "Land use" indicator. The vocabulary and scope associated with the colour code used in the results graphs is presented in Section 4.2.1. In addition to the graphs shown, Table 47 details the impact of each life cycle stage for all packaging systems on the "Land use" indicator and is available in the appendix.

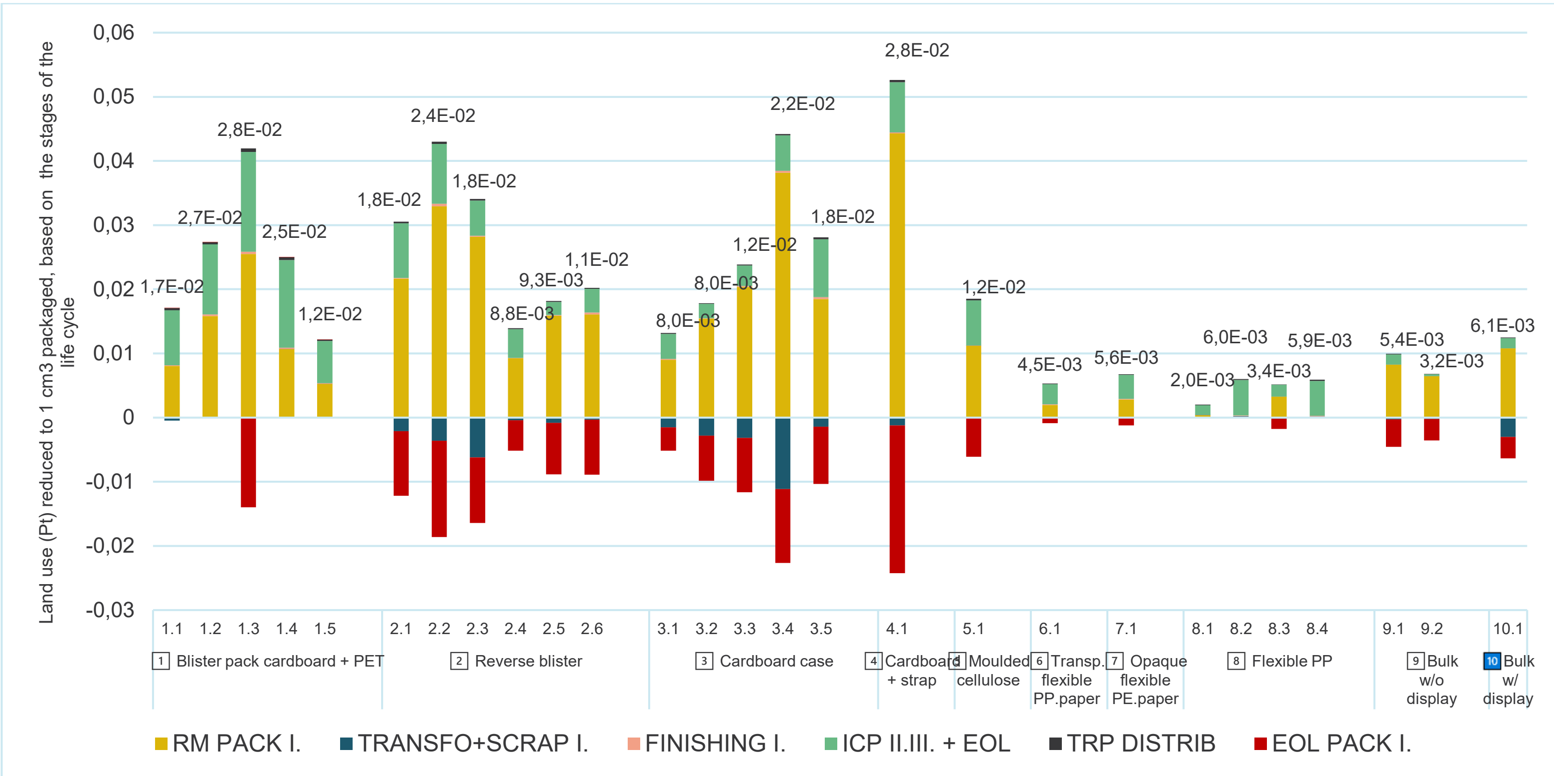


Figure 10 Comparison of packaging systems, by life cycle stage, according to the land use indicator (FU = 1cm³ packed)

Interpretation of the impact on this indicator:

Overall, in terms of land use, the alternatives studied have less impact than the "1. PET/Cardboard blister pack" reference when the primary packaging is mainly made of plastic. For paper/cardboard-based packaging, the environmental gain is non-existent or limited. More specifically, we observe that:

- **Flexible** packaging categories **6 (transparent paper), 7 (opaque paper), 8 (PP) and bulk 9 and 10** have a much lower impact than the benchmark. The reduction in impact observed is at least -51% (packaging 1.5 compared with 8.2) to -93% (packaging 1.3 compared with 8.1). These packs are also the most efficient in terms of mass used per volume packed (seeFigure 5), which explains their low impact.
- Individual packaging categories based on **cardboard/paper**, such as **2 (reverse blister)**, **3 (case), 5 (cellulose)** and **4 (cardboard + straps**) have a lower or equivalent impact to blister references.

Interpretation by life cycle stage:

- In all the scenarios studied, the stages that contribute most to land use are **raw materials** and **ICPs**.
    - **Raw materials** contribute more than **ICPs** in proportion. Packaging systems that use the most paper or cardboard are penalised for this indicator. This is because these materials use wood, the cultivation of which requires the use of land. Logging may be intensive or may lead to deforestation, and these factors are considered in this indicator.
    - In comparison, plastics **raw materials** generate less impact on land use because they do not require industrial processes that consume land space, apart from the industrial installations linked to the extraction and transformation of petroleum raw materials, which are optimised in terms of land use.
- The **finishing** and **transport** stages have a negligible impact on land use.
- **End-of-life** has a negative (environmentally beneficial) contribution to land use for cardboard-based packaging systems that are recyclable at the end of their life. This is explained by the CFF, which attributes end-of-life benefits to avoiding the production of new virgin cardboard boxes that consume floor space. Non-recyclable packaging such as blister packs does not benefit at this stage.
    - This negative contribution is clearly illustrated in the case of **1. cardboard/PET blister packs**, where 1.3 is the only recyclable pack in its category to benefit from a reduced end-of-life impact, unlike other blister packs which have an environmental impact at this stage.
- Similarly, the **raw materials conversion** stage has a negative contribution (beneficial for the environment) because it generates offcuts which are very well recycled at the end of their life cycle and avoid the production of virgin material, which has a major impact on this indicator. It should be noted that the impact of the surplus material used in packaging that produces offcuts is not offset by the benefits of these offcuts at the end of their life.

4.2.1.6 Use of water resources indicator

Figure 11 shows the contribution of each stage in the packaging life cycle, according to the "Water use" indicator. The vocabulary and scope associated with the colour code used in the results graphs is presented in Section 4.2.1. In addition to the graph presented, Table 48 shows the impact of each stage in the life cycle for all packaging systems on the "Water use" indicator and is available in the appendix.

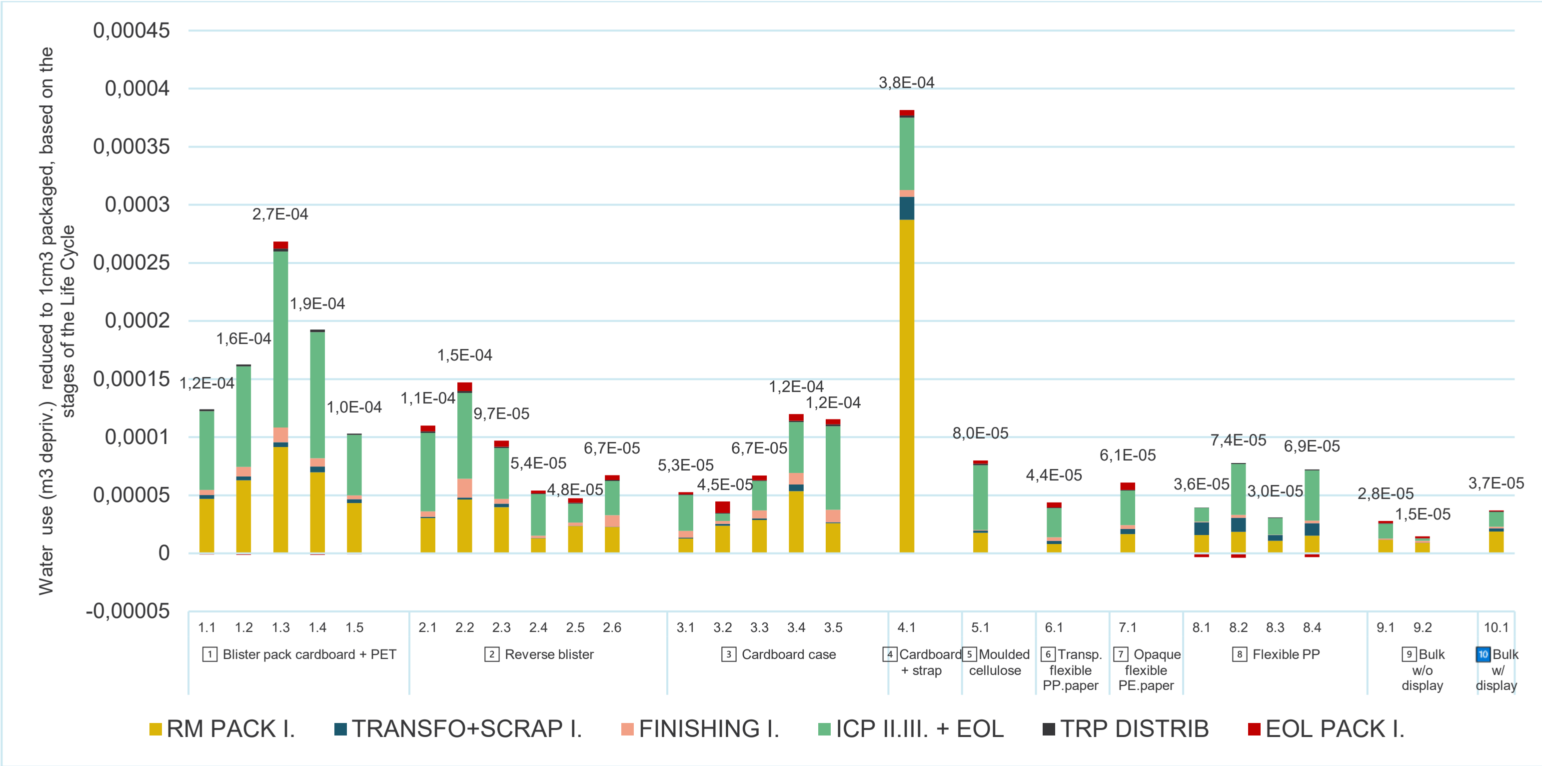


Figure 11 Comparison of packaging systems, by life cycle stage, according to the water use indicator (FU = 1cm^{3}packaged)

Interpretation of the impact on this indicator:

Overall, in terms of the water use indicator, the alternatives studied have less impact than the "1. PET/Carton Blister" reference. More specifically, we can see that:

- **Flexible** packaging categories **6 (transparent paper), 7 (opaque paper), 8 (PP) and bulk 9 and 10** have a significantly lower impact than the benchmark. The reduction in impact observed is at least -28% (packaging 1.5 compared with 8.2) to -95% (packaging 1.3 compared with 9.2). These packs are also the most efficient in terms of mass used per volume packed (see Figure 5), which explains their low impact.
- The individual packaging categories based on **cardboard 2 (reverse blister), 3 (case), and 5 (moulded cellulose)** are better overall than the reference but some designs generate a limited environmental gain (2.1, 2.2, 3.4 and 3.5) due to a low packed volume. The worst packaging (2.2) generates an impact 44% higher than the best reference (1.5), but the reduction in impact in these categories can be as much as 83%.
- Category **4 cardboard + straps** has a greater impact than the reference, but it is difficult to conclude on the irrelevance of this packaging, which is represented only by a design, and which does not protect a defined volume (packaged volume = volume of the object, which may be indirectly underestimated).

Interpretation by life cycle stage:

- Of all the scenarios studied, the stages that contribute most to the impact in terms of water use are **raw materials** and **ICPs**.
    - For **flexible** products (6 to 8) and for some **blister**, **reverse blister** and **cases** designs, the **ICPs** are the components that contribute most to the impact of the system. These components should not be neglected in the eco-design of new alternatives.

- **Raw materials** have a high impact on paper/board-based packaging. Paper-making processes require a lot of water (water for paper pulp, water for rinsing chemicals, evaporation of water into the air, effluent treatment, etc.). Plastics, on the other hand, consume very little water.
- Packaging category **4, cardboard + straps**, is penalised using flat cardboard that is too solid, generating a significant impact on **raw materials**. This cardboard is necessary because the packaged object is heavy, and the cardboard must be thick to guarantee the rigidity of the packaging. For other applications, the weight/volume ratio of this type of packaging can be improved.

- The **finishing** stage has a non-negligible impact on water use, particularly for individual cardboard-based solutions (**blisters 1. and 2., cases 3**.). These types of packaging tend to have a larger printed surface.
- The **end-of-life** stage is a low contributor for the packaging systems studied. The cardboard recycling processes require water, which explains the contribution of this stage to this indicator for recyclable **cardboard-based** packaging and, conversely, the low contribution for **plastic-based** packaging**.**
- **The transformation of raw materials** (except for plastics, whose transformation processes require water, particularly to cool the machines) and **transport** make a small contribution to the impact.

4.2.1.7 Single score indicator

Figure 12 shows the contribution of each stage in the packaging life cycle, according to the "single score" indicator. The vocabulary and scope associated with the colour code used in the results graphs is presented in Section 4.2.1. In addition to the graph presented, Table 49 details the impact of each life cycle stage for all packaging systems on the "single score" indicator and is available in the appendix.

NB: This indicator is presented here for information purposes only. It is not recommended to communicate on the single score indicator. However, the single score was used in this study to select the indicators and gives the reader an indication of the overall environmental issues of the system studied. Under no circumstances should the single score results be communicated on their own.

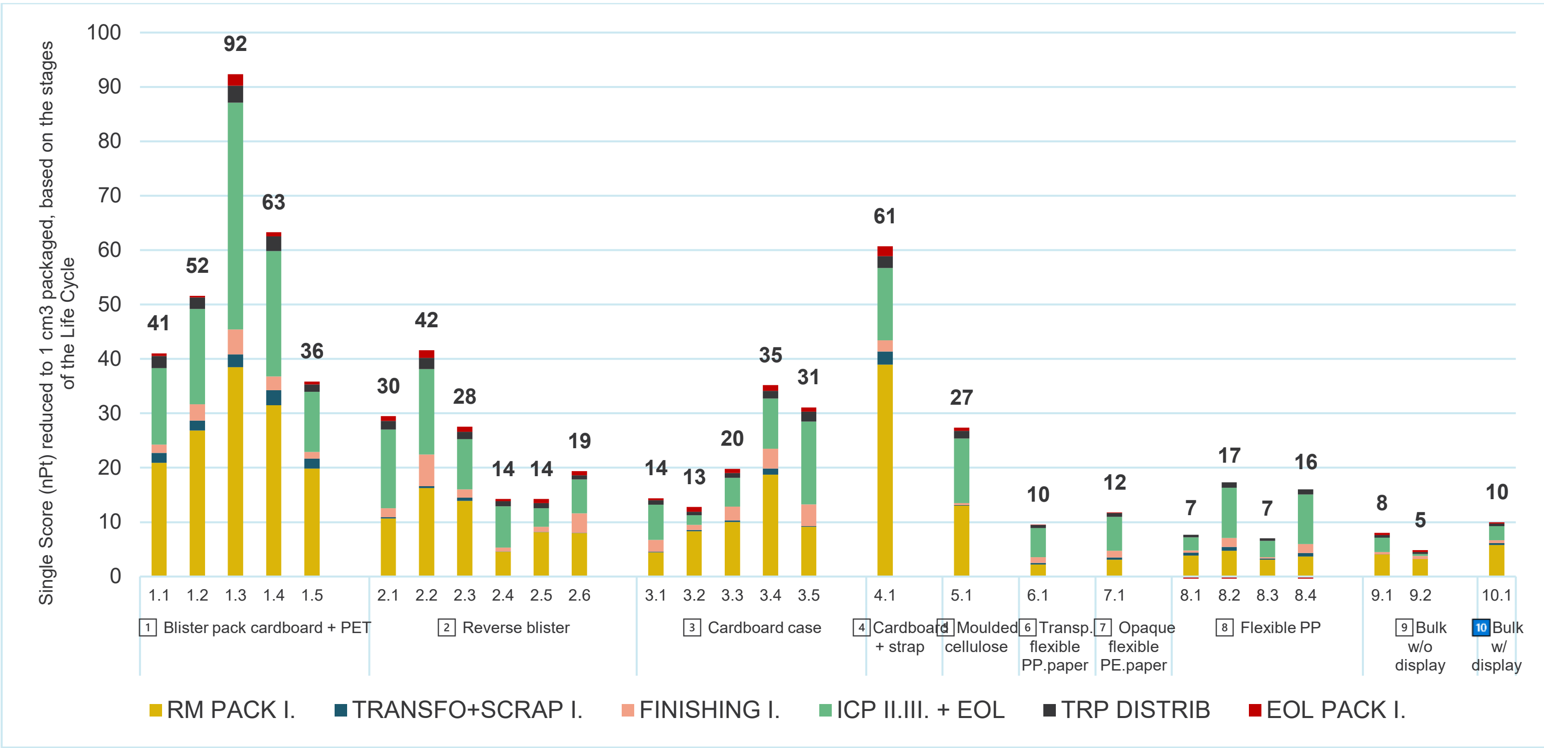


Figure 12 Comparison of packaging systems, by life cycle stage, according to the single score indicator (FU = 1cm^{3}packed)

Interpretation of the impact on this indicator:

Overall, on the single score, the alternatives studied have less impact than the "1. PET/Cardboard blister" reference. More specifically, we can see that:

- **Flexible** packaging categories **6 (transparent paper), 7 (opaque paper), 8 (PP) and bulk 9 and 10** have a much lower impact than the benchmark. The reduction in impact observed is at least -53% (packaging 1.5 compared with 8.2) to -95% (packaging 1.3 compared with 9.2). These packs are also the most efficient in terms of mass used per volume packed (see Figure 5), which explains their low impact.
- The individual packaging categories based on **cardboard 2 (reverse blister), 3 (case), and 5 (moulded cellulose)** are better overall than the reference, but some designs generate limited environmental gains (2.2, 3.4 and 3.5) due to low pack volume. The worst packaging (2.2) generates an impact 16% higher than the best reference (1.5), but the reduction in impact in these categories can be as much as 86%.
- Category **4 cardboard + straps** has an impact comparable to or even greater than the reference, but it is difficult to conclude whether this packaging is irrelevant because it is represented only by a design and does not protect a defined volume (packaged volume = volume of the object, which may be indirectly underestimated).

Interpretation by life cycle stage:

- Of all the scenarios studied, the stages that contribute most to the single score are **raw materials** and **ICPs**.
  - **ICPs**, which are the most represented elements by mass for most of the packaging systems studied (see Figure 5), have a lower overall mass impact than **raw materials** because they generate less production waste, are made from less impactful materials and can be reused (pallets).

    - For **flexible** products (6 to 8) and for certain **blister**, **reverse blister** and **case** designs, the ICPs are the components that contribute most to the impact of the system. These components should not be neglected in the eco-design of new alternatives.
    - packaging category **4. cardboard + straps** is penalised using flat cardboard that is too solid, generating a significant impact on **raw materials**. This cardboard is necessary because the packaged object is heavy, and the cardboard must be thick to guarantee the rigidity of the packaging. For other applications, the weight/volume ratio of this type of packaging can be improved.
- The **finishing** stage has a non-negligible impact on the single score, particularly for solutions based on individual cardboard (**blisters 1. and 2., cases 3.**). These types of packaging tend to have a larger printed surface area.
- The **end-of-life**, **raw materials processing** and **transport** stages make a small contribution to the impact of our products on the environment.

4.2.1.8 Preliminary conclusions on the 6 indicators studied

Overall, the indicators studied show that:

- **Flexible** packaging categories **6 (transparent paper), 7 (opaque paper), 8 (PP) and bulk packaging categories 9 and 10** have a lower impact than the benchmark. The reduction in impact observed varies between the alternatives and the reference packaging, ranging from -28% to -96%, depending on the indicator. This is partly because these packages use the least amount of material per unit of packed volume (seeFigure 5), which is why they have such a low environmental impact.
- The individual packaging categories made up mainly of cardboard **2 (reverse blister), 3 (case) and 5 (moulded cellulose)** are better overall than the reference packaging.
- Category **4 cardboard + starps** has a high overall impact on the various indicators, which can be explained in part by the notion of packaged volume, which is difficult to apply to this type of packaging.

Regarding the modelling error noted by the critical review panel and mentioned in Section 2.7, It is essential for the study to be transparent, which means that its impact on the results must be studied. For paper and cardboard materials, this error should be minimal, since ~0.9 kg of waste is called for 1 kg of post-recycled cardboard obtained. However, for polymers, this modelling error could have a slightly greater impact, since ~1.17 kg of HDPE waste is called for 1 kg of rHDPE obtained post-recycling.

4.2.2 COMPARISON BASED ON SECONDARY FUNCTIONS, OVER THE ENTIRE LIFE CYCLE

The secondary functions are presented in the Section 2.2.1. Table 24 is a simplified version of Table 2 (for more details, please refer to it) and indicates which secondary functions each packaging category fulfils. In this section, we will analyse the results according to the different secondary functions studied.

N°	Scenario	SPO No. 1: Transparency	SF No. 2: Marketing	FS NO. 3: Combating fraud
1	Cardboard blister + PET	Yes	Yes	Yes

2	Reverse blister pack	To be qualified	Yes	Yes
3	Cardboard case	To be qualified	Yes	To be qualified
4	Cardboard + straps	Yes	Yes	Yes
5	Moulded cellulose	Yes	To be qualified	Yes
6	Transp flexible paper.PP	To be qualified	Yes	Yes
7	Opaque flexible paper.PE	No	Yes	Yes
8	Flexible PP	Yes	Yes	Yes
9	Bulk without display	Yes	To be qualified	No
10	Bulk with display	Yes	Yes	No

Table 24 Classification of packaging categories according to their ability to fulfil secondary functions

In this section we invite marketers to compare the different types of packaging, considering their specific packaging needs. In fact, the function of packaging is not just to contain a certain volume, since it fulfils certain secondary functions detailed in the previous table. Even if this comparison does not form part of an ISO report, LCA is a method based on the consideration of a maximum number of parameters, which makes it possible to arrive at an enlightened result that considers the needs of professionals in the sector. That's why it's essential to consider the secondary functions intrinsic to each packaging and not just rely on the environmental performance as presented in this LCA. This is all the more important given that if a packaging is not adapted to the packaged product, this could lead to losses that would significantly increase the impact of the system {packaging + product}, a point that has been developed in theTable 3.

To illustrate this, let's take the example of a professional who needs to package an object while retaining the secondary functions of transparency and fraud prevention. Although bulk packaging families **9. with display** or **10. without display** seem to be packaging types with a low environmental impact, they are not necessarily relevant in this case. The following packaging families fulfil these two secondary functions:

- **Moulded cellulose 5.** packaging is the most effective at combining these two functions, with a more optimised ecological footprint.
- **Flexible packaging 8.** is an interesting compromise, offering limited protection against fraud while maintaining acceptable transparency and further limiting the environmental impact of the packaging system.

This type of thinking can be applied to all combinations of secondary functions, to guide professionals' decisions towards the choice best suited to their needs and with the lowest environmental impact.

4.2.3 COMPARISON ON THE BASIS OF THE MAIN FUNCTIONAL UNIT, FOCUSING ON PRIMARY PACKAGING ONLY

In this section, the calculated impacts will focus solely on primary packaging. **ICPs** and **transport** are excluded from the results and interpretations. These considerations make it possible to study only the design of the primary packaging to identify specific eco-design strategies and levers. As a result, the results are free from any contributions inherent in practices linked to the use of **ICP** and **transport** management, which are specific to each customer.

The tables containing the raw results for the 6 indicators and the single score, used to construct the graphs in this section, are identical to those in Section 4.2.1.

4.2.3.1 *Climate change indicator*

Figure 13 shows the contribution of each stage in the packaging life cycle, according to the "Climate Change" indicator, focusing solely on primary packaging. The vocabulary and scope associated with the colour code used in the results graphs is presented in Section 4.2.1. In addition to the graphs presented, Table 43 details the impact of each life cycle stage for all packaging systems on the "Climate Change" indicator and is available in the appendix.

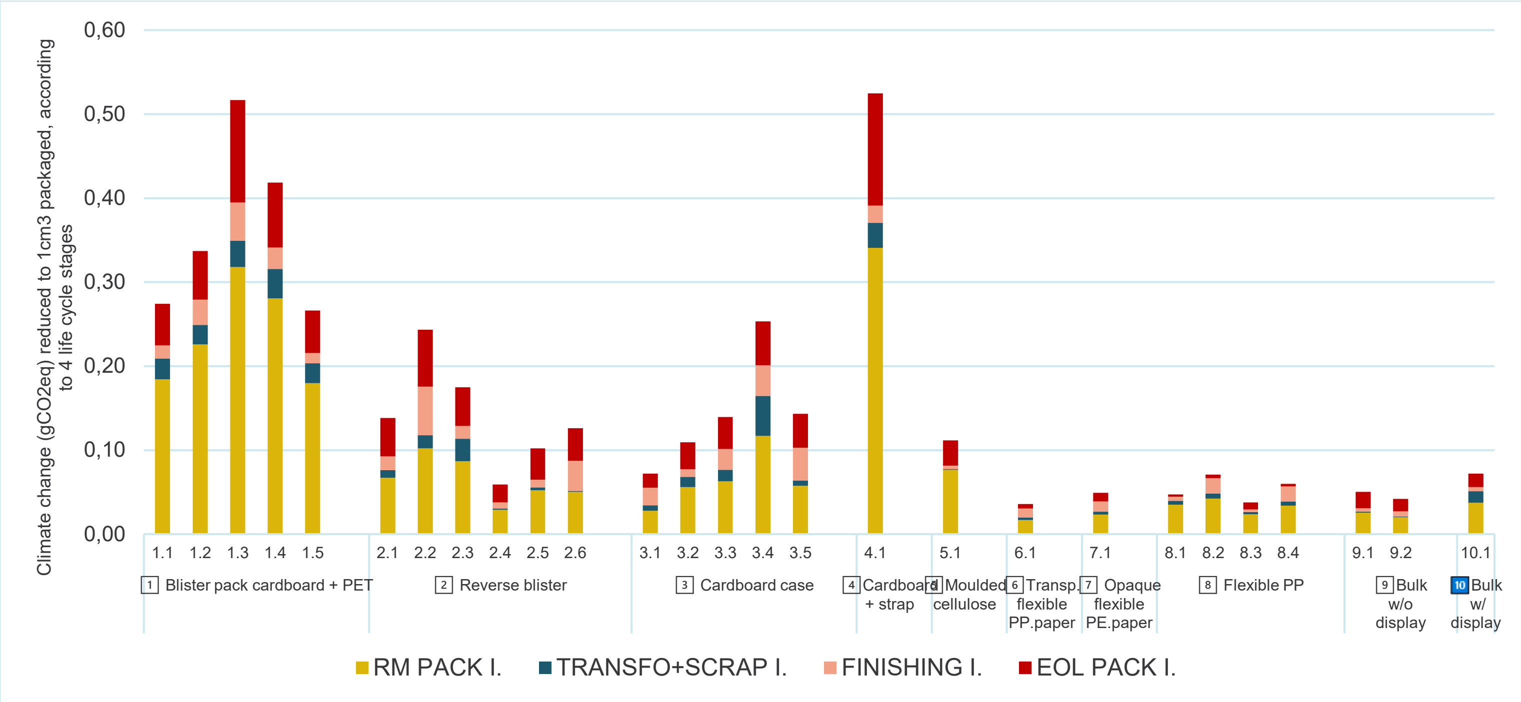


Figure 13 Comparison of packaging systems, focusing on primary packaging only, according to the climate change indicator (FU = 1cm^3 packed)

Interpretation of the impact on this indicator:

Overall, in terms of climate change, even if we consider only the primary packaging, the alternatives studied have less impact than the "1. PET/Cardboard blister" reference. More specifically, we can see that:

- **Flexible** packaging categories **6 (transparent paper), 7 (opaque paper), 8 (PP) and bulk 9 and 10** have a much lower impact than the benchmark. The reduction in impact observed is at least -73% (packaging 1.5 compared with 8.2) to -93% (packaging 1.3 compared with 8.3). These packs are also the most efficient in terms of mass used per volume packed (see Figure 5), which explains their low impact.
- The individual packaging categories based on **cardboard 2 (reverse blister), 3 (case), and 5 (moulded cellulose)** are better overall than the reference, but some designs generate a limited environmental gain (2.2, 2.3, 3.4 and 3.5) because of their low packed volume. The worst packaging (3.4) generates the same impact as the best reference (1.5), but the reduction in impact in these categories can be as much as 89% (1.3 VS 2.4).
- Category **4 cardboard with a link** has an impact comparable to or even greater than the reference, but it is difficult to conclude whether this packaging is irrelevant because it is represented only by a design and does not protect a defined volume (packaged volume = volume of the object, which may be indirectly underestimated).

Interpretation by life cycle stage:

- Of all the scenarios studied, if we consider only primary packaging, the stages that contribute most to the impact on climate change are **raw materials** and **end-of-life**.
    - The **end-of-life** stage is a major contributor for **cardboard-based** packaging and a minor one for **plastic-based** packaging. The justification is as follows:
        - Modelling the end-of-life of cardboard in CFF involves a cardboard recycling process that has a greater impact than virgin material, so the avoided impacts associated with recycling are doubly reduced (recycling process has an impact and avoided impact is low). This is due to the use of co-waste/co-products from the forestry industry, black liquor, which is used as a source of heat and avoids the use of non-renewable resources.
        - Conversely, in the case of recycled plastics, the recycling process has less impact than the virgin material, so the avoided impacts (benefits) associated with recycling are significant on two levels (low-impact recycling process and high avoided impact).

- The **finishing** stage has a significant impact on climate change, particularly for individual cardboard-based solutions (**blisters 1. and 2., cases 3.**). These types of packaging tend to have a larger printed surface.
- The **raw materials processing** stages (except for designs involving a high rate of production waste, such as packaging 3.4 with 45% waste linked to cardboard cutting) and **transport** make a small contribution to the impact on this indicator.

4.2.3.2 Resources use, fossil indicator

Figure 14 shows the contribution of each stage in the packaging life cycle, according to the "Resources use; fossil" indicator, focusing solely on primary packaging. The vocabulary and scope associated with the colour code used in the results graphs is presented in Section 4.2.1. In addition to the graphs presented, Table 44 details the impact of each life cycle stage for all packaging systems on the "Resources use; fossil" indicator and is available in the appendix.

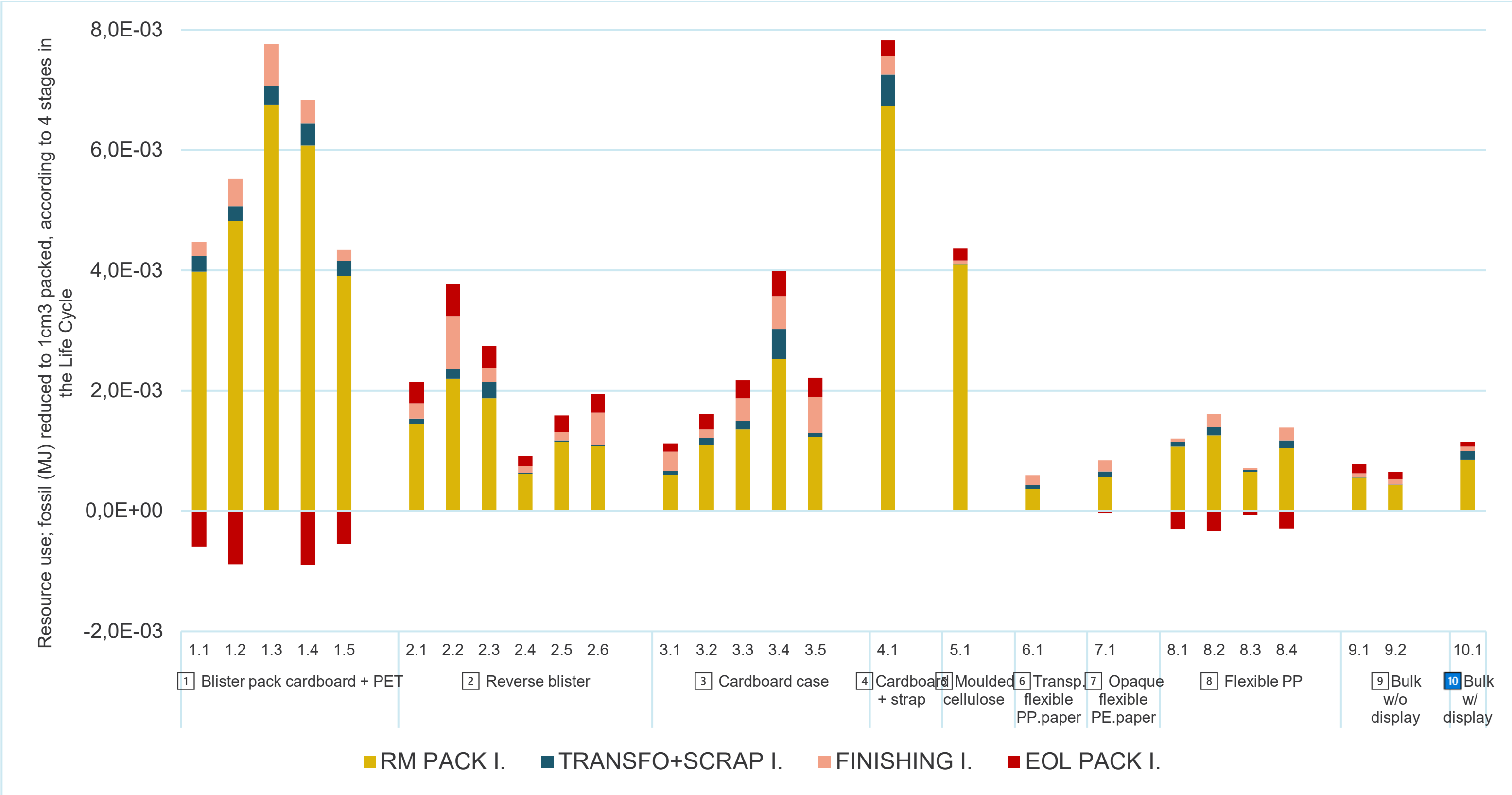


Figure 14 Comparison of packaging systems, focusing on primary packaging only, according to the energy resource use indicator (FU = 1cm^{3}packed)

Interpretation of the impact on this indicator:

Overall, for the use of energy resources indicator, the interpretations that can be made of the results are similar to those made for the climate change indicator (see justification 4.2.1.2), so the alternatives studied are also less impactful than the "1. PET/Cardboard blister" reference. More specifically, we observe that:

- **Flexible** packaging categories **6 (transparent paper), 7 (opaque paper), 8 (PP) and bulk 9 and 10** have a much lower impact than the benchmark. The reduction in impact observed is at least -66% (packaging 1.5 compared with 8.2) to -92% (packaging 1.3 compared with 6.1). These packs are also the most efficient in terms of mass used per volume packed (see Figure 5), which explains their low impact.
- The individual packaging categories based on **cardboard 2 (reverse blister), 3 (case), and 5 (cellulose)** are also better than the reference, but some designs have comparable or even inferior performance to the best-performing reference blisters (1.1 and 1.5), such as the 2.2 and 3.4 packages, due to their low pack volume. For these packs, the variation in impact on these categories ranges from 0% to -65% for **reverse blisters (2.)**, from+ 5% to -86% for **cardboard boxes (3.)** and from +15% to -44% for **moulded cellulose (5.)**.
- The impact of category **4 cardboard + straps** is comparable or even greater than the reference.

Interpretation by life cycle stage:

- Of all the scenarios studied, if we consider only primary packaging, the stages that contribute most to the impact in terms of use of energy resources are raw materials and finishing.
    - The finishing stage has a non-negligible impact on the use of energy resources, particularly for individual cardboard-based solutions (**blisters 1. and 2., cases 3.**). These types of packaging tend to have a larger printed surface.

- The **end-of-life** stage is a significant contributor for **cardboard-based** packaging and a negative contributor (beneficial for the environment) for **plastic-based** packaging. The justification is as follows:
  - The modelling of the end-of-life of cardboard in CFF involves a cardboard recycling process that has a greater impact than virgin material, so the avoided impacts associated with recycling are doubly reduced (impacting recycling process and low avoided impact). This is due to the use of co-waste/co-products from the forestry industry, black liquor, which is used as a source of heat and avoids the use of non-renewable resources.
  - Conversely, in the case of recycled plastics, the recycling process has less impact than virgin material, so the avoided impacts (benefits) associated with recycling are significant on two levels (the recycling process requires few energy resources and makes it possible to avoid virgin material, which uses a lot of resources, generating a high avoided impact).
- The **raw materials processing** stages (except for designs involving a high rate of production waste, such as packaging 3.4 with 45% waste linked to cardboard cutting)**.**

4.2.3.3 Freshwater eutrophication indicator

Figure 15 shows the contribution of each stage in the packaging life cycle, according to the "Eutrophication freshwater" indicator, focusing solely on primary packaging, a priority indicator for CITEO. The vocabulary and scope associated with the colour code used in the results graphs is presented in Section 4.2.1. In addition to the graph presented, Table 45 details the impact of each life cycle stage for all packaging systems on the "Eutrophication freshwater" indicator and is available in the appendix.

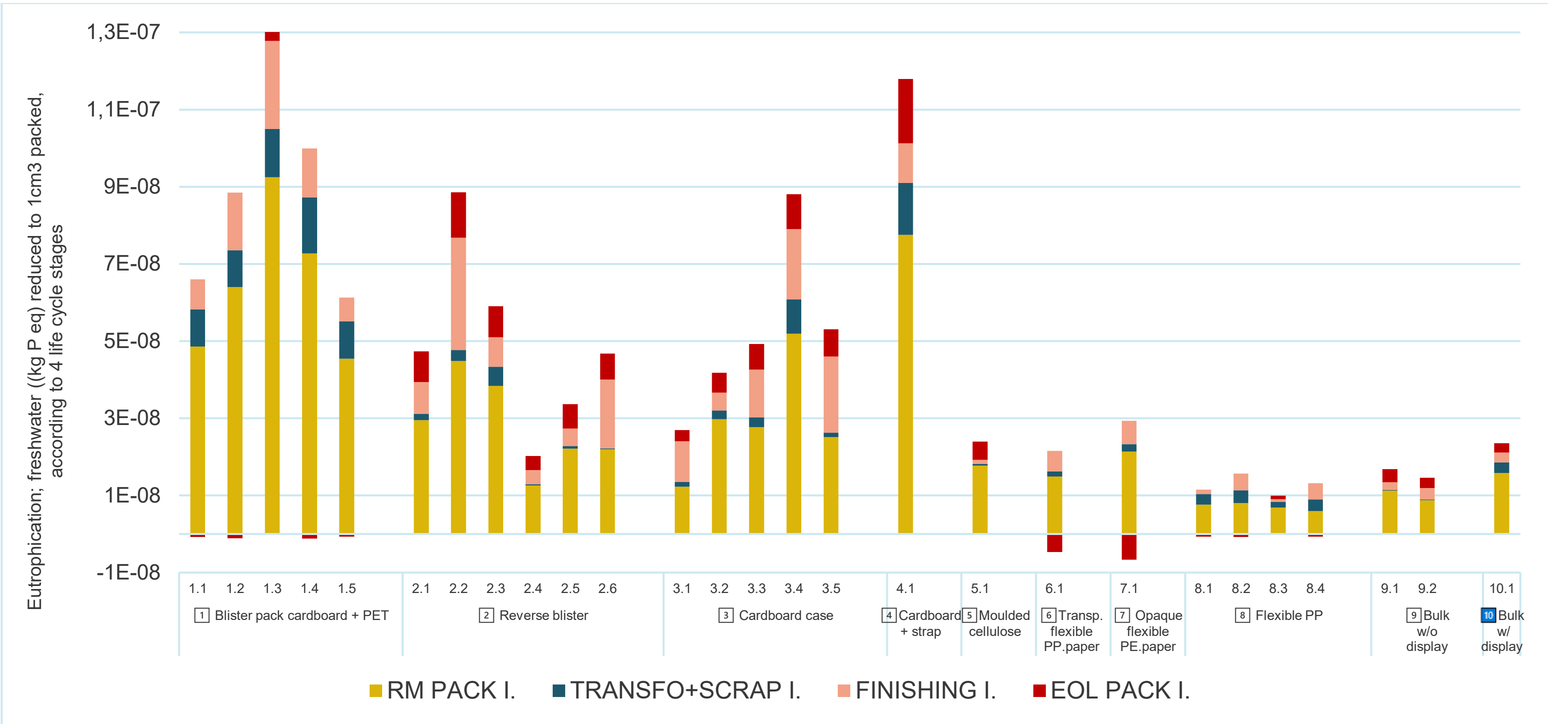


Figure 15 Comparison of packaging systems, focusing on primary packaging only, according to the freshwater eutrophication indicator (FU = 1cm^{3}packaged)

Interpretation of the impact on this indicator:

Overall, in terms of eutrophication in freshwater, the alternatives studied have less impact than the "1. PET/Cardboard blister" reference. More specifically, we note that:

- **Flexible** packaging categories **6 (transparent paper), 7 (opaque paper), 8 (PP) and bulk 9 and 10** have a much lower impact than the benchmark. The reduction in impact observed is at least -63% (packaging 1.5 compared with 7.1) to -92% (packaging 1.5 compared with 8.3). These packages are also the most efficient in terms of mass used per volume packed (seeFigure 5), which explains their low impact.
- The individual packaging categories based on **cartons 2 (reverse blister)** and **3 (case)** are better overall than the reference, but some designs generate a limited environmental gain (2.1, 2.2, 2.3, 3.3, 3.4 and 3.5) because of their low packed volume. The worst packaging (2.2) generates an impact 46% higher than the best reference (1.5) but the reduction in impact in these categories can be as much as 84%.
- **Categories 5 (cellulose)** and **4 (linked cardboard)** have a greater impact than the reference blisters.

Interpretation by life cycle stage:

- Of all the scenarios studied, the stages that contribute most to the impact of eutrophication in freshwater are **raw materials** and **finishing**.
    - Flat cardboard and paper, which are massively used in the **raw materials** for the packaging studied here, also have an impact on freshwater eutrophication. However, they generate half as much impact per kg as corrugated cardboard because they generate less ash (preferential use of electrical energy) and do not use glue or starch.
    - plastic **raw materials** have less impact on eutrophication than paper/cardboard-based materials, which is an advantage for **flexible** packaging.
    - The **finishing** stage has a non-negligible impact on eutrophication in freshwater, particularly for individual cardboard-based solutions (**blisters 1. and 2., case 3**.). These types of packaging tend to have a larger printed surface.
- **End-of-life** is a stage that contributes little to the impact of all scenarios.
- The **raw materials processing** stage makes a small contribution to the impact on this indicator.

4.2.3.1 Depletion of resources, minerals and metals indicator

Figure 16 shows the contribution of each stage in the packaging life cycle, according to the "depletion of resources, minerals and metals" indicator, focusing solely on primary packaging. The vocabulary and scope associated with the colour code used in the results graphs is presented in Section 4.2.1. In addition to the graph presented, Table 46 details the impact of each stage in the life cycle for all packaging systems on the "depletion of resources, minerals and metals" indicator and is available in the appendix.

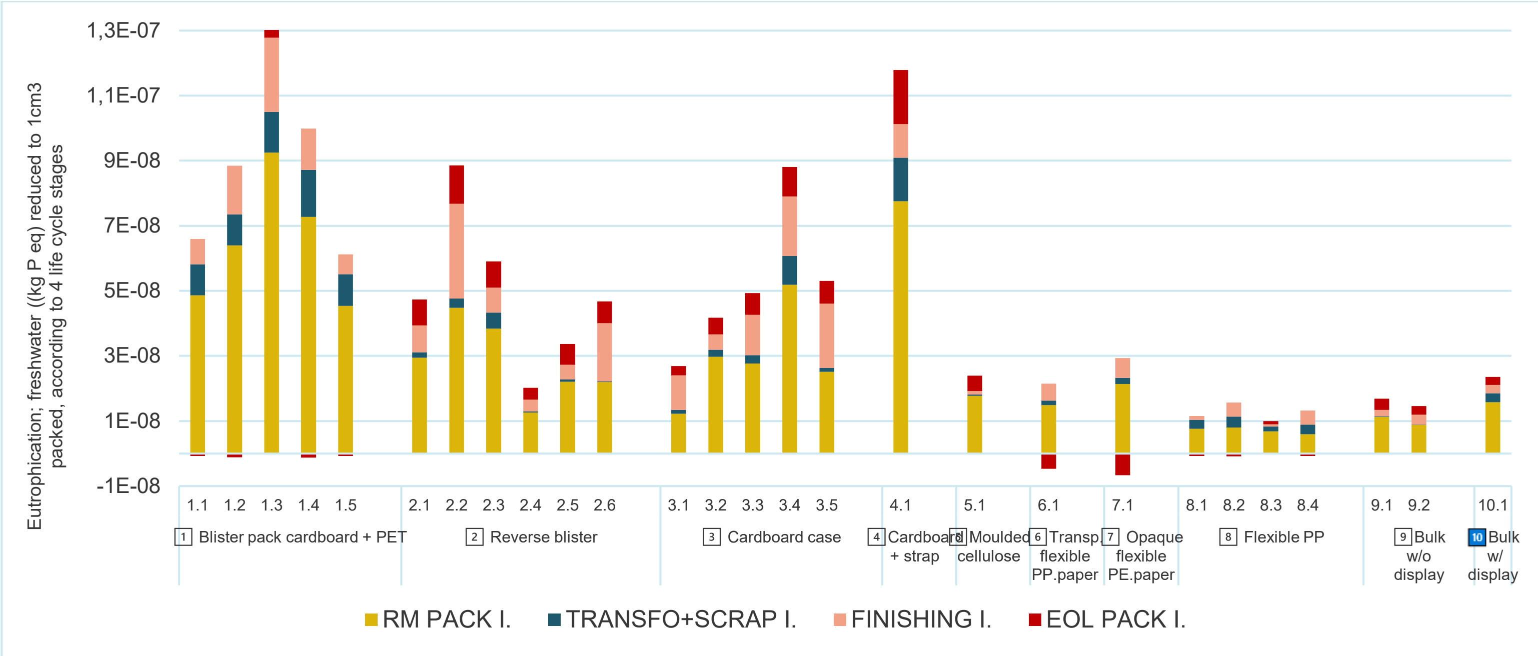


Figure 16 Comparison of packaging systems, focusing on primary packaging only, according to the depletion of resources, minerals and metals indicator (FU = 1cm³ packed)

Interpretation of the impact on this indicator:

In terms of the depletion of mineral and metal resources indicator, all alternatives studied have a lower impact than the "1. PET/Cardboard blister pack" reference, even though **category 4 (cardboard + straps)** has an impact close to that of the best-performing samples in the reference category. An analysis by life cycle stage will help to explain these contrasting results.

Interpretation by life cycle stage:

- Of all the scenarios studied, the stages that contribute most to the impact in terms of depletion of mineral and metal resources are **raw materials** and **finishing**.
    - Blister references have a high impact due to the **raw materials** used, which is explained using PET for the shell. This PET uses terephthalic acid (PTA) as a precursor. Cobalt, a rare metallic element, is used to catalyse the synthesis of PTA, which explains the significant impact of PET-based packaging on this indicator.
    - The remainder of the impact attributed to **raw materials** is due to the use of metals in industrial installations.
    - The **finishing** stage has a significant impact on the depletion of mineral and metal resources, particularly for individual cardboard-based solutions (**blisters 1. and 2., cases 3.**). These types of packaging tend to have a larger printed surface.
- The **end-of-life** and **raw materials processing** stages make a small contribution to the impact on this indicator.

4.2.3.2 Land use indicator

As shown in Section 4.2.1.5, the "land use" indicator is not mainly due to the ICPs, even if this stage remains important and must not be forgotten in this study. Therefore, it does not seem very relevant to interpret the results on this indicator again, especially as the product distribution phase makes virtually no contribution to this indicator.

4.2.3.3 Use of water resources indicator

Figure 17 shows the contribution of each stage in the packaging life cycle, focusing on primary packaging only, according to the "Water use" indicator. The vocabulary and scope associated with the colour code used in the results graphs is presented in Section 4.2.1. In addition to the graphs presented, Table 48 shows the impact of each stage in the life cycle for all packaging systems on the "Water use" indicator, and is available in the appendix.

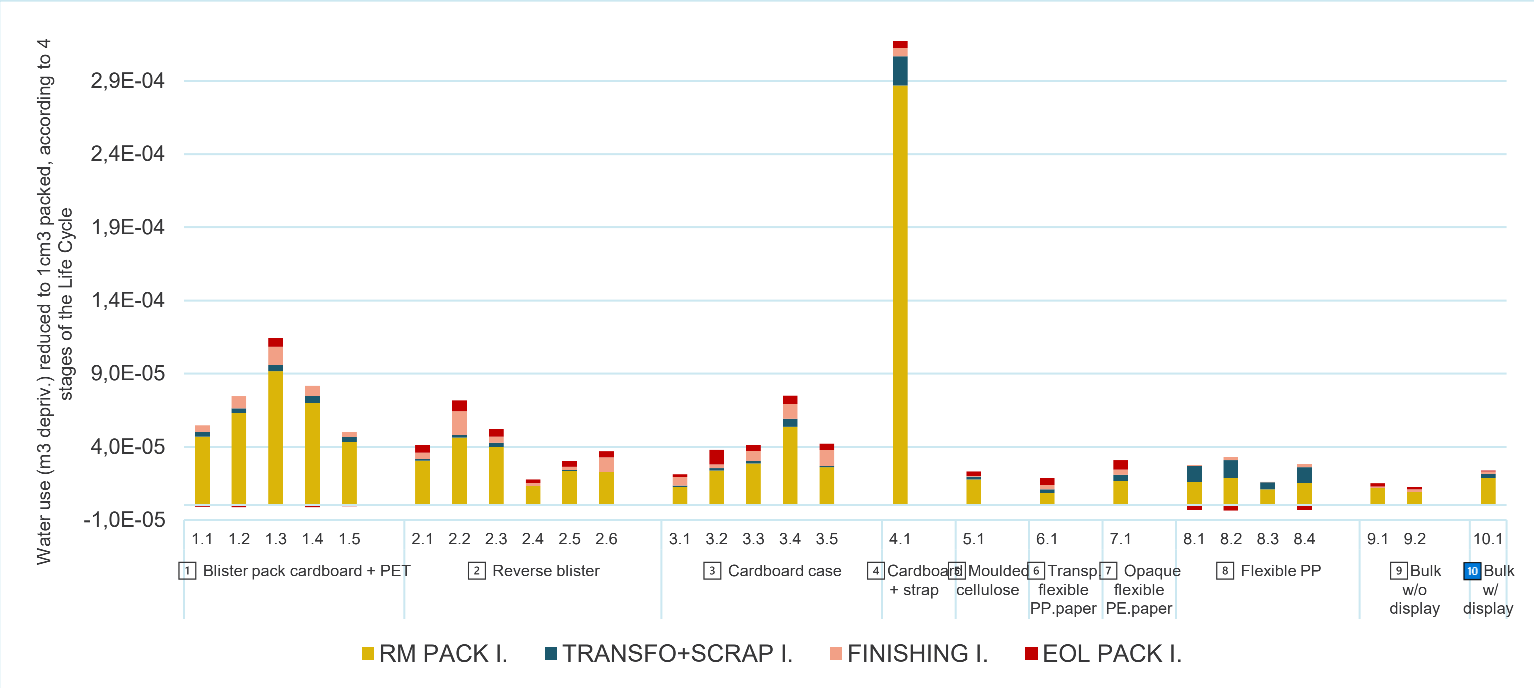


Figure 17 Comparison of packaging systems, focusing on primary packaging only, according to the water use indicator (FU = 1cm^3 packed)

Interpretation of the impact on this indicator:

Overall, in terms of the water use indicator, the alternatives studied have less impact than the "1. PET/Carton Blister" reference. More specifically, we can see that:

- **Flexible** packaging categories **6 (transparent paper), 7 (opaque paper), 8 (PP) and bulk 9 and 10** have a lower impact than the benchmark. The reduction in impact observed is at least -40% (packaging 1.5 compared with 8.2) to -89% (packaging 1.3 compared with 9.2). These packs are also the most efficient in terms of mass used per volume packed (see Figure 5), which explains their low impact.
- The individual packaging categories based on **cardboard 2 (reverse blister), 3 (case), and 5 (moulded cellulose)** are better overall than the reference but some designs generate a limited environmental gain (2.1, 2.2, 2.3, 3.3, 3.4 and 3.5) because of a low packed volume. The worst packaging (2.2) generates an impact 45% higher than the best reference (1.5) but the reduction in impact in these categories can be as much as 73%.
- Category **4 cardboard + straps** has a much greater impact than the reference, but it is difficult to conclude whether this packaging is irrelevant because it is only represented by a design and does not protect a defined volume (packaged volume = volume of the object, which may be indirectly underestimated).

Interpretation by life cycle stage:

- In all the scenarios studied, the stages that contribute most to the impact in terms of water use are **raw materials** and **finishing**.
    - **Raw materials** have a high impact on paper/board-based packaging. Paper-making processes require a lot of water (water for paper pulp, water for rinsing chemicals, evaporation of water into the air, effluent treatment, etc.). Plastics, on the other hand, consume very little water.
    - Packaging category **4. cardboard + straps**, is penalised using flat cardboard that is too solid, generating a significant impact on **raw materials**. This cardboard is necessary because the packaged object is heavy, and the cardboard must be thick to guarantee the rigidity of the packaging. For other applications, the weight/volume ratio of this type of packaging can be improved.
    - The **finishing** stage has a non-negligible impact on water use, particularly for individual cardboard-based solutions (**blisters 1. and 2., cases 3.**). These types of packaging tend to have a larger printed surface.
- The **end-of-life** stage is a low contributor for the packaging systems studied. Cardboard recycling processes require water, which explains why this stage contributes so much to this indicator for recyclable **cardboard-based** packaging and, conversely, contributes little for **plastic-based** packaging**.**
- The **raw materials transformation** stages (except for plastics, where the transformation processes require water, to cool the machines) contribute little to the impact.

4.2.3.4 Single score indicator

Figure 18 shows the contribution of each stage in the packaging life cycle, focusing solely on primary packaging, according to the "single score" indicator. The vocabulary and scope associated with the colour code used in the results graphs is presented in Section 4.2.1. In addition to the graph presented,Table 49 shows the impact of each life cycle stage for all packaging systems on the "single score" indicator and is available in the appendix.

NB: This indicator is presented here for information purposes only. It is not recommended to communicate on the single score indicator. However, the single score was used in this study to select the indicators and gives the reader an indication of the overall environmental issues of the system studied. Under no circumstances should the single score results be communicated on their own.

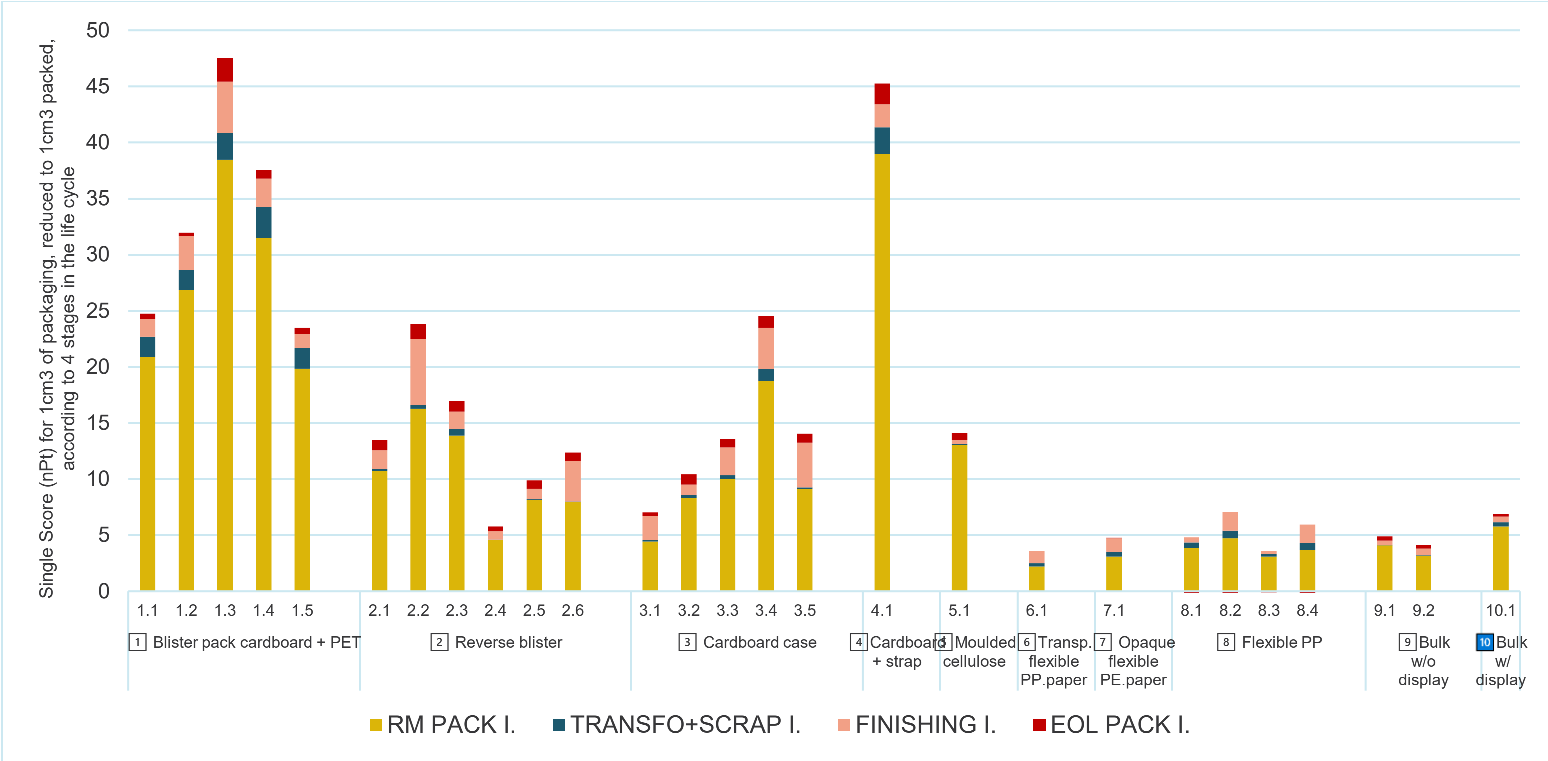


Figure 18 Comparison of packaging systems, focusing on primary packaging only, according to the single score indicator (FU = 1cm^{3}wrapped)

Interpretation of the impact on this indicator:

Overall, on the single score, the alternatives studied have less impact than the "1. PET/Cardboard blister" reference. More specifically, we can see that:

- **Flexible** packaging categories **6 (transparent paper), 7 (opaque paper), 8 (PP) and bulk 9 and 10** have a much lower impact than the benchmark. The reduction in impact observed is at least -71% (packaging 1.5 compared with 10.1) to -93% (packaging 1.3 compared with 8.3). These packs are also the most efficient in terms of mass used per volume packed (seeFigure 5), which explains their low impact.
- The individual packaging categories based on **cardboard 2 (reverse blister), 3 (case), and 5 (cellulose)** are better overall than the reference, but some designs generate limited environmental gains (2.2, 3.4 and 3.5) due to low pack volume. The worst packaging (3.4) generates an impact 4% higher than the best reference (1.5), but the reduction in impact in these categories can be as much as 88%.
- Category **4 cardboard with a link** has an impact comparable to or even greater than the reference, but it is difficult to conclude whether this packaging is irrelevant because it is represented only by a design and does not protect a defined volume (packaged volume = volume of the object, which may be indirectly underestimated).

Interpretation by life cycle stage:

- Of all the scenarios studied, the stages that contribute most to the single score are **raw materials** and **finishing**.
  - Packaging category **4, cardboard + straps**, is penalised using flat cardboard that is too solid, generating a significant impact on **raw materials**. This cardboard is necessary because the packaged object is heavy, and the cardboard must be thick to guarantee

the rigidity of the packaging. For other applications, the weight/volume ratio of this type of packaging can be improved.
    - The finishing stage has a non-negligible impact on the single score, particularly for solutions based on individual cardboard (**blisters 1. and 2., cases 3.**). These types of packaging tend to have a larger printed surface area.
- The **end-of-life** and **raw materials processing** stages contribute little to the impact.

4.2.4 COMPARISON BASED ON THE MAIN FUNCTIONAL UNIT, FOCUSING ON THE VOLUME PACKED

This section presents some of the same results as in the previous sections: the performance of the 27 packs on the "climate change" indicator, compared with the volume packed per pack. To do this, "3 classes" are distinguished by their packed volume:

- Small packaging with a volume of less than 150 cm^3 (orange on Figure 19
- Medium-sized packaging with a volume of between 150 and 350 cm^3 (yellow on Figure 19
- Large packaging with a volume of more than 350 cm^3 (green on Figure 19

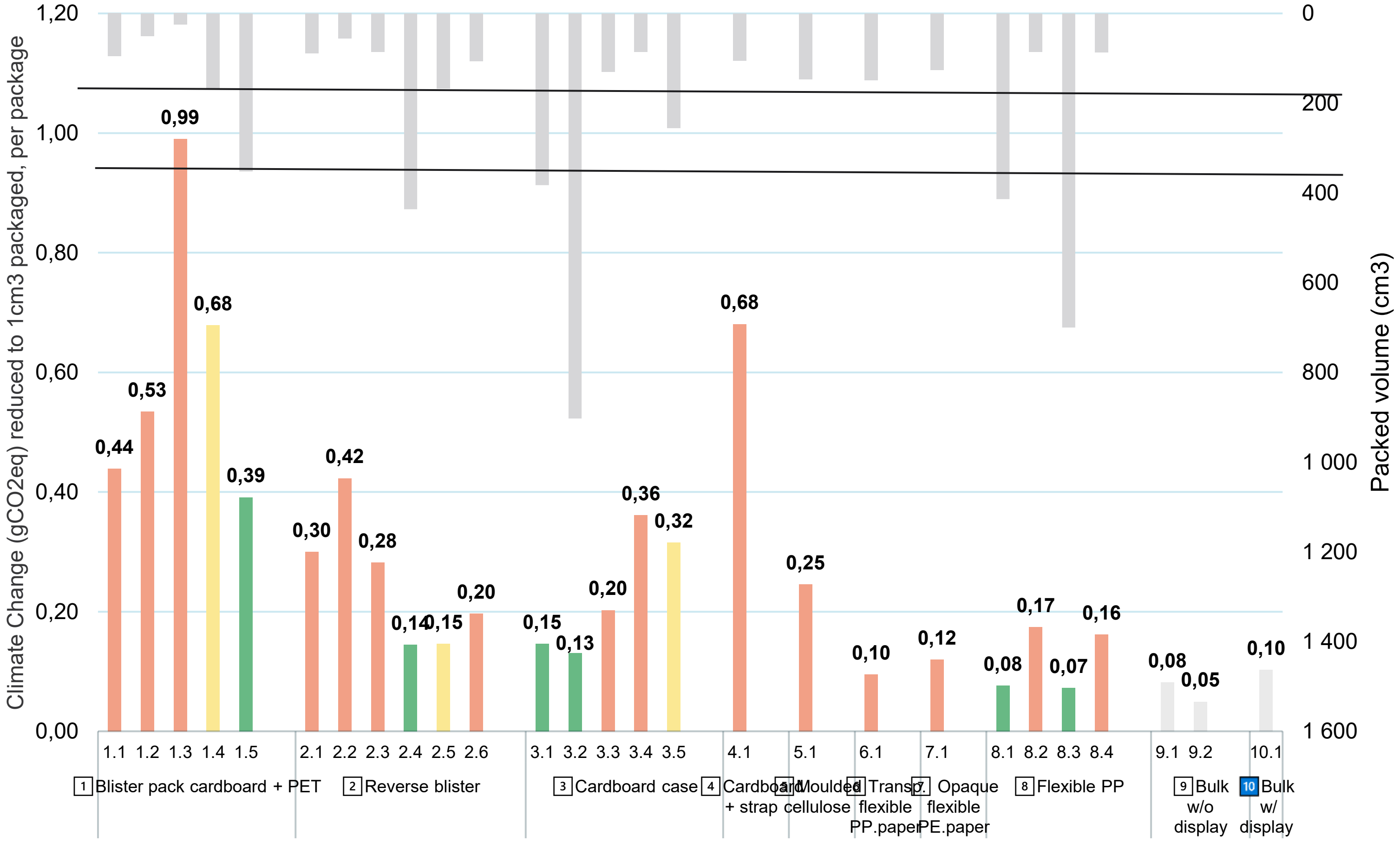


Figure 19 Comparison of packaging systems, focusing on the volume packed, according to the climate change indicator (FU = 1cm^3 packed)

Figure 19 , compares all the packaging on the climate change indicator, as well as the volume packed (in grey). First of all, we can see that a wide variety of packaged volumes are represented in this study, ranging from 25.1 cm^3 (sample 1.5) to 902.7 cm^3 (sample 3.2) if bulk packaging is excluded as it is a special case (greyed out in Figure 19). It is not possible to directly correlate the volume packaged with its impact on the climate change indicator, since categories **5 (moulded cellulose)**, **6 (transparent**

paper) and **7 (opaque paper)** have a relatively small volume and belong to the small packaging category. However, they have little impact on this indicator.

Nevertheless, when focusing on one packaging category at a time, it is interesting to note that some trends emerge. In fact, for packaging families with a significant number of samples, a low volume packed implies an under-performance of the packaging in relation to the average impact of the family in question. This observation is valid for categories **1 (PET/cardboard blister), 2 (reverse blister), 3 (case)** and **8 (PP)**, for which the correlation between packed volume and impact on climate change is systematic. In fact, the ranking of performance on climate change (the 1st being the best) is the same as that of packed volume (the 1st being the largest in volume), for these 3 packaging categories. Small packs have a less optimised ratio [packed volume/primary pack weight] than larger packs. As a result, larger packs have an advantage.

In addition, Figure 19 allows us to compare packaging of different types but with a similar packed volume (around 170 cm^3), such as 1.4, 2.5 and 3.3. In this example, the cardboard alternatives **2 (reverse blister) and 3 (case)** generate environmental impacts 3 times lower than the reference **1 (cardboard/PET blister)**. Similarly, by focusing on packs 2.3, 3.4 and 8.2 (or 8.4), it is possible to deduce that for packs with a comparable volume (around 85 cm^3), family **8 (PP)** has a better environmental performance than families **2 (reverse blister) and 3 (case).** This type of observation makes it possible to avoid the scale effects induced by packaging with a high packed volume and to compare packaging of similar sizes.

However, it is important to bear in mind that a reasonable and adequate quantity of product should be packaged, as closely as possible to the consumer's needs. Packing a large quantity of product that is not ultimately used by the consumer would lead to a transfer of impact through the rebound effect and would reduce the impact of the packaging.

The results presented in this focus on packaged volume have been formatted solely for the climate change indicator. By repeating the exercise of interpretation by volume class for the other indicators, we observe that the conclusions are the same as for climate change, i.e. that:

- Within each packaging family, the most efficient packages are those with the largest volume (e.g. 1.5 for the "cardboard blister + PET" family),
- Between packaging families, with a comparable packed volume, the impact of packaging systems depends on the packaging family and not the volume. The conclusions obtained in the Section 4.2.1 remain the same (for example, for packaging systems with a comparable packed volume (around 170 cm^3) such as packs 1.4, 2.5 and 3.3, the **cardboard** alternatives **2 (reverse blister)** and **3 (case)** generate lower environmental impacts than the reference **1 (cardboard/PET blister)** for all the indicators studied.

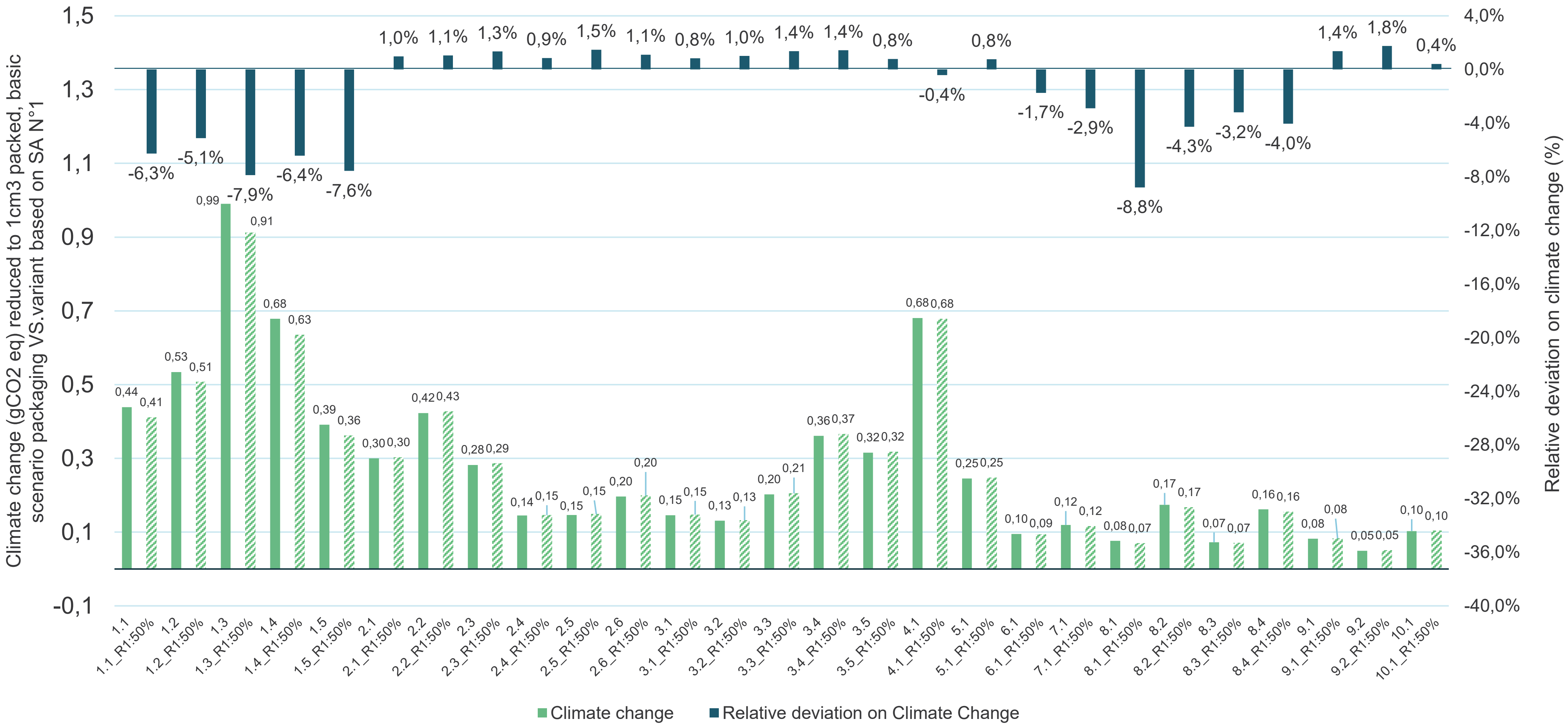
4.3 SENSITIVITY ANALYSES

This section deals with the study's sensitivity analyses. We have chosen to concentrate on the climate change indicator to present the results in a more readable way. Nevertheless, the raw results for each SA on the other five indicators are presented in Appendix 7.4.

4.3.1 SA N°1: VARIATION IN THE RATE OF RECYCLED AND INCORPORATED MATTER FOR CERTAIN MATERIALS

This section deals with a key parameter linked to the use of recycled material: the rate of recycled material incorporated into primary packaging. The latter is set at 0% in this study but is increased here to 50% to study the changes this has on the results and conclusions. Here, the study focuses on the rate of recycled material incorporated into primary packaging. Moreover, this rate of incorporated recycled material is only considered for materials for which recycling (on the scale and in practice) is possible. This is the case for all materials in this LCA, except for the nylon used in packaging 4.1). The modelling is therefore identical between the base scenario and the sensitivity analysis, except for the raw materials used for the primary packaging. The ICPs do not include recycled materials in this analysis.

This sensitivity analysis leads to Figure 20 , showing the results in terms of the climate change indicator for each packaging for the base scenario, then incorporating 50% recycled material for primary packaging materials.
The graph is presented on two axes: the first, represented by green histograms, shows the raw results of the climate change indicator for the 54 scenarios (27 packages times 2) and the second, in blue, shows the relative difference in percentage impact of this same indicator for the baseline scenario and this SA.



2594 **Figure 20 Impact on the climate change indicator of different types of packaging with 0% recycled content VS 50% recycled content (FU =**
2595 **1cm^3 packaged)**

2596 Figure 20 , shows that incorporating 50% recycled material reduces the impact on climate change by 2% to 9% for primary packaging made partly or
2597 entirely of plastic: **1 (PET/cardboard blister pack), 6 (transparent paper), 7 (opaque paper) and 8 (flexible PP).** However, for the other families,

composed mainly of paper/cardboard, the picture is more mixed. In fact, for these categories: **2 (reverse blister), 3 (case), 5 (moulded cellulose) 9 and 10 (bulk)**, incorporating 50% recycled material leads to a slight increase in the impact on climate change from 0% to 2%.

This trend can be partly explained by the fact that when paper is manufactured from virgin material, a co-product called black liquor is used for energy recovery. As this co-product comes from biomass, it contains biogenic carbon, and its combustion leads to a biogenic carbon count of 0/0, which implies a zero impact on the climate change category and more advantageous heat production compared to gas or coal. However, when paper is made from recycled material, there is no production of this black liquor and therefore no production of heat from co-products of the forestry industry. So, in terms of climate change, for paper/cardboard, in most cases, it is better to use virgin material rather than recycled material [xix].

This conclusion is qualified by the fact that in all five of the other impact categories considered in this study, the scenario incorporating 50% recycled material performs better than the baseline scenario, as shown in Table 50 and Table 51. Thus, manufacturers must make a trade-off between slightly increasing the impact on climate change while reducing it on the other indicators studied by incorporating recycled material or slightly decreasing the impact on climate change and increasing the impact on the other indicators studied by not incorporating recycled material.

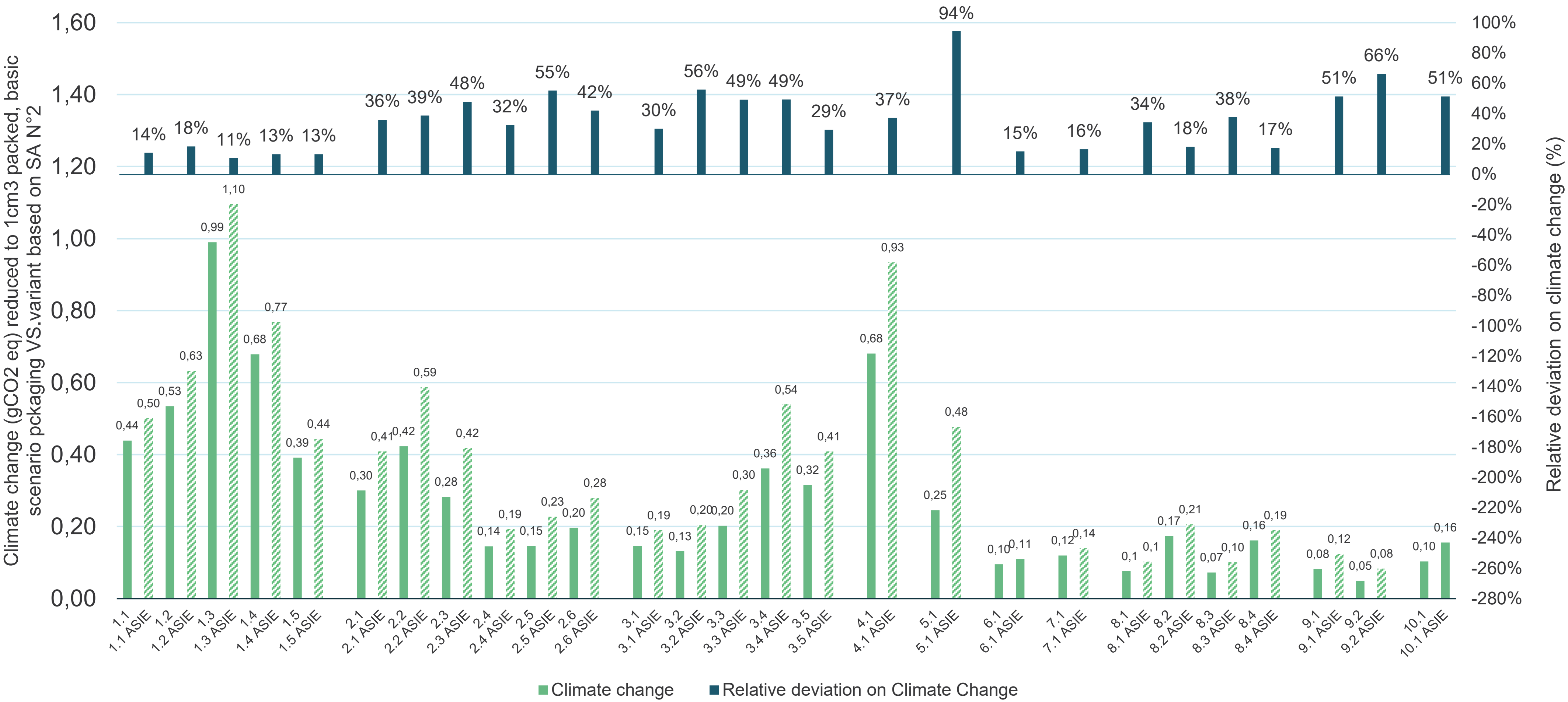
To go further, a specific LCA on this type of material should be carried out, to consider the diversity of parameters that can influence the use of virgin and recycled paper: type and origin of raw materials and fibres, specific practices of each supplier, varieties of "Mill" technologies for the manufacture of paper pulp, among others.

4.3.2 SA N°2: ASIAN ORIGIN OF PRIMARY PACKAGING

This section looks at the sensitivity of the results to the geographical origin of the materials used to produce the primary packaging. In this study, primary packaging materials are produced in Europe, but in this sensitivity analysis, an Asian origin is considered to study whether such a change would have significant repercussions on the results.

This scenario considers an Asian supply of primary packaging raw materials (not ICPs - which is a limitation of this SA) and considers the transport of materials from Asia to Europe with a combined transport of 12,000km by boat and 1,000km by truck (split into 500km in Europe and 500km in Asia). In addition, for this SA, "ROW" data is used to model the origin of raw materials in Asia, as the ecoinvent database does not specifically provide Asian data. The details of the inventory data specific to this sensitivity analysis are not explicitly given. The inventory data are the same as for the base scenario, with the difference of geography: **the background data for raw materials are changed from RER to RoW**. Only sample 5.1 moulded cellulose benefits from the Chinese energy mix (CN). The production and end-of-life of the packaging is still in Europe and France, respectively. The results are presented in the same form as for the first sensitivity analysis: 54 scenarios, 2 vertical axes of results on climate change (1 in absolute, 1 in percentage relative deviation).

2637



2639 **Figure 21 Climate change impact of different types of packaging using primary materials from Europe VS Asia (FU = 1cm^{3}packaged)**

2640 Figure 21 clearly illustrates that sourcing raw materials in Asia implies a very sharp increase, for all packaging, in the impact on the climate change
2641 category. These increases vary between 14% and 68%, depending on the packaging and the proportion of primary packaging and ICP by mass.
2642 Packaging with a high ICP/primary packaging mass ratio is the least impacted by this SA, and the opposite is true (see Figure 5). Most of this increase

in impact comes from the production of raw materials in Asia. The transport of raw materials from their production in Asia to the packaging manufacturing plants in Europe contributes little to the increase in impacts on climate change.

The raw results of this sensitivity analysis can be found atTable 52 andTable 53 . Overall, Asian supply generates greater impacts than the reference scenario for the 6 indicators under study. The conclusions drawn on the other indicators are therefore in line with those drawn here on climate change. However, it is possible to observe that families **7 (opaque paper) and 8 (flexible PP),** on the "consumption of water resources" indicator, generate slightly fewer impacts: from -0% to -7%.

So, sourcing from Europe is certainly more environmentally relevant than sourcing from Asia. This confirms that the geography of raw material production is a key issue in the design of alternatives to blister packs.

As an aside to this sensitivity analysis, if the production and supply of ICPs, as well as the production of primary components, had been carried out in Asia, the increase in impacts would have been even greater, due to a more carbon-intensive energy mix for Asian countries.

4.3.3 SA N°3: VARIATION IN PACKED VOLUME FOR PET/CARDBOARD BLISTERS

This section looks at the sensitivity analysis of the variation in volume that PET/cardboard blisters could theoretically pack while retaining all the secondary functionalities. This family of packaging does not carry the maximum volume theoretically possible, since the PET shell is thermoformed to the exact dimensions of the packaged product to hold it in place. This characteristic, which is specific to this family of packaging, potentially leads to a bias in the environmental performance results for this category of packaging. This is why in this sensitivity analysis the theoretical maximum volume is measured and the LCA results are recalculated.

4.3.3.1 Protocol

To measure this volume, an isosceles trapezoidal cross-section has been considered in order to retain draft angles (angles that allow the part to be demoulded more easily) on the final volume, to maintain a shape that is compatible with the thermoforming shaping process. This theoretical cross-section is measured on the maximum dimensions of the object while retaining the secondary functionality associated with marketing, i.e. considering a free space for printing graphic elements. The volume is then calculated by multiplying by the maximum length of the object. Figure 22 illustrates how the trapezoidal section is measured in relation to the object's dimensions.

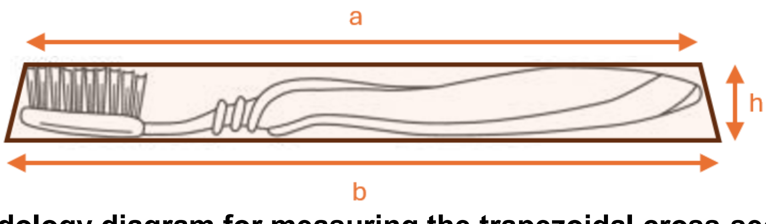


Figure 22 Methodology diagram for measuring the trapezoidal cross-section for the AS3

These measurements are used to calculate the cross-sectional area using the following formula:

$$\frac{(a+b)\times h}{2}$$

Measuring the remaining dimension gives the theoretical maximum volumes, presented inTable 25:

Scenario	Product number	Packaged volume (cm3)	Maximum theoretical volume (cm3)	Maximum volume gain
Cardboard blister + PET	1.1	95,3	115,6	21%
	1.2	50,0	75,5	51%
	1.3	25,1	26,9	7%
	1.4	168,6	287,7	71%
	1.5	352,0	437,0	24%

Table 25 Packed volume VS maximum theoretical volume for PET/cardboard blisters

4.3.3.2 Results

With a new theoretical maximum volume for PET/cardboard blisters,Figure 23 shows the results of this sensitivity analysis:

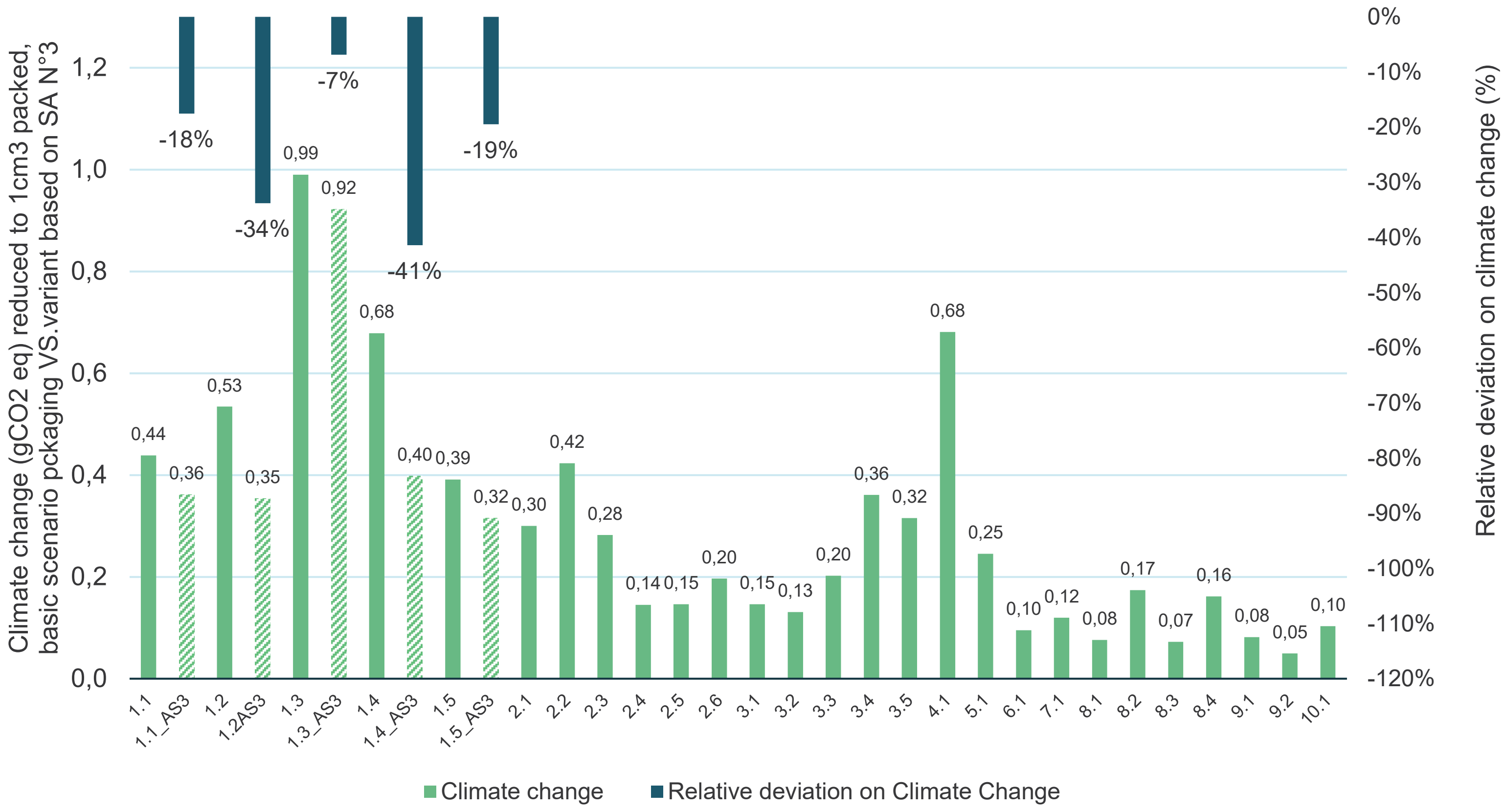


Figure 23 Graph showing the results of SA No. 3 (FU = 1cm³packed)

This increase of packaged volume reduces the impact associated with each PET/cardboard blister pack on the climate change indicator. This reduction depends on the increase in packaged volume, with the two parameters following a virtually proportional relationship.

However, despite this performance gain on the climate change indicator, the study's conclusions regarding the environmental relevance of packaging families **6 (transparent paper)**, **7 (opaque paper)**, **8 (flexible PP)**, **9** and **10 (bulk)** remain unchanged. However, **packaging families 2 (reverse**

blister), **3 (cardboard box)** and **4 (moulded cellulose)** are no longer necessarily better than the reference scenario, even if overall they remain more interesting (excluding family 4).

Furthermore, this sensitivity analysis generates the same decrease (in relative deviation) on the 5 other indicators, as shown in Table 54 and Table 55. In fact, increasing the volume packed reduces the mass/volume ratio, a key parameter in this study. The conclusions observed for the other indicators are therefore in line with those observed here for climate change.

Furthermore, this SA does not change the conclusions of the study, and it is based on a theoretical maximum volume which is ideal and therefore not necessarily realistic. This volume is certainly larger, but it does not allow the packaged product to be held in place, which can cause it to deteriorate. This will depend on the constraints of each customer and each product/packaging pairing. The associated scrap/loss rate should be considered in certain cases, which would increase the environmental impact. Furthermore, these results could encourage marketers to pack a greater volume of product per CSU to reduce the impact associated with packaging. This eco-design approach is partly relevant, but it is worth noting that it could lead consumers to consume more than they initially need, leading to a rebound effect and a transfer of impact from the packaging to the product consumed.

4.3.4 SA N°4: CONSIDERATION OF THE CONTAINER USED FOR SHELF DISPLAY OF BULK ITEMS WITHOUT DIPLAY

This section looks at the sensitivity analysis of the impact of including a bin for displaying products packaged in non-display bulk packaging (family 9). This packaging system requires specific infrastructures to ensure that the product is placed on the shelf and available to the consumer. For this purpose, a plastic crate is included in the system under study. The products are placed directly in this container/display and are reused several times. This SA focuses solely on product 9.1, for which certain data are available and have enabled the attribution calculations to be made between the crate and the primary packaging. The commercial reference of the case is given here[xx] .

4.3.4.1 Data for modelling

Data on the plastic crate:

- Weight: 0.3 kg
- Materials: Polystyrene (GLO)
- Process: Injection moulding (assumption)
- Capacity: 3.8L (3800 cm3)
- Warranty: G=3 years (considered to be the life of the box)
- End of life according to the CITEO 2030 scenario.

Number of uses of a box and allocation factor per cm^3packed:

Based on the annual sales volume of the product (noted P), its unit price (noted T), the number of hypermarket-type shops in France (noted M) and on the assumption that there is one box per shelf (noted B), it is possible to determine the fraction of the till allocated to the sale of a single product. This is calculated using the following formula:

$$\frac{P \times G}{T \times M \times B} = 3823$$

So, over the lifetime of the case (assuming 3 years: product guarantee), the case will enable 3823 products to be displayed on the shelves. Given that the case weighs 0.3 kg, that there are 12 products per primary packaging and that packaging 9.1 is 1120cm^3long, it is possible to allocate: $\frac{1}{3823} \times \frac{12 \times 300}{1120} =$

$\mathbf{8.10^{-4}g}$ of PS per cm^3, for this packaging. This allocation constitutes a first approach leading to a coherent order of magnitude. For the modelling of this system, the raw materials, the shaping and the end of life of the PS box are considered.

4.3.4.2 Results and interpretation

Table 26 shows the results for the 6 selected indicators, and the resulting increase:

Impact category	Unit	9.1	9.1 SA Cashier
Climate change	gCO2 eq	8,2E-02	8,5E-02
Eutrophication Freshwater	kg P eq	3,2E-08	3,3E-08
Land Use	Pt	5,4E-03	5,4E-03
Water use	m3 depriv.	2,8E-05	2,9E-05
Resource use; Fossils	MJ	1,2E-03	13E-03
Resource use; Minerals and Metals	kg Sb eq	3,1E-10	3,3E-10
Relative deviation on Climate change	-	**+4%**	
Relative deviation on Eutrophication Freshwater	-	**+2%**	
Relative deviation on Land Use	-	**0%**	
Relative deviation on Water use	-	**+3%**	
Relative deviation on Resource use; Fossils	-	**+5%**	
Relative deviation on Resource use; Minerals and Metals	-	**+5%**	

Table 26: Impacts on the 6 indicators for packaging 9.1 with and without a case for shelf display

On all the selected indicators (excluding "Land Use "), the inclusion of this plastic crate leads to an increase in impacts. This increase can be as much as +5% for the "Use of resources; Fossils" and "Resource use; Minerals and Metals" indicators. For the "Climate Change" indicator, an increase of 4% is observed. The increase in these indicators is due to the production of petroleum-based polymers to produce the plastic crate.

However, these results need to be qualified. Firstly, they do not change the interpretation of the comparison with families **1 (PET/cardboard blister), 2 (reverse blister) and 3 (case).** In fact, even considering this plastic crate, sample 9.1 has 39% less impact than the best packaging in these categories (3.2) on the "Climate Change" indicator.

In addition, the plastic crate attribution calculations are based on a first-order approach and on assumptions. As a result, the data on which this analysis is based is less reliable than that used in the base scenario of this study. In addition, it is worth noting that for this SA, the impacts associated with the steel hook used to suspend the various products by their European hole should be deducted. In this case, the products are placed directly in the crate, so part of the traditional shelving infrastructure is no longer required.

In conclusion, the analysis of bulk packaging in the base scenario of this study is less robust than for the rest of the systems. This is a limitation and must be considered when interpreting the results.

4.3.5 OTHER PROSPECTS

4.3.5.1 Size of functional unit (2D vs 3D)

To refine the interpretations of this study, it would have been interesting to study the sensitivity of the results to the dimension (2D or 3D) of the functional unit. This is based on packaged volume, although it could have been based on packaged mass or the surface area presented to the consumer. This FU surface could have been interesting to compare the environmental performance of each packaging in terms of their capacity to present 1 cm^2 of product to the consumer.

However, this notion of display is already considered in a qualitative way in the secondary function associated with marketing. This function is based on the packaging's ability to display graphic elements that can influence consumer behaviour. For this function to be fulfilled, the packaging must have a large enough surface area, optimised to display the right amount of information.

In addition, the results of this potential SA could lead to an eco-design bias by encouraging marketers to optimise their packaging to maximise this display surface while packaging an identical volume of product. This would increase the impact in relation to the volume packaged, which would be counterproductive. Furthermore, flat products with a high surface/volume ratio would benefit greatly from this new FU, since the packaging surface displayed to the consumer would be maximised.

In practical terms, it would be possible to carry out this analysis by measuring the display surface of each sample received by EVEA. However, not all the packaging under study was supplied: of the 27 products under study, 20 samples were sent to EVEA. Therefore, for the missing products, this data would have to be approximated as it was not collected from the producers.

4.3.5.2 Recyclability of ICPs processed by manufacturers in the value chain

As suggested in Section 3.7.2 on recyclability, a low recycling rate has been considered for certain ICPs due to a lack of data. In fact, some ICPs, such as palletising film, are processed by manufacturers during the value chain. Good sorting and recycling practices are put in place to process materials of this type, whereas the CITEO rates used in this study relate to household packaging. An additional sensitivity analysis with higher recyclability rates for ICPs would be relevant for a future study.

5 CONCLUSIONS

5.1 GENERAL CONCLUSIONS ON THE RESULTS AND INTERPRETATIONS

Regarding the various results and sensitivity analyses, the comparative LCA assessment of cardboard/PET blister packaging systems and nine families of alternatives used by CITEO's customers, each alternative studied presents advantages and disadvantages depending on the environmental indicators assessed and the secondary functions considered. The conclusions that can be drawn from the interpretation of the results are as follows:

- All the alternatives studied have a lower impact, and in the worst case comparable to the benchmark. The only exception to this generality is:

- Category **4. cardboard + straps**, with potential impacts that are greater than or comparable to the reference. A marketer of packaging of this type must ensure that the mass and surface area of cardboard used is optimised to guarantee a reduction in environmental impact.

- **Flexible** packaging (**6. transp.PP paper**, **7. opaque.PE paper** and **8. PP)** and **bulk** solutions **(9. with display and 10. without display)** stand out for their reduced environmental impact on all the indicators studied. These packaging solutions make it possible to optimise the use of materials and limit the quantity of material required per unit of packaged volume. However, these solutions have their limitations, particularly in terms of fraud prevention and marketing displays. What's more, this type of packaging is not necessarily suitable for all products. The specific packaging requirements of each product must therefore be considered.
- In contrast, **rigid cardboard packaging** (**2. Reverse blister**, **3. Cardboard case** and **5. Moulded cellulose**) offers better product protection and an optimised medium for marketing communication, but at the cost of a potentially greater environmental impact than the other families mentioned in the previous point. The mass/volume ratio and the finishes applied (printing, varnish) significantly increase their impact. These solutions mainly use cardboard for their primary packaging and have a greater impact than the others on the "land use" indicator. Incorporating recycled material into the packaging and increasing the recyclability rate are two key parameters for reducing the impact of these packaging categories on this indicator. It should also be noted that rigid packaging systems with a reduced mass/volume ratio perform just as well as flexible and bulk packaging systems.

No single packaging system perfectly meets all the challenges assessed. The final choice must therefore incorporate compromises based on the specific requirements of the product and the strategies of the marketer.

Indeed, the various points listed below serve as an opening to keep in mind for all readers of this report, to take a step back from the conclusion:

- For the same type of packaging, the volume packed is a key parameter in terms of potential environmental impact. The greater the volume, the lower the potential environmental impact, as studied in Section 4.2.4 (SA no. 3). It is better to use packaging with a large volume to reduce the impact. However, it is important to be aware of the rebound effect that this could have and the resulting shift in impact *(for example, in the DIY sector, offering 5,000 nails when a private customer might only need 500, as opposed to a professional who might have a need that is more consistent with the quantity of nails on offer).*
- The incorporation of recycled material is generally beneficial to environmental performance (see Section 4.3.1 , SA n°1).
- Geographical sourcing is a key factor: sourcing raw materials from Asia is environmentally damaging (see Section 4.3.2 , SA no. 2).

5.2 CONTRIBUTION OF LIFE CYCLE STAGES AND PRODUCT COMPONENTS

For the packaging systems studied, the main environmental impacts come from two **stages in the life cycle:**

- **Primary packaging raw materials**
- **ICP required for transport to points of sale**

For most of the indicators and packaging systems studied, the **raw materials used in primary packaging** are the main contributors to environmental impact. This is all the truer if the packaging has a lot of material in relation to the volume packed, in contrast to other packaging which is much lighter (flexible packaging) where the ICPs have a greater share, relatively speaking, in relation to the primary packaging. The main parameters that influence the impact of materials are as follows:

- Optimisation of the mass/volume ratio to reduce the mass of raw material needed to package the same product.
- Optimisation of scraps, in particular offcuts linked to the cutting of paper/cardboard packaging.
- In addition to the global issue of "climate change", there are also specific issues relating to the raw materials used:
    - For paper/cardboard raw materials, it is the "land use", "eutrophication of water resources" and "water use" indicators that can be specifically studied. Better management of upstream forestry, production processes and their effluents could lead to a reduction in the impact not analysed here, which would require additional specific data.
    - For plastics, the indicators "use of energy resources" and "use of resources, minerals and metals" can be specifically studied. The use of recycled materials or polymerisation agents (in the case of PET catalysts, for example) that have less impact are relevant.
- The inclusion of recycled materials reduces the overall impact of raw materials (except for paper/cardboard on "climate change") (see SA n°1).
- The origin of the raw materials is important, and marketers should favour European raw materials rather than Asian ones to avoid increasing the potential environmental impact. This is true if the end market is the French or European market.

Secondly, the **Industrial and Commercial Packaging required for transport to the point of sale** contributes considerably to the potential environmental impact of packaging, particularly for packaging requiring additional protection for transport, such as flexible packaging. These components should not be neglected in the eco-design of new alternatives, as they form part of the complete packaging system to meet the defined functional unit. The environmental challenges of ICPs are the same as for the paper/cardboard raw materials mentioned above. Increasing the number of primary packaging units per pallet and reducing the mass of secondary cardboards (without any significant loss of strength) are the two main ways of reducing impact (which also means reducing the impact of **transporting packaging from the packaging site to the point of sale**).

The packaging **finishing** stage has a significant impact on indicators of climate change and resources (energy, water, minerals and metals), particularly for individual cardboard-based solutions (**blisters 1. and 2., cases 3.**). These types of packaging tend to have a larger printed surface area.

Finally, the **end-of-life** stage **for primary packaging**, particularly in relation to the recyclability issues mentioned at the beginning of the report, is not a stage that contributes most to the packaging studied. However, this stage does have a significant impact on the "climate change" and "use of energy resources" indicators for **blister packs 1. and 2. and cases 3**. On the other hand, the recyclable nature of this packaging gives it a significant benefit in terms of the "land use" indicator, as it avoids the production of virgin cardboard.

5.3 MAIN LIMITATIONS OF THE STUDY

It is important to take a step back from the results, interpretations and conclusions of this study, particularly in terms of the impact this report could have on CITEO's future CFPs, and the conclusions that packaging marketers may draw about future design choices.

The conclusions are based, among other things, on the quality and exhaustiveness of the data shared by CITEO and its clients. It is risky from a veracity and relevance point of view to apply these conclusions to other packaging that has not been evaluated in the report. However, the study has shown the main environmental issues associated with blister packaging and its alternatives, as well as the stages that contribute most. Based on these conclusions, EVEA shares in Section 5.4 eco-design recommendations applicable to the packaging studied here**. Table 3 lists the various exclusion criteria and limitations of the study.**

In addition, it is important to bear in mind that each result associated with a package is the result of a specific collection for a given product, and therefore for a particular supplier. Thus, the deductions made for a given family must be put into perspective with the number of samples representing that family. In addition, some of the packaging products identified in the Section 1.1 are prototypes. Even if their development is at an advanced stage, characterising the potential environmental impact of this type of product leads to results that are slightly less robust than those for products that are finished and on the market.

One limitation of the study, which it is important to remember, is that it compares many different types of packaging for different products (stationery, DIY, oral hygiene). Even though an approach based on secondary functions has been developed in a non-exhaustive way, the functional specifications that each package must meet depending on the [packaged product/packaging] pairing is much more complex. **One of the key messages to be retained from this study for customers and manufacturers is as follows: the CITEO CFP that will follow this LCA study will, among other things, make it possible to set up comparative LCAs on packaging that has to package the same product, making it possible to strengthen the comparisons that are made and reinforce decision-making. These LCAs for the same product will make it possible, among other things, to take account of specific packaging requirements and to separate flexible and rigid packaging.**

In addition, a modelling error (at the level of the CFF perimeter) estimated by EVEA as having a low impact on the results was mentioned in Section 4.2.1.8. It is EVEA's view that this should not affect the interpretation and conclusions. Nevertheless, for the sake of transparency, it is crucial to mention it here to invite readers to read the relevant section and to bear in mind that future studies should correct this.

Even though the various sensitivity analyses carried out as part of this study cover a large proportion of the limitations, it is worth noting that certain SAs could be used to support and refine certain interpretations. These include the following:

- Sensitivity analysis on the inclusion of transport from the consumer's home to the point of sale, which has not been included in the results of the study to date.
- Sensitivity analysis of the ICP recycling rate

- Sensitivity analysis on the inclusion of shelf space for all packaging categories (not just bulk) to consider the system.

5.4 ECODESIGN RECOMMENDATIONS (NON-EXHAUSTIVE LIST)

The purpose of this final paragraph is to set out the eco-design recommendations for the packaging systems analysed, following on from the results, interpretations and conclusions of this study. These recommendations are in the form of a non-exhaustive list. However, care must be taken not to transfer unwanted impacts when applying these recommendations.

- Optimise the shape of packaging to protect products and reduce the mass/volume ratio:
  - By reducing the weight of primary, secondary and tertiary packaging, the impact of the **raw materials**, **processing**, **transport** and **ICP** stages will be reduced, to a greater or lesser extent depending on the reduction achieved.
  - By increasing the volume contained in a pack to increase the number of products it can hold (bulk packs are a good example of optimisation at this level), while taking care to optimise the palletisation of **ICPs**, and to avoid unwanted bounce-back effects.
  - By reducing waste, particularly from paper and cardboard cutting.
- Use materials with a low environmental impact, in particular recycled materials, taking care to avoid transferring impacts.
- In the case of the French or European market, give preference to sourcing raw materials in Europe rather than in Asia whenever possible.
- Reduce print coverage and surface area.
- Designing packaging that is best suited to current recycling channels and those to come soon
  - In terms of choice of materials and product design.
- Optimising transport to the point of sale
  - Through a palletisation plan that is as optimised as possible.
  - Through a logistics scenario where transport distances are reduced.
- Communicating what to do, particularly at the end of life
  - Communicating how to sort in the household packaging waste bin, and particularly the importance of emptying household packaging before sorting, is a key step in recycling packaging, and can have a major impact when implemented clearly and precisely.
- Exploring the re-use **of ICPs**
  - Through reusable crates
  - Through reusable pallet covers (or similar elements)
  - By paying close attention to the impact of the washing and repackaging sub-steps, if any.
  - By optimising the "For How Many", the number of products in a box, and by extension, limiting the use of associated "Consumables" such as bubble wrap.
- On this comparative LCA in particular:
  - Expand the study by adding other packaging families that could have been included in the study, for example:
    - A 100% plastic blister/double shell.
    - A paper and cardboard blister pack with an internal pre-cut paper architecture to fit the shape of the product so that it can be seen and frozen.

6 CRITICAL REVIEW

The critical review report is attached below in Section 7.1

7 APPENDICES

7.1 CRITICAL REVIEW FINAL REPORT (FRENCH)

Quantis

Annexe (rapport de revue critique externe)

Déclaration de revue critique pour l'étude

ÉVALUATION COMPARATIVE DES CYCLES DE VIE

D'EMBALLAGES BLISTERS ET ALTERNATIVES

VFinale du 20/06/2025

Commanditaire : CITEO

Préparé par : Quantis International, Paris, France

Relecteur : Colin JURY (Quantis – Présidence) ; Christophe Morin (Packagile – Expert packaging) ; Gonzalo Huaroc (Pôle éco-conception – Expert ACV)

Références

- ISO 14040 (2006) : Management environnemental – Analyse du cycle de vie – Principes et cadre
- ISO 14044 (2006) : Management environnemental – Analyse du cycle de vie – Exigences et lignes directrices
- ISO/TS 14071 (2014) : Management environnemental — Analyse du cycle de vie — Processus de revue critique et compétences des réviseurs : exigences et lignes directrices supplémentaires à l'ISO 14044:2006

Portée de la revue critique

Les réviseurs ont eu pour mission d'évaluer si :

- les méthodes utilisées pour réaliser l'ACV sont conformes aux normes internationales ISO 14040 (2006) et ISO 14044 (2006),
- les méthodes utilisées sont scientifiquement et techniquement valides,
- les données utilisées sont appropriées et raisonnables par rapport à l'objectif de l'étude,
- les interprétations reflètent les limites identifiées et les objectifs de l'étude, et
- le rapport d'étude est transparent et cohérent.

L'analyse des jeux de données individuels et la revue des modèles ACV utilisés pour calculer les résultats ne faisaient pas partie du périmètre de cette revue. Il est important de noter que le comité de revue n'a eu accès qu'au rapport final ; aucun fichier de modélisation, de calcul ou de projet ACV sous logiciel n'a été fourni.

2991

Processus de revue

La revue critique peut être considérée comme une enquête « a posteriori », ayant eu lieu en phase finale de l'étude. Elle a été réalisée conformément aux normes ISO 14044 (2006) et ISO/TS 14071 (2014), entre mars et juin 2025. Le processus a débuté en mars 2025 par une réunion durant laquelle les méthodologies appliquées ainsi que les premiers résultats ont été présenté aux relecteurs. A l'issue de cette réunion, les relecteurs ont proposé des améliorations de l'étude. Ensuite, deux cycles de revue rigoureuse ont été réalisés et conclu par une dernière revue pour valider la version finale du rapport.

Lors de la première revue (Mars/Avril), le réviseur a formulé 102 commentaires (généraux, techniques, éditoriaux ou de transparence). Le praticien a intégré ces commentaires dans une nouvelle version du rapport. La deuxième revue (Mai) a examiné cette version avec un focus sur la prise en compte des commentaires initiaux et a ajouté 8 nouveaux commentaires. Après traitement, une version finale a été évaluée lors de la troisième revue (Juin), qui n'a pas apporté de nouveau commentaire. Le praticien a intégré les remarques restantes et transmis la version finale vfinale (Juin), approuvée par les réviseurs.

Cette déclaration de revue concerne le rapport daté de novembre 2022 (reçu le 09.11.2022 ; "ÉVALUATION COMPARATIVE DES CYCLES DE VIE D'EMBALLAGES BLISTERS ET ALTERNATIVES RAPPORT VFinal du 20/06/2025") et se réfère aux annexes suivantes :

- ANNEXE A : Liste de vérification de conformité aux normes ISO 14040-44 du rapport final
- ANNEXE B : Commentaires de la revue et réponses associées

Remarques générales

Cette étude vise à réaliser une ACV comparative entre différent type d'emballage de produits de papèterie, de bricolage ou de brosse à dent. Les types d'emballage visés sont des blisters PET/carton, blister inversé, étui carton, carton plus lien, cellulose moulée, flowpack souple papier opaque et transparent, flowpack souple PP transparent ainsi que du vrac en display et sans display. Les limites du système choisies sont du type « du berceau à la tombe », intégrant la majorité des étapes du cycle de vie, de l'extraction des ressources jusqu'à la gestion de fin de vie. Cela est cohérent avec les objectifs
2992 de l'étude.

Le modèle ACV n'applique pas de seuils d'exclusion ni d'allocations pour les coproduits dans le modèle de premier plan. Pour les données de fond, les allocations définies dans Ecoinvent 3.10 ont été utilisées. L'ensemble des fins de vie ont été modélisée avec la formule CFF issue du PEF. L'évaluation des impacts s'appuie sur la méthode EF 3.1. Elle inclut également une normalisation et pondération pour produire un score unique.

L'étude repose majoritairement sur des données primaires fournies par les clients de CITEO (metteurs sur le marché) ou bien les fabricants/fournisseurs d'emballages des clients de CITEO, concernant les caractéristiques des emballages étudiés pour leur composition ainsi que leur propre emballage lors des différents phases (usine de fabrication jusqu'à l'usine de conditionnement puis vers les lieux de vente. La fabrication et l'assemblage en tant que tel sont basés sur des données génériques. Les éventuelles pertes de produit emballé lors des différentes phases de distribution et le transport du lieu de vente jusque chez le client n'ont pas été incluses, ce qui représentent parmi les principales limitations de l'étude. Les étapes matières premières et fin de vie sont modélisées à partir de données

2993

secondaires de la base ecoinvent, sélectionnées pour leur adéquation avec l'objectif du projet et adaptées conformément à la CFF.

Il a été conclu que les données utilisées sont globalement adéquates et conformes à l'objectif et au périmètre de l'étude. Le panel de relecteur interpelle néanmoins le lecteur de l'étude à considérer l'erreur de modélisation sur la fin de vie lors de l'application de la CFF (Cf. chapitre 2.7). Evea juge que cette erreur ne devrait pas amener de changement significatif dans les conclusions de l'étude, ce que le panel ne peut pas valider.

L'étude intègre une évaluation de la qualité des données ainsi que des analyses de sensibilité notamment pour traiter les incertitudes associées à certaines hypothèses ou données. La robustesse des résultats est bien discutée et contextualisée pour la prise de décision. Les exclusions, choix méthodologique et hypothèses ainsi que les limitations de l'étude sont dûment reportées. Le rapport est structuré et globalement bien rédigé.

Le rapport reconnaît les principales limitations de l'étude, rappelées ci-dessous :

- Comparaison sur la base d'un volume théorique et non pas d'un volume réel associé à un produit
- Absence de prise en compte des pertes produits qui peuvent varier en fonction des emballages
- Absence de prise en compte du transport du lieu de vente chez le particulier
- Nombre d'échantillon non homogène entre les différentes catégories d'emballage et nombre d'échantillon trop petit pour certain emballage
- Erreur de modélisation lors de l'application de la CFF

Le rapport liste les études supplémentaires à réaliser pour améliorer la robustesse et la pertinence des comparaison, rappelées ci-dessous :

- Réaliser des études sur des produits spécifiques
- Réaliser des analyses de sensibilité supplémentaires (e.g., transport du lieu de vente au domicile, taux de recyclage des EIC, prise en compte des infrastructures de mise en rayon)
- Correction de la modélisation de la CFF

Le rapport fournit des éléments pour adapter les conclusions à des cas plus spécifiques et structurer une communication transparente au titre desquels :

- Liste des fonctions secondaires qui pourraient influencer les types d'emballages comparé en
2994 fonction de besoin spécifique

- Liste de l'ensemble des résultats

Conclusions :

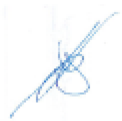
Le panel de revue critique estime que la transparence du rapport sur la méthodologie appliquée, les données utilisées et les limitations de l'étude ainsi que la précaution employée pour tirer les conclusions et les recommandations faites pour améliorer la pertinence des comparaisons sont conformes aux normes ISO 14040 et 14044.

Néanmoins, le panel de revue critique alerte fortement sur le risque de comparer des familles d'emballages de façon trop générique, c'est-à-dire sans considérer un produit ou une famille de produit en particulier. Cette approche revient à comparer des volumes emballés théoriques et non pas
2995 réels (ceci-dit le chapitre 4.2.4 permet une comparaison plus juste). En outre, cette approche ne permet pas d'estimer l'influence de la perte de produit emballé en fonction des types d'emballage, comme cela est mentionné dans l'étude.

Il est donc fortement recommandé de réitérer l'étude sur des produits plus précis de façon à tirer des conclusions plus représentatives et robustes.

Il est également recommandé de prendre la plus grande précaution au moment de la communication des résultats en rappelant les principales limitations aux comparaisons apportées dans l'étude, comme cela a été fait dans le rapport.

Enfin, le panel de revue souligne l'ouverture et la collaboration constructive de l'équipe EVEA et de CITEO pour améliorer la qualité de l'étude.

20 Juin, 2025	20 Juin, 2025	20 Juin, 2025
		
Colin JURY	Christophe Morin	Gonzalo Huaroc

2996

Quantis

Annex A: Liste de vérification de la conformité aux normes ISO 14040-44 du rapport final

Cette liste de vérification pour revue critique a été élaborée afin de garantir que les résultats de la revue critique soient conformes aux lignes directrices des normes ISO 14040-44. La compilation de cette liste a été réalisée par Colin JURY, Christophe Morin et Gonzalo Huaroc, le panel de relecteurs.

Cette liste comprend trois sections :

- Section 1 : correspond à la section 5.1 de la norme ISO 14044 et traite des exigences générales de reporting, applicables à toutes les études d'ACV.
- Section 2 : concerne des exigences supplémentaires de reporting, applicables lorsque les résultats de l'ACV doivent être communiqués à un tiers – c'est-à-dire à toute personne ou organisation intéressée autre que le commanditaire ou le praticien de l'étude.
- Section 3 : contient les exigences spécifiques applicables lorsque la communication à un tiers inclut ce que les normes ISO appellent une assertion comparative, destinée à être rendue publique. Une assertion comparative est définie (voir 3.5 de la norme ISO 14044) comme une « affirmation environnementale concernant la supériorité ou l'équivalence d'un produit par rapport à un produit concurrent remplissant la même fonction. »

SECTION 1 : Exigences générales de reporting et considérations

Les colonnes (ou les cases) situées à gauche sont cochées pour indiquer « oui » et laissées non cochées lorsque l'exigence ne semble pas avoir été respectée.

	Exigences	Commentaire	Réponse	Problème résolu (O/N)
X	Les résultats et conclusions de l'ACV sont-ils rapportés de manière complète et précise, sans biais, pour le public visé ?			
X	Les résultats, données, méthodes, hypothèses et limites sont-ils transparents et présentés avec suffisamment de détails pour permettre au lecteur de comprendre les complexités et les compromis inhérents à l'ACV ?			
X	Le rapport permet-il une utilisation des résultats et de l'interprétation en accord avec les objectifs de l'étude ?			

2997

SECTION 2 : Exigences lorsque les résultats doivent être communiqués à des tiers

Exigences	Commentaire	Réponse	Problème résolu (O/N)
a) Aspects généraux : ☒ Commanditaire de l'ACV, praticien de l'ACV (interne ou externe) ☒ Date du rapport ☒ Déclaration indiquant que l'étude a été menée conformément aux exigences de la norme ISO 14044			
b) Objectif de l'étude : ☒ Raisons de la réalisation de l'étude ☒ Applications prévues ☒ Publics cibles ☒ Déclaration précisant si l'étude vise à soutenir des assertions comparatives destinées à être rendues publiques			
c) Périmètre de l'étude : **Fonction :** ☒ Déclaration des caractéristiques de performance			

2998

Quantis

Exigences	Commentaire	Réponse	Problème résolu (O/N)
☒ Indication de toute omission de fonctions supplémentaires dans les comparaisons **Unité fonctionnelle :** ☒ Cohérence avec l'objectif et le périmètre ☒ Définition ☒ Résultat de l'évaluation des performances **Frontières du système :** ☒ Omission d'étapes du cycle de vie, de processus ou de besoins en données ☒ Quantification des intrants et extrants en énergie et en matières ☒ Hypothèses concernant la production d'électricité **Critères de coupure pour l'inclusion initiale des intrants et extrants :** ☒ Description des critères de coupure et des hypothèses associées ☒ Effet de la sélection sur les résultats ☒ Inclusion des critères de coupure relatifs à la masse, à l'énergie et à l'environnement			
d) Analyse de l'inventaire du cycle de vie : ☒ Procédures de collecte des données ☒ Description qualitative et quantitative des processus unitaires ☒ Sources bibliographiques utilisées ☒ Méthodes de calcul utilisées **Validation des données :** ☒ Évaluation de la qualité des données ☒ Traitement des données manquantes ☒ Analyse de sensibilité pour affiner les frontières du système **Principes et procédures d'allocation :** ☒ Documentation et justification des procédures d'allocation ☒ Application uniforme des procédures d'allocation			

2999

e) Évaluation des impacts du cycle de vie (LCIA) : ☒ Procédures LCIA, calculs et résultats de l'étude ☒ Limitations des résultats LCIA par rapport à l'objectif et au périmètre définis de l'ACV ☒ Lien entre les résultats LCIA et l'objectif/périmètre définis (voir clause 4.2 de la norme 14044) ☒ Lien entre les résultats LCIA et les résultats de l'inventaire (voir clause 4.4 de la norme 14044) ☒ Catégories d'impact et indicateurs considérés, avec justification du choix et source de référence ☒ Description ou référence à tous les modèles de caractérisation, facteurs de caractérisation et méthodes utilisés, y compris toutes les hypothèses et limitations ☒ Description ou référence à tous les choix de valeurs utilisés pour les catégories d'impact, les modèles et facteurs de caractérisation, la normalisation, le regroupement, la pondération, etc., ainsi qu'une justification de leur utilisation et de leur influence sur les résultats, les conclusions et les recommandations ☒ Déclaration précisant que les résultats de la LCIA sont des expressions relatives et ne prédisent pas les impacts sur les points finaux, le dépassement de seuils, les marges de sécurité ou les risques			

3000

Exigences	Commentaire	Réponse	Problème résolu (O/N)
De nouvelles catégories d'impact, indicateurs ou modèles de caractérisation ont-ils été utilisés dans la LCIA ? ☒ NON (Passer à la section f) Interprétation du cycle de vie) ☐ OUI (SI OUI, compléter les points suivants) ☐ Description et justification de la définition et de la description de toute nouvelle catégorie d'impact, indicateur ou modèle de caractérisation utilisé dans la LCIA ☐ Déclaration et justification de tout regroupement des catégories d'impact ☐ Autres procédures de transformation des résultats d'indicateurs et justification des références, facteurs de pondération, etc. ☐ Toute analyse des résultats d'indicateurs, par exemple analyse de sensibilité ou d'incertitude, ou l'utilisation de données environnementales, y compris toute implication sur les résultats ☐ Les données et résultats d'indicateurs obtenus avant toute normalisation, regroupement ou pondération doivent être rendus disponibles avec les résultats normalisés, regroupés ou pondérés			
f) Interprétation du cycle de vie : ☒ Résultats ☒ Hypothèses et limitations associées à l'interprétation des résultats, tant sur le plan méthodologique que sur les données ☒ Évaluation de la qualité des données ☒ Transparence complète sur les choix de valeurs, justifications et jugements d'experts			
g) Revue critique : ☒ Nom et affiliation des réviseurs ☒ Rapport de revue critique ☒ Réponses aux commentaires/recommandations			

SECTION 3 : Exigences pour les Assertions Comparatives destinées à être rendues publiques

Exigences		Commentaire	Réponse	Problème résolu (O/N)
X	Évaluation de la précision, de l'exhaustivité et de la représentativité des données utilisées			
X	Description de l'équivalence des systèmes comparés conformément à la section 4.2.3.6 de la norme ISO 14044			
X	Description du processus de revue critique			
X	Évaluation de l'exhaustivité de l'évaluation des impacts du cycle de vie (LCIA)			
X	Déclaration sur l'existence ou non d'une reconnaissance internationale des indicateurs de catégorie sélectionnés et justification de leur utilisation			
X	Justification de la validité scientifique et technique, ainsi que de la pertinence environnementale des indicateurs de catégorie utilisés dans l'étude			
X	Résultats des analyses d'incertitude et de sensibilité			
X	Évaluation de la signification des différences observées			
X	Évaluation de la précision, de l'exhaustivité et de la représentativité des données utilisées			
	Le regroupement est-il inclus dans l'ACV ?			

	Exigences	Commentaire	Réponse	Problème résolu (O/N)
	☐ NON (La liste de vérification est complète) ☒ OUI (SI OUI, compléter les éléments ci-dessous) ☒ Procédure et résultats utilisés pour le regroupement ☐ Déclaration selon laquelle les conclusions et recommandations issues du regroupement reposent sur des choix de valeurs ☐ Justification des critères de coupure utilisés pour la normalisation et le regroupement (ceux-ci peuvent être des choix de valeur personnels, organisationnels ou nationaux) ☐ Déclaration selon laquelle "la norme ISO 14044 ne spécifie aucune méthodologie particulière ni ne soutient les choix de valeurs sous-jacents utilisés pour regrouper les catégories d'impact" ☐ Déclaration selon laquelle "les choix de valeurs et jugements dans les procédures de regroupement relèvent exclusivement de la responsabilité du commanditaire de l'étude (par exemple, gouvernement, collectivité, organisation, etc.)"			

Annex B : Commentaires du panel et réponses

Les commentaires ne peuvent pas être annexés au rapport de revue pour des raisons de mise en page. Ils sont disponibles sur demande auprès du commanditaire de l'étude.

7.2 SUPPLEMENTS TO THE LIFE CYCLE INVENTORY: MATERIALS, MANUFACTURING PROCESSES AND SPECIFIC FINISHES

7.2.1 AMORPHOUS POLYETHYLENE TEEPRHTHALATE WITH RECYCLED CONTENT

Recycled aPET (**Polyethylene terephthalate amorphous recycled 50% {RER}| market | EVEA CFF - v3.10**) does not exist as a process in the CFF formula. Consequently, a new data item has been created based on "*Polyethylene terephthalate, granulate, amorphous {RER}| polyethylene terephthalate production, granulate, amorphous* | *Cut-off, S*" and the CFF method.

Table 27 below presents the inventory data for X% recycled aPET {RER}. Only material inputs from the technosphere are presented here. Other inputs from nature and the technosphere, and outputs from the technosphere, as well as emissions, are not presented here due to lack of data.

Material created by EVEA	
Polyethylene terephthalate amorphous recycled X% {RER}| market | EVEA CFF - v3.10	
Inputs	**Quantity (kg)**
Polyethylene terephthalate, granulate, amorphous {RER}| polyethylene terephthalate production, granulate, amorphous | Cut-off, S [2]	(1-R1) +(R1*(1-A) *QSin/Qp)
Polyethylene terephthalate, granulate, amorphous, recycled {Europe without Switzerland}| polyethylene terephthalate production, granulate, amorphous, recycled | Cut-off, S [1]	R1*A
Transport, freight train {GLO}| market group for transport, freight train | Cut-off, S	0.2887*[(1-R1)+(R1*(1-A) *QSin/Qp)] (tkm)
Transport, freight, sea, container ship {GLO}| market for transport, freight, sea, container ship | Cut-off, S	0.5248*[(1-R1)+(R1*(1-A) *QSin/Qp)] (tkm)
Transport, freight, lorry, unspecified {GLO}| market group for transport, freight, lorry, unspecified | Cut-off, S	0.4504*[(1-R1)+(R1*(1-A) *QSin/Qp)] (tkm)

Transport, freight train {Europe without Switzerland}| market for transport, freight train | Cut-off, U	0.30672*R1*A (tkm)
Transport, freight, lorry, unspecified {RER}| market for transport, freight, lorry, unspecified | Cut-off, U	0.47231*R1*A (tkm)

Table 27 LCI for Polyethylene terephthalate amorphous recycled X% {RER}| market | EVEA CFF - v3.10- 1 kg

Assumption:
[1] Recycled material
[2] Virgin material

Parameters: R1 = X which varies according to the percentage of recycled raw material, A = 0.5; Qsin/Qp = 0.9 (extract from European Commission parameters, *Appendix C*).

7.2.2 CORRUGATED CARDBOARD WITH % RECYCLED CONTENT {RER}

7.2.2.1 Corrugated cardboard box {RER}| Production via recycling | Cut-Off, U

Recycling production of corrugated board boxes does not exist in the ecoinvent database. Consequently, a new data item has been created on the "**Corrugated board box {RER}| production | Cut-off, U"** database.

A corrugated box is made up of two sheets of linerboard and a piece of fluting, which are glued together to form the corrugated box.

For the corrugated section:
- The equivalent blank process available is "*Containerboard, fluting medium {RER}| cardboard production, fluting medium, **semi-chemical".***
- The recycled equivalent process available is "*Containerboard, fluting medium {RER}| cardboard production, fluting medium, **recycled**".*

For the cardboard sections:
- The equivalent blank process available is "*Containerboard, linerboard {RER}| cointainerboard, linerboard, **kraftliner**".*
- The recycling process available is "*Containerboard, linerboard {RER}| containerboard production, linerboard, **testliner***".

Therefore, to model a corrugated box with a customised percentage of recycled content, one can model a virgin corrugated box or one with recycled content by adjusting the percentage of each sub-process listed above.

The data item *"Containerboard, fluting medium {RER}| market for containerboard, fluting medium| Cut-off, U"* is replaced by *"Containerboard, fluting medium {RER}| containerboard production, fluting medium, **recycled** | Cut-off, U"* and the data item *"Containerboard, linerboard {RER}| market containerboard, linerboard| Cut-off, U"* by *"Containerboard, linerboard {RER}| containerboard production, linerboard, **testliner** | Cut-off, U".*

Table 28 below presents the inventory data to produce **recycled {RER}| corrugated board**. Only inputs and outputs from the technosphere are presented here, other inputs from nature and emissions remain unchanged. **In bold**, the changes made by EVEA to the ecoinvent process.

Material created by EVEA	
Corrugated cardboard box {RER}| Recycling production | Cut-off, U - 1 kg	
Inputs	**Quantity (kg)**
Acrylic varnish, without water, in 87.5% solution state {RER}| market for acrylic varnish, without water, in 87.5% solution state | Cut-off, U	4,80E-04
Borax, anhydrous, powder {GLO}| market for | Cut-off, U	8,90E-04
Diesel, low sulphur {RER}| market group for | Cut-off, U	1,96E-04
Electricity, medium voltage {RER}| market group for | Cut-off, U	7.05E-02(kWh)
Ethylene vinyl acetate copolymer {RER}| market for ethylene vinyl acetate copolymer | Cut-off, U	3,57E-04
Containerboard, fluting medium {RER}| containerboard production, fluting medium, recycled | Cut-off, U	**4,86E-01**
Heavy fuel oil {RER}| market group for | Cut-off, U	4,93E-04
Light fuel oil {RER}| market group for | Cut-off, U	6,09E-04
Containerboard, linerboard {RER}| containerboard production, linerboard, testliner | Cut-off, U	**6,19E-01**
Liquefied petroleum gas {CH}| market for | Cut-off, U	5,65E-04
Maize starch {GLO}| market for | Cut-off, U	1,64E-02
Natural gas, low pressure {CH}| market for | Cut-off, U	1.96E-02(m3)
Packaging box factory {RER}| construction | Cut-off, U	5.44E-11(p)
Printing ink, offset, without solvent, in 47.5% solution state {RER}| market for printing ink, offset, without solvent, in 47.5% solution state | Cut-off, U	9,10E-04
Tap water {RER}| market group for | Cut-off, U	2,36E-01
Waste paperboard, sorted {GLO}| waste paperboard, sorted, Recycled Content cut-off | Cut-off, U	-1,00E-01
Wood chips, dry, measured as dry mass {RER}| market for | Cut-off, U	6,66E-04
Outputs	**Quantity (kg)**
Sludge from pulp and paper production {CH}| market for sludge from pulp and paper production | Cut-off, U	3,51E-07
Sludge from pulp and paper production {Europe without Switzerland} | market for sludge from pulp and paper production | Cut-off, U	4,75E-04
Waste mineral oil {CH}| market for waste mineral oil | Cut-off, U	6,13E-07
Waste mineral oil {Europe without Switzerland} | market for waste mineral oil | Cut-off, U	2,65E-05
Waste paint {CH}| market for waste paint | Cut-off, U	1,07E-06
Waste paint {Europe without Switzerland} | market for waste paint | Cut-off, U	4,58E-04

Table 28 Data inventory for corrugated box {RER}| Recycling production | Cut-Off, U

7.2.2.2 Corrugated cardboard box {RER}| Virgin production | Cut-off, U

The production of virgin corrugated boxes does not exist in the ecoinvent database. Consequently, a new data item has been created based on the "**Corrugated box {RER}| production | Cut-off, U**" database.

A corrugated box is made up of two liner boards and a piece of fluting, which are glued together to form the corrugated box.

For the fluted part:

- The equivalent blank process available is "*Containerboard, fluting medium {RER}| production of cardboard, fluting medium, **semi-chemical**".*
- The recycled equivalent process available is "*Containerboard, fluting medium {RER}| production of cardboard, fluting medium, **recycled**".*

For the cardboard sections:

- The equivalent blank process available is "*Containerboard, linerboard {RER}| production of containerboard, linerboard, **kraftliner**".*
- The recycling process available is "*Containerboard, linerboard {RER}| containerboard production, linerboard, **testliner***".

For example, to model a corrugated box with a customised percentage of recycled content, a virgin corrugated box or one with recycled content can be modelled by adjusting the percentage of each sub-process listed above.

The data item "*Containerboard, fluting medium {RER}| market for containerboard, fluting medium| Cut-off, U"* is replaced by "*Containerboard, fluting medium {RER}| containerboard production, fluting medium, **semichemical** | Cut-off, S"* and the data item "*Containerboard, linerboard {RER}| market containerboard, linerboard| Cut-off, U"* by "*Containerboard, linerboard {RER}| containerboard production, linerboard, kraftliner | Cut-off, S".*

Table 29 below presents the inventory data for the **virgin production of corrugated boxes {RER}**. Only inputs and outputs from the technosphere are presented here, other inputs from nature and emissions remain unchanged. **In bold**, the changes made by EVEA to the ecoinvent process.

Material created by EVEA	
Corrugated box {RER}| Virgin production | Cut-off, U - 1 kg	
Inputs	Quantity (kg)
Acrylic varnish, without water, in 87.5% solution state {RER}| market for acrylic varnish, without water, in 87.5% solution state | Cut-off, U	4,80E-04
Borax, anhydrous, powder {GLO}| market for | Cut-off, U	8,90E-04
Diesel, low sulphur {RER}| market group for | Cut-off, U	1,96E-04
Electricity, medium voltage {RER}| market group for | Cut-off, U	7.05E-02(kWh)
Ethylene vinyl acetate copolymer {RER}| market for ethylene vinyl acetate copolymer | Cut-off, U	3,57E-04
Containerboard, fluting medium {RER}| containerboard production, fluting medium, semichemical | Cut-off, S	**4,86E-01**
Heavy fuel oil {RER}| market group for | Cut-off, U	4,93E-04
Light fuel oil {RER}| market group for | Cut-off, U	6,09E-04
Containerboard, linerboard {RER}| containerboard production, linerboard, kraftliner | Cut-off, S	**6,19E-01**
Liquefied petroleum gas {CH}| market for | Cut-off, U	5,65E-04
Maize starch {GLO}| market for | Cut-off, U	1,64E-02

Natural gas, low pressure {CH}| market for | Cut-off, U	1.96E-02(m3)
Packaging box factory {RER}| construction | Cut-off, U	5.44E-11(p)
Printing ink, offset, without solvent, in 47.5% solution state {RER}| market for printing ink, offset, without solvent, in 47.5% solution state | Cut-off, U	9,10E-04
Tap water {RER}| market group for | Cut-off, U	2,36E-01
Waste paperboard, sorted {GLO}| waste paperboard, sorted, Recycled Content cut-off | Cut-off, U	-1,00E-01
Wood chips, dry, measured as dry mass {RER}| market for | Cut-off, U	6,66E-04
Outputs	**Quantity (kg)**
Sludge from pulp and paper production {CH}| market for sludge from pulp and paper production | Cut-off, U	3,51E-07
Sludge from pulp and paper production {Europe without Switzerland} | market for sludge from pulp and paper production | Cut-off, U	4,75E-04
Waste mineral oil {CH}| market for waste mineral oil | Cut-off, U	6,13E-07
Waste mineral oil {Europe without Switzerland} | market for waste mineral oil | Cut-off, U	2,65E-05
Waste paint {CH}| market for waste paint | Cut-off, U	1,07E-06
Waste paint {Europe without Switzerland} | market for waste paint | Cut-off, U	4,58E-04

Table 29 Data inventory for corrugated box {RER}| Virgin production | Cut-Off, U

7.2.2.3 Corrugated board with a percentage of recycled content {RER}

With the production data for virgin and recycled corrugated board now created, it is possible to apply the CFF to obtain **Corrugated cardboard recycled 0% {RER}| market | EVEA CFF - v3.10** and **Corrugated cardboard recycled 50% {RER}| market | EVEA CFF - v3.10,** used in the LCI of primary packaging and ICPs.

TheTable 30 below shows the inventory data for **Corrugated cardboard recycled R1= [X] % EVEA CFF** with R1 the percentage of recycled material contained in the cardboard.

s

Material created by EVEA	
CARDBOARD WITH [X]% RECYCLED {RER} - 1kg	
Inputs	**Quantity (kg)**
Corrugated box {RER}| Blank production | Cut-Off, U [2]	(1-R1) +(R1*(1-A) *QSin/Qp)
Corrugated cardboard box {RER}| Recycling production | Cut-Off, U [1]	R1*A
Transport, freight train {RER}| market group for transport, freight train | Cut-off, S	0.026 *((1-R1) + R1*(1-A)*Qsin/Qp) (tkm)
Transport, freight, inland waterways, barge {RER}| market for transport, freight, inland waterways, barge | Cut-off, S	0.0025 *((1-R1) + R1*(1-A)*Qsin/Qp) (tkm)
Transport, freight, lorry, unspecified {RER}| market for transport, freight, lorry, unspecified | Cut-off, S	0.19 *((1-R1) + R1*(1-A)*Qsin/Qp) (tkm)

Table 30 LCI for Corrugated cardboard recycled R1= [X]% EVEA CFF - 1 kg

NB: For this material, the data equivalent in market to the recycled material incorporated in the ecoinvente database does not contain any transport (simple mixture of production data to model the market data). As a result, no transport has been associated with this recycled material.

Assumption:

[1] Recycled material
[2] Virgin material

Parameters: R1 = X, which varies according to the percentage of recycled raw material, A = 0.2; Qsin/Qp = 0.85 (extract from European Commission parameters, *Appendix C*).

7.2.3 FLAT CARDBOARD WITH RECYCLED CONTENT

Flat **cardboard recycled 50% {RER}| market | EVEA CFF - v3.10**) does not exist as a process in the CFF formula. Consequently, a new data item has been created based on "*Solid bleached and unbleached board carton {RER}| solid bleached and unbleached board carton production | Cut-off, S*" and the CFF method.

The Table 31 below presents the inventory data for X% recycled cardboard {RER}. Only material inputs from the technosphere are presented here. Other inputs from nature and the technosphere, and outputs from the technosphere, as well as emissions, are not presented here due to lack of data.

Material created by EVEA	
Flat cardboard recycled X% {RER}| market | EVEA CFF - v3.10	
Inputs	**Quantity (kg)**
Solid bleached and unbleached board carton {RER}| solid bleached and unbleached board carton production | Cut-off, S [2]	(1-R1) +(R1*(1-A) *QSin/Qp)
White lined chipboard carton {RER}| white lined chipboard carton production | Cut-off, S [1]	R1*A
Transport, freight train {RER}| market group for transport, freight train | Cut-off, S	0,025*((1-R1)+R1*(1-A)*Qsin/Qp) (tkm)
Transport, freight, inland waterways, barge {RER}| market for transport, freight, inland waterways, barge | Cut-off, S	0,0018*((1-R1)+R1*(1-A)*Qsin/Qp) (tkm)
Transport, freight, lorry, unspecified {RER}| market for transport, freight, lorry, unspecified | Cut-off, S	0,19*((1-R1)+R1*(1-A)*Qsin/Qp) (tkm)
Transport, freight train {RER}| market group for transport, freight train | Cut-off, U	0.025*R1*A (tkm)
Transport, freight, inland waterways, barge {RER}| market for transport, freight, inland waterways, barge | Cut-off, U	0.0018*R1*A (tkm)
Transport, freight, lorry, unspecified {RER}| market for transport, freight, lorry, unspecified | Cut-off, U	0.19*R1*A (tkm)

Table 31 LCI for Flat cardboard recycled X% {RER}| market | EVEA CFF - v3.10 - 1 kg

Assumption:
[1] Recycled material
[2] Virgin material

Parameters: R1 = X, which varies according to the percentage of recycled raw material, A = 0.2; Qsin/Qp = 0.85 (extract from European Commission parameters, *Appendix C*).

7.2.4 VIRGIN MOULDED CELLULOSE WITH RECYCLED CONTENT

Virgin or recycled moulded cellulose (**Cellulose R1=0% EVEA or Cellulose R1=50% EVEA**) does not exist as a process with the CFF formula. Consequently, a new data item has been created based on "*Sulfate pulp, unbleached {RER}| market for sulfate pulp, unbleached | Cut-off, S*" and the CFF method.

For 5.1 packaging, data on virgin and recycled raw materials was required. CITEO's customer, who uses this type of material, was able to provide us with:

- incoming raw materials per 1 kg,
- electricity consumption for 1 kg of moulded cellulose,
- water consumption for 1 kg of moulded cellulose,
- production waste for 1 kg of moulded cellulose *(R)*

Table 32 below presents the inventory data for X% recycled paper {RER}. Only material inputs from the technosphere are presented here. Other inputs from nature and the technosphere, and outputs from the technosphere, as well as emissions, are not presented here due to lack of data.

Material created by EVEA	
Cellulose R1=X% EVEA	
Inputs	**Quantity (kg)**
Sulfate pulp, unbleached {RER}| market for sulfate pulp, unbleached | Cut-off, S	(1-R1) +(R1*(1-A) *QSin/Qp)
Graphic paper, 100% recycled {RER}| graphic paper production, 100% recycled Corrected | Cut-off, S [5]	R1*A
Tap water {RER}| market group for tap water | Cut-off, S	2,5
Electricity, medium voltage {FR}| electricity voltage transformation, residual mix, from high to medium voltage | Cut-off, S	5/(1-fall_rate) (kWh)
Transport, freight train {RER}| market group for transport, freight train | Cut-off, S [4]	0.026* R1*A
Transport, freight, inland waterways, barge {RER}| market for transport, freight, inland waterways, barge | Cut-off, S [4]	0.0025* R1*A
Transport, freight, lorry, unspecified {RER}| market for transport, freight, lorry, unspecified | Cut-off, S [4]	0.19* R1*A

Table 32 LCI for Cellulose R1=X% EVEA - 1 kg

Assumption:

[1] Recycled material
[2] Virgin material
[3] File modified by EVEA following the identification of a confusion between m3 and L by EVEA, then confirmed by Ecoinvent.
[4] The transport of "Graphic paper,100% recycled {RER}| graphic paper production, 100% recycled Corrigé | Cut-off, S" is approximated by that of "Kraft paper recycled 100% {RER}| market | EVEA CFF - v3.10". The detailed calculation in the second column takes account of the mass transported (cross product).

Parameters: R1 = X which varies as a function of the percentage of recycled raw material, scrap_rate=1%, A = 0.2; Qsin/Qp = 0.85 (extract from European Commission parameters, *Appendix C*).

7.2.5 LOW DENSITY POLYETHYLENE WITH RECYCLED CONTENT

The mechanical recycled LDPE data on ecoinvent does not provide a specific percentage of recycled content and does not follow the CFF. Specific data has been created to meet this need.

The LCI of a LDPE material with X% recycled content is explained in Table 33

Material created by EVEA
LDPE POLYETHYLENE LOW DENSITY RECYCLED R1=50% {RER} - EVEA CFF - 1 KG

Inputs	Quantity (kg)
Polyethylene, low density, granulate {RER}| polyethylene production, low density, granulate | Cut-off, S [2]	(1-R1) +(R1*(1-A) *QSin/Qp) = 0.5+0.188 = 0.688
Polyethylene, low density, granulate {RER}| polyethylene production, low density, granulate | Cut-off, S [1]	R1*A = 0.25
Transport, freight train {GLO}| market group for transport, freight train | Cut-off, S	0.2887*[(1-R1)+(R1*(1-A) *QSin/Qp)] (tkm)
Transport, freight, sea, container ship {GLO}| market for transport, freight, sea, container ship | Cut-off, S	0.5248*[(1-R1)+(R1*(1-A) *QSin/Qp)] (tkm)
Transport, freight, lorry, unspecified {GLO}| market group for transport, freight, lorry, unspecified | Cut-off, S	0.4504*[(1-R1)+(R1*(1-A) *QSin/Qp)] (tkm)
Transport, freight train {Europe without Switzerland}| market for transport, freight train | Cut-off, U	0.30672*R1*A (tkm)
Transport, freight, lorry, unspecified {RER}| market for transport, freight, lorry, unspecified | Cut-off, U	0.47231*R1*A (tkm)

Table 33 LCI for Polyethylene low density recycled X% {RER}| market | EVEA CFF - v3.10 - 1 kg

Assumption:

[1] Recycled material
[2] Virgin material

Parameters: R1 = 0.50; A = 0.5; Qsin/Qp = 0.75 (extract from EUROPEAN COMMISSION parameters, appendix C).

7.2.6 PAPER WITH RECYCLED CONTENT

Recycled paper (**Kraft paper recycled 50% {RER}| market | EVEA CFF - v3.10**) does not exist as a process in the CFF formula. Consequently, a new data item has been created based on "*Kraft paper {RER}| kraft paper production | Cut-off, S*" and the CFF method.

Table 34 below presents the inventory data for X% recycled paper {RER}. Only material inputs from the technosphere are presented here. Other inputs from nature and the technosphere, and outputs from the technosphere, as well as emissions, are not presented here due to lack of data.

Material created by EVEA	
Kraft paper recycled X% {RER}| market | EVEA CFF - v3.10	
Inputs	**Quantity (kg)**
Kraft paper {RER}| kraft paper production | Cut-off, S [6]	(1-R1) +(R1*(1-A) *QSin/Qp)
Graphic paper, 100% recycled {RER}| graphic paper production, 100% recycled Corrected | Cut-off, S [5]	R1*A
Transport, freight train {RER}| market group for transport, freight train | Cut-off, S	0.025702908*((1-R1) + R1*(1-A)*Qsin/Qp) (tkm)
Transport, freight, inland waterways, barge {RER}| market for transport, freight, inland waterways, barge | Cut-off, S	0.002513537*((1-R1) + R1*(1-A)*Qsin/Qp) (tkm)
Transport, freight, lorry, unspecified {RER}| market for transport, freight, lorry, unspecified | Cut-off, S	0.187760335*((1-R1) + R1*(1-A)*Qsin/Qp) (tkm)

Table 34 LCI for Kraft paper recycled X% RER}| market | EVEA CFF - v3.10 - 1 kg

NB: For this material, there is no equivalent market data to the recycled material included in the ecoinvente database. As a result, no transport has been associated with this material.

Assumption:

[5] Recycled material
[6] Virgin material

Parameters: R1 = X, which varies according to the percentage of recycled raw material, A = 0.2; Qsin/Qp = 0.85 (extract from European Commission parameters, *Appendix C*).

7.2.7 POLYPROPYLENE WITH RECYCLED CONTENT

Recycled PP (**Polypropylene recycled 50% {RER}| market | EVEA CFF - v3.10**) does not exist as a process in the CFF formula. Consequently, a new data item has been created based on "*Polypropylene, granulate {RER}| polypropylene production, granulate | Cut-off, S*" and the CFF method.

TheTable 35 below presents the inventory data for X% recycled PP {RER}. Only material inputs from the technosphere are presented here. Other inputs from nature and the technosphere, and outputs from the technosphere, as well as emissions, are not presented here due to lack of data.

Material created by EVEA	
Polypropylene recycled X% {RER}| market | EVEA CFF - v3.10	
Inputs	**Quantity (kg)**
Polypropylene, granulate {RER}| polypropylene production, granulate | Cut-off, S [2]	(1-R1) +(R1*(1-A) *QSin/Qp)
Polyethylene, high density, granulate, recycled {Europe without Switzerland}| polyethylene production, high density, granulate, recycled | Cut-off, S [1]	R1*A
Transport, freight train {GLO}| market group for transport, freight train | Cut-off, S	0.2887*[(1-R1)+(R1*(1-A) *QSin/Qp)] (tkm)
Transport, freight, sea, container ship {GLO}| market for transport, freight, sea, container ship | Cut-off, S	0.5248*[(1-R1)+(R1*(1-A) *QSin/Qp)] (tkm)
Transport, freight, lorry, unspecified {GLO}| market group for transport, freight, lorry, unspecified | Cut-off, S	0.4504*[(1-R1)+(R1*(1-A) *QSin/Qp)] (tkm)
Transport, freight train {Europe without Switzerland}| market for transport, freight train | Cut-off, U	0.30672*R1*A (tkm)
Transport, freight, lorry, unspecified {RER}| market for transport, freight, lorry, unspecified | Cut-off, U	0.47231*R1*A (tkm)

Table 35 LCI for recycled polypropylene X% {RER}| market | EVEA CFF - v3.10- 1 kg

Assumption:

[1] Recycled material
[2] Virgin material

Parameters: R1 = X which varies according to the percentage of recycled raw material, A = 0.5; Qsin/Qp = 0.9 (extract from European Commission parameters, *Appendix C*).

7.2.8 FLOWPACKAGE

None of CITEO's customers was able to provide us with an inventory of the flowpacking process (**Flowpackage {RER} EVEA**) for plastic/paper bags. We therefore relied on power consumption data for a FLOWPACK FPFM 400 automatic packaging machine.[xxi]

The inputs to this process are shown in Table 36. The packaging machine seals the bags on both sides and a generic scrap rate of 2% is applied.

Process created by EVEA	
Flowpackage {RER} EVEA	
Inputs	**Quantity (kWh)**
Electricity, medium voltage {FR}| electricity voltage transformation, residual mix, from high to medium voltage | Cut-off, S	2,3

Table 36 LCI for Flowpackage {RER} EVEA - 6000 pieces

7.2.9 LAMINATION

The lamination process without binder (**Lamination {RER} (without binder) EVEA**) does not exist in ecoinvent. As the binder is known specifically in this study, we only want to apply the lamination process alone without binder. The ecoinvent sheet "*Laminating service, foil, with acrylic binder {RER}| laminating service, foil, with acrylic binder | Cut-off, S*" has therefore been adapted to remove the binder used "*Acrylic binder, with water, in 54% solution state {RER}| market for acrylic binder, with water, in 54% solution state | Cut-off, S*". This modification is presented inTable 37 .

Process created by EVEA	
Lamination {RER} (without binder) EVEA	
Inputs	**Quantity**
Laminating service, foil, with acrylic binder {RER}| laminating service, foil, with acrylic binder | Cut-off, S	1 (m^2)
Acrylic binder, with water, in 54% solution state {RER}| market for acrylic binder, with water, in 54% solution state | Cut-off, S	-0.0014 (kg)

Table 37 LCI for Lamination {RER} (without binder) EVEA - 1 m²

7.2.10 OFFSET PRINT

Data relating to offset printing (**RER EVEA Offset Printing**) are not present in the ecoinvent database. However, there is data for offset printed paper (*Printed paper, offset {CH}| offset printing, per kg printed paper | Cut-off, S*). We have therefore modified the inventory of data relating to offset printed paper in order to remove the paper and retain only the inventory associated with the ink and the offset printing process. Electricity has also been adapted to suit the geography of Europe.

7.2.11 FLOXOGRAPHY PRINTING

The flexographic printing process is based on an Ecoemballage document. An EVEA dataset was then constructed from the elements of this report[xxii].

Process created by EVEA (sourced from ecoemballage)	
Flexographic printing {GLO} (source écoemballages) EVEA	
Inputs	**Quantity**
Printing ink, rotogravure, without solvent, in 55% toluene solution state {RoW}| market for printing ink, rotogravure, without solvent, in 55% toluene solution state | Cut-off, S	2,9 (g)
solvent mix for flexographic inks {GLO}	3,6 (g)

Electricity, low voltage {GLO}| market group for electricity, low voltage | Cut-off, S	24 (Wh)
Heat, district or industrial, natural gas {GLO}| market group for heat, district or industrial, natural gas | Cut-off, S	43 (Wh)
Tap water {GLO}| market group for tap water | Cut-off, S	0.002 (kg)

Table 38 Flexographic printing {GLO} (source ecoemballages) - 1m²

7.2.12 ELECTRICITY, MEDIUM VOLTAGE {EN}| MARKET FOR ELECTRICITY, MEDIUM VOLTAGE - 2030 SCENARIO - EVEA

The data item "Electricity, high voltage {FR}| market for | cut off, U" is present by default in ecoinvent, but it does not consider forecasts for the French electricity mix in 2030.

Ecoinvent energy mix	
Electricity, high voltage {FR}| market for | cut off, U - 1 KWH	
Inputs	**Quantity (kWh)**
Electricity, high voltage {FR}| electricity production, deep geothermal | Cut-off, U	2,23E-04
Electricity, high voltage {FR}| electricity production, hard coal | Cut-off, U	6,44E-03
Electricity, high voltage {FR}| electricity production, hydro, reservoir, alpine region | Cut-off, U	6,34E-05
Electricity, high voltage {FR}| electricity production, hydro, run-of-river | Cut-off, U	3,33E-04
Electricity, high voltage {FR}| electricity production, natural gas, combined cycle power plant | Cut-off, U	6,95E-02
Electricity, high voltage {FR}| electricity production, natural gas, conventional power plant | Cut-off, U	1,34E-02
Electricity, high voltage {FR}| electricity production, nuclear, pressure water reactor | Cut-off, U	7,30E-01
Electricity, high voltage {FR}| electricity production, oil | Cut-off, U	5,68E-03
Electricity, high voltage {FR}| electricity production, wind, <1MW turbine, onshore | Cut-off, U	7,73E-04
Electricity, high voltage {FR}| electricity production, wind, >3MW turbine, onshore | Cut-off, U	4,97E-05
Electricity, high voltage {FR}| electricity production, wind, 1-3MW turbine, offshore | Cut-off, U	7,33E-06
Electricity, high voltage {FR}| electricity production, wind, 1-3MW turbine, onshore | Cut-off, U	1,20E-02
Electricity, high voltage {FR}| electricity, high voltage, residual mix | Cut-off, U	3,11E-02
Electricity, high voltage {FR}| heat and power co-generation, biogas, gas engine | Cut-off, U	2,68E-03
Electricity, high voltage {FR}| heat and power co-generation, natural gas, conventional power plant, 100MW electrical | Cut-off, U	3,26E-02
Electricity, high voltage {FR}| heat and power co-generation, oil | Cut-off, U	7,64E-05
Electricity, high voltage {FR}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | Cut-off, U	7,66E-03
Electricity, high voltage {RER}| electricity, high voltage, European attribute mix | Cut-off, U	1,17E-01
Electricity, high voltage {RoW}| heat and power co-generation, hard coal | Cut-off, U	1,15E-03

Table 39 LCI for Electricity, high voltage {FR}| market for | cut off, U - 1 KWH

RTE France, in its report entitled Bilan prévisionnel long terme "Futurs énergétiques 2050"[xxiii] , foresees a change in the French electricity mix, with the following breakdown:

Production sectors	Share of production by 2030
Nuclear	60%
Fossil fuel thermal power	3%
Hydraulics	11%
Wind	15%
Solar	11%

For all the end-of-life scenarios, linked to incineration and energy recovery, the 2030 French electricity mix scenario was used.
As a result, for the 2030 scenario, the *"Electricity, medium voltage {FR}| market for electricity, medium voltage | Cut-off, U"* data has been adapted to the 2030 breakdown presented in the previous table. This data depends on two other ecoinvent sub-data *"Electricity, high voltage {FR}| market for | cut-off, U" and "Electricity, medium voltage {FR}| electricity voltage transformation from high to medium voltage | Cut-off, U", which have* also been adapted to take account of a 2030 scenario.

7.3 OTHER CHARTS

7.4 RESULTS TABLES

Category of damage	Unit	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	2.6	3.1	3.2	3.3	3.4	3.5	4.1	5.1	6.1	7.1	8.1	8.2	8.3	8.4	9.1	9.2	10.1
Total Single Score	nPt	4,1E+01	5,2E+01	9,2E+01	6,3E+01	3,6E+01	3,0E+01	4,2E+01	2,8E+01	1,4E+01	1,4E+01	1,9E+01	1,4E+01	1,3E+01	2,0E+01	3,5E+01	3,1E+01	6,1E+01	2,7E+01	9,5E+00	1,2E+01	7,1E+00	1,7E+01	6,9E+00	1,6E+01	8,0E+00	4,8E+00	1,0E+01
Climate change	nPt	1,2E+01	1,5E+01	2,8E+01	1,9E+01	1,1E+01	8,4E+00	1,2E+01	7,9E+00	4,0E+00	4,1E+00	5,5E+00	4,1E+00	3,7E+00	5,6E+00	1,0E+01	8,8E+00	1,9E+01	6,8E+00	2,7E+00	3,3E+00	2,1E+00	4,9E+00	2,0E+00	4,5E+00	2,3E+00	1,4E+00	2,9E+00
Ozone depletion	nPt	7,4E-01	7,6E-01	1,5E+00	1,2E+00	7,8E-01	9,7E-03	1,4E-02	9,4E-03	4,6E-03	4,9E-03	6,8E-03	4,9E-03	4,4E-03	7,0E-03	1,3E-02	1,0E-02	1,6E-02	4,8E-02	2,9E-03	3,5E-03	2,9E-03	7,2E-03	2,6E-03	6,8E-03	2,7E-03	1,7E-03	3,5E-03
Ionising radiation	nPt	3,3E-01	4,8E-01	9,7E-01	5,2E-01	2,7E-01	4,7E-01	7,3E-01	5,0E-01	2,1E-01	2,6E-01	3,7E-01	2,4E-01	2,3E-01	3,8E-01	6,8E-01	4,9E-01	8,1E-01	1,9E+00	1,3E-01	1,6E-01	5,8E-02	1,6E-01	8,8E-02	1,6E-01	1,4E-01	1,0E-01	1,8E-01
Photochemical ozone formation	nPt	1,9E+00	2,4E+00	4,2E+00	2,9E+00	1,6E+00	1,4E+00	2,0E+00	1,3E+00	6,6E-01	6,5E-01	9,3E-01	6,9E-01	5,9E-01	9,3E-01	1,6E+00	1,5E+00	2,7E+00	1,1E+00	4,6E-01	5,8E-01	4,2E-01	1,0E+00	3,6E-01	9,8E-01	3,7E-01	2,3E-01	4,6E-01
Particulate matter	nPt	3,1E+00	3,9E+00	6,7E+00	4,6E+00	2,6E+00	2,4E+00	3,4E+00	2,3E+00	1,1E+00	1,2E+00	1,6E+00	1,2E+00	1,1E+00	1,7E+00	2,9E+00	2,5E+00	4,8E+00	1,5E+00	6,6E-01	7,9E-01	4,1E-01	1,1E+00	5,0E-01	9,9E-01	6,8E-01	4,4E-01	8,1E-01
Human toxicity, non-cancer	nPt	6,9E-01	8,7E-01	1,5E+00	1,1E+00	6,0E-01	5,2E-01	7,0E-01	4,5E-01	2,5E-01	2,2E-01	3,2E-01	2,5E-01	2,1E-01	3,2E-01	5,6E-01	5,5E-01	7,6E-01	3,7E-01	1,7E-01	2,1E-01	1,0E-01	2,9E-01	1,1E-01	2,7E-01	1,3E-01	6,8E-02	1,5E-01
Human toxicity, cancer	nPt	1,8E+00	2,4E+00	4,1E+00	2,7E+00	1,5E+00	1,3E+00	1,7E+00	1,1E+00	6,3E-01	5,9E-01	7,8E-01	6,2E-01	5,4E-01	8,0E-01	1,4E+00	1,3E+00	2,0E+00	9,6E-01	4,4E-01	5,1E-01	3,3E-01	7,9E-01	3,1E-01	7,0E-01	3,4E-01	2,0E-01	4,1E-01
Acidification	nPt	1,9E+00	2,4E+00	4,3E+00	2,9E+00	1,7E+00	1,4E+00	2,0E+00	1,3E+00	6,6E-01	6,5E-01	9,4E-01	6,9E-01	5,9E-01	9,4E-01	1,7E+00	1,5E+00	2,9E+00	9,6E-01	4,5E-01	5,4E-01	2,7E-01	6,9E-01	2,9E-01	6,4E-01	3,7E-01	2,2E-01	4,5E-01
Eutrophication, freshwater	nPt	2,5E+00	3,1E+00	5,8E+00	4,0E+00	2,1E+00	2,3E+00	3,1E+00	1,9E+00	1,1E+00	9,4E-01	1,4E+00	1,1E+00	9,0E-01	1,4E+00	2,4E+00	2,4E+00	3,4E+00	1,6E+00	8,1E-01	1,0E+00	4,2E-01	1,2E+00	4,6E-01	1,1E+00	5,5E-01	2,8E-01	6,6E-01
Eutrophication, marine	nPt	7,9E-01	1,0E+00	1,7E+00	1,2E+00	6,7E-01	6,6E-01	8,7E-01	5,6E-01	3,2E-01	2,7E-01	4,0E-01	3,1E-01	2,6E-01	3,9E-01	6,9E-01	6,9E-01	1,3E+00	5,1E-01	2,2E-01	2,6E-01	1,2E-01	3,5E-01	1,4E-01	3,3E-01	1,6E-01	8,2E-02	1,9E-01
Eutrophication, terrestrial	nPt	8,7E-01	1,1E+00	1,9E+00	1,4E+00	7,5E-01	7,4E-01	1,0E+00	6,5E-01	3,6E-01	3,3E-01	4,6E-01	3,5E-01	3,0E-01	4,6E-01	8,2E-01	7,7E-01	1,4E+00	5,6E-01	2,4E-01	2,9E-01	1,4E-01	3,7E-01	1,5E-01	3,5E-01	1,9E-01	1,0E-01	2,3E-01
Ecotoxicity, freshwater	nPt	1,0E+00	1,4E+00	2,4E+00	1,6E+00	8,2E-01	7,2E-01	9,6E-01	6,0E-01	3,5E-01	2,9E-01	4,4E-01	3,5E-01	2,8E-01	4,2E-01	7,4E-01	7,7E-01	1,1E+00	5,3E-01	2,8E-01	2,9E-01	1,4E-01	5,0E-01	1,6E-01	4,2E-01	1,7E-01	8,5E-02	2,0E-01
Land use	nPt	1,6E+00	2,6E+00	2,7E+00	2,4E+00	1,2E+00	1,8E+00	2,4E+00	1,7E+00	8,5E-01	9,1E-01	1,1E+00	7,8E-01	7,8E-01	1,2E+00	2,1E+00	1,7E+00	2,8E+00	1,2E+00	4,3E-01	5,4E-01	1,9E-01	5,8E-01	3,3E-01	5,7E-01	5,2E-01	3,1E-01	5,9E-01
Water use	nPt	9,1E-01	1,2E+00	2,0E+00	1,4E+00	7,6E-01	8,2E-01	1,1E+00	7,2E-01	4,0E-01	3,5E-01	5,0E-01	3,9E-01	3,3E-01	5,0E-01	8,9E-01	8,6E-01	2,8E+00	5,9E-01	3,3E-01	4,5E-01	2,7E-01	5,5E-01	2,2E-01	5,1E-01	2,1E-01	1,1E-01	2,7E-01
Resource use, fossils	nPt	7,8E+00	9,3E+00	1,8E+01	1,2E+01	7,0E+00	5,5E+00	7,9E+00	5,3E+00	2,6E+00	2,8E+00	3,7E+00	2,7E+00	2,5E+00	3,8E+00	6,9E+00	5,7E+00	1,3E+01	7,8E+00	1,7E+00	2,2E+00	1,7E+00	3,4E+00	1,4E+00	3,1E+00	1,5E+00	9,8E-01	2,0E+00
Resource use, minerals and metals	nPt	2,9E+00	3,6E+00	6,4E+00	4,4E+00	2,6E+00	1,4E+00	2,0E+00	1,3E+00	6,6E-01	6,6E-01	9,6E-01	7,0E-01	5,9E-01	9,4E-01	1,7E+00	1,5E+00	2,3E+00	9,1E-01	5,0E-01	6,0E-01	4,5E-01	9,5E-01	3,6E-01	8,4E-01	3,7E-01	2,3E-01	4,7E-01

Table 40 Contribution of each packaging system to the single score in absolute terms, on each indicator per 1 cm^3 packed

Category of damage	Unit	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	2.6	3.1	3.2	3.3	3.4	3.5	4.1	5.1	6.1	7.1	8.1	8.2	8.3	8.4	9.1	9.2	10.1
Climate change	kg CO2 eq	4,4E-04	5,3E-04	9,9E-04	6,8E-04	3,9E-04	3,0E-04	4,2E-04	2,8E-04	1,4E-04	1,5E-04	2,0E-04	1,5E-04	1,3E-04	2,0E-04	3,6E-04	3,2E-04	6,8E-04	2,5E-04	9,5E-05	1,2E-04	7,6E-05	1,7E-04	7,3E-05	1,6E-04	8,2E-05	5,0E-05	1,0E-04
Ozone depletion	kg CFC11 eq	6,1E-10	6,3E-10	1,3E-09	9,6E-10	6,5E-10	8,0E-12	1,2E-11	7,8E-12	3,8E-12	4,1E-12	5,7E-12	4,0E-12	3,7E-12	5,8E-12	1,0E-11	8,6E-12	1,3E-11	3,9E-11	2,4E-12	2,9E-12	2,4E-12	6,0E-12	2,1E-12	5,6E-12	2,2E-12	1,4E-12	2,9E-12
Ionising radiation	kBq U-235 eq	2,8E-05	4,0E-05	8,2E-05	4,4E-05	2,3E-05	3,9E-05	6,2E-05	4,2E-05	1,8E-05	2,2E-05	3,1E-05	2,0E-05	1,9E-05	3,2E-05	5,8E-05	4,1E-05	6,8E-05	1,6E-04	1,1E-05	1,4E-05	4,9E-06	1,4E-05	7,4E-06	1,3E-05	1,2E-05	8,5E-06	1,5E-05
Photochemical ozone formation	kg NMVOC eq	1,6E-06	2,1E-06	3,6E-06	2,5E-06	1,4E-06	1,2E-06	1,7E-06	1,1E-06	5,6E-07	5,6E-07	8,0E-07	5,9E-07	5,0E-07	7,9E-07	1,4E-06	1,3E-06	2,3E-06	9,2E-07	3,9E-07	5,0E-07	3,6E-07	8,9E-07	3,1E-07	8,4E-07	3,1E-07	1,9E-07	3,9E-07
Particulate matter	disease inc.	2,0E-11	2,6E-11	4,5E-11	3,1E-11	1,7E-11	1,6E-11	2,3E-11	1,5E-11	7,6E-12	8,2E-12	1,1E-11	7,7E-12	7,1E-12	1,1E-11	1,9E-11	1,7E-11	3,2E-11	1,0E-11	4,4E-12	5,3E-12	2,7E-12	7,0E-12	3,3E-12	6,6E-12	4,5E-12	2,9E-12	5,4E-12
Human toxicity, non-cancer	CTUh	4,8E-12	6,1E-12	1,1E-11	7,6E-12	4,2E-12	3,6E-12	4,9E-12	3,1E-12	1,8E-12	1,6E-12	2,2E-12	1,8E-12	1,5E-12	2,2E-12	3,9E-12	3,9E-12	5,3E-12	2,6E-12	1,2E-12	1,5E-12	7,2E-13	2,0E-12	7,8E-13	1,9E-12	9,1E-13	4,8E-13	1,1E-12
Human toxicity, cancer	CTUh	1,5E-12	1,9E-12	3,3E-12	2,2E-12	1,2E-12	1,0E-12	1,4E-12	9,3E-13	5,1E-13	4,8E-13	6,3E-13	5,0E-13	4,4E-13	6,5E-13	1,1E-12	1,1E-12	1,6E-12	7,7E-13	3,6E-13	4,1E-13	2,7E-13	6,4E-13	2,5E-13	5,7E-13	2,8E-13	1,6E-13	3,4E-13
Acidification	mol H+ eq	1,7E-06	2,1E-06	3,9E-06	2,6E-06	1,5E-06	1,2E-06	1,8E-06	1,1E-06	5,9E-07	5,8E-07	8,5E-07	6,1E-07	5,3E-07	8,4E-07	1,5E-06	1,3E-06	2,6E-06	8,6E-07	4,0E-07	4,9E-07	2,4E-07	6,2E-07	2,6E-07	5,7E-07	3,3E-07	2,0E-07	4,0E-07
Eutrophication, freshwater	kg P eq	1,4E-07	1,8E-07	3,3E-07	2,3E-07	1,2E-07	1,3E-07	1,8E-07	1,1E-07	6,3E-08	5,4E-08	8,3E-08	6,4E-08	5,2E-08	8,0E-08	1,4E-07	1,4E-07	1,9E-07	9,1E-08	4,7E-08	5,8E-08	2,4E-08	6,7E-08	2,7E-08	6,4E-08	3,2E-08	1,6E-08	3,8E-08
Eutrophication, marine	kg N eq	5,2E-07	6,7E-07	1,1E-06	8,2E-07	4,5E-07	4,3E-07	5,8E-07	3,7E-07	2,1E-07	1,8E-07	2,6E-07	2,1E-07	1,7E-07	2,6E-07	4,6E-07	4,6E-07	8,9E-07	3,4E-07	1,4E-07	1,7E-07	7,8E-08	2,3E-07	9,0E-08	2,2E-07	1,1E-07	5,4E-08	1,3E-07
Eutrophication, terrestrial	mol N eq	4,2E-06	5,3E-06	9,3E-06	6,5E-06	3,6E-06	3,5E-06	4,8E-06	3,1E-06	1,7E-06	1,6E-06	2,2E-06	1,7E-06	1,4E-06	2,2E-06	3,9E-06	3,7E-06	6,5E-06	2,7E-06	1,1E-06	1,4E-06	6,5E-07	1,8E-06	7,4E-07	1,7E-06	9,0E-07	4,9E-07	1,1E-06
Ecotoxicity, freshwater	CTUe	3,0E-03	4,2E-03	7,1E-03	4,6E-03	2,4E-03	2,1E-03	2,8E-03	1,8E-03	1,0E-03	8,5E-04	1,3E-03	1,0E-03	8,2E-04	1,2E-03	2,2E-03	2,3E-03	3,1E-03	1,6E-03	8,2E-04	8,4E-04	4,2E-04	1,5E-03	4,6E-04	1,3E-03	5,1E-04	2,5E-04	5,9E-04
Land use	Pt	1,7E-02	2,7E-02	2,8E-02	2,5E-02	1,2E-02	1,8E-02	2,4E-02	1,8E-02	8,8E-03	9,3E-03	1,1E-02	8,0E-03	8,0E-03	1,2E-02	2,2E-02	1,8E-02	2,8E-02	1,2E-02	4,5E-03	5,6E-03	2,0E-03	6,0E-03	3,4E-03	5,9E-03	5,4E-03	3,2E-03	6,1E-03
Water use	m3 depriv.	1,2E-04	1,6E-04	2,7E-04	1,9E-04	1,0E-04	1,1E-04	1,5E-04	9,7E-05	5,4E-05	4,8E-05	6,7E-05	5,3E-05	4,5E-05	6,7E-05	1,2E-04	1,2E-04	3,8E-04	8,0E-05	4,4E-05	6,1E-05	3,6E-05	7,4E-05	3,0E-05	6,9E-05	2,8E-05	1,5E-05	3,7E-05
Resource use, fossils	MJ	6,1E-03	7,3E-03	1,4E-02	9,3E-03	5,4E-03	4,3E-03	6,1E-03	4,2E-03	2,0E-03	2,2E-03	2,9E-03	2,1E-03	1,9E-03	3,0E-03	5,4E-03	4,5E-03	9,9E-03	6,1E-03	1,4E-03	1,7E-03	1,3E-03	2,6E-03	1,1E-03	2,4E-03	1,2E-03	7,6E-04	1,6E-03
Resource use, minerals and metals	kg Sb eq	2,42E-09	2,992 E-09	5,406 E-09	3,74E-09	2,222 E-09	1,15E-09	1,70E-09	1,07E-09	5,57E-10	5,55E-10	8,06E-10	5,93E-10	5,00E-10	7,95E-10	1,40E-09	1,27E-09	1,96E-09	7,68E-10	4,22E-10	5,04E-10	3,79E-10	8,02E-10	3,07E-10	7,11E-10	3,09E-10	1,92E-10	3,97E-10

Table 41 Impact of each packaging system on each indicator per 1 cm^3packed

3282

Impact category	Unit	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	2.6	3.1	3.2	3.3	3.4	3.5	4.1	5.1	6.1	7.1	8.1	8.2	8.3	8.4	9.1	9.2	10.1
Single score	µPt	4,1E+01	5,2E+01	9,2E+01	6,3E+01	3,6E+01	3,0E+01	4,2E+01	2,8E+01	1,4E+01	1,4E+01	1,9E+01	1,4E+01	1,3E+01	2,0E+01	3,5E+01	3,1E+01	6,1E+01	2,7E+01	9,5E+00	1,2E+01	7,1E+00	1,7E+01	6,9E+00	1,6E+01	8,0E+00	4,8E+00	1,0E+01
Climate change	kg CO2 eq	4,4E-04	5,3E-04	9,9E-04	6,8E-04	3,9E-04	3,0E-04	4,2E-04	2,8E-04	1,4E-04	1,5E-04	2,0E-04	1,5E-04	1,3E-04	2,0E-04	3,6E-04	3,2E-04	6,8E-04	2,5E-04	9,5E-05	1,2E-04	7,6E-05	1,7E-04	7,3E-05	1,6E-04	8,2E-05	5,0E-05	1,0E-04
Depletion of the ozone layer	kg CFC11 eq	6,1E-10	6,3E-10	1,3E-09	9,6E-10	6,5E-10	8,0E-12	1,2E-11	7,8E-12	3,8E-12	4,1E-12	5,7E-12	4,0E-12	3,7E-12	5,8E-12	1,0E-11	8,6E-12	1,3E-11	3,9E-11	2,4E-12	2,9E-12	2,4E-12	6,0E-12	2,1E-12	5,6E-12	2,2E-12	1,4E-12	2,9E-12
Ionising radiation	kBq U-235 eq	2,8E-05	4,0E-05	8,2E-05	4,4E-05	2,3E-05	3,9E-05	6,2E-05	4,2E-05	1,8E-05	2,2E-05	3,1E-05	2,0E-05	1,9E-05	3,2E-05	5,8E-05	4,1E-05	6,8E-05	1,6E-04	1,1E-05	1,4E-05	4,9E-06	1,4E-05	7,4E-06	1,3E-05	1,2E-05	8,5E-06	1,5E-05
Photochemical ozone formation	kg NMVOC eq	1,6E-06	2,1E-06	3,6E-06	2,5E-06	1,4E-06	1,2E-06	1,7E-06	1,1E-06	5,6E-07	5,6E-07	8,0E-07	5,9E-07	5,0E-07	7,9E-07	1,4E-06	1,3E-06	2,3E-06	9,2E-07	3,9E-07	5,0E-07	3,6E-07	8,9E-07	3,1E-07	8,4E-07	3,1E-07	1,9E-07	3,9E-07
Fine particles	disease inc.	2,0E-11	2,6E-11	4,5E-11	3,1E-11	1,7E-11	1,6E-11	2,3E-11	1,5E-11	7,6E-12	8,2E-12	1,1E-11	7,7E-12	7,1E-12	1,1E-11	1,9E-11	1,7E-11	3,2E-11	1,0E-11	4,4E-12	5,3E-12	2,7E-12	7,0E-12	3,3E-12	6,6E-12	4,5E-12	2,9E-12	5,4E-12
Human toxicity. non-carcinogenic	CTUh	4,8E-12	6,1E-12	1,1E-11	7,6E-12	4,2E-12	3,6E-12	4,9E-12	3,1E-12	1,8E-12	1,6E-12	2,2E-12	1,8E-12	1,5E-12	2,2E-12	3,9E-12	3,9E-12	5,3E-12	2,6E-12	1,2E-12	1,5E-12	7,2E-13	2,0E-12	7,8E-13	1,9E-12	9,1E-13	4,8E-13	1,1E-12
Human toxicity. cancer	CTUh	1,5E-12	1,9E-12	3,3E-12	2,2E-12	1,2E-12	1,0E-12	1,4E-12	9,3E-13	5,1E-13	4,8E-13	6,3E-13	5,0E-13	4,4E-13	6,5E-13	1,1E-12	1,1E-12	1,6E-12	7,7E-13	3,6E-13	4,1E-13	2,7E-13	6,4E-13	2,5E-13	5,7E-13	2,8E-13	1,6E-13	3,4E-13
Acidification	mol H+ eq	1,7E-06	2,1E-06	3,9E-06	2,6E-06	1,5E-06	1,2E-06	1,8E-06	1,1E-06	5,9E-07	5,8E-07	8,5E-07	6,1E-07	5,3E-07	8,4E-07	1,5E-06	1,3E-06	2,6E-06	8,6E-07	4,0E-07	4,9E-07	2,4E-07	6,2E-07	2,6E-07	5,7E-07	3,3E-07	2,0E-07	4,0E-07
Eutrophication. freshwater	kg P eq	1,4E-07	1,8E-07	3,3E-07	2,3E-07	1,2E-07	1,3E-07	1,8E-07	1,1E-07	6,3E-08	5,4E-08	8,3E-08	6,4E-08	5,2E-08	8,0E-08	1,4E-07	1,4E-07	1,9E-07	9,1E-08	4,7E-08	5,8E-08	2,4E-08	6,7E-08	2,7E-08	6,4E-08	3,2E-08	1,6E-08	3,8E-08
Marine eutrophication	kg N eq	5,2E-07	6,7E-07	1,1E-06	8,2E-07	4,5E-07	4,3E-07	5,8E-07	3,7E-07	2,1E-07	1,8E-07	2,6E-07	2,1E-07	1,7E-07	2,6E-07	4,6E-07	4,6E-07	8,9E-07	3,4E-07	1,4E-07	1,7E-07	7,8E-08	2,3E-07	9,0E-08	2,2E-07	1,1E-07	5,4E-08	1,3E-07
Terrestrial eutrophication	mol N eq	4,2E-06	5,3E-06	9,3E-06	6,5E-06	3,6E-06	3,5E-06	4,8E-06	3,1E-06	1,7E-06	1,6E-06	2,2E-06	1,7E-06	1,4E-06	2,2E-06	3,9E-06	3,7E-06	6,5E-06	2,7E-06	1,1E-06	1,4E-06	6,5E-07	1,8E-06	7,4E-07	1,7E-06	9,0E-07	4,9E-07	1,1E-06
Ecotoxicity. freshwater	CTUe	3,0E-03	4,2E-03	7,1E-03	4,6E-03	2,4E-03	2,1E-03	2,8E-03	1,8E-03	1,0E-03	8,5E-04	1,3E-03	1,0E-03	8,2E-04	1,2E-03	2,2E-03	2,3E-03	3,1E-03	1,6E-03	8,2E-04	8,4E-04	4,2E-04	1,5E-03	4,6E-04	1,3E-03	5,1E-04	2,5E-04	5,9E-04
Land use	Pt	1,7E-02	2,7E-02	2,8E-02	2,5E-02	1,2E-02	1,8E-02	2,4E-02	1,8E-02	8,8E-03	9,3E-03	1,1E-02	8,0E-03	8,0E-03	1,2E-02	2,2E-02	1,8E-02	2,8E-02	1,2E-02	4,5E-03	5,6E-03	2,0E-03	6,0E-03	3,4E-03	5,9E-03	5,4E-03	3,2E-03	6,1E-03
Use of water	m3 depriv.	1,2E-04	1,6E-04	2,7E-04	1,9E-04	1,0E-04	1,1E-04	1,5E-04	9,7E-05	5,4E-05	4,8E-05	6,7E-05	5,3E-05	4,5E-05	6,7E-05	1,2E-04	1,2E-04	3,8E-04	8,0E-05	4,4E-05	6,1E-05	3,6E-05	7,4E-05	3,0E-05	6,9E-05	2,8E-05	1,5E-05	3,7E-05
Use of fossil. resources	MJ	6,1E-03	7,3E-03	1,4E-02	9,3E-03	5,4E-03	4,3E-03	6,1E-03	4,2E-03	2,0E-03	2,2E-03	2,9E-03	2,1E-03	1,9E-03	3,0E-03	5,4E-03	4,5E-03	9,9E-03	6,1E-03	1,4E-03	1,7E-03	1,3E-03	2,6E-03	1,1E-03	2,4E-03	1,2E-03	7,6E-04	1,6E-03
Use of resources. minerals and metals	kg Sb eq	2,42E-09	2,992E-09	5,406E-09	3,74E-09	2,222E-09	1,15E-09	1,70E-09	1,07E-09	5,57E-10	5,55E-10	8,06E-10	5,93E-10	5,00E-10	7,95E-10	1,40E-09	1,27E-09	1,96E-09	7,68E-10	4,22E-10	5,04E-10	3,79E-10	8,02E-10	3,07E-10	7,11E-10	3,09E-10	1,92E-10	3,97E-10

Table 42 Impact of each packaging system on each indicator per 1 cm^3 packed, colour-coded from red (most impactful) to green (least impactful)

FAMILY	PACKAGING	Total	RM PACK I.	TRANSFO+SCRAP I.	FINISHES I.	ICP II.III. + EOL	TRP DISTRIB	EOL PACK I.
1.carton + PET blister	1.1	0,44	0,18	0,02	0,02	0,14	0,02	0,05
	1.2	0,53	0,23	0,02	0,03	0,17	0,02	0,06
	1.3	0,99	0,32	0,03	0,05	0,44	0,03	0,12
	1.4	0,68	0,28	0,04	0,03	0,23	0,03	0,08
	1.5	0,39	0,18	0,02	0,01	0,11	0,02	0,05
2.reverse blister pack	2.1	0,30	0,07	0,01	0,02	0,14	0,02	0,05
	2.2	0,42	0,10	0,02	0,06	0,16	0,02	0,07
	2.3	0,28	0,09	0,03	0,02	0,09	0,02	0,05
	2.4	0,14	0,03	0,00	0,01	0,08	0,01	0,02
	2.5	0,15	0,05	0,00	0,01	0,03	0,01	0,04
	2.6	0,20	0,05	0,00	0,04	0,06	0,01	0,04
3.cardboard case	3.1	0,15	0,03	0,01	0,02	0,06	0,01	0,02
	3.2	0,13	0,06	0,01	0,01	0,01	0,01	0,03
	3.3	0,20	0,06	0,01	0,02	0,05	0,01	0,04
	3.4	0,36	0,12	0,05	0,04	0,09	0,02	0,05
	3.5	0,32	0,06	0,01	0,04	0,15	0,02	0,04
4.card+strap	4.1	0,68	0,34	0,03	0,02	0,13	0,02	0,13
5.moulded cellulose	5.1	0,25	0,08	0,00	0,00	0,12	0,02	0,03
6.trasnp fexible paper.PP	6.1	0,10	0,02	0,00	0,01	0,05	0,01	0,01
7.flexible paper.PE opaque	7.1	0,12	0,02	0,00	0,01	0,06	0,01	0,01
8.flexible PP	8.1	0,08	0,03	0,00	0,00	0,02	0,00	0,00
	8.2	0,17	0,04	0,01	0,02	0,09	0,01	0,00
	8.3	0,07	0,02	0,00	0,00	0,03	0,01	0,01
	8.4	0,16	0,03	0,01	0,02	0,09	0,01	0,00
9.bulk without display	9.1	0,08	0,03	0,00	0,00	0,03	0,01	0,02
	9.2	0,05	0,02	0,00	0,01	0,00	0,00	0,02
10.bulk with display	10.1	0,10	0,04	0,01	0,01	0,03	0,01	0,02

Table 43 Comparison of packaging systems, by life cycle stage, according to the climate change indicator (g CO_2eq.)

FAMILY	PACKAGING	Total	RM PACK I.	TRANSFO+SCRAP I.	FINISHES I.	ICP II.III. + EOL	TRP DISTRIB	EOL PACK I.
1.carton + PET blister	1.1	6,1E-03	4,0E-03	2,5E-04	2,4E-04	1,8E-03	3,7E-04	-5,9E-04
	1.2	7,3E-03	4,8E-03	2,4E-04	4,5E-04	2,3E-03	3,6E-04	-8,8E-04
	1.3	1,4E-02	6,8E-03	3,1E-04	6,9E-04	6,2E-03	5,2E-04	-8,3E-07
	1.4	9,3E-03	6,1E-03	3,7E-04	3,9E-04	3,0E-03	4,5E-04	-9,0E-04
	1.5	5,4E-03	3,9E-03	2,5E-04	1,8E-04	1,4E-03	2,3E-04	-5,5E-04
2.reverse blister pack	2.1	4,3E-03	1,4E-03	9,3E-05	2,5E-04	1,8E-03	2,6E-04	3,6E-04
	2.2	6,1E-03	2,2E-03	1,6E-04	8,8E-04	2,0E-03	3,6E-04	5,4E-04
	2.3	4,2E-03	1,9E-03	2,7E-04	2,3E-04	1,2E-03	2,3E-04	3,7E-04
	2.4	2,0E-03	6,2E-04	1,9E-05	1,1E-04	9,7E-04	1,6E-04	1,7E-04
	2.5	2,2E-03	1,1E-03	3,0E-05	1,4E-04	4,4E-04	1,6E-04	2,8E-04
	2.6	2,9E-03	1,1E-03	1,4E-05	5,4E-04	7,9E-04	1,4E-04	3,1E-04
3.cardboard case	3.1	2,1E-03	6,0E-04	6,7E-05	3,2E-04	8,4E-04	1,4E-04	1,3E-04
	3.2	1,9E-03	1,1E-03	1,2E-04	1,4E-04	2,2E-04	1,1E-04	2,5E-04
	3.3	3,0E-03	1,4E-03	1,4E-04	3,8E-04	6,8E-04	1,5E-04	3,0E-04
	3.4	5,4E-03	2,5E-03	4,9E-04	5,5E-04	1,2E-03	2,4E-04	4,1E-04
	3.5	4,5E-03	1,2E-03	6,3E-05	6,0E-04	2,0E-03	3,0E-04	3,2E-04
4.card+strap	4.1	9,9E-03	6,7E-03	5,3E-04	3,1E-04	1,7E-03	3,6E-04	2,6E-04
5.moulded cellulose	5.1	6,1E-03	4,1E-03	1,4E-05	5,0E-05	1,5E-03	2,4E-04	2,0E-04
6.trasnp fexible paper.PP	6.1	1,4E-03	3,7E-04	6,6E-05	1,6E-04	6,8E-04	9,9E-05	-1,2E-05
7.opaque fexible paper.PE	7.1	1,7E-03	5,6E-04	9,7E-05	1,8E-04	8,1E-04	1,2E-04	-4,3E-05
8.flexible PP	8.1	1,3E-03	1,1E-03	7,8E-05	5,8E-05	3,1E-04	7,4E-05	-3,0E-04
	8.2	2,6E-03	1,3E-03	1,4E-04	2,2E-04	1,2E-03	1,7E-04	-3,4E-04
	8.3	1,1E-03	6,5E-04	3,3E-05	3,4E-05	3,9E-04	7,9E-05	-6,5E-05
	8.4	2,4E-03	1,0E-03	1,3E-04	2,1E-04	1,2E-03	1,6E-04	-2,9E-04
9.bulk without display	9.1	1,2E-03	5,5E-04	1,2E-05	6,0E-05	3,4E-04	7,9E-05	1,5E-04
	9.2	7,6E-04	4,3E-04	9,2E-06	9,0E-05	4,9E-05	6,4E-05	1,2E-04
10.bulk with display	10.1	1,6E-03	8,5E-04	1,4E-04	7,7E-05	3,5E-04	8,2E-05	7,1E-05

Table 44 Comparison of packaging systems, by life cycle stage, according to the resource use; fossil (MJ)

FAMILY	PACKAGING	Total	RM PACK I.	TRANS FO+SC RAP I.	FINISH ES I.	ICP II.III. + EOL	TRP DISTRIB	EOL PACK I.
1.carton + PET blister	1.1	1,4E-07	4,9E-08	9,6E-09	7,8E-09	7,6E-08	1,7E-09	-7,8E-10
	1.2	1,8E-07	6,4E-08	9,5E-09	1,5E-08	9,2E-08	1,7E-09	-1,1E-09
	1.3	3,3E-07	9,2E-08	1,2E-08	2,3E-08	1,9E-07	2,5E-09	1,0E-08
	1.4	2,3E-07	7,3E-08	1,4E-08	1,3E-08	1,3E-07	2,1E-09	-1,2E-09
	1.5	1,2E-07	4,5E-08	9,7E-09	6,1E-09	6,1E-08	1,1E-09	-7,3E-10
2.reverse blister pack	2.1	1,3E-07	2,9E-08	1,7E-09	8,2E-09	8,1E-08	1,2E-09	7,9E-09
	2.2	1,8E-07	4,5E-08	2,9E-09	2,9E-08	8,7E-08	1,7E-09	1,2E-08
	2.3	1,1E-07	3,8E-08	4,9E-09	7,7E-09	5,1E-08	1,1E-09	8,1E-09
	2.4	6,3E-08	1,3E-08	3,3E-10	3,6E-09	4,2E-08	7,4E-10	3,7E-09
	2.5	5,4E-08	2,2E-08	6,4E-10	4,6E-09	1,9E-08	7,4E-10	6,3E-09
	2.6	8,3E-08	2,2E-08	2,5E-10	1,8E-08	3,5E-08	6,4E-10	6,7E-09
3.cardboard case	3.1	6,4E-08	1,2E-08	1,2E-09	1,1E-08	3,6E-08	6,5E-10	2,9E-09
	3.2	5,2E-08	3,0E-08	2,2E-09	4,7E-09	9,3E-09	5,2E-10	5,2E-09
	3.3	8,0E-08	2,8E-08	2,5E-09	1,2E-08	3,0E-08	6,9E-10	6,7E-09
	3.4	1,4E-07	5,2E-08	8,9E-09	1,8E-08	5,1E-08	1,1E-09	9,1E-09
	3.5	1,4E-07	2,5E-08	1,1E-09	2,0E-08	8,5E-08	1,4E-09	7,0E-09
4.card+strap	4.1	1,9E-07	7,8E-08	1,3E-08	1,0E-08	7,5E-08	1,7E-09	1,7E-08
5.moulded cellulose	5.1	9,1E-08	1,8E-08	4,7E-10	1,0E-09	6,6E-08	1,1E-09	4,8E-09
6.trasnp fexible paper.PP	6.1	4,7E-08	1,5E-08	1,3E-09	5,2E-09	2,9E-08	4,7E-10	-4,7E-09
7.opaque fexible paper.PE	7.1	5,8E-08	2,1E-08	1,9E-09	6,1E-09	3,5E-08	5,6E-10	-6,7E-09
8.flexible PP	8.1	2,4E-08	7,6E-09	2,7E-09	1,2E-09	1,3E-08	3,5E-10	-7,2E-10
	8.2	6,7E-08	8,0E-09	3,4E-09	4,3E-09	5,1E-08	7,9E-10	-8,2E-10
	8.3	2,7E-08	6,9E-09	1,5E-09	6,7E-10	1,6E-08	3,7E-10	9,6E-10
	8.4	6,4E-08	6,0E-09	3,0E-09	4,2E-09	5,1E-08	7,7E-10	-7,1E-10
9.bulk without display	9.1	3,2E-08	1,1E-08	2,1E-10	2,0E-09	1,5E-08	3,7E-10	3,4E-09
	9.2	1,6E-08	8,8E-09	1,7E-10	3,0E-09	1,3E-09	3,0E-10	2,6E-09
10.bulk with display	10.1	3,8E-08	1,6E-08	2,8E-09	2,5E-09	1,4E-08	3,8E-10	2,4E-09

Table 45 Comparison of packaging systems, by life cycle stage, according to the eutrophication; freshwater indicator (kg P eq.)

FAMILY	PACKAGING	Total	RM PACK I.	TRANS FO+SC RAP I.	FINISHES I.	ICP II.III. + EOL	TRP DISTRIB	EOL PACK I.
1.carton + PET blister	1.1	2,4E-09	1,7E-09	4,1E-12	9,6E-11	5,6E-10	6,9E-11	-3,6E-11
	1.2	3,0E-09	2,1E-09	3,3E-12	1,8E-10	7,2E-10	6,7E-11	-5,3E-11
	1.3	5,4E-09	2,9E-09	3,9E-12	2,8E-10	2,1E-09	9,8E-11	-5,4E-12
	1.4	3,7E-09	2,6E-09	4,9E-12	1,6E-10	9,1E-10	8,4E-11	-5,5E-11
	1.5	2,2E-09	1,7E-09	3,3E-12	7,5E-11	4,4E-10	4,2E-11	-3,3E-11
2.reverse blister pack	2.1	1,1E-09	4,1E-10	4,9E-12	1,0E-10	5,7E-10	4,9E-11	1,9E-11
	2.2	1,7E-09	6,2E-10	8,5E-12	3,6E-10	6,2E-10	6,6E-11	2,8E-11
	2.3	1,1E-09	5,3E-10	1,5E-11	9,4E-11	3,7E-10	4,2E-11	1,9E-11
	2.4	5,6E-10	1,7E-10	9,8E-13	4,4E-11	3,0E-10	2,9E-11	8,7E-12
	2.5	5,6E-10	3,2E-10	3,9E-13	5,6E-11	1,3E-10	3,0E-11	1,4E-11
	2.6	8,1E-10	3,0E-10	7,3E-13	2,2E-10	2,4E-10	2,5E-11	1,6E-11
3.cardboard case	3.1	5,9E-10	1,7E-10	3,5E-12	1,3E-10	2,6E-10	2,6E-11	6,7E-12
	3.2	5,0E-10	3,1E-10	6,9E-12	5,7E-11	6,9E-11	2,1E-11	3,3E-11
	3.3	8,0E-10	3,8E-10	7,4E-12	1,5E-10	2,1E-10	2,7E-11	1,6E-11
	3.4	1,4E-09	7,1E-10	2,6E-11	2,2E-10	3,7E-10	4,4E-11	2,1E-11
	3.5	1,3E-09	3,5E-10	3,4E-12	2,4E-10	6,0E-10	5,7E-11	1,6E-11
4.card+strap	4.1	2,0E-09	1,2E-09	5,8E-11	1,3E-10	5,2E-10	6,7E-11	-2,9E-11
5.moulded cellulose	5.1	7,7E-10	2,3E-10	1,5E-12	1,7E-11	4,7E-10	4,5E-11	1,0E-11
6.trasnp fexible paper.PP	6.1	4,2E-10	1,2E-10	4,1E-12	6,6E-11	2,1E-10	1,9E-11	5,7E-12
7.opaque fexible paper.PE	7.1	5,0E-10	1,5E-10	6,9E-12	7,4E-11	2,5E-10	2,2E-11	6,5E-12
8.flexible PP	8.1	3,8E-10	3,0E-10	8,0E-12	2,0E-11	9,8E-11	1,4E-11	-5,8E-11
	8.2	8,0E-10	3,8E-10	9,9E-12	7,5E-11	3,7E-10	3,1E-11	-6,5E-11
	8.3	3,1E-10	1,8E-10	1,7E-13	1,2E-11	1,2E-10	1,5E-11	-2,1E-11
	8.4	7,1E-10	2,9E-10	8,6E-12	7,4E-11	3,6E-10	3,0E-11	-5,6E-11
9.bulk without display	9.1	3,1E-10	1,6E-10	6,2E-13	2,4E-11	1,1E-10	1,5E-11	7,9E-12
	9.2	1,9E-10	1,2E-10	4,9E-13	3,6E-11	1,6E-11	1,2E-11	6,2E-12
10.bulk with display	10.1	4,0E-10	2,4E-10	8,5E-12	3,1E-11	1,1E-10	1,5E-11	-2,2E-12

Table 46 Comparison of packaging systems, by life cycle stage, according to resource use; minerals and metals indicator (kg Sb eq.)

FAMILY	PACKAGING	Total	RM PACK I.	TRANS FO+SC RAP I.	FINISHES I.	ICP II.III. + EOL	TRP DISTRIB	EOL PACK I.
1.carton + PET blister	1.1	1,7E-02	8,1E-03	-4,9E-04	1,2E-04	8,5E-03	3,7E-04	3,4E-06
	1.2	2,7E-02	1,6E-02	-4,7E-05	2,3E-04	1,1E-02	3,6E-04	7,7E-06
	1.3	2,8E-02	2,6E-02	-8,8E-05	3,4E-04	1,6E-02	5,3E-04	-1,4E-02
	1.4	2,5E-02	1,1E-02	1,6E-05	1,9E-04	1,4E-02	4,6E-04	4,9E-06
	1.5	1,2E-02	5,3E-03	2,3E-05	9,2E-05	6,6E-03	2,3E-04	2,3E-06
2.reverse blister pack	2.1	1,8E-02	2,2E-02	-2,1E-03	1,2E-04	8,5E-03	2,6E-04	-1,0E-02
	2.2	2,4E-02	3,3E-02	-3,6E-03	4,4E-04	9,3E-03	3,6E-04	-1,5E-02
	2.3	1,8E-02	2,8E-02	-6,2E-03	1,2E-04	5,5E-03	2,3E-04	-1,0E-02
	2.4	8,8E-03	9,2E-03	-4,2E-04	5,4E-05	4,5E-03	1,6E-04	-4,7E-03
	2.5	9,3E-03	1,6E-02	-8,2E-04	6,9E-05	2,1E-03	1,6E-04	-8,0E-03
	2.6	1,1E-02	1,6E-02	-3,1E-04	2,7E-04	3,7E-03	1,4E-04	-8,6E-03
3.cardboard case	3.1	8,0E-03	9,0E-03	-1,5E-03	1,6E-04	3,9E-03	1,4E-04	-3,7E-03
	3.2	8,0E-03	1,5E-02	-2,8E-03	7,0E-05	2,2E-03	1,1E-04	-7,0E-03
	3.3	1,2E-02	2,0E-02	-3,2E-03	1,9E-04	3,2E-03	1,5E-04	-8,5E-03
	3.4	2,2E-02	3,8E-02	-1,1E-02	2,8E-04	5,5E-03	2,4E-04	-1,2E-02
	3.5	1,8E-02	1,8E-02	-1,4E-03	3,0E-04	9,1E-03	3,1E-04	-8,9E-03
4.card+strap	4.1	2,8E-02	4,4E-02	-1,2E-03	1,5E-04	7,8E-03	3,6E-04	-2,3E-02
5.moulded cellulose	5.1	1,2E-02	1,1E-02	1,4E-05	2,5E-05	7,0E-03	2,4E-04	-6,1E-03
6.trasnp fexible paper.PP	6.1	4,5E-03	2,0E-03	-8,4E-06	7,9E-05	3,2E-03	1,0E-04	-8,6E-04
7.opaque fexible paper.PE	7.1	5,6E-03	2,8E-03	-5,3E-06	9,1E-05	3,7E-03	1,2E-04	-1,2E-03
8.flexible PP	8.1	2,0E-03	3,6E-04	6,2E-05	2,9E-05	1,5E-03	7,5E-05	-5,0E-06
	8.2	6,0E-03	1,4E-04	1,0E-04	1,1E-04	5,5E-03	1,7E-04	-5,8E-06
	8.3	3,4E-03	3,3E-03	-1,7E-04	1,7E-05	1,8E-03	8,0E-05	-1,6E-03
	8.4	5,9E-03	1,1E-04	8,9E-05	1,1E-04	5,4E-03	1,6E-04	-5,0E-06
9.bulk without display	9.1	5,4E-03	8,2E-03	-2,7E-04	3,0E-05	1,6E-03	7,9E-05	-4,3E-03
	9.2	3,2E-03	6,4E-03	-2,1E-04	4,5E-05	2,5E-04	6,4E-05	-3,4E-03
10.bulk with display	10.1	6,1E-03	1,1E-02	-3,0E-03	3,8E-05	1,6E-03	8,2E-05	-3,3E-03

Table 47 Comparison of packaging systems, by life cycle stage, according to the land use indicator (Pt)

FAMILY	PACKAGING	Total	RM PACK I.	TRANS FO+SC RAP I.	FINISHES I.	ICP II.III. + EOL	TRP DISTRIB	EOL PACK I.
1.carton + PET blister	1.1	1,2E-04	4,7E-05	3,4E-06	4,3E-06	6,8E-05	1,8E-06	-9,4E-07
	1.2	1,6E-04	6,3E-05	3,2E-06	8,3E-06	8,7E-05	1,7E-06	-1,4E-06
	1.3	2,7E-04	9,2E-05	4,2E-06	1,3E-05	1,5E-04	2,5E-06	6,0E-06
	1.4	1,9E-04	7,0E-05	4,9E-06	7,0E-06	1,1E-04	2,2E-06	-1,4E-06
	1.5	1,0E-04	4,3E-05	3,3E-06	3,4E-06	5,2E-05	1,1E-06	-8,8E-07
2.reverse blister pack	2.1	1,1E-04	3,0E-05	1,1E-06	4,6E-06	6,8E-05	1,3E-06	5,0E-06
	2.2	1,5E-04	4,6E-05	1,8E-06	1,6E-05	7,4E-05	1,7E-06	7,4E-06
	2.3	9,7E-05	4,0E-05	3,1E-06	4,2E-06	4,4E-05	1,1E-06	5,0E-06
	2.4	5,4E-05	1,3E-05	2,1E-07	2,0E-06	3,6E-05	7,6E-07	2,3E-06
	2.5	4,8E-05	2,4E-05	3,2E-07	2,5E-06	1,6E-05	7,6E-07	3,9E-06
	2.6	6,7E-05	2,3E-05	1,6E-07	9,9E-06	3,0E-05	6,5E-07	4,2E-06
3.cardboard case	3.1	5,3E-05	1,3E-05	7,6E-07	5,9E-06	3,1E-05	6,7E-07	1,8E-06
	3.2	4,5E-05	2,4E-05	1,5E-06	2,6E-06	6,4E-06	5,4E-07	1,0E-05
	3.3	6,7E-05	2,9E-05	1,6E-06	6,9E-06	2,5E-05	7,1E-07	4,2E-06
	3.4	1,2E-04	5,4E-05	5,6E-06	1,0E-05	4,4E-05	1,1E-06	5,7E-06
	3.5	1,2E-04	2,6E-05	7,2E-07	1,1E-05	7,2E-05	1,5E-06	4,4E-06
4.card+strap	4.1	3,8E-04	2,9E-04	2,0E-05	5,7E-06	6,3E-05	1,7E-06	4,7E-06
5.moulded cellulose	5.1	8,0E-05	1,8E-05	1,8E-06	5,5E-07	5,6E-05	1,2E-06	3,0E-06
6.trasnp fexible paper.PP	6.1	4,4E-05	8,1E-06	2,6E-06	3,1E-06	2,5E-05	4,8E-07	4,5E-06
7.opaque fexible paper.PE	7.1	6,1E-05	1,6E-05	4,5E-06	3,4E-06	3,0E-05	5,8E-07	6,4E-06
8.flexible PP	8.1	3,6E-05	1,6E-05	1,1E-05	6,4E-07	1,2E-05	3,6E-07	-3,3E-06
	8.2	7,4E-05	1,9E-05	1,2E-05	2,4E-06	4,4E-05	8,1E-07	-3,7E-06
	8.3	3,0E-05	1,1E-05	4,8E-06	3,7E-07	1,4E-05	3,8E-07	-5,8E-07
	8.4	6,9E-05	1,5E-05	1,1E-05	2,3E-06	4,3E-05	7,9E-07	-3,2E-06
9.bulk without display	9.1	2,8E-05	1,2E-05	1,3E-07	1,1E-06	1,3E-05	3,8E-07	2,1E-06
	9.2	1,5E-05	9,1E-06	1,1E-07	1,6E-06	2,0E-06	3,1E-07	1,7E-06
10.bulk with display	10.1	3,7E-05	1,9E-05	2,9E-06	1,4E-06	1,3E-05	4,0E-07	7,6E-07

Table 48 Comparison of packaging systems, by life cycle stage, according to use water indicator (m^3 depriv.)

FAMILY	PACKAGING	Total	RM PACK I.	TRANSFO+SCRAP I.	FINISHES I.	ICP II.III. + EOL	TRP DISTRIB	EOL PACK I.
1.carton + PET blister	1.1	41	21	2	2	14	2	0
	1.2	52	27	2	3	18	2	0
	1.3	92	38	2	5	42	3	2
	1.4	63	32	3	3	23	3	1
	1.5	36	20	2	1	11	1	1
		-	-	-	-	-	-	-
2.reverse blister pack	2.1	30	11	0	2	14	2	1
	2.2	42	16	0	6	16	2	1
	2.3	28	14	1	2	9	1	1
	2.4	14	5	0	1	8	1	0
	2.5	14	8	0	1	3	1	1
	2.6	19	8	0	4	6	1	1
		-	-	-	-	-	-	-
3.cardboard case	3.1	14	4	0	2	7	1	0
	3.2	13	8	0	1	2	1	1
	3.3	20	10	0	2	5	1	1
	3.4	35	19	1	4	9	1	1
	3.5	31	9	0	4	15	2	1
		-	-	-	-	-	-	-
4.card+strap	4.1	61	39	2	2	13	2	2
		-	-	-	-	-	-	-
5.moulded cellulose	5.1	27	13	0	0	12	1	1
		-	-	-	-	-	-	-
6.trasnp fexible paper.PP	6.1	10	2	0	1	5	1	0
		-	-	-	-	-	-	-
7.opaque fexible paper.PE	7.1	12	3	0	1	6	1	0
		-	-	-	-	-	-	-
8.flexible PP	8.1	7	4	0	0	2	0	-1
	8.2	17	5	1	2	9	1	-1
	8.3	7	3	0	0	3	0	0
	8.4	16	4	1	2	9	1	-1
		-	-	-	-	-	-	-
9.bulk without display	9.1	8	4	0	0	3	0	0
	9.2	5	3	0	1	0	0	0
10.bulk with display	10.1	10	6	0	1	3	0	0

Table 49 Comparison of packaging systems, by life cycle stage, according to the single score indicator (nPt)

3364

Impact category	Unit	1.1	1.1_R1:50%	1.2	1.2_R1:50%	1.3	1.3_R1:50%	1.4	1.4_R1:50%	1.5	1.5_R1:50%	2.1	2.1_R1:50%	2.2	2.2_R1:50%	2.3	2.3_R1:50%	2.4	2.4_R1:50%	2.5	2.5_R1:50%	2.6	2.6_R1:50%	3.1	3.1_R1:50%	3.2	3.2_R1:50%	3.3
Climate change	gCO2 eq	4,39E-01	4,11E-01	5,34E-01	5,07E-01	9,90E-01	9,12E-01	6,79E-01	6,35E-01	3,91E-01	3,62E-01	3,00E-01	3,03E-01	4,23E-01	4,28E-01	2,82E-01	2,86E-01	1,45E-01	1,46E-01	1,46E-01	1,49E-01	1,97E-01	1,99E-01	1,46E-01	1,47E-01	1,31E-01	1,32E-01	2,02E-01
Eutrophication, freshwater	kg P eq	1,43E-07	1,37E-07	1,81E-07	1,75E-07	3,31E-07	3,11E-07	2,29E-07	2,20E-07	1,23E-07	1,17E-07	1,30E-07	1,29E-07	1,77E-07	1,76E-07	1,11E-07	1,10E-07	6,29E-08	6,26E-08	5,38E-08	5,32E-08	8,28E-08	8,23E-08	6,35E-08	6,32E-08	5,16E-08	5,03E-08	7,95E-08
Land use	Pt	1,66E-02	1,54E-02	2,73E-02	2,49E-02	2,80E-02	3,80E-02	2,50E-02	2,34E-02	1,22E-02	1,14E-02	1,83E-02	1,50E-02	2,44E-02	1,93E-02	1,76E-02	1,32E-02	8,82E-03	7,38E-03	9,35E-03	6,87E-03	1,13E-02	8,84E-03	8,02E-03	6,62E-03	8,00E-03	5,61E-03	1,22E-02
Water use	m3 depriv.	1,23E-04	1,16E-04	1,61E-04	1,53E-04	2,68E-04	2,50E-04	1,91E-04	1,80E-04	1,02E-04	9,47E-05	1,10E-04	1,09E-04	1,47E-04	1,45E-04	9,69E-05	9,51E-05	5,40E-05	5,34E-05	4,76E-05	4,66E-05	6,72E-05	6,62E-05	5,26E-05	5,20E-05	4,48E-05	4,42E-05	6,71E-05
Resource use, fossils	MJ	6,08E-03	5,35E-03	7,30E-03	6,54E-03	1,44E-02	1,22E-02	9,34E-03	8,20E-03	5,44E-03	4,67E-03	4,26E-03	4,24E-03	6,14E-03	6,10E-03	4,16E-03	4,13E-03	2,05E-03	2,03E-03	2,18E-03	2,17E-03	2,87E-03	2,85E-03	2,09E-03	2,08E-03	1,94E-03	1,91E-03	3,01E-03
Resource use, minerals and metals	kg Sb eq	2,42E-09	2,10E-09	2,99E-09	2,65E-09	5,41E-09	4,88E-09	3,74E-09	3,23E-09	2,22E-09	1,88E-09	1,15E-09	1,12E-09	1,70E-09	1,66E-09	1,07E-09	1,03E-09	5,57E-10	5,46E-10	5,55E-10	5,37E-10	8,06E-10	7,87E-10	5,93E-10	5,82E-10	5,00E-10	4,82E-10	7,95E-10
Relative gap on climate change			-6,27%		-5,12%		-7,87%		-6,42%		-7,56%		0,97%		1,05%		1,35%		0,86%		1,47%		1,10%		0,83%		1,01%	
Relative gap on Eutrophication Freshwater			-3,90%		-3,33%		-6,00%		-3,80%		-4,71%		-0,60%		-0,67%		-0,92%		-0,53%		-1,07%		-0,70%		-0,51%		-2,44%	
Relative variance in land use and development			-7,35%		-8,87%		35,61%		-6,44%		-6,47%		-18,35%		-20,99%		-24,89%		-16,30%		-26,45%		-22,07%		-17,48%		-29,88%	
Relative variation in the consumption of water resources			-5,97%		-4,99%		-7,02%		-5,98%		-7,41%		-1,25%		-1,42%		-1,84%		-1,08%		-2,11%		-1,51%		-1,08%		-1,26%	
Relative gap in resource use; Fossils			-11,93%		-10,35%		-15,84%		-12,19%		-14,05%		-0,57%		-0,60%		-0,76%		-0,51%		-0,82%		-0,63%		-0,49%		-1,16%	
Relative gap in resource use; Minerals and Metals			-13,42%		-11,49%		-9,75%		-13,63%		-15,33%		-2,19%		-2,26%		-3,08%		-1,93%		-3,33%		-2,32%		-1,77%		-3,63%	

3365

Table 50 SA1 raw results (table 1/2)

Impact category	Unit	3.3_R1:50%	3.4	3.4_R1:50%	3.5	3.5_R1:50%	4.1	4.1_R1:50%	5.1	5.1_R1:50%	6.1	6.1_R1:50%	7.1	7.1_R1:50%	8.1	8.1_R1:50%	8.2	8.2_R1:50%	8.3	8.3_R1:50%	8.4	8.4_R1:50%	9.1	9.1_R1:50%	9.2	9.2_R1:50%	10.1	10.1_R1:50%
Climate change	gCO2 eq	2,05E-01	3,61E-01	3,66E-01	3,15E-01	3,18E-01	6,81E-01	6,78E-01	2,45E-01	2,47E-01	9,53E-02	9,37E-02	1,20E-01	1,16E-01	7,62E-02	6,95E-02	1,74E-01	1,67E-01	7,25E-02	7,02E-02	1,62E-01	1,55E-01	8,19E-02	8,30E-02	4,96E-02	5,05E-02	1,03E-01	1,03E-01
Eutrophication, freshwater	kg P eq	7,88E-08	1,40E-07	1,39E-07	1,39E-07	1,39E-07	1,94E-07	1,91E-07	9,07E-08	9,17E-08	4,67E-08	4,49E-08	5,80E-08	5,50E-08	2,40E-08	2,29E-08	6,69E-08	6,59E-08	2,65E-08	2,60E-08	6,38E-08	6,30E-08	3,18E-08	3,15E-08	1,62E-08	1,59E-08	3,79E-08	3,73E-08
Land use	Pt	9,04E-03	2,16E-02	1,56E-02	1,78E-02	1,49E-02	2,84E-02	2,15E-02	1,24E-02	1,08E-02	4,46E-03	4,19E-03	5,55E-03	5,15E-03	2,00E-03	1,96E-03	6,02E-03	6,01E-03	3,41E-03	2,90E-03	5,90E-03	5,89E-03	5,38E-03	4,10E-03	3,23E-03	2,23E-03	6,11E-03	4,43E-03
Water use	m3 depriv.	6,58E-05	1,20E-04	1,18E-04	1,15E-04	1,14E-04	3,82E-04	3,70E-04	8,00E-05	8,33E-05	4,40E-05	4,36E-05	6,10E-05	5,84E-05	3,63E-05	3,25E-05	7,40E-05	6,98E-05	3,02E-05	2,84E-05	6,89E-05	6,52E-05	2,80E-05	2,74E-05	1,48E-05	1,43E-05	3,69E-05	3,51E-05
Resource use, fossils	MJ	2,98E-03	5,41E-03	5,37E-03	4,48E-03	4,45E-03	9,91E-03	9,53E-03	6,12E-03	6,13E-03	1,36E-03	1,31E-03	1,72E-03	1,61E-03	1,30E-03	1,04E-03	2,64E-03	2,35E-03	1,11E-03	1,01E-03	2,43E-03	2,18E-03	1,20E-03	1,19E-03	7,63E-04	7,56E-04	1,57E-03	1,52E-03
Resource use, minerals and metals	kg Sb eq	7,72E-10	1,40E-09	1,35E-09	1,27E-09	1,25E-09	1,96E-09	1,83E-09	7,68E-10	7,58E-10	4,22E-10	4,08E-10	5,04E-10	4,75E-10	3,79E-10	3,15E-10	8,02E-10	7,29E-10	3,07E-10	2,76E-10	7,11E-10	6,48E-10	3,09E-10	2,99E-10	1,92E-10	1,85E-10	3,97E-10	3,75E-10
Relative gap on climate change		1,36%		1,43%		0,79%		-0,42%		0,76%		-1,74%		-2,89%		-8,80%		-4,27%		-3,20%		-4,04%		1,36%		1,75%		0,42%
Relative gap on Eutrophication Freshwater		-0,93%		-0,99%		-0,48%		-1,81%		1,16%		-3,95%		-5,20%		-4,53%		-1,46%		-1,81%		-1,34%		-0,94%		-1,44%		-1,66%
Relative variance in land use and development		-25,94%		-27,57%		-16,16%		-24,24%		-12,71%		-6,25%		-7,19%		-2,20%		-0,16%		-14,89%		-0,15%		-23,84%		-30,97%		-27,46%
Relative variation in the consumption of water resources		-1,92%		-2,02%		-1,01%		-3,15%		4,05%		-0,82%		-4,19%		-10,26%		-5,69%		-5,85%		-5,36%		-1,87%		-2,76%		-4,72%
Relative gap in resource use; Fossils		-0,76%		-0,80%		-0,46%		-3,82%		0,05%		-3,97%		-6,74%		-19,77%		-10,85%		-9,85%		-10,31%		-0,78%		-0,95%		-3,19%
Relative gap in resource use; Minerals and Metals		-2,98%		-3,18%		-1,69%		-6,83%		-1,28%		-3,20%		-5,74%		-17,07%		-9,01%		-9,97%		-8,91%		-3,10%		-3,89%		-5,56%

Table 51 SA1 raw results (table 2/2)

Impact category	Unit	1.1	1.1 SAIA	1.2	1.2 ASIA	1.3	1.3 ASIA	1.4	1.4 ASIA	1.5	1.5 SAIA	2.1	2.1 ASIA	2.2	2.2 ASIA	2.3	2.3 ASIA	2.4	2.4 ASIA	2.5	2.5 ASIA	2.6	2.6 ASIA	3.1	3.1 ASIA	3.2	3.2 ASIA	3.3
Climate change	gCO2 eq	4,39E-01	5,00E-01	5,34E-01	6,32E-01	9,90E-01	1,10E+00	6,79E-01	7,68E-01	3,91E-01	4,43E-01	3,00E-01	4,08E-01	4,23E-01	5,86E-01	2,82E-01	4,17E-01	1,45E-01	1,92E-01	1,46E-01	2,27E-01	1,97E-01	2,79E-01	1,46E-01	1,90E-01	1,31E-01	2,04E-01	2,02E-01
Eutrophication, freshwater	kg P eq	1,43E-07	1,54E-07	1,81E-07	2,00E-07	3,31E-07	3,49E-07	2,29E-07	2,44E-07	1,23E-07	1,31E-07	1,30E-07	1,56E-07	1,77E-07	2,17E-07	1,11E-07	1,45E-07	6,29E-08	7,42E-08	5,38E-08	7,32E-08	8,28E-08	1,02E-07	6,35E-08	7,44E-08	5,16E-08	7,22E-08	7,95E-08
Land use	Pt	1,66E-02	1,71E-02	2,73E-02	2,83E-02	2,80E-02	4,33E-02	2,50E-02	2,57E-02	1,22E-02	1,25E-02	1,83E-02	1,95E-02	2,44E-02	2,62E-02	1,76E-02	1,91E-02	8,82E-03	9,33E-03	9,35E-03	1,02E-02	1,13E-02	1,22E-02	8,02E-03	8,50E-03	8,00E-03	8,79E-03	1,22E-02
Water use	m3 depriv.	1,23E-04	1,28E-04	1,61E-04	1,68E-04	2,68E-04	2,71E-04	1,91E-04	1,99E-04	1,02E-04	1,07E-04	1,10E-04	1,17E-04	1,47E-04	1,58E-04	9,69E-05	1,06E-04	5,40E-05	5,72E-05	4,76E-05	5,30E-05	6,72E-05	7,27E-05	5,26E-05	5,56E-05	4,48E-05	5,04E-05	6,71E-05
Resource use, fossils	MJ	6,08E-03	6,47E-03	7,30E-03	7,91E-03	1,44E-02	1,41E-02	9,34E-03	9,92E-03	5,44E-03	5,78E-03	4,26E-03	5,09E-03	6,14E-03	7,39E-03	4,16E-03	5,16E-03	2,05E-03	2,41E-03	2,18E-03	2,81E-03	2,87E-03	3,51E-03	2,09E-03	2,42E-03	1,94E-03	2,50E-03	3,01E-03
Resource use, minerals and metals	kg Sb eq	2,42E-09	2,44E-09	2,99E-09	3,01E-09	5,41E-09	5,36E-09	3,74E-09	3,77E-09	2,22E-09	2,25E-09	1,15E-09	1,37E-09	1,70E-09	2,03E-09	1,07E-09	1,34E-09	5,57E-10	6,53E-10	5,55E-10	7,21E-10	8,06E-10	9,75E-10	5,93E-10	6,83E-10	5,00E-10	6,49E-10	7,95E-10
Relative gap on climate change			14%		18%		11%		13%		13%		36%		39%		48%		32%		55%		42%		30%		56%	
Relative gap on Eutrophication Freshwater			8%		10%		5%		7%		7%		20%		23%		30%		18%		36%		24%		17%		40%	
Relative variance in land use and development			3%		3%		55%		3%		3%		6%		7%		8%		6%		9%		8%		6%		10%	
Relative variation in the consumption of water resources			4%		4%		1%		4%		4%		7%		7%		9%		6%		11%		8%		6%		12%	
Relative gap in resource use; Fossils			6%		8%		-3%		6%		6%		19%		20%		24%		18%		29%		23%		16%		29%	
Relative gap in resource use; Minerals and Metals			1%		1%		-1%		1%		1%		19%		20%		26%		17%		30%		21%		15%		30%	

Table 52 SA2 raw results (table 1/2)

Impact category	Unit	3.3 ASIA	3.4	3.4 ASIA	3.5	3.5 ASIA	4.1	4.1 ASIA	5.1	5.1 ASIA	6.1	6.1 ASIA	7.1	7.1 ASIA	8.1	8.1 ASIA	8.2	8.2 ASIA	8.3	8.3 ASIA	8.4	8.4 ASIA	9.1	9.1 ASIA	9.2	9.2 ASIA	10.1	10.1 ASIA
Climate change	gCO2 eq	3,02E-01	3,61E-01	5,39E-01	3,15E-01	4,08E-01	6,81E-01	9,33E-01	2,45E-01	4,77E-01	9,53E-02	1,10E-01	1,20E-01	1,39E-01	7,62E-02	1,02E-01	1,74E-01	2,06E-01	7,25E-02	9,99E-02	1,62E-01	1,90E-01	8,19E-02	1,24E-01	4,96E-02	8,24E-02	1,03E-01	1,56E-01
Eutrophication, freshwater	kg P eq	1,04E-07	1,40E-07	1,86E-07	1,39E-07	1,62E-07	1,94E-07	2,52E-07	9,07E-08	1,28E-07	4,67E-08	5,24E-08	5,80E-08	6,54E-08	2,40E-08	3,07E-08	6,69E-08	7,44E-08	2,65E-08	3,31E-08	6,38E-08	7,04E-08	3,18E-08	4,18E-08	1,62E-08	2,40E-08	3,79E-08	5,12E-08
Land use	Pt	1,33E-02	2,16E-02	2,35E-02	1,78E-02	1,88E-02	2,84E-02	3,10E-02	1,24E-02	1,52E-02	4,46E-03	5,03E-03	5,55E-03	6,36E-03	2,00E-03	2,17E-03	6,02E-03	6,14E-03	3,41E-03	3,63E-03	5,90E-03	6,00E-03	5,38E-03	5,83E-03	3,23E-03	3,59E-03	6,11E-03	6,68E-03
Water use	m3 depriv.	7,38E-05	1,20E-04	1,32E-04	1,15E-04	1,22E-04	3,82E-04	3,82E-04	8,00E-05	1,02E-04	4,40E-05	4,41E-05	6,10E-05	5,69E-05	3,63E-05	3,38E-05	7,40E-05	7,15E-05	3,02E-05	3,03E-05	6,89E-05	6,68E-05	2,80E-05	3,08E-05	1,48E-05	1,69E-05	3,69E-05	3,86E-05
Resource use, fossils	MJ	3,76E-03	5,41E-03	6,70E-03	4,48E-03	5,19E-03	9,91E-03	1,19E-02	6,12E-03	5,21E-03	1,36E-03	1,45E-03	1,72E-03	1,83E-03	1,30E-03	1,50E-03	2,64E-03	2,84E-03	1,11E-03	1,32E-03	2,43E-03	2,61E-03	1,20E-03	1,53E-03	7,63E-04	1,02E-03	1,57E-03	1,96E-03
Resource use, minerals and metals	kg Sb eq	1,00E-09	1,40E-09	1,77E-09	1,27E-09	1,46E-09	1,96E-09	2,46E-09	7,68E-10	9,47E-10	4,22E-10	4,47E-10	5,04E-10	5,33E-10	3,79E-10	4,19E-10	8,02E-10	8,45E-10	3,07E-10	3,56E-10	7,11E-10	7,49E-10	3,09E-10	3,95E-10	1,92E-10	2,60E-10	3,97E-10	5,04E-10
Relative gap on climate change		49%		49%		29%		37%		94%		15%		16%		34%		18%		38%		17%		51%		66%		51%
Relative gap on Eutrophication Freshwater		31%		33%		16%		30%		41%		12%		13%		28%		11%		25%		10%		32%		49%		35%
Relative variance in land use and development		9%		9%		6%		9%		23%		13%		15%		8%		2%		6%		2%		8%		11%		9%
Relative variation in the consumption of water resources		10%		10%		5%		0%		28%		0%		-7%		-7%		-3%		0%		-3%		10%		15%		5%
Relative gap in resource use; Fossils		25%		24%		16%		20%		-15%		6%		6%		15%		8%		19%		7%		27%		34%		24%
Relative gap in resource use; Minerals and Metals		26%		26%		15%		25%		23%		6%		6%		10%		5%		16%		5%		28%		35%		27%

Table 53 SA2 raw results (table 2/2)

Impact category	Unit	1.1	1.1_AS3	1.2	1.2AS3	1.3	1.3_AS3	1.4	1.4_AS3	1.5	1.5_AS3	2.1	2.2	2.3	2.4	2.5	2.6
Climate change	gCO2 eq	4,4E-01	3,6E-01	5,3E-01	3,5E-01	9,9E-01	9,2E-01	6,8E-01	4,0E-01	3,9E-01	3,2E-01	3,0E-01	4,2E-01	2,8E-01	1,4E-01	1,5E-01	2,0E-01

Eutrophication, freshwater	kg P eq	1,43E-07	1,18E-07	1,81E-07	1,20E-07	3,31E-07	3,09E-07	2,29E-07	1,34E-07	1,23E-07	9,91E-08	1,30E-07	1,77E-07	1,11E-07	6,29E-08	5,38E-08	8,28E-08
Land use	Pt	1,66E-02	1,37E-02	2,73E-02	1,81E-02	2,80E-02	2,61E-02	2,50E-02	1,47E-02	1,22E-02	9,80E-03	1,83E-02	2,44E-02	1,76E-02	8,82E-03	9,35E-03	1,13E-02
Water use	m3 depriv.	1,23E-04	1,02E-04	1,61E-04	1,07E-04	2,68E-04	2,50E-04	1,91E-04	1,12E-04	1,02E-04	8,24E-05	1,10E-04	1,47E-04	9,69E-05	5,40E-05	4,76E-05	6,72E-05
Resource use, fossils	MJ	6,08E-03	5,01E-03	7,30E-03	4,83E-03	1,44E-02	1,34E-02	9,34E-03	5,47E-03	5,44E-03	4,38E-03	4,26E-03	6,14E-03	4,16E-03	2,05E-03	2,18E-03	2,87E-03
Resource use, minerals and metals	kg Sb eq	2,42E-09	2,00E-09	2,99E-09	1,98E-09	5,41E-09	5,03E-09	3,74E-09	2,19E-09	2,22E-09	1,79E-09	1,15E-09	1,70E-09	1,07E-09	5,57E-10	5,55E-10	8,06E-10
Relative gap on climate change			-18%		-34%		-7%		-41%		-19%						
Relative gap on Eutrophication Freshwater			-18%		-34%		-7%		-41%		-19%						
Relative variance in land use and usage			-18%		-34%		-7%		-41%		-19%						
Relative variation in the consumption of water resources			-18%		-34%		-7%		-41%		-19%						
Relative gap in resource use; Fossils			-18%		-34%		-7%		-41%		-19%						
Relative gap in resource use; Minerals and Metals			-18%		-34%		-7%		-41%		-19%						

3369 **Table 54 SA3 raw results (table 1/2)**

Impact category	Unit	3.1	3.2	3.3	3.4	3.5	4.1	5.1	6.1	7.1	8.1	8.2	8.3	8.4	9.1	9.2	10.1
Climate change	gCO2 eq	1,5E-01	1,3E-01	2,0E-01	3,6E-01	3,2E-01	6,8E-01	2,5E-01	9,5E-02	1,2E-01	7,6E-02	1,7E-01	7,3E-02	1,6E-01	8,2E-02	5,0E-02	1,0E-01
Eutrophication, freshwater	kg P eq	6,35E-08	5,16E-08	7,95E-08	1,40E-07	1,39E-07	1,94E-07	9,07E-08	4,67E-08	5,80E-08	2,40E-08	6,69E-08	2,65E-08	6,38E-08	3,18E-08	1,62E-08	3,79E-08
Land use	Pt	8,02E-03	8,00E-03	1,22E-02	2,16E-02	1,78E-02	2,84E-02	1,24E-02	4,46E-03	5,55E-03	2,00E-03	6,02E-03	3,41E-03	5,90E-03	5,38E-03	3,23E-03	6,11E-03
Water use	m3 depriv.	5,26E-05	4,48E-05	6,71E-05	1,20E-04	1,15E-04	3,82E-04	8,00E-05	4,40E-05	6,10E-05	3,63E-05	7,40E-05	3,02E-05	6,89E-05	2,80E-05	1,48E-05	3,69E-05
Resource use, fossils	MJ	2,09E-03	1,94E-03	3,01E-03	5,41E-03	4,48E-03	9,91E-03	6,12E-03	1,36E-03	1,72E-03	1,30E-03	2,64E-03	1,11E-03	2,43E-03	1,20E-03	7,63E-04	1,57E-03
Resource use, minerals and metals	kg Sb eq	5,93E-10	5,00E-10	7,95E-10	1,40E-09	1,27E-09	1,96E-09	7,68E-10	4,22E-10	5,04E-10	3,79E-10	8,02E-10	3,07E-10	7,11E-10	3,09E-10	1,92E-10	3,97E-10
Relative gap on climate change																	
Relative gap on Eutrophication Freshwater																	
Relative variance in land use and development																	
Relative variation in the consumption of water resources																	
Relative gap in resource use; Fossils																	
Relative gap in resource use; Minerals and Metals																	

3370 **Table 55 SA3 raw results (table 2/2)**

3371

3372 # 8 BIBLIOGRAPHY

[i] USEtox® 2.0 Documentation (Version 1.00) Fantke, P., Bijster, M., Hauschild, M. Z., Huijbregts, M., Jolliet, O., Kounina, A., Magaud, V., Margni, M., McKone, T. E., Rosenbaum, R. K., Van De Meent, D., & Van Zelm, R. (2017). https://doi.org/10.11581/DTU:00000011

[ii] AFNOR. (2006). Environmental management - Life cycle assessment - Principles and framework. NF EN ISO 14040. La Plaine Saint Denis: AFNOR.

[iii] AFNOR. (2006). Environmental management - Life cycle assessment - Requirements and guidelines. NF EN ISO ISO 14044. La Plaine Saint Denis: AFNOR.

[iv] EUROPEAN COMMISSION. (2019). European Platform on Life Cycle Assessment. Life Cycle Assessment (LCA). https://epACV.jrc.ec.europa.eu/lifecycleassessment.html

[v] EUROPEAN COMMISSION. European Platform on Life Cycle Assessment. Environmental Footprint. 2019. Retrieved on 9 August[th], 2022 from https://epACV.jrc.ec.europa.eu/EnvironmentalFootprint.html

[vi] Manfredi, S., et al. (2012). Product Environmental Footprint (PEF) Guide. Accessed on 9 August[th], 2022 on https://ec.europa.eu/environment/eussd/pdf/footprint/PEF%20methodology%20final%20draft.pdf

[vii] Fazio, S., et al. (2018). Information in support of the recommended FE characterisation factors. Life cycle impact assessment method. Retrieved August 9, 2022, from https://epACV.jrc.ec.europa.eu/permalink/supporting_Information_final.pdf

[viii] Pant, R., & et al. (2011). ILCD Handbook Recommendations for Life Cycle Impact Assessment in the European context - based on existing environmental impact assessment models and factors. Retrieved August[th]9, 2022, from https://epACV.jrc.ec.europa.eu/uploads/ILCD-Recommendation-of-methods-for-LCIA-def.pdf

[ix] Product Environmental Footprint Category. Rules Guidance 3 Version 6.3. May 2018 https://eplca.jrc.ec.europa.eu/permalink/PEFCR_guidance_v6.3-2.pdf#page=176&zoom=100,92,716

[x] Water-Based Heat Seal Varnish for Bonding of PVC/Pet to Paper - Made in China website - Accessed on 15/04/2025 https://183edf5e932b6624.en.made-in-china.com/product/TtmroSqMOJVc/China-Water-Based-Heat-Seal-Varnish-for-Bonding-of-PVC-Pet-to-Paper.html?pv_id=1iosoesgbb&faw_id=1iosoetadd4f

[xi] Strong Blister Packaging Coating Blister Varnish for Pet Heat Seal White Cardboard - Made in China website - Accessed on 15/04/2025 https://www.made-in-china.com/video-channel/183edf5e932b6624_oQUrnNylbbcV_Strong-Blister-Packaging-Coating-Blister-Varnish-for-Pet-Heat-Seal-White-Cardboard.html

[xii] Dispersion Varnish WB3800 - Blister Pack - 20kg - IGEPA website - consulted on 24/03/2025 https://igepa.be/fr/Vernis-de-dispersion-WB3800-Blister-Pack-20kg/31-2000-0183.1

[xiii] Johannes Svensson - Deep decarbonisation trajectories for freight transport in France - published in 2019 https://www.academia.edu/104302597/Trajectoires_de_d%C3%A9carbonation_profonde_du_transport_de_marchandises_en_France

[xiv] CITEO - Household packaging: What are the projected trajectories for 2030? Press briefing - 15 May 2023

https://bo.citeo.com/sites/default/files/2023-05/Citeo_Pr%C3%A9sentation%20conf%C3%A9rence%2015%20mai%203R.pdf

[xv] FNADE - Accelerating the ecological and energy transition in France: FNADE presents a prospective analysis of waste management up to 2050 - 26 January 2023 https://www.fnade.org/fr/kiosque-agenda/cp/4378%2Ccp-fnade-accelerer-concretement-la-transition-ecologique-energetique-france-analyse-prospective-gestion-dechets-horizon-2050?utm_source=chatgpt.com

[xvi] CITEO - Household packaging: What trajectories are forecast for 2030? - Press briefing - 15 May 2023 - https://bo.citeo.com/sites/default/files/2023-05/Citeo_Pr%C3%A9sentation%20conf%C3%A9rence%2015%20mai%203R.pdf

[xvii]European Commission - Environmental Footprint reference packages - https://eplca.jrc.ec.europa.eu/LCDN/developerEF.html

[xviii] GUIOT Marianne, GUEUDET Alice, PARISOT Florian, PASQUIER Sylvain, ADEME, PALLUAU Magali, HUGREL Charlotte, BLEU SAFRAN. 2022. Cadre de Référence - ACV comparatives entre différentes solutions d'emballage | Version 01. 147 p. https://librairie.ademe.fr/dechets-economie-circulaire/5309-cadre-de-reference-acv-comparatives-entre-differentes-solutions-d-emballages.html

[xix] Caroline Gaudreault - Life cycle greenhouse gases and non-renewable energy benefits of kraft black liquor recovery - Published in 2012, https://www.sciencedirect.com/science/article/abs/pii/S0961953412002693?via%3Dihub

[xx]Commercial reference for the PS body - AS N°4 - https://www.manutan.fr/fr/maf/bac-a-bec-gerbable-longueur-230-mm-3-8-l-a025868?utm_source=google&utm_medium=cpc&utm_campaign=GG-PM-M-FR-FR-Top_Products&shopping=true&gad_source=1&gclid=EAIaIQobChMIgYTkhKbajAMVmLRoCR3WcCoyEAQYCyABEgLoYPD_BwE

[xxi]FERPLAST - FLOWPACK FPFM 400 - Consulted on 17/03/2025 https://www.fer-plast.com/fr/produits/emballage/ensacheuses/imbustatrici-orizzontali/confezionatrice-flowpack-fp420-detail

[xxii] Ecoemballage - consulted on 17/03/2025, since https://web.archive.org/web/20190215003021/ecoemballages.fr/sites/default/files/documents/mise_en_ligne_acv_0.pdf

[xxiii] RTE France - Long-term forecast "Energy futures 2050". https://assets.rte-france.com/prod/public/2021-01/Bilan%20Previsionnel%202050-consultation-complet.pdf