



R3PACK – REDUCE, REUSE, RETHINK PACKAGING TOWARDS NOVEL FIBRE-BASED PACKAGING AND REUSE SCHEMES

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LCA Inventory and scenario building

Acronyms

CFF: Circular Footprint Formula

EF: Environmental Footprint

LCA: Life Cycle Assessment

LCI: Life Cycle Inventory

PEF: Product Environmental Footprint

PEFCRs: Product Environmental Footprint Category Rules

PP+M: PreProduction & Manufacturing

Pt= Points

EoL: End-of-life

EF: Environmental Footprint

SoA: State-of-the-art

Sub: Substituted

Definitions

Life cycle Assessment (LCA) – Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14040:2006).

Product Environmental Footprint Category Rules (PEFCRs) – Product category specific, life cycle based rules that complement general methodological guidance for PEF studies by providing further specification at the level of a specific product category. PEFCRs help to shift the focus of the PEF study towards those aspects and parameters that matter the most, and hence contribute to increased relevance, reproducibility and consistency of the results by reducing costs versus a study based on the comprehensive requirements of the PEF method. Only the PEFCRs listed on the European Commission website:

(http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm) are recognised as in line with this method).



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1. INTRODUCTION

The analysis is based on data developed within the R3PACK project, collected in collaboration with the project partners. The data presented in this report refers to already commercialized paper-based materials, which enable a short-term strategy. Therefore, the authors do not consider the results to be generalizable beyond the defined scope. The life cycle inventory data are based on information collected by the project coordinator from the partners. The authors assume no responsibility for the quality, accuracy, or representativeness of the original data, and limit their liability to the processing and assessment carried out within this study.

The primary aim of this document is to compare the state-of-the art product vs the substituted product selected in the previous Deliverable.

As mentioned in D6.2, due to the complexity of obtaining new cellulose-based packaging materials with all the required properties and performances, it was decided to have a short-term strategy for pilot and industrial up-scaling towards a potential demonstration, using mature barrier products commercially available and with a potential compromise on fossil-based content

It was necessary to make several changes respect to the analysis presented in D6.1A due to reasons remarked in D6.2, that are summarized as the follow:

- Variations in product quantities
- Variation in version both of LCA Software and both of Database used
- Implementation of transportation and CFF Formula

Based on these considerations and the change from the D6.1A, the following data have been integrated or modified:

- **LCI:** Update of some tables
- **Results of state-of-the-art product:** (i) New results based on the product quantity and (ii) update of results with integration of transportation and End of Life based on CFF formula

SUBSTITUTION

As Known, the main scope of the Substitution research is to develop renewable fiber-based food packaging solutions, with a **minimum of 90% cellulose-based material**, able to fully substitute existing **complex multi-component** flexible and rigid plastic packaging, the latter called state-of-the-art products.

The first part (A) of D6.1 provided the results of Life Cycle Assessment (LCA) studies related to nine existing packaging (state of the art) selected to be substituted.

Compared to D6.2, Table 1 presents the new information of Product 9 and 10 (both SoA and Sub) and the delating of Product 01. In Annex I the new data collection table of Product 9, 10 and 10-s are reported.

Tab 1. Products considered in the comparative analysis: Single use state-of-the-art packaging and packaging for Substitution

STATE OF THE ART (SUBSTITUTION)		SUBSTITUTION PACKAGING	
Food category: Prepared salad			
Product: Salad MDD			
	Format	PET Tray	Format
	Food weight	250 g	Cardboard bowl + barrier coating
	Company	LSDH	Food weight
	LCA ID	02	250 gr
			Company
		LSDH	
		LCA ID	
		02-s	



Food category: Sour cream			
Product: Yoghurt			
	Format PP Cup Food weight 200 g Company Yoplait LCA ID 03	Format LDPE + Paperboard + HDPE Food weight 200 gr Company Yoplait/SODIAAL LCA ID 03-s	
Food category: Yoghurt			
Product: Greek Yoghurt			
	Format PP Cup Food weight 450 g Company Yoplait LCA ID 04	Format wet molded cellulose + PE Food weight 200 gr Company LCA ID 04-s	
Food category: In-shop product			
Product: Pork chop			
	Format EPS Tray Food weight 500 g Company (none) LCA ID 05	Format cellulosic + modified starch Food weight 1355 ml Company System U & Carrefour LCA ID 05-s	
Food category: Bagged salad			
Product: Florette Mache			
	Format OPP Film Food weight 125 g Company Floréale LCA ID 06	Format Bleached paper + PE Food weight 125 g Company Floréale LCA ID 06-s	
Food category: Butter			
Product: Butter classic			
	Format Aluminium & OPP Film Food weight 250 g Company Sodiaal LCA ID 07	Format Paper + Aluminium + coating Food weight 250 gr Company Sodiaal LCA ID 07-s	
Food category: Cheese			
Product: Grated cheese			
	Format OPA & LDPE Film Food weight 180 g Company Sodiaal LCA ID 08	Format Paper + Aluminium + coating Food weight 180 gr Company Sodiaal LCA ID 08-s	
Food category: Chips			
Product: Peanutes curl			
	Format OPP Film Food weight 250 g Company Altho LCA ID 09	Format Paper + PP Food weight 125 gr Company Altho LCA ID 09-s	

Food category: Savory biscuits	
Product: Savory biscuits	
	Format OPP Sachet
	Food weight 25 g
	Company Europe Snacks
	LCA ID 10
	Format Paper + PP
	Food weight 25 g
	Company Europe Snacks
	LCA ID 10-s

2.1 GOAL OF THE STUDIES

The aim of this study is to compare the paper-based packaging solution selected in WP4 to the “state of the-art” solution. The impact evaluation will be conducted through Life Cycle Assessment (LCA) defined by standards ISO 14040 and 14044, using the SimaPro software (PRé Sustainability). The impact assessment will be carried out considering datasets and environmental indicators defined in the PEF methodology proposed by European Commission. The standard methods to measure the life cycle environmental performances have been included in the Commission Recommendation 2021/2279 published in December 2021. Environmental Footprint (EF) methods are in a transition phase, and – to date – no PEFCRs are available for packaging products.

2.2 SCOPE OF THE STUDIES

a. Functional Unit and reference flow

The Functional Unit of the analyzed system is defined as follows: “The packaging required to contain, protect, and preserve 100 grams of food over the duration of the expected shelf life, to ensure food safety, quality, and integrity throughout the distribution chain”.

Tab 2. Functional Unit aspects

ASPECT	DESCRIPTION
i) Functions or services provided (What)	Contain, preserve, protect food, and provide product information about the product content defined in the “Food category” item in Table 1 (e.g. prepared fruits) throughout the distribution chain.
ii) Extent of the function (How much)	The quantity of product to be packaged is 100 grams.
iii) Expected level of quality (What quality)	Guarantee food safety performance and shelf-life
iv) Duration/lifetime of the product (For how long)	Equal to the food’s expected shelf-life.
Reference Flow	The mass of packaging material required to deliver 100 grams of food.

2.3 SYSTEM BOUNDARY

The nine food categories selected in the state-of-the-art for substitution in R3PACK project have been: bagged salad, butter, cheese, chips, in-shop products, prepared salad, savory biscuits, prepared fruits and yoghurt. The project partners have selected a representative product for each category (both state-of-the-art and substituted product) and are those in Table 1.

The analyses will consider **primary packaging** raw material acquisition and pre-



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processing, manufacturing, distribution stage and end-of-life. Use stage, secondary packaging, packaging-related food waste, packaging geometric features (e.g. emptyability) and the packaging filling phase will be excluded from the system boundary because they are taken as unvaried characteristics for the substitution purpose. All the processes attributed to the packaging are listed in the Life Cycle Inventory (LCI) divided by life cycle stages. Here below, a list of the processes considered for each stage is provided:

- **Raw material acquisition:** this life cycle stage begins when resources are extracted from nature and ends when product components enter the packaging production plant. In particular, it includes the pre-processing of material inputs. The transportation related to the acquisition of raw material is partly modelled by Ecoinvent (embedded in the Market processes, selected whenever available).
- **Pre-processing and Manufacturing:** the production stage begins when the product components enter the production site and ends when the finished product leaves the production facility.
- **Distribution stage:** this phase corresponds to the packaged product's distribution and storage (warehouse/retail). It was assumption as 100 km for each product
- **End-of-life:** this stage begins when the user disposes of the packaging and ends when it is returned to nature as a waste product or enters another product's life cycle (i.e. as a recycled input). In this case, recycling operations, incineration and landfilling are considered. The following analyses will account for recycling, incineration and landfilling-related contributions to define the impact assessment results. A specific waste scenario has been modelled for the analyses considering French data on packaging EoL.

System boundary diagram: the following map in Figure 1 shows the different life cycle stages considered. Pre-processing and Manufacturing phases, Distribution and EoL are merged in the process inventory and in the presentation of the results. Use is not associated with any flow.

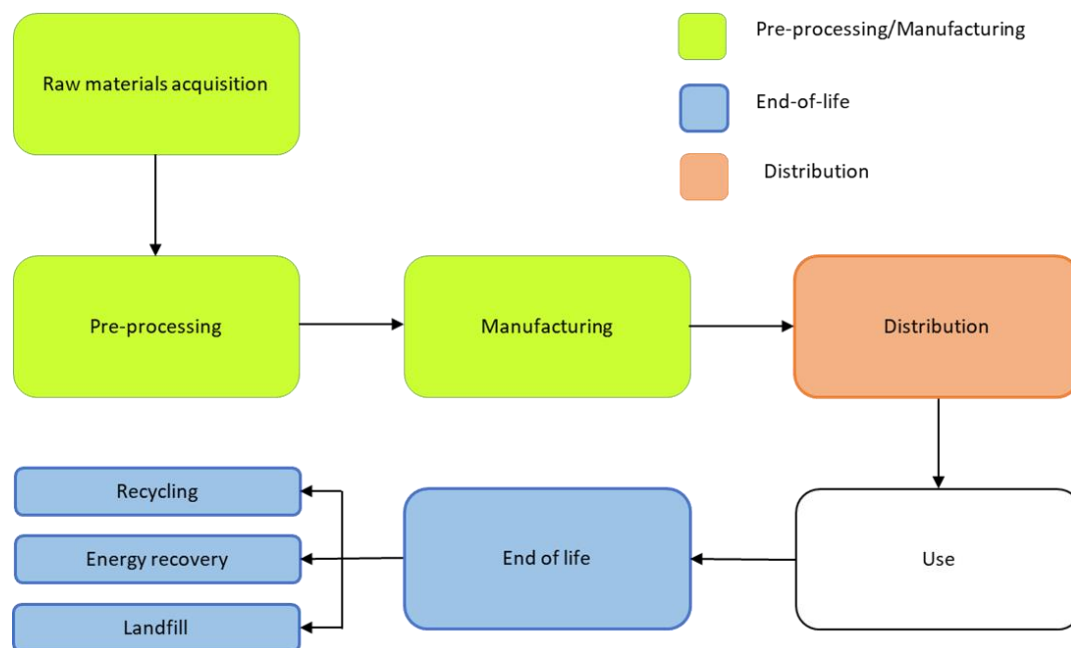


Figure 1: System boundaries diagram.



2.4 ENVIRONMENTAL FOOTPRINT IMPACT CATEGORIES

LCA results are presented through various environmental impact categories. For the impact assessment all the 16 EF (Environmental Footprint) impact categories shown in Table 3 are considered together with an all-encompassing value expressed in Pt obtained by weighting the different categories through appropriate factors. In the interpretation phase, only the most relevant impact categories are considered. Table 3 shows the list of all the EF 3.1 impact categories and related indicators and units are provided¹.

Tab 3. EF 3.1 impact categories and related indicators and units.

Impact category	Indicator	Unit	LCIA method
Acidification	Accumulated Exceedance (AE)	mol H+ eq	Accumulated Exceedance
Climate change	Radiative forcing as Global Warming Potential (GWP100)	kg CO2 eq	Baseline model of 100 years of the IPCC (based on IPCC 2013)
Ecotoxicity, freshwater	Comparative Toxic Unit for ecosystems (CTUe)	CTUe	USEtox model
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	Kg N eq	EUTREND model
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	Kg P eq	EUTREND model
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N eq	Accumulated Exceedance
Human toxicity, cancer	Comparative Toxic Unit for humans (CTUh)	CTUh	USEtox model
Human toxicity, non-cancer	Comparative Toxic Unit for humans (CTUh)	CTUh	USEtox model
Ionising radiation	Human exposure efficiency relative to U235	KBq U-235 eq	Human health effect model
Land use	Soil quality index	Dimensionless (pt)	Soil quality index based on LANCA (ECJRC)
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11 eq	Steady-state ODPs as in (WMO 1999)
Particulate matter	Impact on human health	disease inc.	PM method recommended by UNEP
Photochemical ozone formation	Tropospheric ozone concentration increase	kg NMVOC eq	LOTOS-EUROS model as implemented in ReCiPe 2008
Resource use, fossils	Abiotic resource depletion – fossil fuels (ADP-fossil)	MJ	CML 2002
Resource use, minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb eq	CML 2002
Water use	User deprivation potential (deprivation-weighted water consumption)	m3 depriv.	Available Water REmaining (AWARE)

¹ Zampori, L. and Pant, R., Suggestions for updating the Product Environmental Footprint (PEF) method, EUR 29682 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76- 00654-1, doi:10.2760/424613, JRC11595. § 3.2.3 Environmental Footprint impact categories, Tab. 2



2.5 DATA COLLECTION AND QUALITY

a. Data collection

In the present deliverable, the comparison between the products should have been initially between the state-of-the-art and the new solutions developed in WP4.

As already mentioned, in this deliverable the comparison is made with commercial products identified among those already available on the market.

b. Data quality

To support the initiation of Life Cycle Assessment (LCA) studies, the quality and consistency of the collected data are essential. In the present data collection, regarding Substitution it is possible to see primary and secondary data sources.

In particular, for primary data, detailed information on packaging layers—including materials, weights, manufacturing processes, nominal capacity, and production technology—was provided by (RE)SET, supplemented with reference images to ensure accurate representation. Where detailed information was not available or for some commercial products, reference was made to Ecoinvent database, to ensure a solid and comprehensive basis for our LCA assessments.

The secondary data included in this study cover key aspects such as Material Composition, which provides insights into the packaging materials' families, combining primary data from (RE)SET with supplementary information from the Ecoinvent database. Production Processes are detailed using standardized datasets from the Ecoinvent database, ensuring alignment with industry norms and practices. In some case the dataset was modified with primary data. Finally, End of Life (EoL) processes are sourced from EUROSTAT and the EU Commission.

Temporal Representativeness: The majority of primary data collected pertains to the current operational context. Secondary data were sourced from the most recent datasets available in Ecoinvent, ensuring alignment with to date industry practices.

Geographical Representativeness: Primary data about the distribution transports provides insights into specific operational sites and logistical routes, offering a clear and precise geographical scope. For secondary data, Ecoinvent datasets related to processes and materials have been aligned with the French Energy Mix. End-of-Life (EoL) rates, including recycling, landfill, and incineration percentages, are based on French national data.

Technological Representativeness: Primary data captures the specific technologies involved in packaging manufacturing, detailing each layer's material composition and associated production processes. Secondary data reflects industry-standard practices for material characteristics and EoL management.

Completeness: Primary data comprehensively covers all major life cycle stages, enriched by specific secondary data on materials, production processes, and EoL considerations.

Methodological Consistency: The integration of primary and secondary data follows a harmonized approach aligned with the PEF framework. To fill remaining data gaps, Ecoinvent datasets, have been utilized to ensure robustness and consistency in the LCA assessments.

It is also worth noting that the quality of the data collected for substitution is aligned with the data obtained for the state of the art, ensuring that these studies remain comparable. Despite these challenges, the data collected so far, supplemented by Ecoinvent, provides a solid foundation for LCA studies, with further refinements expected to enhance the accuracy and reliability of the assessments.



2.6 LCI – LIFE CYCLE INVENTORY

In this paragraph, the inventory tables are provided and organized to keep the various phases of the packaging life cycle separate as described in the system boundary diagram.

PRE-PROCESSING AND MANUFACTURING LCI

Some tables are changed from deliverable 6.2 due to the new information received. The product 10.0 LCI is also changed due to a different state-of-the-art product choose from the company for comparison with the new one.

Here below, for each state-of-the-art and substituted product, a table describing the pre-processing (PP) and manufacturing (M) processes of the packaging is provided. The inventory is structured as a bill of materials: each component that makes the product up is associated with a position number that reflects the structure of the assemblies; quantity and weight in grams are indicated for each component/assembly and are referred to the FU (**100 grams** of product). Regarding pre-processing, the material (as declared by the company in the data collection form) is indicated for each layer, together with the corresponding raw material selected in SimaPro.

With respect to manufacturing, a description of the processes used and an indication of the corresponding processes in Ecoinvent is provided. If the original datasets have been modified to adapt them to the Inventory or to the French context, all the modifications made are reported in a dedicated column.

In correspondence with each table, any limitations and assumptions made during the compilation of the inventory are reported.



PRODUCT 02

• STATE OF THE ART - TABLE A2, PP-M LCI, – Salad MDD, PET Tray

Assumptions and limitations: no information has been provided regarding eventual printing processes and related inks or other labels, which therefore were not included in the analysis.

Tab A2. PP-M LCI, PRODUCT 02 – Salad MDD, PET Tray

TABLE A2			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
2	PET Tray	12	/	/	Inline manual closing	/	/
2.1	PET Lid	4	PET	Polyethylene terephthalate, granulate, amorphous {RER} production	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing	/
2.2	PET Bowl	8	PET	Polyethylene terephthalate, granulate, amorphous {RER} production	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing	/

• SUBSTITUTION - TABLE (B2), PP-M LCI, – Prepared Salad, Cardboard Tray

Assumptions and limitations: no information has been provided regarding eventual printing processes and related inks or other labels, which therefore were not included

For the Cardboard cup (2.2-s) has been used a dataset for the production of Liquid packaging board for the body and a dataset for a starch biopolymer product for the plant-based coating

Tab B2. PP-M LCI, PRODUCT 02-s – Prepared Salad, Cardboard Tray

TABLE B2			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
2-s	Cardboard Tray	4,604	/	/	/	/	/
2.1-s	PET foil Lid	0,004	PET	Polyethylene terephthalate, granulate, amorphous {RER} production	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing	/
2.2-s	Cardboard cup	/	/	/	/	/	/
2.3-s	Cardboard cup - paper	3,68	Cardboard	Liquid packaging board {RER} liquid packaging board production	/	/	/
2.4-s	Cardboard cup - coating	0,92	Plant based coating	Polyester-complexed starch biopolymer {RER} polyester-complexed starch biopolymer production	/	/	/



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PRODUCT 03

• STATE OF THE ART - TABLE A3, PP-M LCI, – Sour cream, Cup

Assumptions and limitations: the sealing process for components 3.2 and 3.3 and the closing process for components 3.1 and 3.3 have been omitted due to the lack of specific information retrieved in the data collection and suitable Ecoinvent datasets. The manufacturing process for the monolayer Aluminum Lid (3.2) was not declared, thus, sheet rolling was assumed as the most suitable option. Furthermore, no information has been provided regarding eventual printing processes and related ink, which therefore were not included in the analysis.

Tab A3. PP-M LCI, PRODUCT 03 – Sour cream, Cup

TABLE A3			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
3	Cup	6,18	/	/	Inline closing and sealing	/	/
3.1	PET Overcap	1,525	PET	Polyethylene terephthalate, granulate, amorphous {RER} production	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing	/
3.2	Aluminium Lid	0,405	Aluminum	Aluminium alloy, AlMg3 {GLO} market for	Sheet rolling	Sheet rolling, aluminium {RER} processing	• Water, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for
3.3	PP Bowl	4,25	PP	Polypropylene, granulate {RER} production	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing	/



• **SUBSTITUTION - TABLE (B3), PP-M LCI, – Sour cream, Paper Cup**

Assumption and limitations: in data collection, the dimensions are assumed and lid and overcap are assumed as the same as state-of-the-art product 03.

The sealing process for components 3.2-s and 3.3-s and the closing process for components 3.1-s and 3.3-s have been omitted due to the lack of specific information retrieved in the data collection and suitable Ecoinvent datasets. The manufacturing process for the monolayer Aluminum Lid (3.2-s) was not declared, thus, sheet rolling was assumed as the most suitable option. Furthermore, no information has been provided regarding possible printing processes and related ink, which therefore were not included in the analysis.

Tab B3. PP-M LCI, PRODUCT 03-s – Sour cream, Paper Cup

TABLE B3			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
3-s	Cup	4,95	/	/	/	/	/
3.1-s	PET Overcap	1,525	PET	Polyethylene terephthalate, granulate, amorphous {RER} production	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing	/
3.2-s	Aluminum Lid	0,405	Aluminum	Aluminium alloy, AlMg3 {GLO} market for	Sheet rolling	Sheet rolling, aluminium {RER} processing	• Water, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for
3.3-s	Paper based cup	/	/	/	Pulping, bleaching, calendering	Thermoforming, with calendering {RER} thermoforming, with calendering	/
3.4-s	Cup layer 1	0,37	HDPE	Polyethylene, high density, granulate {RER} polyethylene production, high density, granulate	Extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for
3.5-s	Cup layer 2	2,44	Paper/Card board	Sulfate pulp, bleached {RER} market for sulfate pulp, bleached	/	/	/
3.6-s	Cup layer 3	0,21	LDPE	Polyethylene, linear low density, granulate {RER} polyethylene production, linear low density, granulate	Extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for

PRODUCT 04

• STATE OF THE ART - TABLE A4, PP-M LCI, – Greek yoghurt, Cup

Assumptions and limitations: the sealing process for components 4.2 and 4.3 and the closing process for components 4.1 and 4.3 have been omitted due to the lack of specific information retrieved in the data collection and suitable Ecoinvent datasets. The manufacturing process for the monolayer Aluminium Lid (4.2) was not declared, thus, sheet rolling was assumed as the most suitable option. Furthermore, no information has been provided regarding eventual printing processes and related ink, which therefore were not included in the analysis.

Tab A4. PP-M LCI, PRODUCT 04 – Greek yoghurt, Cup

TABLE A4			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
4	Cup	4,5	/	/	Inline closing and sealing	/	/
4.1	PET Overcap	1,11	PET	Polyethylene terephthalate, granulate, amorphous {RER} production	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR}	/
4.2	Aluminium Lid	0,278	Aluminium	Aluminium alloy, AlMg3 {GLO} market for	Sheet rolling	Sheet rolling, aluminium {RER} processing	• Water, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for
4.3	PP Bowl	3,11	PP	Polypropylene, granulate {RER} production	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing	/

• SUBSTITUTION - TABLE (B4), PP-M LCI, – Greek yoghurt, Paper Cup

Note: All the assumption are taken from the Technical data sheet

Tab B4. PP-M LCI, PRODUCT 04-s – Greek yoghurt, Paper Cup

TABLE B4			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
4-s	Cup	5,37	/	/	Thermoforming	Thermoforming of plastic sheets {FR}	/
4.1-s	Moulded pulp	5	Virgin bleached pulp	Sulfate pulp, bleached {RER} market for sulfate pulp, bleached	/	/	/
4.2-s	PE film	0,37	LDPE	Polyethylene, linear low density, granulate {RER} polyethylene production, linear low density, granulate	Extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for



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PRODUCT 05

• STATE OF THE ART - TABLE A5, PP-M LCI, – Pork chop, Wrapped Tray

Note: for the “In-shop products” food category a specific EPS tray was not supplied by the partners, therefore a suitable one for the reference product (2 pork chops) was selected by the authors. Specifically, the product is made up of an expanded polystyrene tray and a PVC film.

Assumptions and limitations: the wrapping process (manual or automatic) has been omitted as considered negligible and due to the absence of suitable Ecoinvent datasets.

Tab A5. PP-M LCI, PRODUCT 05 – Pork chop, Wrapped Tray

TABLE A5			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
5	Wrapped Tray	2,76	/	/	Wrapping	/	/
5.1	PVC Wrapping Film	0,58	PVC	Polyvinylchloride, suspension polymerised {RER} polyvinylchloride production, suspension polymerisation	Bubble extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for
5.2	PSE Tray	2,18	EPS	Polystyrene, expandable {RER} production	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR}	/
					Foaming	Polymer foaming {RER} processing	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for



• **SUBSTITUTION - TABLE (B5), PP-M LCI, – Pork chop, Cellulose tray**

Note: No info about the lid/wrapping film. For wrapping film (5.3-s) has been used the same amount and type of state-of-the rt wrapping film (5.1)

Assumption: the type of pulp (5.1-s) has been considered as the same of product 04-s

Tab B5. PP-M LCI, PRODUCT 05-s – Pork chop, Cellulose tray

TABLE B5			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
5-s	Cellulose tray	3,6	/	/	Thermoforming	Thermoforming of plastic sheets {FR} thermoforming of plastic sheets	/
5.1-s	wet molded cellulose	2,9		Sulfate pulp, bleached {RER} market for sulfate pulp, bleached			
5.2-s	biofilm	0,12	cellulosic emulsion + modified starch	Polyester-complexed starch biopolymer {RER} polyester-complexed starch biopolymer production			
5.3-s	PVC Wrapping Film	0,58	PVC	Polyvinylchloride, suspension polymerised {RER} polyvinylchloride production, suspension polymerisation	Bubble extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film	- Water, cooling, unspecified natural origin, FR; - Electricity, medium voltage {FR} market for



PRODUCT 06

• STATE OF THE ART - TABLE A6, PP-M LCI, – Florette Mache, OPP Film

Assumptions and limitations: The laminating process (6.2) has been modified changing the typology of adhesive (Polyurethane adhesive instead of acrylic binder as specified in data collection). The printing process has been omitted due to the absence of suitable Ecoinvent datasets, only the date of ink has been considered.

Tab A6. PP-M LCI, PRODUCT 06 – Florette Mache, OPP Film

TABLE A6			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
6	Bag	4,464	/	/	/		/
6.1	OPP Film	0,128	Ink	Printing ink, offset, without solvent, in 47% solution state {RER}	Printing Ink	/	/
6.2	OPP Film	0,256	Adhesive	Polyurethane adhesive {GLO} market for polyurethane adhesive	Lamination	Laminating service, foil, with acrylic binder {RER} processing	- Amount of Polyurethane - Electricity, medium voltage {FR} market
6.3	PP Foil	4,08	PP	Polypropylene, granulate {RER} production	Extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film	- Water, cooling, unspecified natural origin, FR; - Electricity, medium voltage {FR} market

• SUBSTITUTION - TABLE (B6), PP-M LCI, – Florette Mache, Paper/PE bag

Assumptions and limitations: The bag dimensions and the amount of adhesive and ink are assumed as the same as plastics products.

For the Paper/PE bag (6.1-s) has been used a dataset to produce an "average European paper sack", which is a hybrid mix of all types of multiwall paper sacks in Europe. It mixes brown (unbleached) and white (bleached) sack kraft paper, LDPE and HDPE plastic liners and different kinds of glues, all in one.

This dataset is modified with the value of Paper, PE and Ink collected in the Data Collection table.

Tab B6. PP-M LCI, PRODUCT 06-s – Florette Mache, Paper/PE bag

TABLE B6			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
6-s	Bag	/	/	/	/	/	/
6.1-s	Paper & PE bag	10,24	/	/	/	Paper sack {RER} paper sack production	- Variation amount paper, PE and ink - Electricity, medium voltage {FR} market for



PRODUCT 07

• STATE OF THE ART - TABLE A7, PP-M LCI, – Butter, Aluminium & OPP Film

Assumptions and limitations: The manufacturing process for the layer Aluminium Lid (7.2) was not declared, thus, sheet rolling was assumed as the most suitable option.

Tab A7. PP-M LCI, PRODUCT 07 – Butter, Aluminium & OPP Film

TABLE A7			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
7	Aluminium & OPP Film	0,78	/	/	Lamination	Laminating service, foil, with acrylic binder {RER} processing	• Electricity, medium voltage {FR} market for
7.1	OPP Film	0,512	PP	Polypropylene, granulate {RER} production	Extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for
7.2	Aluminium Lid	0,268	Aluminium	Aluminium alloy, AlMg3 {GLO} market for	Sheet rolling	Sheet rolling, aluminium {RER} processing	• Water, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for

• SUBSTITUTION - TABLE (B7), PP-M LCI, – Butter, Aluminium & Paper Film

Note: Not a lot of details for this product from data collection

Assumptions and limitations: The dimensions and grammage are assumed.

Dataset for Greaseproof base paper (7.2-s) is not present in Ecoinvent, a generic Kraft paper dataset was used.

No information about type of coating or type of material for coating has been provide, it has been entered only the quantity in the inventory.

Tab B7. PP-M LCI, PRODUCT 07-s – Butter, Aluminium & Paper Film

TABLE B7			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
7-s	Aluminium & Paper film	1,32	/	/	Lamination	Laminating service, foil, with acrylic binder {RER}	Electricity, medium voltage {FR} market
7.1-s	Printable top-coating	0,0528	/	/	Blade coating	/	/
7.2-s	Greaseproof base paper	1,232		Kraft paper {RER} market for kraft paper	/	/	/
7.3-s	Aluminium	0,0016	Aluminum	Aluminium alloy, AlMg3 {GLO} market for	Sheet rolling	Sheet rolling, aluminium {RER} processing	• Water, unspecified natural origin, FR; • Electricity, medium voltage {FR} market
7.4-s	Pre-coating	0,0352	/	/	Blade coating	/	/



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PRODUCT 08

• STATE OF THE ART - TABLE A8, PP-M LCI, – Grated cheese, OPA & LDPE Film

Assumptions and limitations: The printing process has been omitted due to the absence of suitable Ecoinvent datasets, only the date of ink has been considered.

Tab A8. PP-M LCI, PRODUCT 08 – Grated cheese, OPA & LDPE Film

TABLE A8			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
8	Grated Cheese Bag	2,811	/	/	/		/
8.1	OPA & LDPE Film	0,0611	Ink	Printing ink, offset, without solvent, in 47% solution state {RER}	Printing Ink	/	/
8.2	Complexing Film	0,0833	Adhesive	Acrylic binder, with water, in 54% solution state {RER}	Lamination	Laminating service, foil, with acrylic binder {RER}	• Electricity, medium voltage {FR} market
8.3	LDPE Foil	1,944	LDPE	Polyethylene, linear low density, granulate {RER} polyethylene production, linear low density, granulate	Extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market
8.4	OPA Foil	0,722	PA	Nylon 6 {RER}	Extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market



• **SUBSTITUTION - TABLE (B8), PP-M LCI, – Grated cheese, Paper bag**

Assumptions and limitations: The dimensions are assumed to be the same as plastic products. The amount of aluminum nanolayer is an assumption of the grammage; amount of ink is assumed as the same as plastic product.

No information about type of coating or type of material for coating has been provide, it has been entered only the quantity in the inventory.

Tab B8. PP-M LCI, PRODUCT 08-s – Grated cheese, Paper bag

TABLE B8			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
8-s	Grated Cheese Paper Bag	3,7	/	/	/	/	/
8.1-s	Paper & Aluminum bag	0,083	Ink	Printing ink, offset, without solvent, in 47% solution state {RER}	/	/	/
8.2-s	Paper	3.4	Paper	Kraft paper {RER} kraft paper production	/	/	/
8.3-s	Coating 1	0.083	/	/	Lamination	Laminating service, foil, with acrylic binder {RER} processing	• Electricity, medium voltage {FR} market for
8.4-s	Aluminum Nanolayer	0,0044	Aluminum	/	Vacuum metallization	Sheet rolling, aluminium {FR} processing	/
8.5-s	Top-coating	0,128	/	/	Lamination	Laminating service, foil, with acrylic binder {RER} processing	Electricity, medium voltage {FR} market for



PRODUCT 09

• STATE OF THE ART - TABLE A9, PP-M LCI, – Peanut curl, OPP Film

Assumptions and limitations: The Metallization process for OPP film (9.2) has been omitted due to the lack of specific information retrieved in the data collection (type of metal and type of process). The printing process has been omitted due to the absence of suitable Ecoinvent datasets, only the date of ink has been considered.

Tab A9. PP-M LCI, PRODUCT 09 – Peanut curl, OPP Film

TABLE A9			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
9	Bag	3.242	/	/	/		/
9.1	OPP Film	0,2496	Ink	Printing ink, offset, without solvent, in 47% solution state {RER}	Printing Ink	/	/
9.2	OPP Film	0,1808	Adhesive	Polyurethane adhesive {GLO} market for polyurethane adhesive	Lamination	Laminating service, foil, with acrylic binder {RER} processing	• Amount of Polyurethane • Electricity, medium voltage {FR} market
9.3	PP Foil	2.812	PP	Polypropylene, granulate {RER} production	Extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for

• SUBSTITUTION - TABLE (B9), PP-M LCI, – Peanut curl, Paper & PP bag

Assumptions and limitations: The dimensions are assumed as the same as plastics products

For the Paper/PP bag (9.1-s) has been used a dataset to produce an "average European paper sack", which is a hybrid mix of all types of multiwall paper sacks in Europe. It mixes brown (unbleached) and white (bleached) sack kraft paper, LDPE and HDPE plastic liners and different kinds of glues, all in one.

This dataset is modified with the value of Paper, PP and Ink collected in the Data Collection table.

Tab B9. PP-M LCI, PRODUCT 09-s – Peanut curl, Paper & PP bag

TABLE B9			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
9-s	Bag	4,8	/	/	/	/	/
9.1-s	Paper & PP bag	4,8	/	/	/	Paper sack {RER} paper sack production	• Variation amount paper, PP and ink • Electricity, medium voltage {FR} market for



PRODUCT 10

• STATE OF THE ART - TABLE A10, PP-M LCI, – Savory biscuits, OPP Film

Assumptions and limitations: The metallization process for OPP film (10.1) has been omitted due to the lack of specific information retrieved in the data collection (type of metal and type of process).

The printing process has been omitted due to the absence of suitable Ecoinvent datasets, only the date of ink has been considered.

Tab A10. PP-M LCI, PRODUCT 10 – Savory biscuits, OPP

TABLE B10			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
10	Savory Biscuit	3,63	/	/	/		/
10.1	OPP Film	0,23	Adhesive	Acrylic binder, with water, in 54% solution state {RER}	Lamination	Laminating service, foil, with acrylic binder {RER} processing	• Variation type and amount of adhesive • Electricity, medium voltage {FR} market
		0,18	Ink	Printing ink, offset, without solvent, in 47% solution state {RER}	Printing Ink	/	/
10.2	PP Foil	3,22	PP	Polypropylene, granulate {RER} production	Extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for

• SUBSTITUTION - TABLE (B10), PP-M LCI, – Savory biscuits, Paper & PP bag

Assumptions and limitations: The dimensions are assumed as the same as plastics products

For the Paper/PP bag (10.1-s) has been used a dataset to produce an "average European paper sack", which is a hybrid mix of all types of multiwall paper sacks in Europe. It mixes brown (unbleached) and white (bleached) sack kraft paper, LDPE and HDPE plastic liners and different kinds of glues, all in one. This dataset is modified with the value of Paper, PP and Ink collected in the Data Collection table.

Tab B10. PP-M LCI, PRODUCT 10-s – Savory biscuits, Paper&PP bag

TABLE B10			PRE-PROCESSING		MANUFACTURING		
ID	Description	Weight per 100g of product [g]	Material	Material (Ecoinvent dataset)	Processing	Processing (Original Ecoinvent dataset)	Processing variations (available FR datasets)
10-s	Bag	7,39	/	/	/	/	/
10.1-s	Paper & PP bag	7,39	/	/	/	Paper sack {RER} paper sack production	• Variation amount paper, PP and ink • Electricity, medium voltage {FR} market for



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TRANSPORTS

The inventory data for the transport phase was assumption as 100 km for each product, both state-of-the-art and substituted product.

The dataset used was “Transport, freight, lorry, unspecified {RER} transport, freight, lorry, all sizes, EURO5 to generic market for transport, freight, lorry, unspecified”

End of Life (EoL): MATERIALS RECOVERY MODELLING CHOICES - CFF APPLICATION

In order to calculate credits and impacts connected to recycling and energy recovery in the PEF Method, the use of the Circular Footprint Formula (CFF) is prescribed². CFF is composed of three parts corresponding, respectively, to material, energy and disposal (Fig. 2).

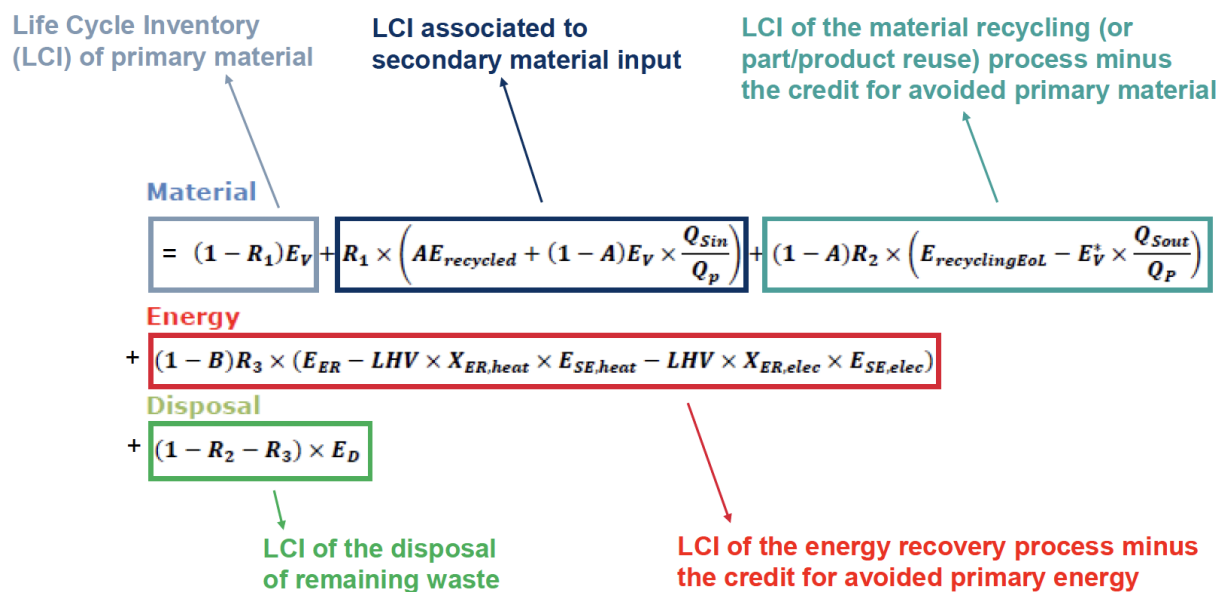


Figure 2: Circular Footprint Formula (CFF)

The CFF allows the connection with subsequent and preceding life cycles via debiting (Fig. 4, left) and crediting (Fig. 4, right) which in the cut-off approach, are not considered³.

² Zampori, L. and Pant, R., Suggestions for updating the Product Environmental Footprint (PEF) method, EUR 29682 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76- 00654-1, doi:10.2760/424613, JRC11595. § 4.4.8.1 The Circular Footprint Formula (CFF)

³ Wolf, M. A., The Circular Footprint Formula (CFF) and its practical application training. Environmental Footprint (EF) transition phase, 2019. Webinar available in: <https://ec.europa.eu/environment/eussd/videos/2019-10-08%2016.01%20The%20Circular%20Footprint%20Formula.mp4>



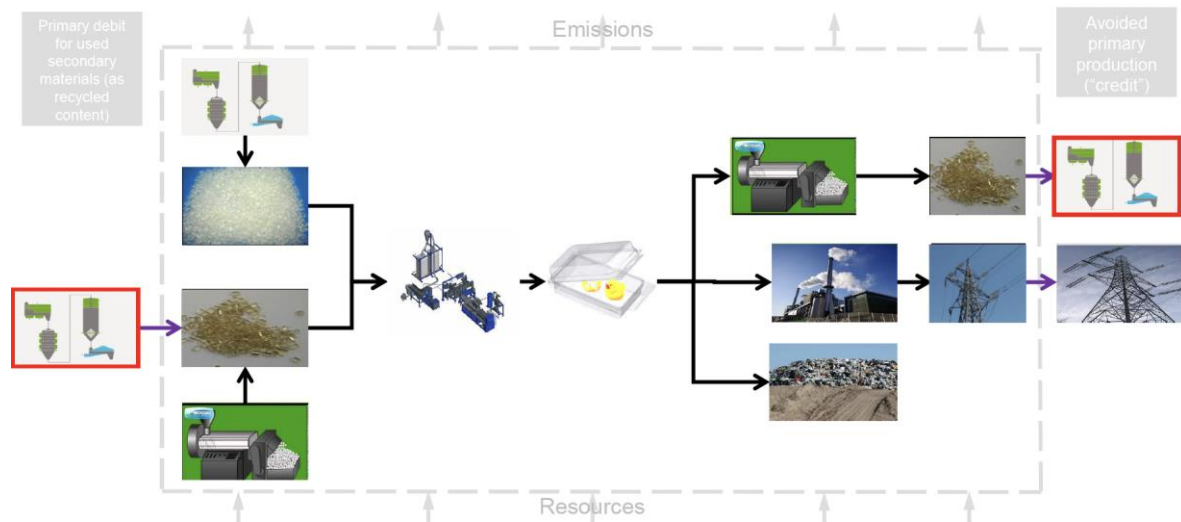


Figure 3: CFF debiting (left) and crediting (right)

Circular Footprint Formula will be implemented in the following deliverable thanks to the recent release of the new EF 3.1 database⁴ containing the needed datasets for the calculation in SimaPro.

This deliverable compiles a list of datasets and parameters that will be implemented in the formula. The selected datasets come from the ecoinvent Cut-Off database, ensuring compliance with the current restrictions on publishing EF dataset assessment results.

Tab 5. CFF parameters - end-of-life processes

MATERIAL	PROCESS	PARAMETER	VALUE	SOURCE
CARDBOARD	CARDBOARD Recycle	R_2	0,75	RCP Made Green in Italy "Pere"
		E^*v	Sulfate pulp, unbleached {RER} sulfate pulp production, from softwood, unbleached Cut-off, U	RCP Made Green in Italy "Pere"
		$E_{recyclingEOL}$	Waste paper, sorted {Europe without Switzerland} treatment of waste paper, unsorted, sorting Cut-off, U	RCP Made Green in Italy "Pere"
		A	0,2	Annex C
		Q_{SOUT}/Q_P	0,85	Annex C
	CARDBOARD Disposal	D	0,14	
		E_d	Waste paperboard {CH} treatment of, sanitary landfill Cut-off, U	RCP Made Green in Italy "Pere"
	CARDBOARD Energy Recovery	R_3	0,11	RCP Made Green in Italy "Pere"
		E_{ER}	Waste paperboard {CH} treatment of, municipal incineration Cut-off, U	RCP Made Green in Italy "Pere"
		$E_{SE,heat}$	Heat, central or small-scale, natural gas {RER} market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		$E_{SE,elec}$	Electricity, high voltage {Europe without Switzerland} market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		LHV	19,7	GRANTA CES
		$X_{ER,heat}$	0,31	RCP Made Green in Italy "Scatole in cartone ondulato"
		$X_{ER,elec}$	0,101	RCP Made Green in Italy "Scatole in cartone ondulato"
		B	0	ANNEX C

⁴ Environmental Footprint database 3.1: <https://simapro.com/products/environmental-footprint-database/>

MATERIAL	PROCESS	PARAMETER	VALUE	SOURCE
PET	PET Recycle	R_2	0,27	Plastics Europe, 2022
		E^*v	Polyethylene terephthalate, granulate, bottle grade (CH) polyethylene terephthalate, granulate, bottle grade, recycled to generic market for bottle grade PET granulate Cut-off, U	RCP Made Green in Italy "Gelato in vaschetta e multipack"
		$E_{recyclingBoL}$	Polyethylene terephthalate, granulate, amorphous, recycled (Europe without Switzerland) market for polyethylene terephthalate, granulate, amorphous, recycled Cut-off, U	RCP Made Green in Italy "Gelato in vaschetta e multipack"
		A	0,5	ANNEX C
		Q_{Sout}/Q_p	0,9	ANNEX C, PET mechanical recycling
	PET Disposal	D	0,29	Plastics Europe, 2022
		E_d	Waste polyethylene terephthalate (Europe without Switzerland) treatment of waste polyethylene terephthalate, sanitary landfill Cut-off, U	RCP Made Green in Italy "Gelato in vaschetta e multipack"
	PET Energy Recovery	R_3	0,44	Plastics Europe, 2022
		E_{ER}	Waste polyethylene terephthalate (Europe without Switzerland) treatment of waste polyethylene terephthalate, municipal incineration Cut-off, U	RCP Made Green in Italy "Gelato in vaschetta e multipack"
		$E_{SE,heat}$	Heat, central or small-scale, natural gas (RER) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		$E_{SE,elec}$	Electricity, high voltage (Europe without Switzerland) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		LHV	23,6	GRANTA CES
		$X_{ER,heat}$	0,31	RCP Made Green in Italy "Scatole in cartone ondulato"
		$X_{ER,elec}$	0,101	RCP Made Green in Italy "Scatole in cartone ondulato"
		B	0	ANNEX C
		R_2	0,58	Citeo Adelphe, 2021
		E^*v	Aluminium alloy, AlMg3 (GLO) market for aluminium alloy, AlMg3 Cut-off, U	
		$E_{recyclingBoL}$	Aluminium scrap, post-consumer (GLO) market for aluminium scrap, post-consumer Cut-off, U	
		A	0,2	ANNEX C
		Q_{Sout}/Q_p	1	ANNEX C
ALUMINIUM FOIL	ALUMINIUM FOIL Recycle	D	0,42	Eurostat, 2018
		E_d	Waste aluminium (RoW) treatment of waste aluminium, sanitary landfill Cut-off, U	
	ALUMINIUM FOIL Disposal	R_3	0	
		E_{ER}	-	
		$E_{SE,heat}$	Heat, central or small-scale, natural gas (RER) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		$E_{SE,elec}$	Electricity, high voltage (Europe without Switzerland) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		LHV	0	GRANTA CES
		$X_{ER,heat}$	0,31	RCP Made Green in Italy "Scatole in cartone ondulato"
		$X_{ER,elec}$	0,101	RCP Made Green in Italy "Scatole in cartone ondulato"
		B	0	ANNEX C
	ALUMINIUM FOIL Energy Recovery	R_2	0,27	Plastics Europe, 2022
		E^*v	Polypropylene, granulate (RER) production Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		$E_{recyclingBoL}$	Polyethylene, high density, granulate, recycled (Europe without Switzerland) polyethylene production, high density, granulate, recycled Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		A	0,5	ANNEX C
		Q_{Sout}/Q_p	0,9	ANNEX C
PP	PP Recycle	D	0,39	Plastics Europe, 2022
		E_d	Waste polypropylene (CH) treatment of, sanitary landfill Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
	PP Disposal	R_3	0,44	Plastics Europe, 2022
		E_{ER}	Waste polypropylene (CH) treatment of, municipal incineration Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		$E_{SE,heat}$	Heat, central or small-scale, natural gas (RER) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		$E_{SE,elec}$	Electricity, high voltage (Europe without Switzerland) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		LHV	44,3	GRANTA CES
		$X_{ER,heat}$	0,31	RCP Made Green in Italy "Scatole in cartone ondulato"
		$X_{ER,elec}$	0,101	RCP Made Green in Italy "Scatole in cartone ondulato"
		B	0	ANNEX C
	PP Energy Recovery	R_2	0,27	Plastics Europe, 2022
		E^*v	Polypropylene, granulate (RER) production Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		$E_{recyclingBoL}$	Polyethylene, high density, granulate, recycled (Europe without Switzerland) polyethylene production, high density, granulate, recycled Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		A	0,5	ANNEX C
		Q_{Sout}/Q_p	0,9	ANNEX C

MATERIAL	PROCESS	PARAMETER	VALUE	SOURCE
PVC	PVC Recycle	R_2	0,27	Plastics Europe, 2022
		E^*v	Polyvinylchloride, suspension polymerised (GLO) market for polyvinylchloride, suspension polymerised Cut-off, U	
		$E_{recyclingBoL}$	Polyethylene terephthalate, granulate, amorphous, recycled (Europe without Switzerland) polyethylene terephthalate production, granulate, amorphous, recycled Cut-off, U	
		A	0,5	ANNEX C
		Q_{sout}/Q_p	0,75	ANNEX C
	PVC Disposal	D	0,29	Plastics Europe, 2022
		E_d	Waste polyvinylchloride (CH) treatment of, sanitary landfill Cut-off, U	
		R_3	0,44	Plastics Europe, 2022
	PVC Energy Recovery	E_{ER}	Waste polyvinylchloride (CH) treatment of, municipal incineration Cut-off, U	
		$E_{se,heat}$	Heat, central or small-scale, natural gas (RER) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		$E_{se,elec}$	Electricity, high voltage (Europe without Switzerland) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		LHV	17,95	GRANTA CES
		$X_{ER,heat}$	0,31	RCP Made Green in Italy "Scatole in cartone ondulato"
		$X_{ER,elec}$	0,101	RCP Made Green in Italy "Scatole in cartone ondulato"
		B	0	ANNEX C
EPS	EPS Recycle	R_2	0,27	Plastics Europe, 2022
		E^*v	Polystyrene, expandable (RoW) polystyrene production, expandable Cut-off, U	
		$E_{recyclingBoL}$	Polyethylene terephthalate, granulate, amorphous, recycled (Europe without Switzerland) polyethylene terephthalate production, granulate, amorphous, recycled Cut-off, U	
		A	0,5	ANNEX C
		Q_{sout}/Q_p	0,9	ANNEX C
	EPS Disposal	D	0,29	Plastics Europe, 2022
		E_d	Waste polystyrene (CH) treatment of, sanitary landfill Cut-off, U	
		R_3	0,44	Plastics Europe, 2022
	EPS Energy Recovery	E_{ER}	Waste expanded polystyrene (CH) treatment of, municipal incineration Cut-off, U	
		$E_{se,heat}$	Heat, central or small-scale, natural gas (RER) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		$E_{se,elec}$	Electricity, high voltage (Europe without Switzerland) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		LHV	41,1	GRANTA CES
		$X_{ER,heat}$	0,31	RCP Made Green in Italy "Scatole in cartone ondulato"
		$X_{ER,elec}$	0,101	RCP Made Green in Italy "Scatole in cartone ondulato"
		B	0	ANNEX C
LDPE	LDPE Recycle	R_2	0,29	Plastics Europe, 2022
		E^*v	Polyethylene, low density, granulate (RER) production Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		$E_{recyclingBoL}$	Polyethylene, high density, granulate, recycled (Europe without Switzerland) polyethylene production, high density, granulate, recycled Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		A	0,5	ANNEX C
		Q_{sout}/Q_p	0,75	ANNEX C
	LDPE Disposal	D	0,39	Plastics Europe, 2022
		E_d	Waste polyethylene (CH) treatment of, sanitary landfill Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		R_3	0,32	Plastics Europe, 2022
	LDPE Energy Recovery	E_{ER}	Waste polyethylene (CH) treatment of, municipal incineration Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		$E_{se,heat}$	Heat, central or small-scale, natural gas (RER) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		$E_{se,elec}$	Electricity, high voltage (Europe without Switzerland) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		LHV	42,27	GRANTA CES
		$X_{ER,heat}$	0,31	RCP Made Green in Italy "Scatole in cartone ondulato"
		$X_{ER,elec}$	0,101	RCP Made Green in Italy "Scatole in cartone ondulato"
		B	0	ANNEX C

MATERIAL	PROCESS	PARAMETER	VALUE	SOURCE
PA	PA Recycle	R_2	0,27	Plastics Europe, 2022
		E^*v	Nylon 6 (RER) market for nylon 6 Cut-off, U	
		$E_{recycling\&ol}$	Polyethylene terephthalate, granulate, amorphous, recycled (Europe without Switzerland) polyethylene terephthalate production, granulate, amorphous, recycled Cut-off, U	
		A	0,5	ANNEX C
		Q_{sout}/Q_p	0,75	ANNEX C
	PA Disposal	D	0,29	Plastics Europe, 2022
		E_d	Waste plastic, mixture (CH) treatment of waste plastic, mixture, sanitary landfill Cut-off, U	
	PA Energy Recovery	R_3	0,44	Plastics Europe, 2022
		E_{ER}	Waste plastic, mixture (CH) treatment of waste plastic, mixture, municipal incineration Cut-off, U	
		$E_{SE,heat}$	Heat, central or small-scale, natural gas (RER) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		$E_{SE,elec}$	Electricity, high voltage (Europe without Switzerland) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		LHV	30,85	GRANTA CES
		$X_{ER,heat}$	0,31	RCP Made Green in Italy "Scatole in cartone ondulato"
		$X_{ER,elec}$	0,101	RCP Made Green in Italy "Scatole in cartone ondulato"
		B	0	ANNEX C
HDPE	HDPE Recycle	R_2	0,29	Plastics Europe, 2022
		E^*v	Polyethylene, low density, granulate (RER) production Cut-off, U	
		$E_{recycling\&ol}$	Polyethylene, high density, granulate, recycled (Europe without Switzerland) polyethylene production, high density, granulate, recycled Cut-off, U	
		A	0,5	ANNEX C
		Q_{sout}/Q_p	0,75	ANNEX C
	HDPE Disposal	D	0,39	Plastics Europe, 2022
		E_d	Waste polyethylene (CH) treatment of, sanitary landfill Cut-off, U	
	HDPE Energy Recovery	R_3	0,32	Plastics Europe, 2022
		E_{ER}	Waste polyethylene (CH) treatment of, municipal incineration Cut-off, U	
		$E_{SE,heat}$	Heat, central or small-scale, natural gas (RER) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		$E_{SE,elec}$	Electricity, high voltage (Europe without Switzerland) market group for Cut-off, U	RCP Made Green in Italy "Scatole in cartone ondulato"
		LHV	42,27	GRANTA CES
		$X_{ER,heat}$	0,31	RCP Made Green in Italy "Scatole in cartone ondulato"
		$X_{ER,elec}$	0,101	RCP Made Green in Italy "Scatole in cartone ondulato"
		B	0	ANNEX C

2. IMPACT ASSESSMENT RESULTS

PEF results

In this section, the impact assessment results are presented through 16 environmental impact indicators defined by the PEF method and described above at §2.4.

The selected calculation method in SimaPro for the impact assessment is the EF 3.1, as defined in the Product Environmental Footprint.

For each product, both State-of-the-art and Substitution, results are presented as follow:

- **Characterised** results of all EF impact categories: the multiple impact contributions are transformed into results for each of the 16 impact categories through characterization factors. Each category has a specific unit of measure.
- **Normalised and weighted** results: by weighting the different EF impact categories through appropriate factors the relative shares of the impacts of the analysed system can be expressed in Pt. In this way it is possible to establish comparisons among different contributions.
- **Weighted results as single score** in μPt for all the life cycle stages (Pre-processing and Manufacturing + Transportation + End-of-Life): the weighted results are then aggregated into an all-encompassing indicator



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PRODUCT 02 – Salad MDD, PET Tray

Characterised results

- **Characterised** results of all EF impact categories

Tab 6. Characterised results PRODUCT 02 – Salad MDD, PET Tray

IMPACT CATEGORY	UNIT	TOTAL	02. SALAD MDD, PET TRAY - PP+M	02. SALAD MDD, PET TRAY - T	02. SALAD MDD, PET TRAY - EOL
Acidification	mol H+ eq	1,79E-04	1,94E-04	5,60E-07	-1,60E-05
Climate change	kg CO2 eq	5,28E-02	4,72E-02	1,78E-04	5,40E-03
Ecotoxicity, freshwater	CTUe	1,94E-01	1,94E-01	6,54E-04	-8,35E-04
Particulate matter	disease inc.	1,84E-09	1,84E-09	1,53E-11	-1,56E-11
Eutrophication, marine	kg N eq	4,09E-05	3,45E-05	1,89E-07	6,18E-06
Eutrophication, freshwater	kg P eq	7,77E-06	1,09E-05	1,22E-08	-3,16E-06
Eutrophication, terrestrial	mol N eq	3,28E-04	3,41E-04	2,05E-06	-1,57E-05
Human toxicity, cancer	CTUh	1,46E-10	1,52E-10	1,18E-12	-6,91E-12
Human toxicity, non-cancer	CTUh	5,14E-10	5,02E-10	1,59E-12	1,06E-11
Ionising radiation	kBq U-235 eq	1,02E-02	1,27E-02	3,32E-06	-2,49E-03
Land use	Pt	1,37E-01	1,43E-01	1,95E-03	-8,07E-03
Ozone depletion	kg CFC11 eq	1,93E-07	1,93E-07	3,55E-12	-1,52E-10
Photochemical ozone formation	kg NMVOC eq	1,85E-04	1,92E-04	8,93E-07	-8,03E-06
Resource use, fossils	MJ	1,08E+00	1,19E+00	2,53E-03	-1,21E-01
Resource use, minerals and metals	kg Sb eq	4,53E-07	4,53E-07	5,45E-10	-7,27E-10
Water use	m3 depriv.	9,38E-03	1,03E-02	1,12E-05	-9,63E-04

Tab 7. Characterised results PRODUCT 02-s – Salad MDD, Cardboard Tray

IMPACT CATEGORY	UNIT	TOTAL	02-S. SALAD MDD, CARDBOARD TRAY - PP+M	02-S. SALAD MDD, CARDBOARD TRAY - T	02-S. SALAD MDD, CARDBOARD TRAY - EOL
Acidification	mol H+ eq	2,04E-05	2,44E-05	2,15E-07	-4,25E-06
Climate change	kg CO2 eq	4,17E-03	3,97E-03	6,83E-05	1,32E-04
Ecotoxicity, freshwater	CTUe	2,99E-02	3,13E-02	2,51E-04	-1,61E-03
Particulate matter	disease inc.	1,79E-10	2,38E-10	5,86E-12	-6,52E-11
Eutrophication, marine	kg N eq	7,59E-06	8,22E-06	7,23E-08	-6,98E-07
Eutrophication, freshwater	kg P eq	1,22E-06	1,44E-06	4,66E-09	-2,24E-07
Eutrophication, terrestrial	mol N eq	5,09E-05	6,63E-05	7,87E-07	-1,62E-05
Human toxicity, cancer	CTUh	1,43E-11	1,55E-11	4,52E-13	-1,73E-12
Human toxicity, non-cancer	CTUh	3,90E-11	4,11E-11	6,11E-13	-2,75E-12
Ionising radiation	kBq U-235 eq	2,18E-03	2,76E-03	1,28E-06	-5,83E-04
Land use	Pt	2,85E-01	7,55E-01	7,48E-04	-4,71E-01
Ozone depletion	kg CFC11 eq	1,64E-10	1,81E-10	1,36E-12	-1,81E-11
Photochemical ozone formation	kg NMVOC eq	1,60E-05	2,04E-05	3,42E-07	-4,72E-06
Resource use, fossils	MJ	9,30E-02	1,13E-01	9,71E-04	-2,12E-02
Resource use, minerals and metals	kg Sb eq	2,40E-08	2,66E-08	2,09E-10	-2,89E-09
Water use	m3 depriv.	3,12E-03	3,22E-03	4,28E-06	-1,06E-04



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Weighted results

- Normalised and **weighted** results

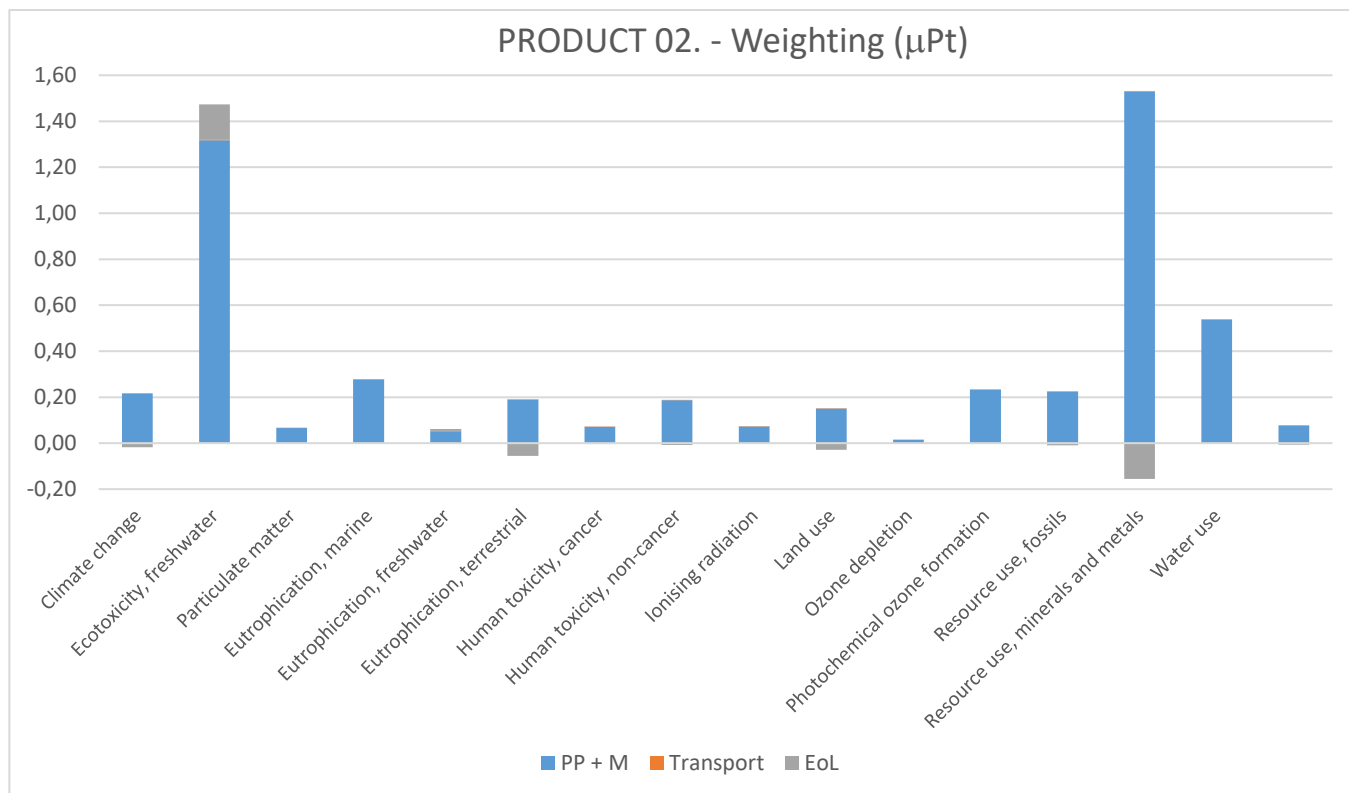


Figure 1: Normalised and weighted results - PRODUCT 02 – Salad MDD, PET Tray

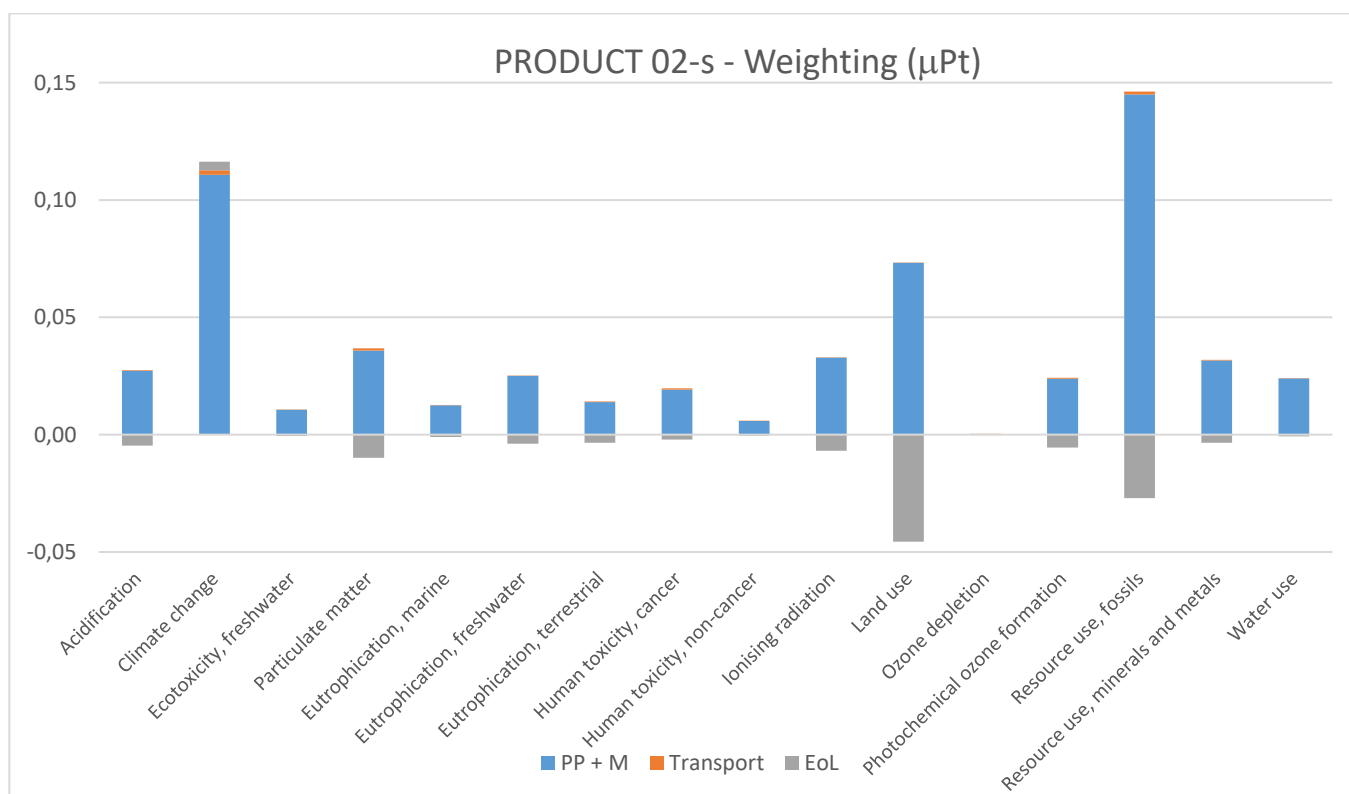


Figure 8: Normalised and weighted results - PRODUCT 02-s – Salad MDD, Cardboard Tray



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Single score

- Weighted results as single score in μPt for all the life cycle stages (Pre-processing and manufacturing, Transport and End-of-Life)
- For product 02 – Salad MDD, PET Tray, the most relevant processes (processes details are shown in table A2) are related to component 2.2 PET Bowl and are Polyethylene terephthalate pre-processing and manufacturing.
- For product 02-s – Salad MDD, Cardboard Tray, the most relevant processes (processes details are shown in table B2) are related to component 2.3-s Carboard Cup-Paper

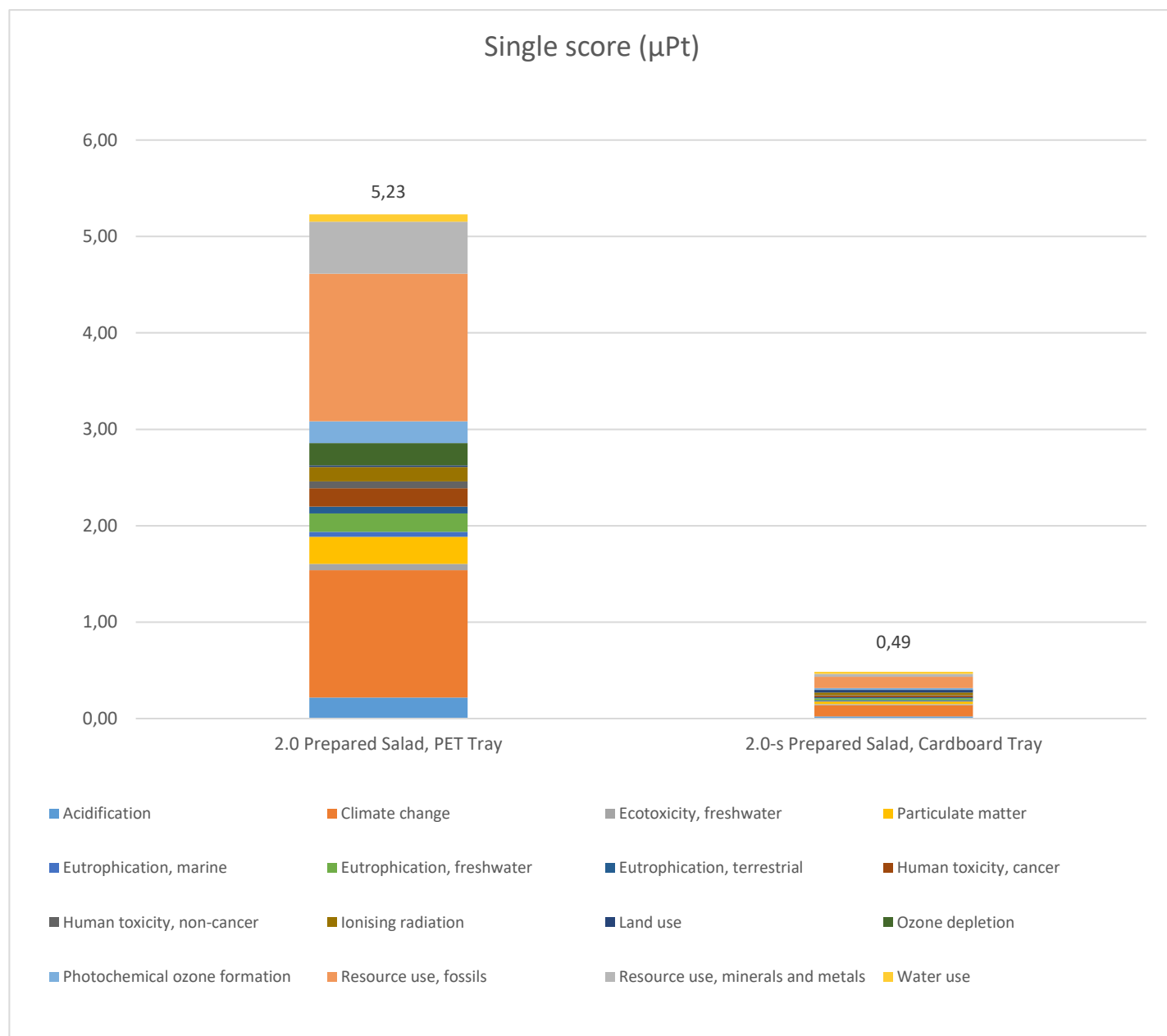


Figure 9: Weighted results as single score in μPt - PRODUCT 02 – Salad MDD, PET Tray and PRODUCT 02-s – Salad MDD, Cardboard Tray



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PRODUCT 03 – Sour cream, Cup

Characterised results

- **Characterised** results of all EF impact categories

Tab 8. Characterised results PRODUCT 03 – Sour cream, Cup

IMPACT CATEGORY	UNIT	TOTAL	03. SOUR CREAM, CUP - PP+M	03. SOUR CREAM, CUP - T	03. SOUR CREAM, CUP - EOL
Acidification	mol H+ eq	6,61E-05	7,88E-05	2,89E-07	-1,30E-05
Climate change	kg CO2 eq	2,22E-02	2,09E-02	9,16E-05	1,20E-03
Ecotoxicity, freshwater	CTUe	1,09E-01	8,81E-02	3,37E-04	2,04E-02
Particulate matter	disease inc.	8,83E-10	9,92E-10	7,87E-12	-1,17E-10
Eutrophication, marine	kg N eq	1,45E-05	1,52E-05	9,71E-08	-8,03E-07
Eutrophication, freshwater	kg P eq	3,55E-06	4,45E-06	6,26E-09	-9,08E-07
Eutrophication, terrestrial	mol N eq	1,31E-04	1,52E-04	1,06E-06	-2,16E-05
Human toxicity, cancer	CTUh	8,10E-11	8,88E-11	6,06E-13	-8,39E-12
Human toxicity, non-cancer	CTUh	1,76E-10	1,90E-10	8,21E-13	-1,48E-11
Ionising radiation	kBq U-235 eq	3,30E-03	5,90E-03	1,71E-06	-2,60E-03
Land use	Pt	5,56E-02	5,96E-02	1,00E-03	-5,01E-03
Ozone depletion	kg CFC11 eq	2,50E-08	2,51E-08	1,83E-12	-1,27E-10
Photochemical ozone formation	kg NMVOC eq	8,46E-05	9,64E-05	4,60E-07	-1,23E-05
Resource use, fossils	MJ	4,78E-01	6,02E-01	1,30E-03	-1,25E-01
Resource use, minerals and metals	kg Sb eq	1,69E-07	1,92E-07	2,80E-10	-2,32E-08
Water use	m3 depriv.	6,11E-03	7,16E-03	5,75E-06	-1,05E-03

Tab 9. Characterised results PRODUCT 03-s – Sour cream, Paper Cup

IMPACT CATEGORY	UNIT	TOTAL	03-S. SOUR CREAM,PAPER CUP - PP+M	03-S. SOUR CREAM,PAPER CUP - T	03-S. SOUR CREAM,PAPER CUP - EOL
Acidification	mol H+ eq	5,47E-05	6,62E-05	2,31E-07	-1,18E-05
Climate change	kg CO2 eq	1,36E-02	1,36E-02	7,34E-05	-7,25E-05
Ecotoxicity, freshwater	CTUe	9,04E-02	6,78E-02	2,70E-04	2,23E-02
Particulate matter	disease inc.	8,44E-10	9,64E-10	6,30E-12	-1,26E-10
Eutrophication, marine	kg N eq	1,20E-05	1,27E-05	7,78E-08	-8,06E-07
Eutrophication, freshwater	kg P eq	3,43E-06	4,31E-06	5,01E-09	-8,79E-07
Eutrophication, terrestrial	mol N eq	1,05E-04	1,28E-04	8,46E-07	-2,38E-05
Human toxicity, cancer	CTUh	5,66E-11	6,17E-11	4,85E-13	-5,59E-12
Human toxicity, non-cancer	CTUh	1,25E-10	1,34E-10	6,57E-13	-1,03E-11
Ionising radiation	kBq U-235 eq	1,40E-03	2,45E-03	1,37E-06	-1,05E-03
Land use	Pt	2,30E-01	4,83E-01	8,04E-04	-2,53E-01
Ozone depletion	kg CFC11 eq	3,27E-08	3,27E-08	1,47E-12	-5,05E-11
Photochemical ozone formation	kg NMVOC eq	4,76E-05	5,56E-05	3,68E-07	-8,45E-06
Resource use, fossils	MJ	2,17E-01	2,69E-01	1,04E-03	-5,26E-02
Resource use, minerals and metals	kg Sb eq	1,05E-07	1,20E-07	2,25E-10	-1,56E-08
Water use	m3 depriv.	5,99E-03	6,59E-03	4,61E-06	-6,00E-04



Weighted results

- Normalised and **weighted** results

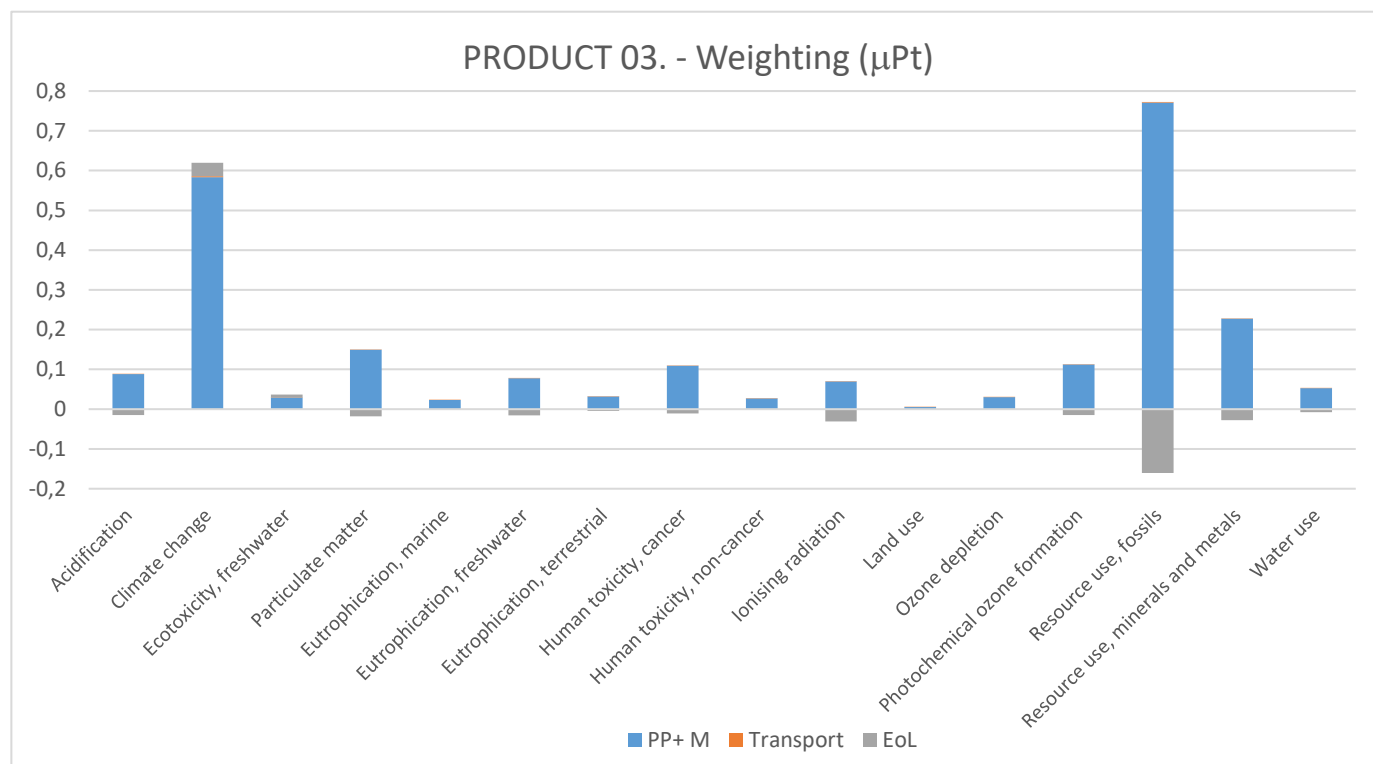


Figure 10: Normalised and weighted results - PRODUCT 03 – Sour cream, Cup

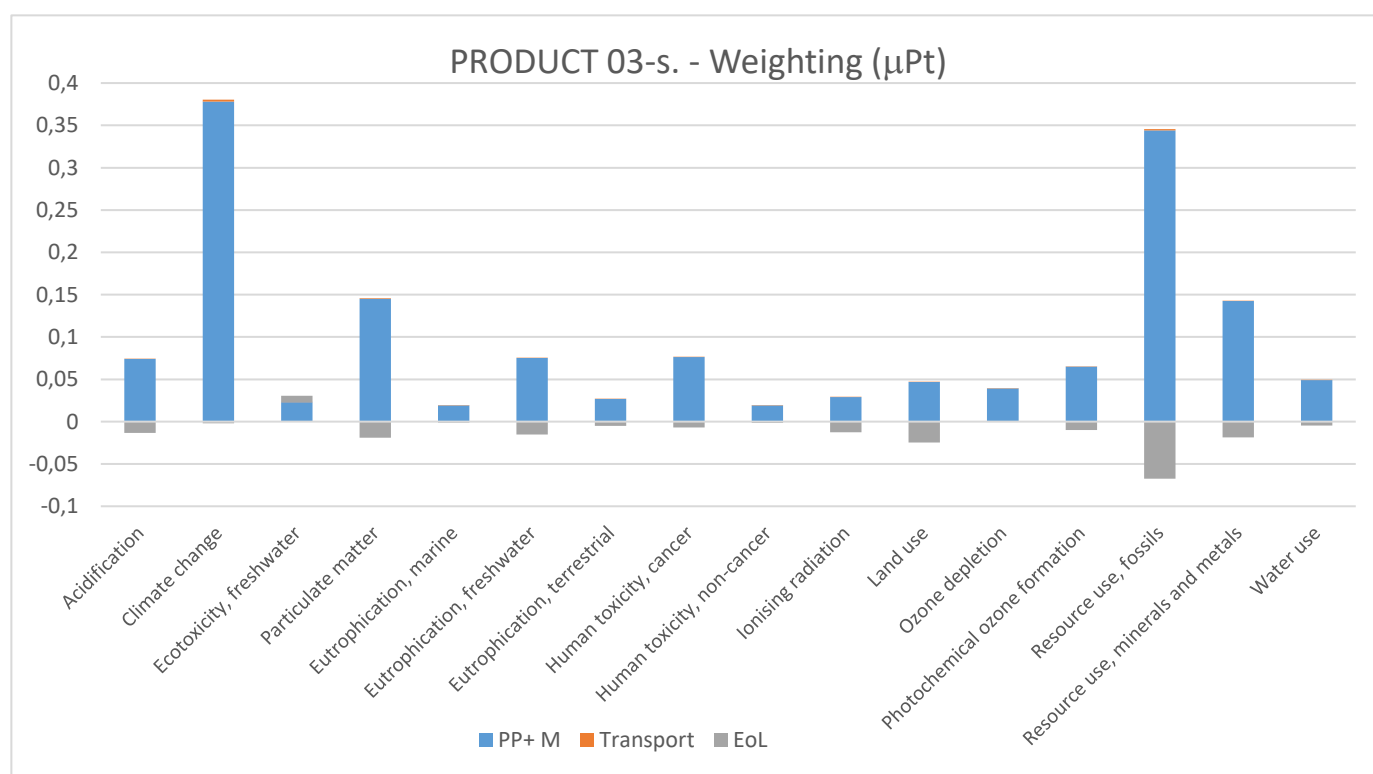


Figure 11: Normalised and weighted results - PRODUCT 03-s. – Sour cream, PaperCup



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Single score

- Weighted results as single score in μPt for all the life cycle stages (Pre-processing and manufacturing, Transport and End-of-Life)
- For product 03 – Sour cream, Cup, the most relevant processes (processes details are shown in table A3) are related to component 3.3 PP Bowl and are Polypropylene pre-processing and manufacturing.
- For product 03-s. – Sour cream, Cup, the most relevant processes (processes details are shown in table B3) are related to component 3.1-s PET Overcup and are Polyethylene terephthalate pre-processing and manufacturing.

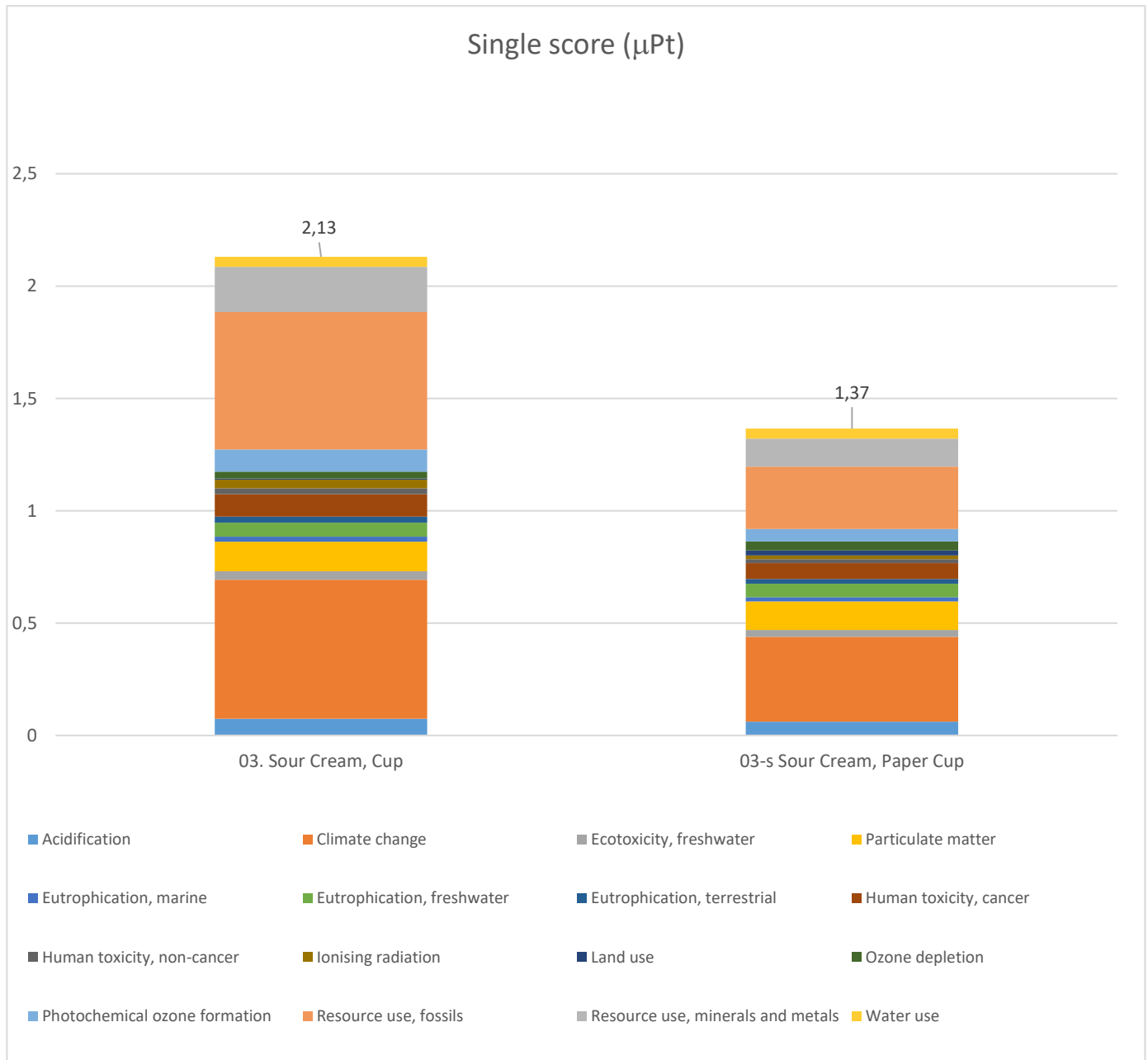


Figure 12: Weighted results as single score in μPt - PRODUCT 03 – Sour cream, Cup and PRODUCT 03-s. – Sour cream, Paper Cup



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PRODUCT 04 – Greek yoghurt, Cup

Characterised results

- **Characterised** results of all EF impact categories

Tab 10. Characterised results PRODUCT 04 – Greek Yoghurt, Cup

IMPACT CATEGORY	UNIT	TOTAL	04. GREEK YOGHURT, CUP - PP+M	04. GREEK YOGHURT, CUP - T	04. GREEK YOGHURT, CUP - EOL
Acidification	mol H+ eq	4,78E-05	5,67E-05	2,10E-07	-9,16E-06
Climate change	kg CO2 eq	1,61E-02	1,51E-02	6,67E-05	9,26E-04
Ecotoxicity, freshwater	CTUe	7,75E-02	6,34E-02	2,45E-04	1,39E-02
Particulate matter	disease inc.	6,28E-10	7,04E-10	5,73E-12	-8,17E-11
Eutrophication, marine	kg N eq	1,05E-05	1,10E-05	7,07E-08	-5,38E-07
Eutrophication, freshwater	kg P eq	2,56E-06	3,21E-06	4,56E-09	-6,48E-07
Eutrophication, terrestrial	mol N eq	9,48E-05	1,09E-04	7,69E-07	-1,52E-05
Human toxicity, cancer	CTUh	5,82E-11	6,38E-11	4,41E-13	-6,00E-12
Human toxicity, non-cancer	CTUh	1,28E-10	1,37E-10	5,98E-13	-1,04E-11
Ionising radiation	kBq U-235 eq	2,40E-03	4,30E-03	1,25E-06	-1,90E-03
Land use	Pt	4,04E-02	4,33E-02	7,31E-04	-3,57E-03
Ozone depletion	kg CFC11 eq	1,82E-08	1,83E-08	1,33E-12	-9,28E-11
Photochemical ozone formation	kg NMVOC eq	6,15E-05	7,00E-05	3,35E-07	-8,83E-06
Resource use, fossils	MJ	3,48E-01	4,39E-01	9,49E-04	-9,13E-02
Resource use, minerals and metals	kg Sb eq	1,22E-07	1,39E-07	2,04E-10	-1,64E-08
Water use	m3 depriv.	4,45E-03	5,21E-03	4,19E-06	-7,57E-04

Tab 11. Characterised results PRODUCT 04-s – Greek Yoghurt, Paper Cup

IMPACT CATEGORY	UNIT	TOTAL	04-S. GREEK YOGHURT, PAPER CUP - PP+M	04-S. GREEK YOGHURT PAPER CUP - T	04-S. GREEK YOGHURT PAPER CUP - EOL
Acidification	mol H+ eq	1,70E-05	2,18E-05	2,51E-07	-5,01E-06
Climate change	kg CO2 eq	4,15E-03	3,77E-03	7,96E-05	2,93E-04
Ecotoxicity, freshwater	CTUe	2,17E-02	2,35E-02	2,93E-04	-2,05E-03
Particulate matter	disease inc.	3,15E-10	3,82E-10	6,84E-12	-7,37E-11
Eutrophication, marine	kg N eq	5,38E-06	6,10E-06	8,44E-08	-8,08E-07
Eutrophication, freshwater	kg P eq	7,58E-07	1,02E-06	5,44E-09	-2,64E-07
Eutrophication, terrestrial	mol N eq	4,39E-05	6,13E-05	9,18E-07	-1,83E-05
Human toxicity, cancer	CTUh	1,94E-11	2,12E-11	5,27E-13	-2,30E-12
Human toxicity, non-cancer	CTUh	3,18E-11	3,47E-11	7,13E-13	-3,59E-12
Ionising radiation	kBq U-235 eq	1,53E-03	2,42E-03	1,49E-06	-8,90E-04
Land use	Pt	3,41E-01	8,53E-01	8,72E-04	-5,12E-01
Ozone depletion	kg CFC11 eq	7,07E-11	9,83E-11	1,59E-12	-2,92E-11
Photochemical ozone formation	kg NMVOC eq	1,74E-05	2,29E-05	3,99E-07	-5,89E-06
Resource use, fossils	MJ	7,22E-02	1,04E-01	1,13E-03	-3,30E-02
Resource use, minerals and metals	kg Sb eq	2,07E-08	2,45E-08	2,44E-10	-3,99E-09
Water use	m3 depriv.	2,15E-03	2,35E-03	5,00E-06	-2,09E-04



Weighted results

- Normalised and **weighted** results

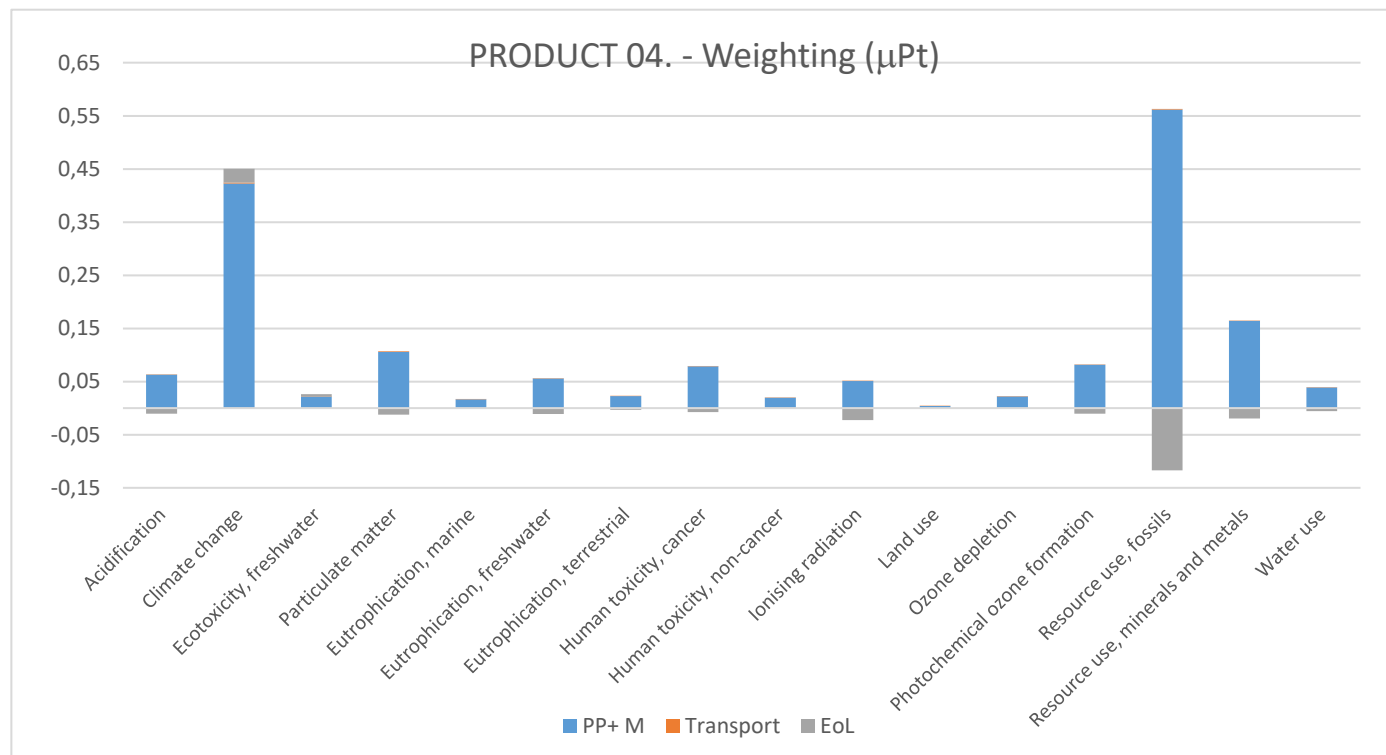


Figure 13: Normalised and weighted results - PRODUCT 04 – Greek yoghurt, Cup

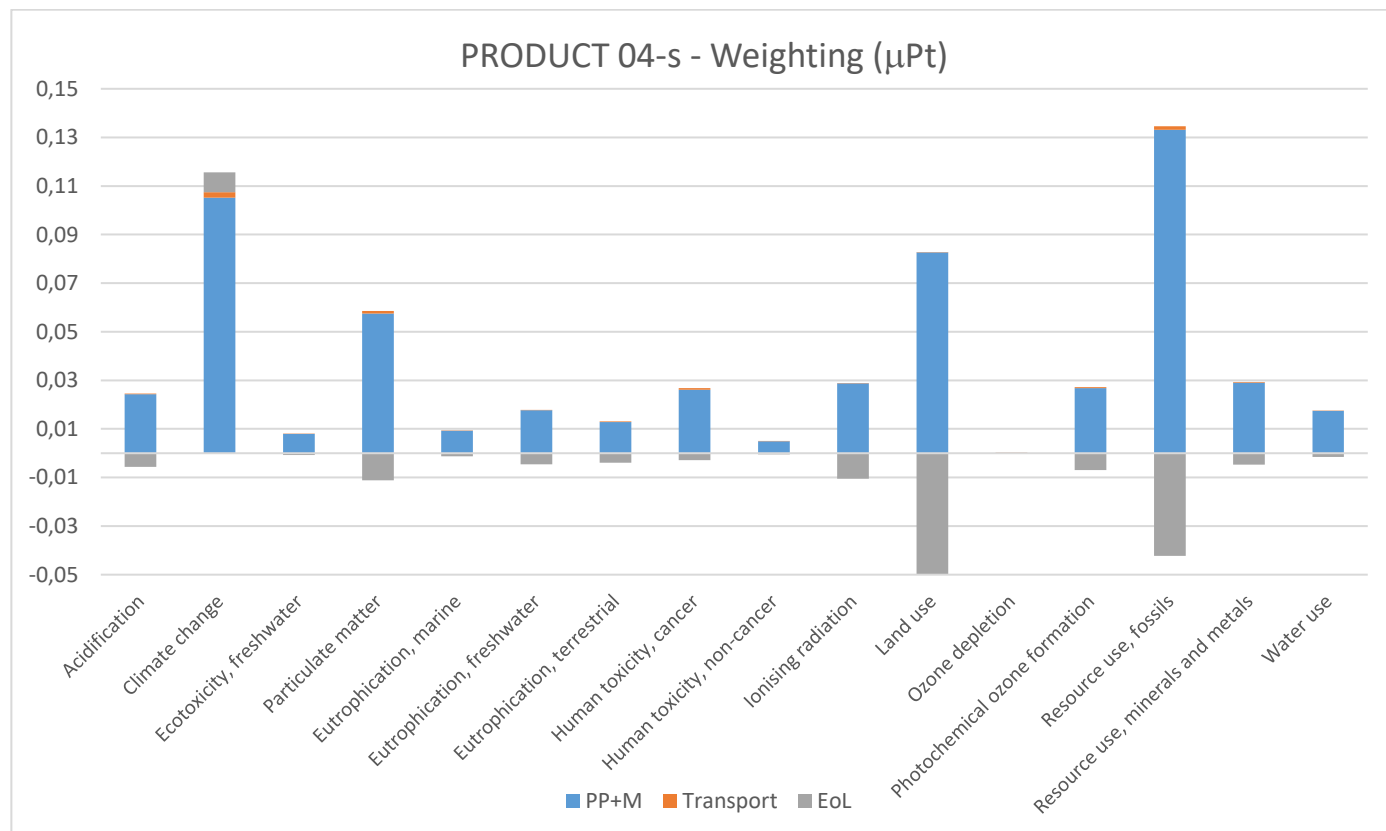


Figure 14: Normalised and weighted results - PRODUCT 04-s – Greek yoghurt, Paper Cup



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Single score

- Weighted results as single score in μPt for all the life cycle stages (Pre-processing and manufacturing, Transport and End-of-Life)
- For product 04 – Greek yoghurt, Cup, the most relevant processes (processes details are shown in table A4) are related to component 4.3 PP Bowl and are Polypropylene pre-processing and manufacturing.
- For product 04-s – Greek yoghurt, Paper Cup, the most relevant processes (processes details are shown in table B4) are related to component 4.1-s Moulded Pulp and are Bleached Sulphate Pulp pre-processing and manufacturing.

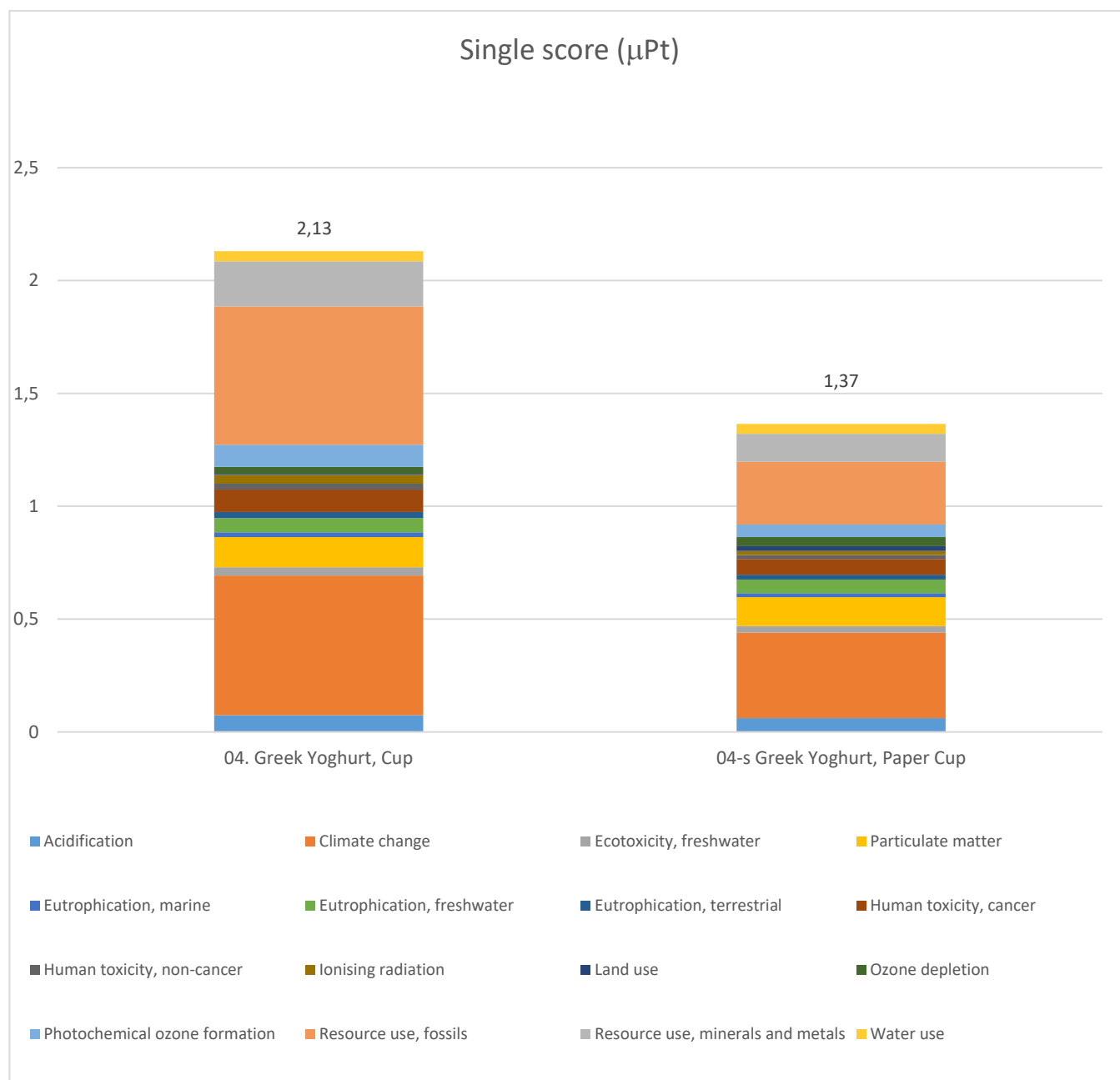


Figure 152: Weighted results as single score in μPt - PRODUCT 04 – Greek yoghurt, Cup and PRODUCT 04-s – Greek yoghurt, Paper Cup



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PRODUCT 05 – Pork chop, Wrapped Tray

Characterised results

- **Characterised** results of all EF impact categories

Tab 12. Characterised results PRODUCT 05 – Pork Chop, Wrapped Tray

IMPACT CATEGORY	UNIT	TOTAL	05. PORK CHOP, WRAPPED TRAY - PP+M	05. PORK CHOP, WRAPPED TRAY - T	05. PORK CHOP, WRAPPED TRAY - EOL
Acidification	mol H+ eq	3,67E-05	4,03E-05	1,29E-07	-3,65E-06
Climate change	kg CO2 eq	1,23E-02	1,07E-02	4,09E-05	1,54E-03
Ecotoxicity, freshwater	CTUe	4,87E-02	1,58E-02	1,50E-04	3,27E-02
Particulate matter	disease inc.	3,90E-10	4,29E-10	3,51E-12	-4,29E-11
Eutrophication, marine	kg N eq	6,67E-06	6,70E-06	4,34E-08	-7,53E-08
Eutrophication, freshwater	kg P eq	1,01E-06	9,60E-07	2,80E-09	5,04E-08
Eutrophication, terrestrial	mol N eq	6,25E-05	6,77E-05	4,72E-07	-5,72E-06
Human toxicity, cancer	CTUh	1,09E-11	1,13E-11	2,71E-13	-6,58E-13
Human toxicity, non-cancer	CTUh	3,62E-11	3,23E-11	3,66E-13	3,50E-12
Ionising radiation	kBq U-235 eq	8,79E-04	2,96E-03	7,65E-07	-2,09E-03
Land use	Pt	1,53E-02	1,40E-02	4,48E-04	8,44E-04
Ozone depletion	kg CFC11 eq	5,79E-10	6,08E-10	8,17E-13	-2,92E-11
Photochemical ozone formation	kg NMVOC eq	5,43E-05	5,82E-05	2,05E-07	-4,13E-06
Resource use, fossils	MJ	2,14E-01	2,95E-01	5,82E-04	-8,20E-02
Resource use, minerals and metals	kg Sb eq	2,31E-08	2,30E-08	1,25E-10	-6,93E-11
Water use	m3 depriv.	7,63E-03	8,39E-03	2,57E-06	-7,64E-04

Tab 13. Characterised results PRODUCT 05-s – Pork Chop, Cellulose Tray

IMPACT CATEGORY	UNIT	TOTAL	05-S.. PORK CHOP, CELLULOSE TRAY - PP+M	05-S.. PORK CHOP, CELLULOSE TRAY - T	05-S.. PORK CHOP, CELLULOSE TRAY - EOL
Acidification	mol H+ eq	1,20E-05	1,45E-05	1,41E-07	-2,57E-06
Climate change	kg CO2 eq	3,11E-03	2,69E-03	4,48E-05	3,78E-04
Ecotoxicity, freshwater	CTUe	4,86E-02	1,90E-02	1,65E-04	2,94E-02
Particulate matter	disease inc.	1,79E-10	2,17E-10	3,84E-12	-4,10E-11
Eutrophication, marine	kg N eq	3,55E-06	3,82E-06	4,74E-08	-3,12E-07
Eutrophication, freshwater	kg P eq	7,40E-07	8,49E-07	3,06E-09	-1,11E-07
Eutrophication, terrestrial	mol N eq	2,80E-05	3,75E-05	5,16E-07	-9,94E-06
Human toxicity, cancer	CTUh	1,41E-11	1,52E-11	2,96E-13	-1,39E-12
Human toxicity, non-cancer	CTUh	2,83E-11	2,80E-11	4,01E-13	-5,63E-14
Ionising radiation	kBq U-235 eq	8,37E-04	1,38E-03	8,37E-07	-5,47E-04
Land use	Pt	1,14E-01	4,23E-01	4,91E-04	-3,09E-01
Ozone depletion	kg CFC11 eq	4,51E-10	4,42E-10	8,94E-13	8,64E-12
Photochemical ozone formation	kg NMVOC eq	1,13E-05	1,43E-05	2,25E-07	-3,16E-06
Resource use, fossils	MJ	5,09E-02	7,01E-02	6,37E-04	-1,98E-02
Resource use, minerals and metals	kg Sb eq	2,26E-08	2,46E-08	1,37E-10	-2,14E-09
Water use	m3 depriv.	2,18E-03	2,19E-03	2,81E-06	-1,79E-05



Weighted results

- Normalised and **weighted** results

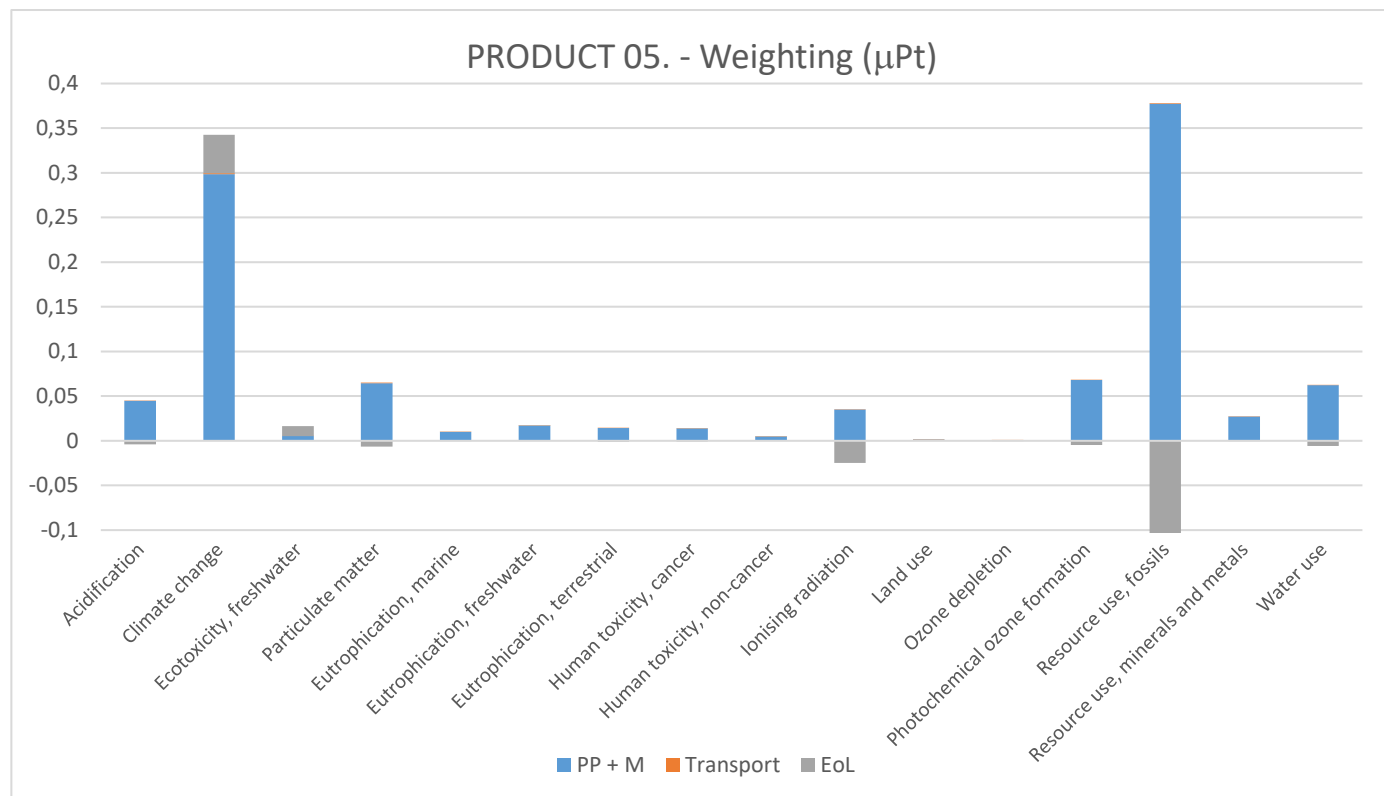


Figure 16: Normalised and weighted results - PRODUCT 05 – Pork chop, Wrapped Tray

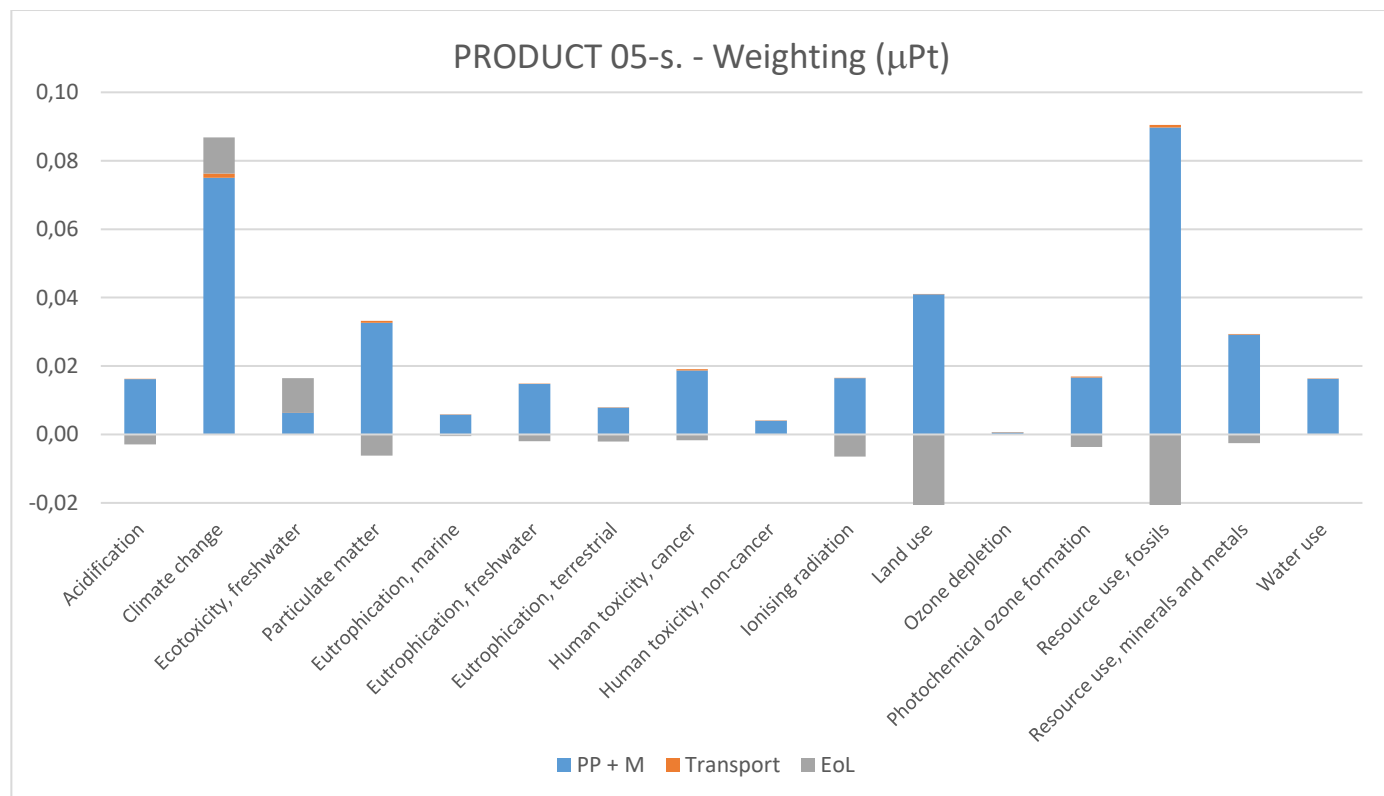


Figure 17: Normalised and weighted results - PRODUCT 05-s – Pork chop, Cellulose Tray

Single score



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- Weighted results as single score in μPt for all the life cycle stages (Pre-processing and manufacturing, Transport and End-of-Life)
- For product 05 – Pork chop, Wrapped Tray, the most relevant processes (processes details are shown in table A5) are related to component 5.2 PSE Tray and are Expandable Polystyrene pre-processing and manufacturing.
- For product 05-s – Pork chop, Cellulose Tray, the most relevant processes (processes details are shown in table B5) are related to component 5.1 Wet Molded Cellulose and are Bleached Sulphate Pulp pre-processing and manufacturing.

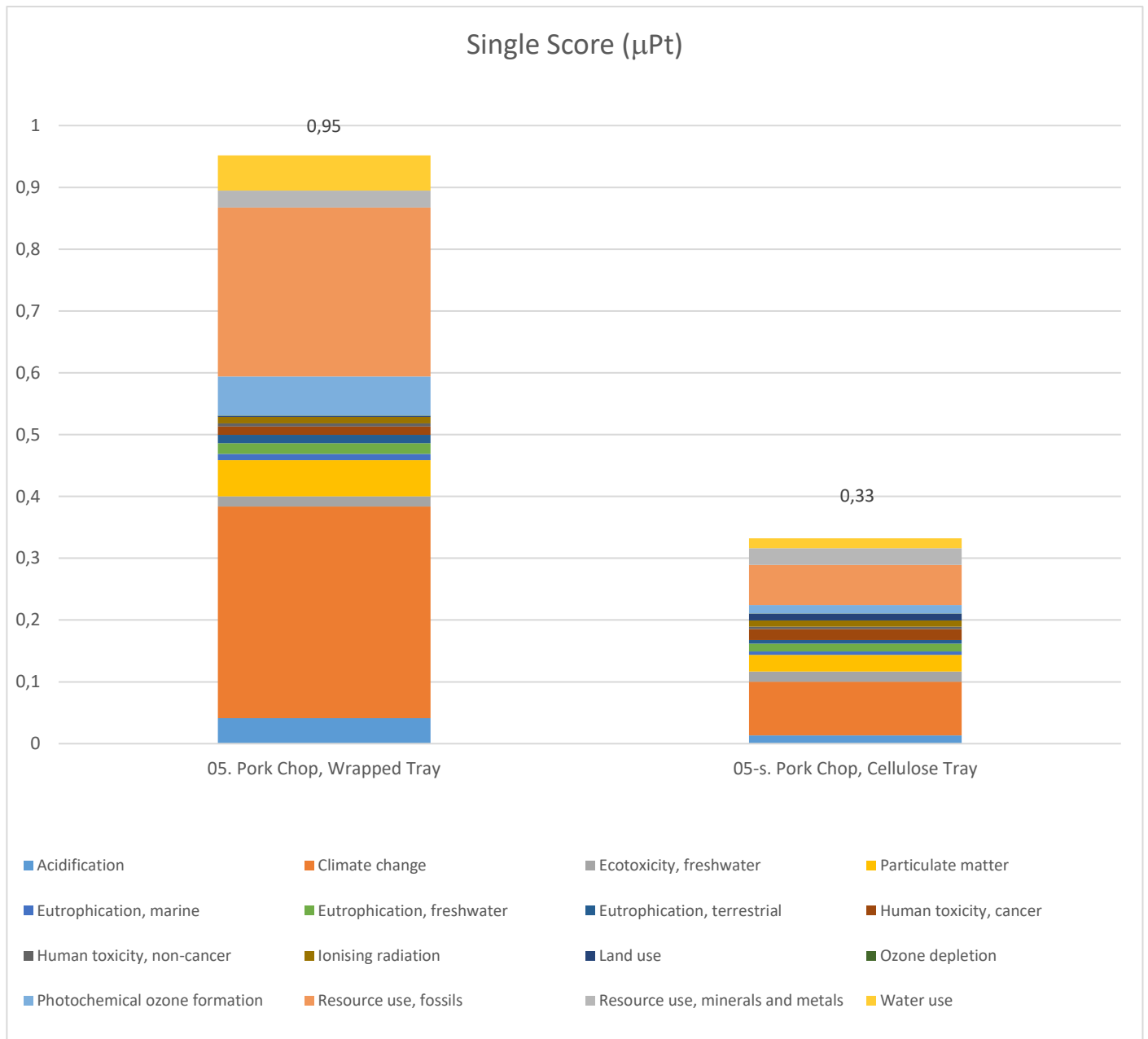


Figure 18: Weighted results as single score in μPt - PRODUCT 05 – Pork chop, Wrapped Tray and PRODUCT 05-s – Pork chop, CelluloseTray



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PRODUCT 06 – Florette Mache, OPP Film

Characterised results

- **Characterised** results of all EF impact categories

Tab 14. Characterised results PRODUCT 06 – Florette Mache, OPP Film

IMPACT CATEGORY	UNIT	TOTAL	06. FLORETTE MACHE, OPP FILM - PP+M	06. FLORETTE MACHE, OPP FILM - T	06. FLORETTE MACHE, OPP FILM - EOL
Acidification	mol H+ eq	4,28E-05	4,68E-05	2,17E-07	-4,21E-06
Climate change	kg CO2 eq	1,57E-02	1,39E-02	6,88E-05	1,66E-03
Ecotoxicity, freshwater	CTUe	1,58E-01	1,62E-01	2,53E-04	-3,37E-03
Particulate matter	disease inc.	3,88E-10	4,14E-10	5,91E-12	-3,16E-11
Eutrophication, marine	kg N eq	9,67E-06	1,01E-05	7,29E-08	-4,64E-07
Eutrophication, freshwater	kg P eq	2,54E-06	2,73E-06	4,70E-09	-1,90E-07
Eutrophication, terrestrial	mol N eq	8,92E-05	9,63E-05	7,93E-07	-7,92E-06
Human toxicity, cancer	CTUh	6,51E-11	6,92E-11	4,55E-13	-4,60E-12
Human toxicity, non-cancer	CTUh	1,24E-10	1,30E-10	6,16E-13	-7,25E-12
Ionising radiation	kBq U-235 eq	1,36E-03	3,74E-03	1,29E-06	-2,37E-03
Land use	Pt	6,97E-02	7,09E-02	7,54E-04	-1,94E-03
Ozone depletion	kg CFC11 eq	7,38E-10	8,44E-10	1,37E-12	-1,07E-10
Photochemical ozone formation	kg NMVOC eq	6,13E-05	6,89E-05	3,45E-07	-7,92E-06
Resource use, fossils	MJ	3,41E-01	4,45E-01	9,78E-04	-1,05E-01
Resource use, minerals and metals	kg Sb eq	1,15E-07	1,26E-07	2,11E-10	-1,09E-08
Water use	m3 depriv.	5,69E-03	6,38E-03	4,32E-06	-6,89E-04

Tab 15. Characterised results PRODUCT 06-s – Florette Mache, Paper/PE Bag

IMPACT CATEGORY	UNIT	TOTAL	06-S. FLORETTE MACHE, PAPER/PE BAG - PP+M	06-S. FLORETTE MACHE, PAPER/PE BAG - T	06-S. FLORETTE MACHE, PAPER/PE BAG - EOL
Acidification	mol H+ eq	5,01E-05	5,93E-05	4,78E-07	-9,68E-06
Climate change	kg CO2 eq	1,14E-02	1,06E-02	1,52E-04	7,38E-04
Ecotoxicity, freshwater	CTUe	9,42E-02	9,77E-02	5,58E-04	-4,07E-03
Particulate matter	disease inc.	4,20E-10	5,47E-10	1,30E-11	-1,41E-10
Eutrophication, marine	kg N eq	1,87E-05	2,01E-05	1,61E-07	-1,57E-06
Eutrophication, freshwater	kg P eq	1,18E-05	1,23E-05	1,04E-08	-5,11E-07
Eutrophication, terrestrial	mol N eq	1,45E-04	1,78E-04	1,75E-06	-3,49E-05
Human toxicity, cancer	CTUh	4,52E-11	4,88E-11	1,00E-12	-4,69E-12
Human toxicity, non-cancer	CTUh	1,12E-10	1,18E-10	1,36E-12	-7,14E-12
Ionising radiation	kBq U-235 eq	4,65E-04	2,40E-03	2,84E-06	-1,94E-03
Land use	Pt	7,82E-01	1,74E+00	1,66E-03	-9,57E-01
Ozone depletion	kg CFC11 eq	3,55E-10	4,15E-10	3,03E-12	-6,30E-11
Photochemical ozone formation	kg NMVOC eq	4,85E-05	5,93E-05	7,62E-07	-1,16E-05
Resource use, fossils	MJ	1,16E-01	1,85E-01	2,16E-03	-7,13E-02
Resource use, minerals and metals	kg Sb eq	4,38E-08	5,14E-08	4,65E-10	-8,06E-09
Water use	m3 depriv.	5,12E-03	5,56E-03	9,53E-06	-4,51E-04



Weighted results

- Normalised and **weighted** results

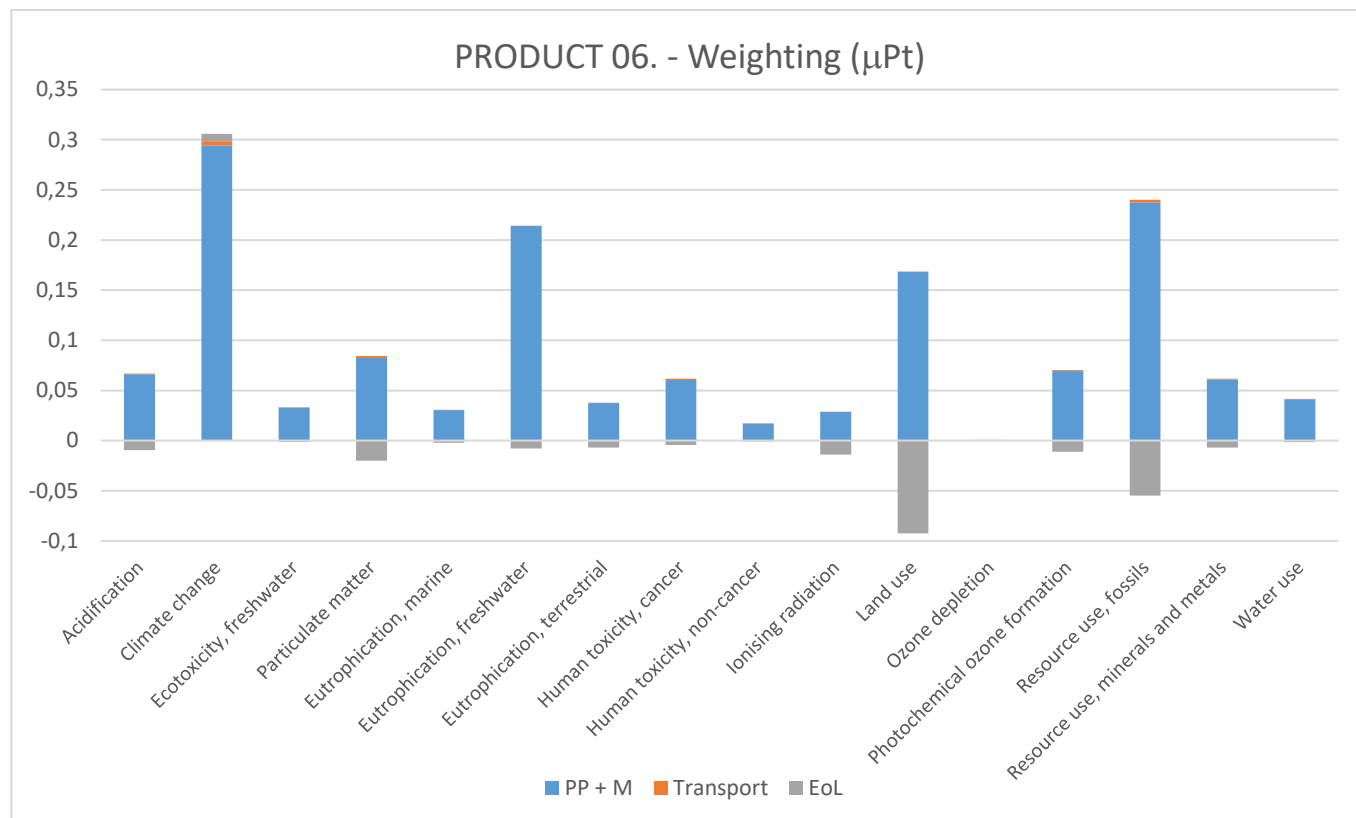


Figure 39: Normalised and weighted results - PRODUCT 06 – Florette Mache, OPP Film

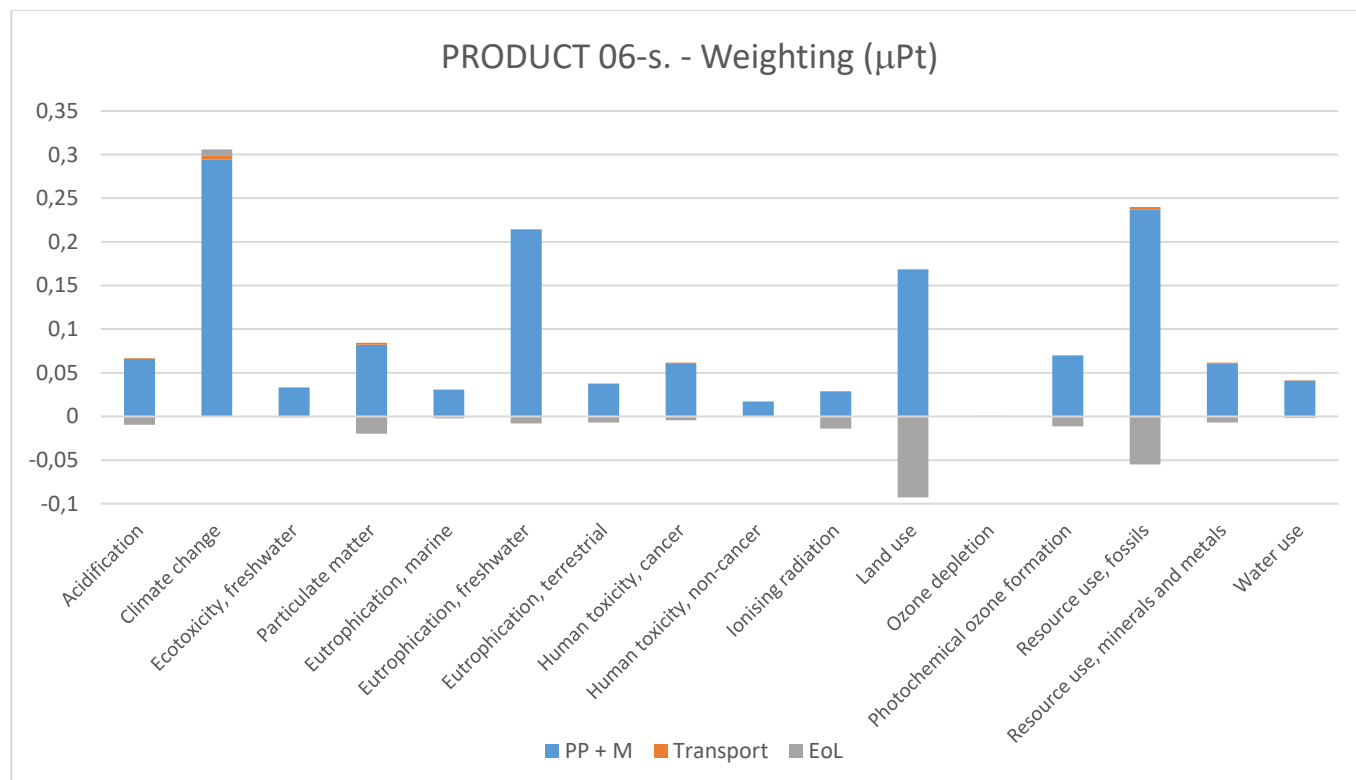


Figure 20: Normalised and weighted results - PRODUCT 06-s – Florette Mache, Paper/PE Bag



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Single score

- Weighted results as single score in μPt for all the life cycle stages (Pre-processing and manufacturing, Transport and End-of-Life)
- For product 06– Florette Mache, OPP Film, the most relevant processes (processes details are shown in table A6) are related to component 6.2 OPP Film and are Polypropylene pre-processing and manufacturing.
- For product 06-s. – Florette Mache, Paper/PE Bag, the most relevant processes (processes details are shown in table B6) are related to component 6.1-s Paper Sack Production and Kraft Paper pre-processing and manufacturing.

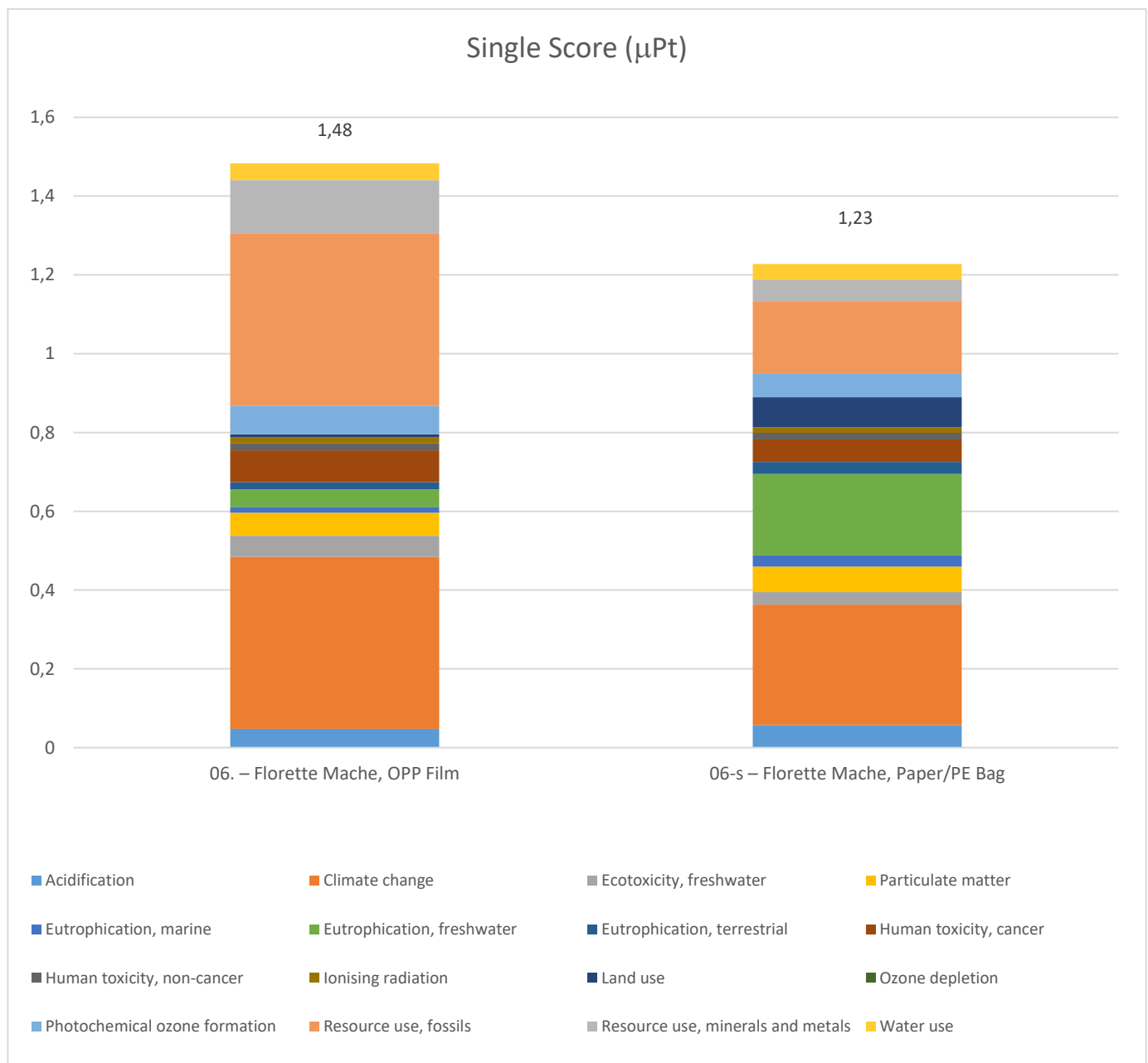


Figure 21: Weighted results as single score in μPt - PRODUCT 06 – Florette Mache, OPP Film and PRODUCT 06-s, – Florette Mache, Paper/PE Bag



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PRODUCT 07 – Butter, Aluminium & OPP Film

Characterised results

- **Characterised** results of all EF impact categories

Tab 16. Characterised results PRODUCT 07 – Butter, Al & OPP Film

IMPACT CATEGORY	UNIT	TOTAL	07. BUTTER, AL & OPP FILM - PP+M	07. BUTTER, AL & OPP FILM - T	07. BUTTER, AL & OPP FILM - EOL
Acidification	mol H+ eq	2,00E-05	2,51E-05	3,64E-08	-5,06E-06
Climate change	kg CO2 eq	5,00E-03	5,51E-03	1,16E-05	-5,15E-04
Ecotoxicity, freshwater	CTUe	5,64E-02	4,11E-02	4,25E-05	1,53E-02
Particulate matter	disease inc.	3,96E-10	4,55E-10	9,93E-13	-5,98E-11
Eutrophication, marine	kg N eq	4,07E-06	4,87E-06	1,23E-08	-8,12E-07
Eutrophication, freshwater	kg P eq	1,22E-06	1,45E-06	7,90E-10	-2,37E-07
Eutrophication, terrestrial	mol N eq	4,04E-05	4,91E-05	1,33E-07	-8,87E-06
Human toxicity, cancer	CTUh	2,46E-11	2,71E-11	7,65E-14	-2,60E-12
Human toxicity, non-cancer	CTUh	8,55E-11	9,23E-11	1,04E-13	-6,98E-12
Ionising radiation	kBq U-235 eq	2,83E-03	3,12E-03	2,16E-07	-2,88E-04
Land use	Pt	1,68E-02	1,83E-02	1,27E-04	-1,64E-03
Ozone depletion	kg CFC11 eq	8,70E-11	1,03E-10	2,31E-13	-1,66E-11
Photochemical ozone formation	kg NMVOC eq	1,77E-05	2,10E-05	5,80E-08	-3,38E-06
Resource use, fossils	MJ	1,32E-01	1,51E-01	1,64E-04	-1,88E-02
Resource use, minerals and metals	kg Sb eq	3,68E-08	4,64E-08	3,54E-11	-9,63E-09
Water use	m3 depriv.	1,46E-03	1,72E-03	7,26E-07	-2,60E-04

Tab 17. Characterised results PRODUCT 07-s – Butter, Al & Paper Film

IMPACT CATEGORY	UNIT	TOTAL	07-S. BUTTER, AL & PAPER FILM - PP+M	07-S. BUTTER, AL & PAPER FILM - T	07-S. BUTTER, AL & PAPER FILM - EOL
Acidification	mol H+ eq	1,08E-05	1,20E-05	6,16E-08	-1,25E-06
Climate change	kg CO2 eq	2,42E-03	2,37E-03	1,96E-05	3,30E-05
Ecotoxicity, freshwater	CTUe	1,39E-02	1,42E-02	7,19E-05	-3,69E-04
Particulate matter	disease inc.	1,01E-10	1,18E-10	1,68E-12	-1,90E-11
Eutrophication, marine	kg N eq	3,15E-06	3,34E-06	2,07E-08	-2,05E-07
Eutrophication, freshwater	kg P eq	1,86E-06	1,92E-06	1,34E-09	-6,54E-08
Eutrophication, terrestrial	mol N eq	2,63E-05	3,07E-05	2,26E-07	-4,68E-06
Human toxicity, cancer	CTUh	7,78E-12	8,16E-12	1,29E-13	-5,07E-13
Human toxicity, non-cancer	CTUh	7,02E-11	7,09E-11	1,75E-13	-8,26E-13
Ionising radiation	kBq U-235 eq	2,85E-03	3,02E-03	3,66E-07	-1,67E-04
Land use	Pt	1,03E-01	2,38E-01	2,14E-04	-1,35E-01
Ozone depletion	kg CFC11 eq	4,92E-11	5,40E-11	3,91E-13	-5,21E-12
Photochemical ozone formation	kg NMVOC eq	1,04E-05	1,17E-05	9,82E-08	-1,37E-06
Resource use, fossils	MJ	8,90E-02	9,48E-02	2,78E-04	-6,11E-03
Resource use, minerals and metals	kg Sb eq	1,49E-08	1,58E-08	5,99E-11	-8,80E-10
Water use	m3 depriv.	1,23E-03	1,26E-03	1,23E-06	-3,15E-05

Weighted results



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- Normalised and **weighted** results

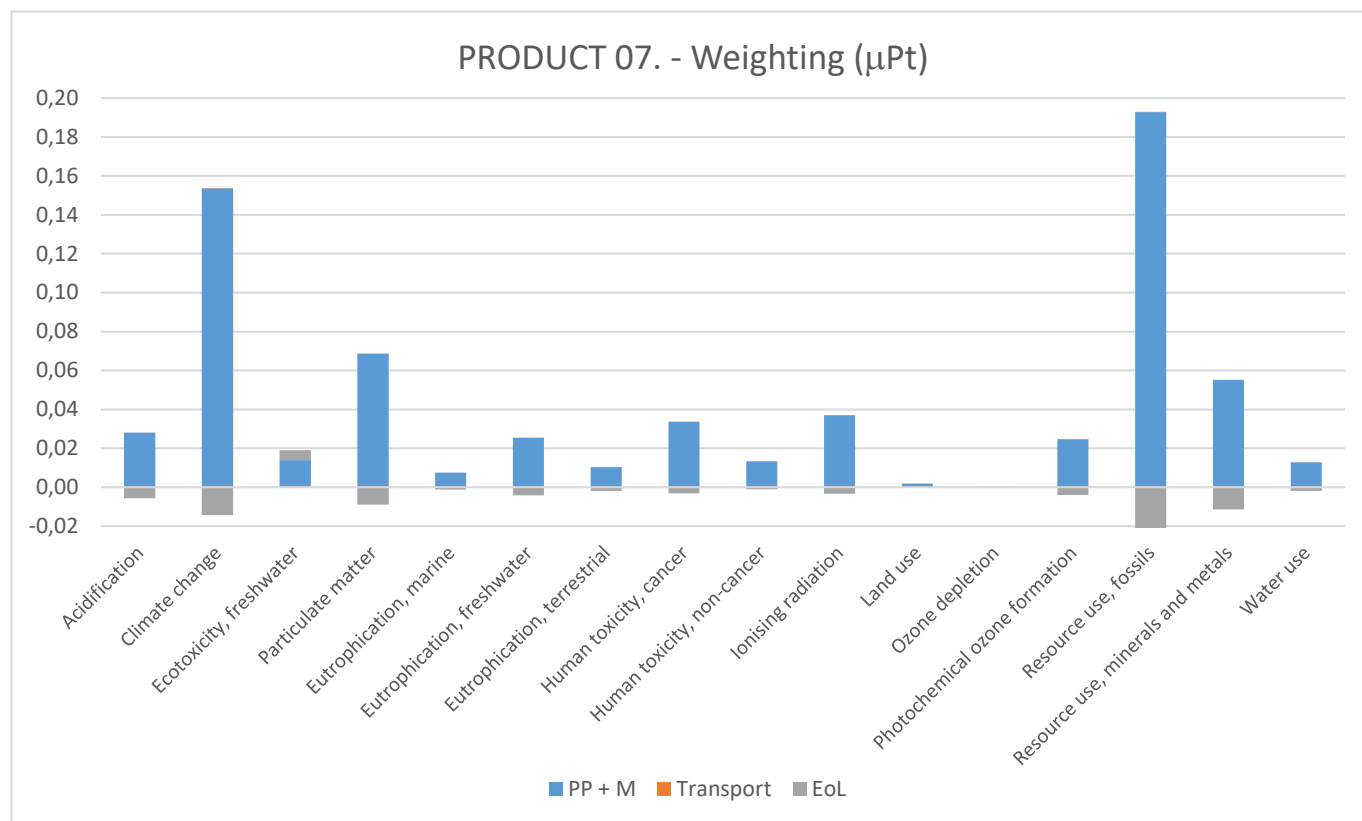


Figure 22: Normalised and weighted results - PRODUCT 07 – Butter, Aluminium, & OPP Film

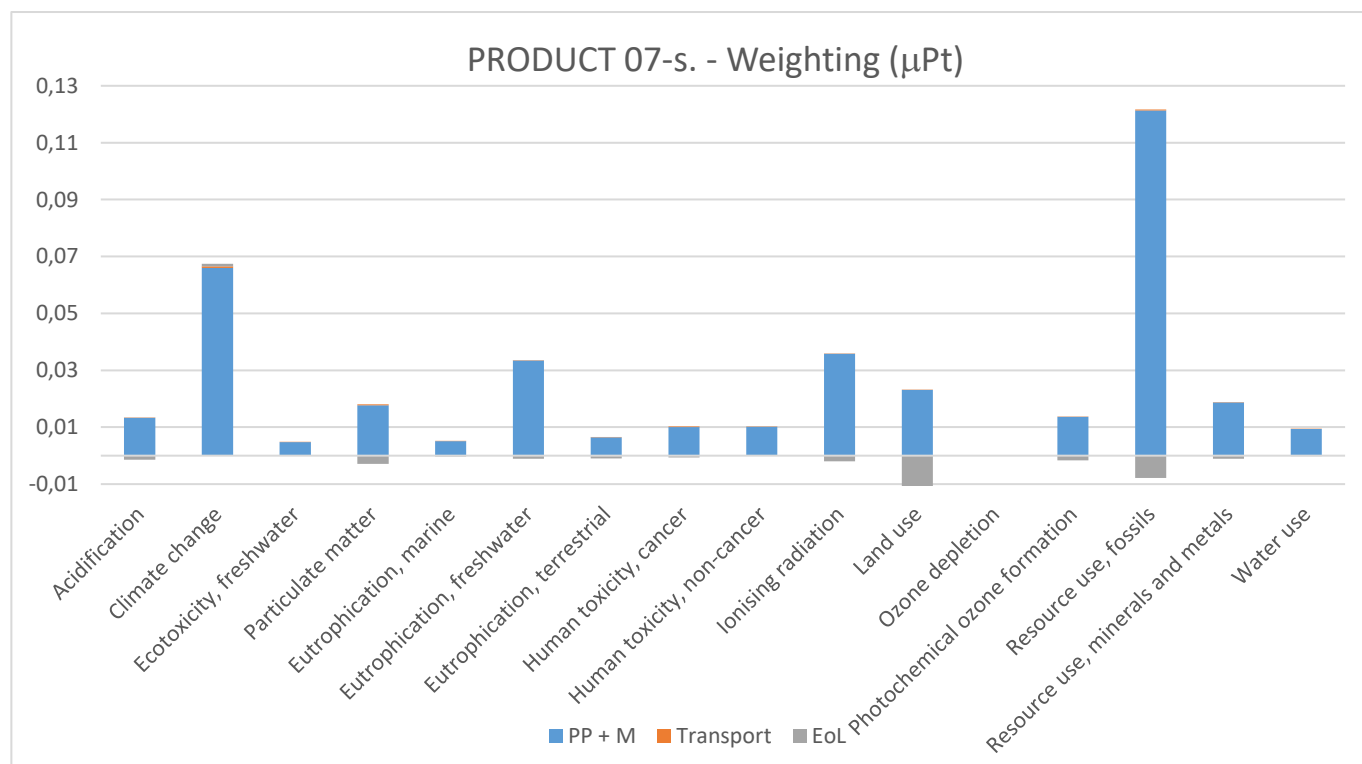


Figure 23: Normalised and weighted results - PRODUCT 07 – Butter, Aluminium, & Paper Film



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Single score

- Weighted results as single score in μPt for all the life cycle stages (Pre-processing and manufacturing, Transport and End-of-Life)
- For product 07 – Butter, Al & OPP Film, the most relevant life cycle stage is PP+M (96,1%). The most relevant processes (processes details are shown in table A7) are related to component 7.2 Aluminium Lid and are Aluminium pre-processing and manufacturing.
- For product 07-s – Butter, Al & Paper Film, the most relevant processes (processes details are shown in table B7) are related to component 7.2 Greaseproof Base Paper and are Kraft Paper pre-processing and manufacturing.

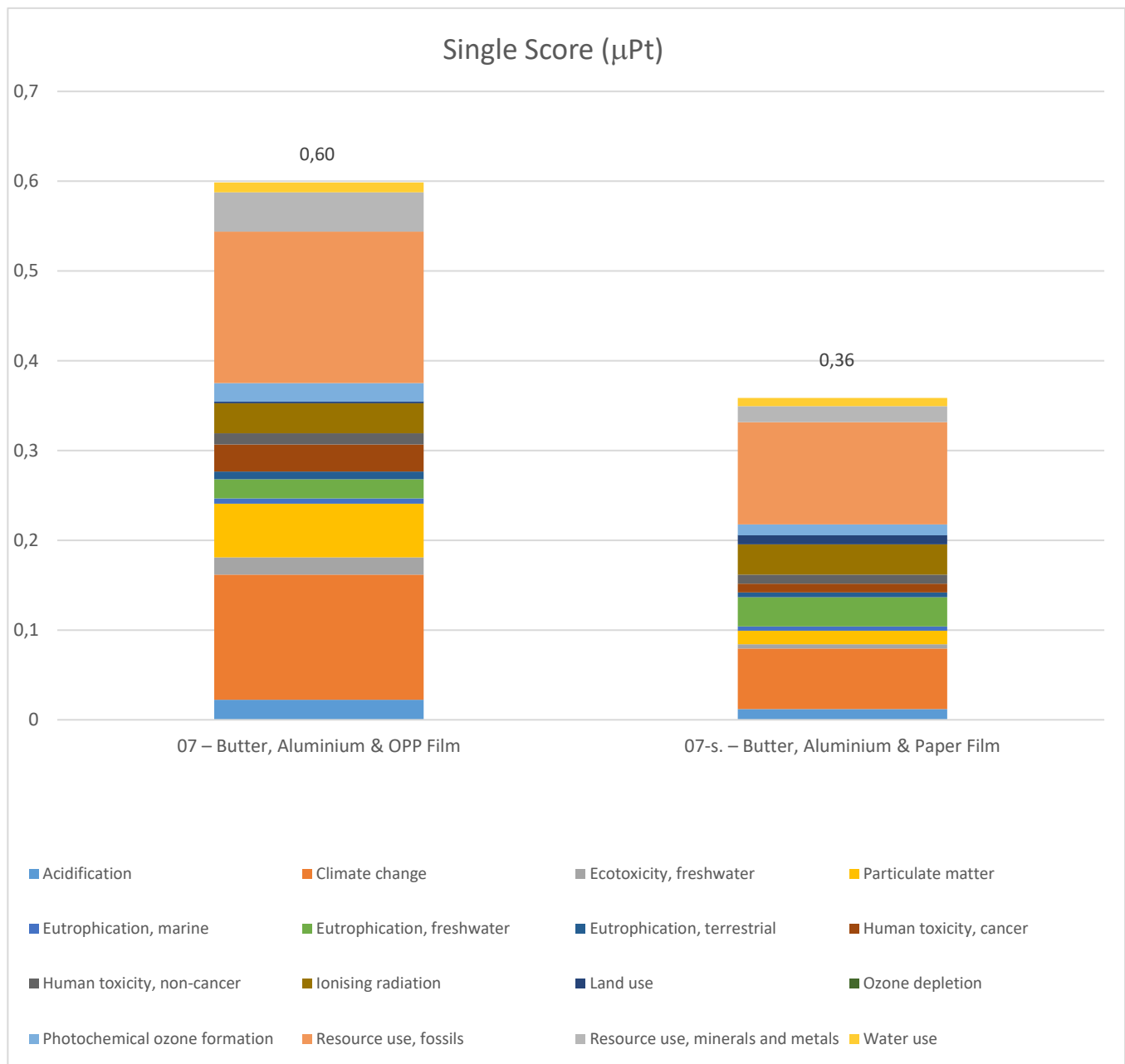


Figure 24: Weighted results as single score in μPt - PRODUCT 07 – Butter, Aluminium, & OPP Film



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PRODUCT 08 – Grated cheese, OPA & LDPE Film

Characterised results

- **Characterised** results of all EF impact categories

Tab 18. Characterised results PRODUCT 08 – Grated Cheese, OPA & LDPE Film

IMPACT CATEGORY	UNIT	TOTAL	08. GRATED CHEESE, OPA & LDPE FILM - PP+M	08. GRATED CHEESE, OPA & LDPE FILM - T	08. GRATED CHEESE, OPA & LDPE FILM - EOL
Acidification	mol H+ eq	4,26E-05	4,72E-05	1,31E-07	-4,77E-06
Climate change	kg CO2 eq	1,39E-02	1,31E-02	4,17E-05	7,37E-04
Ecotoxicity, freshwater	CTUe	6,62E-02	6,59E-02	1,53E-04	1,76E-04
Particulate matter	disease inc.	4,45E-10	4,87E-10	3,58E-12	-4,60E-11
Eutrophication, marine	kg N eq	1,02E-05	1,06E-05	4,42E-08	-3,96E-07
Eutrophication, freshwater	kg P eq	1,28E-06	1,39E-06	2,85E-09	-1,12E-07
Eutrophication, terrestrial	mol N eq	9,33E-05	1,03E-04	4,80E-07	-9,89E-06
Human toxicity, cancer	CTUh	3,19E-11	3,39E-11	2,76E-13	-2,27E-12
Human toxicity, non-cancer	CTUh	5,98E-11	6,19E-11	3,73E-13	-2,45E-12
Ionising radiation	kBq U-235 eq	-1,91E-04	1,73E-03	7,79E-07	-1,92E-03
Land use	Pt	3,65E-02	3,68E-02	4,57E-04	-7,58E-04
Ozone depletion	kg CFC11 eq	3,32E-10	3,91E-10	8,32E-13	-5,93E-11
Photochemical ozone formation	kg NMVOC eq	4,51E-05	5,13E-05	2,09E-07	-6,43E-06
Resource use, fossils	MJ	2,07E-01	2,84E-01	5,93E-04	-7,79E-02
Resource use, minerals and metals	kg Sb eq	9,36E-08	1,03E-07	1,28E-10	-9,24E-09
Water use	m3 depriv.	1,07E-02	1,15E-02	2,62E-06	-7,53E-04

Tab 19. Characterised results PRODUCT 08-s – Grated Cheese, Paper Bag

IMPACT CATEGORY	UNIT	TOTAL	08-S. GRATED CHEESE, PAPER BAG - PP+M	08-S. GRATED CHEESE, PAPER BAG - T	08-S. GRATED CHEESE, PAPER BAG - EOL
Acidification	mol H+ eq	1,51E-05	1,84E-05	1,73E-07	-3,49E-06
Climate change	kg CO2 eq	3,09E-03	2,94E-03	5,49E-05	9,27E-05
Ecotoxicity, freshwater	CTUe	3,62E-02	3,70E-02	2,02E-04	-1,04E-03
Particulate matter	disease inc.	1,08E-10	1,56E-10	4,71E-12	-5,33E-11
Eutrophication, marine	kg N eq	5,86E-06	6,37E-06	5,81E-08	-5,74E-07
Eutrophication, freshwater	kg P eq	4,21E-06	4,39E-06	3,75E-09	-1,83E-07
Eutrophication, terrestrial	mol N eq	4,24E-05	5,49E-05	6,32E-07	-1,31E-05
Human toxicity, cancer	CTUh	8,76E-12	9,82E-12	3,63E-13	-1,42E-12
Human toxicity, non-cancer	CTUh	4,10E-11	4,28E-11	4,91E-13	-2,31E-12
Ionising radiation	kBq U-235 eq	8,37E-04	1,30E-03	1,03E-06	-4,67E-04
Land use	Pt	2,68E-01	6,46E-01	6,01E-04	-3,78E-01
Ozone depletion	kg CFC11 eq	2,10E-10	2,24E-10	1,10E-12	-1,46E-11
Photochemical ozone formation	kg NMVOC eq	1,46E-05	1,81E-05	2,75E-07	-3,83E-06
Resource use, fossils	MJ	4,56E-02	6,20E-02	7,80E-04	-1,71E-02
Resource use, minerals and metals	kg Sb eq	1,12E-08	1,35E-08	1,68E-10	-2,46E-09
Water use	m3 depriv.	1,54E-03	1,63E-03	3,44E-06	-8,80E-05



Weighted results

- Normalised and **weighted** results

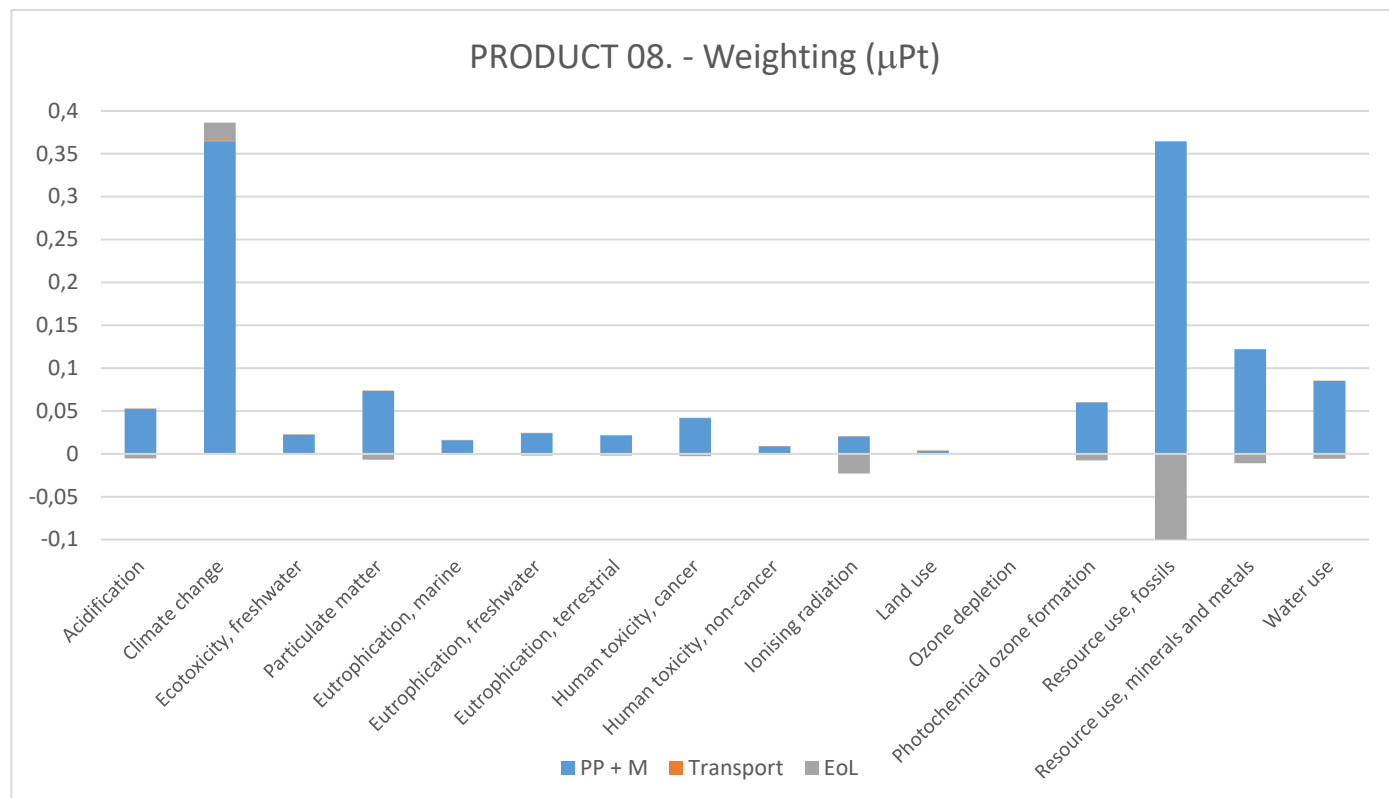


Figure 25: Normalised and weighted results - PRODUCT 08 – Grated cheese, OPA & LDPE Film

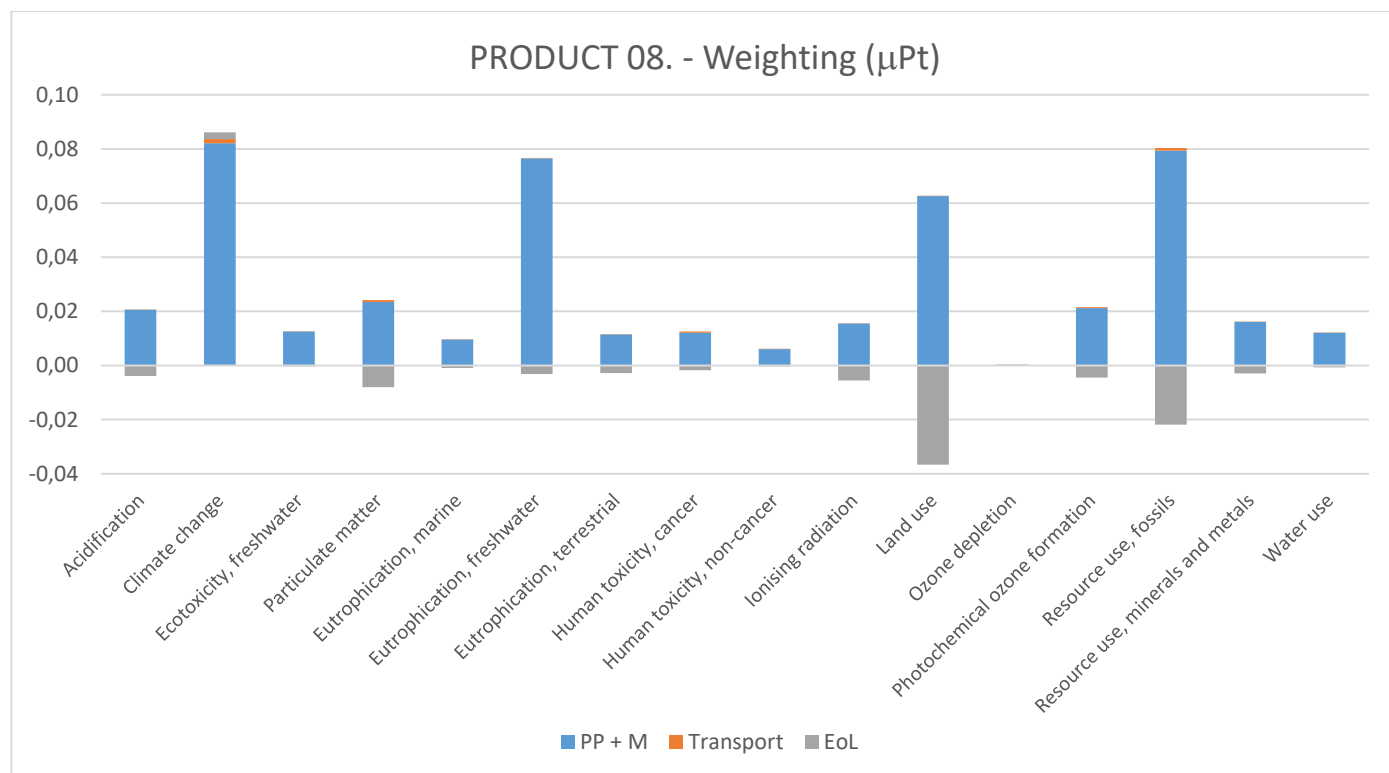


Figure 26: Normalised and weighted results - PRODUCT 08-s – Grated cheese, Paper Bag



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Single score

- Weighted results as single score in μPt for all the life cycle stages (Pre-processing and manufacturing, Transport and End-of-Life)
- For product 08. Grated cheese, OPA&LDPE Film, the most relevant processes (processes details are shown in table A8) are related to component 8.3 LDPE Foil and are Polyethylene, linear low density pre-processing and manufacturing.
- For product 08-s. Grated cheese, Paper Bag, the most relevant processes (processes details are shown in table B8) are related to component 8.2-s Paper and are Kraft Paper pre-processing and manufacturing.

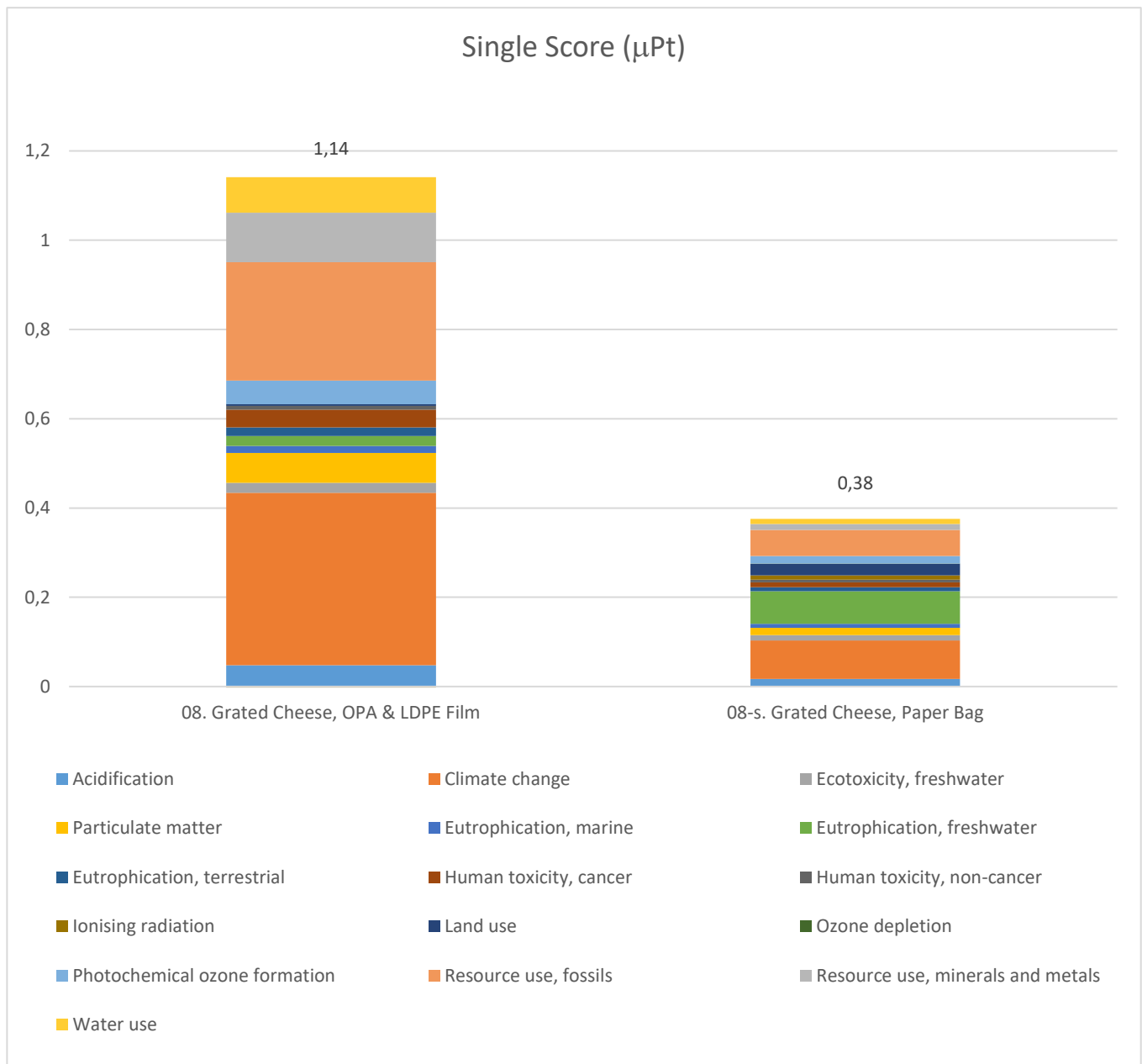


Figure 27: Weighted results as single score in μPt - PRODUCT 08 – Grated cheese, OPA & LDPE Film and PRODUCT 08-s – Grated cheese, Paper Bag



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PRODUCT 09 – Chips, OPP Film

Characterised results

- **Characterised** results of all EF impact categories

Tab 20. Characterised results PRODUCT 09 – Chips, OPP Film

IMPACT CATEGORY	UNIT	TOTAL	09. CHIPS, OPP FILM - PP+M	09. CHIPS, OPP FILM - T	09. CHIPS, OPP FILM - EOL
Acidification	mol H ⁺ eq	2,98E-05	3,28E-05	1,51E-07	-3,06E-06
Climate change	kg CO ₂ eq	1,11E-02	9,81E-03	4,81E-05	1,21E-03
Ecotoxicity, freshwater	CTUe	1,33E-01	1,35E-01	1,77E-04	-2,44E-03
Particulate matter	disease inc.	2,77E-10	2,96E-10	4,13E-12	-2,29E-11
Eutrophication, marine	kg N eq	7,56E-06	7,84E-06	5,09E-08	-3,37E-07
Eutrophication, freshwater	kg P eq	1,78E-06	1,91E-06	3,28E-09	-1,38E-07
Eutrophication, terrestrial	mol N eq	6,24E-05	6,76E-05	5,54E-07	-5,75E-06
Human toxicity, cancer	CTUh	4,26E-11	4,56E-11	3,18E-13	-3,34E-12
Human toxicity, non-cancer	CTUh	8,62E-11	9,11E-11	4,30E-13	-5,27E-12
Ionising radiation	kBq U-235 eq	5,29E-04	2,25E-03	8,98E-07	-1,72E-03
Land use	Pt	5,67E-02	5,76E-02	5,27E-04	-1,41E-03
Ozone depletion	kg CFC11 eq	8,30E-10	9,06E-10	9,60E-13	-7,74E-11
Photochemical ozone formation	kg NMVOC eq	4,29E-05	4,84E-05	2,41E-07	-5,75E-06
Resource use, fossils	MJ	2,28E-01	3,04E-01	6,84E-04	-7,61E-02
Resource use, minerals and metals	kg Sb eq	7,89E-08	8,67E-08	1,47E-10	-7,95E-09
Water use	m ³ depriv.	3,87E-03	4,37E-03	3,02E-06	-5,00E-04

Tab 21. Characterised results PRODUCT 09-s – Chips, Paper & PP Bag

IMPACT CATEGORY	UNIT	TOTAL	09-S. CHIPS CHEESE, PAPER & PP BAG - PP+M	09-S. CHIPS CHEESE, PAPER & PP BAG - T	09-S. CHIPS CHEESE, PAPER & PP BAG - EOL
Acidification	mol H ⁺ eq	3,02E-05	3,44E-05	2,24E-07	-4,44E-06
Climate change	kg CO ₂ eq	7,54E-03	7,10E-03	7,12E-05	3,62E-04
Ecotoxicity, freshwater	CTUe	8,66E-02	8,82E-02	2,62E-04	-1,94E-03
Particulate matter	disease inc.	2,85E-10	3,42E-10	6,11E-12	-6,32E-11
Eutrophication, marine	kg N eq	1,02E-05	1,08E-05	7,54E-08	-6,97E-07
Eutrophication, freshwater	kg P eq	5,51E-06	5,73E-06	4,86E-09	-2,29E-07
Eutrophication, terrestrial	mol N eq	7,98E-05	9,46E-05	8,20E-07	-1,57E-05
Human toxicity, cancer	CTUh	2,58E-11	2,75E-11	4,71E-13	-2,23E-12
Human toxicity, non-cancer	CTUh	6,76E-11	7,05E-11	6,37E-13	-3,54E-12
Ionising radiation	kBq U-235 eq	2,57E-04	1,13E-03	1,33E-06	-8,73E-04
Land use	Pt	3,20E-01	7,43E-01	7,80E-04	-4,23E-01
Ozone depletion	kg CFC11 eq	4,20E-10	4,50E-10	1,42E-12	-3,20E-11
Photochemical ozone formation	kg NMVOC eq	3,13E-05	3,63E-05	3,57E-07	-5,41E-06
Resource use, fossils	MJ	1,10E-01	1,43E-01	1,01E-03	-3,45E-02
Resource use, minerals and metals	kg Sb eq	3,57E-08	3,97E-08	2,18E-10	-4,22E-09
Water use	m ³ depriv.	2,88E-03	3,07E-03	4,47E-06	-1,97E-04



Weighted results

- Normalised and **weighted** results

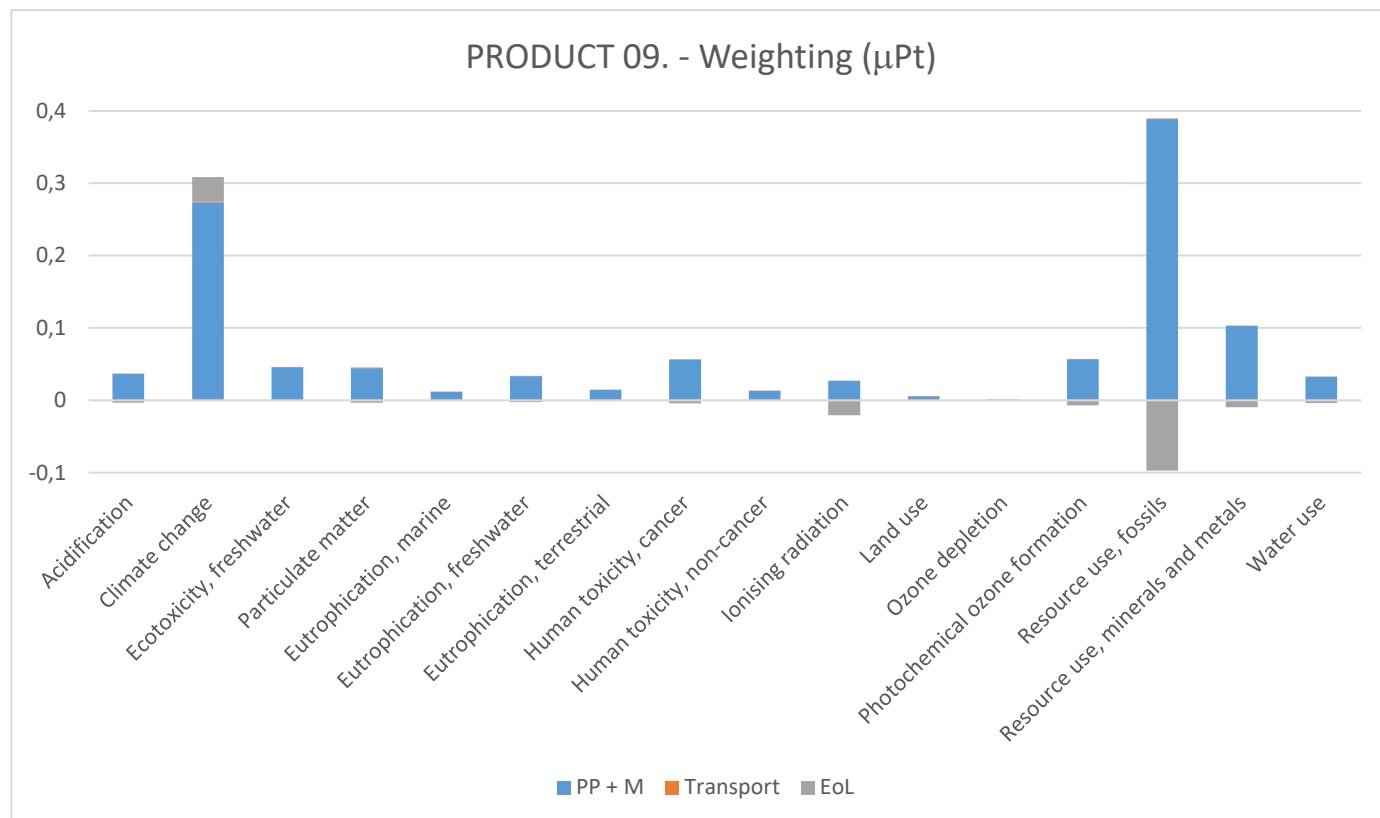


Figure 28: Normalised and weighted results - PRODUCT 09 – Chips, OPP Film

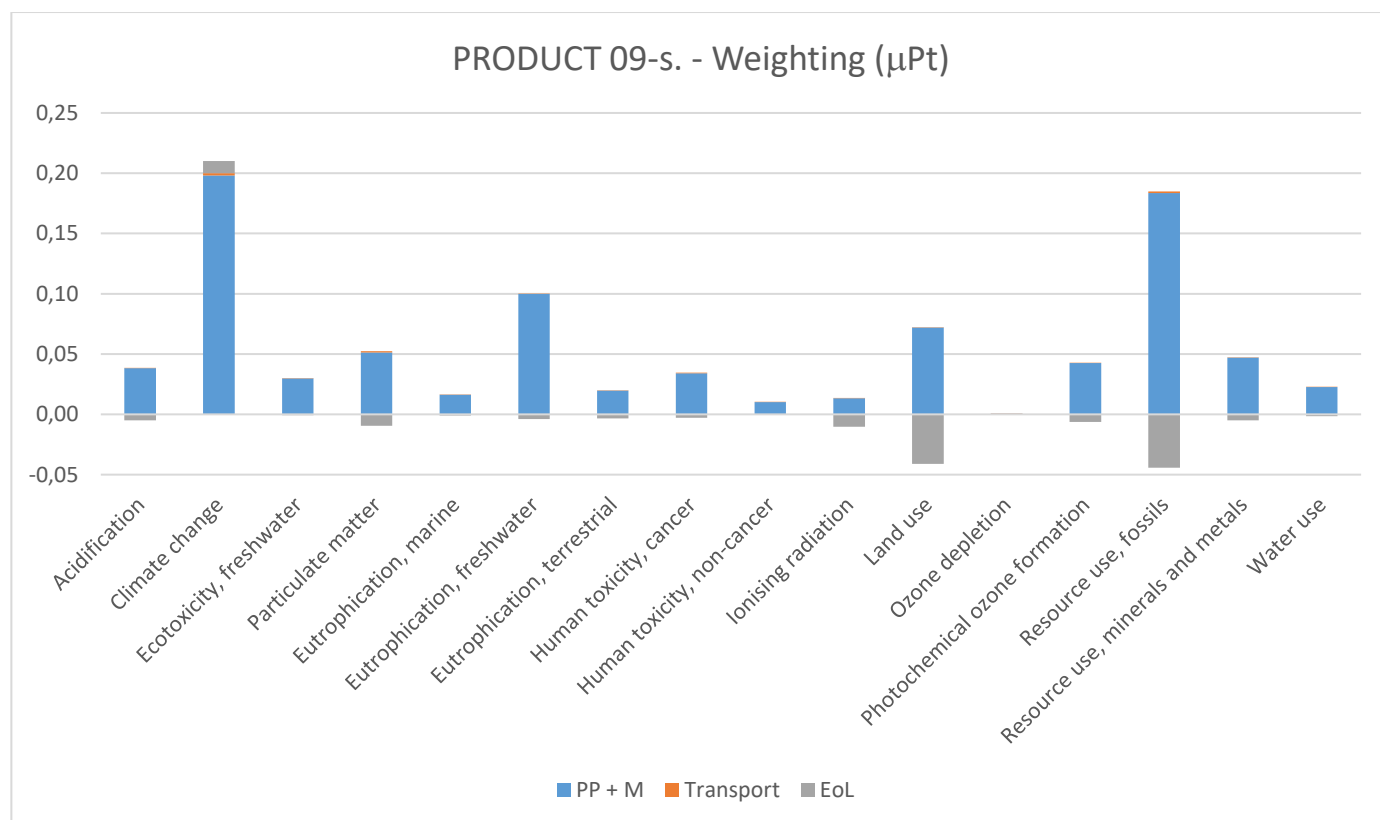


Figure 29: Normalised and weighted results - PRODUCT 09-s – Chips, Paper & PP Bag



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Single score

- Weighted results as single score in μPt for all the life cycle stages (Pre-processing and manufacturing, Transport and End-of-Life)
- For product 09. Chips, OPP Film, the most relevant processes (processes details are shown in table A9 are related to component 9.2 OPP Film and are Polypropylene pre-processing and manufacturing.
- For product 09-s. Chips, Paper & PP Bag, the most relevant processes (processes details are shown in table B9 are related to component 9.1-s Paper Sack and are Kraft Paper pre-processing and manufacturing.

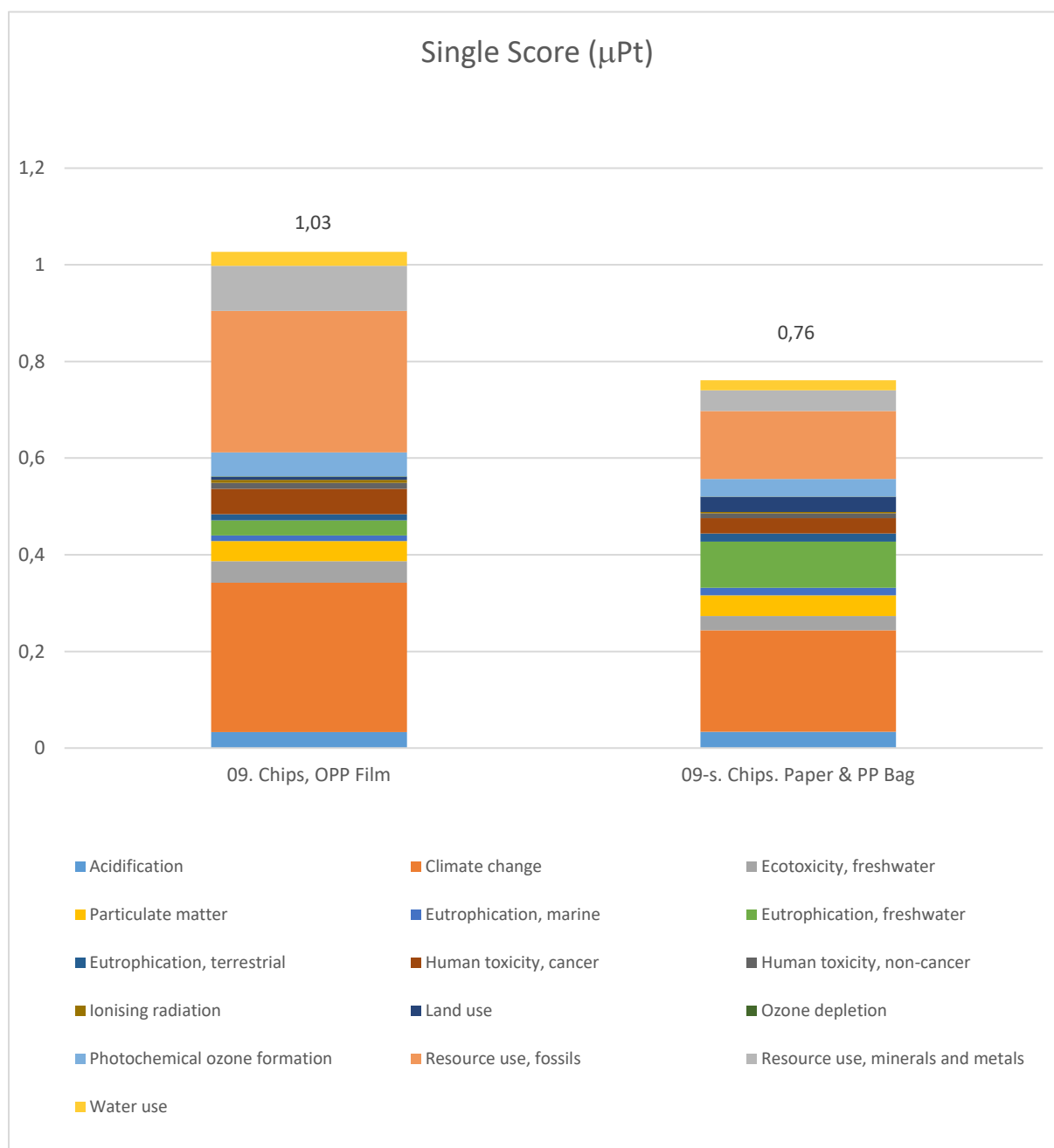


Figure 30: Weighted results as single score in μPt - PRODUCT 09 – Chips, OPP Film and - PRODUCT 09-s – Chips, Paper & PP Bag



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PRODUCT 10 – Savory biscuits, OPP & Cardboard

Characterised results

- **Characterised** results of all EF impact categories

Tab 22. Characterised results PRODUCT 10 – Savory Biscuits, OPP Film

IMPACT CATEGORY	UNIT	TOTAL	10. SAVORY BISCUITS, OPP FILM - PP+M	10. SAVORY BISCUITS, OPP FILM - T	10. SAVORY BISCUITS, OPP FILM - EOL
Acidification	mol H+ eq	2,93E-05	3,25E-05	1,69E-07	-3,43E-06
Climate change	kg CO2 eq	1,18E-02	1,04E-02	5,38E-05	1,35E-03
Ecotoxicity, freshwater	CTUe	3,70E-02	3,96E-02	1,98E-04	-2,74E-03
Particulate matter	disease inc.	2,60E-10	2,81E-10	4,62E-12	-2,57E-11
Eutrophication, marine	kg N eq	6,40E-06	6,72E-06	5,70E-08	-3,77E-07
Eutrophication, freshwater	kg P eq	1,77E-06	1,92E-06	3,67E-09	-1,54E-07
Eutrophication, terrestrial	mol N eq	6,17E-05	6,75E-05	6,20E-07	-6,44E-06
Human toxicity, cancer	CTUh	3,65E-11	3,99E-11	3,56E-13	-3,74E-12
Human toxicity, non-cancer	CTUh	1,11E-10	1,17E-10	4,81E-13	-5,90E-12
Ionising radiation	kBq U-235 eq	1,07E-03	3,00E-03	1,00E-06	-1,93E-03
Land use	Pt	4,92E-02	5,02E-02	5,89E-04	-1,58E-03
Ozone depletion	kg CFC11 eq	3,68E-10	4,53E-10	1,07E-12	-8,66E-11
Photochemical ozone formation	kg NMVOC eq	4,71E-05	5,33E-05	2,70E-07	-6,44E-06
Resource use, fossils	MJ	2,67E-01	3,51E-01	7,65E-04	-8,52E-02
Resource use, minerals and metals	kg Sb eq	8,04E-08	8,91E-08	1,65E-10	-8,90E-09
Water use	m3 depriv.	4,60E-03	5,16E-03	3,37E-06	-5,60E-04

Tab 23. Characterised results PRODUCT 10-s – Savory Biscuits, Paper & PP Bag

IMPACT CATEGORY	UNIT	TOTAL	10-S. SAVORY BISCUITS, PAPER & PP BAG - PP+M	10-S. SAVORY BISCUITS, PAPER & PP BAG - T	10-S. SAVORY BISCUITS, PAPER & PP BAG - EOL
Acidification	mol H+ eq	4,46E-05	5,11E-05	3,45E-07	-6,84E-06
Climate change	kg CO2 eq	1,08E-02	1,02E-02	1,10E-04	5,04E-04
Ecotoxicity, freshwater	CTUe	1,19E-01	1,22E-01	4,03E-04	-2,94E-03
Particulate matter	disease inc.	4,12E-10	5,01E-10	9,41E-12	-9,86E-11
Eutrophication, marine	kg N eq	1,53E-05	1,63E-05	1,16E-07	-1,08E-06
Eutrophication, freshwater	kg P eq	8,67E-06	9,01E-06	7,49E-09	-3,54E-07
Eutrophication, terrestrial	mol N eq	1,20E-04	1,43E-04	1,26E-06	-2,45E-05
Human toxicity, cancer	CTUh	3,77E-11	4,03E-11	7,25E-13	-3,33E-12
Human toxicity, non-cancer	CTUh	9,78E-11	1,02E-10	9,81E-13	-5,30E-12
Ionising radiation	kBq U-235 eq	4,53E-04	1,73E-03	2,05E-06	-1,28E-03
Land use	Pt	5,31E-01	1,20E+00	1,20E-03	-6,69E-01
Ozone depletion	kg CFC11 eq	5,51E-10	5,95E-10	2,19E-12	-4,62E-11
Photochemical ozone formation	kg NMVOC eq	4,56E-05	5,32E-05	5,50E-07	-8,23E-06
Resource use, fossils	MJ	1,52E-01	2,01E-01	1,56E-03	-5,02E-02
Resource use, minerals and metals	kg Sb eq	4,91E-08	5,50E-08	3,35E-10	-6,22E-09
Water use	m3 depriv.	4,34E-03	4,62E-03	6,88E-06	-2,83E-04



Weighted results

- Normalised and **weighted** results

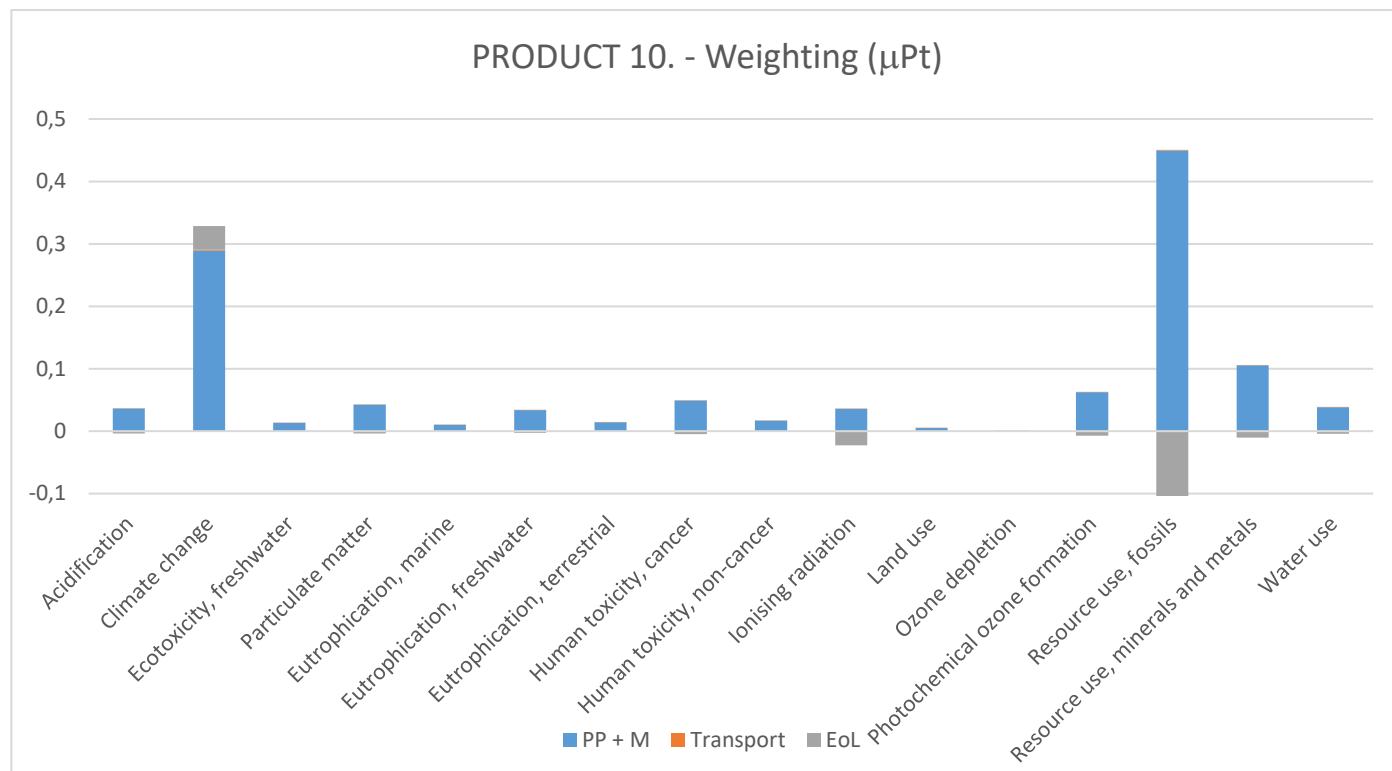


Figure 31: Normalised and weighted results - PRODUCT 10 – Savory biscuits, OPP Film

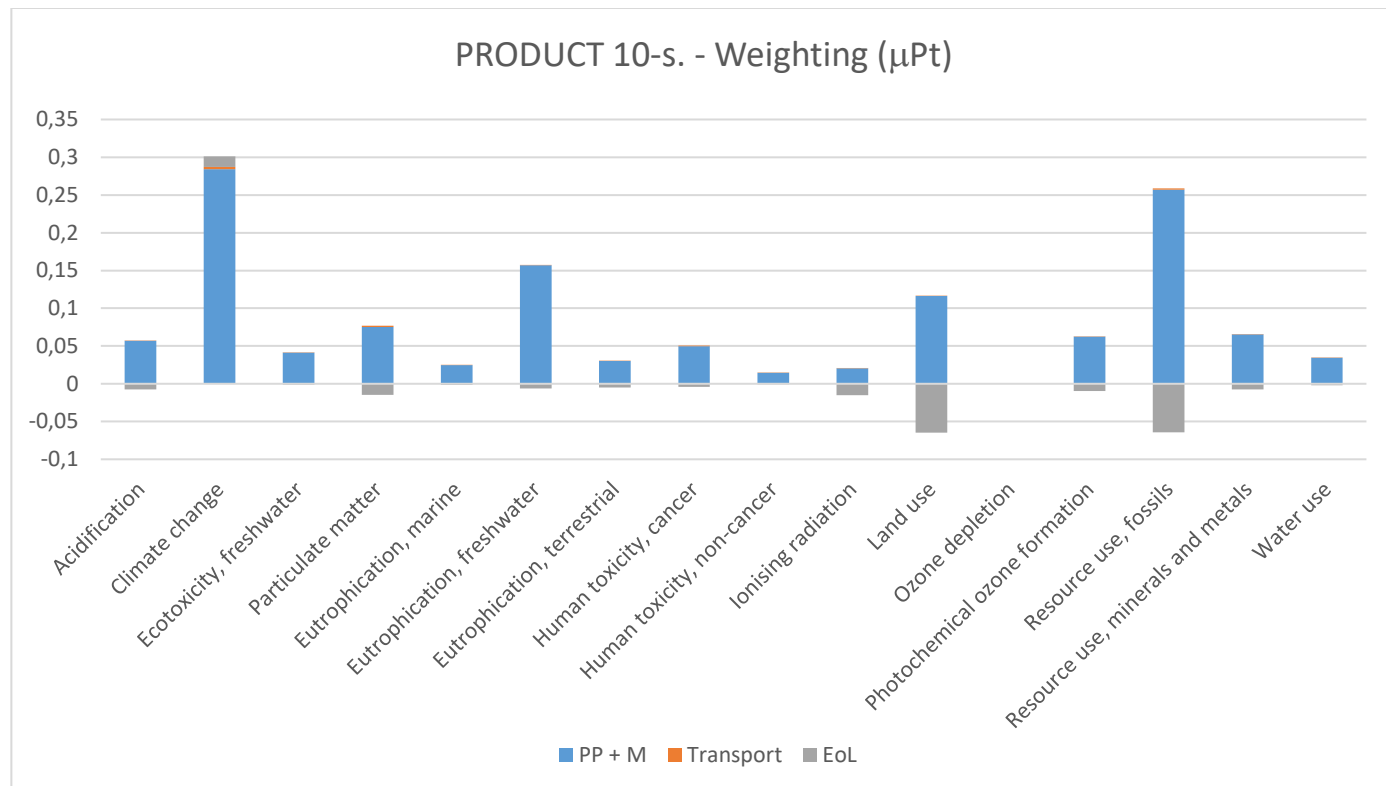


Figure 32: Normalised and weighted results - PRODUCT 10-s – Savory biscuits, Paper & PP Bag



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Single score

- Weighted results as single score in μPt for all the life cycle stages (Pre-processing and manufacturing, Transport and End-of-Life)
- For product 10. Savory biscuits, OPP Film the most processes (processes details are shown in table A10) are related to component 10.1 OPP Film are Polypropylene pre-processing and manufacturing.
- For product 10-s. Savory biscuits, Paper & PP Bag the most processes (processes details are shown in table B10) are related to component 10.1-s Paper Sack and are Kraft Paper pre-processing and manufacturing.

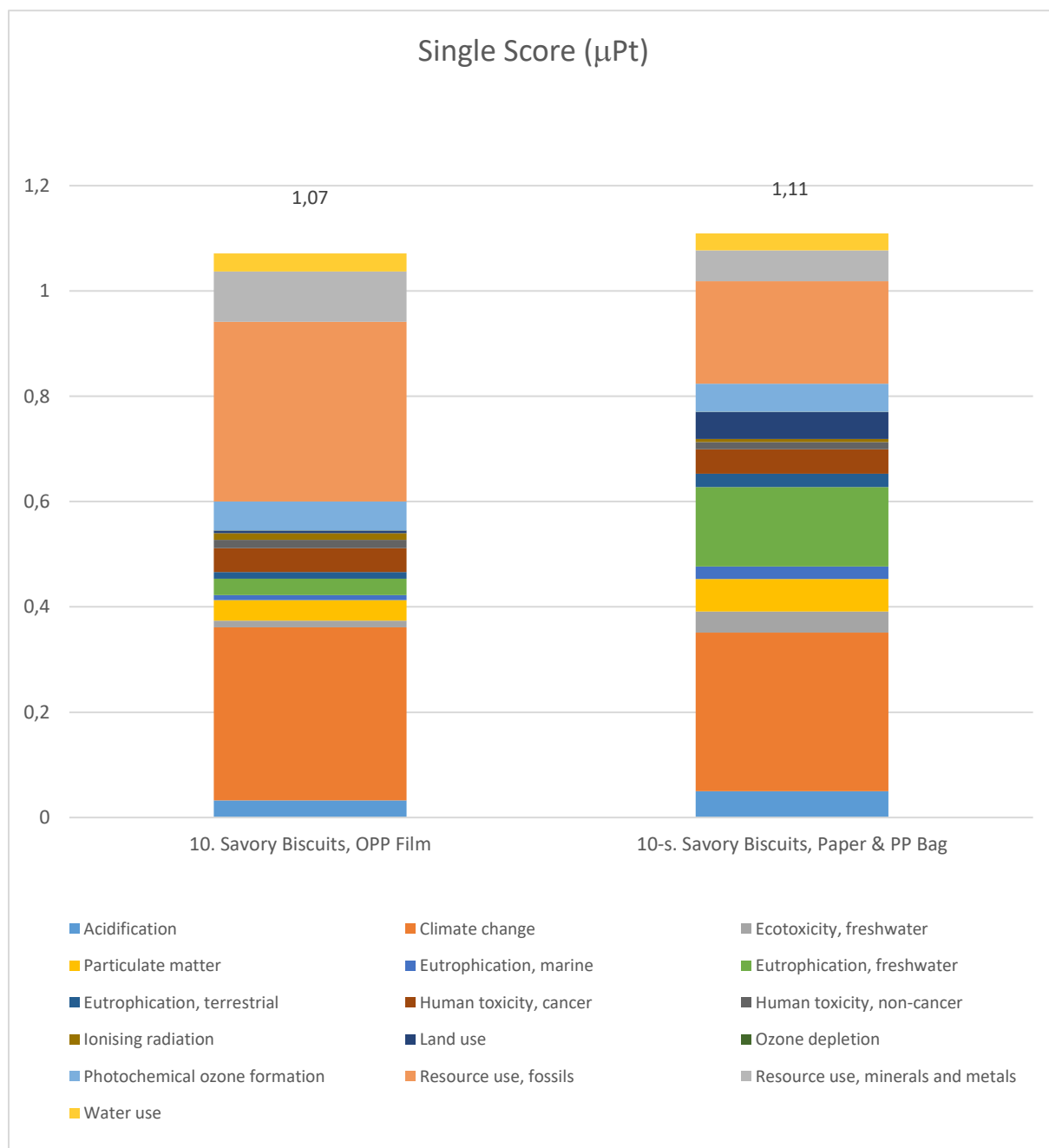


Figure 33: Weighted results as single score in μPt - PRODUCT 10 – Savory biscuits, OPP Film and PRODUCT 10-s – Savory biscuits, Paper & PP Bag



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3. INTERPRETING PEF RESULTS

3.1. Global Comparison

In this section, the impact assessment results of all products (SoA and Sub) are presented as follow:

- **Normalised** and **weighted** results: by % weighting for all the life cycle stages (**P**re-Processing and **M**anufacturing + **T**ransportation + **E**nd-of-Life). In this way it is possible to establish comparisons among different cycle stage contribution.
- Weighted results as **single score** in μ Pt for all product: In this way it is possible to establish comparisons between SoA and Sub products.

Weighted results

For all products the most relevant life cycle stage is Pre-Processing and Manufacturing (PP+M), Transportation has very low value in all products and the contribution of End-of-life is negative in all products, due in particular to the benefit of recycling.

The higher values (up to -20%) are in products 02-s Prepared Salad, Cardboard Tray, 04-s Greek yoghurt, Paper Cup and 08-s Grated cheese, Paper bag.

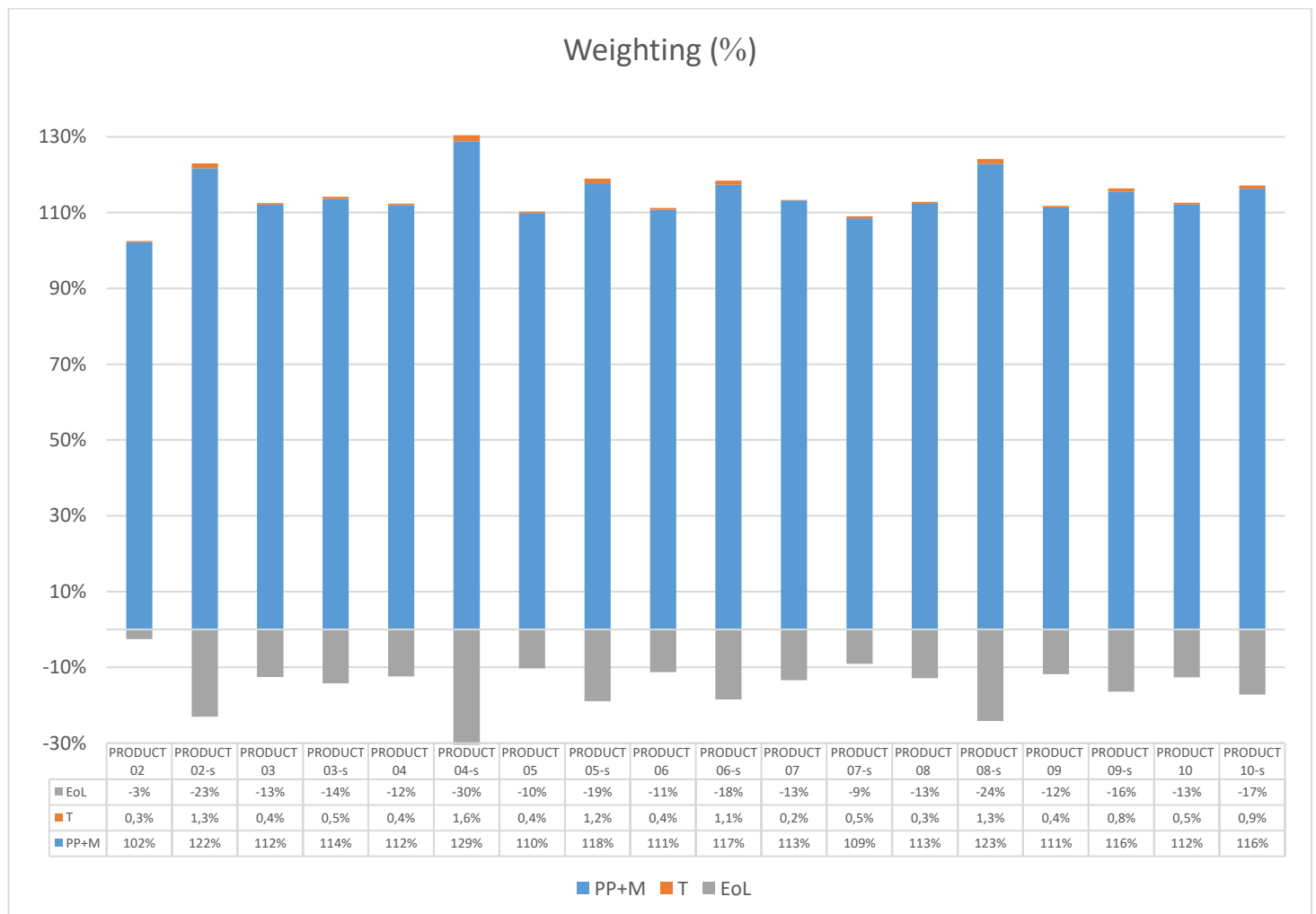


Figure 34: Weighted results as single score in % of the three Life Cycle Stage considered (pp+m, T, EoL) of all product



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Single score

For all couple of products, single score value is lower in the Substituted product, except that product #10 in which was found a little increase in impact value (4%).

In figure 35 are shown the results of single score of all products, each colour represent a couple (SoA and Sub); in tab 24 are shown the difference (in numeric value and in %) in weight of packaging and in single score, for each product.

As it is possible to note, the decrease in impact is not due to a reduction in packaging weight, because only in products #02 and #03 this is do. In all other products we have a higher weight in the substituted product with value from 19 and 130% more than SoA, but this has not influence on the single score value.

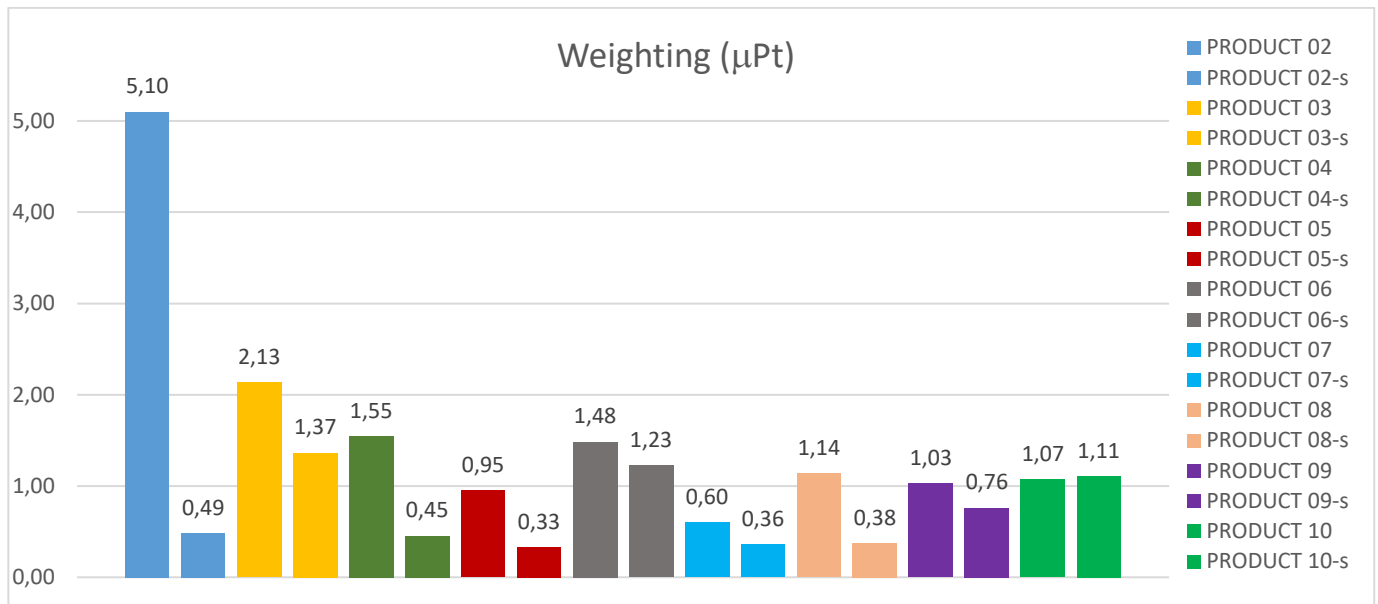


Figure 35: Single score results in μPt of all products

#Product	Packaging Weight (g) related to 100 grams of product content			Single Score (μPt) related to 100 grams of product content		
	State-of-the-Art	Substituted	Difference (%)	State-of-the-Art	Substituted	Difference (%)
#02	12,00	4,61	-62	5,10	0,49	-90
#03	6,18	4,95	-20	2,13	1,37	-36
#04	4,50	5,37	+19	1,55	0,45	-71
#05	2,76	3,60	+30	0,95	0,33	-65
#06	4,46	10,24	+130	1,48	1,23	-17
#07	0,78	1,32	+69	0,60	0,36	-40
#08	2,81	3,70	+32	1,14	0,38	-67
#09	3,24	4,80	+48	1,03	0,76	-26
#10	3,63	7,39	+104	1,07	1,11	+4

Tab 24. Percentage change in weights and in Single score for Functional Unit



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3.2. Most Relevant impact categories

In the previous section, characterized, normalised and weighted results for each EF impact category have been presented together with the single score for each life cycle stage. In this paragraph, the most relevant impact categories will be highlighted. As prescribed in the PEF method, impact categories cumulatively contributing at least 80% of the total environmental impact will be identified for each product based on the normalised and weighted results.

Below, for each product, a table is provided in which most relevant impact categories are ranked in descending order of impact on the total life cycle.

PRODUCT 02 – Salad MDD, PET Tray

Tab 25. Most relevant impact categories - PRODUCT 02 – Salad MDD, PET Tray

Label	Total (μPt)	%
Climate change	1,473	28,9%
Resource use, fossils	1,377	27,0%
Resource use, minerals and metals	0,538	10,5%
Particulate matter	0,276	5,4%
Ozone depletion	0,223	4,6%
Photochemical ozone formation	0,216	4,2%
Sum		80,6%

PRODUCT 02-s – Salad MDD, Cardboard Tray

Tab 26. Most relevant impact categories - PRODUCT 02-s – Salad MDD, Cardboard Tray

Label	Total (μPt)	%
Resource use, fossils	0,116	24,5%
Climate change	0,119	23,9%
Resource use, minerals and metals	0,028	5,9%
Land use	0,028	5,7%
Particulate matter	0,027	5,5%
Ionising radiation	0,026	5,3%
Water use	0,023	4,8%
Acidification	0,023	4,7%
Sum		80,3%

PRODUCT 03 – Sour cream, Cup

Tab 27. Most relevant impact categories - PRODUCT 03 – Sour cream, Cup

Label	Total (μPt)	%
Climate change	0,620	29,1%
Resource use, fossils	0,612	28,7%
Resource use, minerals and metals	0,200	9,4%
Particulate matter	0,133	6,2%
Human toxicity, cancer	0,100	4,7%
Photochemical ozone formation	0,099	4,6%
Sum		82,8%



PRODUCT 03-s – Sour cream, Paper Cup

Tab 28. Most relevant impact categories - *PRODUCT 03-s – Sour cream, Paper Cup*

Label	Total (μPt)	%
Climate change	0,378	27,7%
Resource use, fossils	0,278	20,4%
Particulate matter	0,127	9,3%
Resource use, minerals and metals	0,124	9,1%
Human toxicity, cancer	0,070	5,1%
Acidification	0,061	4,5%
Eutrophication, freshwater	0,060	4,4%
Sum		80,4%

PRODUCT 04 – Greek yoghurt, Cup

Tab 29. Most relevant impact categories - *PRODUCT 04 – Greek yoghurt, Cup*

Label	Total (μPt)	%
Climate change	0,450	29,1%
Resource use, fossils	0,446	28,9%
Resource use, minerals and metals	0,145	9,4%
Particulate matter	0,095	6,1%
Photochemical ozone formation	0,072	4,7%
Human toxicity, cancer	0,072	4,7%
Sum		82,8%

PRODUCT 04-s – Greek yoghurt, Paper Cup

Tab 30. Most relevant impact categories - *PRODUCT 04-s – Greek yoghurt, Paper Cup*

Label	Total (μPt)	%
Climate change	0,116	25,5%
Resource use, fossils	0,092	20,4%
Particulate matter	0,047	10,5%
Land use	0,033	7,3%
Resource use, minerals and metals	0,025	5,4%
Human toxicity, cancer	0,024	5,3%
Photochemical ozone formation	0,020	4,5%
Acidification	0,019	4,2%
Sum		83,1%

PRODUCT 05 – Pork chop, Wrapped Tray

Tab 31. Most relevant impact categories - *PRODUCT 05 – Pork chop, Wrapped Tray*

Label	Total (μPt)	%
Climate change	0,342	36,0%
Resource use, fossils	0,273	28,7%
Photochemical ozone formation	0,064	6,7%
Particulate matter	0,059	6,2%
Water use	0,057	6,0%
Sum		83,5%



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PRODUCT 05-s – Pork chop, Cellulose Tray

Tab 32. Most relevant impact categories - *PRODUCT 05-s – Pork chop, Cellulose Tray*

Label	Total (µPt)	%
Climate change	0,087	26,1%
Resource use, fossils	0,065	19,6%
Particulate matter	0,027	8,1%
Resource use, minerals and metals	0,027	8,1%
Human toxicity, cancer	0,017	5,2%
Ecotoxicity, freshwater	0,017	5,0%
Water use	0,016	4,9%
Acidification	0,013	4,0%
Sum		81,0%

PRODUCT 06 – Florette Mache, OPP Film

Tab 33. Most relevant impact categories - *PRODUCT 06 – Florette Mache, OPP Film*

Label	Total (µPt)	%
Resource use, fossils	0,437	29,4%
Climate change	0,436	29,4%
Resource use, minerals and metals	0,137	9,2%
Human toxicity, cancer	0,080	5,4%
Photochemical ozone formation	0,072	4,8%
Particulate matter	0,058	3,9%
Sum		82,3%

PRODUCT 06-s – Florette Mache, Paper/PE Bag

Tab 34. Most relevant impact categories - *PRODUCT 06-s – Florette Mache, Paper/PE Bag*

Label	Total (µPt)	%
Climate change	0,306	24,9%
Eutrophication, freshwater	0,206	16,8%
Resource use, fossils	0,185	15,1%
Land use	0,076	6,2%
Particulate matter	0,064	5,2%
Photochemical ozone formation	0,059	4,8%
Human toxicity, cancer	0,057	4,7%
Acidification	0,057	4,7%
Sum		82,3%



PRODUCT 07 – Butter, Aluminium & OPP Film

Tab 35. Most relevant impact categories - PRODUCT 07 – Butter, Aluminium & OPP Film

Label	Total (µPt)	%
Resource use, fossils	0,169	28,2%
Climate change	0,139	23,3%
Particulate matter	0,060	10,0%
Resource use, minerals and metals	0,044	7,3%
Ionising radiation	0,034	5,6%
Human toxicity, cancer	0,030	5,1%
Sum		79,5%

PRODUCT 07-s – Butter, Aluminium & Paper Film

Tab 36. Most relevant impact categories - PRODUCT 07-s – Butter, Aluminium & Paper Film

Label	Total (µPt)	%
Resource use, fossils	0,114	31,8%
Climate change	0,067	18,8%
Ionising radiation	0,034	9,4%
Eutrophication, freshwater	0,032	9,0%
Resource use, minerals and metals	0,018	4,9%
Particulate matter	0,015	4,2%
Photochemical ozone formation	0,012	3,4%
Sum		81,6%

PRODUCT 08 – Grated cheese, OPA & LDPE Film

Tab 37. Most relevant impact categories - PRODUCT 08 – Grated Cheese, OPA & LDPE Film

Label	Total (µPt)	%
Climate change	0,387	33,9%
Resource use, fossils	0,265	23,3%
Resource use, minerals and metals	0,111	9,8%
Water use	0,079	7,0%
Particulate matter	0,067	5,9%
Sum		79,8%

PRODUCT 08-s – Grated cheese, Paper Bag

Tab 38. Most relevant impact categories - PRODUCT 08-s – Grated Cheese, Paper Bag

Label	Total (µPt)	%
Climate change	0,086	22,9%
Eutrophication, freshwater	0,073	19,5%
Resource use, fossils	0,058	15,6%
Land use	0,026	6,9%
Photochemical ozone formation	0,017	4,5%
Acidification	0,017	4,5%
Particulate matter	0,016	4,3%
Resource use, minerals and metals	0,013	3,6%
Sum		81,8%



PRODUCT 09 – Chips, OPP Film

Tab 39. Most relevant impact categories - *PRODUCT 09 – Chips, OPP Film*

Label	Total (µPt)	%
Climate change	0,309	30,1%
Resource use, fossils	0,292	28,5%
Resource use, minerals and metals	0,094	9,1%
Human toxicity, cancer	0,053	5,1%
Photochemical ozone formation	0,050	4,9%
Ecotoxicity, freshwater	0,045	4,4%
Sum		82,0%

PRODUCT 09-s – Chips, Paper & PP Bag

Tab 40. Most relevant impact categories - *PRODUCT 09-s – Chips, Paper & PP Bag*

Label	Total (µPt)	%
Climate change	0,210	27,6%
Resource use, fossils	0,141	18,5%
Eutrophication, freshwater	0,096	12,6%
Particulate matter	0,043	5,6%
Resource use, minerals and metals	0,042	5,6%
Photochemical ozone formation	0,037	4,8%
Acidification	0,034	4,4%
Sum		79,1%

PRODUCT 10 – Savory biscuits, OPP Film

Tab 41. Most relevant impact categories - *PRODUCT 10 – Savory biscuits, OPP Film*

Label	Total (µPt)	%
Resource use, fossils	0,341	31,9%
Climate change	0,328	30,7%
Resource use, minerals and metals	0,095	8,9%
Photochemical ozone formation	0,055	5,1%
Human toxicity, cancer	0,045	4,2%
Sum		80,8%

PRODUCT 10-s – Savory biscuits, Paper & PP Bag

Tab 42. Most relevant impact categories - *PRODUCT 10-s – Savory biscuits, Paper & PP Bag*

Label	Total (µPt)	%
Climate change	0,301	27,2%
Resource use, fossils	0,195	17,5%
Eutrophication, freshwater	0,151	13,6%
Particulate matter	0,062	5,6%
Resource use, minerals and metals	0,058	5,3%
Photochemical ozone formation	0,053	4,8%
Land use	0,051	4,6%
Acidification	0,050	4,5%
Sum		83,1%



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3.3. Relevant Impact categories overview

The graphic below (Fig.36 and 37) groups the impacts of all the products into the consistent impact categories, presented as percentage contribution (Tab. 24-41).

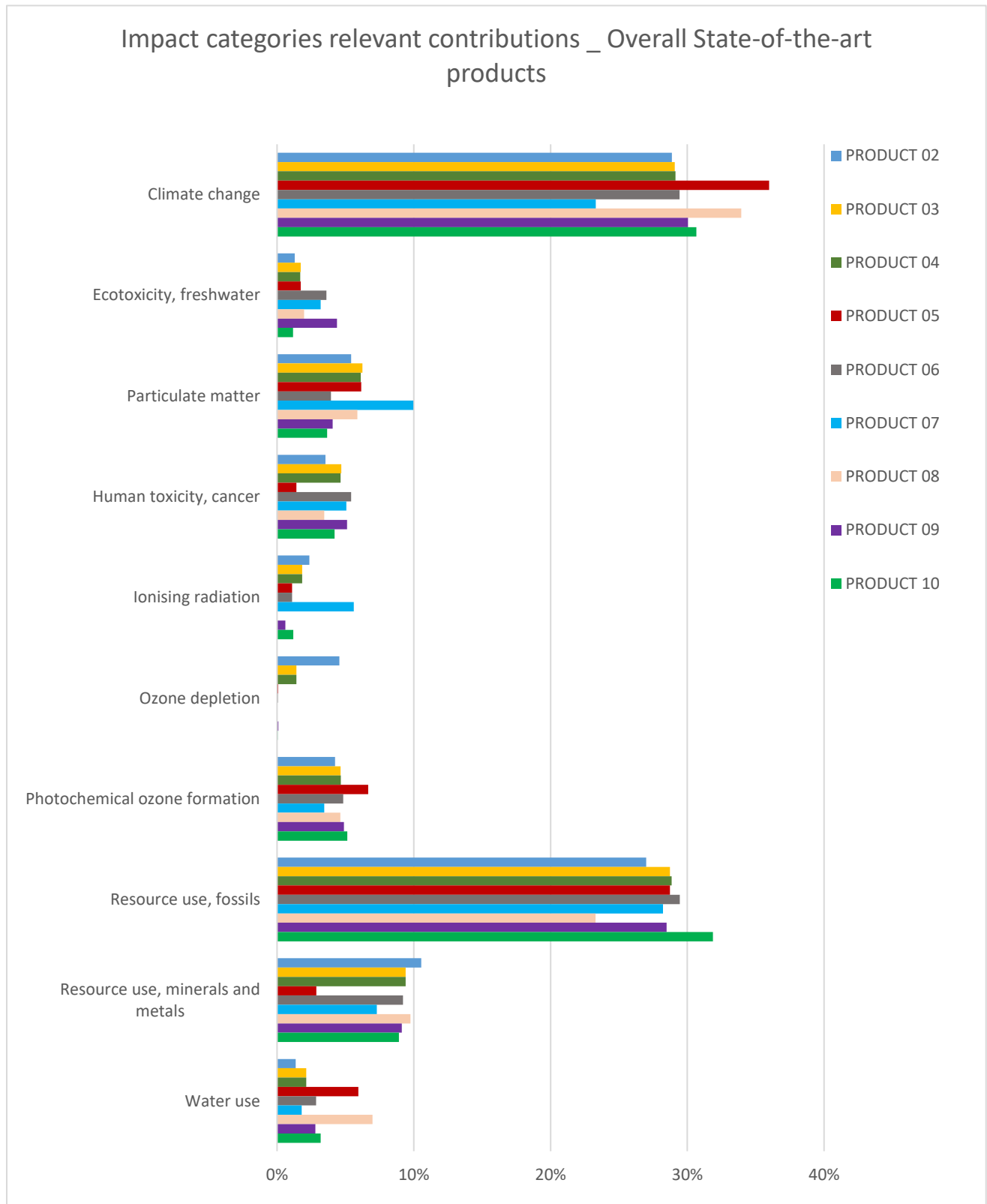


Figure 364: Impact categories relevant contributions on overall products (State-of-the-art products)



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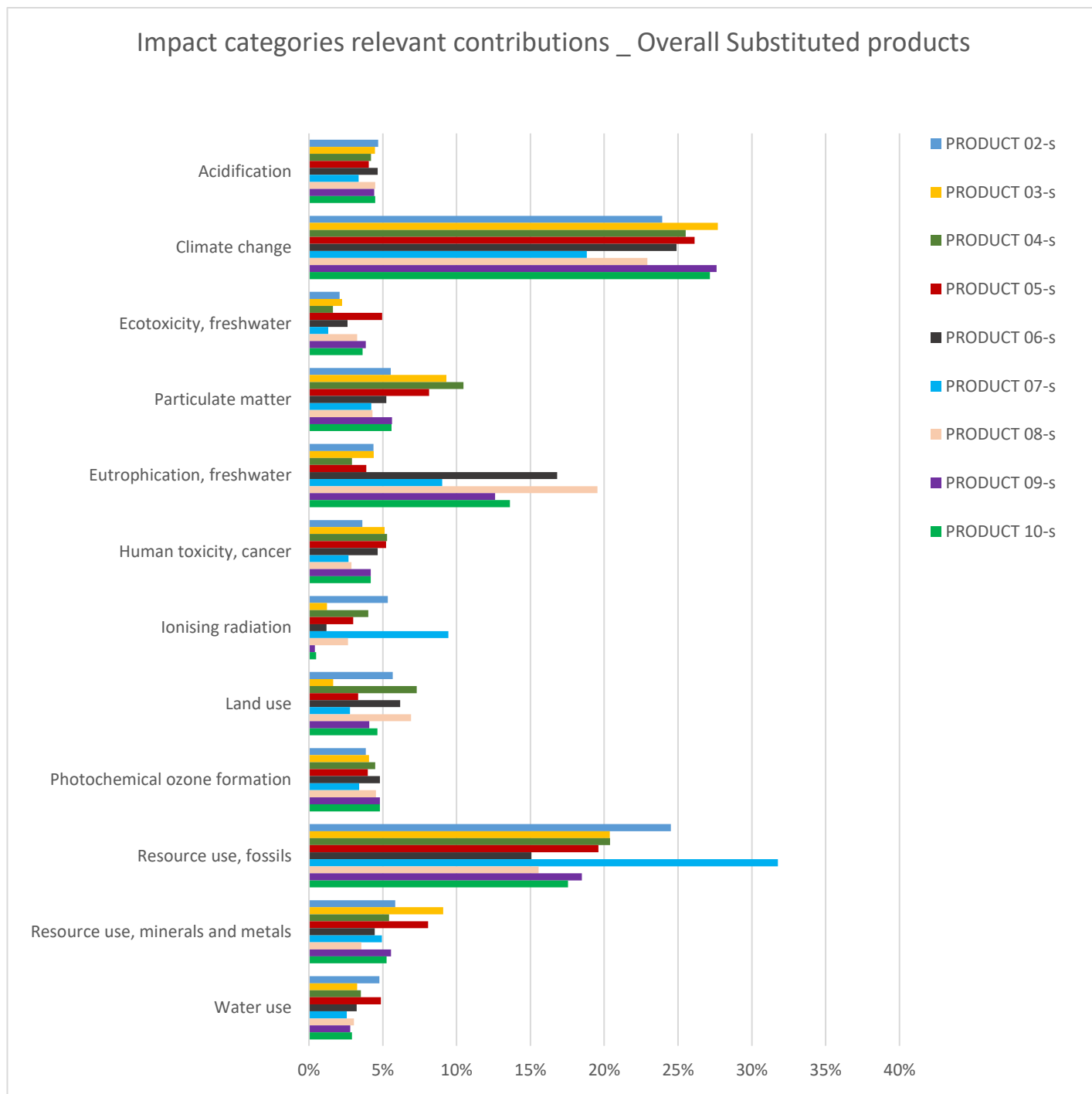


Figure 375: Impact categories relevant contributions on overall products (Substituted products)

From these graphics it is possible to highlight that, for all products analysed, the two most relevant impact categories are climate change and fossil resources use, both in SoA and Sub products. These results mainly derive from the use of fossil-based polymeric materials in the manufacturing of the analysed packaging and in manufacturing process.

In the end-of-life phase, the incineration and landfill processes, whose impact is included in the calculation, strongly impact climate change.

The relative differences among the products, within the same impact categories, are mainly due to the type and amount of constituent polymeric materials, amount of coating or additive (binder, ink...) and the impact of their production process.



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For example, considered product with **similar production process and similar composition** (the three bags made in 100% PP) we can observe that the percentage of impact are very similar each other, only some value in has a bit different, due probably to a different amount of ink and acrylic binder used in the products

	PRODUCT 06	PRODUCT 09	PRODUCT 10
Acidification	3,2%	3,2%	3,0%
Climate change	29,4%	30,1%	30,7%
Ecotoxicity, freshwater	3,6%	4,4%	1,2%
Particulate matter	3,9%	4,1%	3,7%
Eutrophication, marine	1,0%	1,1%	0,9%
Eutrophication, freshwater	3,0%	3,0%	2,9%
Eutrophication, terrestrial	1,3%	1,3%	1,2%
Human toxicity, cancer	5,4%	5,1%	4,2%
Human toxicity, non-cancer	1,2%	1,2%	1,5%
Ionising radiation	1,1%	0,6%	1,2%
Land use	0,5%	0,5%	0,4%
Ozone depletion	0,1%	0,1%	0,0%
Photochemical ozone formation	4,8%	4,9%	5,1%
Resource use, fossils	29,4%	28,5%	31,9%
Resource use, minerals and metals	9,2%	9,1%	8,9%
Water use	2,8%	2,8%	3,2%

Tab 436: Comparison of Impact categories contributions on products similar production process and similar composition (06, 09 and 10)

If we considered product with **similar production process but different composition** (bags with different compositions) we can observe that the differences are in the categories derived from the raw materials, the change from fossil to cellulose materials has influence on these categories involved in the production, as, for example, “Land use” and “Resource use”

	100% PP	74%LDPE - 26%PA	86% Paper - 14%PP
	PRODUCT 06	PRODUCT 08	PRODUCT 09-s
Acidification	3,2%	4,2%	4,4%
Climate change	29,4%	33,9%	27,6%
Ecotoxicity, freshwater	3,6%	2,0%	3,8%
Particulate matter	3,9%	5,9%	5,6%
Eutrophication, marine	1,0%	1,4%	2,0%
Eutrophication, freshwater	3,0%	2,0%	12,6%
Eutrophication, terrestrial	1,3%	1,7%	2,2%
Human toxicity, cancer	5,4%	3,5%	4,2%
Human toxicity, non-cancer	1,2%	0,8%	1,3%
Ionising radiation	1,1%	-0,2%	0,4%
Land use	0,5%	0,3%	4,1%
Ozone depletion	0,1%	0,0%	0,1%
Photochemical ozone formation	4,8%	4,6%	4,8%
Resource use, fossils	29,4%	23,3%	18,5%
Resource use, minerals and metals	9,2%	9,8%	5,6%
Water use	2,8%	7,0%	2,8%

Tab 447: Comparison of Impact categories contributions on products similar production process but different composition (06, 08 and 09-s)



If we considered product with **different production process and similar composition** (Sheet and bag in 99.9% Kraft paper and 0.1% Al) we can observe that the differences are in the categories derived from the industrial process as, for example, “Climate change”, “Ionizing radiation” and “Resource use, fossil”.

	Sheet	Bag
	PRODUCT 07-s	PRODUCT 08-s
Acidification	3,4%	4,5%
Climate change	18,8%	22,9%
Ecotoxicity, freshwater	1,3%	3,3%
Particulate matter	4,2%	4,3%
Eutrophication, marine	1,3%	2,4%
Eutrophication, freshwater	9,0%	19,5%
Eutrophication, terrestrial	1,5%	2,4%
Human toxicity, cancer	2,7%	2,9%
Human toxicity, non-cancer	2,8%	1,6%
Ionising radiation	9,4%	2,6%
Land use	2,8%	6,9%
Ozone depletion	0,0%	0,1%
Photochemical ozone formation	3,4%	4,5%
Resource use, fossils	31,8%	15,6%
Resource use, minerals and metals	4,9%	3,6%
Water use	2,6%	3,0%

Tab 458: Comparison of Impact categories contributions on products different production process and different composition (07-s and 08-s)

If we considered product with **different production process and different composition**, we can observe that the differences are due both raw materials and manufactory processes.

	Cup 100% PET	Tray 84% Paper-16% PVC	Sheet 66% PP-34% Al	Bag 88% Paper-12% PP
	PRODUCT 02	PRODUCT 05-s	PRODUCT 07	PRODUCT 10-s
Acidification	3,9%	4,0%	3,7%	4,5%
Climate change	28,9%	26,1%	23,3%	27,2%
Ecotoxicity, freshwater	1,3%	5,0%	3,2%	3,6%
Particulate matter	5,4%	8,1%	10,0%	5,6%
Eutrophication, marine	1,2%	1,6%	1,0%	2,1%
Eutrophication, freshwater	2,7%	3,9%	3,5%	13,6%
Eutrophication, terrestrial	1,3%	1,8%	1,4%	2,3%
Human toxicity, cancer	3,5%	5,2%	5,1%	4,2%
Human toxicity, non-cancer	1,4%	1,2%	2,0%	1,3%
Ionising radiation	2,4%	3,0%	5,6%	0,5%
Land use	0,3%	3,3%	0,3%	4,6%
Ozone depletion	4,6%	0,2%	0,0%	0,1%
Photochemical ozone formation	4,2%	4,0%	3,5%	4,8%
Resource use, fossils	27,0%	19,6%	28,2%	17,5%
Resource use, minerals and metals	10,5%	8,1%	7,3%	5,3%
Water use	1,4%	4,9%	1,8%	2,9%

Tab 469: Comparison of Impact categories contributions on products different production process and different composition (02, 05-s, 07 and 10-s)



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In general, if it considered an average value of the percentage impact value for each category, we can observe that the main impacts are “Climate change” and “Resource use, fossil” in both type of products with higher value in SoA products.

In the other categories, Sub products have higher values in “Eutrophication, freshwater” and “Land use”, category that involve the production of cellulose/paper, while SoA products have higher values in “Resource use, minerals and metals”. The other categories are, more or less, similar.

	SoA_Average Value	Sub_Average Value
Acidification	3,6%	4,3%
Climate change	30,1%	25,0%
Ecotoxicity, freshwater	2,3%	2,8%
Particulate matter	5,7%	6,5%
Eutrophication, marine	1,1%	1,9%
Eutrophication, freshwater	2,7%	9,7%
Eutrophication, terrestrial	1,4%	2,1%
Human toxicity, cancer	4,2%	4,2%
Human toxicity, non-cancer	1,2%	1,4%
Ionising radiation	1,7%	3,1%
Land use	0,3%	4,7%
Ozone depletion	0,9%	0,4%
Photochemical ozone formation	4,8%	4,3%
Resource use, fossils	28,3%	20,4%
Resource use, minerals and metals	8,5%	5,8%
Water use	3,2%	3,4%

Tab 4710: Comparison of Impact categories contributions on average value of SoA products and Sub products



3.4. Comparison of MIC

In order to evaluate the Substituted products (Sub) vs. the State-of-the-art products (SoA), a comparison of the Most Important Category was made.

In particular, for each couple of products was considered the increase/decrease in as the percentage results for the main categories, where 100% is awarded to the product with the highest impact in the specific category.

PRODUCT #02. – PREPARED SALAD

- SoA product has higher values, in many cases more then 90%, in all the impact categories analyzed except in the « Land use » category.

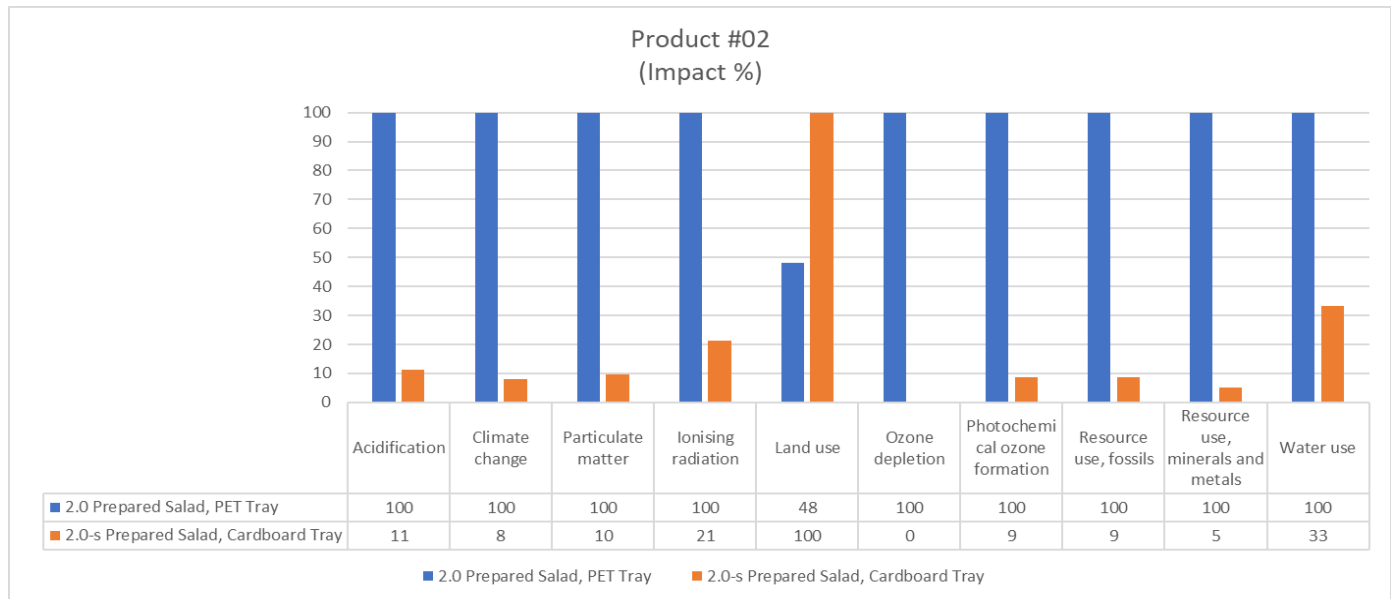


Figure 38. Impact percentage of the main categories for PRODUCT #02 – Prepared Salad

PRODUCT #03. - SOUR CREAM

- SoA product has higher values than Sub, between 20 and 55%, in all the impact categories analyzed except in the « Particulate matter » and « Eutrophication, freshwater » categories in which the values are similar.

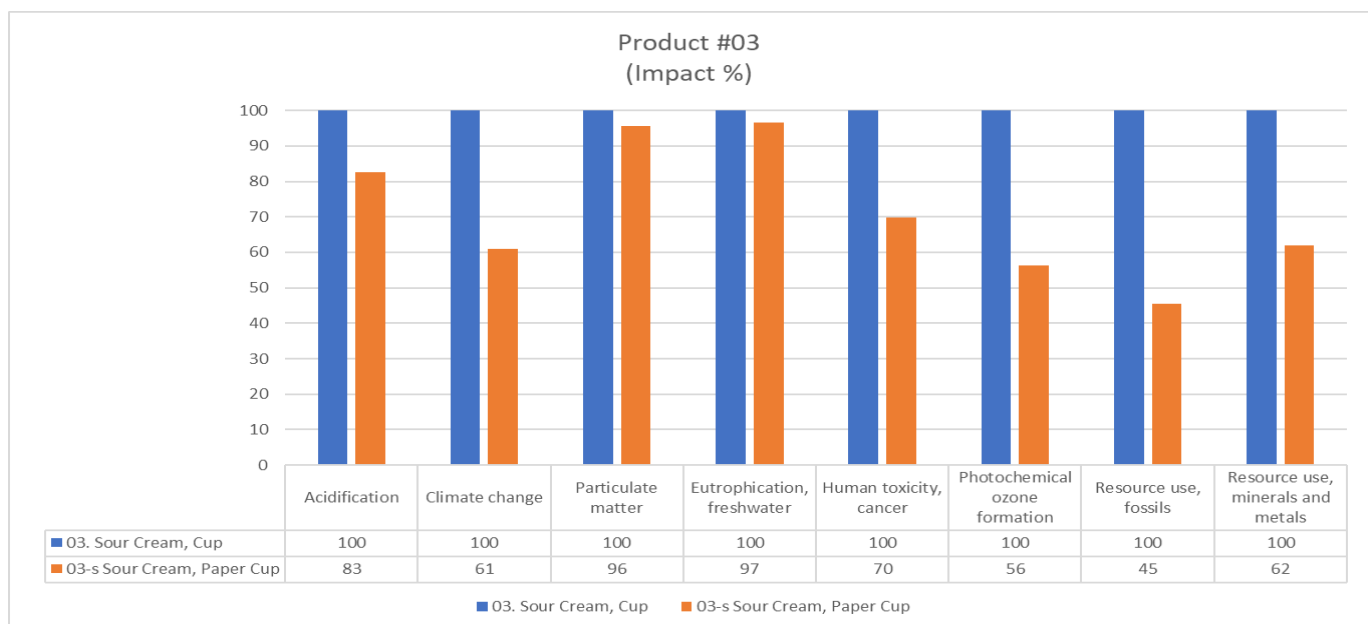


Figure 39. Impact percentage of the main categories for PRODUCT #03 – Sour Cream



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PRODUCT #04. – GREEK YOGHURT

- SoA product has higher values than Sub, in many cases more then 70%, in all the impact categories analyzed except in the « Land use » category.

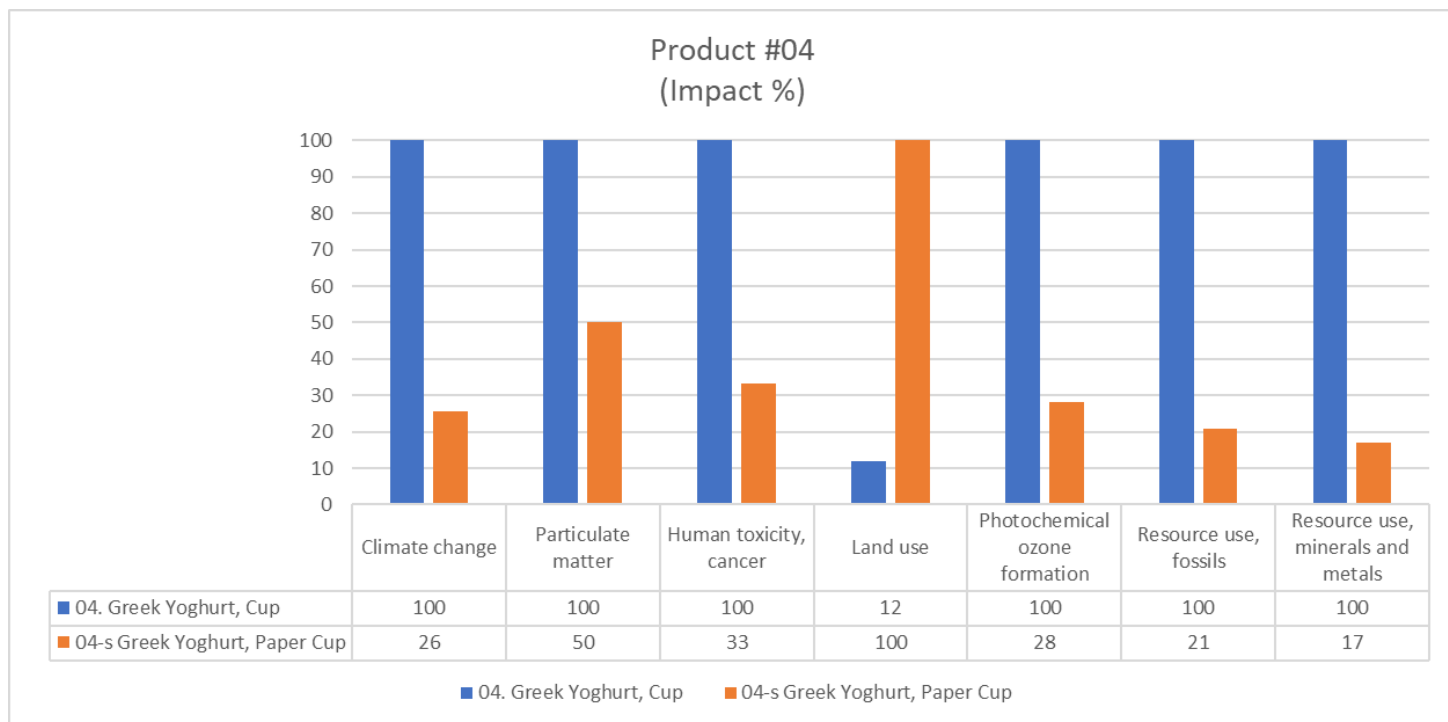


Figure 40. Impact percentage of the main categories for PRODUCT #04 – Greek Yoghurt

PRODUCT #05. – PORK CHOP

- SoA product has higher values than Sub, between 55 and 80%, in all the impact categories analyzed except in the « Ecotoxicity, freshwater », « Human toxicity, cancer » and « Resource use, minerals and metals » categories in which the values are similar.

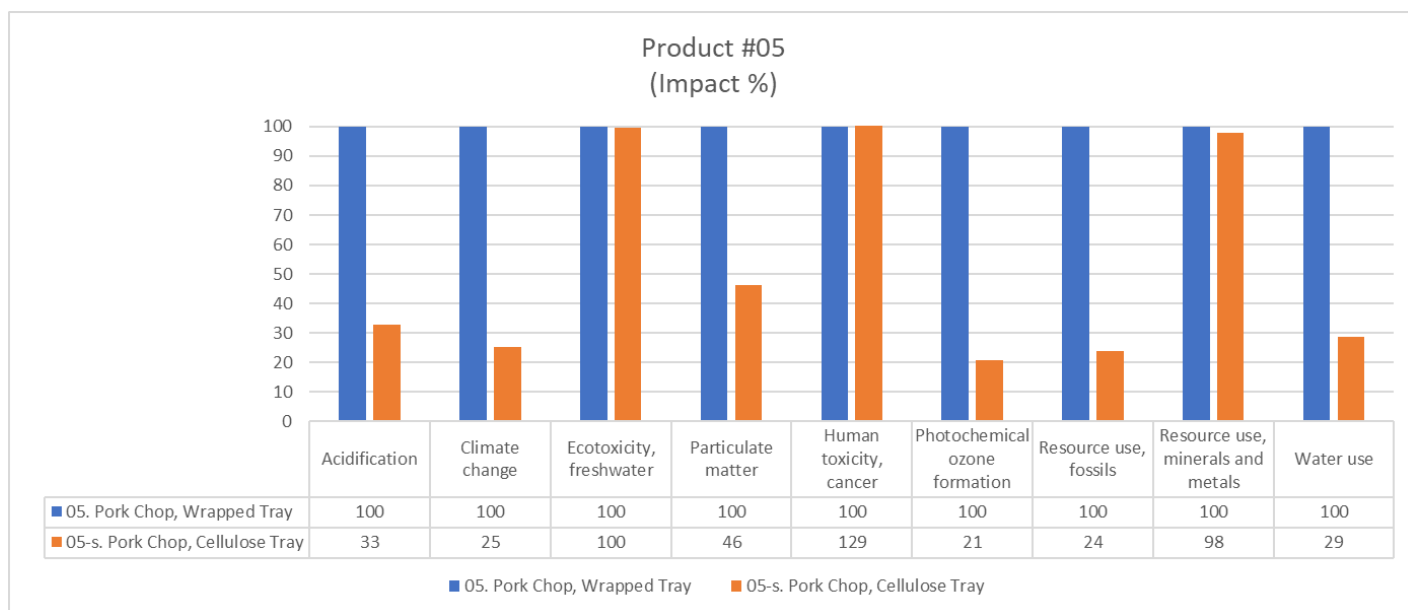


Figure 41. Impact percentage of the main categories for PRODUCT #05 – Pork chop



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PRODUCT #06. – FLORETTE MACHE

- SoA product has higher values than Sub, between 25 and 65%, in many impact categories analyzed except in the « Acidification» and « Particulat matter » categories in which the values are almost similar, and in « Land use » and « Eutrophication, freshwater » categories in which Sub products has higher value

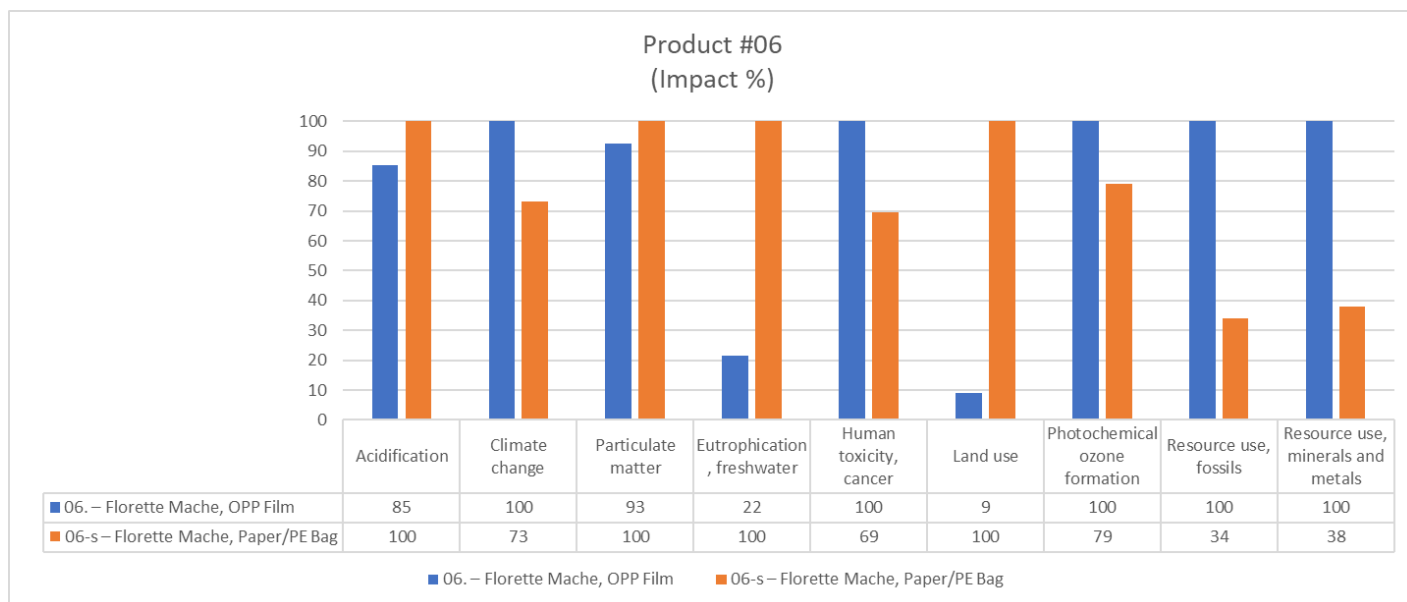


Figure 42. Impact percentage of the main categories for PRODUCT #06 – Florette mache

PRODUCT #07. – BUTTER

- SoA product has higher values than Sub, between 30 and 75%, in all the impact categories analyzed except in the « Eutrophication, freshwater » category. In « Ionising radiation » category the value is similar.

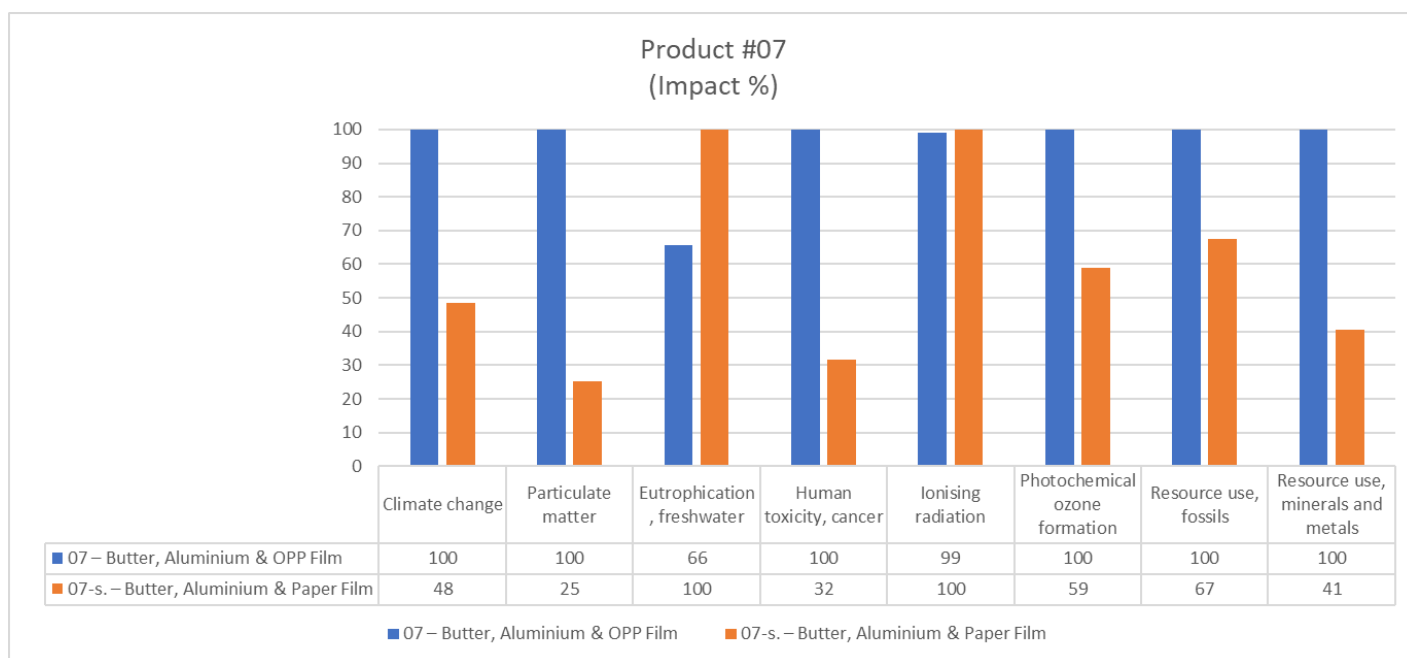


Figure 43. Impact percentage of the main categories for PRODUCT #07 – Butte



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PRODUCT #08. – GRATED CHEESE

- SoA product has higher values than Sub, between 65 and 90%, in all the impact categories analyzed except in the « Eutrophication, freshwater » and « Land use » categories.

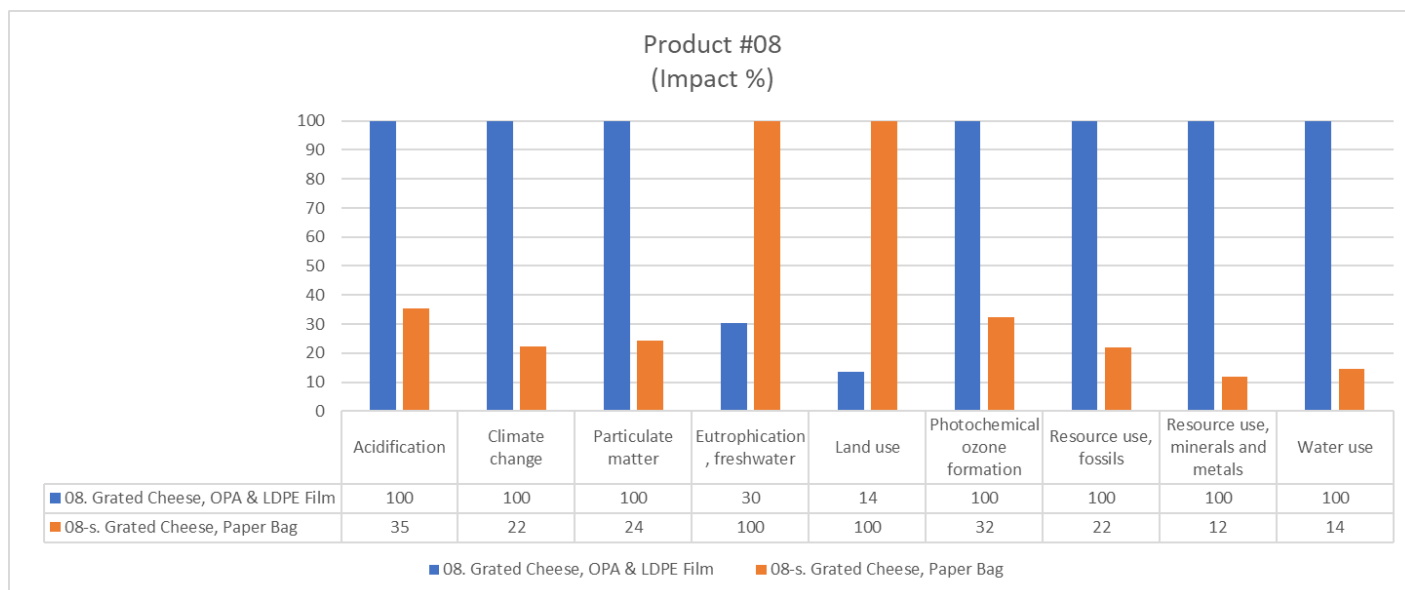


Figure 44. Impact percentage of the main categories for PRODUCT #08 – Grated cheese

PRODUCT #09. – CHIPS

- SoA product has higher values than Sub, between 30 and 50%, in all the impact categories analyzed except in the « Acidification » and « Particulate matter » categories in which has similar value and in « Eutrophication, freshwater » in which Sub products has higher value

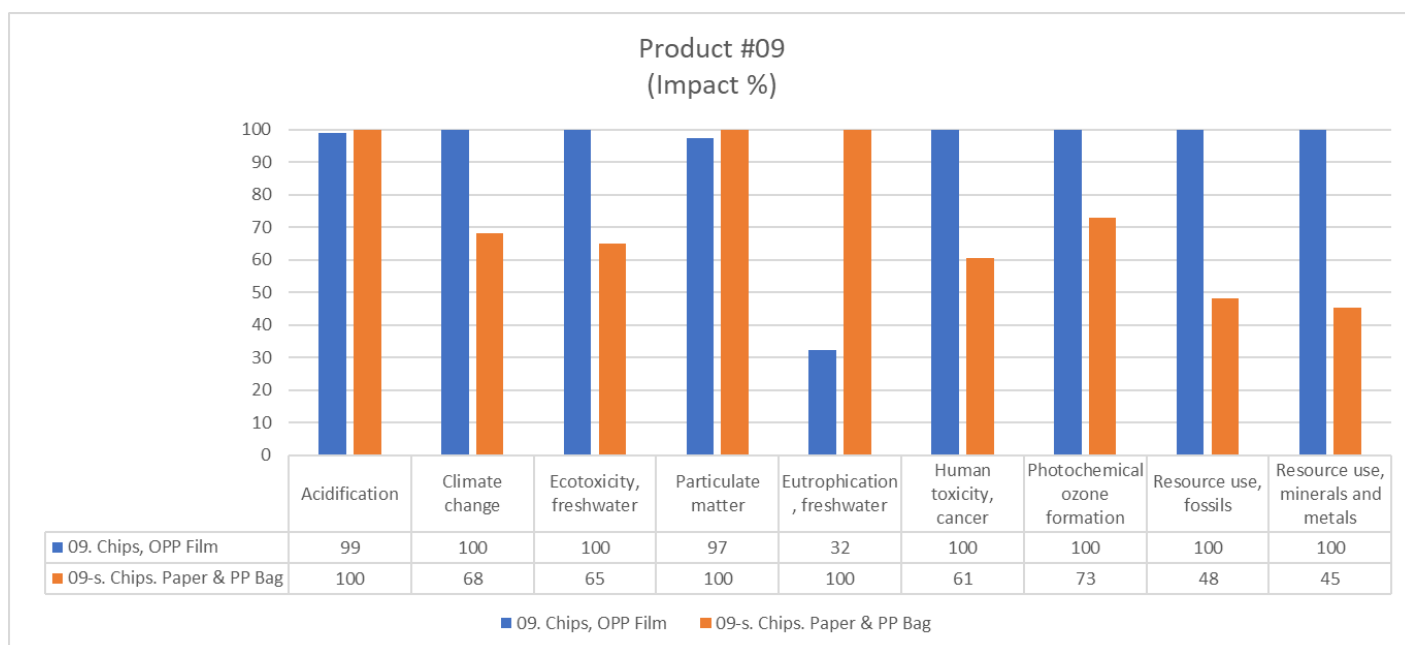


Figure 45. Impact percentage of the main categories for PRODUCT #09 – Chips

PRODUCT #10. – SAVORY BISCUITS

- SoA product has lower values than Sub, between 35 and 95%, in many impact categories analyzed except in the « Climate change », « Human toxicity, cancer » and « Photochemical ozone formation » categories in which has similar value and in « Resource use » both fossil and minerals and metals, in which SoA products has higher value

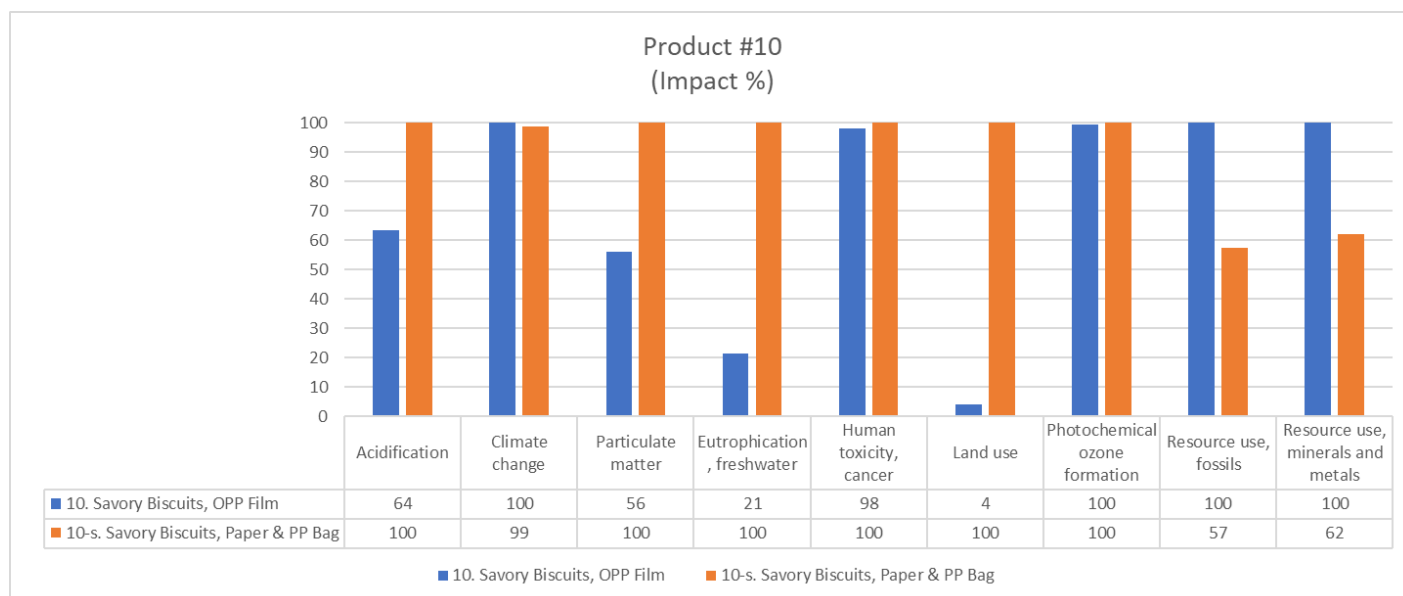


Figure 46. Impact percentage of the main categories for PRODUCT #10 – Savory biscuits



4. CONCLUSION

PRODUCT #02. – PREPARED SALAD

The SoA Packaging for Prepared salad product made in 100% PET was substituted with a packaging made in 99,9% paper and the weight of the Sub product, referred to the functional unit, is 62% lower (from 12 to 4.6 grams)

These elements have a positive influence in term of impact, the LCA results shown that the Sub products made il paper has a significative reduction (90%) in term of Single score from 5 to 0.5 μ Pt.

The change from PET to Paper has influence on the type of impact category involved.

SoA product has higher values, in many cases more than 90%, in all the impact categories considered, especially in “Climate change” and “Resources use, fossil” that derive from the use of fossil-based polymeric materials. Sub product has an higher value (50%) in the “Land use” category derive from the use of cellulose material.

For both products, the most relevant processes are related to pre-processing and manufacturing: PET production for SoA product and Carboard Cup-Paper for Sub product.

PRODUCT #03. – SOUR CREAM

The SoA Packaging for Sour Cream product made in PP with a lid in Aluminium and an overcup in PET was substituted with a packaging made in 80% Cellulose and 20% LDPE with a lid in Aluminium and an overcup in PET; the weight of the Sub product, referred to the functional unit, is 20% lower (from 6.2 to 5 grams)

The change from PP to Cellulose/LDPE product for the body of packaging and the weight loss has a positive influence in term of impact, the LCA results shown that the Sub products made il paper has a reduction (36%) in term of Single score from 2.1 to 1.4 μ Pt.

The change from PET to Paper has influence on the type of impact category involved.

SoA product has higher values, between 20 and 55%, in all the impact categories considered, especially in “Resources use, fossil” and “Photochemical ozone formation”; the two products have similar value in “Particulate matter” and “Eutrophication, freshwater” categories in which the values are similar. These data derive from two factors: (i) the use of fossil-based polymeric materials in SoA product and (ii) the presence of LDPE in the body and of Al and PET in the lid in a percentage of about 50% that limits the benefits of using the cellulose

For both products, the most relevant processes are related to pre-processing and manufacturing: PP production for SoA product and PET production for the overcup in Sub product.

PRODUCT #04. – GREEK YOGHURT

The SoA Packaging for Greek Yoghurt product made in PP was substituted with a packaging made in 93% Cellulose and 7% LDPE; the weight of the Sub product, referred to the functional unit, is 20% higher (from 4.5 to 5.4 grams)

The change from PP to Cellulose/LDPE product for the body of packaging has a positive influence in term of impact, despite the weight gain; the LCA results shown that the Sub products made in cellulose has a reduction (71%) in term of Single score from 1.5 to 0.4 μ Pt.

The change from PP to Paper has influence on the type of impact category involved.



SoA product has higher values, in many cases more than 70%, in all the impact categories considered, especially in “Climate change” and “Resources use, fossil” that derive from the use of fossil-based polymeric materials. Sub product has an higher value (90%) in the “Land use” category derive from the use of cellulose material.

For both products, the most relevant processes are related to pre-processing and manufacturing: PP production for SoA product and Cellulose production for Sub product.

PRODUCT #05. – PORK CHOP

The SoA Packaging for Pork Chop product made in EPS with a lid/wrapping film in PVC was substituted with a packaging made in 96% cellulose and 4% biofilm with a lid/wrapping film in PVC; the weight of the Sub product, referred to the functional unit, is 30% higher (from 2.8 to 3.6 grams)

The change from EPS to Paper/Biofilm product for the body of packaging has a positive influence in term of impact, despite the weight gain; the LCA results shown that the Sub products made il paper has a reduction (65%) in term of Single score from 0.9 to 0.3 μ Pt.

The change from EPS to Cellulose has influence on the type of impact category involved.

SoA product has higher values, between 55 and 80%, in all the impact categories considered, especially in “Climate change”, “Resources use, fossil” and “Photochemical ozone formation”; the two products have similar value in “Ecotoxicity, freshwater”, “Human toxicity, cancer” and “Resource use, minerals and metals” categories in which the values are similar. These data derive from the use of fossil-based polymeric materials in SoA product and the use of 16% of PVC in Sub product

For both products, the most relevant processes are related to pre-processing and manufacturing: EPV production for SoA product and Cellulose production for Sub product.

PRODUCT #06. – FLORETTE MACHE

The SoA Packaging for Florette mache product made in 100% PP was substituted with a packaging made in 91,2% paper and 9% HDPE and the weight of the Sub product, referred to the functional unit, is 130% higher (from 4.6 to 10 grams)

The change from PP to Paper/HDPE product has a positive influence in term of impact, despite the high weight gain; the LCA results shown that the Sub products made il paper has a reduction (17%) in term of Single score from 1.5 to 1.2 μ Pt.

The change from PP to Paper has influence on the type of impact category involved.

SoA product has higher values, between 25 and 65%, in all the impact categories considered, especially in “Resources use” both fossil and “minerals and metals; the two products have similar value in “Particulate matter”, and “Acidification” categories in which the values are similar. These data derive from the use of fossil-based polymeric materials in SoA product and the use of 9% of HDPE in Sub product. Also, Sub product has a higher value (90%) in the “Land use” category and in “Eutrophication, freshwater” (80%) derive from the use of cellulose material.

For both products, the most relevant processes are related to pre-processing and manufacturing: PP production for SoA product and Kraft Paper for Sub product.



PRODUCT #07. – BUTTER

The SoA Packaging for Butter product made in 66% PP and 34% Al was substituted with a packaging made in 99,9% greaseproof coated paper and 0.1% Al and the weight of the Sub product, referred to the functional unit, is 69% higher (from 0.8 to 1.3 grams)

The change from PP/Al to Paper/Al product has a positive influence in term of impact, despite the high weight gain; the LCA results shown that the Sub products made il paper has a reduction (40%) in term of Single score from 0.6 to 0.36 μ Pt.

The change from PP/Al to Paper has influence on the type of impact category involved.

SoA product has higher values, between 30 and 75%, in all the impact categories considered, especially in “Particulate matter” and “Human toxicity, cancer”; the two products have similar value in “Ionizing radiation” category in which the values are similar. These data derive from the use of French energy mix in the industrial processes. Also, Sub product has an higher value (35%) in “Eutrophication, freshwater” derive from the production of cellulose material.

For both products, the most relevant processes are related to pre-processing and manufacturing: Al production for SoA product and Kraft Paper for Sub product.

PRODUCT #08. – GRATED CHEESE

The SoA Packaging for Grated cheese product made in 74% LDPE and 26% PA was substituted with a packaging made in 99.9% Paper and 0.1% Al; the weight of the Sub product, referred to the functional unit, is 32% higher (from 2.8 to 3.7 grams)

The change from LDPE/PA to Paper product for the packaging has a positive influence in term of impact, despite the weight gain; the LCA results shown that the Sub products made in paper has a reduction (67%) in term of Single score from 1.1 to 0.4 μ Pt.

The change from LDPE/PA to Paper has influence on the type of impact category involved.

SoA product has higher values, between 65 and 90%, in all the impact categories considered, especially in “Resource use, minerals and metals” and “Water use” that derive from the use of fossil-based polymeric materials. Sub product has an higher value (85%) in the “Land use” category and in “Eutrophication, freshwater” (70%) derive from the use of cellulose material.

For both products, the most relevant processes are related to pre-processing and manufacturing: HDPE production for SoA product and Paper production for Sub product.

PRODUCT #09. – CHIPS

The SoA Packaging for Chips product made in PP was substituted with a packaging made in 86% Paper and 14% PP; the weight of the Sub product, referred to the functional unit, is 48% higher (from 3.2 to 4.8 grams)

The change from PP to Paper/PP product for the packaging has a positive influence in term of impact, despite the weight gain; the LCA results shown that the Sub products made in paper has a reduction (26%) in term of Single score from 1.0 to 0.76 μ Pt.

The adding of PP to Paper has influence on the type of impact category involved.

SoA product has higher values, between 30 and 50%, in all the impact categories considered, especially in “Climate change” and in “Resource use, fossil”; the two products have similar value in “Acidification” and “Particulate matter” categories in which the values are similar. These data derive from the use of fossil-based polymeric materials in SoA product and the use of 14% of PP in Sub product. Sub product has an higher value (85%) in “Eutrophication, freshwater” (70%) derive from the use of cellulose material.



For both products, the most relevant processes are related to pre-processing and manufacturing: PP production for SoA product and Paper production for Sub product.

PRODUCT #10. – SAVORY BISCUITS

The SoA Packaging for Savory Biscuits made in PP was substituted with a packaging made in 88% Paper and 12% PP; the weight of the Sub product, referred to the functional unit, is 104% higher (from 3.6 to 7.4 grams)

The change from PP to Paper/PP product for the packaging has a slight negative influence in term of impact, due probably to the strong weight gain; the LCA results shown that the Sub products made in paper has a increase (26%) in term of Single score from 1.07 to 1.11 μ Pt.

The adding of PP to Paper has influence on the type of impact category involved.

SoA product has lower values, between 35 and 95%, in all the impact categories considered, especially in “Land use” and in “Eutrophication, freshwater”; the two products have similar value in “Climate change”, “Human toxicity, cancer” and “Photochemical ozone formation” categories in which the values are similar. These data derive from the use of cellulose material and 14% of PP in Sub product. SoA product has a higher value (85%) in “Resource use”, both fossil (45%) and minerals and metals (40%) derive from the use of fossil-based polymeric materials.

For both products, the most relevant processes are related to pre-processing and manufacturing: PP production for SoA product and Paper production for Sub product.

MAIN CONCLUSION

Summarizing the main results is it possible to note that the **Industrial processes** and **Raw Materials** are the categories that make the greatest contribution, while the **Transport's** contribution is negligible and **End-of-life** contribution make an advantage, in term of impact, due in particular to the benefit of recycling.

Considering the Single score value, this is lower in the **Substituted product** and the decrease in impact is not always due to a **reduction in packaging weight**.

“**Climate change**” and “**Resource use, fossil**” are the main both type of products due to not-recyclable EoL and to the plastic-base material. “**Eutrophication, freshwater**” and “**Land use**” are the main impact in Paper Base material due to the production of cellulose/paper and “**Resource use, minerals and metals**” is the main impact in the plastic-base material.

The differences are mainly due to the different types of raw materials used and the different production technologies.

5. SOCIAL RISK ASSESSMENT

The results of Social-LCA are insert in D6.3 Part B, together at Reuse product assessment, in paragraph 3. For Substituted products is used the Product 4-s.



6. ANNEXES

6.1. Annex I: Data collection substitution

PRODUCT 10 – Savory biscuits, OPP Film

STATE OF THE ART PRODUCT ID	ID 10- Savory biscuits
Name of the NEW product	Savory biscuits
PACKAGING WEIGHT	0,91
CAPACITY (FOOD WEIGHT) - FORMAT	25g
TECHNICAL DATASHEETS AVAILABLE	NO

PRODUCT COMPOSITION

	Commercial name of the product (Material Data Sheet)	WEIGHT	WEIGHT	Process technology	Notes
		UNIT	UNIT		
		(g/mq)	(g)		
PACKAGING BODY					
Layer 1	OPPcoex	13,8	0,40227	flexography	
Layer 2	OPPcoex met	13,8	0,40227	coextrusion	
ADHESIVE					
	Adhesive	2	0,0583		
INK					
		1,5	0,043725		
TOTAL PACKAGING WEIGHT		31,10	0,91		
Packaging production technologies (Indicate the type of processes, e.g: extrusion, lamination, thermoforming, folding and cutting, printing, dyeing)					

END-OF-LIFE

Tipologia di smaltimento	yes/no	Note
RECYCLING	YES	
COMPOSTING	NO	
THERMOVALORIZATION	NO	
LANDFILL	NO	



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PRODUCT 10-s – Savory biscuits, Paper & PP Bag

STATE OF THE ART PRODUCT ID	ID 10- Savory biscuits
Name of the NEW product	Savory biscuits
PACKAGING WEIGHT	1,85
CAPACITY (FOOD WEIGHT) - FORMAT	25g
TECHNICAL DATASHEETS AVAILABLE	NO

PRODUCT COMPOSITION

	Commercial name of the product (Material Data Sheet)	WEIGHT	WEIGHT	Process technology	Notes
		UNIT	UNIT		
		(g/mq)	(g)		
PACKAGING BODY					
Layer 1	paper 1 side coated	50	1,54	flexography	
Layer 2	Ppcoex met	7	0,2156	coextrusion	
ADHESIVE					
	Adhesive	1,5	0,0462		
OVERPRINT VARNISH					
	Ink + Varnish printing	1,5	0,0462	flexography	
TOTAL PACKAGING WEIGHT		60,00	1,85		
Packaging production technologies (Indicate the type of processes, e.g: extrusion, lamination, thermoforming, folding and cutting, printing, dyeing)					

END-OF-LIFE

Tipologia di smaltimento	yes/no	Note
RECYCLING	YES	
COMPOSTING	NO	
THERMOVALORIZATION	NO	
LANDFILL	NO	

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R3PACK – REDUCE, REUSE, RETHINK PACKAGING TOWARDS NOVEL FIBRE- BASED PACKAGING AND REUSE SCHEMES

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Reuse comparative analysis

Acronyms

CFF: Circular Footprint Formula
EF: Environmental Footprint
LCA: Life Cycle Assessment
LCI: Life Cycle Inventory
PEF: Product Environmental Footprint
PEFCRs: Product Environmental Footprint Category Rules
PP+M: PreProduction & Manufacturing
Pt= Points
EoL: End-of-life
EF: Environmental Footprint
GTAP: Global Trade Analysis Project

Definitions

Life cycle Assessment (LCA) – Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14040:2006)

Product Environmental Footprint Category Rules (PEFCRs) – Product category specific, life cycle based rules that complement general methodological guidance for PEF studies by providing further specification at the level of a specific product category. PEFCRs help to shift the focus of the PEF study towards those aspects and parameters that matter the most, and hence contribute to increased relevance, reproducibility and consistency of the results by reducing costs versus a study based on the comprehensive requirements of the PEF method. Only the PEFCRs listed on the European Commission website:

(http://ec.europa.eu/environment/eussd/smgrp/PEFCR_OEFSR_en.htm) are recognised as in line with this method).



1. Introduction

The analysis is based on data developed within the R3PACK project, collected in France in collaboration with the project partners. The data presented in this report refer to solutions developed during the demonstration phase of the project, within specific contexts and scenarios. Therefore, the authors do not consider the results to be generalizable beyond the defined scope. The life cycle inventory data are based on information collected by the project coordinator from the partners. The authors assume no responsibility for the quality, accuracy, or representativeness of the original data, and limit their liability to the processing and assessment carried out within this study.

To ensure that the reuse LCA analysis covered a sufficiently diverse and representative set of packaging formats and product types, the assessment scope was expanded to include additional products available in Carrefour and U stores. This extension was necessary because the number and diversity of reusable products available from beneficiary partners alone were not sufficient to perform the full set of LCAs planned in the project.

All LCAs were conducted strictly within the allocated budget of the work package. The inclusion of these additional products increased the robustness, comparability and learning value of the environmental assessment, without altering the financial perimeter of the project.

PRODUCTS

Table A presents both the single-use products initially identified and assessed in D6.1B, and the corresponding reusable alternatives introduced for demonstration. In the last six reusable products (15-r, 16-r, 17-r, 18-r, 19-r, 20-r), the state-of-the-art packaging reference correspond to the same product modelled in the reuse system.

Tab A. Products considered in the comparative analysis: Single use state of the art packaging and packaging for REUSE

STATE OF THE ART – SINGLE USE			REUSE PACKAGING		
Food category: Prepared fruits					
Product: Florette Shaker Ananas					
	Format	Preformed PET Shaker, thin PET foil lid		Format	PP Tray + PP lid
	Food weight	230 g		Food weight	250 gr
	Company	Floréale		Company	Floréale (Agrial)
	LCA ID	01		LCA ID	01-r
Food category: Prepared salad					
Product: Salad MDD					
	Format	PET Tray		Format	PP Tray + PP lid
	Food weight	250 g		Food weight	1261 ml - 250 gr
	Company	LSDH		Company	LSDH/ Sodebo / Floreale
	LCA ID	02		LCA ID	02-r



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Food category: Sour cream					
Food category: Yogurt					
	Format	PP Cup		Format	PP Bucket + PP lid
	Food weight	200 g		Food weight	500 gr
	Company	Yoplait		Company	Yoplait
	LCA ID	03		LCA ID	03-r
Food category: Yogurt					
Product: Greek Yogurt					
	Format	PP Cup		Format	PP Bucket + PP lid
	Food weight	450 g		Food weight	500 gr
	Company	Yoplait		Company	System U & Carrefour
	LCA ID	04		LCA ID	04-r
Food category: In-shop product					
Product: Pork chop					
	Format	EPS Tray		Format	Pork chop, PP Tray + Lid
	Food weight	500 g		Food weight	500g
	Company	(none)		Company	System U & Carrefour
	LCA ID	05		LCA ID	05-r
Food category: Chips					
Product: Chips					
	Format	OPP Film		Format	PP Bucket 3,5L
	Food weight	125 g		Food weight	250 gr - 3500 ml
	Company	Altho		Company	Altho
	LCA ID	09		LCA ID	09-r
Food category: Chips					
Product: Pétales salées					
	Format	OPP Sachet & Cardboard		Format	PP Bucket 1L
	Food weight	75 g		Food weight	100 gr
	Company	Europe Snacks		Company	Europe Snacks
	LCA ID	10		LCA ID	10-r1
Food category: Chips					
Product: Pétales salées					
	Format	OPP Sachet & Cardboard		Format	PP Bucket 2L
	Food weight	75 g		Food weight	200 gr
	Company	Europe Snacks		Company	Europe Snacks
	LCA ID	10		LCA ID	10-r2
Food category: Juice					
Product: Orange Juice					
	Format	Clear Bottle with 50% recycled		Format	Glass bottle 1L
	Food weight	1 l		Food weight	1 l
	Company	LSDH		Company	LSDH
	LCA ID	11		LCA ID	11-r

Food category: Milk					
Product: UHT milk					
	Format	PET opaque Bottle		Format	Glass bottle 1L
	Food weight	1 l		Food weight	1 l
	Company	LSDH		Company	LSDH
	LCA ID	12		LCA ID	12-r
Food category: Milk					
Product: UHT milk					
	Format	PEHD Bottle		Format	Glass bottle 1L
	Food weight	1 l		Food weight	1 l
	Company	Sodiaal		Company	Sodiaal
	LCA ID	13		LCA ID	13-r
Food category: Savory biscuits					
Product: Minis GF Choco					
	Format	cardboard box + flowpacks		Format	PP Bucket 1L
	Food weight	168 g		Food weight	350g
	Company	Biscuit bouvard		Company	Biscuit bouvard
	LCA ID	14		LCA ID	14-r
Food category: Yogurts					
Product: Fromage blanc 2 kg					
	Format	PP Bucket 2L		Format	PP Bucket 2L
	Food weight	2 kg		Food weight	2 kg
	Company	Rians		Company	Rians
	LCA ID	15-r		LCA ID	15-r
Food category: Boissons					
Product: Syrup					
	Format	Clear glass bottle with PEHD Closure		Format	Clear glass bottle with PEHD Closure
	Food weight	700 ml		Food weight	700 ml
	Company	Monin		Company	Monin
	LCA ID	16-r		LCA ID	16-r
Food category: Condiments					
Product: Mayonnaise					
	Format	Clear glass jar with metallize closure		Format	Clear glass jar with metallize closure
	Food weight	475 g		Food weight	475 g
	Company	Lesieur		Company	Lesieur
	LCA ID	17-r		LCA ID	17-r
Food category: Oil					
Product: Olive Oil					
	Format	Glass bottle with PEHD closure		Format	Glass bottle with PEHD closure
	Food weight	250 ml		Food weight	250 ml
	Company	Lesieur		Company	Lesieur
	LCA ID	18-r		LCA ID	18-r
Food category: Boissons					



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Product: Sweet/brut cider					
	Format	Glass bottle with cork and metal lid		Format	Glass bottle with cork and metal lid
	Food weight	750 ml		Food weight	750 ml
	Company	Eclor		Company	Eclor
	LCA ID	19-r		LCA ID	19-r
Food category: Boissons					
Product: Lemonade					
	Format	Glass bottle		Format	Glass bottle
	Food weight	750 ml		Food weight	750 ml
	Company	Source de Soulmatt		Company	Source de Soulmatt
	LCA ID	20-r		LCA ID	20-r

As shown in Table A, many of the selected packaging options have undergone size increases to accommodate the logistical needs of reuse systems. For example, yogurt containers have shifted from 200g to 500g, and chip bags from 125g to 600g. These changes raise implications for the environmental analysis, as the need to set a Functional Unit based on the packaging needed to host a specific quantity of food content.

GOAL OF THE STUDIES

The goal of this comparative LCA study is to identify the break-even point, defined as the moment when the reuse system begins to generate net environmental benefits compared to disposable systems.

The figure below illustrates the relationship between environmental impact and the number of uses for two packaging systems: a single-use system (represented by the dashed blue line) and a reusable system (represented by the orange curve). The break-even point, marked with a red "X", indicates the point where the reusable system begins to generate net environmental benefits compared to the single-use system. As shown, with each additional use, the environmental impact of the reusable system decreases until it flattens, signifying convergence in the long-term impact.

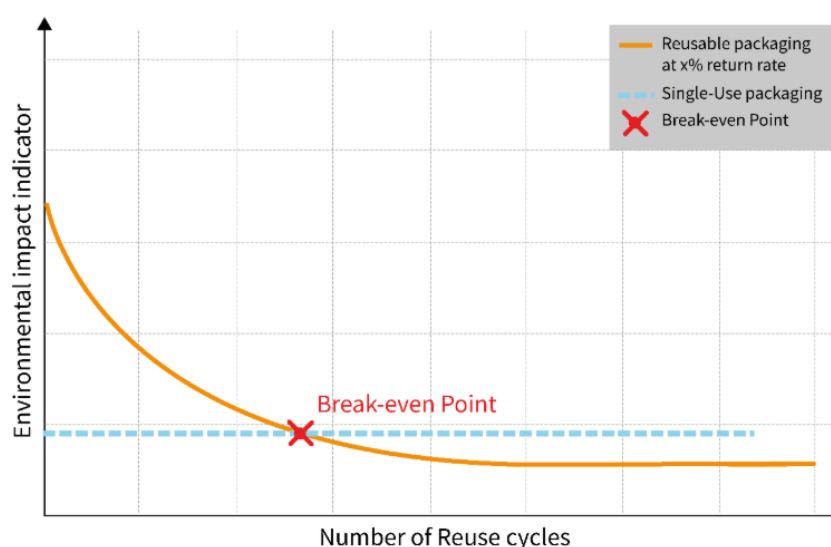


Figure A: Break-even Point definition



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The objective is to evaluate the performance of both systems at the break-even point and, if relevant, at different cycle numbers, especially when the environmental impact curve of the reuse system flattens.

The data about the return rate has been taken from the projects outputs of WP2 and WP3. In particular, in *D3.4: Decision-support model for reuse logistic network design* (pag.36), state that consumer return behaviour showed a 60% likelihood of returning packaging to stores, 8% in residential districts, and 32% not returning it at all. Additionally, a 5% scrap rate was applied to account for packaging losses due to breakage and wear.

This provides a global 64,6% return rate on the entire reuse system.

If with the assumption of a return rate based on 64,6%, a break-even point has not found, a second analysis has been carried out, considering a 90% likelihood of returning the package from the customer and a 5% scrap rate due to breakage and wear. This second scenario considers an overall 85,5% return rate on the system.

The impact evaluation follows the Life Cycle Assessment (LCA) methodology, in compliance with ISO 14040 and 14044 standards, and is performed using SimaPro Craft software (Sustainability, PRé, s.d.) and ecoinvent cut-off datasets v3.10 (ecoinvent, s.d.), due to the unavailability of EF-compliant datasets to PEFCR, to generate values elaborated on a calculation tool working on Ms Office Excel. The environmental indicators align with the Product Environmental Footprint (PEF) methodology, as recommended by the European Commission in Recommendation 2021/2279 (European Commission, 2021). Although ISO 14044 discourages the use of single-score indicators for decision-making purposes, in this deliverable the Single Score analysis is employed solely for communicative and comparative purposes, to provide a concise representation of overall environmental performance. This approach facilitates the interpretation of general trends across systems while maintaining full transparency regarding methodological assumptions and limitations. A more detailed discussion on individual environmental indicators is then showed and analyzed during the analysis, providing an holistic view of the impacts of the solutions.

Due to the transitional phase of the Environmental Footprint (EF) framework and the absence of finalized PEFCRs for packaging products, the study transparently declares all limitations, assumptions, and deviations from the PEF methodology throughout the report.

FUNCTIONAL UNIT AND REFERENCE FLOW

In some cases, the capacity of the containers changed compared to the packaging considered in the state-of-the-art analyses.

This change of size implies that, in these cases, the functions of the two containers are not completely comparable. A package made to carry a large amount of food does not fulfil the same function as a smaller size package. It often happens, for example, that the two food quantities are sold to a different target audience.

It was therefore chosen to introduce a fixed amount of food contained in the packaging as a Functional Unit.

The Functional Unit of the analyzed system is defined as follows: “The packaging required to contain, protect, and preserve 100 grams of food over the duration of the expected shelf life, to ensure food safety, quality, and integrity throughout the distribution chain”.



Tab B. Functional Unit aspects

ASPECT	DESCRIPTION
i) Functions or services provided (What)	Contain, preserve, protect food, and provide product information about the product content defined in the "Food category" item in Table 10 (e.g. prepared fruits) throughout the distribution chain.
ii) Extent of the function (How much)	The quantity of product to be packaged is 100 grams.
iii) Expected level of quality (What quality)	Guarantee food safety performance and shelf-life
iv) Duration/lifetime of the product (For how long)	Equal to the food's expected shelf-life.
Reference Flow	The mass of packaging material (single-use or allocated for reuse cycles) required to deliver 100 grams of food.

A density of 1 g/cm³ was assumed for liquid products to simplify calculations and enhance the clarity of inventory proportioning steps.



SYSTEM BOUNDARIES

The life cycle processes included in the study are the following:

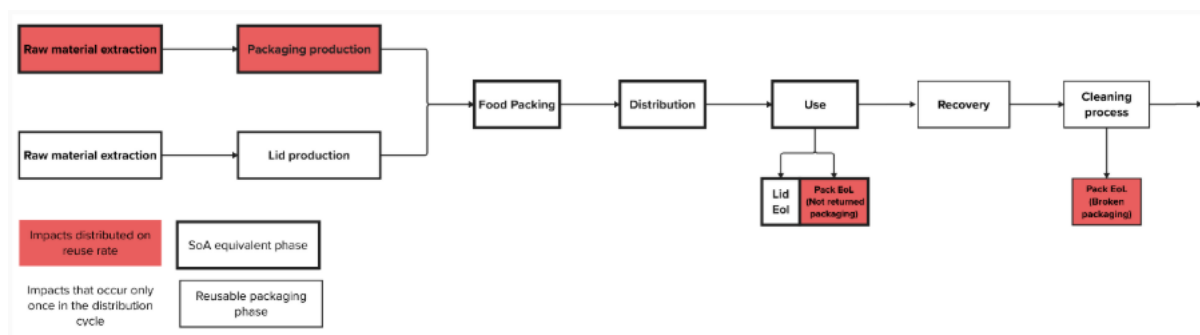


Figure B: Expanded modelisation of the Life Cycle of reusable packaging

Packaging raw material acquisition and pre-processing: this life cycle stage begins when resources are extracted from nature and ends when product components enter the packaging production plant. In particular, it includes the pre-processing of material inputs. According to PEF method, the raw material consumption shall be calculated dividing the actual weight of the packaging by the number of times the packaging is reused. In this way, the impacts coming from the extraction of resources are distributed over the reuse rate. The transportation related to the acquisition of raw material is partly modelled by ecoinvent market processes datasets.

Packaging manufacturing: the production stage begins when the raw materials enter the production site and ends when the packaging components leave the production facility.

Packaging transport from packaging manufacturer to the product factory: according to PEF method, this transport impact shall be calculated, as all phases that are unique during the lifecycle, by dividing the one-way trip impact by the number of times the packaging is reused.

Filling stage: In this phase the packaging is filled with food and all the other accessory components, as the single use lids, are added to the assembly.

Distribution to final user: this transport stage has been modelled considering the one way trip from the filling plant to the user house.

Use stage: In this phase, it is assumed that users dispose of the single-use lids, while a fraction of the containers are retained by customers and eventually reach end-of-life. This fraction represents the likelihood that some packaging will be removed from the reuse scheme by customers and is object of sensitivity analysis.

Recovery: empty packaging are recovered by using Reverse Vending Machines, placed in stores or in district.

Transport to washing centers: empty packaging are then transferred to the washing center, where they are inspected and cleaned.

Washing process: in this stage, packaging are cleaned and regenerated for further reuses. The fraction that is damaged due to previous uses is sent to end of life treatment processes.

LOSS RATE MODELLING

In the life cycle modelling, two points were identified where packaging output flows are concentrated, within the use and withing the washing phases. In contrast, at each reuse cycle, packaging that is lost is reintegrated by feeding new packaging into the stream.

As reuse cycles increase, the virtual composition of containers varies, with containers having experienced different numbers of reuses across the different cycles.

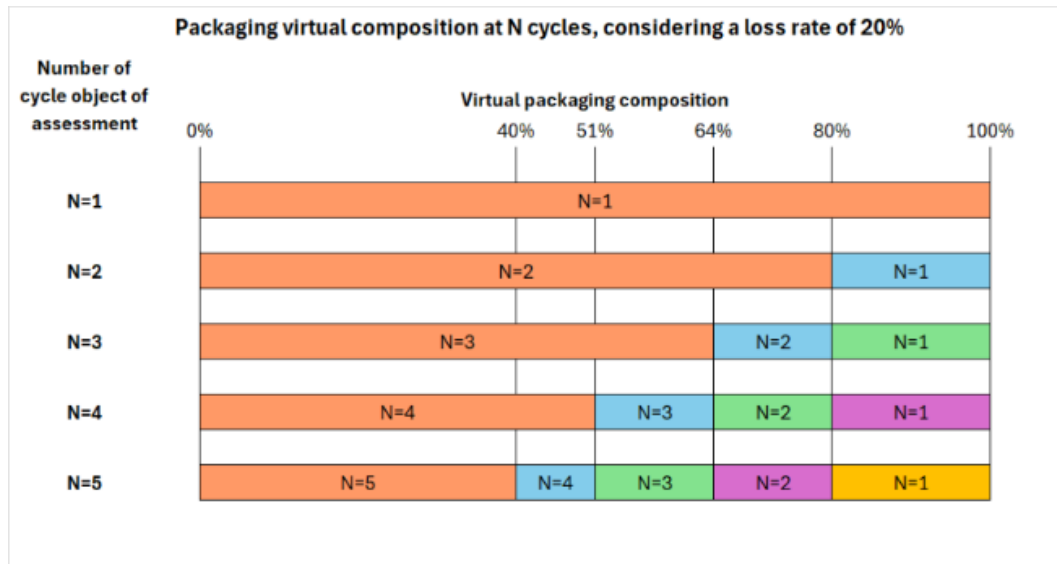


Figure C: Virtual composition of containers

To accurately describe the virtual mass of the containers, taking into account the different allocation of reuse cycles for progressively reintegrated containers, the following function has been defined:

$$m(n) = \frac{(1-q)^n}{n+1} + q \sum_{k=1}^{n-1} \frac{(1-q)^k}{k+1}$$

where $m(n)$ represents the virtual composition of the packaging, at n number of cycles, q the percentage of containers loss at every reuse cycles and k denotes each intermediate cycle from 1 to $n-1$.

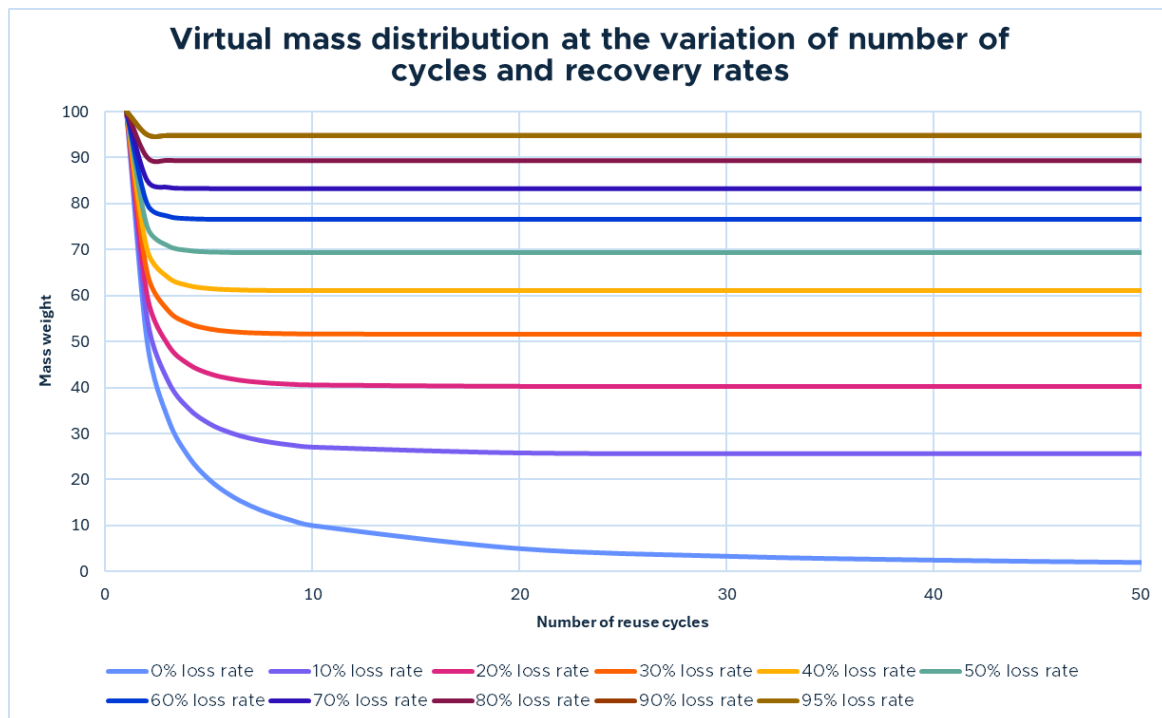


Figure D: Virtual mass of containers change over number of cycles and recovery rates

At low loss rates, the benefits of reuse systems are evident: after a certain number of cycles, the impact of the original material mass becomes negligible. At high loss rates, however, the system behaves almost linearly, reducing the overall effectiveness of reuse. Another important point is that the system's response to changes in the loss rate is not linear: improving the recovery rate at already high levels of return has a greater effect, producing a steeper decline in the curve, than a similar improvement at lower recovery rates.

The behavior described by this formula has been employed to model the virtual composition of the mass of reusable packaging as the number of reuses changes. In particular, this formula has been used to allocate the mass on the number of reuses for the phases of raw materials acquisition and pre-processing, production, transport to filling plant and end of life stages for reusable packaging.

TRANSPORT MODELLING

Transport distances used in the model were sourced from WP3. Specifically, precise transport distances between the different stages were determined accounting for variations in the system at the variation of return and breakage rates.



2. Environmental Assessment

MAIN ASSUMPTIONS

- Container lids are always considered as disposable items. It is assumed that users collect and dispose the lids after using the goods contained in the packaging. Lids are then sent to waste management facilities.
- Transport data for the main logistics routes (provided by UNiBo) are taken into account; these vary according to the return rate in order to optimise the efficiency of the logistics system. Consequently, scenarios consider both a different return rate *and* a different logistics.
- Washing data is processed for each product group, as the type of container and operating conditions (temperature, amount of water, detergent, energy) can vary significantly.
- A dynamic Excel programme has been developed to simulate environmental results by varying key parameters, such as the return rate, transport data and reuse cycles. This dynamic tool has been based on data provided by the ecoinvent databased, then associated to the specific LCI of the scenario considered.

REPORTING STRUCTURE OF THE RESULTS

Description of products

- Types of packaging analyzed (single-use vs reusable).
- Basic data: weight, material, associated processes.

Break-even point determination

Scenario 1

- Parameters: return rate = 70%, scrap rate = 5% (effective efficiency 64,6%).
- Presentation of the inventory data for the reusable system.
- Single Score graph (single-use vs reusable).

IF the break-even is not achieved → Scenario 2 evaluation.

Scenario 2

- Parameters: return rate = 90%, scrap rate = 5% (effective efficiency 85,5%).
- Presentation of the inventory data for the reusable system.
- Single Score graph (single-use vs reusable).



Detailed analysis

Weighted values

- Shows the contribution of each material and process (production, transport, washing, end-of-life).
- Direct comparison single-use vs reuse, across different numbers of cycles.

Characterized values

Comparison of the results from characterization stage for all environmental indicators between single use and reuse

- Graph and Table at the break-even point (number of cycles):
 - If achieved, indicate the exact number of cycles at which parity occurs.
- Graph and Table and values at 20 cycles:
 - Highlight the flattening of the curve (plateau).



2.1. Product 01 – Prepared fruits

The comparison concerns the following products:

STATE OF THE ART – SINGLE USE – Florette Shaker, PET Cup

Table 1: State of the art PRODUCT 01

Format	Preformed PET Shaker, thin PET foil lid	
Food weight	400 ml	
Company	Floréale	
LCA ID	01	

Inventory data are in the *Deliverable 6.2 – LCA Inventory and scenario building, Tab E1. PP-M LCI, PRODUCT 01 – Florette Shaker, PET Cup*

Tab E1. PP-M LCI, PRODUCT 01 – Florette Shaker, PET Cup

TABLE E1				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
1	PET Cup	1	5,391	/	/	Heat sealing	/	/
1.1	PET Foil Lid	1	0,348	PET	Polyethylene terephthalate, granulate, amorphous {RER} production Cut-off, U	Extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film Cut-off, U	Water, cooling, unspecified natural origin, FR; Electricity, medium voltage {FR} market for Cut-off, U
1.2	PET Shaker	1	5,043	PET	Polyethylene terephthalate, granulate, amorphous {RER} production Cut-off, U	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing Cut-off, U	/

REUSE - TABLE F1, PP-M LCI,– Florette Shaker, PP Tray + Lid

Table 2: REUSE Product 01r

Format	PP Tray + PP lid	
Food weight	1261 ml - 250 gr	
Company	Floréale (Agrial)	
LCA ID	01-r	

Inventory data are in the *Deliverable 6.2 – LCA Inventory and scenario building*

Tab F1. PP-M LCI, PRODUCT 01-r – Florette Shaker, PP Tray + Lid

REUSE

Table F1				Pre-processing		Manufacturing		
Position	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
1-R	PP Tray + Lid	1	18,44	/	/	/	/	/
1.1-R	PP Lid	1	0,8	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/
1.2-R	PP Tray	1	17,640	PP	Polypropylene, granulate {RER} production Cut-off, U	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing Cut-off, U	/

SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 3: PRODUCT 01R_Reuse Data Inventory SCENARIO 1

Inventory data	01R_FLORETTE SHAKER_ANANAS	Unit of Measure
Pack Type	PKG_01	
Pack material	PP	
Pack amount	17,64	g
Lid material	PP	
Lid amount	0,80	g
Producer to filler distance	42,79	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	104,77	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	140,69	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	53,14	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Salad tray	
Washing water [l]	0,09	l
Washing detergent [g]	0,23	g
Washing energy [kWh]	0,01	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	81,62	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 1, the break-even point is not reached at a return rate of 64,6%. Even with high numbers of reuse cycles, the environmental impacts of single-use packaging remain lower (-51,6% at 20th cycle).

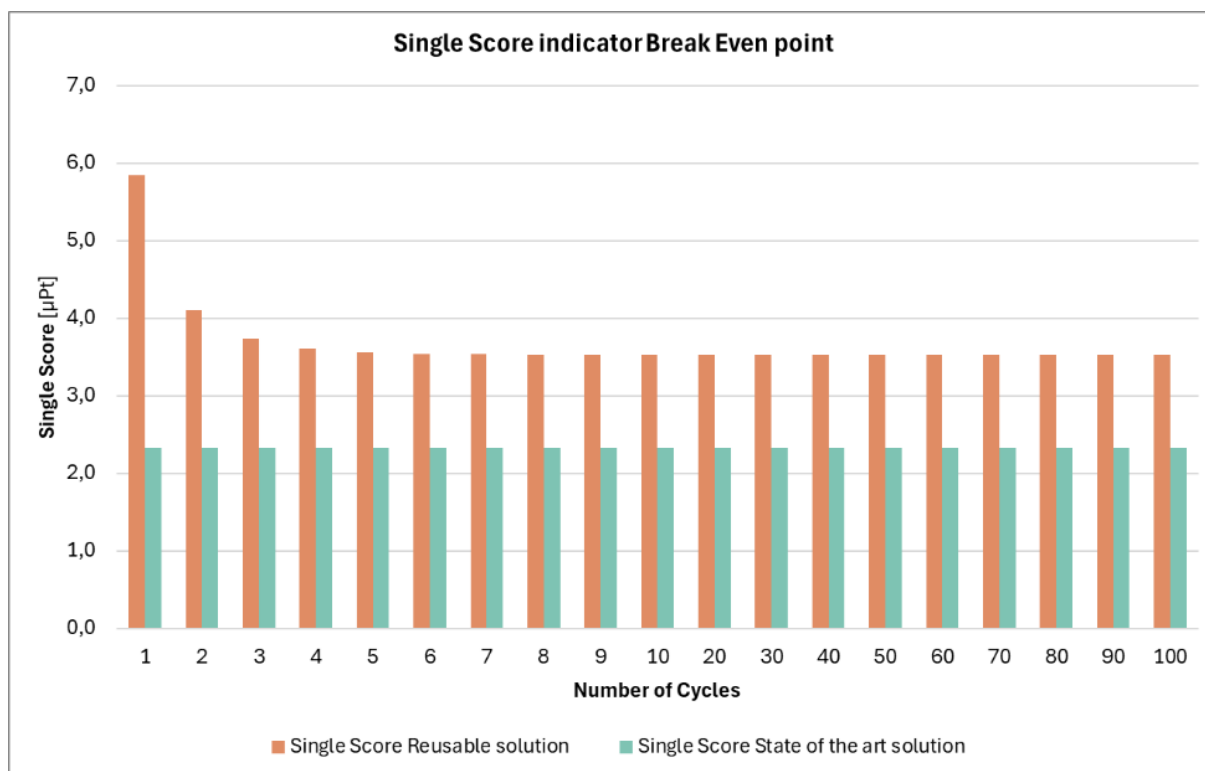


Figure 1: Product01_Single Score Chart_Return_Rate 64,6%

SCENARIO 2: LCA AT 90% OF RETURN RATE AND 5% OF SCRAP RATE (85,5%)

Table 4: Product 01R_ REUSE inventory data on scenario 2

Inventory data	01R_FLORETTE SHAKER_ANANAS	Unit of Measure
Pack Type	PKG_01	
Pack material	PP	
Pack amount	17,64	g
Lid material	PP	
Lid amount	0,80	g
Producer to filler distance	42,79	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	104,77	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	90%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	140,69	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	53,14	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Salad tray	
Washing water [l]	0,09	l
Washing detergent [g]	0,23	g
Washing energy [kWh]	0,01	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	81,62	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

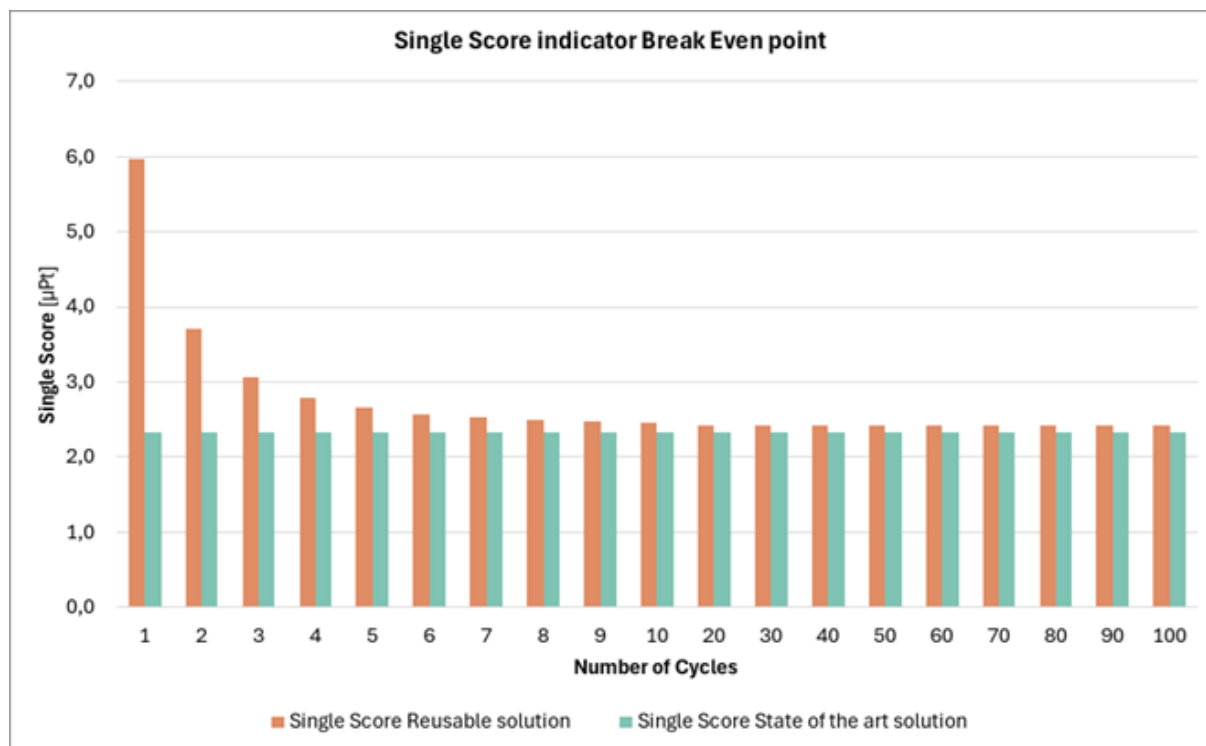


Figure 2: Product01_Single Score Chart_Return_Rate 85,5%

Even with a return rate of 85,5%, it is not possible to identify a break-even point. Single use packaging has a total impact of -4% at 20th cycle.

The main reason for missing the break-even point is that the mass per functional unit of 100 g of product content (see Table 1) is significantly lower (5.391 g) than that of reused product content (18.4 g). This is to be considered in addition to the extra processes in the reuse system.



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Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 3) and Reuse System (Fig 4) as the number of cycles varies.

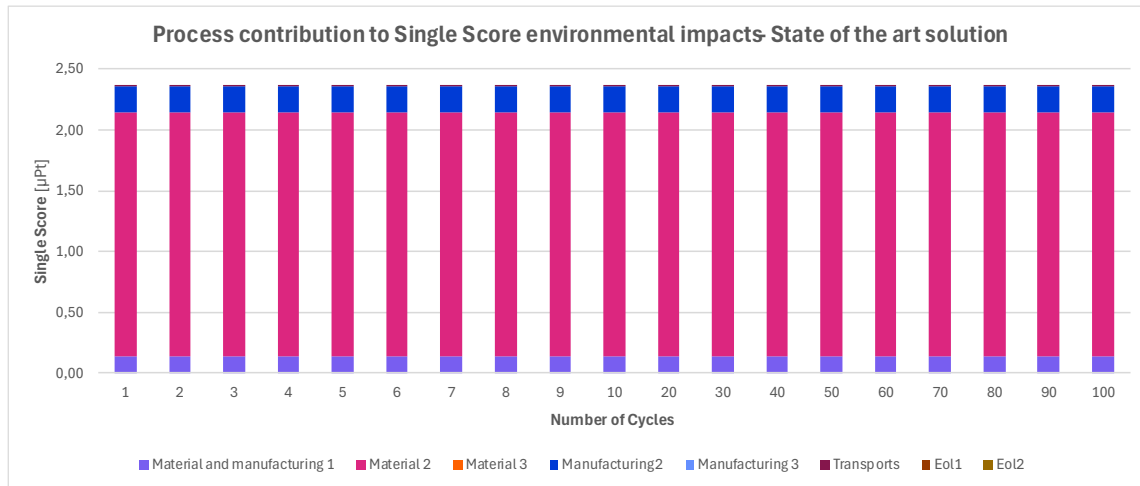


Figure 3: Product01_SingleUse_Weighted Results: Material 1: PET foil lid Material 2: PET shaker Manufacturing 1: PET extrusion. Manufacturing 2: PET thermoforming.

As shown in Fig 3, in the single-use system (packaging referred to Table 1) shows the greatest impact (86%) for Material 2: PET shaker, as it represents the largest proportion of material, associated with its production (Manufacturing 2) representing the 9% of total impacts.

As shown in Fig 4, in reuse system (packaging referred to Table 2) shows the greatest impact (74% at 20th cycle) for Packaging material (PP), associated with its production (Pack Manufacturing) representing the 12% of total impacts followed by the washing process (12%).

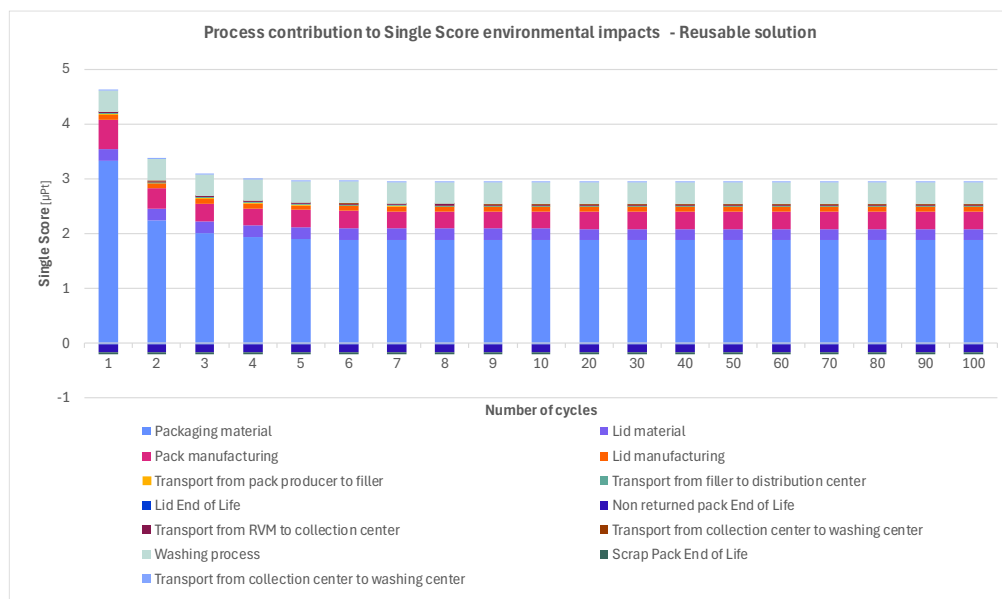


Figure 4: Product01_Reuse_Weighted Results_Return Rate 64,6%



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Characterization results comparison

Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

At 20-cycle: Flattening the curve

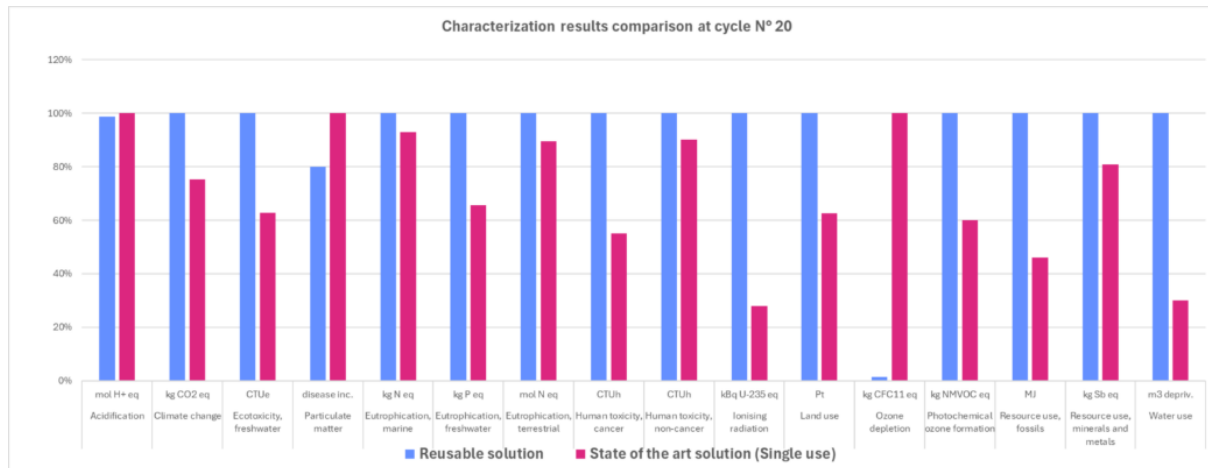


Figure 5: Product01r_Graph at 20 reuse cycles_Return Rate 64,6%

Table 5: Product01r_Values at 20 reuse cycles_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	8,89E-05	9,01E-05
Climate change	kg CO2 eq	3,33E-02	2,51E-02
Ecotoxicity, freshwater	CTUe	7,78E-03	4,88E-03
Particulate matter	disease inc.	8,33E-10	1,04E-09
Eutrophication, marine	kg N eq	2,19E-05	2,04E-05
Eutrophication, freshwater	kg P eq	5,41E-06	3,54E-06
Eutrophication, terrestrial	mol N eq	1,90E-04	1,70E-04
Human toxicity, cancer	CTUh	1,11E-10	6,13E-11
Human toxicity, non-cancer	CTUh	2,54E-10	2,30E-10
Ionising radiation	kBq U-235 eq	1,27E-02	3,55E-03
Land use	Pt	1,02E-01	6,42E-02
Ozone depletion	kg CFC11 eq	1,19E-09	8,15E-08
Photochemical ozone formation	kg NMVOC eq	1,43E-04	8,56E-05
Resource use, fossils	MJ	1,00E+00	4,61E-01
Resource use, minerals and metals	kg Sb eq	2,37E-07	1,92E-07
Water use	m3 depriv.	1,21E-02	3,65E-03

The reuse-use scenario has a greater impact on most indicators apart from 'Acidification, Particulate matter (due to materials, transport and washing), Ozone depletion (due to Material 2 "PET).

2.2. Product 02 – Prepared salad

The comparison concerns the following products:

STATE OF THE ART – SINGLE USE - Salad MDD, PET Tray

Table 6: State of the art PRODUCT 02

Format	PET Tray	
Food weight	250 g	
Company	LSDH	
LCA ID	02	

Inventory data are in the Deliverable 6.2 – LCA Inventory and scenario building, Tab E2. PP-M LCI, PRODUCT 02 – Salad MDD, PET Tray

TABLE E2				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
2	PET Tray	1	12	/	/	Inline manual closing	/	/
2.1	PET Lid	1	4	PET	Polyethylene terephthalate, granulate, amorphous {RER} production Cut-off, U	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing Cut-off, U	/
2.2	PET Bowl	1	8	PET	Polyethylene terephthalate, granulate, amorphous {RER} production Cut-off, U	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing Cut-off, U	/



REUSE – Prepared Salad Tray 1261 mL

Table 7: REUSE Product 02-r

Format	PP Tray + PP lid	
Food weight	1261 ml - 250 gr	
Company	LSDH/ Sodebo / Floreale	
LCA ID	02-r	

Inventory data are in the Deliverable 6.2 – LCA Inventory and scenario building, Tab F2. PP-M LCI, PRODUCT 02-r – Prepared Salad Tray 1261 mL

TABLE F2				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
2-r	PP Salad tray + lid	1	18,44	/	/	/	/	/
2.1-r	PP Lid	1	0,8	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/
2.2-r	PP Tray	1	17,640	PP	Polypropylene, granulate {RER} production Cut-off, U	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing Cut-off, U	/



SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 8: PRODUCT 02R_Reuse Data Inventory SCENARIO 1

Inventory data	02R_SALAD MDD_SALAD	Unit of Measure
Pack Type	PKG_01	
Pack material	PP	
Pack amount	17,64	g
Lid material	PP	
Lid amount	0,80	g
Producer to filler distance	42,79	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	104,77	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	140,69	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance2	53,14	km
Transport from RVM to collection center mean of transport2	Truck transport, average	
Washing container type	Salad tray	
Washing water [l]	0,09	l
Washing detergent [g]	0,23	g
Washing energy [kWh]	0,01	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	81,62	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 6, the break-even point is reached at a return rate of 64,6%. This is reached in the second reuse cycle. Analysis indicates that the system would have been balanced at a return rate of 20% and a scrap rate of 5%.

At the ideal return rate of 64,6%, the break-even point was reached, with a difference of 32,1 % in the total impacts generated after 20 cycles.

The main reason lies in the fact that reusable packaging has a mass per functional unit reasonably close to that of the packaging it replaces (18.4g vs. 12g). As the number of cycles increases, these impacts are distributed in a way that is advantageous for the reuse system.

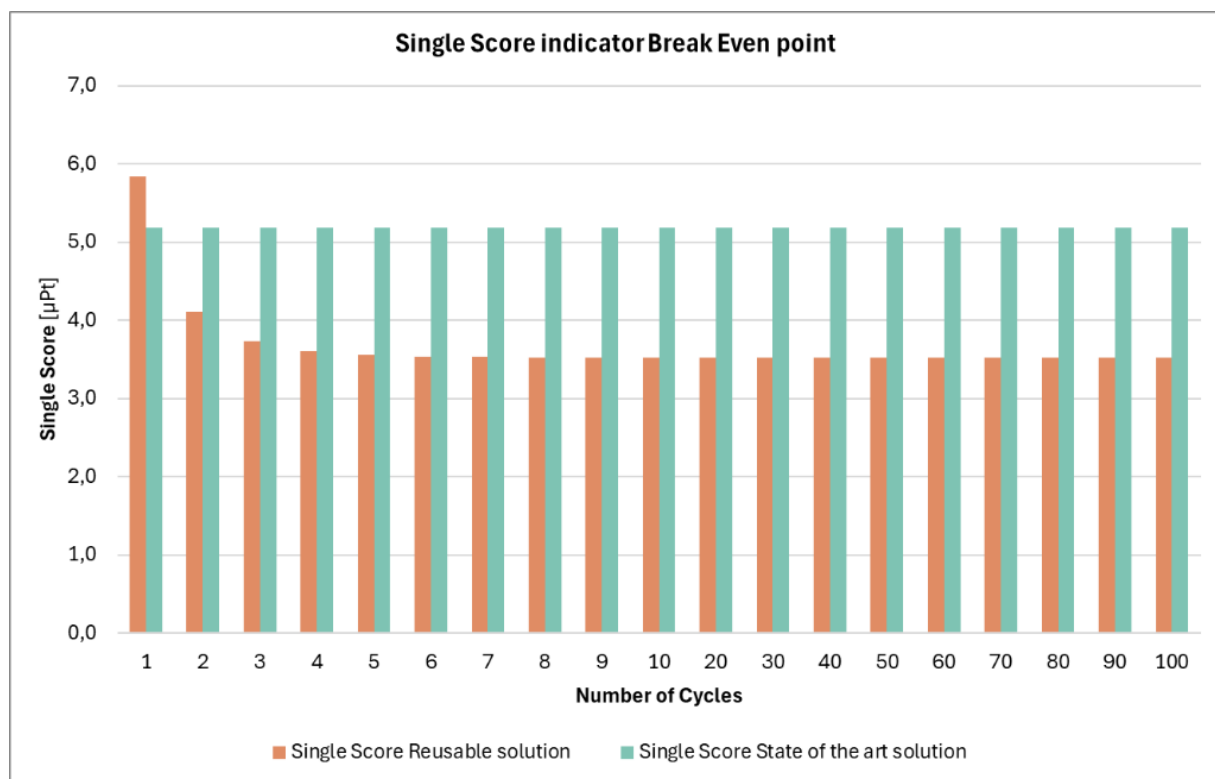


Figure 6: Product02_Single Score Chart_Return_Rate 64,6%



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Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 7) and Reuse System (Fig 8) as the number of cycles varies.

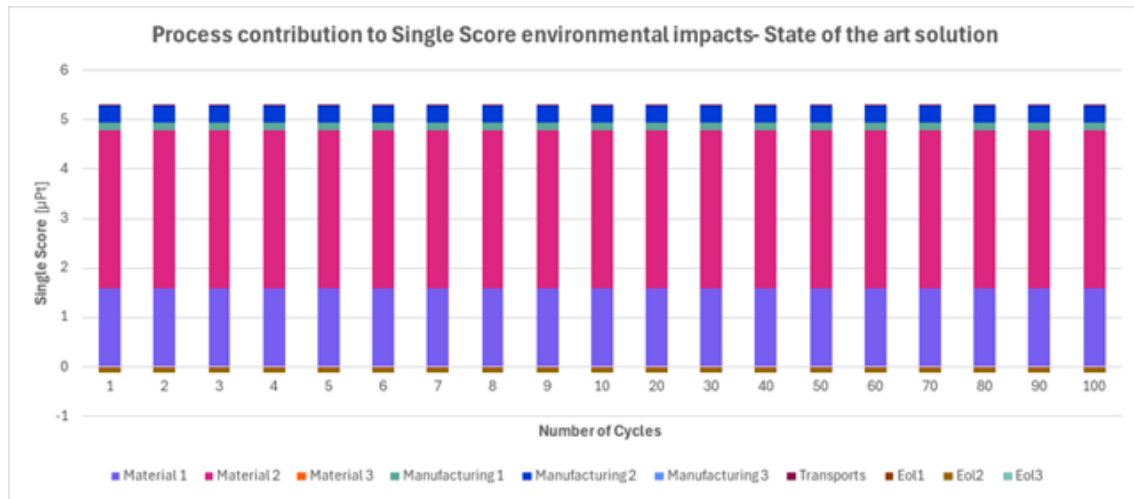


Figure 7: Product02_SingleUse_Weighted Results: Material 1: PET Lid Material 2: PET Bowl

As shown in Fig 7, in the single-use system (packaging referred to Table 6) shows the greatest impact (61%) for Material 2: PET Bowl, as it represents the largest proportion of material, associated with its production (Manufacturing 2) representing the 7% of total impacts. The second largest contributor is Material 1: PET Lid representing 31% of total impacts.

As shown in Fig 8, in reuse system (packaging referred to Table 7) shows the greatest impact (74% at 20th cycle) for Packaging material (PP), associated with its production (Pack Manufacturing) representing the 12% of total impacts followed by the washing process (12%).

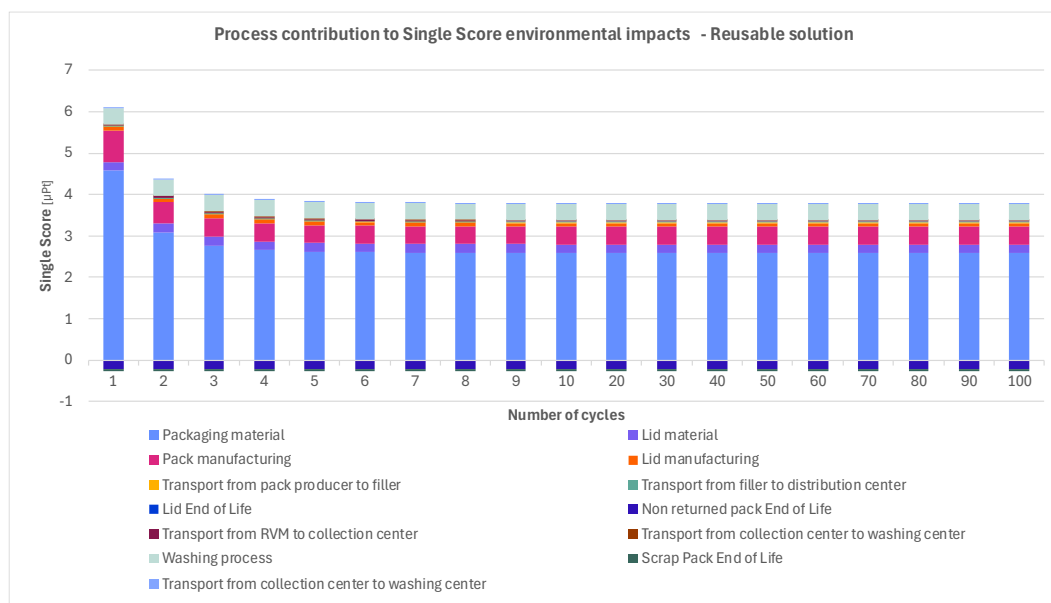


Figure 8: Product02_Reuse_Weighted Results_Return Rate 64,6%



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Characterization results comparison

Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

At break-even point

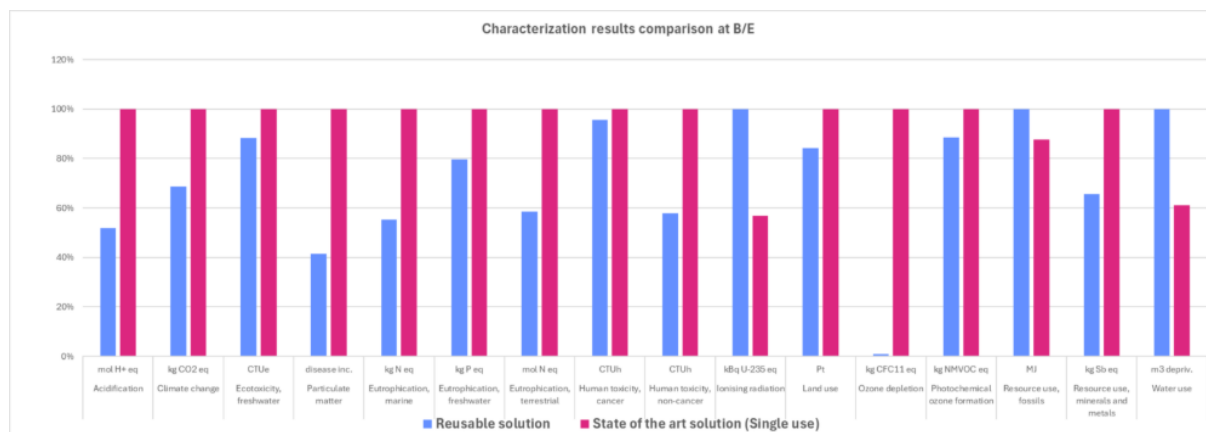


Figure 9: Product02r_Graph at 2 reuse cycles (break-even point)_Return Rate 64,6%

Table 9: Product02r_Values at 2 reuse cycles (break-even point)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	1,04E-04	2,00E-04
Climate change	kg CO2 eq	3,83E-02	5,59E-02
Ecotoxicity, freshwater	CTUe	9,69E-03	1,10E-02
Particulate matter	disease inc.	9,59E-10	2,32E-09
Eutrophication, marine	kg N eq	2,51E-05	4,53E-05
Eutrophication, freshwater	kg P eq	6,28E-06	7,88E-06
Eutrophication, terrestrial	mol N eq	2,21E-04	3,79E-04
Human toxicity, cancer	CTUh	1,30E-10	1,36E-10
Human toxicity, non-cancer	CTUh	2,96E-10	5,11E-10
Ionising radiation	kBq U-235 eq	1,44E-02	8,20E-03
Land use	Pt	1,17E-01	1,39E-01
Ozone depletion	kg CFC11 eq	1,42E-09	1,81E-07
Photochemical ozone formation	kg NMVOC eq	1,69E-04	1,91E-04
Resource use, fossils	MJ	1,18E+00	1,03E+00
Resource use, minerals and metals	kg Sb eq	2,81E-07	4,28E-07
Water use	m3 depriv.	1,44E-02	8,77E-03

At 20-cycle: Flattening the curve

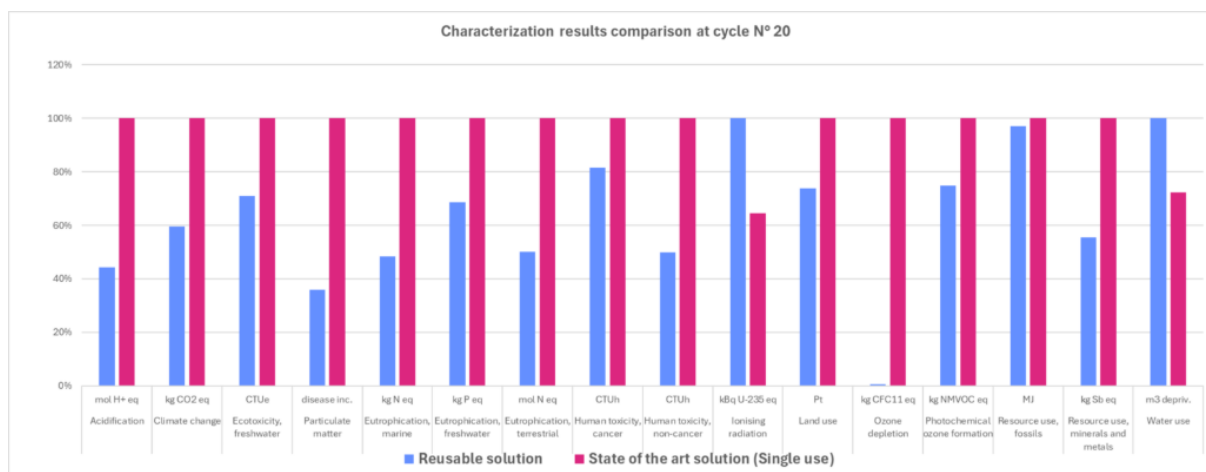


Figure 10: Product02-r_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 10: Product02-r_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	8,89E-05	2,00E-04
Climate change	kg CO2 eq	3,33E-02	5,59E-02
Ecotoxicity, freshwater	CTUe	7,78E-03	1,10E-02
Particulate matter	disease inc.	8,33E-10	2,32E-09
Eutrophication, marine	kg N eq	2,19E-05	4,53E-05
Eutrophication, freshwater	kg P eq	5,41E-06	7,88E-06
Eutrophication, terrestrial	mol N eq	1,90E-04	3,79E-04
Human toxicity, cancer	CTU _h	1,11E-10	1,36E-10
Human toxicity, non-cancer	CTU _h	2,54E-10	5,11E-10
Ionising radiation	kBq U-235 eq	1,27E-02	8,20E-03
Land use	Pt	1,02E-01	1,39E-01
Ozone depletion	kg CFC11 eq	1,19E-09	1,81E-07
Photochemical ozone formation	kg NMVOC eq	1,43E-04	1,91E-04
Resource use, fossils	MJ	1,00E+00	1,03E+00
Resource use, minerals and metals	kg Sb eq	2,37E-07	4,28E-07
Water use	m3 depriv.	1,21E-02	8,77E-03

The single-use scenario has a greater impact on most indicators apart from 'ionising radiation' due to the production and washing processes. The former is an implication of the French energy mix, which has a high percentage of nuclear energy, while the latter is mainly due to the quantities of reusable packaging material used. Water use is also higher due to the material (PP compared to PET) and the quantities of material involved in reusable packaging.

2.3. Product 03 – Sour cream

The comparison concerns the following products:

STATE OF THE ART – SINGLE USE - TABLE E3, PP-M LCI, – Sour cream, Cup

Table 11: State of the art PRODUCT 03

Format	PP Cup
Food weight	200 g
Company	Yoplait
LCA ID	03



Inventory data are in the Deliverable 6.2 – LCA Inventory and scenario building, Tab E3. PP-M LCI, PRODUCT 03 – Sour cream, Cup

TABLE E3				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
3	Sour Cream bowl and lid	1	6,18	/	/	Inline closing and sealing	/	/
3.1	PET Overcap	1	1,525	PET	Polyethylene terephthalate, granulate, amorphous {RER} production Cut-off, U	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing Cut-off, U	/
3.2	Aluminium Lid	1	0,405	Aluminium	Aluminium alloy, AlMg3 {GLO} market for Cut-off, U	Sheet rolling	Sheet rolling, aluminium {RER} processing Cut-off, U	• Water, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for Cut-off, U
3.3	PP Bowl	1	4,25	PP	Polypropylene, granulate {RER} production Cut-off, U	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing Cut-off, U	/

REUSE - TABLE F3, PP-M LCI, – Sour cream PP Bucket + Lid

Table 12: REUSE Product 03-r

Format	PP Bucket + PP lid	
Food weight	500 gr	
Company	Yoplait	
LCA ID	03-r	

Inventory data are in the Deliverable 6.2 – LCA Inventory and scenario building, Tab F3. PP-M LCI, PRODUCT 03-r – Sour cream PP Bucket + Lid

TABLE F3				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
3-r	PP Bucket + Lid	1	4,58	/	/	/	/	/
3.1-r	PP Lid	1	1,12	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/
3.2-r	PP Bucket	1	3,46	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/

SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 13: PRODUCT 03R_Reuse Data Inventory SCENARIO 1

Inventory data	03R_SOUR CREAM	Unit of Measure
Pack Type	PKG_02	
Pack material	PP	
Pack amount	3,46	g
Lid material	PP	
Lid amount	1,12	g
Producer to filler distance	167,84	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	273,01	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,82	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	161,10	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance2	49,69	km
Transport from RVM to collection center mean of transport2	Truck transport, average	
Washing container type	Pot 500g	
Washing water [l]	0,02	l
Washing detergent [g]	0,04	g
Washing energy [kWh]	0,00	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	454,30	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 11, the break-even point is reached at a rate of return of 64,6%. As the reusable product has a lower environmental impact, the break-even point is reached after the first cycle of reuse.

At the ideal return rate of 64,6%, the break-even point is reached, with a difference of 41,6% in total impacts generated after 20 cycles.

The main reason lies in the fact that reusable packaging has a mass per functional unit lower to that of the packaging it replaces (4,58g vs. 6,18g). As the number of cycles increases, these impacts are distributed in a way that is further advantageous for the reuse system.

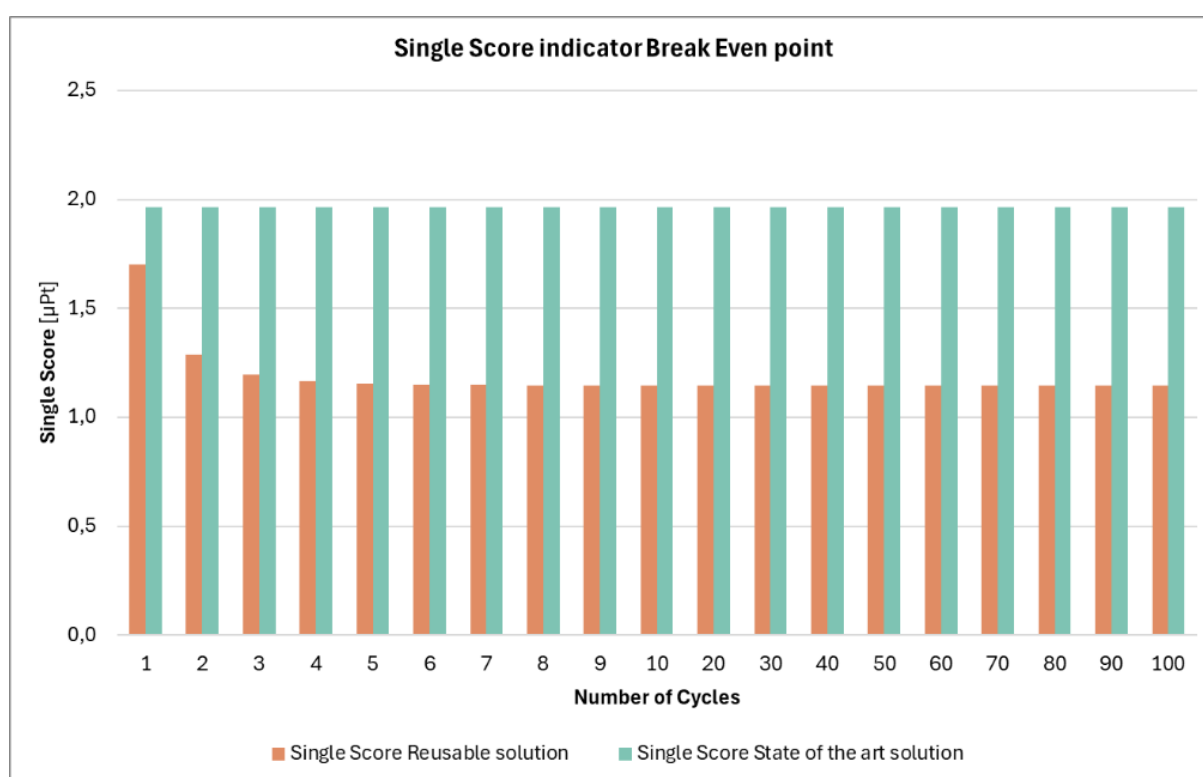


Figure 11: Product03_Single Score Chart_Return_Rate 64,6%

Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 7) and Reuse System (Fig 8) as the number of cycles varies.

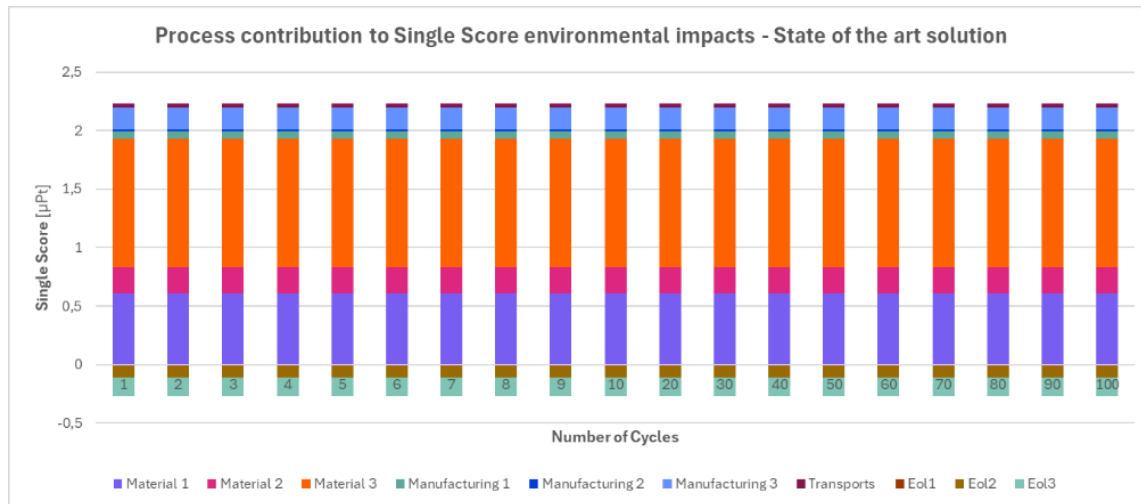


Figure 12: Product02_SingleUse_Weighted Results: Material 1: PET Overcap; Material 2: Aluminium Lid; Material3: PP Bowl

As shown in Fig 12, in the single-use system (packaging referred to Table 11) shows the greatest impact (56%) for Material 3: PP Bowl, as it represents the largest proportion of material, associated with its production (Manufacturing 3) representing the 9% of total impacts. The second largest contributor is Material 1: PET Overcap representing 31% of total impacts. End of Life processes: Eol2 and Eol3, thanks to the recyclability respectively of Aluminium and polypropylene contribute to a reduction in the total impacts of -5% and -8%.

As shown in Fig 13, in reuse system (packaging referred to Table 12) shows the greatest impact (44% at 20th cycle) for Packaging material (PP), associated with its production (Pack Manufacturing) representing the 19% of total impacts followed by the disposable Lid material (25%) and associated manufacturing 11%.

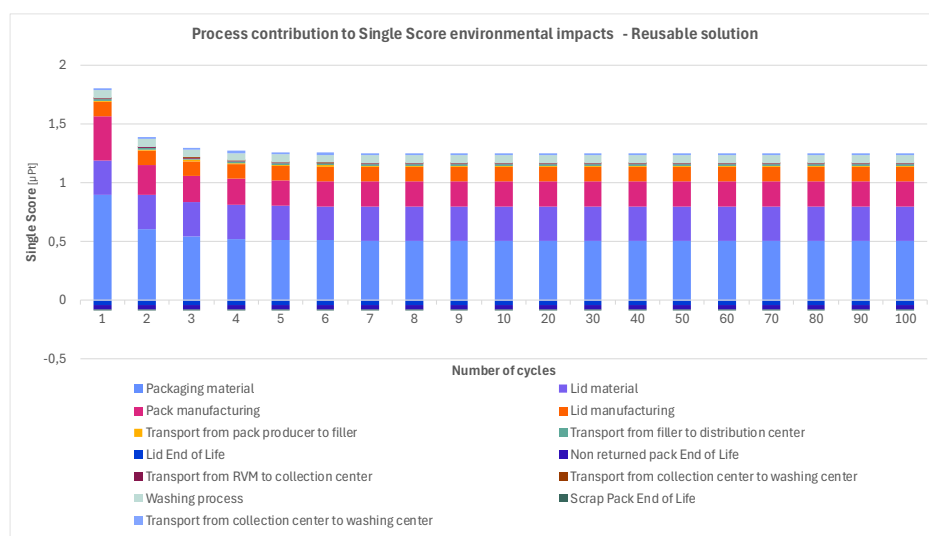


Figure 13: Product03_Reuse_Weighted Results_Return Rate 64,6%

Characterization results comparison

Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

At break-even point

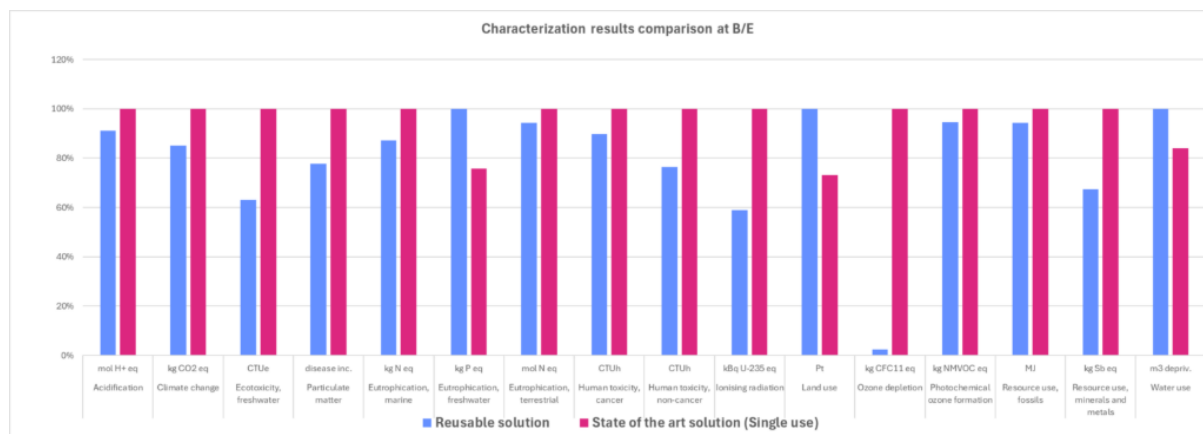


Figure 14: Product03r_Graph at 1 reuse cycles (break-even point)_Return Rate 64,6%

Table 14: Product03r_Values at 2 reuse cycles (break-even point)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	5,86E-05	6,43E-05
Climate change	kg CO2 eq	1,82E-02	2,14E-02
Ecotoxicity, freshwater	CTUe	1,67E-02	2,65E-02
Particulate matter	disease inc.	5,29E-10	6,81E-10
Eutrophication, marine	kg N eq	1,24E-05	1,42E-05
Eutrophication, freshwater	kg P eq	4,20E-06	3,18E-06
Eutrophication, terrestrial	mol N eq	1,21E-04	1,29E-04
Human toxicity, cancer	CTUh	5,45E-11	6,07E-11
Human toxicity, non-cancer	CTUh	1,27E-10	1,67E-10
Ionising radiation	kBq U-235 eq	1,60E-03	2,71E-03
Land use	Pt	7,62E-02	5,58E-02
Ozone depletion	kg CFC11 eq	5,76E-10	2,35E-08
Photochemical ozone formation	kg NMVOC eq	7,61E-05	8,05E-05
Resource use, fossils	MJ	4,17E-01	4,42E-01
Resource use, minerals and metals	kg Sb eq	1,04E-07	1,55E-07
Water use	m3 depriv.	6,66E-03	5,59E-03

At 20-cycle: Flattening the curve

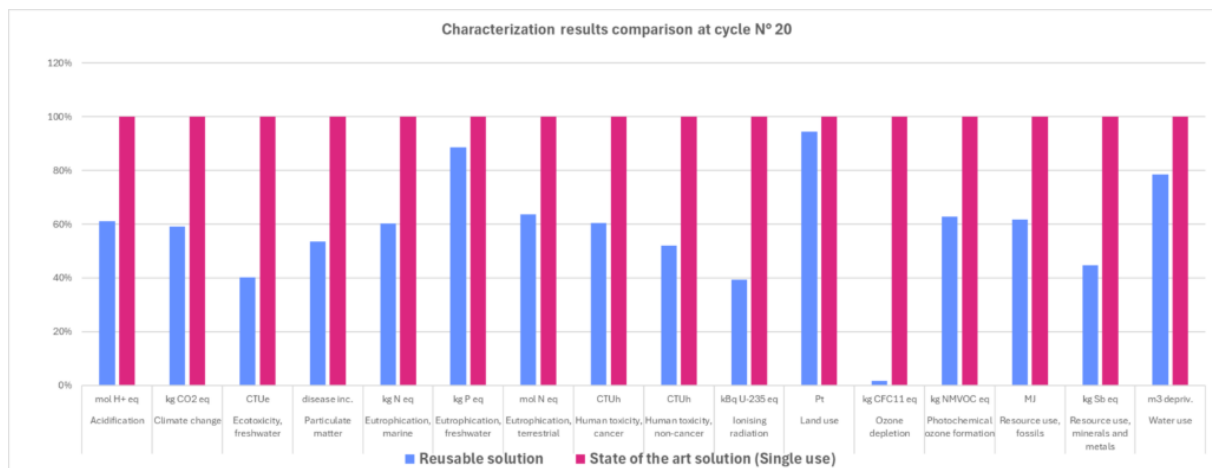


Figure 15: Product03-r_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 15: Product03-r_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	3,93E-05	6,43E-05
Climate change	kg CO2 eq	1,27E-02	2,14E-02
Ecotoxicity, freshwater	CTUe	1,06E-02	2,65E-02
Particulate matter	disease inc.	3,64E-10	6,81E-10
Eutrophication, marine	kg N eq	8,58E-06	1,42E-05
Eutrophication, freshwater	kg P eq	2,82E-06	3,18E-06
Eutrophication, terrestrial	mol N eq	8,19E-05	1,29E-04
Human toxicity, cancer	CTUh	3,67E-11	6,07E-11
Human toxicity, non-cancer	CTUh	8,68E-11	1,67E-10
Ionising radiation	kBq U-235 eq	1,07E-03	2,71E-03
Land use	Pt	5,27E-02	5,58E-02
Ozone depletion	kg CFC11 eq	3,75E-10	2,35E-08
Photochemical ozone formation	kg NMVOC eq	5,05E-05	8,05E-05
Resource use, fossils	MJ	2,73E-01	4,42E-01
Resource use, minerals and metals	kg Sb eq	6,92E-08	1,55E-07
Water use	m3 depriv.	4,39E-03	5,59E-03

The single-use scenario has the greatest impact on all indicators.

Reusable packaging uses fewer materials per unit of function: the ratio of packaging mass to food capacity is lower, making it more environmentally efficient.

2.4. Product 04 – Greek yogurt

The comparison concerns the following products:

STATE OF THE ART – SINGLE USE - TABLE E4, PP-M LCI – Greek yogurt, Cup

Table 16: State of the art PRODUCT 04

Format	PP Cup	
Food weight	450 g	
Company	Yoplait	
LCA ID	04	

Inventory data are in the Deliverable 6.2 – LCA Inventory and scenario building, Tab E4. PP-M LCI, PRODUCT 04 – Greek yogurt, Cup

TABLE E4				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
4	PP Bowl and Lid	1	4,5	/	/	Inline closing and sealing	/	/
4.1	PET Overcap	1	1,111	PET	Polyethylene terephthalate, granulate, amorphous {RER} production Cut-off, U	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing Cut-off, U	/
4.2	Aluminium Lid	1	0,278	Aluminium	Aluminium alloy, AlMg3 {GLO} market for Cut-off, U	Sheet rolling	Sheet rolling, aluminium {RER} processing Cut-off, U	• Water, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for Cut-off, U
4.3	PP Bowl	1	3,111	PP	Polypropylene, granulate {RER} production Cut-off, U	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing Cut-off, U	/

REUSE - TABLE F4, PP-M LCI, – Greek yogurt, PP Cup + Lid

Table 17: REUSE Product 03-r

Format	PP Bucket + PP lid	
Food weight	500 gr	
Company	SystemU & Carrefour	
LCA ID	04-r	

Inventory data are in the Deliverable 6.2 – LCA Inventory and scenario building, Tab F4. PP-M LCI, PRODUCT 04-r – Greek yogurt, PP Cup + Lid

TABLE F4				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
4-r	PET Bucket + Lid	1	4,58	/	/	/	/	/
4.1-r	PP Lid	1	1,12	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/
4.2-r	PP Bucket	1	3,46	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/

SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 18: PRODUCT 04R_Reuse Data Inventory SCENARIO 1

Inventory data	04R_GREEK YOGURT	Unit of Measure
Pack Type	PKG_02	
Pack material	PP	
Pack amount	3,46	g
Lid material	PP	
Lid amount	1,12	g
Producer to filler distance	167,84	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	273,01	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,82	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	161,10	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	49,69	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Pot 500g	
Washing water [l]	0,02	l
Washing detergent [g]	0,04	g
Washing energy [kWh]	0,00	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	454,30	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 16, the break-even point is reached at a return rate of 64,6%. This is reached in the second reuse cycle. Analysis indicates that the system would be balanced at a return rate of 40% and a scrap rate of 5%.

At the ideal return rate of 64,6%, the break-even point was reached, with a difference of 19,7% in the total impacts generated after 20 cycles.

The main reason lies in the fact that reusable packaging has a mass per functional unit almost equal to that of the packaging it replaces (4,58 g vs. 4,5 g). As the number of cycles increases, these impacts are distributed in a way that is advantageous for the reuse system.

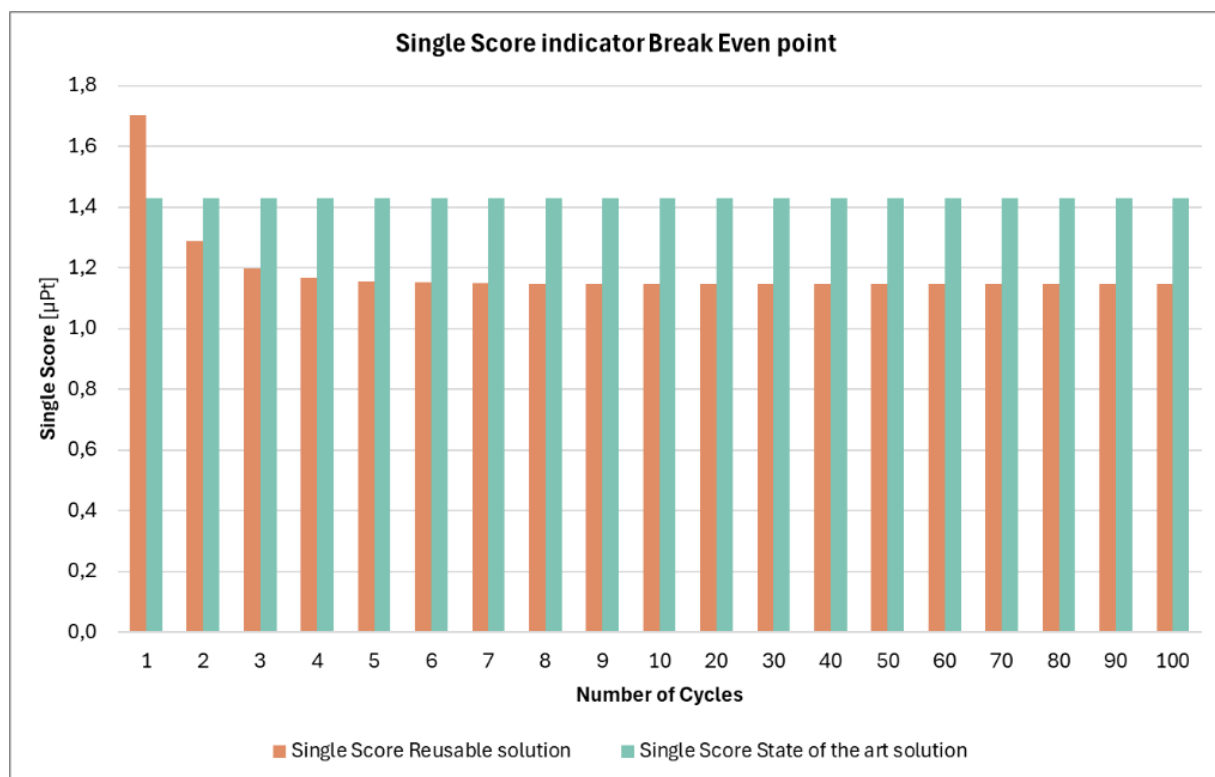


Figure 16: Product04_Single Score Chart_Return_Rate 64,6%

Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 7) and Reuse System (Fig 8) as the number of cycles varies.

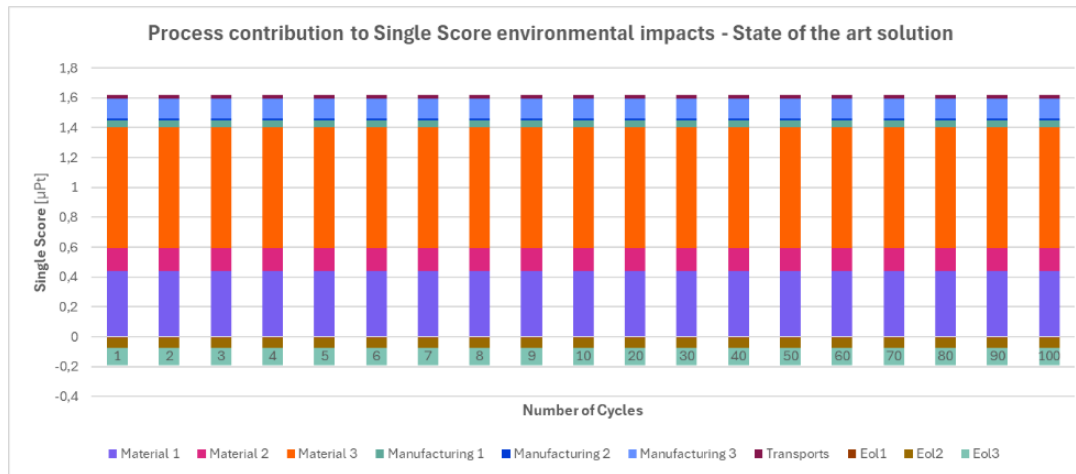


Figure 17: Product04_SingleUse_Weighted Results: Material 1: PET Overcap; Material 2: Aluminium Lid; Material3: PP Bowl

As shown in Fig 17, in the single-use system (packaging referred to Table 16) shows the greatest impact (57%) for Material 3: PP Bowl, as it represents the largest proportion of material, associated with its production (Manufacturing 3) representing the 9% of total impacts. The second largest contributor is Material 1: PET Overcap representing 31% of total impacts. End of Life processes: Eol2 and Eol3, thanks to the recyclability respectively of Aluminium and polypropylene contribute to a reduction in the total impacts of -4% and -8%.

As shown in Fig 18, in reuse system (packaging referred to Table 17) shows the greatest impact (44% at 20th cycle) for Packaging material (PP), associated with its production (Pack Manufacturing) representing the 19% of total impacts followed by the disposable Lid material (25%) and associated manufacturing 11%.

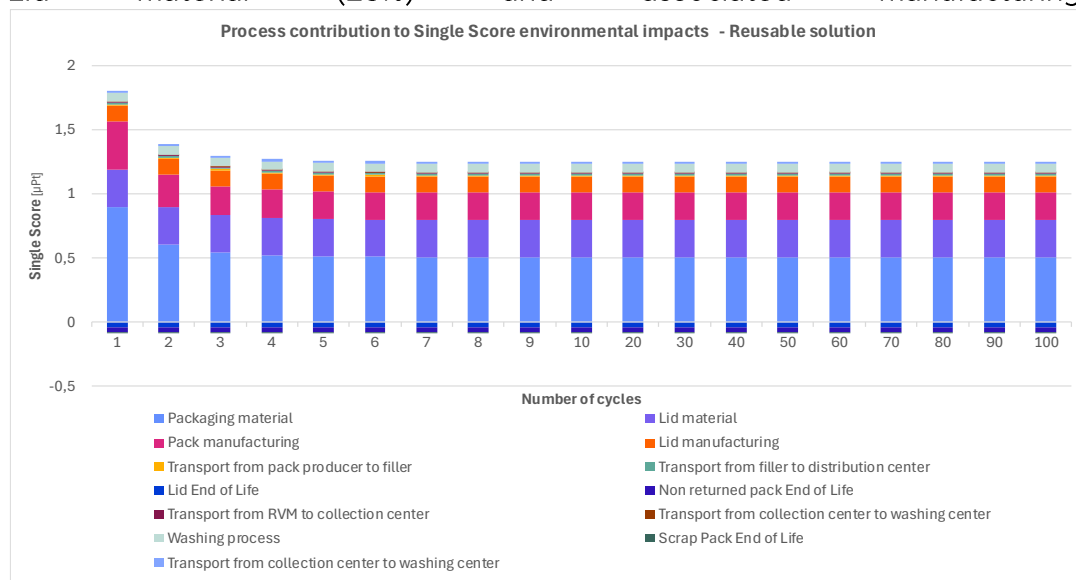


Figure 18: Product04_Reuse_Weighted Results_Return Rate 64,6%

Characterization results comparison

Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

At break-even point

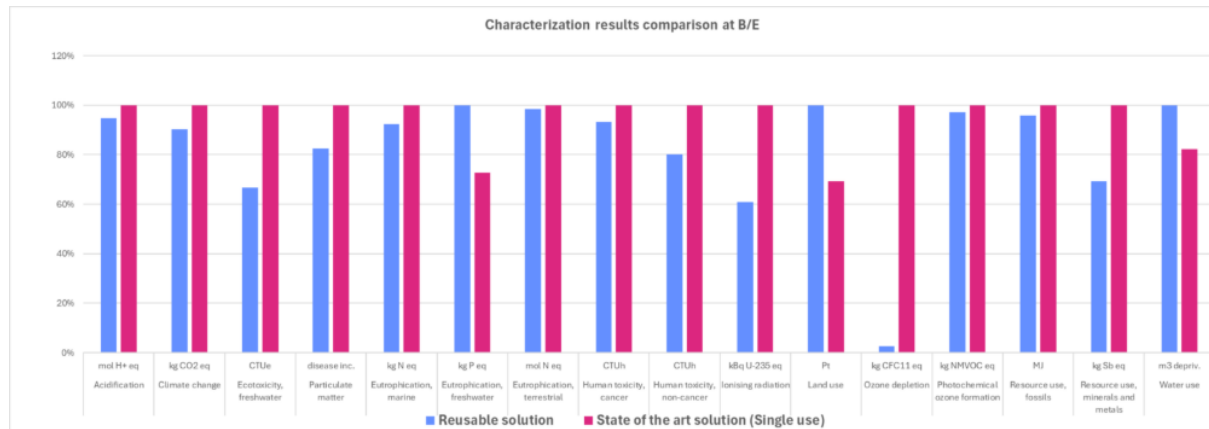


Figure 19: Product04r_Graph at 2 reuse cycles (break-even point)_Return Rate 64,6%

Table 19: Product04r_Values at 2 reuse cycles (break-even point)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H ⁺ eq	4,41E-05	4,66E-05
Climate change	kg CO ₂ eq	1,41E-02	1,56E-02
Ecotoxicity, freshwater	CTUe	1,22E-02	1,83E-02
Particulate matter	disease inc.	4,06E-10	4,92E-10
Eutrophication, marine	kg N eq	9,55E-06	1,03E-05
Eutrophication, freshwater	kg P eq	3,17E-06	2,30E-06
Eutrophication, terrestrial	mol N eq	9,18E-05	9,33E-05
Human toxicity, cancer	CTUh	4,12E-11	4,42E-11
Human toxicity, non-cancer	CTUh	9,71E-11	1,21E-10
Ionising radiation	kg U-235 eq	1,20E-03	1,98E-03
Land use	Pt	5,86E-02	4,06E-02
Ozone depletion	kg CFC11 eq	4,26E-10	1,71E-08
Photochemical ozone formation	kg NMVOC eq	5,69E-05	5,86E-05
Resource use, fossils	MJ	3,09E-01	3,22E-01
Resource use, minerals and metals	kg Sb eq	7,81E-08	1,13E-07
Water use	m ³ depriv.	4,96E-03	4,08E-03

At 20-cycle: Flattening the curve

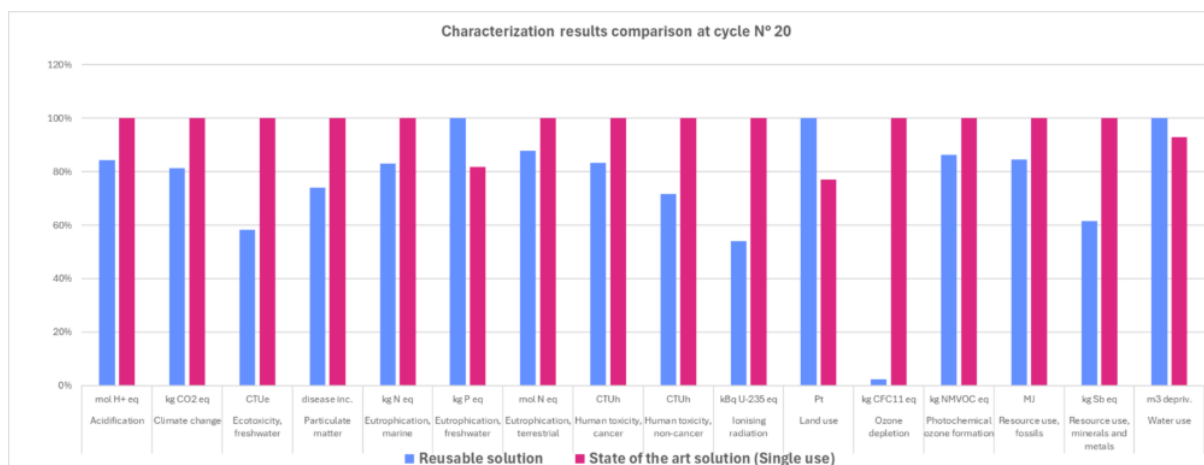


Figure 20: Product04-r_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 20: Product04-r_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	3,93E-05	4,66E-05
Climate change	kg CO2 eq	1,27E-02	1,56E-02
Ecotoxicity, freshwater	CTUe	1,06E-02	1,83E-02
Particulate matter	disease inc.	3,64E-10	4,92E-10
Eutrophication, marine	kg N eq	8,58E-06	1,03E-05
Eutrophication, freshwater	kg P eq	2,82E-06	2,30E-06
Eutrophication, terrestrial	mol N eq	8,19E-05	9,33E-05
Human toxicity, cancer	CTUh	3,67E-11	4,42E-11
Human toxicity, non-cancer	CTUh	8,68E-11	1,21E-10
Ionising radiation	kBq U-235 eq	1,07E-03	1,98E-03
Land use	Pt	5,27E-02	4,06E-02
Ozone depletion	kg CFC11 eq	3,75E-10	1,71E-08
Photochemical ozone formation	kg NMVOC eq	5,05E-05	5,86E-05
Resource use, fossils	MJ	2,73E-01	3,22E-01
Resource use, minerals and metals	kg Sb eq	6,92E-08	1,13E-07
Water use	m3 depriv.	4,39E-03	4,08E-03

The single-use scenario has a greater impact on most indicators, except for 'freshwater eutrophication' and 'land use', due to the production process of the packaging; 'water use' is affected by the material (polypropylene, or PP) and the quantities of material involved in reusable packaging.

2.5. Product 05 – In shop product

The comparison concerns the following products:

STATE OF THE ART – SINGLE USE - TABLE E5, PP-M LCI, – Pork chop, Wrapped Tray

Table 21: State of the art PRODUCT 05

Format	EPS Tray	
Food weight	500 g	
Company	(none)	
LCA ID	05	

Inventory data are in the Deliverable 6.2 – LCA Inventory and scenario building, TABLE E5, PP-M LCI, – Pork chop, Wrapped Tray

TABLE E5				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
5	Wrapped Tray	1	2,76	/	/	Wrapping	/	/
5.1	PVC Wrapping Film	1	0,58	PVC	Polyvinylchloride, suspension polymerised {RER} polyvinylchloride production, suspension polymerisation Cut-off, U	Bubble extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film Cut-off, U	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for Cut-off, U
5.2	PSE Tray	1	2,18	EPS	Polystyrene, expandable {RER} production Cut-off, U	Extrusion of plastic sheets and thermoforming Foaming	Extrusion of plastic sheets and thermoforming, inline {FR} processing Cut-off, U Polymer foaming {RER} processing Cut-off, U	/ • Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for Cut-off, U

REUSE - TABLE (F5), PP-M LCI, – PP Tray + Lid

Table 22: REUSE Product 05-r

Format	Pork chop, PP Tray + Lid	
Food weight	500g	
Company	System U & Carrefour	
LCA ID	05-r	

Inventory data are in the Deliverable 6.2 – LCA Inventory and scenario building, Tab E5. PP-M LCI, PRODUCT 05-r– Pork chop, PP Tray + Lid

TABLE F5				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
5-r	Wrapped Tray	1	8,4	/	/	/	/	/
5.1-r	Tray	1	8	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/
5.2-r	Lid	1	0,4	PP	Polypropylene, granulate {RER} production Cut-off, U	Extrusion of plastic sheets and thermoforming	Extrusion of plastic sheets and thermoforming, inline {FR} processing Cut-off, U	/



SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 23: PRODUCT 05R_Reuse Data Inventory SCENARIO 1

Inventory data	05R_TRAY_PORK CHOP	Unit of Measure
Pack Type	PKG_01	
Pack material	PP	
Pack amount	8,00	g
Lid material	PP	
Lid amount	0,40	g
Producer to filler distance	42,79	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	104,77	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	140,69	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	53,14	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Salad tray	
Washing water [l]	0,09	l
Washing detergent [g]	0,23	g
Washing energy [kWh]	0,01	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	81,62	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 21, the break-even point is not reached at a return rate of 64,6%. Even at high numbers of reuse cycles, the environmental impact of single-use packaging remains lower. At the 20th reuse cycle, the impacts of the reusable solution are 126.7% higher.

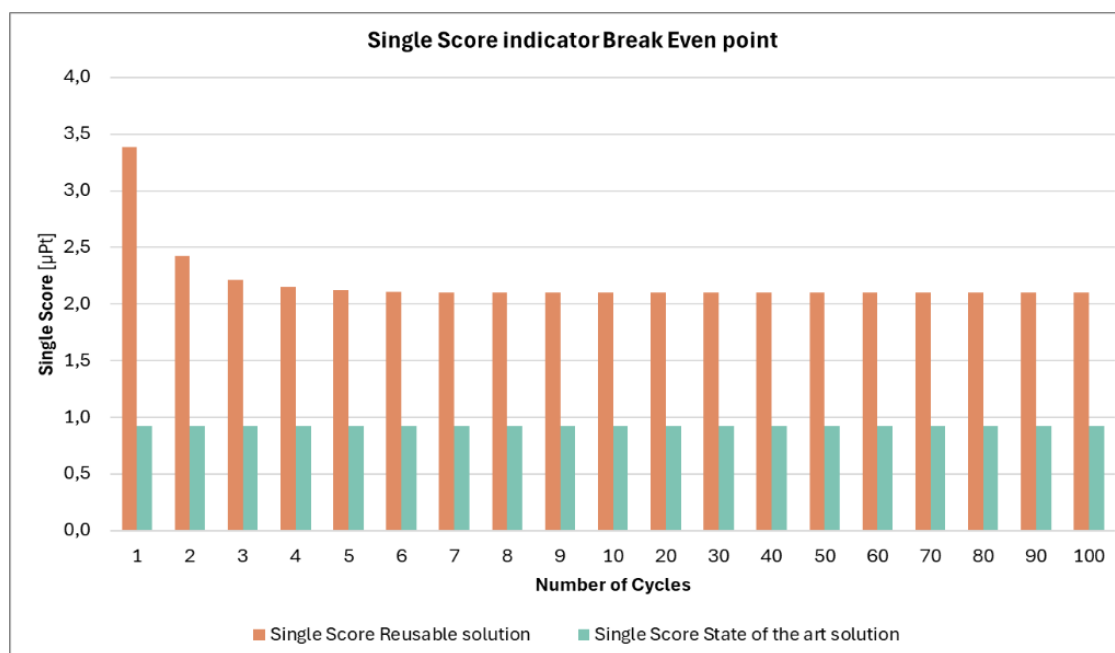


Figure 21: Product05_Single Score Chart_Return_Rate 64,6%



SCENARIO 2: RETURN RATE 90% SCRAP RATE 5% (85,5%)

Table 24: PRODUCT 05R_Reuse Data Inventory SCENARIO 2

Inventory data	05R_TRAY_PORK CHOP	Unit of Measure
Pack Type	PKG_01	
Pack material	PP	
Pack amount	8,00	g
Lid material	PP	
Lid amount	0,40	g
Producer to filler distance	42,79	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	104,77	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	90%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	140,69	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	53,14	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Salad tray	
Washing water [l]	0,09	l
Washing detergent [g]	0,23	g
Washing energy [kWh]	0,01	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	81,62	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

Even with a return rate of 85.5% and a high number of reuse cycles, no environmental benefit is achieved through the reuse system. At the 20th reuse cycle, the impacts of the reusable solution are 59.7% higher.

The main reason for missing the break-even point is that the mass per functional unit of 100 g of product content of Single use product (see Table 21) is significantly lower (2,76 g) than that of reused product (8,4 g). This is to be considered in addition to the extra processes in the reuse system.

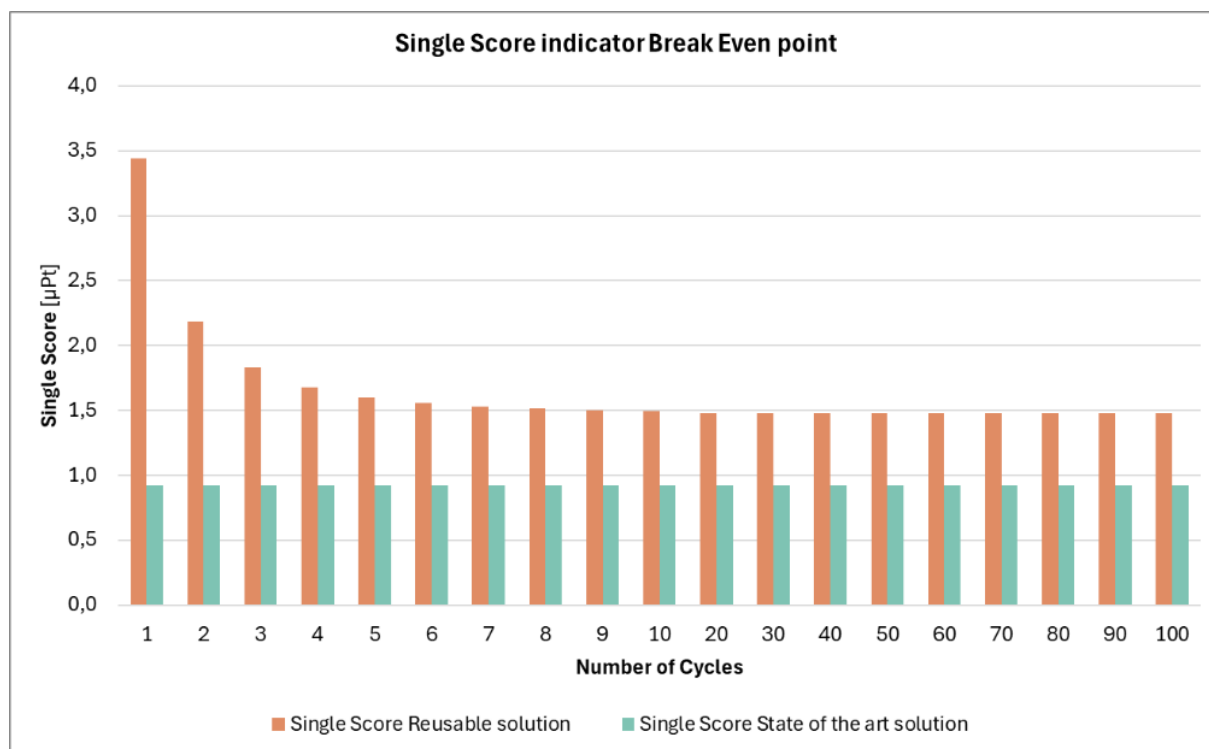


Figure 22: Product05_Single Score Chart_Return_Rate 85,5%



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Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 7) and Reuse System (Fig 8) as the number of cycles varies.

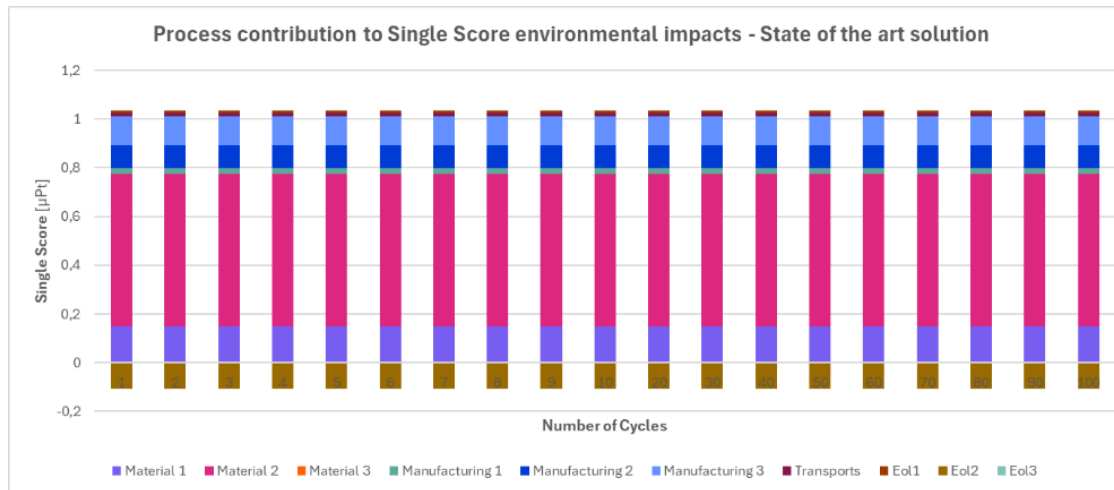


Figure 23: Product05_SingleUse_Weighted Results: Material 1: PVC wrapping film; Material 2: PSE Tray; Manufacturing 1: bubble extrusion, Manufacturing 2: extrusion and thermoforming, Manufacturing 3: foaming.

As shown in Fig 23, in the single-use system (packaging referred to Table 21) shows the greatest impact (67%) for Material 2: PSE Tray, as it represents the largest proportion of material, associated with its production (Manufacturing 2) representing the 10% of total impacts. The second largest contributor is Material 1: PVC wrapping film representing 16% of total impacts. End of Life process Eol2 thanks to the recyclability of PSE contributes to a reduction in the total impacts of -12%.

As shown in Fig 24, in reuse system (packaging referred to Table 22) shows the greatest impact (56% at 20th cycle) for Packaging material (PP), associated with its production (Pack Manufacturing) representing the 24% of total impacts followed by washing process (19%).

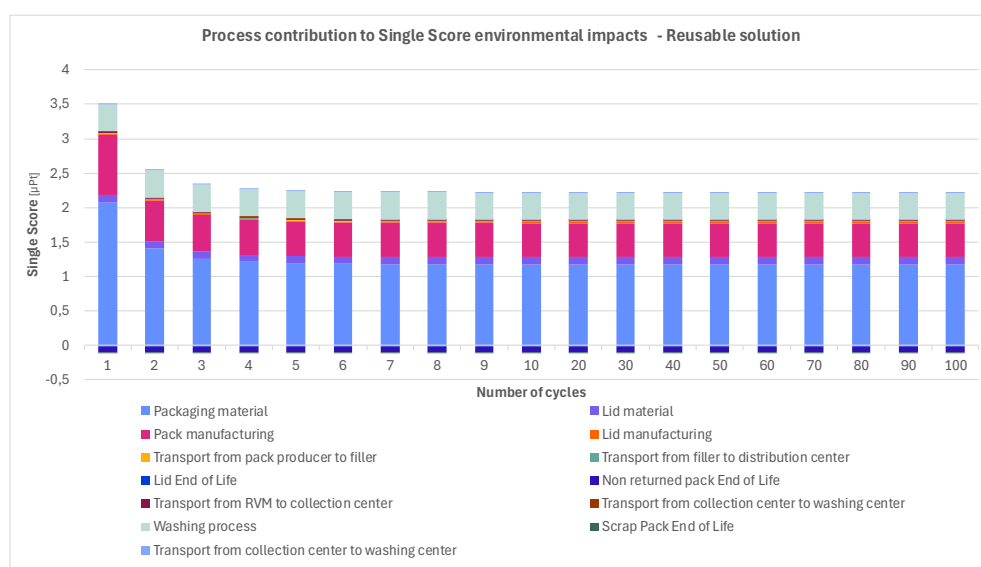


Figure 24: Product05_Reuse_Weighted Results_Return Rate 64,6%



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Characterization results comparison

Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

At 20-cycle: Flattening the curve

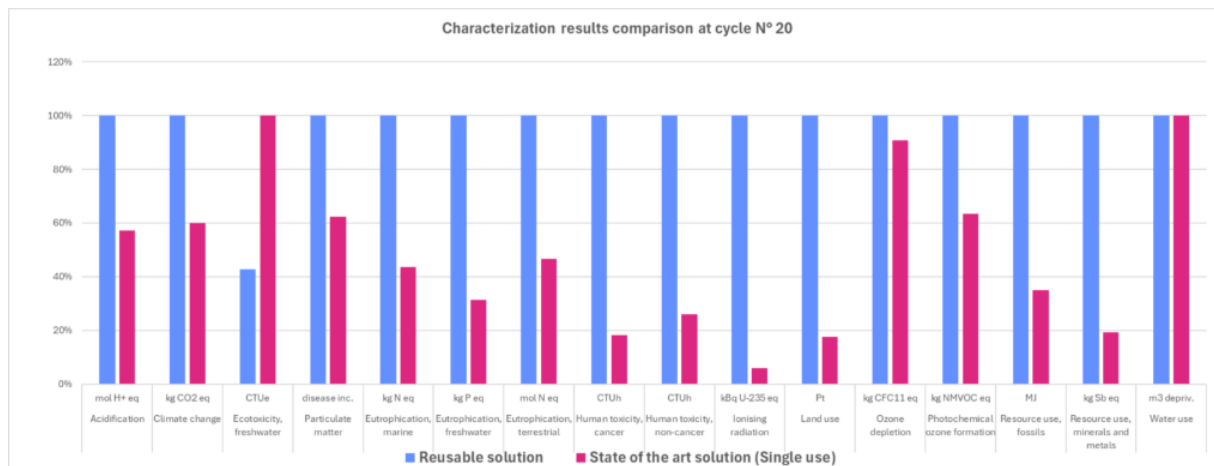


Figure 25: Product05-r_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 25: Product05-r_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	6,46E-05	3,70E-05
Climate change	kg CO2 eq	2,04E-02	1,22E-02
Ecotoxicity, freshwater	CTUe	1,62E-02	3,79E-02
Particulate matter	disease inc.	6,04E-10	3,76E-10
Eutrophication, marine	kg N eq	1,55E-05	6,77E-06
Eutrophication, freshwater	kg P eq	4,62E-06	1,45E-06
Eutrophication, terrestrial	mol N eq	1,35E-04	6,27E-05
Human toxicity, cancer	CTUh	6,25E-11	1,13E-11
Human toxicity, non-cancer	CTUh	1,50E-10	3,91E-11
Ionising radiation	kBq U-235 eq	7,51E-03	4,47E-04
Land use	Pt	8,38E-02	1,47E-02
Ozone depletion	kg CFC11 eq	6,31E-10	5,72E-10
Photochemical ozone formation	kg NMVOC eq	8,24E-05	5,23E-05
Resource use, fossils	MJ	5,63E-01	1,97E-01
Resource use, minerals and metals	kg Sb eq	1,19E-07	2,29E-08
Water use	m3 depriv.	7,28E-03	7,28E-03

The reuse system has a greater environmental impact in most indicators, except for ecotoxicity and water use, due to the materials and production processes used for the primary packaging.

2.6. Product 09 - Chips

The comparison concerns the following products:

STATE OF THE ART – Chips

Table 26: State of the art PRODUCT 09

Format	OPP Film	
Food weight	125 g	
Company	Altho	
LCA ID	09	

Inventory data are updated from the Deliverable 6.2 – LCA Inventory and scenario building, Tab E9. PP-M LCI, PRODUCT 09 – Peanut curl, OPP Film

TABLE E9				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
9	Bag	1	3,2424	/	/	/		/
9.1	Ink	1	0,2496	Ink	Printing ink, offset, without solvent, in 47% solution state {RER}	Printing Ink	/	/
9.2	Adhesive	1	0,1808	Adhesive	Polyurethane adhesive {GLO} market for polyurethane adhesive Cut-off, S	Lamination	Laminating service, foil, with acrylic binder {RER} processing Cut-off, U	• Electricity, medium voltage {FR} market for Cut-off, U
9.3	PP Foil	1	2,812	PP	Polypropylene, granulate {RER} production Cut-off, U	Extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film Cut-off, U	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for Cut-off, U

REUSE - TABLE F9, PP-M LCI, – Chips PP Bucket + Lid

Table 27: REUSE Product 09-r

Format	PP Bucket 3,5L	
Food weight	250 gr - 3500 ml	
Company	Altho	
LCA ID	09-r	

Inventory data are in the Deliverable 6.2 – LCA Inventory and scenario building, Tab F9. PP-M LCI, PRODUCT 09-r – Chips PP Bucket + Lid

TABLE F9				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
9-r	PP Bucket + lid	1	56,32	/	/	/	/	/
9.1-r	PP Clip Lid	1	13,12	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/
9.2-r	PP Bucket	1	43,2	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/



SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 28: PRODUCT 09R_Reuse Data Inventory SCENARIO 1

Inventory data	09R_FILM_PEAUT CURL	Unit of Measure
Pack Type	PKG_03	
Pack material	PP	
Pack amount	43,20	g
Lid material	PP	
Lid amount	13,12	g
Producer to filler distance	511,35	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	336,80	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	164,84	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	62,72	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Bucket 3,5L	
Washing water [l]	0,19	l
Washing detergent [g]	0,46	g
Washing energy [kWh]	0,03	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	163,03	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 26, the break-even point is not reached at a return rate of 64,6%. Even at high numbers of reuse cycles, the environmental impact of single-use packaging remains lower. After 20 reuse cycles, the impact of the reuse system is 1333% greater.

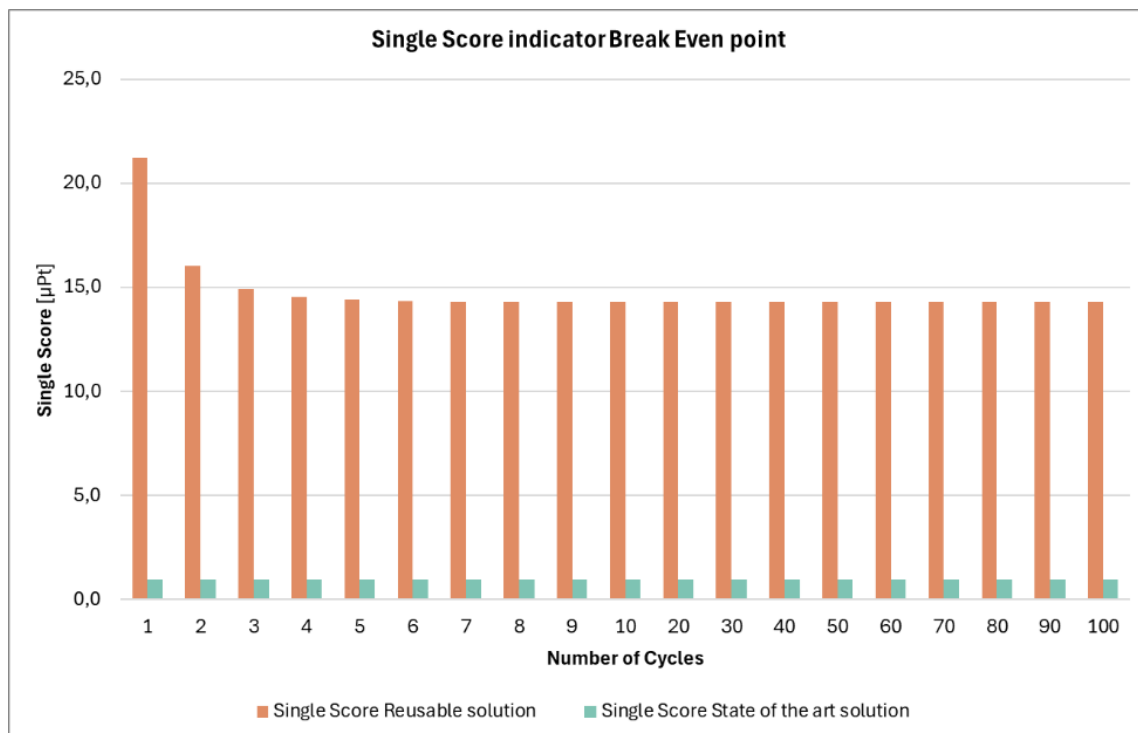


Figure 26: Product09_Single Score Chart_Return_Rate 64,6%



SCENARIO 2: RETURN RATE 90% SCRAP RATE 5% (85,5%)

Table 29: PRODUCT 09R_Reuse Data Inventory SCENARIO 2

Inventory data	09R_FILM_PEAUT CURL	Unit of Measure
Pack Type	PKG_03	
Pack material	PP	
Pack amount	43,20	g
Lid material	PP	
Lid amount	13,12	g
Producer to filler distance	511,35	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	336,80	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	90%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	164,84	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	62,72	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Bucket 3,5L	
Washing water [l]	0,19	l
Washing detergent [g]	0,46	g
Washing energy [kWh]	0,03	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	163,03	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 27, even with a return rate of 85.5% and a high number of reuse cycles, no environmental benefit is achieved through the reuse system. After 20 reuse cycles, the impact of the reuse system is 990% greater.

The main reason for missing the break-even point is that the mass per functional unit of 100 g of product content of Single use packaging (see Table 26) is incredibly lower (3,24 g) than that of reused product content (56,32 g), of which already 13 g comes from the disposable lid. This is to be considered the main reason, in addition to the extra processes in the reuse system.

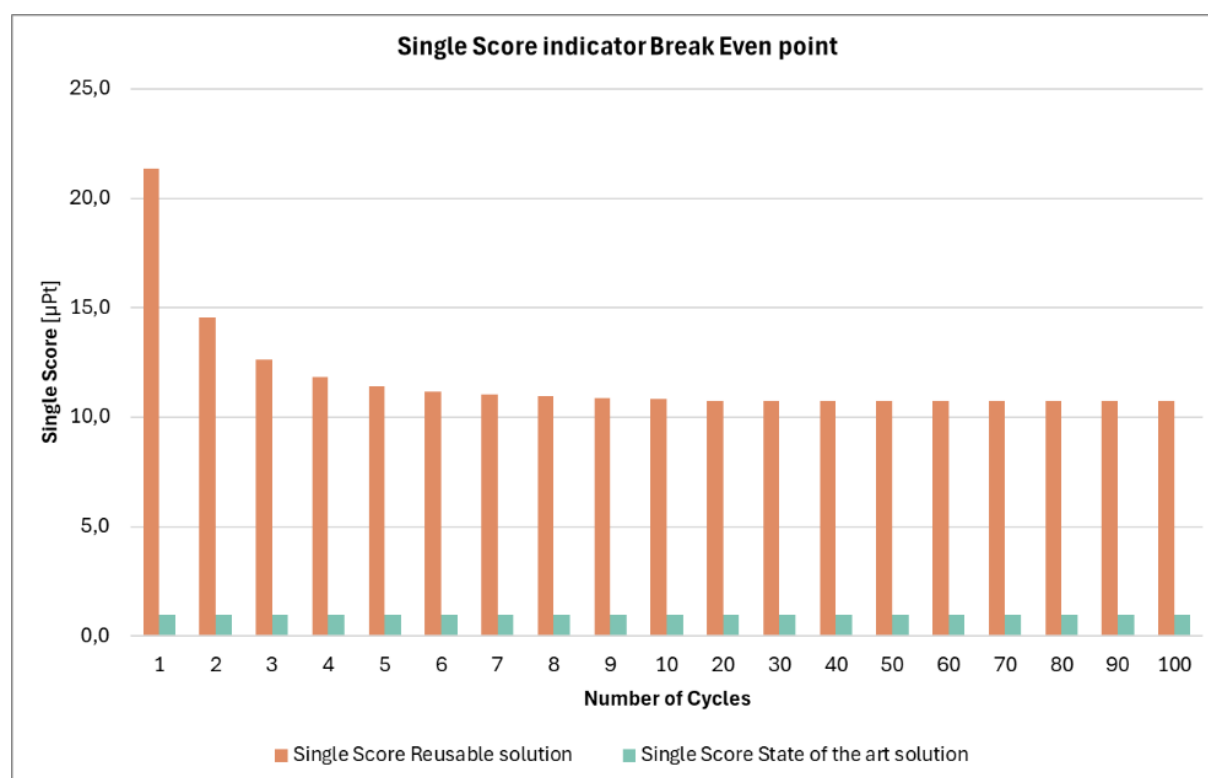


Figure 27: Product09_Single Score Chart_Return_Rate 85,5%



Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 28) and Reuse System (Fig 29) as the number of cycles varies.

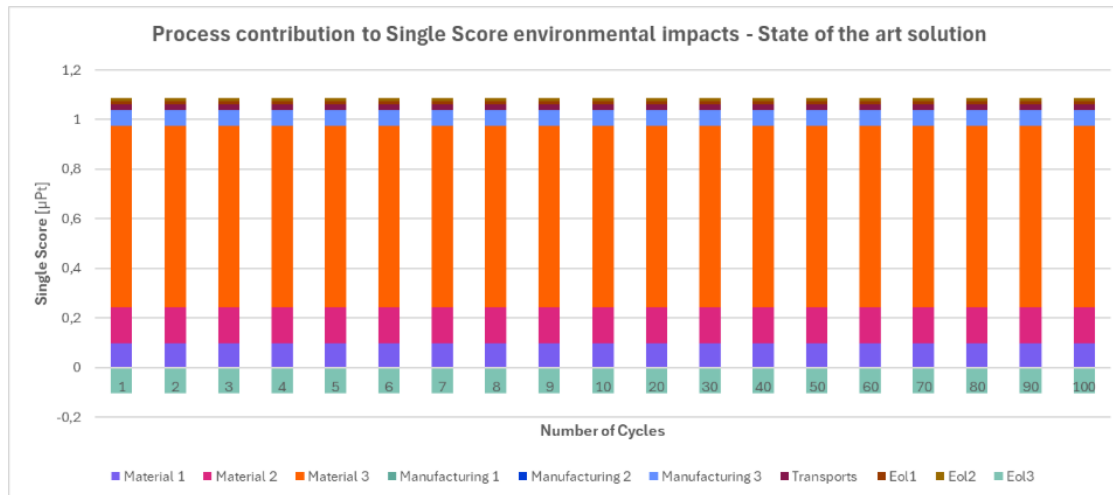


Figure 28: Product09_SingleUse_Weighted Results: Material 1: Ink; Material 2: polyurethane adhesive; Material 3: PP bowl; Manufacturing1: Printing Ink; Manufacturing 2: Lamination; Manufacturing 3: Extrusion of plastic film

As shown in Fig 28, in the single-use system (packaging referred to Table 26) shows the greatest impact (74%) for Material 3: PP bowl, as it represents the largest proportion of material, associated with its production (Manufacturing 3) representing the 6% of total impacts. The second largest contributor is Material 2: polyurethane adhesive representing 15% of total impacts. End of Life processes Eol3, thanks to the recyclability of polypropylene contribute to a reduction in the total impacts of -11%.

As shown in Fig 29, in reuse system (packaging referred to Table 27) shows the greatest impact (45% at 20th cycle) for Packaging material (PP), associated with its production (Pack Manufacturing) representing the 19% of total impacts followed by the disposable Lid material (24%) and associated associated manufacturing 10%.

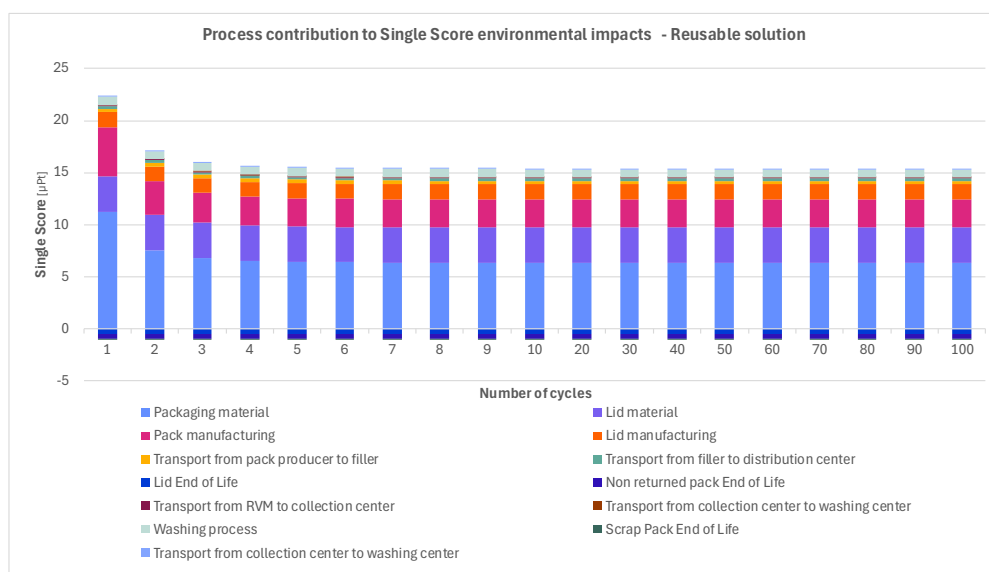


Figure 29: Product09_Reuse_Weighted Results_Return Rate 64,6%



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Characterization results comparison

Comparison of the values characterized for all environmental indicators (e.g. GWP - Global Warming Potential, water consumption, energy, etc.) between State of the art and Reuse systems.

At 20-cycle: Flattening the curve

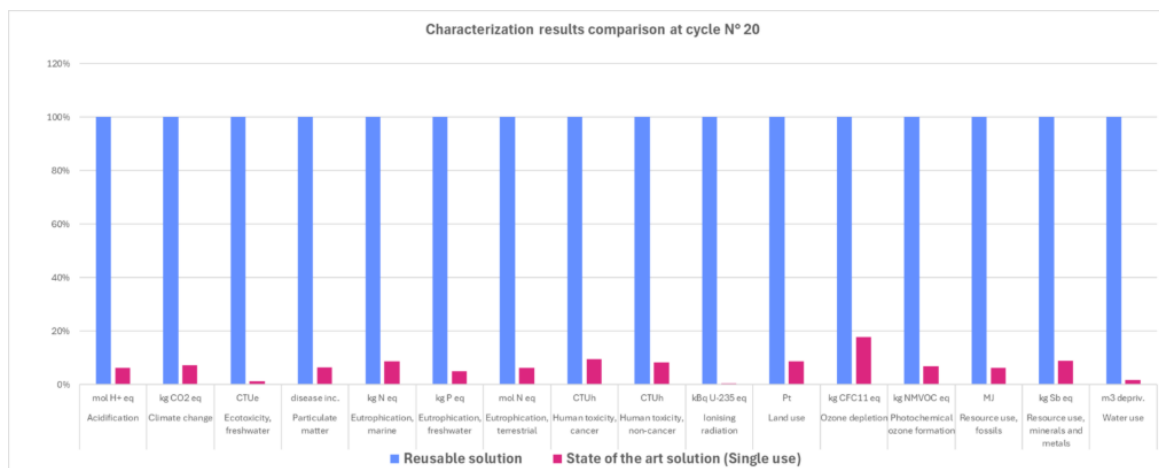


Figure 30: Product09-r_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 30: Product09-r_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	4,82E-04	2,96E-05
Climate change	kg CO2 eq	1,56E-01	1,11E-02
Ecotoxicity, freshwater	CTUe	1,30E-01	1,63E-03
Particulate matter	disease inc.	4,54E-09	2,88E-10
Eutrophication, marine	kg N eq	1,06E-04	9,16E-06
Eutrophication, freshwater	kg P eq	3,44E-05	1,72E-06
Eutrophication, terrestrial	mol N eq	1,01E-03	6,38E-05
Human toxicity, cancer	CTUh	4,53E-10	4,34E-11
Human toxicity, non-cancer	CTUh	1,07E-09	8,91E-11
Ionising radiation	kBq U-235 eq	1,29E-02	5,98E-05
Land use	Pt	6,57E-01	5,69E-02
Ozone depletion	kg CFC11 eq	4,61E-09	8,22E-10
Photochemical ozone formation	kg NMVOC eq	6,20E-04	4,19E-05
Resource use, fossils	MJ	3,34E+00	2,10E-01
Resource use, minerals and metals	kg Sb eq	8,48E-07	7,60E-08
Water use	m3 depriv.	5,37E-02	9,33E-04

The reuse system generates greater environmental impacts in all the indicators.



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2.7. Product 10-1 – Petals salées

The comparison concerns the following products:

STATE OF THE ART – Pétales salées

Table 31: State of the art PRODUCT 10

Format	OPP Sachet & Cardboard	
Food weight	75 g	
Company	Europe Snacks	
LCA ID	10	

Inventory data have been updated compared to D 6.2

Table E10				Pre-processing		Manufacturing		
Position	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
10	Pétales salées	1	39,07043	/	/	/		/
10.1	Cardboard Box	1	37,4			Flat cut	Folding boxboard carton production {RER} production Cut-off, U	• Variation amount of Varnish and Ink • Electricity, medium voltage {FR} market for Cut-off, U
10.2	Adhesive	1	0,20827	Adhesive	Acrylic binder, with water, in 54% solution state {RER} Cut-off, U	Lamination	Laminating service, foil, with acrylic binder {RER} processing Cut-off, U	• Electricity, medium voltage {FR} market for Cut-off, U
10.3	OPP Film	1	1,46216	PP	Polypropylene, granulate {RER} production Cut-off, U	Extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film Cut-off, U	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for Cut-off, U

REUSE - TABLE F10, PP-M LCI – Pétales salés PP Bucket 1L + Lid

Table 32: REUSE Product 10-r1

Format	PP Bucket 1L	
Food weight	100 gr	
Company	Europe Snacks	
LCA ID	10-r1	

Inventory data have been updated and presented here:

Table F10				Pre-processing		Manufacturing		
Position	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
10-r1	PET Cup	1	44,7	/	/	/	/	/
10.1-r1	PP Clip Lid	1	7,7	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/
10.2-r1	PP Bucket	1	37	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/



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SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 33: PRODUCT 10r1_Reuse Data Inventory SCENARIO 1

Inventory data	10R1_SAVORY BISCUITS_1 L BUCKET	Unit of Measure
Pack Type	PKG_04	
Pack material	PP	
Pack amount	37,00	g
Lid material	PP	
Lid amount	7,70	g
Producer to filler distance	264,94	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	471,23	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	176,45	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	58,14	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Bucket 1L	
Washing water [l]	0,23	l
Washing detergent [g]	0,58	g
Washing energy [kWh]	0,04	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	124,67	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 31, the break-even point is not reached at a return rate of 64,6%. Even at high numbers of reuse cycles, the environmental impact of single-use packaging remains lower. Single use system impact at -80% at 20°cycle.

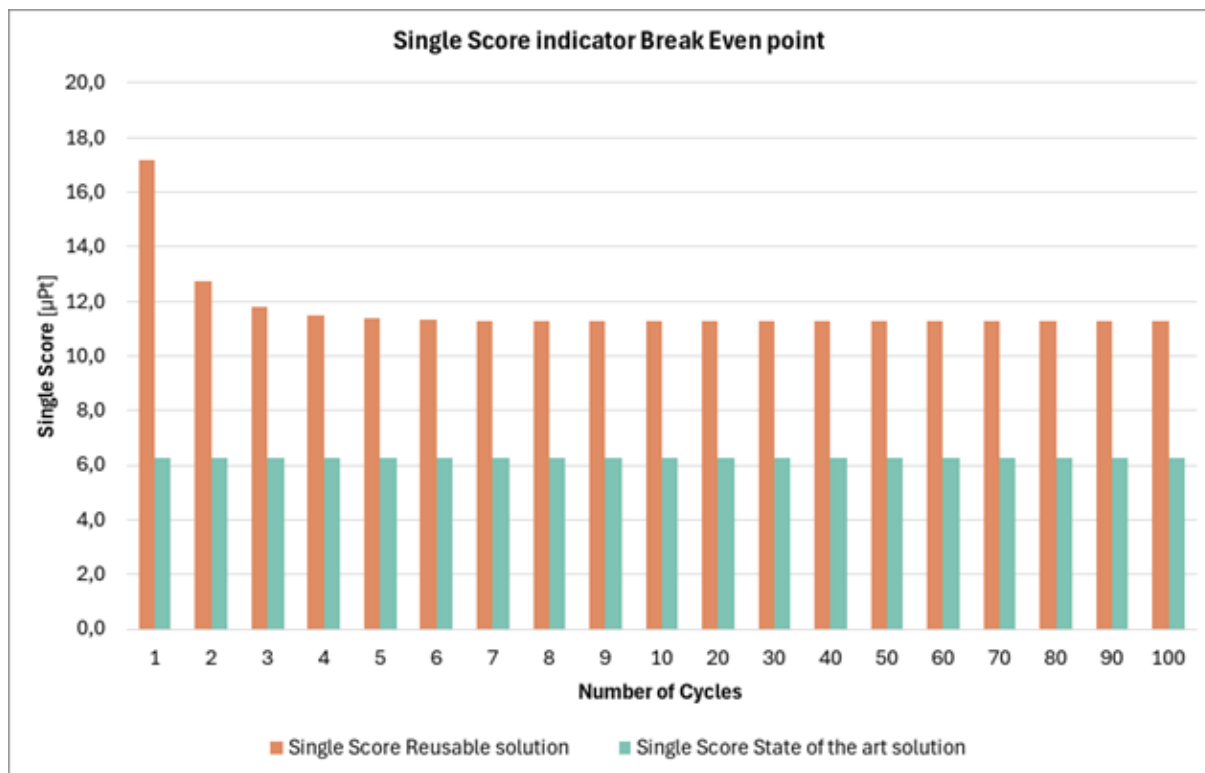


Figure 31: Product10-1_Single Score Chart_Return_Rate 64,6%

SCENARIO 2: RETURN RATE 90% SCRAP RATE 5% (85,5%)

Table 34: Product10-1_Data Inventory SCENARIO 2

Inventory data	10R1_SAVORY BISCUITS_1 L BUCKET	Unit of Measure
Pack Type	PKG_04	
Pack material	PP	
Pack amount	37,00	g
Lid material	PP	
Lid amount	7,70	g
Producer to filler distance	264,94	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	471,23	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	90%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	176,45	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	58,14	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Bucket 1L	
Washing water [l]	0,23	l
Washing detergent [g]	0,58	g
Washing energy [kWh]	0,04	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	124,67	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 32, even with a return rate of 85.5% and a high number of reuse cycles, no environmental benefit is achieved through the reuse system. Single use system impact at -34% at 20°C cycle.

There are two main reasons why the break-even point is not reached. The first is related to the main materials involved: cardboard has a lower impact than PP and its production, in addition to the fact that the mass per functional unit of 100 g of product content of single-use packaging (see Table 36) is lower (39 g) than that of reused product content (44,7 g). This aspect must be considered in addition to the supplementary processes required by the reuse system.

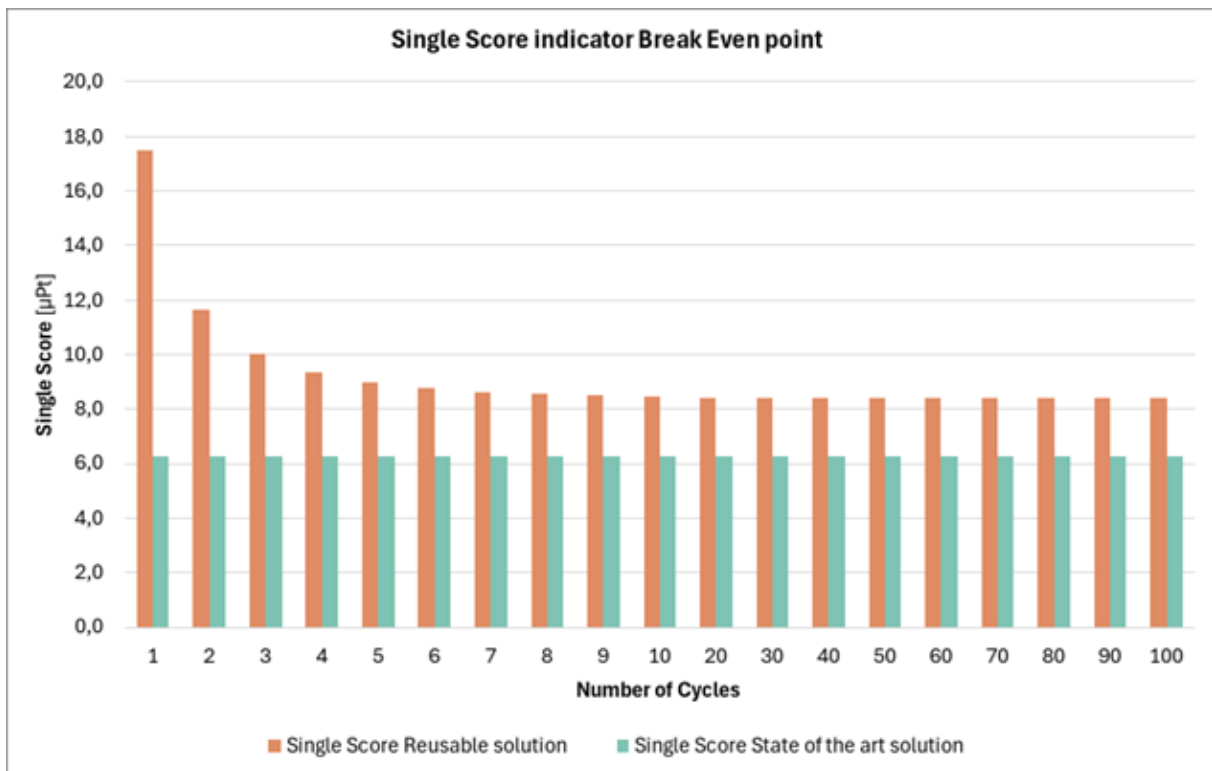


Figure 32: Product10-1_Single Score Chart_Return_Rate 85,5%



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Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 33) and Reuse System (Fig 34) as the number of cycles varies.

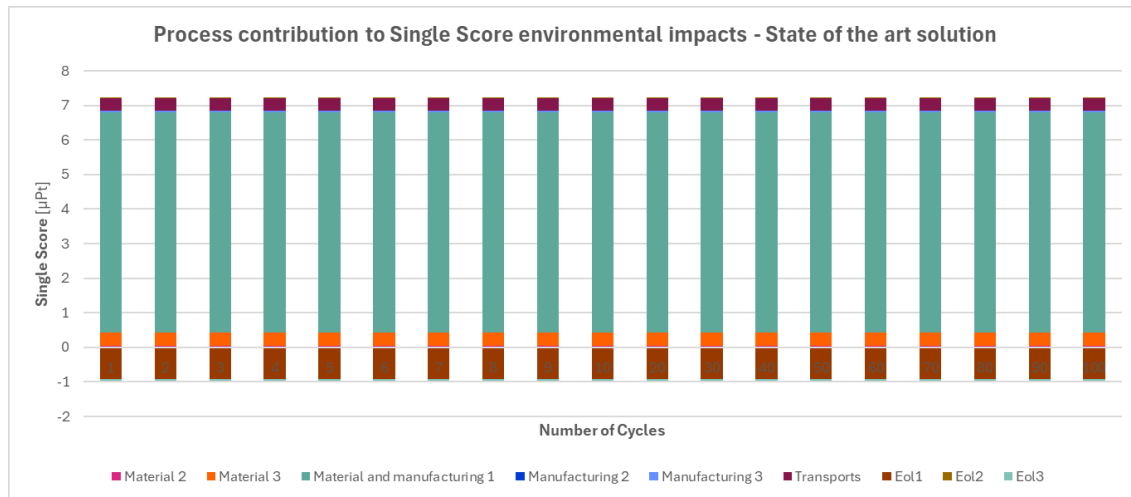


Figure 33: Product10_SingleUse_Weighted Results: Material and manufacturing 1: Cardboard Box and Flat Cut; Material 2: Adhesive; Material 3: OPP Film; Manufacturing 2: Lamination; Manufacturing 3: Extrusion of plastic film

As shown in Fig 33, the single-use system (packaging referred to Table 31) shows the greatest impact (102% of the total including the positive impacts) for Material and Manufacturing 1: cardboard and its Flat cut. End of Life process: Eol1, thanks to the recyclability of cardboard contributes to a reduction in the total impacts of –15%. As shown in Fig 34, in reuse system (packaging referred to Table 32) shows the greatest impact (48% at 20th cycle) for Packaging material (PP), associated with its production (Pack Manufacturing) representing the 20% of total impacts followed by disposable Lid material (18%) and its manufacturing (7%).

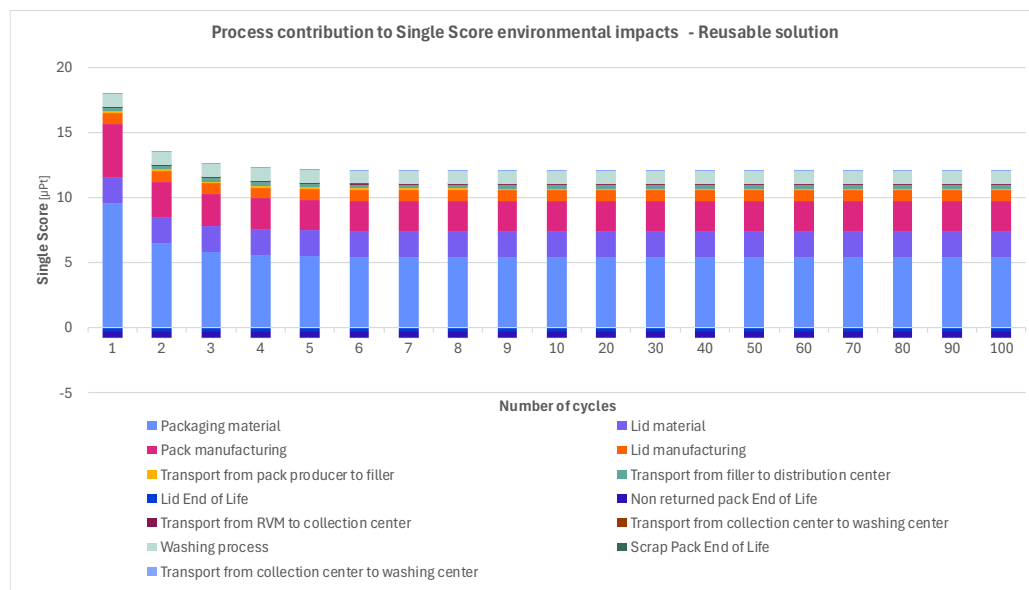


Figure 34: Product10-r1_Reuse_Weighted Results_Return Rate 64,6%

Characterization results comparison

Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

At 20-cycle: Flattening the curve

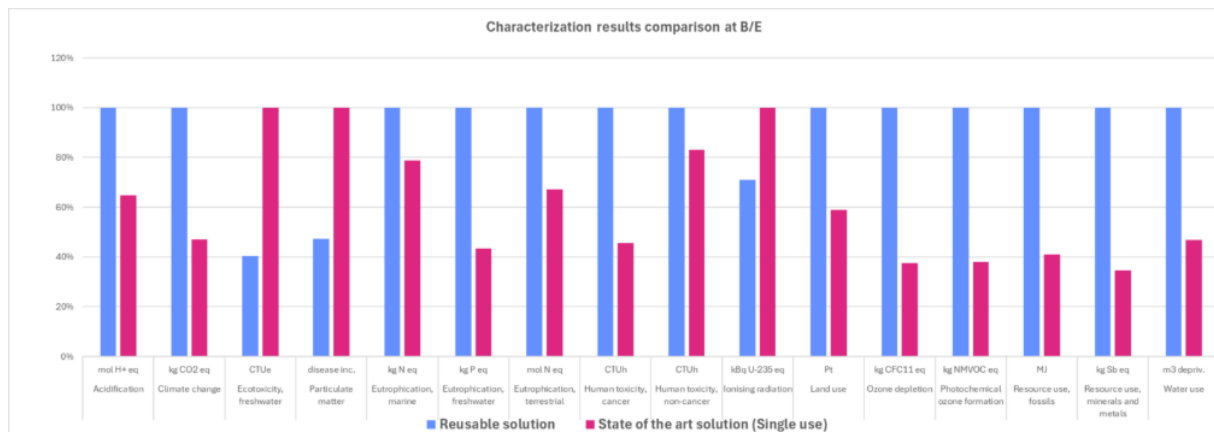


Figure 35: Product10-r1_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 35: Product10-r1_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	3,77E-04	2,44E-04
Climate change	kg CO2 eq	1,20E-01	5,66E-02
Ecotoxicity, freshwater	CTUe	9,98E-02	2,48E-01
Particulate matter	disease inc.	3,64E-09	7,70E-09
Eutrophication, marine	kg N eq	8,53E-05	6,72E-05
Eutrophication, freshwater	kg P eq	2,68E-05	1,16E-05
Eutrophication, terrestrial	mol N eq	7,95E-04	5,34E-04
Human toxicity, cancer	CTUh	3,58E-10	1,63E-10
Human toxicity, non-cancer	CTUh	8,52E-10	7,07E-10
Ionising radiation	kBq U-235 eq	1,74E-02	2,45E-02
Land use	Pt	5,22E-01	3,08E-01
Ozone depletion	kg CFC11 eq	3,61E-09	1,36E-09
Photochemical ozone formation	kg NMVOC eq	4,83E-04	1,83E-04
Resource use, fossils	MJ	2,74E+00	1,12E+00
Resource use, minerals and metals	kg Sb eq	6,62E-07	2,29E-07
Water use	m3 depriv.	4,16E-02	1,94E-02

The reuse system has a negative environmental impact on most indicators, except for freshwater ecotoxicity, particulate matter, ionising radiations due to the materials and processes involved in the production of primary packaging.

2.8. Product 10-2 - Petals salées

The comparison concerns the following products:

STATE OF THE ART – Pétales salées

Table 36: State of the art PRODUCT 10

Format	OPP Sachet & Cardboard	
Food weight	75 g	
Company	Europe Snacks	
LCA ID	10	

REUSE - Pétales salées 2L

Table 37: REUSE Product 10-r2

Format	PP Bucket 2L	
Food weight	200 gr	
Company	Europe Snacks	
LCA ID	10-r2	

Inventory data have been updated and presented here:

Table G10				Pre-processing		Manufacturing		
Position	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
10-r2	PET Cup	1	43,16	/	/	/	/	/
10.1-r2	PP Clip Lid	1	8,58	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/
10.2-r2	PP Bucket	1	34,58	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/



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SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 38: PRODUCT 10r2_Reuse Data Inventory SCENARIO 1

Inventory data	10R2_SAVORY BISCUITS_2 L BUCKET	Unit of Measure
Pack Type	PKG_04	
Pack material	PP	
Pack amount	34,58	g
Lid material	PP	
Lid amount	8,58	g
Producer to filler distance	264,94	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	471,23	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	176,45	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	58,14	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Bucket 2L	
Washing water [l]	0,12	l
Washing detergent [g]	0,29	g
Washing energy [kWh]	0,02	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	124,67	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 36, the break-even point is not reached at a return rate of 64,6%. Even at high numbers of reuse cycles, the environmental impact of single-use packaging remains lower. State of the art impacts at -70% at 20th cycle.

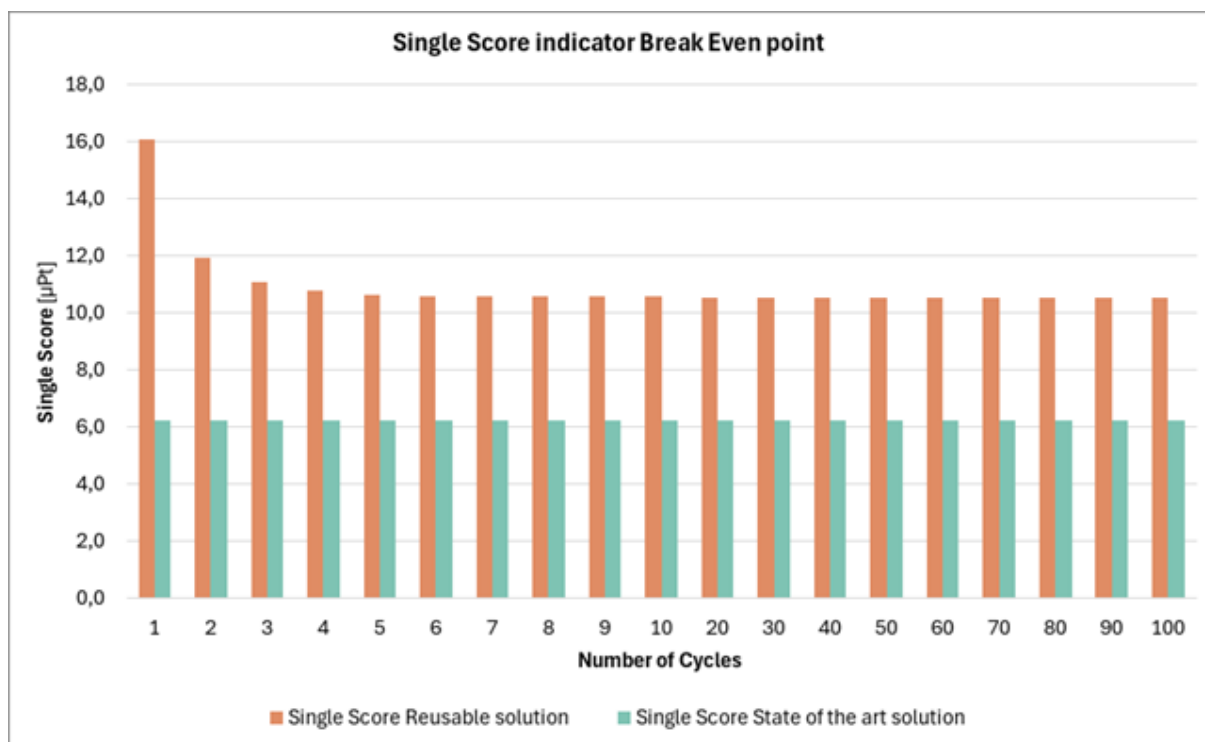


Figure 36: Product10-2_Single Score Chart_Return_Rate 64,6%



SCENARIO 2: RETURN RATE 90% SCRAP RATE 5% (85,5%)

Table 39: Product10-2_Data Inventory SCENARIO 2

Inventory data	10R2_SAVORY BISCUITS_2 L BUCKET	Unit of Measure
Pack Type	PKG_04	
Pack material	PP	
Pack amount	34,58	g
Lid material	PP	
Lid amount	8,58	g
Producer to filler distance	264,94	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	471,23	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	90%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	176,45	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	58,14	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Bucket 2L	
Washing water [l]	0,12	l
Washing detergent [g]	0,29	g
Washing energy [kWh]	0,02	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	124,67	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 37, even with a return rate of 85.5% and a high number of reuse cycles, no environmental benefit is achieved through the reuse system. State of the art impacts at -26% at 20th cycle.

There are two main reasons why the break-even point is not reached. The first is related to the main materials involved: cardboard has a lower impact than PP and its production, in addition to the fact that the mass per functional unit of 100 g of product content of single-use packaging (see Table 36) is lower (39 g) than that of reused product content (43 g). This aspect must be considered in addition to the supplementary processes required by the reuse system.

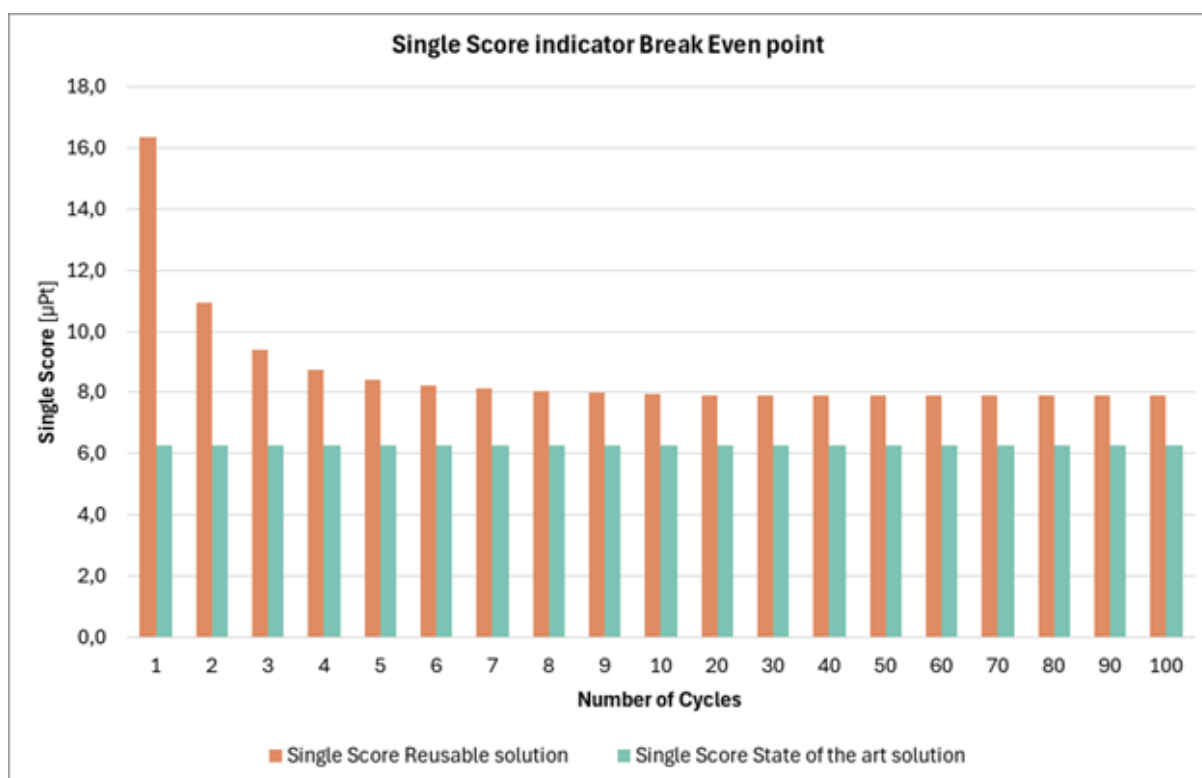


Figure 37: Product10-2_Single Score Chart_Return_Rate 85,5%



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Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 38) and Reuse System (Fig 39) as the number of cycles varies.

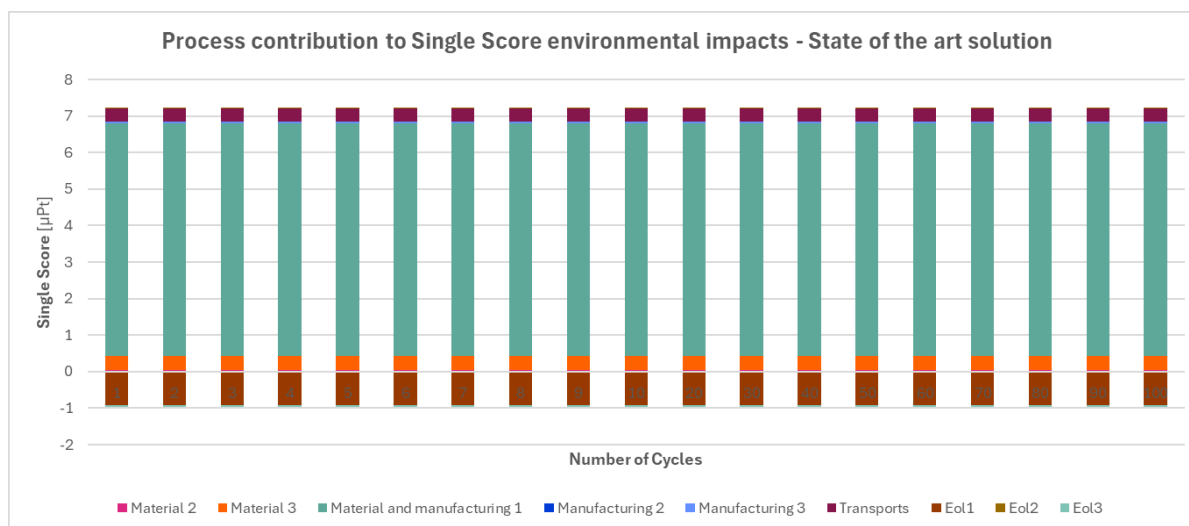


Figure 38: Product10_SingleUse_Weighted Results: Material and manufacturing 1: Cardboard Box and Flat Cut; Material 2: Adhesive; Material 3: OPP Film; Manufacturing 2: Lamination; Manufacturing 3: Extrusion of plastic film

As shown in Fig 38, in the single-use system (packaging referred to Table 36) shows the greatest impact (102% of the total including the positive impacts) for Material and Manufacturing 1: cardboard and its Flat cut. End of Life process: Eol1, thanks to the recyclability of cardboard, contributes to a reduction in the total impacts of -15%.

As shown in Fig 39, in reuse system (packaging referred to Table 37) shows the greatest impact (48% at 20th cycle) for Packaging material (PP), associated with its production (Pack Manufacturing) representing the 20% of total impacts followed by disposable Lid material (21%) and its manufacturing (9%).

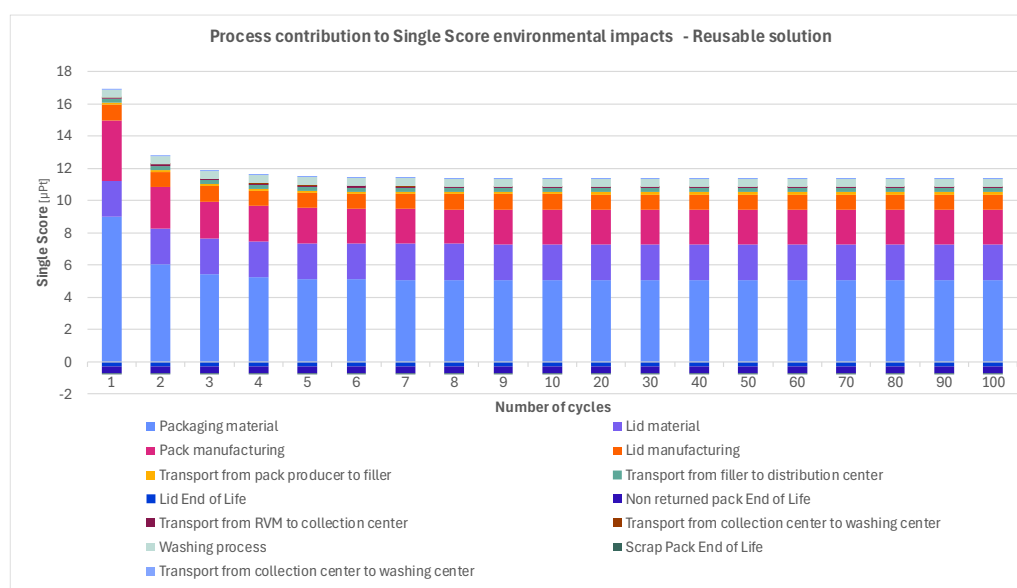


Figure 39: Product10-r2_Reuse_Weighted Results_Return Rate 64,6%

Characterization results comparison

Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

At 20-cycle: Flattening the curve

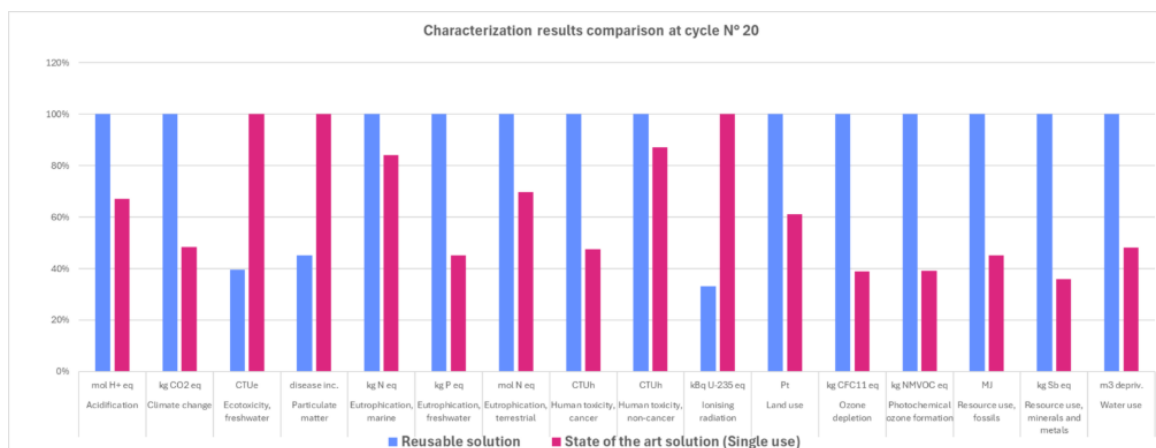


Figure 40: Product10-r2_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 40: Product10-r2_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	3,63E-04	2,44E-04
Climate change	kg CO2 eq	1,17E-01	5,66E-02
Ecotoxicity, freshwater	CTUe	9,78E-02	2,48E-01
Particulate matter	disease inc.	3,48E-09	7,70E-09
Eutrophication, marine	kg N eq	7,98E-05	6,72E-05
Eutrophication, freshwater	kg P eq	2,58E-05	1,16E-05
Eutrophication, terrestrial	mol N eq	7,66E-04	5,34E-04
Human toxicity, cancer	CTUh	3,43E-10	1,63E-10
Human toxicity, non-cancer	CTUh	8,11E-10	7,07E-10
Ionising radiation	kBq U-235 eq	8,12E-03	2,45E-02
Land use	Pt	5,04E-01	3,08E-01
Ozone depletion	kg CFC11 eq	3,49E-09	1,36E-09
Photochemical ozone formation	kg NMVOC eq	4,69E-04	1,83E-04
Resource use, fossils	MJ	2,49E+00	1,12E+00
Resource use, minerals and metals	kg Sb eq	6,37E-07	2,29E-07
Water use	m3 depriv.	4,03E-02	1,94E-02

The reuse system has a negative environmental impact in most areas, except for the indicators of freshwater ecotoxicity, particulate matter and ionising radiation. This is due to the materials and processes involved in primary packaging.

2.9. Product 11 – Orange juice

The comparison concerns the following products:

STATE OF THE ART – Orange Juice- PET Clear Bottle

Table 41: State of the art PRODUCT 11

Format	Clear Bottle with 50% recycled	
Food weight	1 l	
Company	LSDH	
LCA ID	11	

Inventory data are in the Deliverable 6.2 – LCA Inventory and scenario building, Tab E11. PP-M LCI, PRODUCT 11 – Orange Juice- PET Clear Bottle

TABLE E11				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
11	Clear bottle	1	3,2	/	/	Capping	/	/
11.1	HDPE Cap	1	0.3	HDPE	Polyethylene, high density, granulate {RER} polyethylene production, high density, granulate Cut-off, U	Injection moulding	Injection moulding {RER} injection moulding Cut-off, U	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for Cut-off, U
11.2	OPP Foil	1	0.1	PP	Polypropylene, granulate {RER} production Cut-off, U	Extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film Cut-off, U	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for Cut-off, U
11.3	PET Bottle	1	1,4	PET	Polyethylene terephthalate, granulate, bottle grade {RER} polyethylene terephthalate production, granulate, bottle grade Cut-off, U	Stretch blow moulding	Stretch blow moulding {RER} stretch blow moulding Cut-off, U	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for Cut-off, U
			1,4	rPET	rPET CIRCULAR FOOTPRINT FORMULA DATASET	Injection moulding	Injection moulding {RER} injection moulding Cut-off, U	Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for Cut-off, U

REUSE - Orange Juice- Glass Bottle 1l



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Table 42: REUSE Product 11-r

Format	Glass bottle 1L	
Food weight	1 l	
Company	LSDH	
LCA ID	11-r	

Inventory data have been updated from Tab F11. PP-M LCI, PRODUCT 11-r – Orange Juice- Glass Bottle 1l - and are here reported:

TABLE F11				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material	Processing	Processing	Processing variations (available FR datasets)
					(ecoinvent dataset)		(Original ecoinvent dataset)	
11-r	Bottle system	1	38	/	/	/	/	/
11.1-r	Twist-off capsule	1	0,5	Aluminium	Aluminium, cast alloy {GLO} market for aluminium, cast alloy Cut-off, S	Sheet rolling	Sheet rolling, aluminium {FR} sheet rolling, aluminium Cut-off, U	/
11.2-r	Glass Bottle	1	37,5	GLASS	White Glass Circular Footprint Formula Dataset	*Data for processing are included in material's dataset	*Data for processing are included in material's dataset	/

SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 43: PRODUCT 11R_Reuse Data Inventory SCENARIO 1

Inventory data	11r_ORANGE JUICE_GLASS BOTTLE	Unit of Measure
Pack Type	PKG_05	
Pack material	COLOURLESS GLASS CFF	
Pack amount	37,50	g
Lid material	ALUMINIUM FOIL	
Lid amount	0,50	g
Producer to filler distance	412,43	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	131,42	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	141,03	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	48,98	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Glass	
Washing water [l]	0,13	l
Washing detergent [g]	0,93	g
Washing energy [kWh]	0,03	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	67,75	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 69, at a return rate of 64,6, the break-even point is not reached. Even at high numbers of reuse cycles, the environmental impact of single-use packaging remains lower (-252% at the 20th cycle).

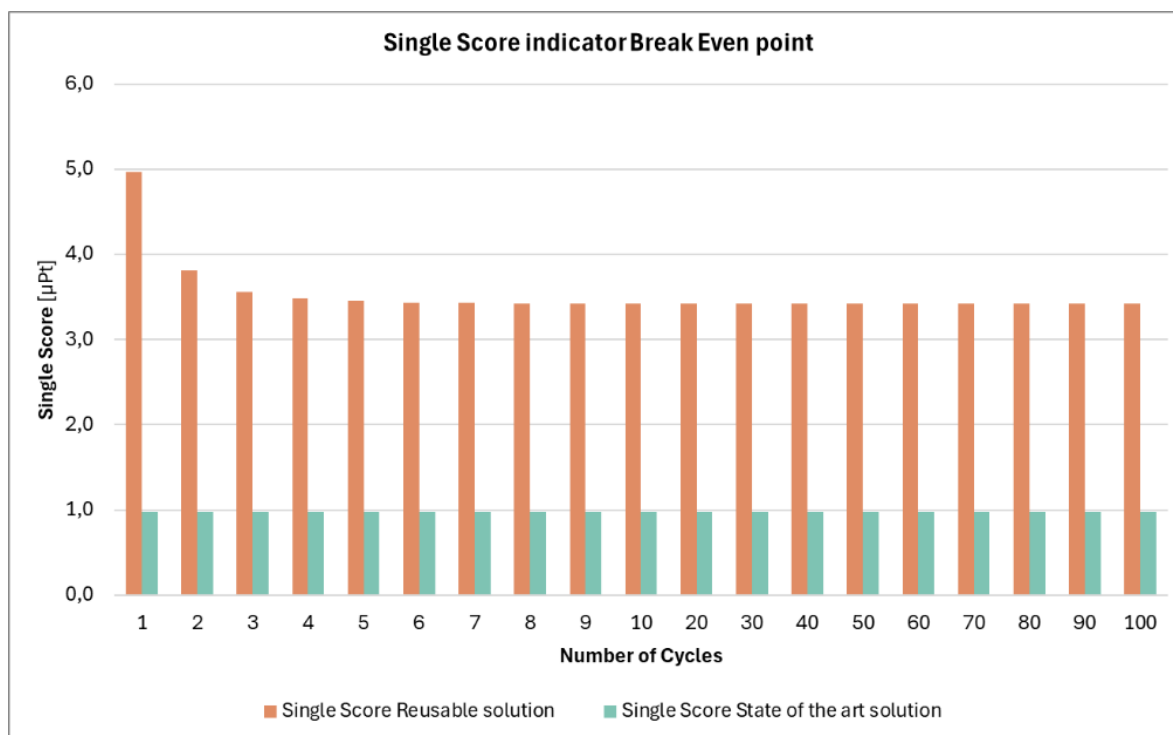


Figure 41: Product11_Single Score Chart_Return_Rate 64,6%



Scenario 2: Return rate 90% scrap rate 5% (85,5%)

Table 44: PRODUCT 11R_Reuse Data Inventory SCENARIO 2

Inventory data	11r_ORANGE JUICE_GLASS BOTTLE	Unit of Measure
Pack Type	PKG_05	
Pack material	COLOURLESS GLASS CFF	
Pack amount	37,50	g
Lid material	ALUMINIUM FOIL	
Lid amount	0,50	g
Producer to filler distance	412,43	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	131,42	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	90%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	141,03	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	48,98	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Glass	
Washing water [l]	0,13	l
Washing detergent [g]	0,93	g
Washing energy [kWh]	0,03	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	67,75	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

Even with a return rate of 85.5%, the reuse system does not achieve any environmental benefit, even with a high number of reuse cycles (-167% at the 20th cycle).

The main reason for missing the break-even point is that the mass per functional unit of 100 g of product content of Single use packaging (see Table 41) is significantly lower thanks to PET (3,2 g) than that of reused product in glass (38 g). This is to be considered in addition to the extra processes in the reuse system.

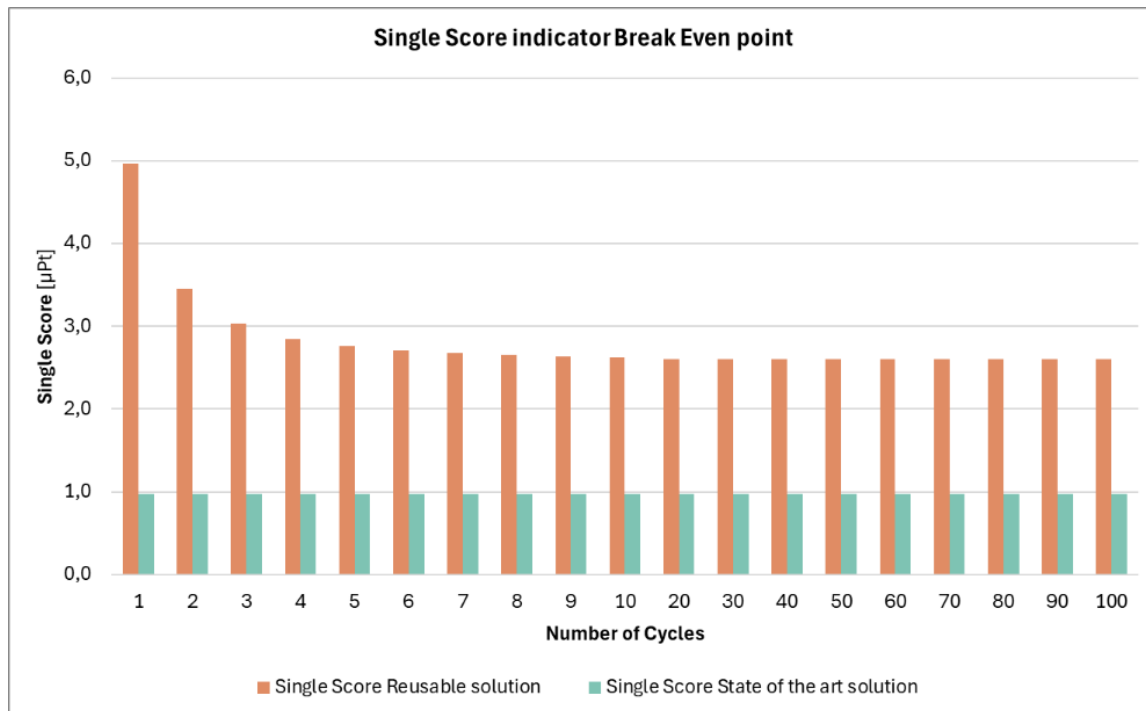


Figure 42: Product11_Single Score Chart_Return_Rate 85,5%



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Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 44) and Reuse System (Fig 45) as the number of cycles varies.

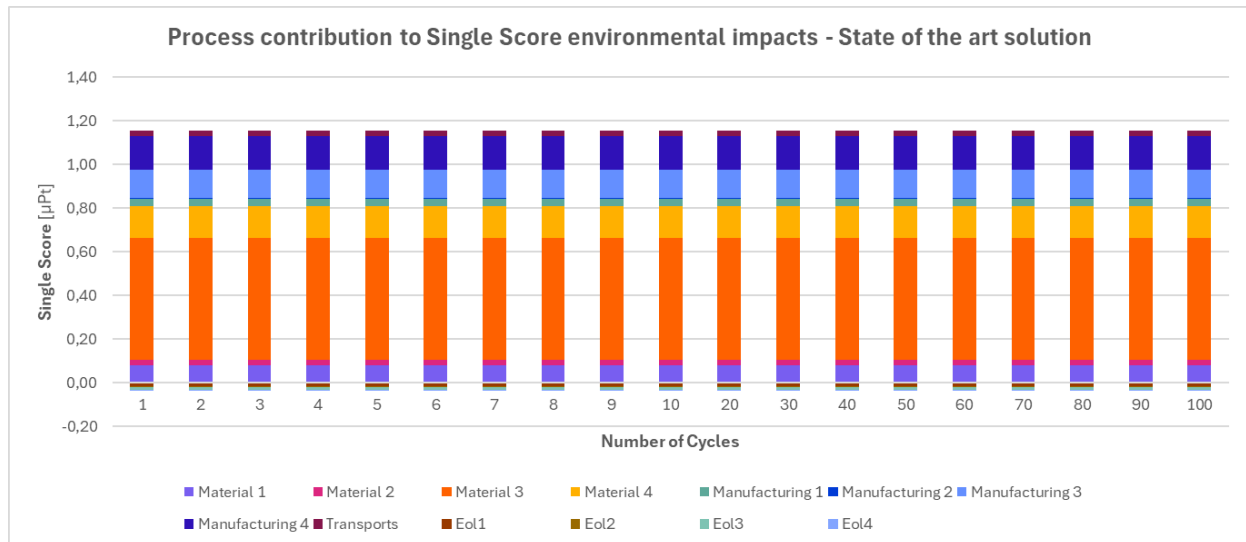


Figure 43: Product11_SingleUse_Weighted Results: Material 1: HDPE Cap; Material 2: OPP Foil, Material 3: PET; Material 4: rPET; Manufacturing 2: Extrusion of plastic film; Manufacturing 3-4: Stretch blow moulding.

As shown in Fig 43, the single-use system (packaging referred to Table 41) shows the greatest impact (50%) for Material 3: PET, associated with its production (Manufacturing 3) representing 12% of total impacts. The second largest contributor is Material 4: rPET representing 13%, associated with its production (Manufacturing 4) representing the 12% of total impacts.

As shown in Fig 44, the reuse system (packaging referred to Table 42) shows the greatest impact (58% at 20th cycle) for Packaging material (glass) which contain production impacts. This is followed by the washing process (27%) and disposable Lid material (8%).

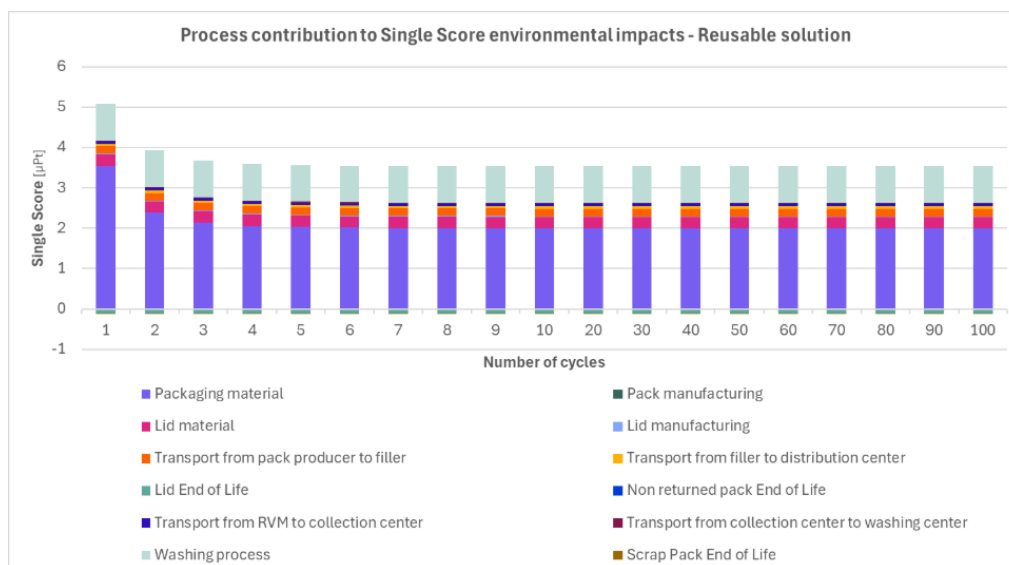


Figure 44: Product11_Reuse_Weighted Results_Return Rate 64,6%



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Characterization results comparison

Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

At 20-cycle: Flattening the curve

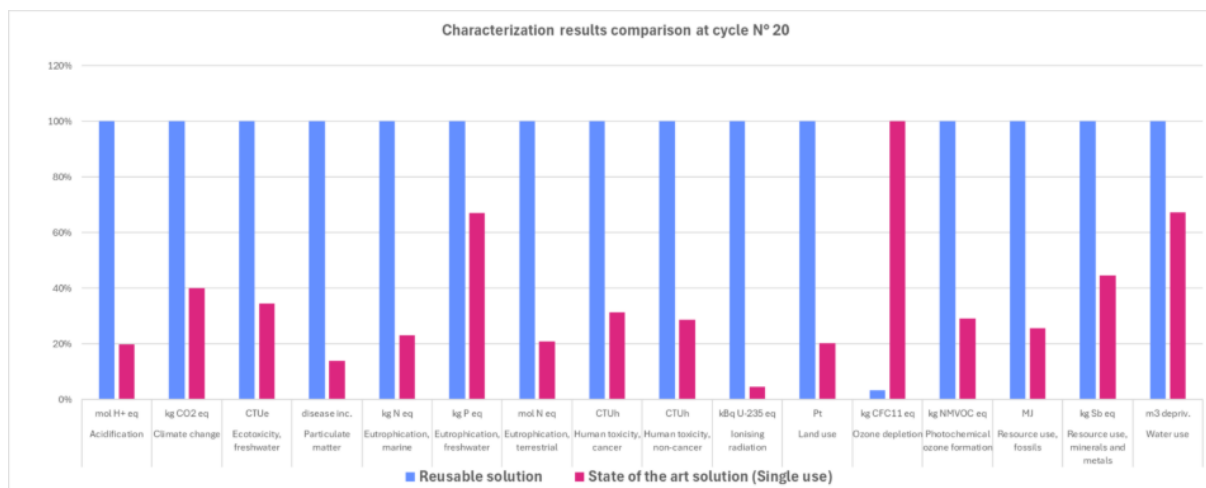


Figure 45: Product11-r_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 45: Product11-r_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	2,10E-04	4,16E-05
Climate change	kg CO2 eq	2,77E-02	1,11E-02
Ecotoxicity, freshwater	CTUe	3,06E-02	1,05E-02
Particulate matter	disease inc.	3,00E-09	4,14E-10
Eutrophication, marine	kg N eq	3,81E-05	8,83E-06
Eutrophication, freshwater	kg P eq	4,38E-06	2,94E-06
Eutrophication, terrestrial	mol N eq	3,80E-04	7,89E-05
Human toxicity, cancer	CTUh	8,48E-11	2,67E-11
Human toxicity, non-cancer	CTUh	3,10E-10	8,92E-11
Ionising radiation	kBq U-235 eq	1,86E-02	8,48E-04
Land use	Pt	2,48E-01	5,02E-02
Ozone depletion	kg CFC11 eq	7,04E-10	2,12E-08
Photochemical ozone formation	kg NMVOC eq	1,27E-04	3,72E-05
Resource use, fossils	MJ	7,15E-01	1,83E-01
Resource use, minerals and metals	kg Sb eq	1,42E-07	6,35E-08
Water use	m3 depriv.	3,82E-03	2,57E-03

The reuse system has a worse environmental impact in most areas, except for ozone depletion, due to the use of material 3 (PET), which significantly increases the indicator.

2.10. Product 12 – UHT milk

The comparison concerns the following products:

STATE OF THE ART – UHT Milk – PET Opaque Bottle

Table 46: State of the art PRODUCT 12

Format	PET opaque Bottle	
Food weight	1 l	
Company	LSDH	
LCA ID	12	

Inventory data are in the Deliverable 6.2 – LCA Inventory and scenario building, Tab E12. PP-M LCI, PRODUCT 12 – UHT Milk – PET Opaque Bottle

TABLE E12				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
12	Opaque bottle	1	2,8	/	/	Capping	/	/
12.1	HDPE Cap	1	0,3	HDPE	Polyethylene, high density, granulate {RER} polyethylene production, high density, granulate Cut-off, U	Injection moulding	Injection moulding {RER} injection moulding Cut-off, U	- Water, cooling, unspecified natural origin, FR; - Electricity, medium voltage {FR} market for Cut-off, U
12.2	OPP Foil	1	0,1	PP	Polypropylene, granulate {RER} production Cut-off, U	Extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film Cut-off, U	- Water, cooling, unspecified natural origin, FR; - Electricity, medium voltage {FR} market for Cut-off, U
12.3	PET Bottle	1	1,2	PET	Polyethylene terephthalate, granulate, bottle grade {RER} polyethylene terephthalate production, granulate, bottle grade Cut-off, U	Stretch blow moulding	Stretch blow moulding {RER} stretch blow moulding Cut-off, U	- Water, cooling, unspecified natural origin, FR; - Electricity, medium voltage {FR} market for Cut-off, U
			1,2	rPET	rPET CIRCULAR FOOTPRINT FORMULA DATASET	Injection moulding	Injection moulding {RER} injection moulding Cut-off, U	- Water, cooling, unspecified natural origin, FR; - Electricity, medium voltage {FR} market for Cut-off, U

REUSE - UHT Milk – White Glass bottle

Table 47: REUSE Product 12-r

Format	Glass bottle 1L	
Food weight	1 l	
Company	LSDH	
LCA ID	12-r	

Inventory data have been updated from Tab F12. PP-M LCI, PRODUCT 12-r – UHT Milk – White Glass bottle - and are here reported:

TABLE F12				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
12-r	Bottle	1	36,5	/	/	/	/	/
12.1-r	Twist-off capsule	1	0,5	Aluminium	Aluminium, cast alloy {GLO} market for aluminium, cast alloy Cut-off, S	Sheet rolling	Sheet rolling, aluminium {FR} sheet rolling, aluminium Cut-off, U	/
12.2-r	Glass Bottle	1	36	GLASS	White Glass Circular Footprint Formula Dataset	*Data for processing are included in material's dataset	*Data for processing are included in material's dataset	/

SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 48: PRODUCT 12R_Reuse Data Inventory SCENARIO 1

Inventory data	12r_MILK_GLASS BOTTLE	Unit of Measure
Pack Type	PKG_05	
Pack material	COLOURLESS GLASS CFF	
Pack amount	36,00	g
Lid material	ALUMINIUM FOIL	
Lid amount	0,50	g
Producer to filler distance	412,43	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	131,42	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	141,03	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	48,98	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Glass	
Washing water [l]	0,13	l
Washing detergent [g]	0,93	g
Washing energy [kWh]	0,03	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	67,75	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 46, the break-even point is not reached at a return rate of 64,6%. Even at high numbers of reuse cycles, the environmental impact of single-use packaging remains lower. The impact of the single-use system is 300% lower by the 20th cycle.

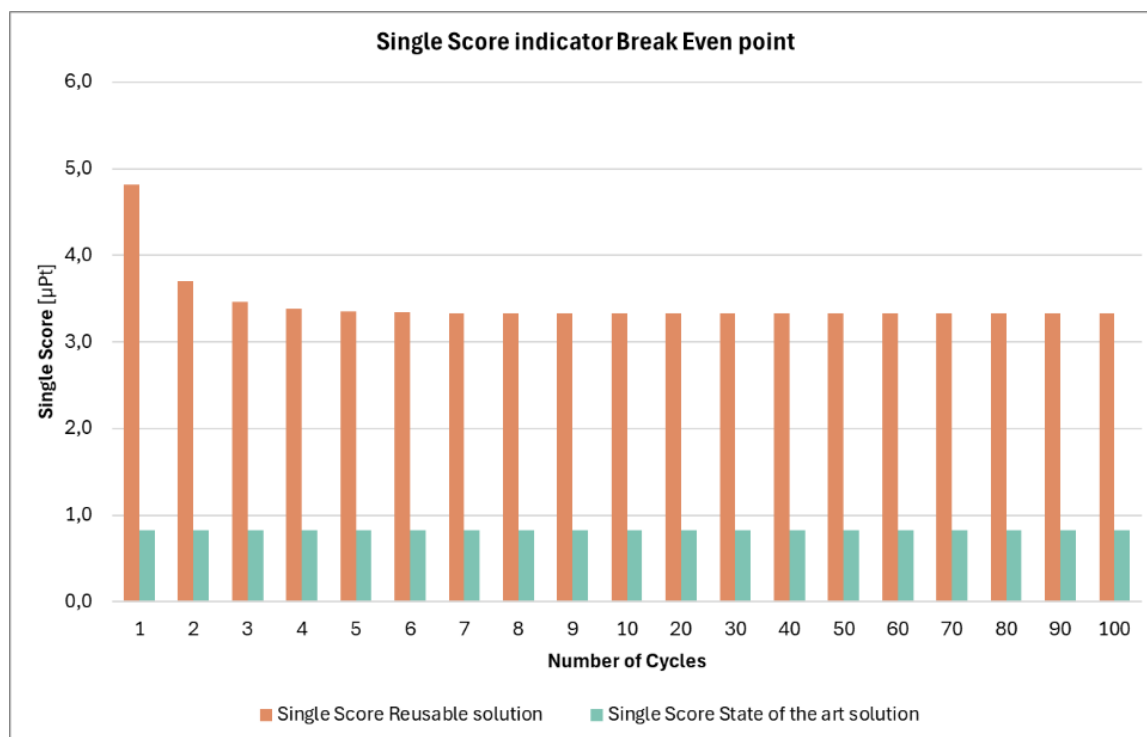


Figure 46: Product12_Single Score Chart_Return_Rate 64,6%

SCENARIO 2: RETURN RATE 90% SCRAP RATE 5% (85,5%)

Table 49: PRODUCT 12R_Reuse Data Inventory SCENARIO 2

Inventory data	12r_MILK_GLASS BOTTLE	Unit of Measure
Pack Type	PKG_05	
Pack material	COLOURLESS GLASS CFF	
Pack amount	36,00	g
Lid material	ALUMINIUM FOIL	
Lid amount	0,50	g
Producer to filler distance	412,43	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	131,42	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	90%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	141,03	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	48,98	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Glass	
Washing water [l]	0,13	l
Washing detergent [g]	0,93	g
Washing energy [kWh]	0,03	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	67,75	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 48, even with a return rate of 85.5% and a high number of reuse cycles, no environmental benefit is achieved through the reuse system. The impact of the single-use system is 208% lower by the 20th cycle.

The main reason for missing the break-even point is that the mass per functional unit of 100 g of product content of Single use packaging (see Table 46) is significantly lower thanks to PET (2,8 g) than that of reused product in glass (36,5 g). This is to be considered in addition to the extra processes in the reuse system.

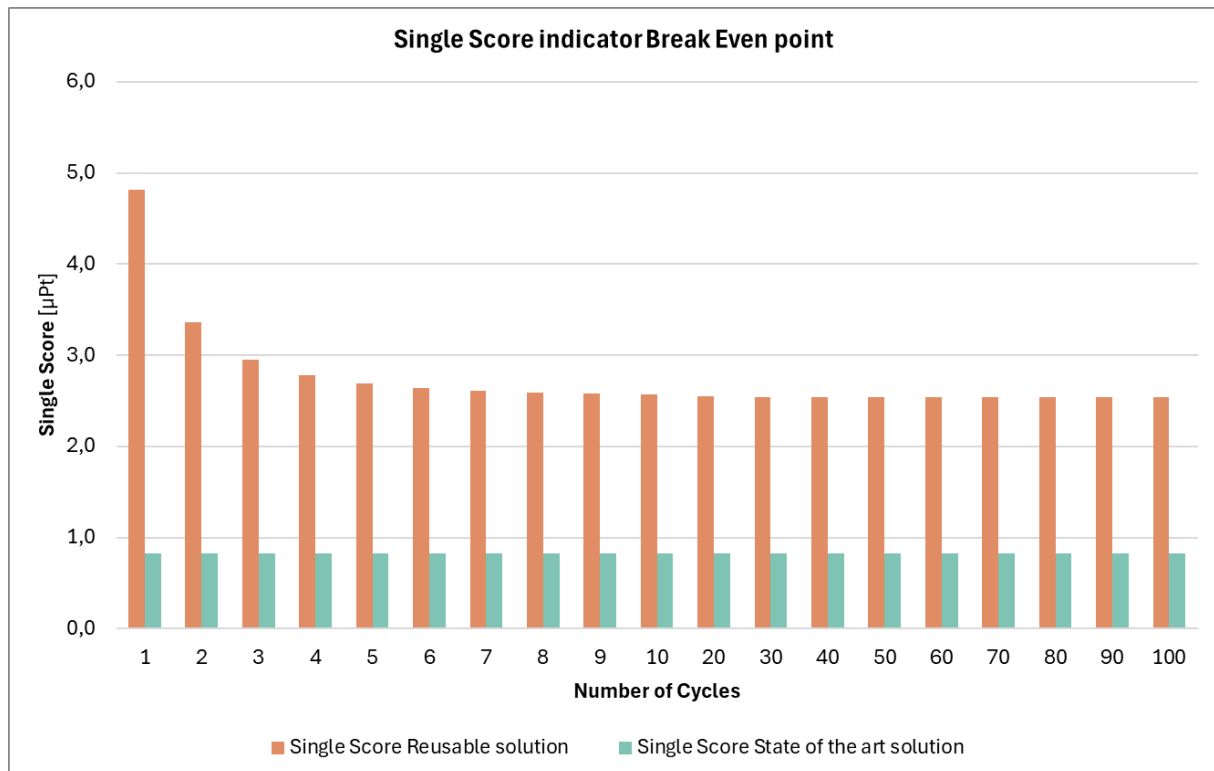


Figure 48: Product12_Single Score Chart_Return_Rate 85,5%



Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 7) and Reuse System (Fig 8) as the number of cycles varies.

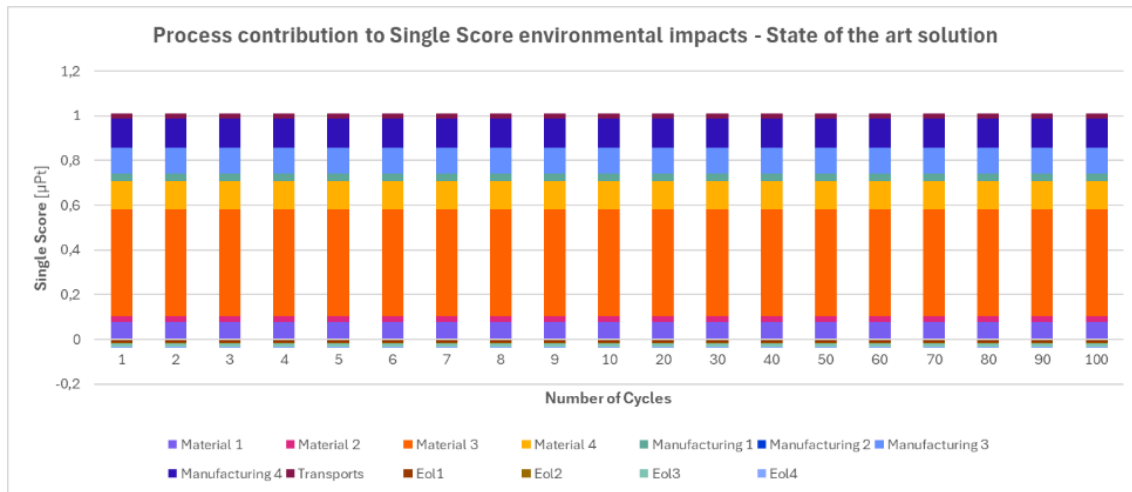


Figure 47: Product12_SingleUse_Weighted Results: Material 1:HDPE; Material 2: OPP Foil; Material 3: PET; Material 4; R-PET; Manufacturing 1: Injection moulding; Manufacturing 2: extrusion, Stretch Blow Moulding; Manufacturing 3: Injection moulding; Manufacturing 4: Injection moulding.

As shown in Fig 47, the single-use system (packaging referred to Table 46) shows the greatest impact (49%) for Material 3: PET, associated with its production (Manufacturing 3) representing 12% of total impacts. The second largest contributor is Material 4: rPET representing 13%, associated with its production (Manufacturing 4) representing the 13% of total impacts.

As shown in Fig 48, the reuse system (packaging referred to Table 47) shows the greatest impact (57% at 20th cycle) for Packaging material (glass) which contain production impacts. This is followed by the washing process (28%) and disposable Lid material (8%).

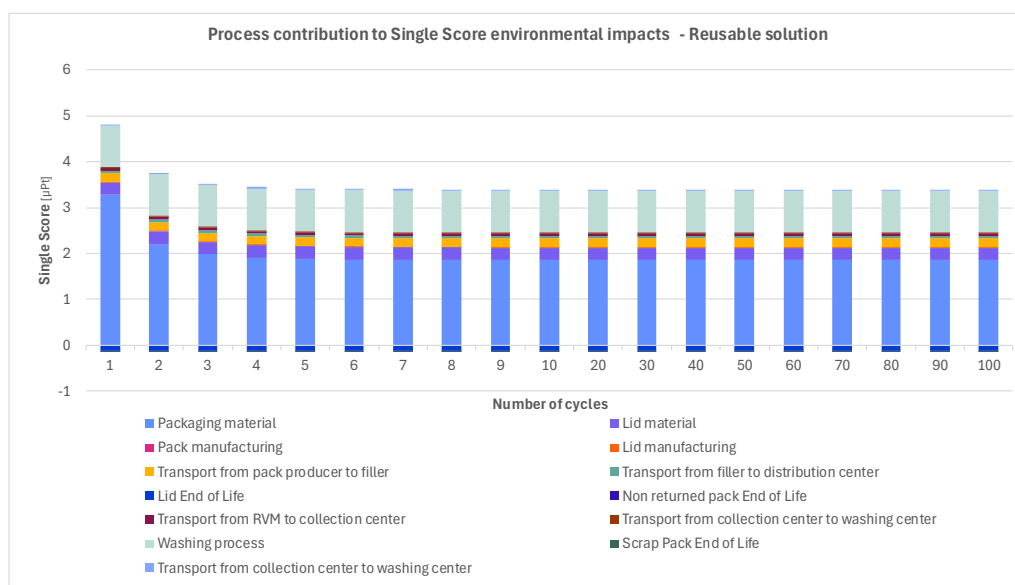


Figure 48: Product12_Reuse_Weighted Results_Return Rate 64,6%



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Characterization results comparison

Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

At 20-cycle: Flattening the curve

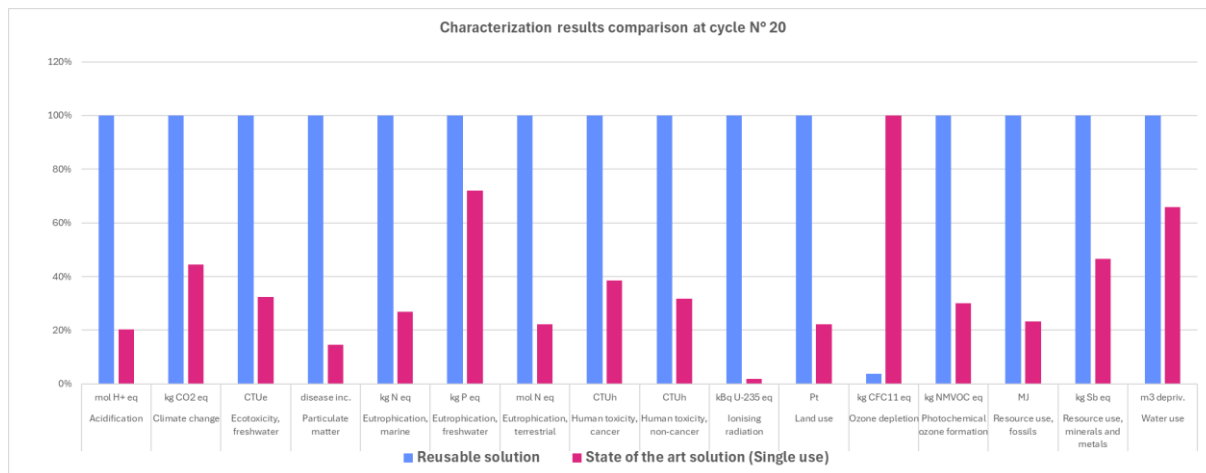


Figure 49: Product12-r_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 50: Product12-r_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H ⁺ eq	2,02E-04	4,10E-05
Climate change	kg CO ₂ eq	2,67E-02	1,19E-02
Ecotoxicity, freshwater	CTUe	3,06E-02	9,87E-03
Particulate matter	disease inc.	2,89E-09	4,19E-10
Eutrophication, marine	kg N eq	3,69E-05	9,92E-06
Eutrophication, freshwater	kg P eq	4,26E-06	3,07E-06
Eutrophication, terrestrial	mol N eq	3,66E-04	8,10E-05
Human toxicity, cancer	CTUh	8,23E-11	3,17E-11
Human toxicity, non-cancer	CTUh	3,00E-10	9,56E-11
Ionising radiation	kBq U-235 eq	1,85E-02	3,38E-04
Land use	Pt	2,39E-01	5,30E-02
Ozone depletion	kg CFC11 eq	6,80E-10	1,82E-08
Photochemical ozone formation	kg NMVOC eq	1,23E-04	3,70E-05
Resource use, fossils	MJ	7,02E-01	1,63E-01
Resource use, minerals and metals	kg Sb eq	1,38E-07	6,42E-08
Water use	m ³ depriv.	3,73E-03	2,45E-03

The reuse system has a worse environmental impact in most areas, except for ozone depletion, due to the use of material 3 (PET), which has a significant impact on this indicator.

2.11. Product 13 - Milk

The comparison concerns the following products:

STATE OF THE ART – UHT Milk – PEHD

Table 51: State of the art PRODUCT 13

Format	PEHD Bottle	
Food weight	1 l	
Company	Sodiaal	
LCA ID	13	

Inventory data are in the Deliverable 6.2 – LCA Inventory and scenario building, Tab E13. PP-M LCI, PRODUCT 13 – UHT Milk – PEHD Bottle

TABLE E13				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
13	HDPE bottle	1	3,57	/	/	Capping		/
13.1	HDPE Cap	1	0,27	HDPE	Polyethylene, high density, granulate {RER} polyethylene production, high density, granulate Cut-off, U	Injection moulding	Injection moulding {RER} injection moulding Cut-off, U	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for Cut-off, U
13.2	Bottle	1	3,3	HDPE	Polyethylene, high density, granulate {RER} polyethylene production, high density, granulate Cut-off, U	Stretch blow moulding	Stretch blow moulding {RER} stretch blow moulding Cut-off, U	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for Cut-off, U
						Co-extrusion	Extrusion, co-extrusion {FR} extrusion, co-extrusion of plastic sheets Cut-off, U	/

REUSE - UHT Milk – Glass Bottle

Table 52: REUSE Product 13-r

Format	Glass bottle 1L	
Food weight	1 l	
Company	Sodiaal	
LCA ID	13-r	

Inventory data has been updated from Tab Tab F13. PP-M LCI, PRODUCT 13-r – UHT Milk – Glass Bottle - and are here reported:

TABLE F13				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
13-r	Glass bottle	1	36,5	/	/	/	/	/
13.1-r	Twist-off capsule	1	0,5	Aluminium	Aluminium, cast alloy {GLO} market for aluminium, cast alloy Cut-off, S	Sheet rolling	Sheet rolling, aluminium {FR} sheet rolling, aluminium Cut-off, U	/
13.2-r	Glass Bottle	1	36	GLASS	White Glass Circular Footprint Formula Dataset	*Data for processing are included in material's dataset	*Data for processing are included in material's dataset	/

SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 53: PRODUCT 13-R_Reuse Data Inventory SCENARIO 1

Inventory data	13r_MILK_GLASS BOTTLE	Unit of Measure
Pack Type	PKG_05	
Pack material	COLOURLESS GLASS CFF	
Pack amount	36,00	g
Lid material	ALUMINIUM FOIL	
Lid amount	0,50	g
Producer to filler distance	412,43	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	131,42	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	141,03	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	48,98	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Glass	
Washing water [l]	0,13	l
Washing detergent [g]	0,93	g
Washing energy [kWh]	0,03	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	67,75	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 50, the break-even point is *not reached at a return rate of 64,6%*. Even at high numbers of reuse cycles, the environmental impact of single-use packaging remains lower. By the 20th cycle, single-use packaging has an impact that is 169% lower.

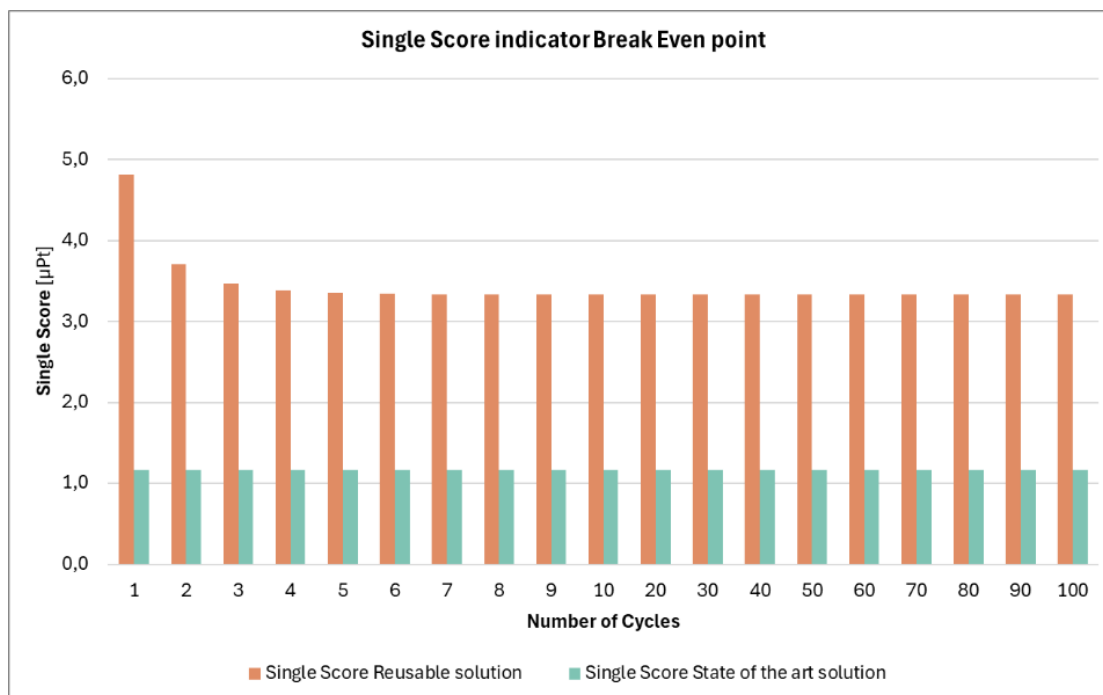


Figure 50: Product13_Single Score Chart_Return_Rate 64,6%



SCENARIO 2: RETURN RATE 90% SCRAP RATE 5% (85,5%)

Table 54: PRODUCT 13R_Reuse Data Inventory SCENARIO 2

Inventory data	13r_MILK_GLASS BOTTLE	Unit of Measure
Pack Type	PKG_05	
Pack material	COLOURLESS GLASS CFF	
Pack amount	36,00	g
Lid material	ALUMINIUM FOIL	
Lid amount	0,50	g
Producer to filler distance	412,43	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	131,42	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	90%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	141,03	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	48,98	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Glass	
Washing water [l]	0,13	l
Washing detergent [g]	0,93	g
Washing energy [kWh]	0,03	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	67,75	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 51, even with a return rate of 85.5% and a high number of reuse cycles, no environmental benefit is achieved through the reuse system. Using it once at the 20th cycle results in a 106% lower environmental impact.

The main reason for missing the break-even point is that the mass per functional unit of 100 g of product content of Single use packaging (see Table 51) is significantly lower thanks to HDPE (3,57 g) than that of reused product in glass (18.4 g). This is to be considered in addition to the extra processes in the reuse system.

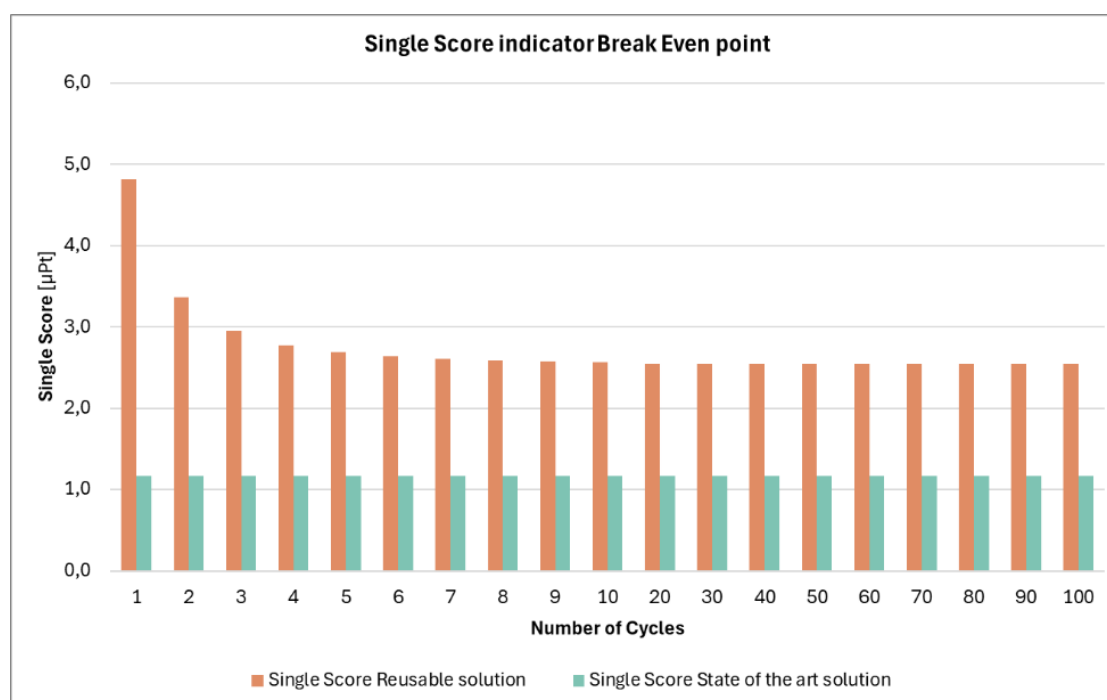


Figure 51: Product13_Single Score Chart_Return_Rate 85,5%



Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 52) and Reuse System (Fig 53) as the number of cycles varies.

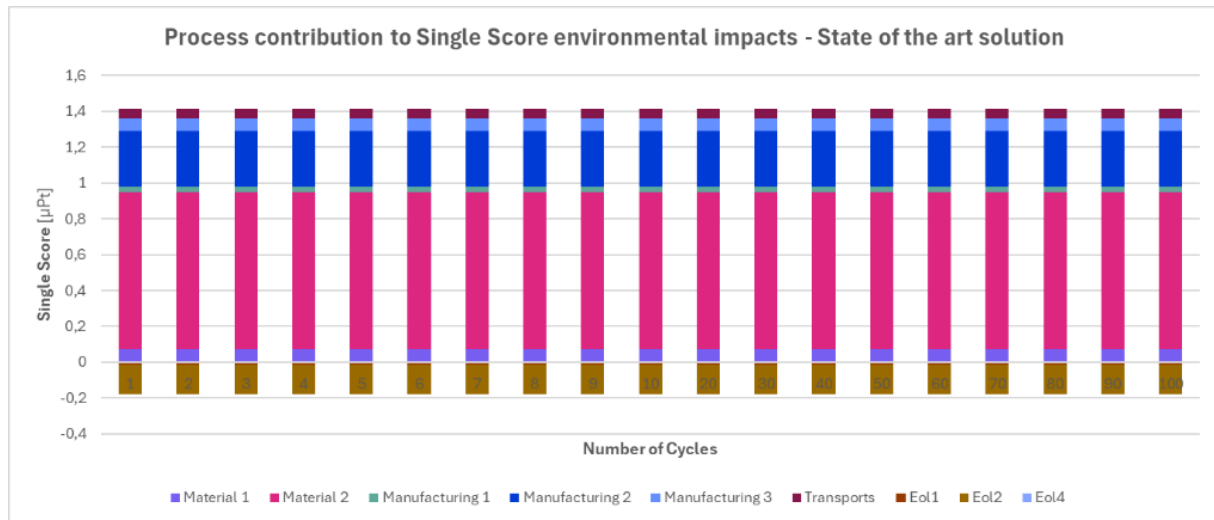


Figure 52: Product13_SingleUse_Weighted Results: Material 1: HDPE; Material 2: HDPE; Manufacturing 1: Injection moulding, Manufacturing 2: Stretch blow moulding, Manufacturing 3: co-extrusion.

As shown in Fig 52, the single-use system (packaging referred to Table 51) shows the greatest impact (71%) for Material 2: HDPE, associated with its production (Manufacturing 2) representing 25% of total impacts. End of Life process Eol2, thanks to the recyclability of HDPE contributes to a reduction in the total impacts of -13%.

As shown in Fig 53, the reuse system (packaging referred to Table 52) shows the greatest impact (57% at 20th cycle) for Packaging material (glass) which contain production impacts. This is followed by the washing process (28%) and disposable Lid material (8%).

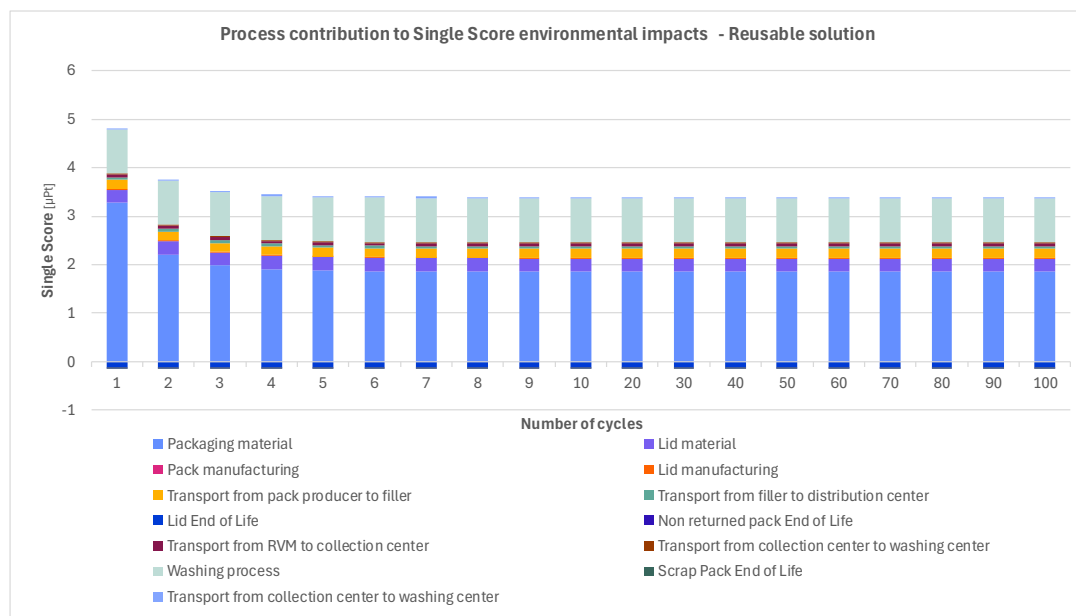


Figure 53: Product13_Reuse_Weighted Results_Return Rate 64,6%



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Characterization results comparison

Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

At 20-cycle: Flattening the curve

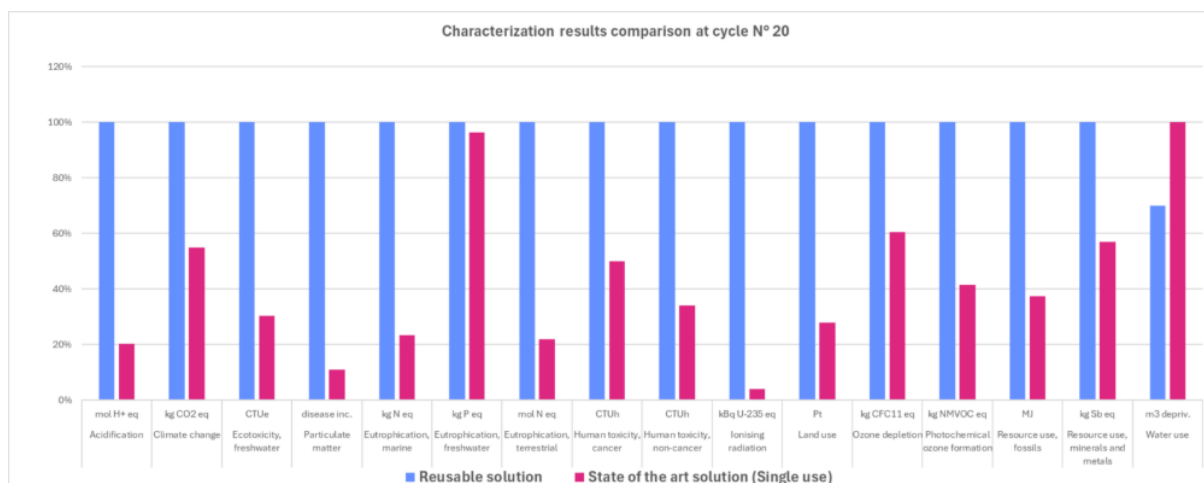


Figure 54: Product13-r_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 55: Product13-r_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	2,02E-04	4,11E-05
Climate change	kg CO2 eq	2,67E-02	1,47E-02
Ecotoxicity, freshwater	CTUe	3,06E-02	9,24E-03
Particulate matter	disease inc.	2,89E-09	3,15E-10
Eutrophication, marine	kg N eq	3,69E-05	8,61E-06
Eutrophication, freshwater	kg P eq	4,26E-06	4,10E-06
Eutrophication, terrestrial	mol N eq	3,66E-04	7,99E-05
Human toxicity, cancer	CTUh	8,23E-11	4,11E-11
Human toxicity, non-cancer	CTUh	3,00E-10	1,02E-10
Ionising radiation	kg U-235 eq	1,85E-02	7,45E-04
Land use	Pt	2,39E-01	6,68E-02
Ozone depletion	kg CFC11 eq	6,80E-10	4,12E-10
Photochemical ozone formation	kg NMVOC eq	1,23E-04	5,11E-05
Resource use, fossils	MJ	7,02E-01	2,63E-01
Resource use, minerals and metals	kg Sb eq	1,38E-07	7,87E-08
Water use	m3 depriv.	3,73E-03	5,33E-03

The reuse system has an higher environmental impact on most indicators, except for water use, due to the quantities of HDPE material involved.

2.12. Product 14 – Savory biscuits

The comparison concerns the following products:

STATE OF THE ART – Biscuits, BOPP & Cardboard

Table 56: State of the art PRODUCT 14

Format	cardboard box + flowpacks	
Food weight	168 g	
Company	Biscuit bouvard	
LCA ID	14	

Inventory data are in the Deliverable 6.2 – LCA Inventory and scenario building, Tab E14. PP-M LCI, PRODUCT 14- Biscuits, BOPP & Cardboard

TABLE E14				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
14	Biscuits	1	17,85	/	/	/	/	/
14.1	Cardboard Box	1	16,07		/	Flat cut	Folding boxboard carton production {RER} production Cut-off, U	• Variation amount of Varnish and Ink • Electricity, medium voltage {FR} market for Cut-off, U
14.2	OPP Foil	1	1,78	PP	Polypropylene, granulate {RER} production Cut-off, U	Extrusion of plastic film	Extrusion, plastic film {RER} extrusion, plastic film Cut-off, U	• Water, cooling, unspecified natural origin, FR; • Electricity, medium voltage {FR} market for Cut-off, U



REUSE - Biscuits – PP Bucket + Lid

Table 57: REUSE Product 14-r

Format	PP Bucket 1L	
Food weight	350g	
Company	Biscuit bouvard	
LCA ID	14-r	

Inventory data are in the Deliverable 6.2 – LCA Inventory and scenario building, Tab F14. PP-M LCI, PRODUCT 14-r- Biscuits, PP Bucket + Lid

TABLE F14				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
14-r	PET Cup	1	13,342	/	/	/	/	/
14.1-r	Clip lid	1	2,771	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/
14.2-r	Bucket	1	10,571	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/



SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 58: PRODUCT 14R_Reuse Data Inventory SCENARIO 1

Inventory data	14R1_SAVORY BISCUITS_1L BUCKET	Unit of Measure
Pack Type	PKG_04	
Pack material	PP	
Pack amount	10,57	g
Lid material	PP	
Lid amount	2,77	g
Producer to filler distance	264,94	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	471,23	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	176,45	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	58,14	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Bucket 1L	
Washing water [l]	0,23	l
Washing detergent [g]	0,58	g
Washing energy [kWh]	0,04	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	124,67	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 55, the break-even point is not reached at a return rate of 64,6%. Even at high numbers of reuse cycles, the environmental impact of single-use packaging remains lower. The impact of single use is 38,1% lower after 20 cycles.

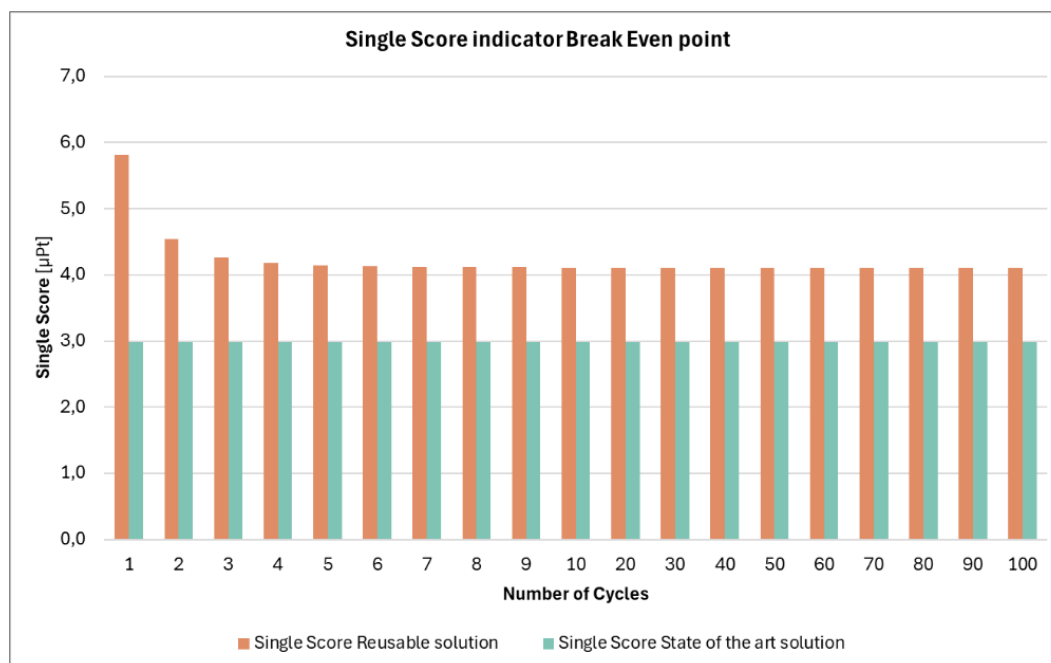


Figure 55: Product14_Single Score Chart_Return_Rate 64,6%



SCENARIO 2: RETURN RATE 90% SCRAP RATE 5% (85,5%)

Table 59: PRODUCT 14-r_Reuse Data Inventory SCENARIO 2

Inventory data	14R1_SAVORY BISCUITS_1L BUCKET	Unit of Measure
Pack Type	PKG_04	
Pack material	PP	
Pack amount	10,57	g
Lid material	PP	
Lid amount	2,77	g
Producer to filler distance	264,94	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	471,23	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	90%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	176,45	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	58,14	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Bucket 1L	
Washing water [l]	0,23	l
Washing detergent [g]	0,58	g
Washing energy [kWh]	0,04	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	124,67	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 56, even with a return rate of 85.5% and a high number of reuse cycles, the reuse system does not offer any environmental benefits. The environmental impact of single-use packaging is 10% lower by the 20th cycle. The main reason for missing the break-even point is related to the materials involved: cardboard, thanks to its recyclability (that generates positive impacts) has a lower impact than PP and its production. This aspect must be considered in addition to the supplementary processes required by the reuse system.

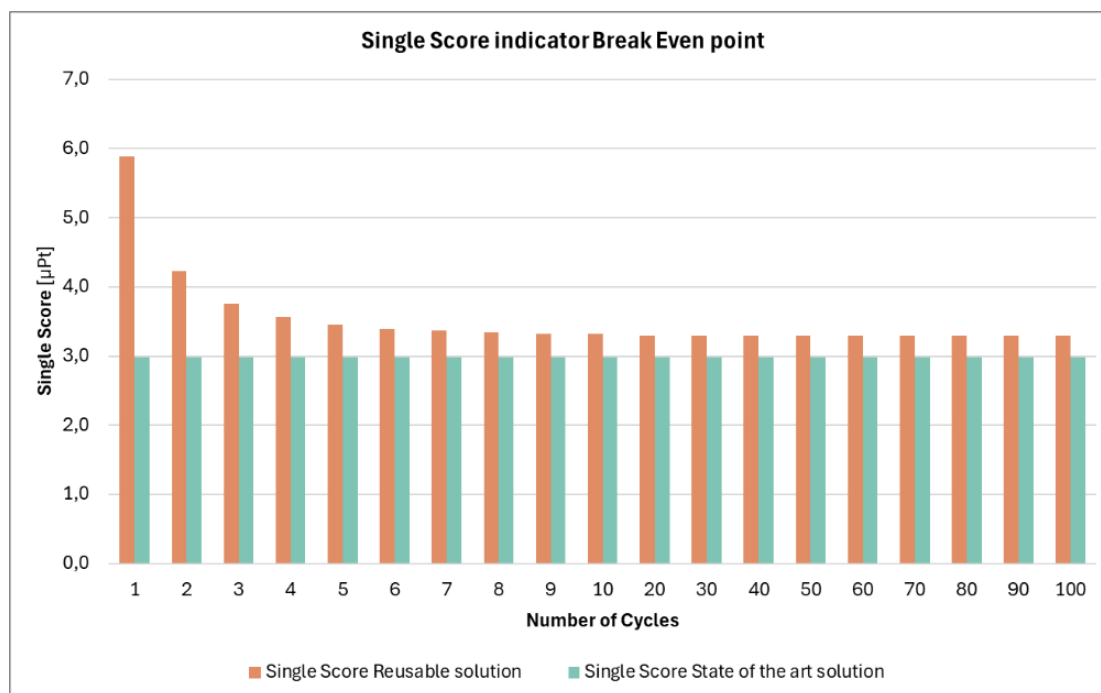


Figure 56: Product14_Single Score Chart_Return_Rate 85,5%



Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 57) and Reuse System (Fig 58) as the number of cycles varies.

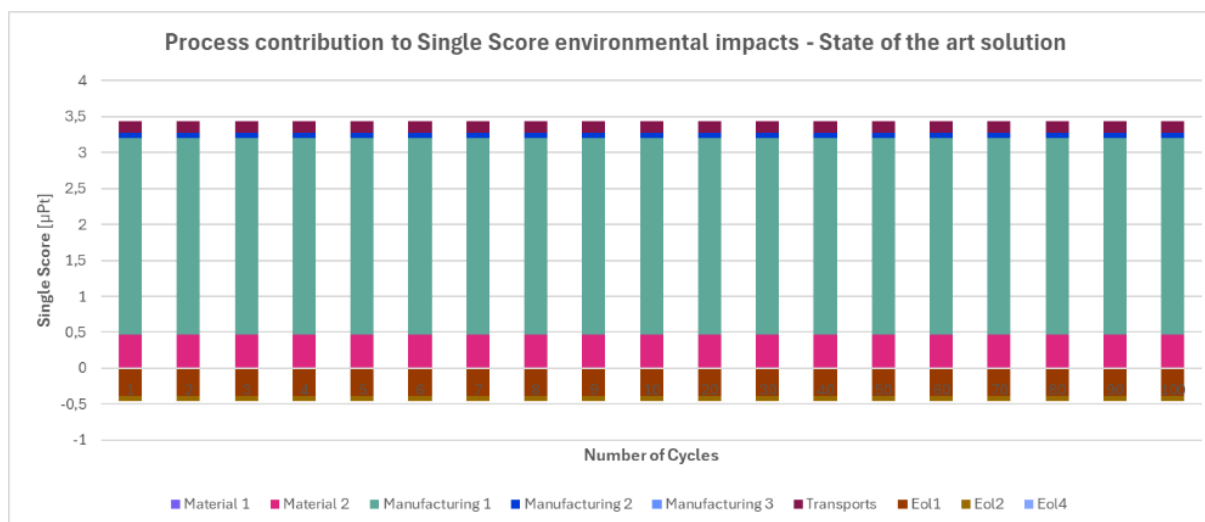


Figure 57: Product14_SingleUse_Weighted Results: Material 2: PP film; Manufacturing 1: Cardboard production, Manufacturing 2: extrusion

As shown in Fig 57, the single-use system (packaging referred to Table 56) shows the greatest impact (92% of the total including the positive impacts) for Material and Manufacturing 1: cardboard and its Flat cut. End of Life process: Eol1, thanks to the recyclability of cardboard, contributes to a reduction in the total impacts of -13%.

As shown in Fig 58, in reuse system (packaging referred to Table 57) shows the greatest impact (38% at 20th cycle) for Packaging material (PP), associated with its production (Pack Manufacturing) representing the 16% of total impacts followed by Washing (24%) and disposable Lid material (17%) and its manufacturing (7%).

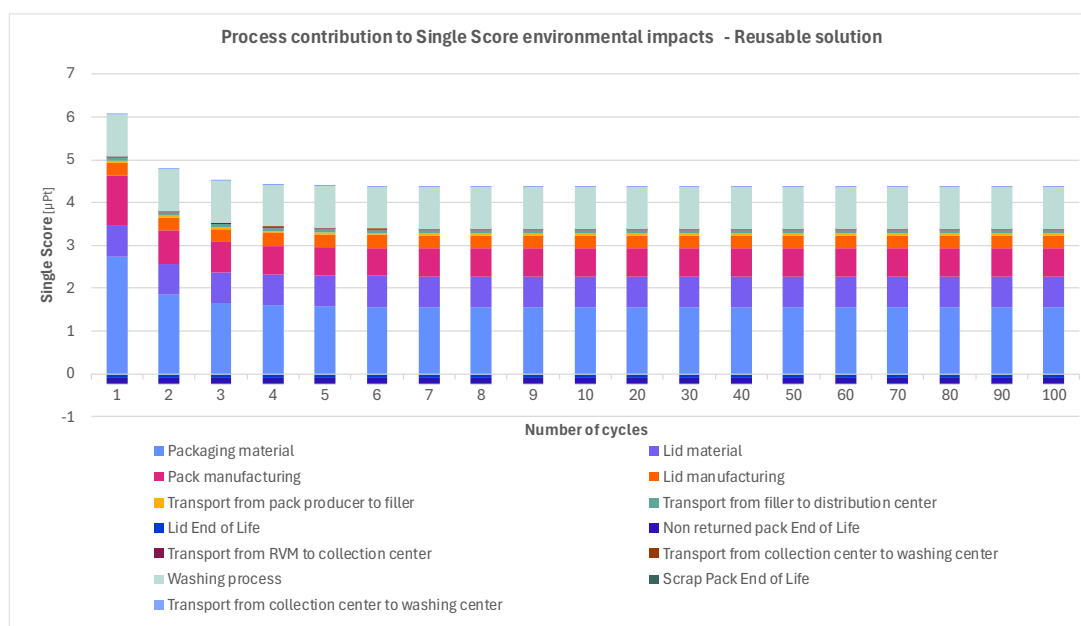


Figure 58: Product14_Reuse_Weighted Results_Return Rate 64,6%



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Characterization results comparison

Comparison of the values characterized for all environmental indicators (e.g. GWP - Global Warming Potential, water consumption, energy, etc.) between State of the art and Reuse systems.

At 20-cycle: Flattening the curve

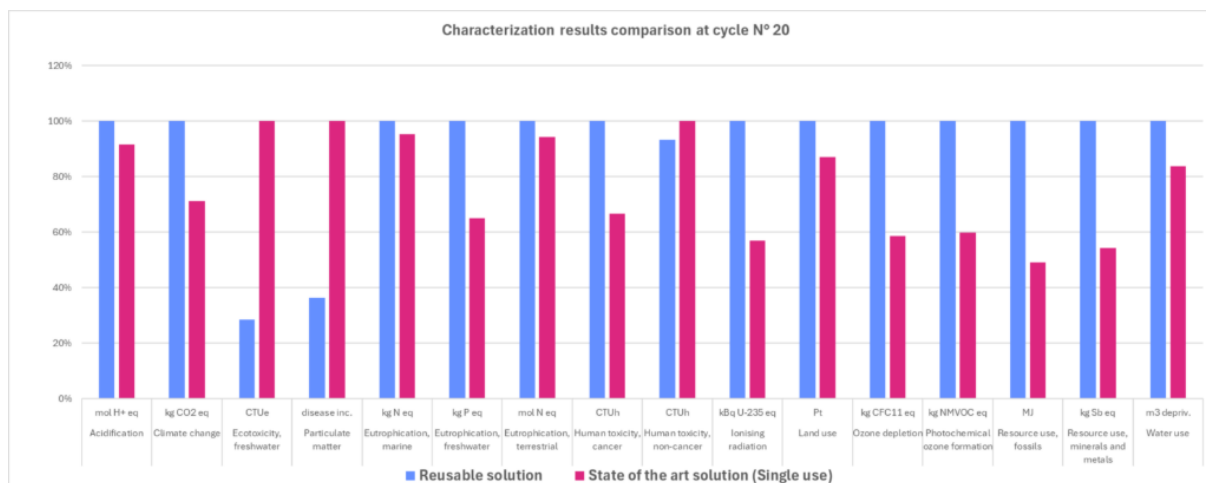


Figure 59: Product14-r_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 60: Product14-r_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	1,24E-04	1,14E-04
Climate change	kg CO2 eq	3,89E-02	2,77E-02
Ecotoxicity, freshwater	CTUe	3,04E-02	1,07E-01
Particulate matter	disease inc.	1,23E-09	3,38E-09
Eutrophication, marine	kg N eq	3,14E-05	3,00E-05
Eutrophication, freshwater	kg P eq	8,84E-06	5,74E-06
Eutrophication, terrestrial	mol N eq	2,62E-04	2,47E-04
Human toxicity, cancer	CTUh	1,21E-10	8,05E-11
Human toxicity, non-cancer	CTUh	2,95E-10	3,16E-10
Ionising radiation	kBq U-235 eq	1,78E-02	1,01E-02
Land use	Pt	1,70E-01	1,48E-01
Ozone depletion	kg CFC11 eq	1,17E-09	6,88E-10
Photochemical ozone formation	kg NMVOC eq	1,54E-04	9,21E-05
Resource use, fossils	MJ	1,11E+00	5,45E-01
Resource use, minerals and metals	kg Sb eq	2,20E-07	1,19E-07
Water use	m3 depriv.	1,35E-02	1,13E-02

The reuse system has a worse environmental impact in most areas, except for ecotoxicity freshwater, particulate matter, human toxicity (non-cancer). This is due to the materials and production processes used to for the primary packaging.

2.13. Product 15 - Yogurts

The comparison was made using the same packaging, which was inserted into either the single-use or the reuse system:

STATE OF THE ART – Fromage Blanc – PP Bucket + Lid

Table 61: PRODUCT 15

Format	PP Bucket 2L	
Food weight	2 kg	
Company	Rians	
LCA ID	15-r	

Tab E15. PP-M LCI, PRODUCT 15 – Fromage Blanc – PP Bucket + Lid

TABLE E15				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
15	Fromage Blanc	1	4,425	/	/	/	/	/
15.1	PP Bucket 2L	1	3,545	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/
15.2	Clip lid	1	0,88	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/

SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 62: PRODUCT 15_Reuse Data Inventory SCENARIO 1

Inventory data	15_FROMAGE BLANC_2L BUCKET	Unit of Measure
Pack Type	PKG_06	
Pack material	PP	
Pack amount	3,55	g
Lid material	PP	
Lid amount	0,88	g
Producer to filler distance	251,24	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	415,26	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	151,66	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	62,72	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Bucket 2L	
Washing water [l]	0,12	l
Washing detergent [g]	0,29	g
Washing energy [kWh]	0,02	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	395,42	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

Despite achieving comparable environmental impacts from the third reuse cycle onwards, the break-even point is not reached at a return rate of 64,6%, as shown in Fig.60. By the 20th reuse cycle, the reusable system has generated impacts that are 0.8% greater than those of the disposable system.

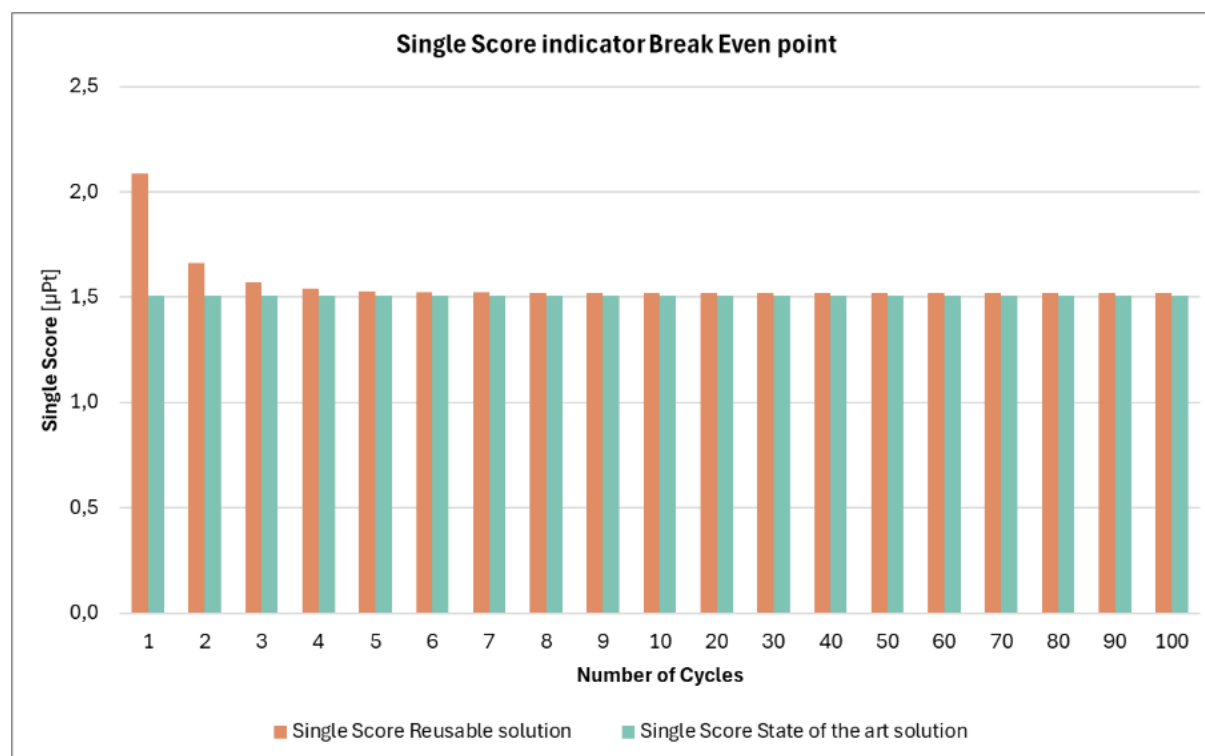


Figure 60: Product15_Single Score Chart_Return_Rate 64,6%

SCENARIO 2: RETURN RATE 90% SCRAP RATE 5% (85,5%)

Table 63: PRODUCT 15_Reuse Data Inventory SCENARIO 2

Inventory data	15_FROMAGE BLANC_2L BUCKET	Unit of Measure
Pack Type	PKG_06	
Pack material	PP	
Pack amount	3,55	g
Lid material	PP	
Lid amount	0,88	g
Producer to filler distance	251,24	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	415,26	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	90%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	151,66	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	62,72	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Bucket 2L	
Washing water [l]	0,12	l
Washing detergent [g]	0,29	g
Washing energy [kWh]	0,02	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	395,42	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 61, the break-even point is reached at a return rate of 85.5% with greater significance. The break-even point is reached in the third reuse cycle, with a difference of 17.4% in the total impacts generated after 20 cycles.

The main reason for this lies in the fact that state-of-the-art packaging is represented by a unique solution (see Table 61). In the reuse system, additional processes (washing) and transport shift the impact in the initial cycles, which balances out by the third cycle and reduces the impact in subsequent cycles.

This relationship was not advantageous in scenario 1 due to the high impact of the washing cycle in proportion to the low mass per functional unit (4,425g) due to the high food quantity contained per unit of packaging (2kg).

Washing phase is the main factor differentiating these results from the other scenarios. For this container, energy consumption is higher than for other packaging options; however, the key aspect is that the contributions from other life cycle phases are relatively marginal. Material production and processing per functional unit are low, due to the efficient product-to-packaging weight ratio. Consequently, the washing phase accounts for a larger share of the total impacts of the product. In the reuse scenario, the presence of this additional and relatively impactful phase is what drives the difference compared to the single-use simulation.

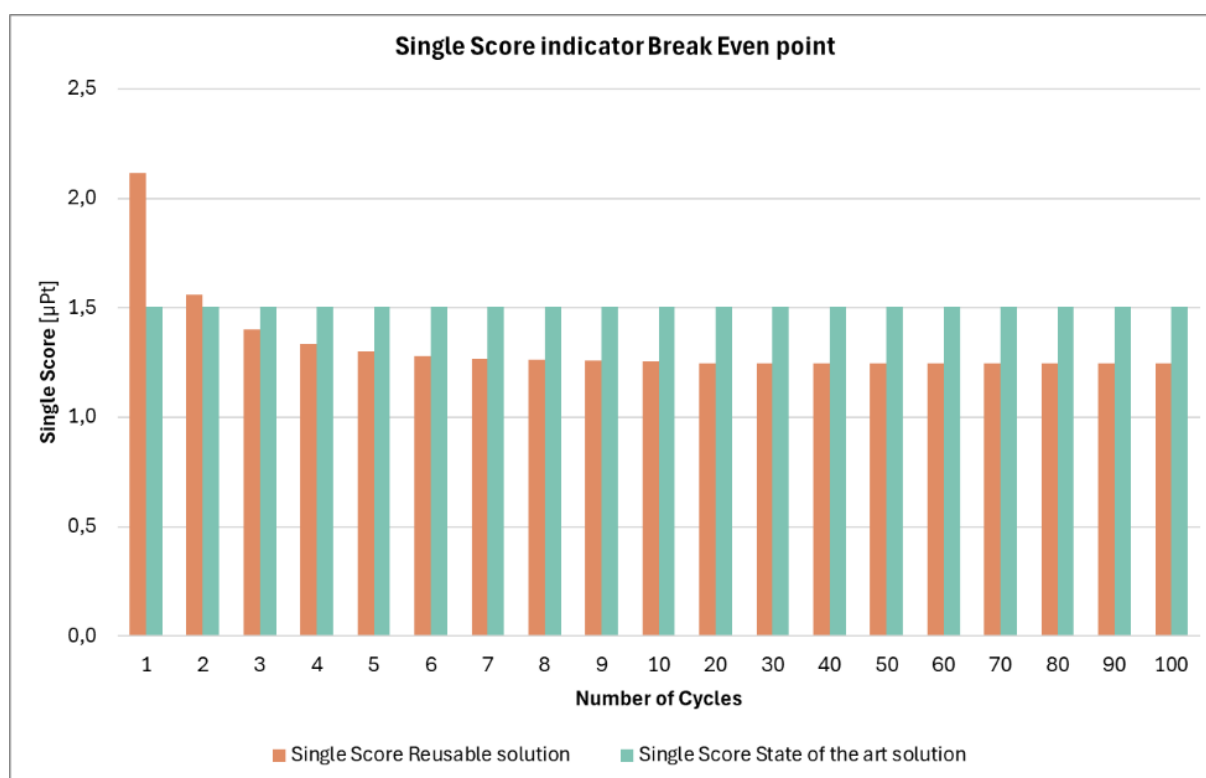


Figure 61: Product15_Single Score Chart_Return_Rate 85,5%



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Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 7) and Reuse System (Fig 8) as the number of cycles varies.

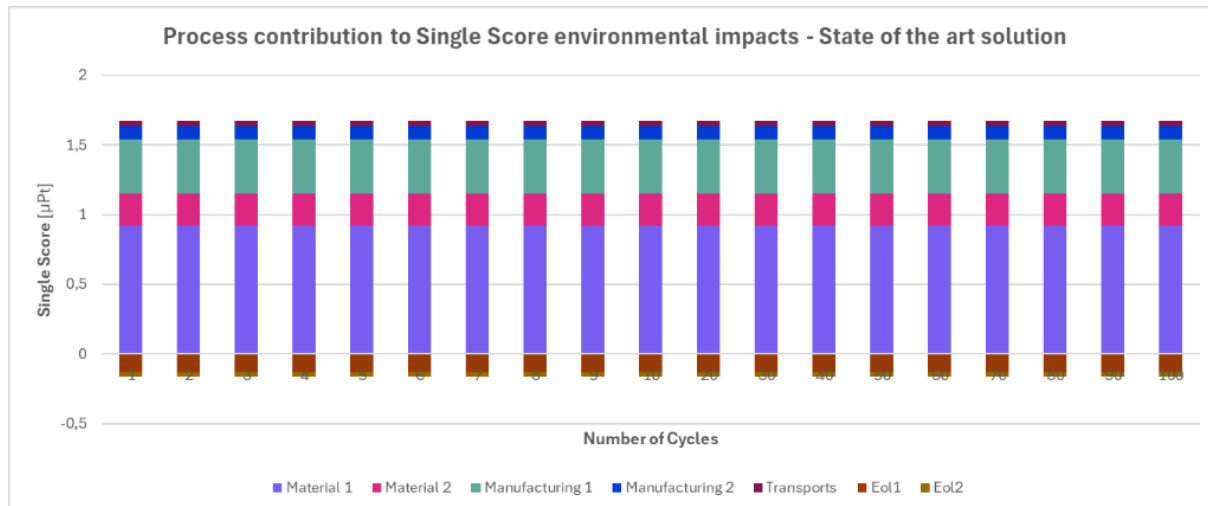


Figure 62: Product15_SingleUse_Weighted Results: Material 1: PP pack; Material 2: PP cup; Manufacturing 1: Pack injection, Manufacturing 2: cup injection.

As shown in Fig 62, in the single-use system (packaging referred to Table 61) shows the greatest impact (61%) for Material 1: PP pack, as it represents the largest proportion of material, associated with its production (Manufacturing 1) representing the 26%.

As shown in Fig 63, reuse system - considering the same packaging (referred to Table 61) - shows that there is almost a tie between the impacts of PP packaging material (34% at the 20th cycle), associated with its production (14% at the 20th cycle), and the impacts of the washing process (32%).

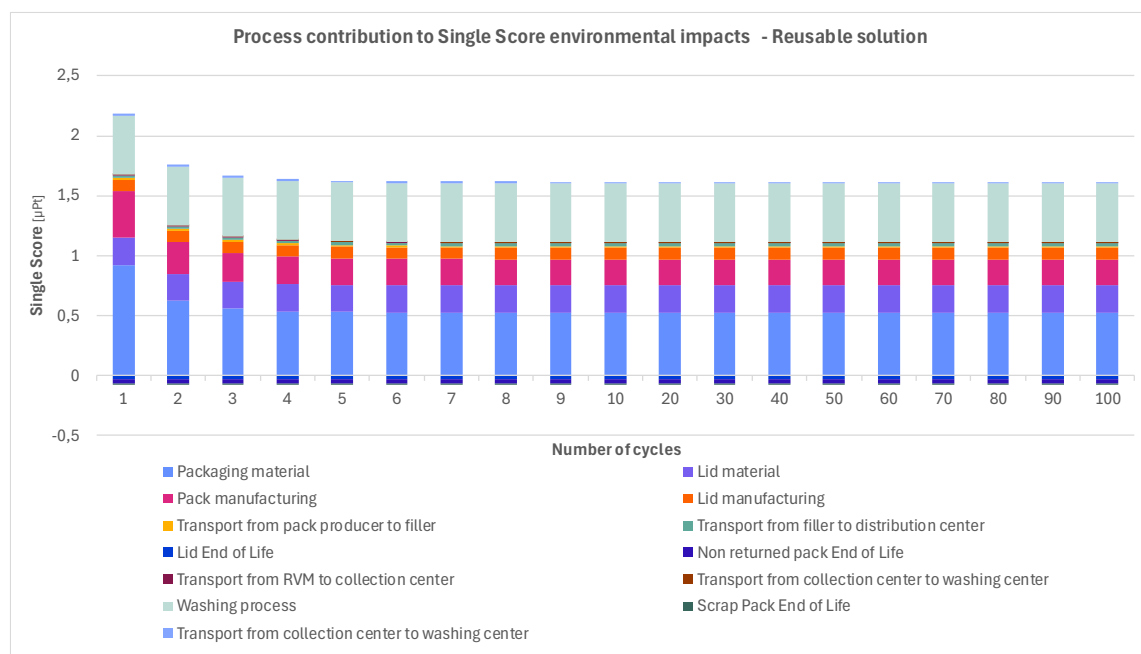


Figure 63: Product15_Reuse_Weighted Results_Return Rate 64,6%

Characterization results comparison



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Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

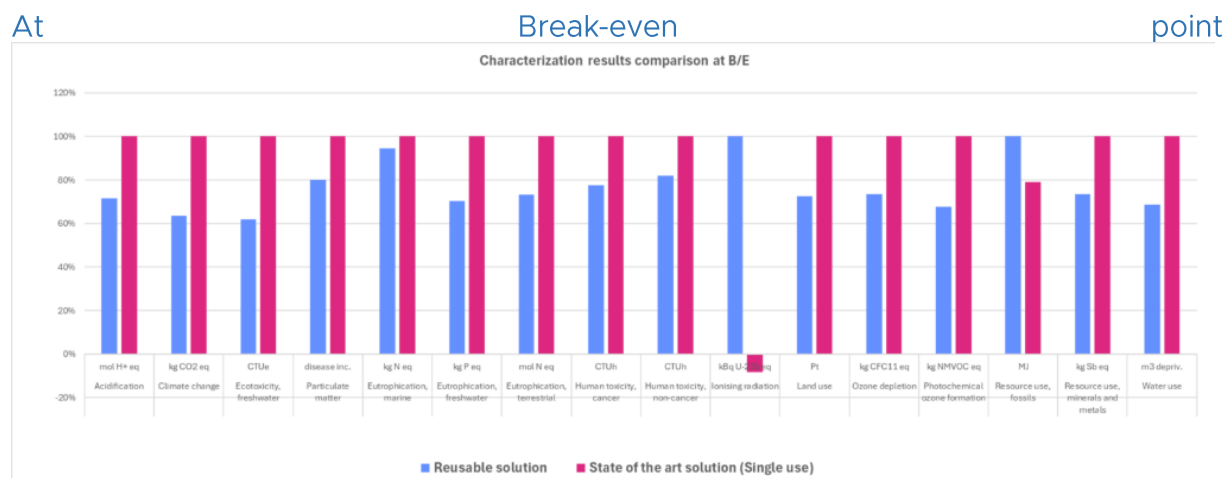


Figure 64: Product15_Graph at 3rd reuse cycle (Break-even point)_Return Rate 85,5%

Table 64: Product15_ Graph at 3rd reuse cycle (Break-even point)_Return Rate 85,5%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H ⁺ eq	3,86E-05	5,39E-05
Climate change	kg CO ₂ eq	1,16E-02	1,83E-02
Ecotoxicity, freshwater	CTUe	8,98E-03	1,45E-02
Particulate matter	disease inc.	3,93E-10	4,91E-10
Eutrophication, marine	kg N eq	1,07E-05	1,14E-05
Eutrophication, freshwater	kg P eq	2,75E-06	3,91E-06
Eutrophication, terrestrial	mol N eq	8,21E-05	1,12E-04
Human toxicity, cancer	CTUh	3,85E-11	4,97E-11
Human toxicity, non-cancer	CTUh	9,61E-11	1,17E-10
Ionising radiation	kBq U-235 eq	9,19E-03	-7,74E-04
Land use	Pt	5,26E-02	7,26E-02
Ozone depletion	kg CFC11 eq	3,68E-10	5,00E-10
Photochemical ozone formation	kg NMVOC eq	4,70E-05	6,93E-05
Resource use, fossils	MJ	4,14E-01	3,27E-01
Resource use, minerals and metals	kg Sb eq	6,92E-08	9,42E-08
Water use	m ³ depriv.	4,15E-03	6,04E-03

At 20-cycle: Flattening the curve

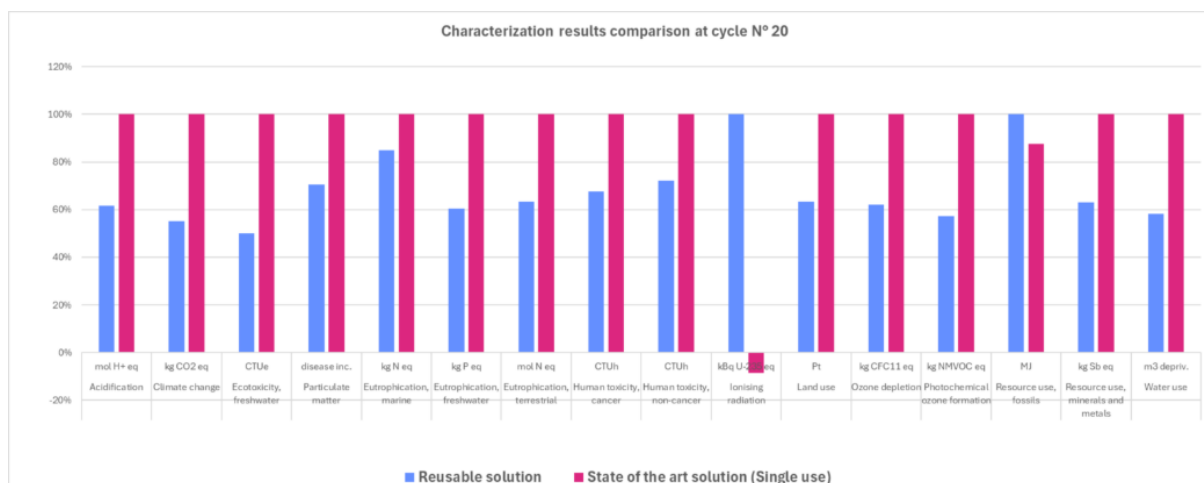


Figure 65: Product15_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 85,5%

Table 65: Product15_Values at 20 reuse cycles (Flattening the curve)_Return Rate 85,5%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	3,32E-05	5,39E-05
Climate change	kg CO2 eq	1,01E-02	1,83E-02
Ecotoxicity, freshwater	CTUe	7,28E-03	1,45E-02
Particulate matter	disease inc.	3,47E-10	4,91E-10
Eutrophication, marine	kg N eq	9,66E-06	1,14E-05
Eutrophication, freshwater	kg P eq	2,36E-06	3,91E-06
Eutrophication, terrestrial	mol N eq	7,10E-05	1,12E-04
Human toxicity, cancer	CTUh	3,35E-11	4,97E-11
Human toxicity, non-cancer	CTUh	8,47E-11	1,17E-10
Ionising radiation	kBq U-235 eq	9,04E-03	-7,74E-04
Land use	Pt	4,60E-02	7,26E-02
Ozone depletion	kg CFC11 eq	3,11E-10	5,00E-10
Photochemical ozone formation	kg NMVOC eq	3,97E-05	6,93E-05
Resource use, fossils	MJ	3,73E-01	3,27E-01
Resource use, minerals and metals	kg Sb eq	5,93E-08	9,42E-08
Water use	m3 depriv.	3,51E-03	6,04E-03

The reuse system has a lower environmental impact for most indicators, with the exception of: Resource use (fossils), due to the electricity used in the washing process and ionising radiation is much lower for the state of the art due to the end-of-life benefits of PP. With CFF, there are benefits in terms of electricity savings through energy recovery from the incineration of material, thus avoiding the production of energy through nuclear power.

2.14. Product 16 - Syrup

The comparison was made using the same packaging, which was inserted into either the single-use or the reuse system:

PRODUCT – Syrup – Glass Bottle

Table 66: PRODUCT 16

Format	Clear glass bottle with PEHD Closure	
Food weight	700 ml	
Company	Monin	
LCA ID	16-r	

Data has been updated from Tab E16. PP-M LCI, PRODUCT 16 – Syrup – Glass Bottle

TABLE E16				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
16	Syrup	1	105,525	/	/	/	/	/
16.1	Glass bottle 70cl	1	105,023	GLASS	White Glass Circular Footprint Formula Dataset	*Data for processing are included in material's dataset	*Data for processing are included in material's dataset	/
16.2	Clip lid	1	0,502	HDPE	Polyethylene, high density, granulate {RER} polyethylene production, high density, granulate Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/

SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 67: PRODUCT 16_Reuse Data Inventory SCENARIO 1

Inventory data	16_SYRUP_GLASS BOTTLE	Unit of Measure
Pack Type	PKG_07	
Pack material	COLOURLESS GLASS CFF	
Pack amount	105,02	g
Lid material	HDPE	
Lid amount	0,50	g
Producer to filler distance	280,86	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	397,61	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	145,53	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	49,69	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Glass	
Washing water [l]	0,13	l
Washing detergent [g]	0,93	g
Washing energy [kWh]	0,03	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	402,54	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 66, the break-even point is reached at a return rate of 64,6%. This is reached in the second reuse cycle. At an ideal return rate of 64,6%, the break-even point is reached, with a difference of 30% in total impacts generated after 20 cycles. The main reason for this lies in the fact that state-of-the-art packaging is represented by a unique solution (see Table 66). In the reuse system, additional processes (washing) and transport shift the impact in the initial cycles, which balances out by the second cycle and reduces the impact in subsequent cycles.

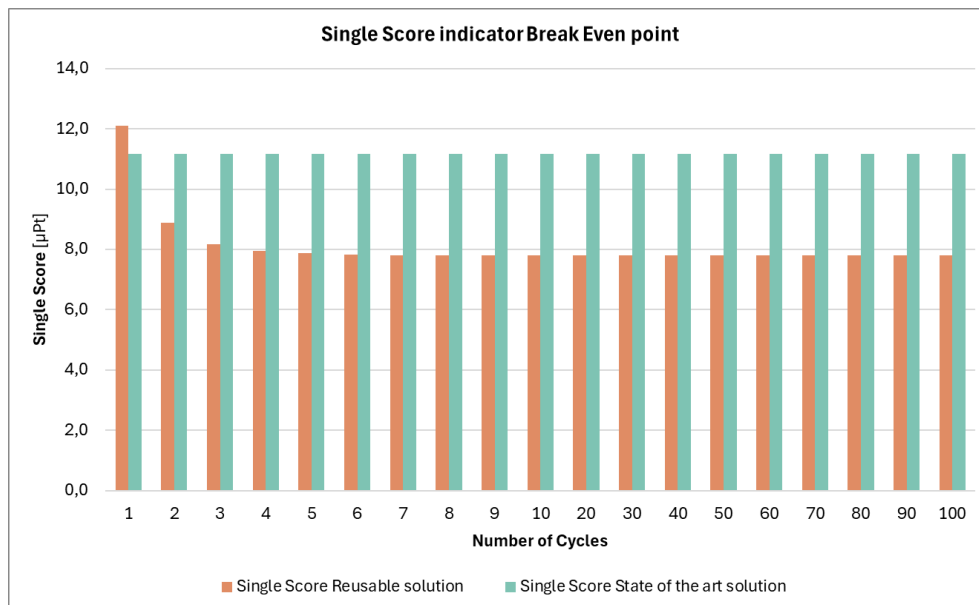


Figure 66: Product16_Single Score Chart_Return_Rate 64,6%



Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 67) and Reuse System (Fig 68) as the number of cycles varies.

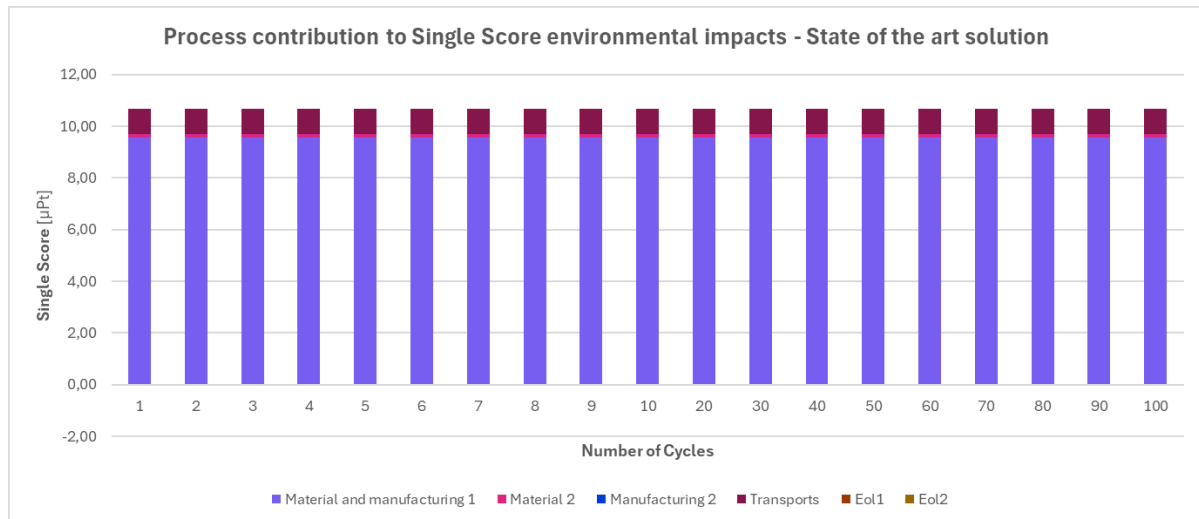


Figure 67: Product16_SingleUse_Weighted Results: Material 1: Glass; Material 2: HDPE;

As shown in Fig 67, the single-use system of the packaging referred to Table 66 shows the greatest impact (90%) for Material 1: glass calculated with its production.

As shown in Fig 68, reuse system - considering the same packaging (referred to Table 66), has the greatest impact (71% at 20th cycle) for Packaging material (glass) which contain production impacts. This is followed by the washing process (12%) and disposable Lid material (2%).

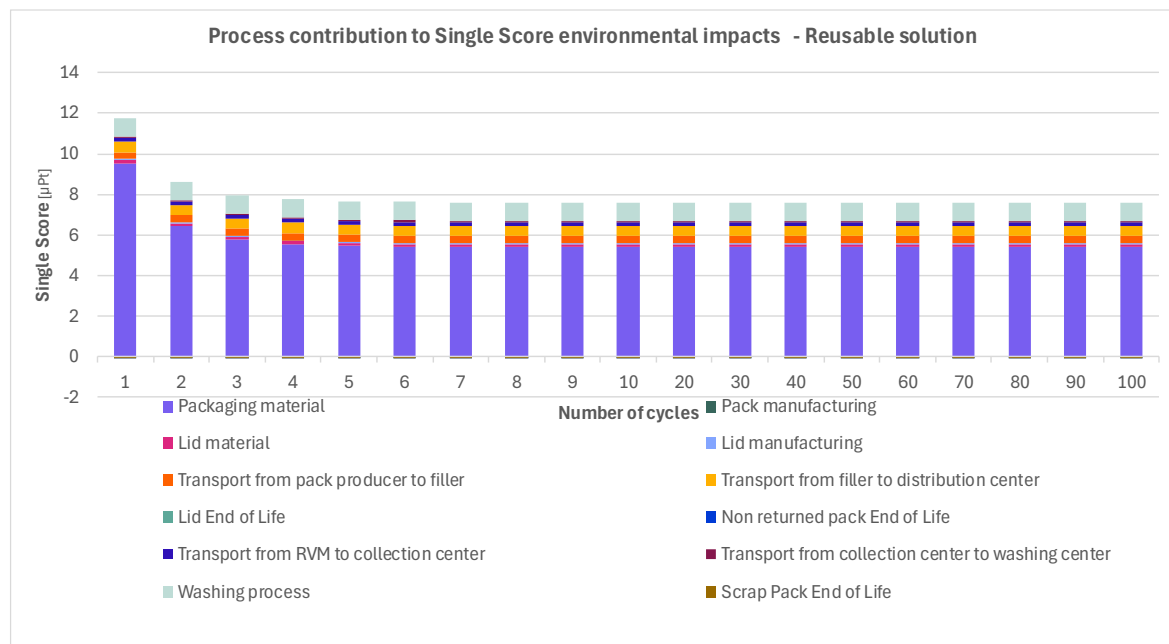


Figure 68: Product16_Reuse_Weighted Results_Return Rate 64,6%



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Characterization results comparison

Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

At Break-even point

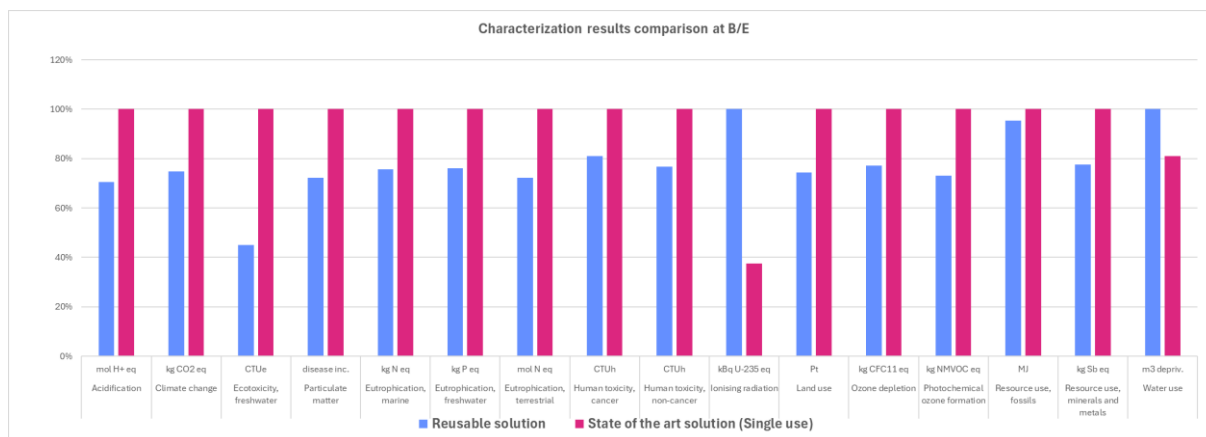


Figure 69: Product16_Graph at 2nd reuse cycles (Break-even point)_Return Rate 64,6%

Table 68: Product16_Graph at 2nd reuse cycles (Break-even point)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	6,42E-04	9,11E-04
Climate change	kg CO2 eq	8,21E-02	1,10E-01
Ecotoxicity, freshwater	CTUe	3,89E-03	8,65E-03
Particulate matter	disease inc.	9,25E-09	1,28E-08
Eutrophication, marine	kg N eq	1,09E-04	1,43E-04
Eutrophication, freshwater	kg P eq	1,15E-05	1,50E-05
Eutrophication, terrestrial	mol N eq	1,15E-03	1,59E-03
Human toxicity, cancer	CTU _h	2,35E-10	2,90E-10
Human toxicity, non-cancer	CTU _h	8,99E-10	1,17E-09
Ionising radiation	kBq U-235 eq	2,21E-02	8,29E-03
Land use	Pt	7,86E-01	1,06E+00
Ozone depletion	kg CFC11 eq	2,12E-09	2,75E-09
Photochemical ozone formation	kg NMVOC eq	3,89E-04	5,33E-04
Resource use, fossils	MJ	1,48E+00	1,55E+00
Resource use, minerals and metals	kg Sb eq	3,66E-07	4,72E-07
Water use	m3 depriv.	1,08E-02	8,73E-03

At 20-cycle: Flattening the curve

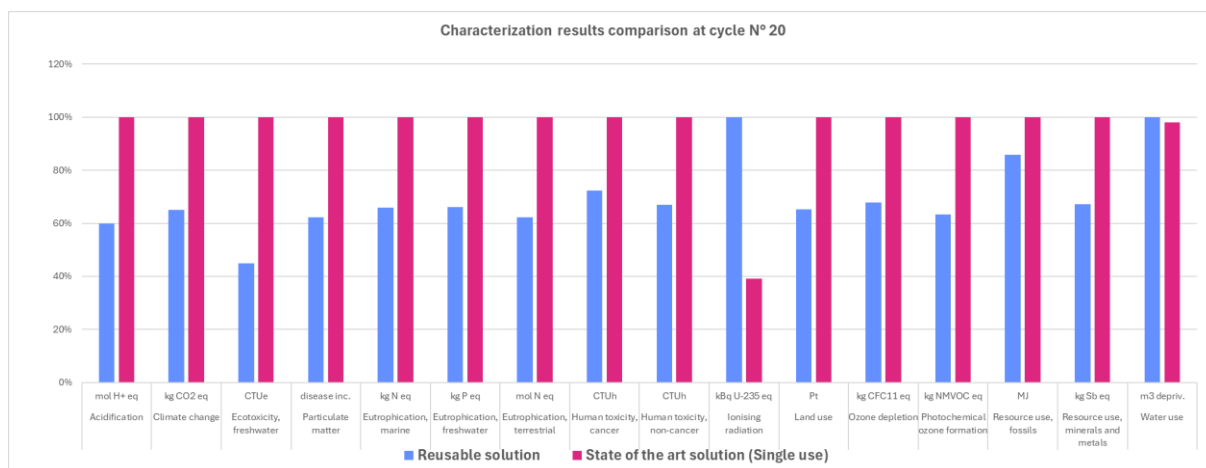


Figure 70: Product16_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 69: Product16_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		Reusable solution	State of the art solution (Single use)
Acidification	mol H+ eq	5,46E-04	9,11E-04
Climate change	kg CO2 eq	7,13E-02	1,10E-01
Ecotoxicity, freshwater	CTUe	3,89E-03	8,65E-03
Particulate matter	disease inc.	7,97E-09	1,28E-08
Eutrophication, marine	kg N eq	9,46E-05	1,43E-04
Eutrophication, freshwater	kg P eq	9,94E-06	1,50E-05
Eutrophication, terrestrial	mol N eq	9,93E-04	1,59E-03
Human toxicity, cancer	CTUh	2,10E-10	2,90E-10
Human toxicity, non-cancer	CTUh	7,84E-10	1,17E-09
Ionising radiation	kBq U-235 eq	2,12E-02	8,29E-03
Land use	Pt	6,89E-01	1,06E+00
Ozone depletion	kg CFC11 eq	1,86E-09	2,75E-09
Photochemical ozone formation	kg NMVOC eq	3,37E-04	5,33E-04
Resource use, fossils	MJ	1,33E+00	1,55E+00
Resource use, minerals and metals	kg Sb eq	3,17E-07	4,72E-07
Water use	m3 depriv.	8,91E-03	8,73E-03

The reuse system has a lower environmental impact for most indicators, with the exception of:

- Ionising radiation, due to the energy-intensive washing process.
- Water use due to the washing processes.

2.15. Product 17 - Mayonnaise

The comparison was made using the same packaging, which was inserted into either the single-use or the reuse system:

STATE OF THE ART – Mayonnaise – Glass Jar + Lid

Table 70: PRODUCT 17

Format	Clear glass jar with metallize closure	
Food weight	475 g	
Company	Lesieur	
LCA ID	17-r	

Data have been updated from Tab E17. PP-M LCI, PRODUCT 17 – Mayonnaise – Glass Jar + Lid

TABLE E17				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
17	Mayonnaise	1	99,498	/	/	/	/	/
17.1	Glass Jar	1	96,234	GLASS	White Glass Circular Footprint Formula Dataset	*Data for processing are included in material's dataset	*Data for processing are included in material's dataset	/
17.2	Twist-off Lid	1	3,264	Tin plated steel	Tin plated chromium steel sheet, 2 mm {RER} tin plated chromium steel sheet production, 2 mm Cut-off, U	Sheet rolling	Sheet rolling, chromium steel {RER} sheet rolling, chromium steel Cut-off, U	/

SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 71: PRODUCT 17_Reuse Data Inventory SCENARIO 1

Inventory data	17_MAYONNAISE_GLASS JAR	Unit of Measure
Pack Type	PKG_08	
Pack material	COLOURLESS GLASS CFF	
Pack amount	96,23	g
Lid material	ALUMINIUM FOIL	
Lid amount	3,26	g
Producer to filler distance	378,08	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	590,26	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	259,99	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance	177,34	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Washing container type	Pot 500g	
Washing water [l]	0,02	l
Washing detergent [g]	0,04	g
Washing energy [kWh]	0,00	kWh
Washing scrap rate	5%	
Transport from washing center to filler distance	616,03	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 71, the break-even point is reached at a return rate of 64,6%. This is reached in the second reuse cycle. At an ideal return rate of 64,6%, the break-even point was reached, with a difference of 30,2% in total impacts generated after 20 cycles. The main reason for this lies in the fact that state-of-the-art packaging is represented by a unique solution (see Table 70). In the reuse system, additional processes (washing) and transport shift the impact in the initial cycles, which balances out by the second cycle and reduces the impact in subsequent cycles.

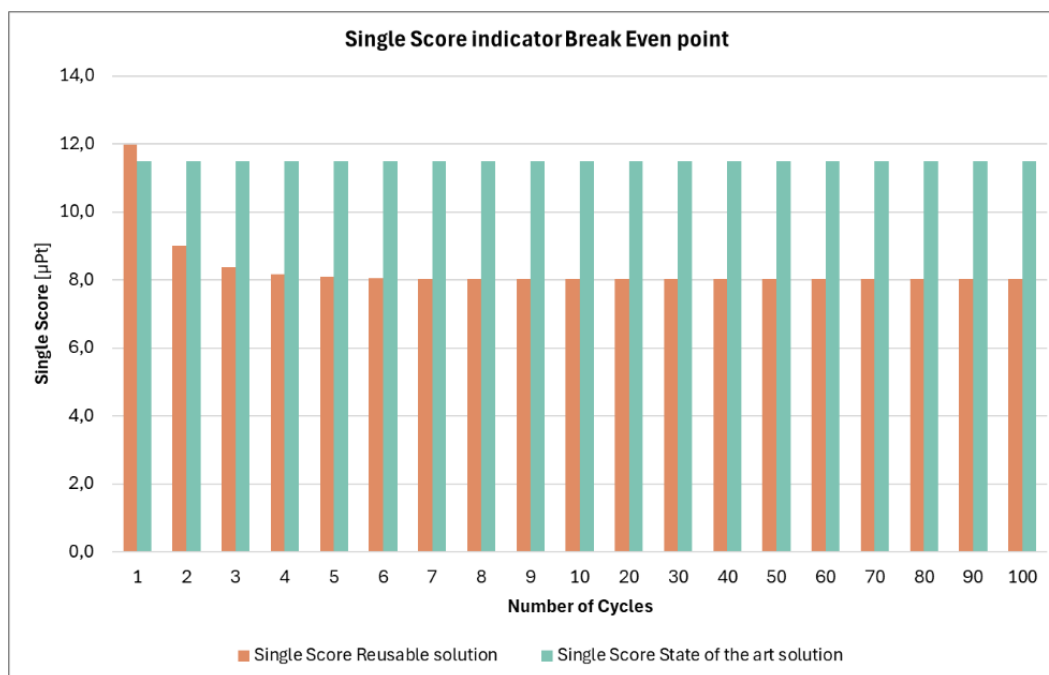


Figure 71: Product17_Single Score Chart_Return_Rate 64,6%



Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 72) and Reuse System (Fig 73) as the number of cycles varies.

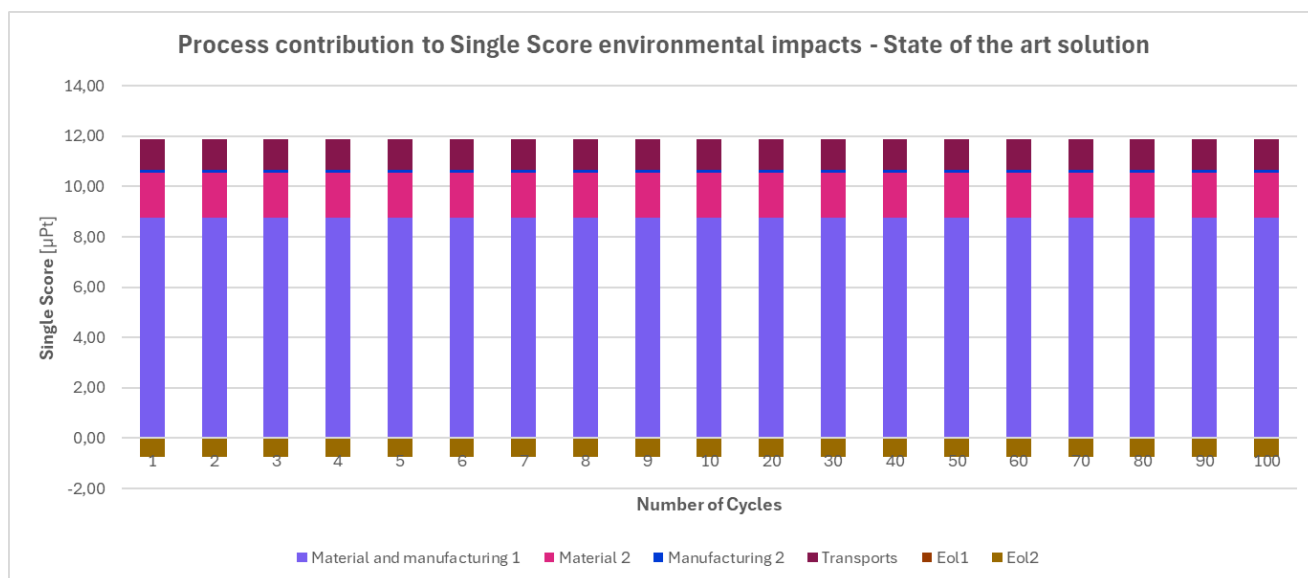


Figure 72: Product17_SingleUse_Weighted Results: Material 1: Glass; Material 2: Tin plated steel

As shown in Fig 72, the single-use system of the packaging referred to Table 70 shows the greatest impact (70%) for Material and Manufacturing 1: glass calculated with its production.

As shown in Fig 73, reuse system - considering the same packaging (referred to Table 70), has the greatest impact (63% at 20th cycle) for Packaging material (glass) which contain production impacts. This is followed by disposable Lid material (23%).

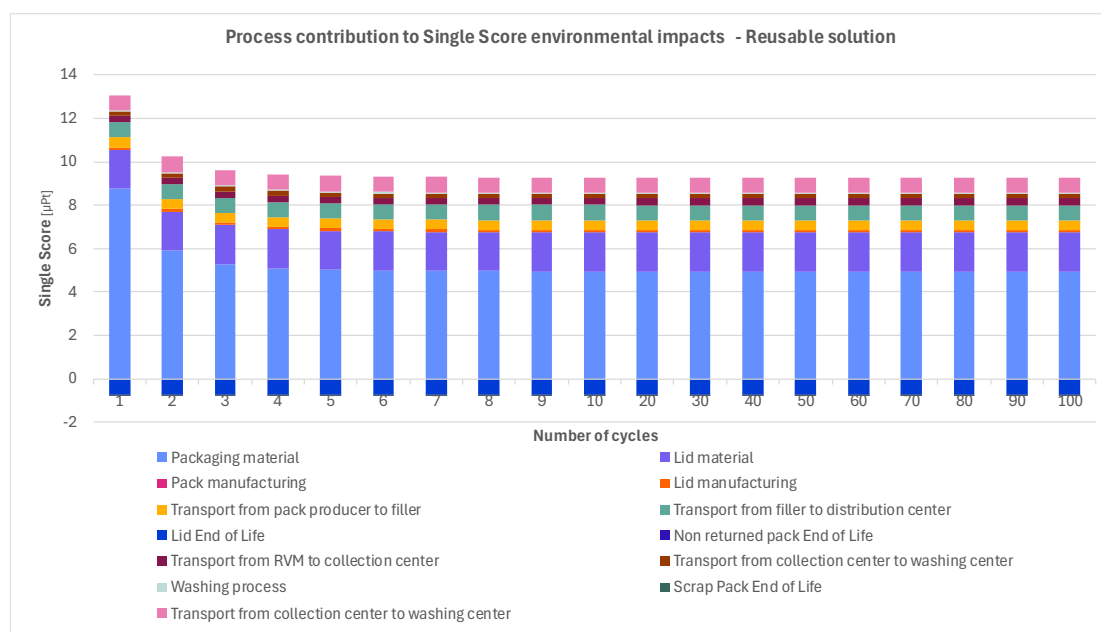


Figure 73: Product17_Reuse_Weighted Results_Return Rate 64,6%



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Characterization results comparison

Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

At Break-even point

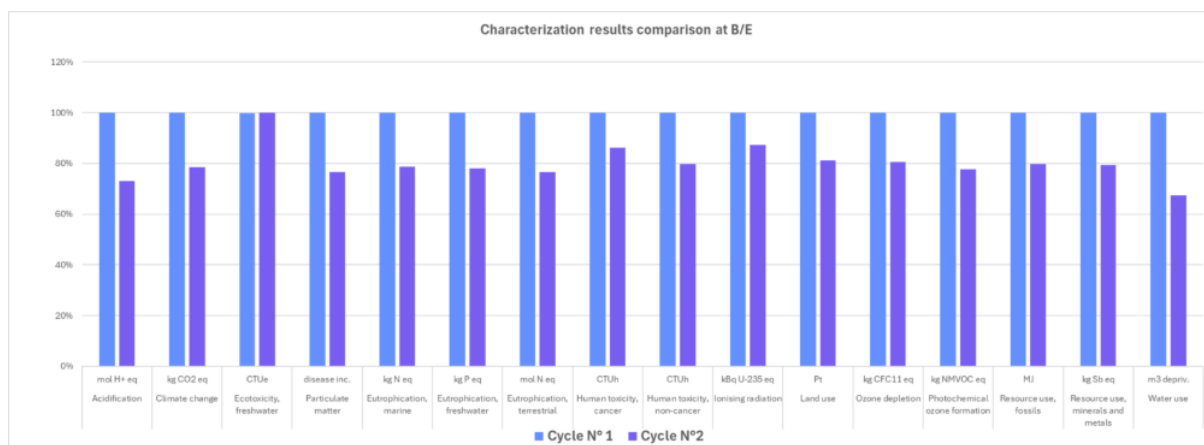


Figure 74: Product17_Graph at 2nd reuse cycles (Break-even point)_Return Rate 64,6%

Table 72: Product17_Values at 2nd reuse cycles (B/E point)_Return Rate 64,6%

		State of the art solution (Single use)	Reusable solution
Acidification	mol H+ eq	9,05E-04	6,62E-04
Climate change	kg CO2 eq	1,12E-01	8,81E-02
Ecotoxicity, freshwater	CTUe	1,96E-01	1,96E-01
Particulate matter	disease inc.	1,28E-08	9,78E-09
Eutrophication, marine	kg N eq	1,45E-04	1,14E-04
Eutrophication, freshwater	kg P eq	1,68E-05	1,31E-05
Eutrophication, terrestrial	mol N eq	1,59E-03	1,22E-03
Human toxicity, cancer	CTUh	3,06E-10	2,63E-10
Human toxicity, non-cancer	CTUh	1,21E-09	9,64E-10
Ionising radiation	kBq U-235 eq	8,58E-03	7,48E-03
Land use	Pt	1,00E+00	8,14E-01
Ozone depletion	kg CFC11 eq	2,63E-09	2,11E-09
Photochemical ozone formation	kg NMVOC eq	5,29E-04	4,11E-04
Resource use, fossils	MJ	1,53E+00	1,23E+00
Resource use, minerals and metals	kg Sb eq	5,63E-07	4,47E-07
Water use	m3 depriv.	1,56E-02	1,05E-02

At 20-cycle: Flattening the curve

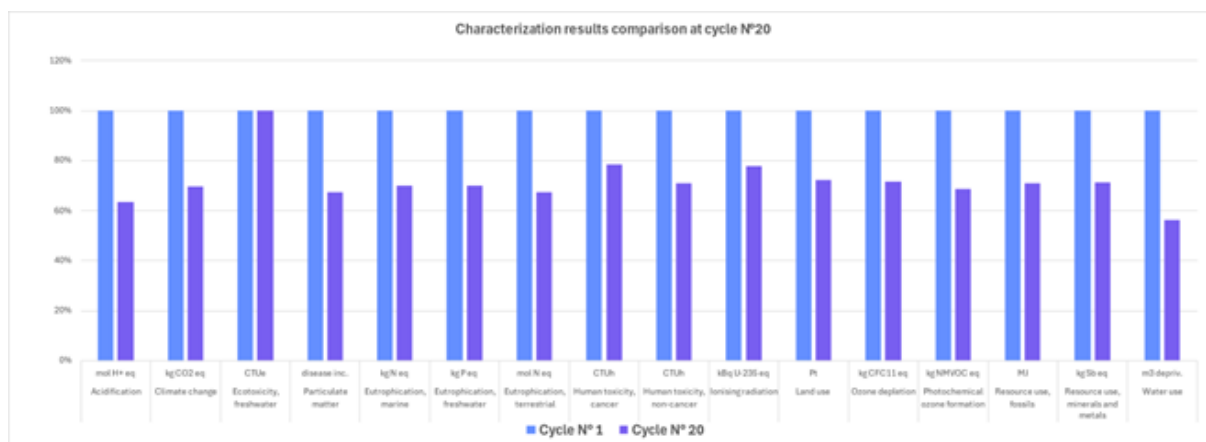


Figure 75: Product15_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 73: Product17_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		Single solution	Reusable solution
Acidification	mol H+ eq	9,05E-04	5,74E-04
Climate change	kg CO2 eq	1,12E-01	7,82E-02
Ecotoxicity, freshwater	CTUe	1,96E-01	1,96E-01
Particulate matter	disease inc.	1,28E-08	8,60E-09
Eutrophication, marine	kg N eq	1,45E-04	1,01E-04
Eutrophication, freshwater	kg P eq	1,68E-05	1,17E-05
Eutrophication, terrestrial	mol N eq	1,59E-03	1,07E-03
Human toxicity, cancer	CTUh	3,06E-10	2,40E-10
Human toxicity, non-cancer	CTUh	1,21E-09	8,59E-10
Ionising radiation	kBq U-235 eq	8,58E-03	6,68E-03
Land use	Pt	1,00E+00	7,26E-01
Ozone depletion	kg CFC11 eq	2,63E-09	1,88E-09
Photochemical ozone formation	kg NMVOC eq	5,29E-04	3,63E-04
Resource use, fossils	MJ	1,53E+00	1,09E+00
Resource use, minerals and metals	kg Sb eq	5,63E-07	4,02E-07
Water use	m3 depriv.	1,56E-02	8,78E-03

The reuse system has a lower environmental impact in most areas, except for ecotoxicity, due to the washing process and the energy involved.

2.16. Product 18 – Olive oil

The comparison was made using the same packaging, which was inserted into either the single-use or the reuse system:

STATE OF THE ART – Olive Oil – Glass bottle

Table 74: PRODUCT 18

Format	Glass bottle with PEHD closure	
Food weight	250 ml	
Company	Lesieur	
LCA ID	18-r	

Inventory data have been updated in Tab E18. PP-M LCI, PRODUCT 18 – Olive Oil – Glass bottle (*It was considered that the pourer is discarded during washing, while the clip lid is discarded by the consumer.)

*Data for processing are included in material's dataset TABLE E18				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
18	Olive oil	1	69,2	/	/	/	/	/
18.1	Glass Bottle	1	64	GLASS	White Glass Circular Footprint Formula Dataset	Blow Moulding	*Data for processing are included in material's dataset	/
18.2	Clip lid	1	2	Aluminium	Aluminium alloy, AlMg3 {GLO} market for Cut-off, U	Sheet rolling	Sheet rolling, aluminium {RER} processing Cut-off, U	- Water, unspecified natural origin, FR; - Electricity, medium voltage {FR} market for Cut-off, U
18.3	Pourer	1	3,2	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/

SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 75: PRODUCT 18_Reuse Data Inventory SCENARIO 1

Inventory data	18_OLIVE OIL BOTTLE	Unit of Measure
Pack Type	PKG_09	
Pack material	COLOURLESS GLASS CFF	
Pack amount	64,00	g
Lid material	ALUMINIUM FOIL	
Lid amount	2,00	g
Producer to filler distance	226,80	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	585,43	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	259,99	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance2	177,34	km
Transport from RVM to collection center mean of transport2	Truck transport, average	
Washing container type	Glass	
Washing water [l]	0,13	l
Washing detergent [g]	0,93	g
Washing energy [kWh]	0,03	kWh
Washing scrap rate	0,05	
Lid material 2	PP	
Lid amount 2	3,2	g
Transport from washing center to filler distance	616,0285	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 76, the break-even point is reached at a return rate of 64,6%. This is reached in the second reuse cycle.

At an ideal return rate of 64,6%, the break-even point was reached, with a difference of 16,9% in total impacts generated after 20 cycles.

The main reason for this lies in the fact that state-of-the-art packaging is represented by a unique solution (see Table 74). In the reuse system, additional processes (washing) and transport shift the impact in the initial cycles, which balances out by the second cycle and reduces the impact in subsequent cycles.

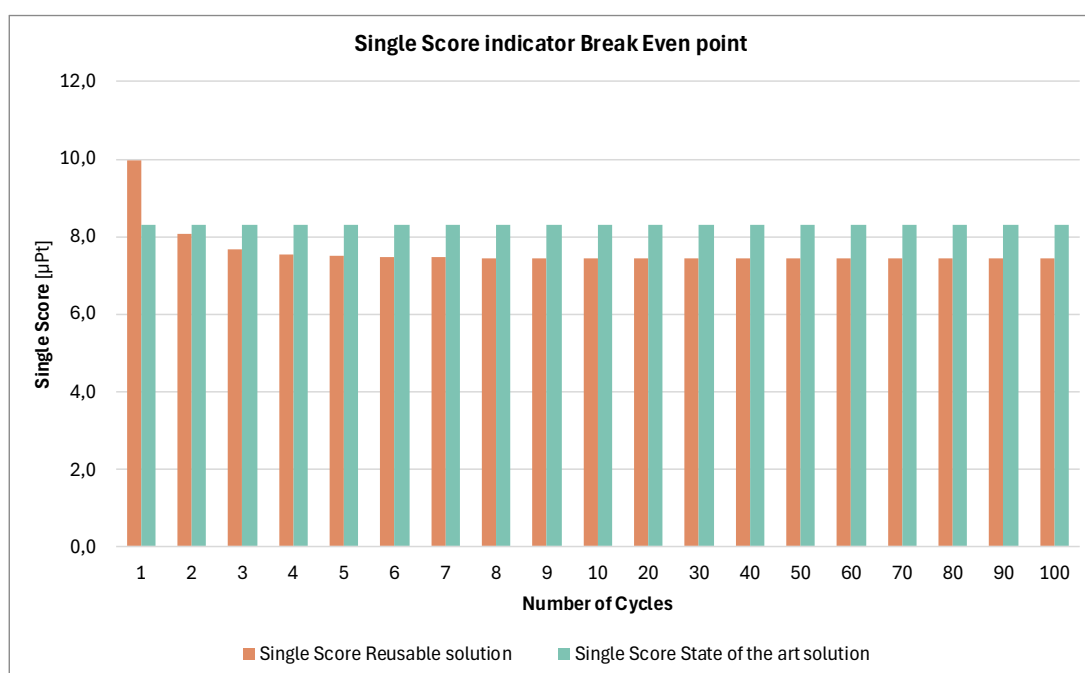


Figure 76: Product18_Single Score Chart_Return_Rate 64,6%

Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 77) and Reuse System (Fig 78) as the number of cycles varies.

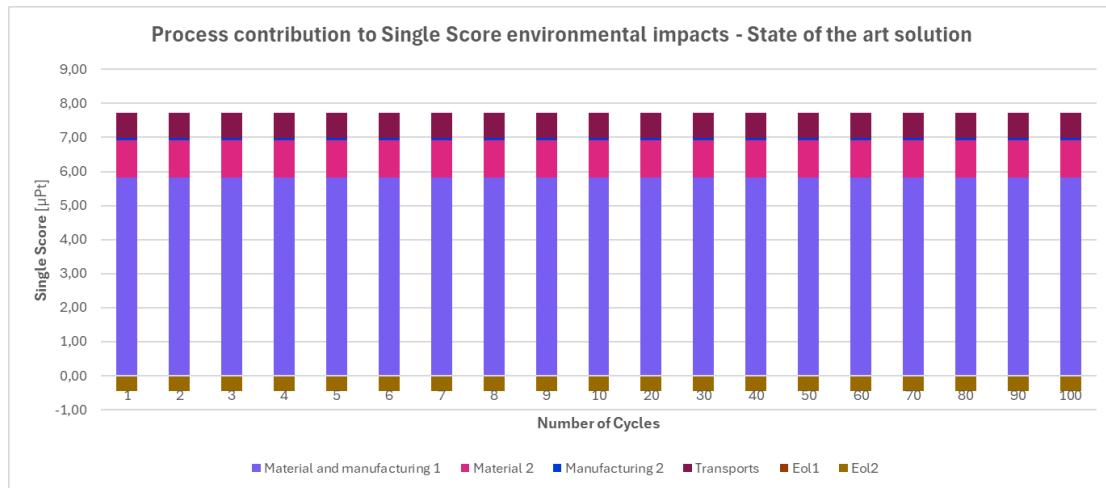


Figure 77: Product18_SingleUse_Weighted Results: Material 1: Glass Bottle, Material 2: Aluminium Clip lid, Material 3: PP Pourer; Manufacturing 1: Metal Sheet rolling; Manufacturing 2: Injection moulding.

As shown in Fig 77, the single-use system of the packaging referred to Table 74 shows the greatest impact (70%) for Material and Manufacturing 1: glass calculated with its production.

As shown in Fig 78, reuse system - considering the same packaging (referred to Table 74), has the greatest impact (47% at 20th cycle) for Packaging material (glass) which contain production impacts. This is followed by disposable Lid material divided as follows: Aluminium clip lid (16%) plus 1% for its Manufacturing; Plastic Pourer 12% plus 5% for its Manufacturing.

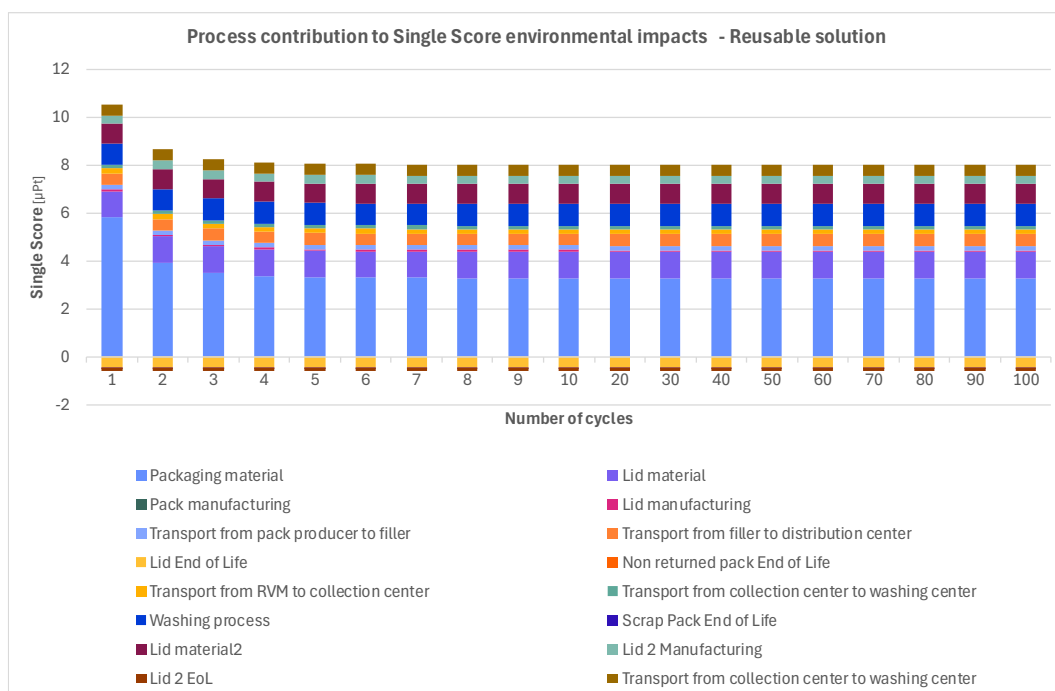


Figure 78: Product18_Reuse_Weighted Results_Return Rate 64,6%



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Characterization results comparison

Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

At Break-even point

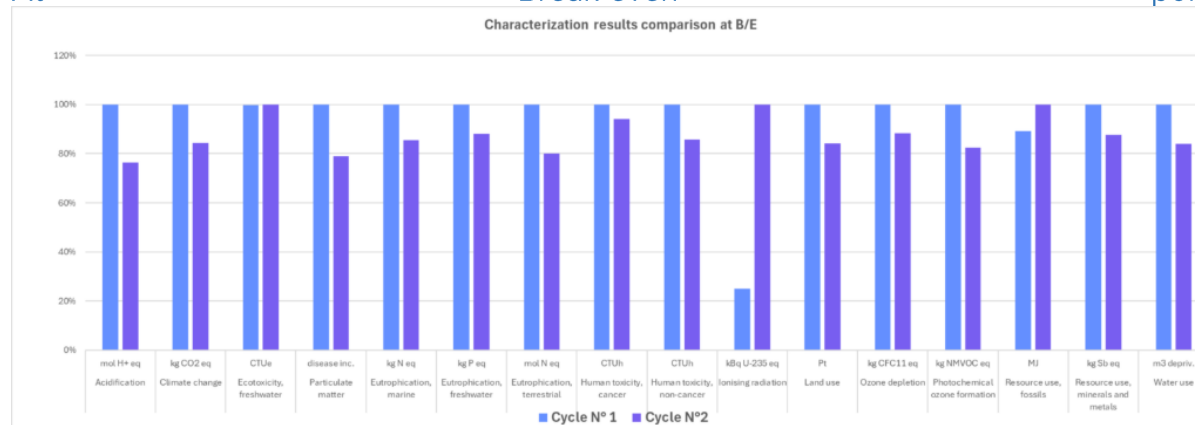


Figure 79: Product18_Graph at 2nd reuse cycles (Break-even point)_Return Rate 64,6%

Table 76: Product18_Values at at 2nd reuse cycles (Break-even point)_Return Rate 64,6%

		State of the art solution (Single use)	Reusable solution
Acidification	mol H+ eq	6,34E-04	4,84E-04
Climate change	kg CO2 eq	8,62E-02	7,28E-02
Ecotoxicity, freshwater	CTUe	1,31E-01	1,31E-01
Particulate matter	disease inc.	8,69E-09	6,86E-09
Eutrophication, marine	kg N eq	1,02E-04	8,74E-05
Eutrophication, freshwater	kg P eq	1,37E-05	1,21E-05
Eutrophication, terrestrial	mol N eq	1,12E-03	8,98E-04
Human toxicity, cancer	CTUh	2,32E-10	2,18E-10
Human toxicity, non-cancer	CTUh	8,69E-10	7,45E-10
Ionising radiation	kBq U-235 eq	5,07E-03	2,03E-02
Land use	Pt	7,02E-01	5,91E-01
Ozone depletion	kg CFC11 eq	2,06E-09	1,82E-09
Photochemical ozone formation	kg NMVOC eq	3,95E-04	3,25E-04
Resource use, fossils	MJ	1,23E+00	1,39E+00
Resource use, minerals and metals	kg Sb eq	4,32E-07	3,79E-07
Water use	m3 depriv.	1,45E-02	1,22E-02

At 20-cycle: Flattening the curve

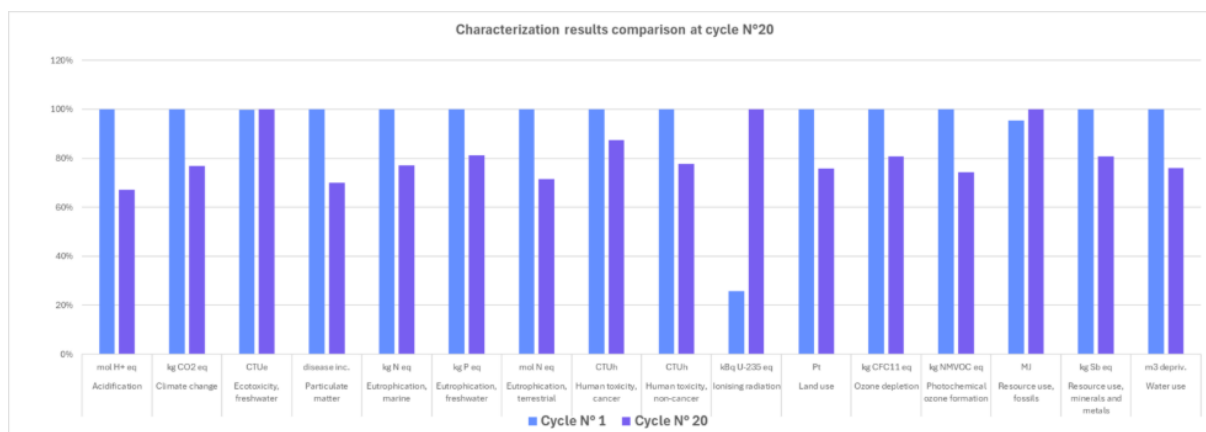


Figure 80: Product18_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 77: Product18_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		State of the art solution (Single use)	Reusable solution
Acidification	mol H+ eq	6,34E-04	4,25E-04
Climate change	kg CO2 eq	8,62E-02	6,63E-02
Ecotoxicity, freshwater	CTUe	1,31E-01	1,31E-01
Particulate matter	disease inc.	8,69E-09	6,07E-09
Eutrophication, marine	kg N eq	1,02E-04	7,89E-05
Eutrophication, freshwater	kg P eq	1,37E-05	1,12E-05
Eutrophication, terrestrial	mol N eq	1,12E-03	8,01E-04
Human toxicity, cancer	CTUh	2,32E-10	2,03E-10
Human toxicity, non-cancer	CTUh	8,69E-10	6,75E-10
Ionising radiation	kBq U-235 eq	5,07E-03	1,98E-02
Land use	Pt	7,02E-01	5,32E-01
Ozone depletion	kg CFC11 eq	2,06E-09	1,66E-09
Photochemical ozone formation	kg NMVOC eq	3,95E-04	2,94E-04
Resource use, fossils	MJ	1,23E+00	1,29E+00
Resource use, minerals and metals	kg Sb eq	4,32E-07	3,49E-07
Water use	m3 depriv.	1,45E-02	1,11E-02

The reuse system has a lower environmental impact in most areas, except for ionising radiation, resource use and fossil fuels. This is due to the increased electricity usage during the washing phase of the French mix (which uses nuclear energy).

2.17. Product 19 - Cider

The comparison was made using the same packaging, which was inserted into either the single-use or the reuse system:

STATE OF THE ART – Sweet Cyder – Glass Bottle

Table 78: PRODUCT 19

Format	Glass bottle with corp and metal lid	
Food weight	750 ml	
Company	Eclor	
LCA ID	Glass bottle with corp and metal lid	

Inventory data have been updated in Tab Tab E19. PP-M LCI, PRODUCT 19 – Sweet Cyder – Glass Bottle

TABLE E19				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
19	Brut Cyder	1	76,249	/	/	/	/	/
19.1	Glass Bottle	1	74,667	Green Glass	Green Glass Circular Footprint Formula Dataset	Blow Moulding	*Data for processing are included in material's dataset	/
19.2	Cork stopper	1	0,949	Cork	Cork, raw {RoW} cork forestry Cut-off, U	Shaping	Bark {Europe without Switzerland} sawing, softwood Cut-off, U	/
19.3	Metallic Wire	1	0,633	Steel	Steel, low-alloyed {GLO} market for steel, low-alloyed Cut-off, U	Wire Drawing	Wire drawing, steel {RER} wire drawing, steel Cut-off, U	/



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SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 79: PRODUCT 19_Reuse Data Inventory SCENARIO 1

Inventory data	19_SWEET CYDER	Unit of Measure
Pack Type	PKG_10	
Pack material	GREEN GLASS CFF	
Pack amount	74,67	g
Lid material	CORK	
Lid amount	0,95	g
Producer to filler distance	280,03	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	352,59	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	157,01	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance2	49,69	km
Transport from RVM to collection center mean of transport2	Truck transport, average	
Washing container type	Glass	
Washing water [l]	0,13	l
Washing detergent [g]	0,93	g
Washing energy [kWh]	0,03	kWh
Washing scrap rate	0,05	
Lid material 2	STEEL	
Lid amount 2	0,633	g
Transport from washing center to filler distance	422,0525	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig 81, the break-even point is reached at a return rate of 64,6%. This is reached in the second reuse cycle. At an ideal return rate of 64,6%, the break-even point was reached, with a difference of 25.8% in total impacts generated after 20 cycles. The main reason for this lies in the fact that state-of-the-art packaging is represented by a unique solution (see Table 78). In the reuse system, additional processes (washing) and transport shift the impact in the initial cycles, which balances out by the second cycle and reduces the impact in subsequent cycles.

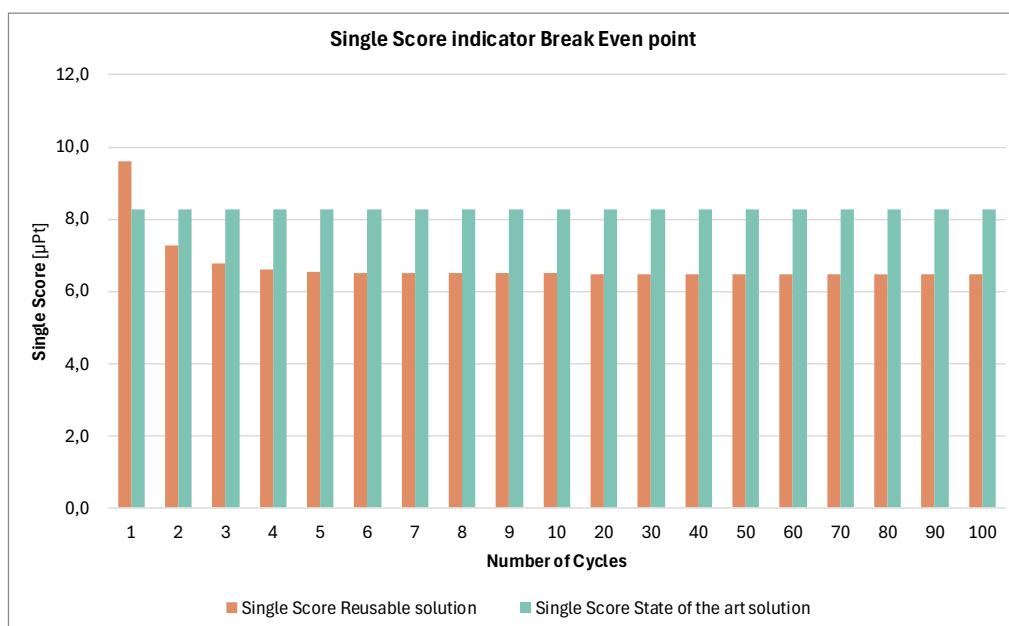


Figure 81: Product19_Single Score Chart_Return_Rate 64,6%



Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 84) and Reuse System (Fig 85) as the number of cycles varies.

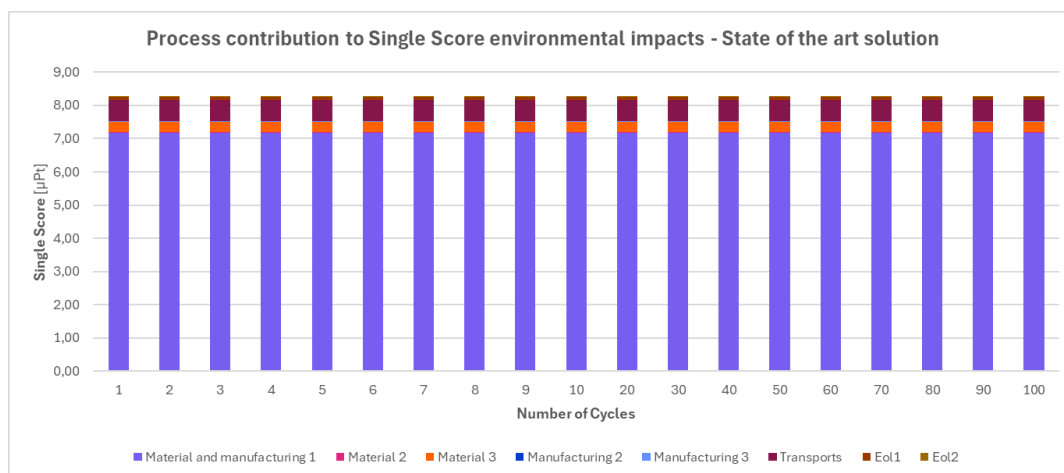


Figure 82: Product19_SingleUse_Weighted Results: Material 1: Glass Bottle; Material 2: Cork stopper; Material 3: Metallic Wire; Manufacturing 1: Cork Shaping; Manufacturing 2: Wire Drawing

As shown in Fig 82, the single-use system of the packaging referred to Table 78 shows the greatest impact (87%) for Material and Manufacturing 1: glass calculated with its production.

As shown in Fig 83, reuse system - considering the same packaging (referred to Table 78), has the greatest impact (66% at 20th cycle) for Packaging material (glass) which contain production impacts. This is followed by washing process (15%). Disposable lid impact represents the 5% of the total impacts.

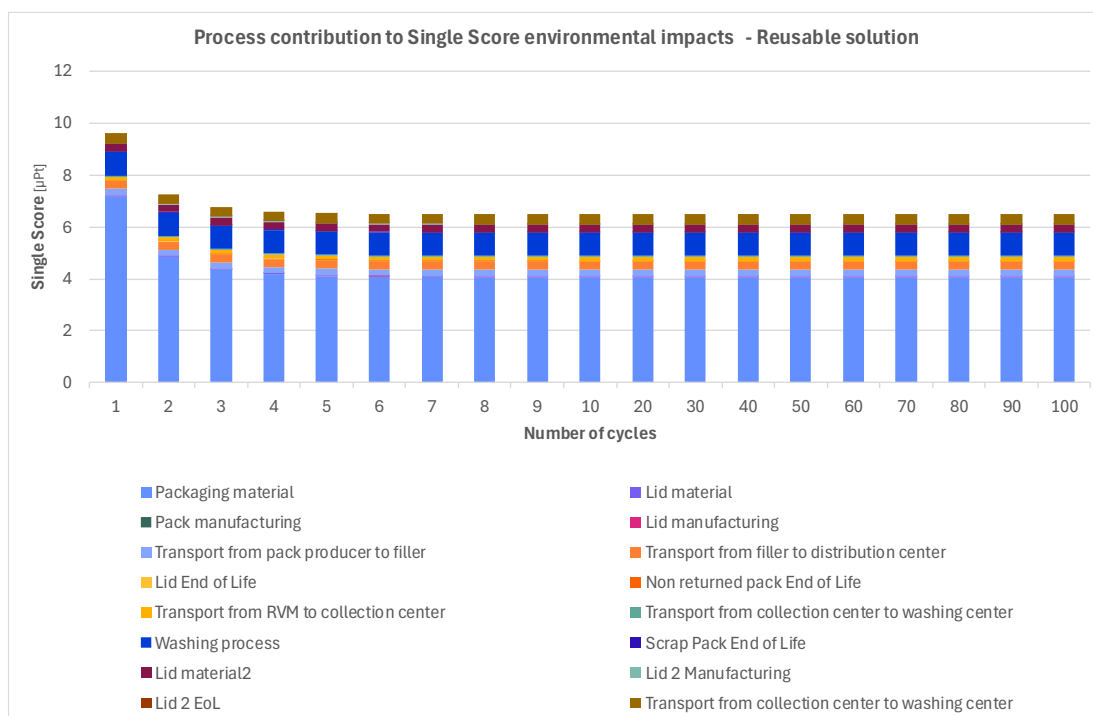


Figure 83: Product19_Reuse_Weighted Results Return Rate 64,6%



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Characterization results comparison

Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

At Break-even point

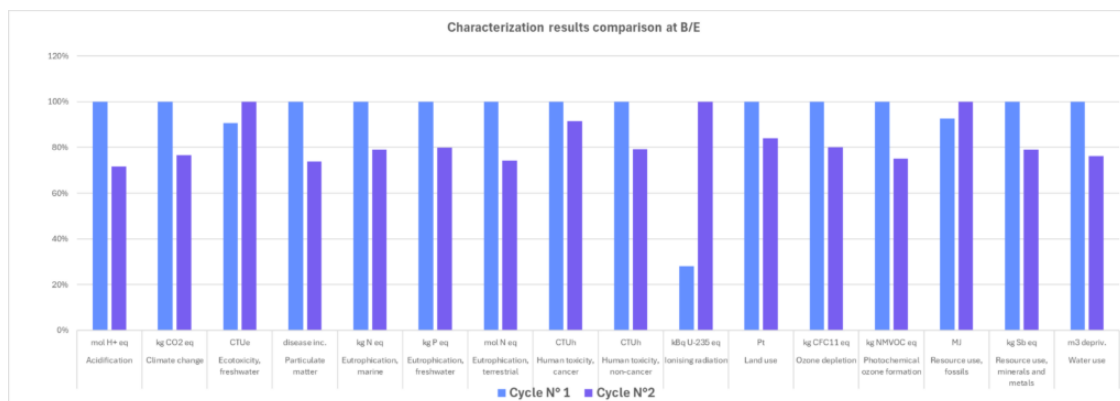


Figure 84: Product19_Graph at 2nd reuse cycles (Break-even point)_Return Rate 64,6%

Table 80: Product19_Values at at 2nd reuse cycles (Break-even point)_Return Rate 64,6%

		State of the art solution (Single use)	Reusable solution
Acidification	mol H+ eq	6,48E-04	4,64E-04
Climate change	kg CO2 eq	7,78E-02	5,96E-02
Ecotoxicity, freshwater	CTUe	1,01E-02	1,12E-02
Particulate matter	disease inc.	9,08E-09	6,71E-09
Eutrophication, marine	kg N eq	1,01E-04	7,95E-05
Eutrophication, freshwater	kg P eq	1,11E-05	8,87E-06
Eutrophication, terrestrial	mol N eq	1,13E-03	8,37E-04
Human toxicity, cancer	CTUh	3,39E-10	3,10E-10
Human toxicity, non-cancer	CTUh	8,52E-10	6,75E-10
Ionising radiation	kBq U-235 eq	5,82E-03	2,08E-02
Land use	Pt	1,01E+00	8,44E-01
Ozone depletion	kg CFC11 eq	1,87E-09	1,50E-09
Photochemical ozone formation	kg NMVOC eq	3,71E-04	2,79E-04
Resource use, fossils	MJ	1,07E+00	1,15E+00
Resource use, minerals and metals	kg Sb eq	3,52E-07	2,78E-07
Water use	m3 depriv.	1,26E-02	9,56E-03

At 20-cycle: Flattening the curve

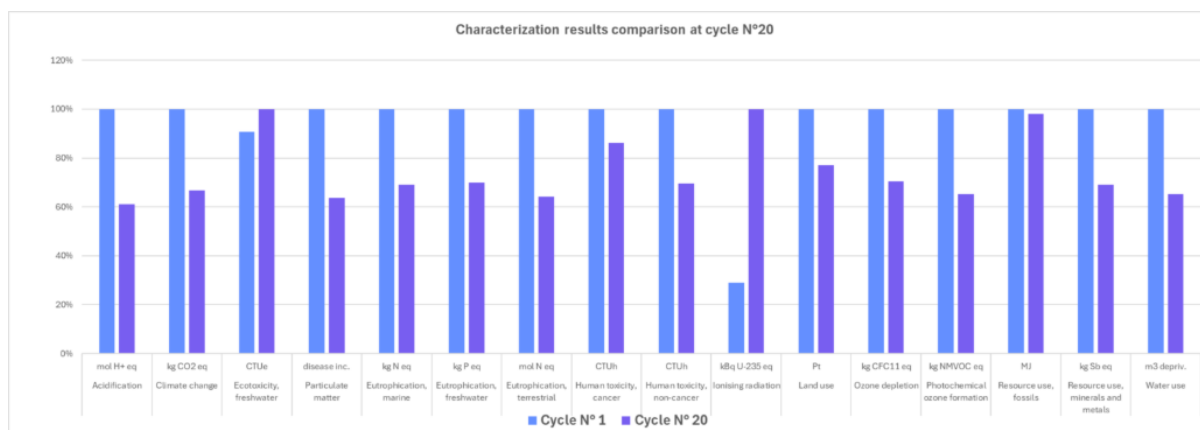


Figure 85: Product19_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 81: Product19_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		State of the art solution (Single use)	Reusable solution
Acidification	mol H+ eq	6,48E-04	3,96E-04
Climate change	kg CO2 eq	7,78E-02	5,19E-02
Ecotoxicity, freshwater	CTUe	1,01E-02	1,12E-02
Particulate matter	disease inc.	9,08E-09	5,79E-09
Eutrophication, marine	kg N eq	1,01E-04	6,95E-05
Eutrophication, freshwater	kg P eq	1,11E-05	7,78E-06
Eutrophication, terrestrial	mol N eq	1,13E-03	7,23E-04
Human toxicity, cancer	CTUh	3,39E-10	2,92E-10
Human toxicity, non-cancer	CTUh	8,52E-10	5,93E-10
Ionising radiation	kBq U-235 eq	5,82E-03	2,01E-02
Land use	Pt	1,01E+00	7,76E-01
Ozone depletion	kg CFC11 eq	1,87E-09	1,32E-09
Photochemical ozone formation	kg NMVOC eq	3,71E-04	2,42E-04
Resource use, fossils	MJ	1,07E+00	1,04E+00
Resource use, minerals and metals	kg Sb eq	3,52E-07	2,43E-07
Water use	m3 depriv.	1,26E-02	8,19E-03

The reuse system has a lower environmental impact in most categories, except for ionising radiation and freshwater eutrophication. The former is due to the greater use of electricity in the French nuclear energy mix during the washing phase, and the latter is due to the washing phase itself.

2.18. Product 20 - Lemonade

The comparison was made using the same packaging, which was inserted into either the single-use or the reuse system:

STATE OF THE ART – Brut cider – Glass Bottle

Table 82: PRODUCT 20

Format	Glass bottle with corp and metal lid	
Food weight	750 ml	
Company	Eclor	
LCA ID	20-r	

Inventory data have been updated in Tab E20. PP-M LCI, PRODUCT 20 – Brut cider – Glass Bottle

TABLE E20				PRE-PROCESSING		MANUFACTURING		
ID	Description	Quantity	Weight per 100g of product [g]	Material	Material (ecoinvent dataset)	Processing	Processing (Original ecoinvent dataset)	Processing variations (available FR datasets)
20	Brut Cyder	1	77,667	/	/	/	/	/
20.1	Glass Bottle	1	74,667	GLASS	White Glass Circular Footprint Formula Dataset	Blow Moulding	*Data for processing are included in material's dataset	/
20.2	Plastic Stopper	1	1	PP	Polypropylene, granulate {RER} production Cut-off, U	Injection Moulding	Injection moulding {GLO} market for injection moulding Cut-off, U	/
20.3	Metallic Wire	1	2	Metal	Steel, low-alloyed {GLO} market for steel, low-alloyed Cut-off, U	Wire Drawing	Wire drawing, steel {RER} wire drawing, steel Cut-off, U	/

SCENARIO 1: RETURN RATE 70% SCRAP RATE 5% (64,6%)

Table 83: PRODUCT 20_Reuse Data Inventory SCENARIO 1

Inventory data	20_BRUT CYDER	Unit of Measure
Pack Type	PKG_10	
Pack material	GREEN GLASS CFF	
Pack amount	74,67	g
Lid material	PP	
Lid amount	1,00	g
Producer to filler distance	280,03	km
Producer to filler mean of transport	Truck transport, average	
Filler to distribution center distance	352,59	km
Filler to distribution center mean of transport	Truck transport, average	
Distribution center to shop distance	62,84	km
Distribution center to shop mean of transport	Truck transport, average	
Use return rate	70%	
RVM energy consumption	0,01	kWh
Transport from RVM to collection center distance	157,01	km
Transport from RVM to collection center mean of transport	Truck transport, average	
Transport from RVM to collection center distance2	49,69	km
Transport from RVM to collection center mean of transport2	Truck transport, average	
Washing container type	Glass	
Washing water [l]	0,13	l
Washing detergent [g]	0,93	g
Washing energy [kWh]	0,03	kWh
Washing scrap rate	0,05	
Lid material 2	STEEL	
Lid amount 2	2	g
Transport from washing center to filler distance	422,0525	km
Transport from washing center to filler mean of transport	Truck transport, average	



RESULTS

Single Score chart and results comment

As shown in Fig.86, the break-even point is reached at a return rate of 64,6%. This is reached in the second reuse cycle.

At an ideal return rate of 64,6%, the break-even point was reached, with a difference of 22.9% in total impacts generated after 20 cycles.

The main reason for this lies in the fact that state-of-the-art packaging is represented by a unique solution (see Table 82). In the reuse system, additional processes (washing) and transport shift the impact in the initial cycles, which balances out by the second cycle and reduces the impact in subsequent cycles.

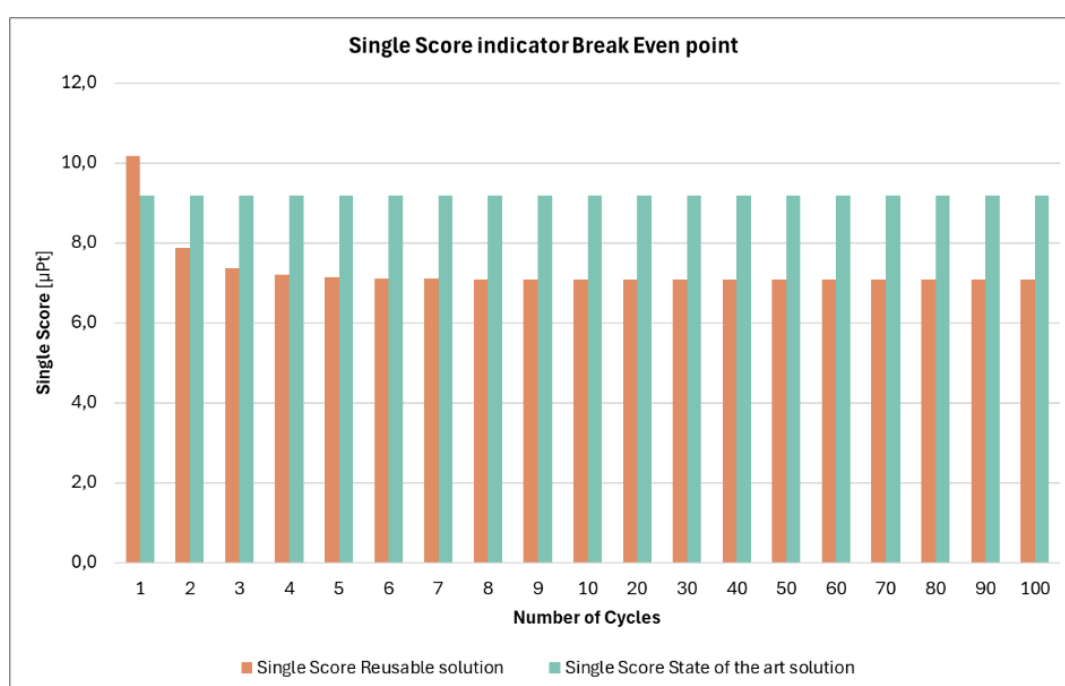


Figure 86: Product20_Single Score Chart Return Rate 64,6%

Process and life cycle stage contribution to Single Score

The following graphs show the specific contribution of each process to the different environmental indicators for the Single-Use System (Fig 87) and Reuse System (Fig 88) as the number of cycles varies.

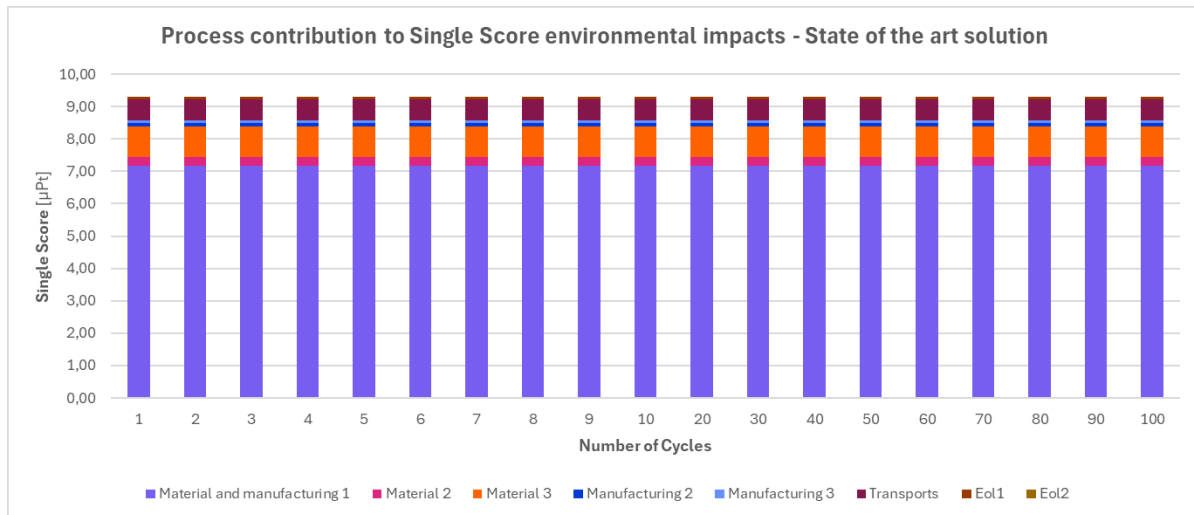


Figure 87: Product20_SingleUse_Weighted Results; Material 1: Glass Bottle ; Material 2: PP stopper; Material 3: Metallic Wire; Manufacturing 1: Injection moulding; Manufacturing 2: Wire Drawing

As shown in Fig 87, the single-use system of the packaging referred to Table 82 shows the greatest impact (77%) for Material and Manufacturing 1: glass calculated with its production.

As shown in Fig 88, reuse system - considering the same packaging (referred to Table 74), has the greatest impact (57% at 20th cycle) for Packaging material (glass) which contain production impacts. This is followed by disposable Lid material (18%) divided as follows: PP stopper (4%) plus 2% for its Manufacturing, Metallic wire 12%. Washing process represents the 13% of the total impacts.

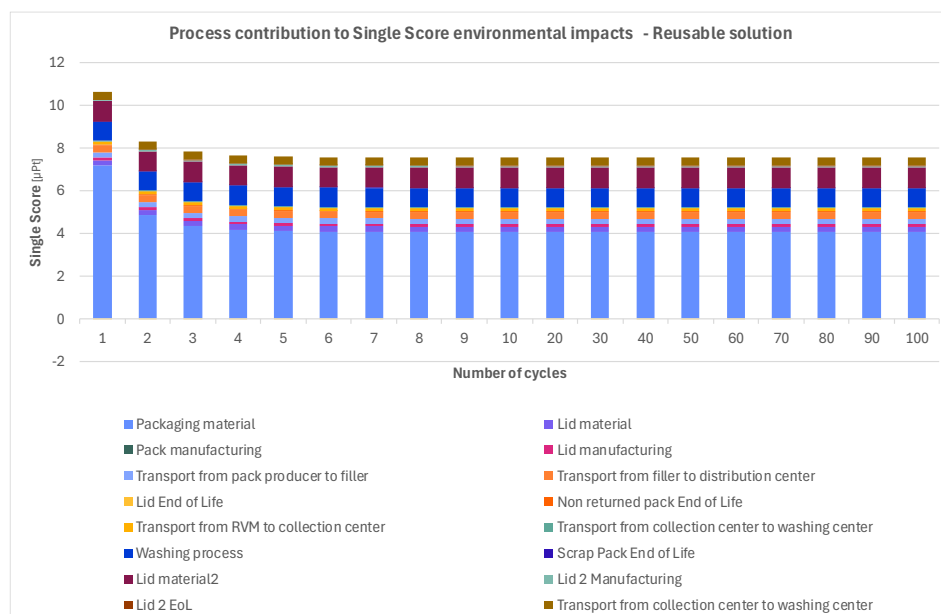


Figure 88: Product20_Reuse_Weighted Results Return Rate 64,6%



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Characterization results comparison

Comparison of the values characterized for all E.F. 3.1 environmental indicators between State of the art and Reuse systems.

At Break-even point

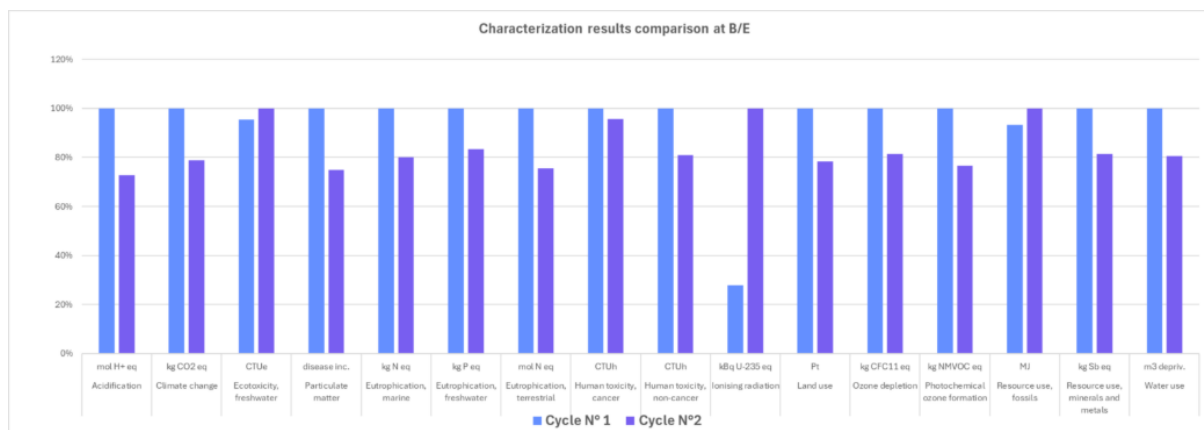


Figure 89: Product20_Graph at 2nd reuse cycles (Break-even point)_Return Rate 64,6%

Table 84: Product20_Values at at 2nd reuse cycles (Break-even point)_Return Rate 64,6%

		State of the art solution (Single use)	Reusable solution
Acidification	mol H+ eq	6,73E-04	4,90E-04
Climate change	kg CO2 eq	8,52E-02	6,71E-02
Ecotoxicity, freshwater	CTUe	2,12E-02	2,22E-02
Particulate matter	disease inc.	9,47E-09	7,10E-09
Eutrophication, marine	kg N eq	1,06E-04	8,49E-05
Eutrophication, freshwater	kg P eq	1,34E-05	1,12E-05
Eutrophication, terrestrial	mol N eq	1,18E-03	8,92E-04
Human toxicity, cancer	CTUh	6,58E-10	6,29E-10
Human toxicity, non-cancer	CTUh	9,36E-10	7,58E-10
Ionising radiation	kBq U-235 eq	5,78E-03	2,07E-02
Land use	Pt	7,49E-01	5,87E-01
Ozone depletion	kg CFC11 eq	2,01E-09	1,63E-09
Photochemical ozone formation	kg NMVOC eq	3,96E-04	3,04E-04
Resource use, fossils	MJ	1,17E+00	1,26E+00
Resource use, minerals and metals	kg Sb eq	3,96E-07	3,22E-07
Water use	m3 depriv.	1,54E-02	1,24E-02

At 20-cycle: Flattening the curve

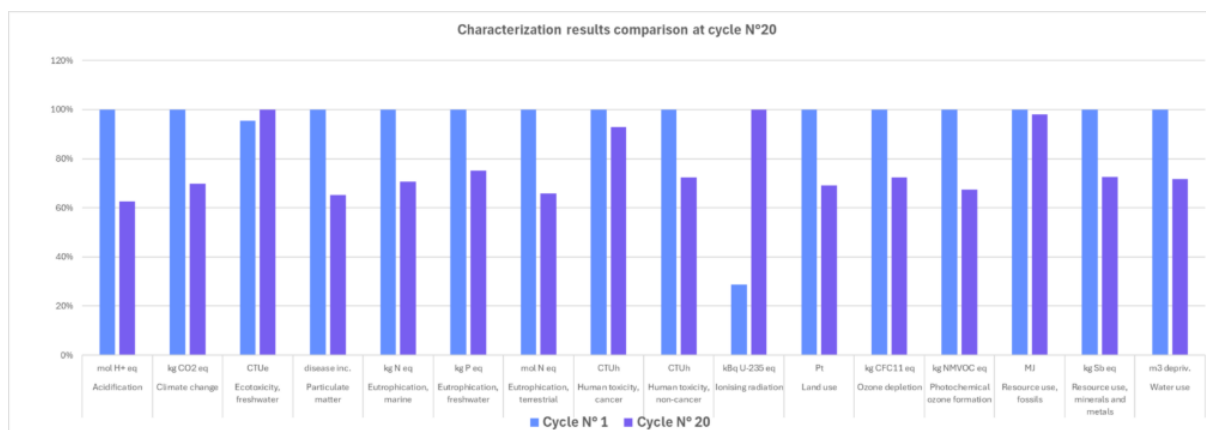


Figure 90: Product20_Graph at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

Table 85: Product20_Values at 20 reuse cycles (Flattening the curve)_Return Rate 64,6%

		State of the art solution (Single use)	Reusable solution
Acidification	mol H+ eq	6,73E-04	4,21E-04
Climate change	kg CO2 eq	8,52E-02	5,94E-02
Ecotoxicity, freshwater	CTUe	2,12E-02	2,22E-02
Particulate matter	disease inc.	9,47E-09	6,18E-09
Eutrophication, marine	kg N eq	1,06E-04	7,49E-05
Eutrophication, freshwater	kg P eq	1,34E-05	1,01E-05
Eutrophication, terrestrial	mol N eq	1,18E-03	7,78E-04
Human toxicity, cancer	CTU _h	6,58E-10	6,11E-10
Human toxicity, non-cancer	CTU _h	9,36E-10	6,76E-10
Ionising radiation	kBq U-235 eq	5,78E-03	2,01E-02
Land use	Pt	7,49E-01	5,18E-01
Ozone depletion	kg CFC11 eq	2,01E-09	1,45E-09
Photochemical ozone formation	kg NMVOC eq	3,96E-04	2,67E-04
Resource use, fossils	MJ	1,17E+00	1,15E+00
Resource use, minerals and metals	kg Sb eq	3,96E-07	2,87E-07
Water use	m3 depriv.	1,54E-02	1,10E-02

The reuse system has a lower environmental impact in most areas, except for the freshwater ecotoxicity and ionising radiation indicators, due to the washing process.

2.19. Environmental Cross Analysis

PRODUCT AND BREAK-EVEN SUMMARIES

Table 86: Products characteristics and Break-even point summary

ID	Food Category / Product	Format (Single-use → Reuse)	Picture (Reuse)	State of art weight per FU (g)	Reuse pack weight per FU (g)	Break-even @ 64,6%	Break-even @ 85,5%
01	Florette shaker ananas	PET tray + lid → PP tray + lid		5,391	18,44	X (+51,6% at 20th cycle)	X (+4% at 20th cycle)
02	Salad MDD tray	PET tray + lid → PP tray + lid		12	18,44	✓ (2 cycles) (-31,1 % at 20 cycles)	-
03	Sour cream	PP cup + aluminium lid + PET overcup → PP bucket + PP lid		6,18	4,58	✓ (1 cycle) (-41,6% at 20 cycles)	-
04	Greek yogurt	PP cup + aluminium lid + PET overcup → PP bucket + PP lid		4,5	4,58	✓ (2 cycles) -19,7% a 20 cicli	-
05	Pork chop tray	EPS tray + PVC film → PP tray + PP lid		2,76	8,4	X (+126,7% at 20th cycle)	X (+ 59,7% at 20th cycle)
09	Chips	PP foil + adhesive → PP bucket + PP lid		3,24	56,32	X (+1333% at 20th cycle)	X (+990% at 20th cycle)
10_1	Pétales salées	OPP + cardboard box + adhesive → 1 PP bucket + PP lid		39,07	44,7	X (+80% at 20th cycle)	X (+34% at 20th cycle)
10_2	Pétales salées	OPP + cardboard box + adhesive → 2 PP bucket + PP lid		39,07	43,16	X (+70% al 20th cycle)	X (+26% at 20th cycle)
11	Orange juice	PET bottle (50% recycled) + HDPE cap + OPP foil → Glass bottle + AL Twist-off capsule		3,2	38	X (+252% at 20th cycle)	X (+167% at 20th cycle)
12	Milk	PET bottle (50% recycled) + HDPE cap + OPP foil → Glass bottle + AL Twist-off capsule		2,8	36,5	X (+300% at 20th cycle)	X (+208% at 20°ciclo)
13	Milk	HDPE Bottle + HDPE cap → Glass bottle + AL Twist-off capsule		3,57	36,5	X (+169% at 20th cycle)	X (+106% at 20th cycle)

14	Biscuits choco	Cardboard box + OPP foil → PP bucket 1L + PP Lid		17,85	13,342	X (+38,1% at 20th cycle)	X (+10% at 20th cycle)
15	Fromage Blanc	2 L PP Bucket + PP lid		4,425	4,425	X (+0,8% at 20th cycle)	✓ (3 cycles) --17,4% at 20 cicli
16	Syrup	Glass bottle + HDPE clip lid		105,525	105,525	✓ (2 cycle) -30% a 20 cicli	-
17	Mayonnaise	Glass jar + twist off metal lid		99,498	99,498	✓ (2 cycle) -30,2% a 20 cicli	
18	Olive Oil	Glass bottle + AL clip lid, + PP pourer		69,2	69,2	✓ (2 cycle) -16,9% a 20 cicli	
19	Sweet/brut cider	Glass Bottle + Cork stopper + Metallic Wire		76,249	76,249	✓ (2 cycle) -25,8% a 20 cicli	
20	Sweet/brut cider	Glass Bottle + Plastic Stopper + Metallic Wire		77,667	77,667	✓ (2 cycle) -22,9% a 20 cicli	

Analyzing weight variations per functional unit (100 g of product) reveals substantial differences between single-use and reusable formats. These variations, shown in Fig.91, substantially impact the overall results, as in many cases, it is not a direct comparison of two identical systems, but rather of products with different formats, filling volumes and materials. To make the comparison fairer, the functional unit was set at 100 g of product to reduce distortions due to different packaging quantities contained.

No weight variation is observed for products already marketed in formats that are compatible with reuse (ID15-20). In these cases, there are no uncertainties related to changes in format or material, allowing for a more direct assessment of the actual efficiency of the reuse system, free from the side effects of design or structure. Here, therefore, it will be possible to observe the intrinsic effectiveness of the reuse model compared to single-use in almost ideal conditions.

Overall, packaging for reuse requires, in most cases, higher-performance and therefore heavier materials, especially to ensure durability, washability, and resistance to cycles of use. However, this increase in weight must be interpreted, some variations, which are too significant, lead to a worsened scenario and make it impossible to justify the environmental result.

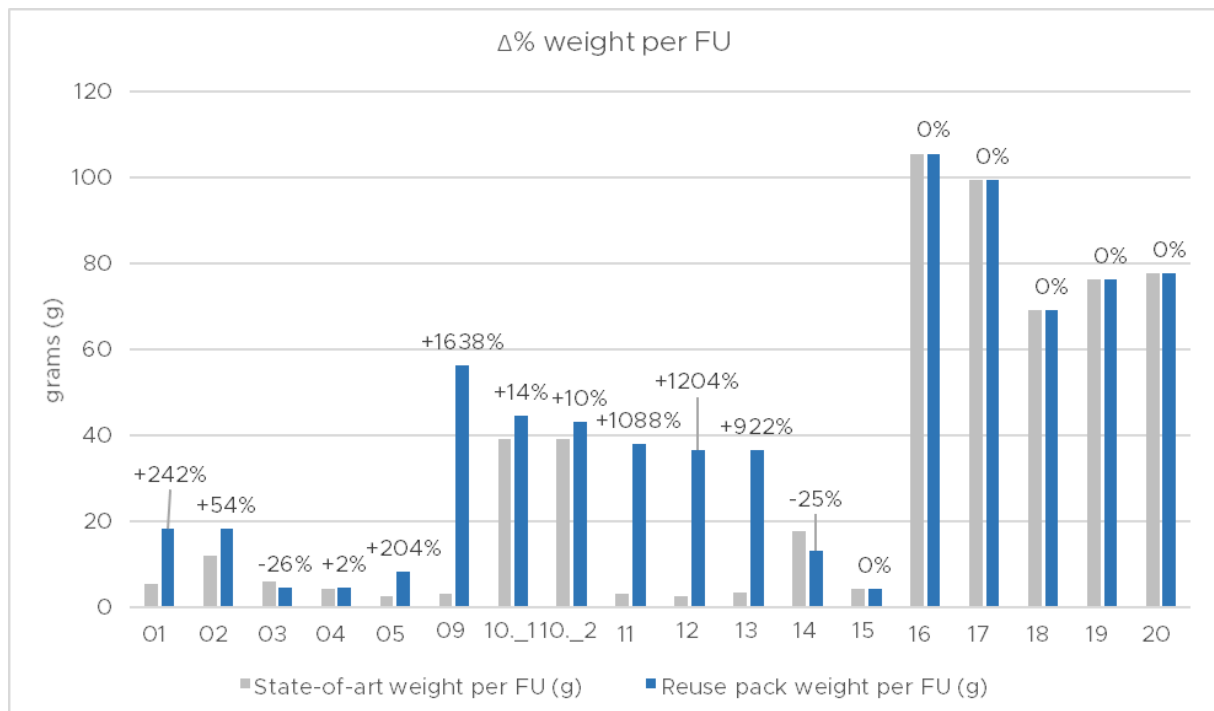


Figure 91: Percentage change in weights for Functional Unit

PP trays

PP trays, used as a replacement for PET trays in PRODUCT 01 and 02 and for EPS in PRODUCT 05, showed poor performance in general, failing to reach the break-even point except in PRODUCT 02, where the weights per functional unit were similar. This remains the main reason for not reaching the break-even point in the other two products, whose weights per functional unit are more imbalanced (P01: 5.391 g vs. 18.44 g and P05: 2.76 g vs. 8.4 g).

PP cups

The PP cups used in products 03 and 04 are favourably positioned in relation to the product they replace: another PP cup with aluminium foil and a PET lid. This favourable relationship is reflected in the weight of the packaging per functional unit (P03: 6.18 g vs. 4.58 g and P04: 4.5 g vs. 4.58 g). The break-even point is therefore reached in both cases with a low number of cycles. As they contain liquid foods, they make good use of the weight of the packaging.

PP buckets

PP buckets used in products 09, 10-1, 10-2, 14 and 15 tend to perform poorly as replacements for state-of-the-art products. For example, product 09 replaced a lightweight PP foil (3.24 g per FU) with a heavy bucket weighing 56.32 g per FU. This issue is exacerbated by the fact that the 3.5-litre bucket can only hold 250 g of chips and therefore transports a lot of air. Additionally, the disposable lid itself weighs 13 g per unit of use (FU) and generates a third of the impact.

The PP buckets used to replace cardboard boxes and OPP film in products 10-1 and 10-2 have a more favourable weight ratio for FU (39 g vs. 44.7 g and 43.16 g), but still fail to reach break-even. The disposable cap is also a critical element in these products, accounting for 25% and 30% of the environmental impact of products 10-1 and 10-2, respectively. The situation does not improve significantly when the volume increases from 1 L to 2 L for these two products.



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Despite its lower weight per functional unit, the PP bucket used to replace the cardboard box and OPP foil in product 14 does not perform well due to the low impacts of the cardboard material (the main component of the state of the art). The environmental impact would be almost equivalent but, thanks to its recyclability, cardboard is able to reduce its embodied footprint.

The PP bucket used for Product 15 was considered for single-use and reuse scenarios. Therefore, with the packaging remaining constant, its performance was evaluated in different scenarios. It showed slightly better performance in the reuse scenario, reaching break-even at three cycles with an 85,5% return rate. The fact that the state-of-the-art is represented by the same packaging allows for a more objective comparison of the two systems. The additional washing and transport processes for the reuse system have a significant impact, keeping the percentage difference between the two systems low (17,4% at the 20th cycle and 85,5% return rate).

Clear glass twist off capsule

Clear glass packaging is used in two main cases: as a replacement for PET and HDPE for products 11, 12 and 13, and in comparison to the same product in the Single Use System for products 16, 17 and 18. In the former case, the weight difference per FU remains high when compared with polymer products (from about 3 to 37 g), which makes it difficult to reach the break-even point. Furthermore, the environmental benefits of glass are insufficient to justify this weight difference.

This is because two different types of material are being compared, and the polymer counterparts do not perform in the same way when subjected to different reuse cycles.

In the latter cases (products 16, 17 and 18), glass is used in both single-use and reuse systems. This clearly demonstrates the efficiency of the adopted reuse system. In fact, the packaging demonstrates that the break-even point is reached in the second cycle, with an RR of 64,6%, and that differences range from 30% to 20% in the 20th cycle. The caps, which are also considered disposable in these cases, had a particular impact on product 18, as it has a pourer and a disposable cap.

Green glass bottles

Green glass bottles are used for products 19 and 20; the only difference is the type of cap, which is made of either cork or plastic. A comparison of the Single Use and Reuse systems with the same packaging proves positive, reaching break-even in the second cycle with a 64,6% return rate. The difference in impact between the two caps is 2.9% in favour of the cork solution after 20 reuse cycles.

General considerations:

1. The key factor is the balance between the weight of the reusable container and the number of times it is used. If the container is too heavy compared to the single-use alternative, the system becomes unsustainable.
2. This also depends on the filling density: it is high for soft foods such as yogurt and cheese, while there is less efficiency for the same packaging with light products and those whose arrangement tends to create air pockets and high volume.
3. The recovery rates of 64,6% and 85.5%, derived from project assumptions, do not currently reflect the reality of the ongoing demonstration, with the actual figures falling far short of these averages.



RANKING OF PRODUCTS' IMPACT VARIATION

The following table ranks the comparisons in order of break-even achievement and impact variation, from best to worst.

Table 87: Ranking of products' impact variation

ID	Product	Reuse material	Break-even	Δ% @20 cycles
03	Sour cream	PP	✓ 1 cycle (BE @64,6%)	-41.6%
02	Salad MDD tray	PP	✓ 2 cycles (BE @64,6%)	-32.1%
17	Mayonnaise (glass)	Glass	✓ 2 cycles (BE @64,6%)	-30.2%
16	Syrup (glass)	Glass	✓ 2 cycles (BE @64,6%)	-30%
19	Cider (glass, cork stopper)	Glass	✓ 2 cycles (BE @64,6%)	-25.8%
20	Cider (glass, plastic stopper)	Glass	✓ 2 cycles (BE @64,6%)	-22.9%
04	Greek yogurt	PP	✓ 2 cycles (BE @64,6%)	-19.7%
18	Olive Oil (glass)	Glass	✓ 2 cycles (BE @64,6%)	-16.9%
15	Fromage Blanc	PP	X (@64,6% rr: +0.8%) ✓ @85,5% rr (3 cycles)	-17.4% (@85,5% rr)
14	Biscuits choco	PP	X	+38.1% (@64,6%) / +10% (@85,5%)
01	Florette shaker pineapple	PP	X	+51.6% (@64,6%) / +4% (@85,5%)
10_2	Pétales salées (43.16 L bucket)	PP	X	+70% (@64,6%) / +26% (@85,5%)
10_1	Pétales salées (44.7 L bucket)	PP	X	+80% (@64,6%) / +34% (@85,5%)
05	Pork chop tray	PP	X	+127% (@64,6%) / +59.7% (@85,5%)
13	Milk (glass)	Glass	X	+169% (@64,6%) / +106% (@85,5%)
11	Orange juice (glass)	Glass	X	+252%
12	Milk (glass)	Glass	X	+300% (@64,6%) / +208% (@85,5%)
09	Chips	PP	X	+1333% (@64,6%) / +990% (@85,5%)

Half of the products demonstrate an increase in their environmental impact (Single Score variation). As analyzed above, this is due to the difference in packaging between Single Use and Reuse systems, which only match in some cases (Products 15–20). The



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following Figure shows the variations of impacts at the two different return rates considered at the 20th cycles of reuse.

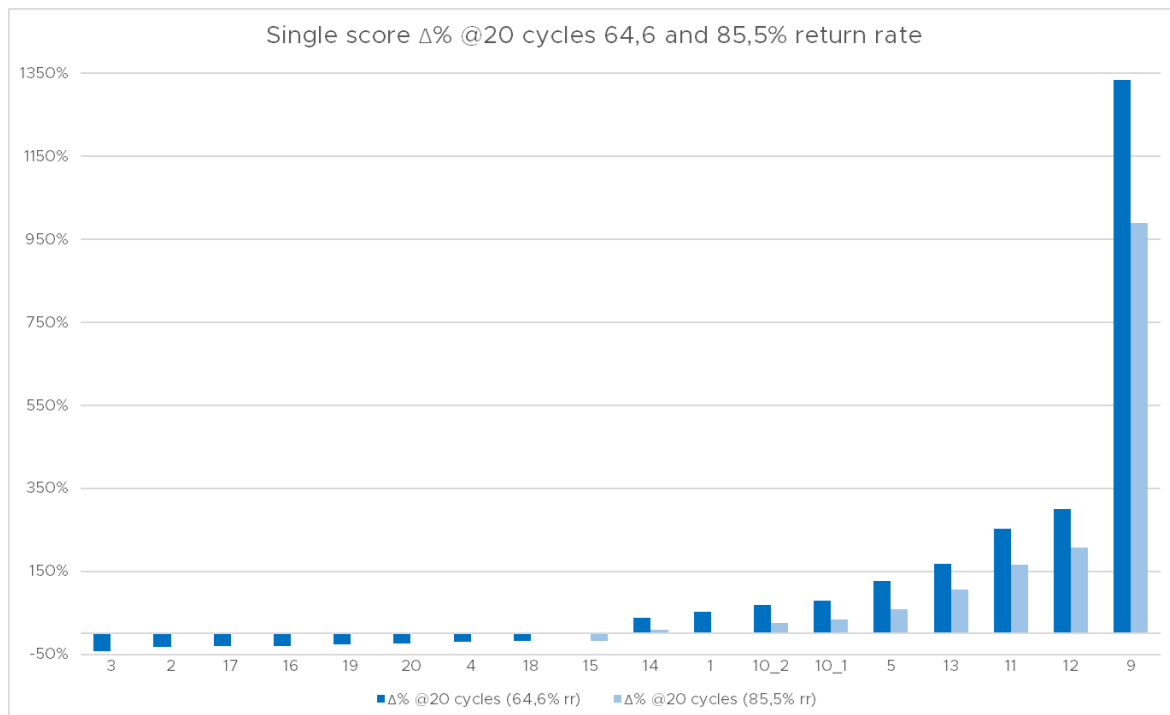


Figure 92: Single score difference at 20 cycles for 64,6 and 85,5% return rate comparison between SoA and reusable system solutions

As the variations in worsening products are much more significant than those in improved products, the following graph focuses on improving products in the reuse system at different return rates.

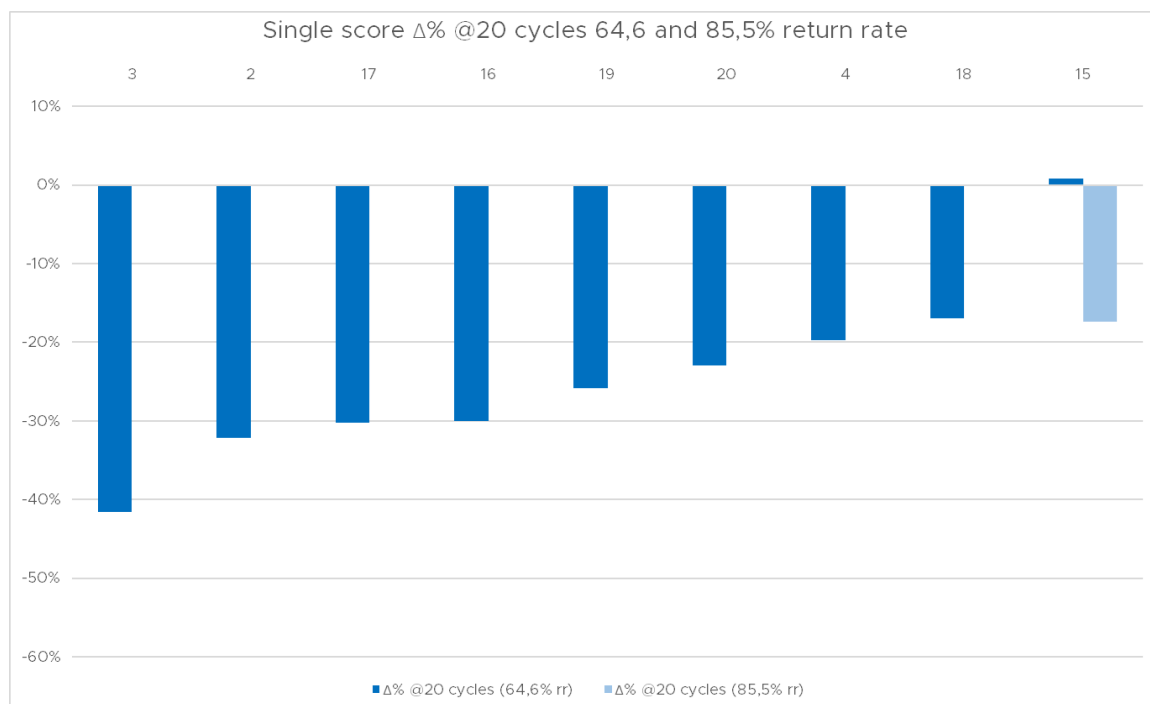


Figure 93: Single score reduction at 20 cycles for 64,6 and 85,5% return rate comparison between SoA and reusable system solutions (focus on products with reduction)



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ANALYSIS OF ENVIRONMENTAL INDICATORS

The table below, considering the E.F. 3.1 indicators calculated at Scenario 1, with a return rate of 64,6%, highlights how the transition from single use to reuse does not necessarily produce uniform improvements across all environmental indicators. On the contrary, the performance is highly differentiated: some categories clearly benefit from reuse, while others systematically worsen.

Table 88: Classification of percentage variation in environmental impacts between the reference system and the reuse system. Negative values indicate improvements (green), while positive values indicate worsening (red). Values are categorized as follows:

From (%)	To (%)	Description	Color
-∞%	-80%	Much better reuse	
-79%	-50%	Better reuse	
-49%	-20%	Good improvement	
-19%	-10%	Slightly better	
-9%	+9%	No significant change	
+10%	+19%	Slightly worse	
+20%	+49%	Worse reuse	
+50%	+79%	Much worse	
+80%	+∞	Extremely worse	



ID/Environmental Indicator	1	2	3	4	5	9	10r1	10r2	11	12	13	14	15	16	17	18	19	20
Acidification	-1%	-56%	-9%	-16%	75%	1528%	55%	49%	405%	393%	391%	9%	-20%	-40%	-37%	-33%	-39%	-37%
Climate change	33%	-40%	-15%	-19%	67%	1305%	112%	107%	150%	124%	82%	40%	-27%	-35%	-30%	-23%	-33%	-30%
Ecotoxicity, freshwater	59%	-29%	-37%	-42%	-57%	7875%	-60%	-61%	191%	210%	231%	-72%	-31%	-55%	0%	0%	11%	5%
Particulate matter	-20%	-64%	-22%	-26%	61%	1476%	-53%	-55%	625%	590%	817%	-64%	-12%	-38%	-33%	-30%	-36%	-35%
Eutrophication, marine	7%	-52%	-13%	-17%	129%	1057%	27%	19%	331%	272%	329%	5%	3%	-34%	-30%	-23%	-31%	-29%
Eutrophication, freshwater	53%	-31%	32%	23%	219%	1900%	131%	122%	49%	39%	4%	54%	-21%	-34%	-30%	-18%	-30%	-25%
Eutrophication, terrestrial	12%	-50%	-6%	-12%	115%	1483%	49%	43%	382%	352%	358%	6%	-19%	-38%	-33%	-28%	-36%	-34%
Human toxicity, cancer	81%	-18%	-10%	-17%	453%	944%	120%	110%	218%	160%	100%	50%	-15%	-28%	-22%	-13%	-14%	-7%
Human toxicity, non-cancer	10%	-50%	-24%	-28%	284%	1101%	21%	15%	248%	214%	194%	-7%	-10%	-33%	-29%	-22%	-30%	-28%
Ionising radiation	258%	55%	-41%	-46%	1580%	21472%	-29%	-67%	2093%	5373%	2383%	76%	-1257%	156%	-22%	291%	245%	248%
Land use	59%	-27%	37%	30%	470%	1055%	69%	64%	394%	351%	258%	15%	-20%	-35%	-27%	-24%	-23%	-31%
Ozone depletion	-99%	-99%	-98%	-98%	10%	461%	165%	157%	-97%	-96%	65%	70%	-19%	-32%	-29%	-19%	-29%	-28%
Photochemical ozone formation	67%	-25%	-5%	-14%	58%	1380%	164%	156%	241%	232%	141%	67%	-24%	-37%	-31%	-26%	-35%	-33%
Resource use, fossils	117%	-3%	-6%	-15%	186%	1490%	145%	122%	291%	331%	167%	104%	33%	-14%	-29%	5%	-3%	-2%
Resource use, minerals and metals	23%	-45%	-33%	-39%	420%	1016%	189%	178%	124%	115%	75%	85%	-19%	-33%	-29%	-19%	-31%	-28%
Water use	232%	38%	19%	8%	0%	5656%	114%	108%	49%	52%	-30%	19%	-23%	2%	-44%	-23%	-35%	-29%

The comparison between the single-use and reuse systems shows that the environmental performance of reusable packaging is highly dependent on the type and quantity of material, and the additional operational processes involved in the reuse system (particularly washing and transport).

Indicators with predominantly positive performance in reuse systems

- **Particulate matter:** reuse leads to improvements when a reduction in material extraction per functional unit occurred.
- **Ozone depletion:** reusable solutions reduce impacts in particular when PET is replaced.

Indicators with predominantly negative performance in reuse systems

- **Eutrophication (marine, freshwater):** generally worsens with reuse, mainly due to water and detergent consumption during washing.
- **Ionizing radiation:** strongly worsens in almost all scenarios due to the French energy mix, which relies heavily on nuclear power. State of the Art solutions, sending material to energy recovery, avoid the production of nuclear energy, making the disposal of material “more convenient” than its reuse.
- **Land use:** Glass and PP containers shows worsening of this indicator, in particular, when in disadvantageous packaging material-content rate.
- **Resource use (fossils):** reuse solutions often require larger amounts of raw materials and higher energy demand, which in turn increases these indicators, in particular, when in disadvantageous packaging material-content rate.
- **Water use:** systematically higher in reuse systems, mainly due to the use of more material-intensive packaging and washing operations.

Indicators with variable performance

- **Acidification**
- **Climate change**
- **Ecotoxicity, freshwater**
- **Eutrophication (terrestrial)**
- **Human toxicity (cancer and non-cancer)**
- **Photochemical ozone formation**
- **Resource use (minerals and metals)**

The variability of environmental performances of reusable systems depends on various interconnected factors across their lifecycle, as the product to packaging weight ratio, the material choice, the reuse-related processes, as transport and cleaning processes.



ADDED ANALYSIS

What if...reusable lid?

This analysis aims to evaluate the environmental performance of the 1L bucket (ID 10_1r) equipped with a reusable lid. The goal is to test how the introduction of a reusable component can shift the results.

In the analysis performed with the disposable lid, the break-even point was not reached even at a return rate of 64,6%.

At the 20th cycle, the state-of-the art still showed an 80% lower impact compared to the reuse scenario.

When considering the lid reusable (shown in orange in the figure), the break-even point remains unreached; however, the impact difference with respect to the state-of-the-art system decreases to 60% at the 20th cycle.

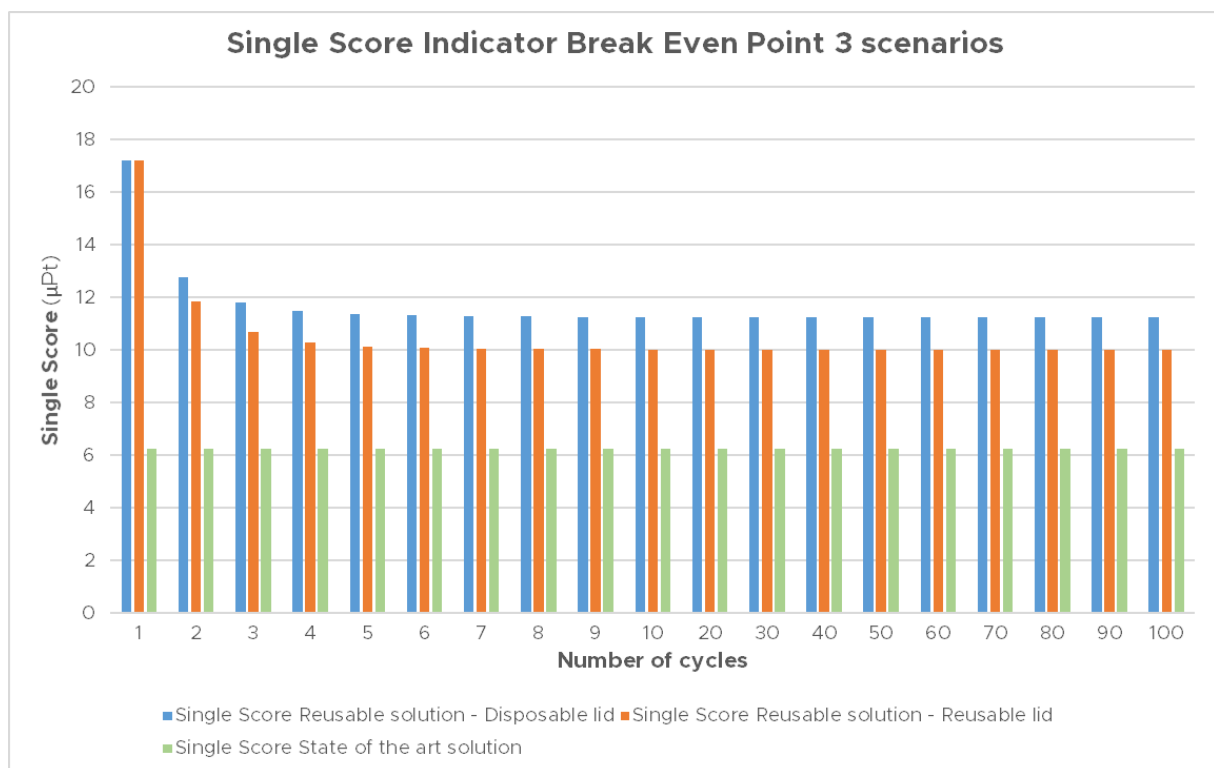


Figure 94: Product 10 reusable lid comparison – Scenario 1, Return rate 70%, scrap rate 5% (64,6%)

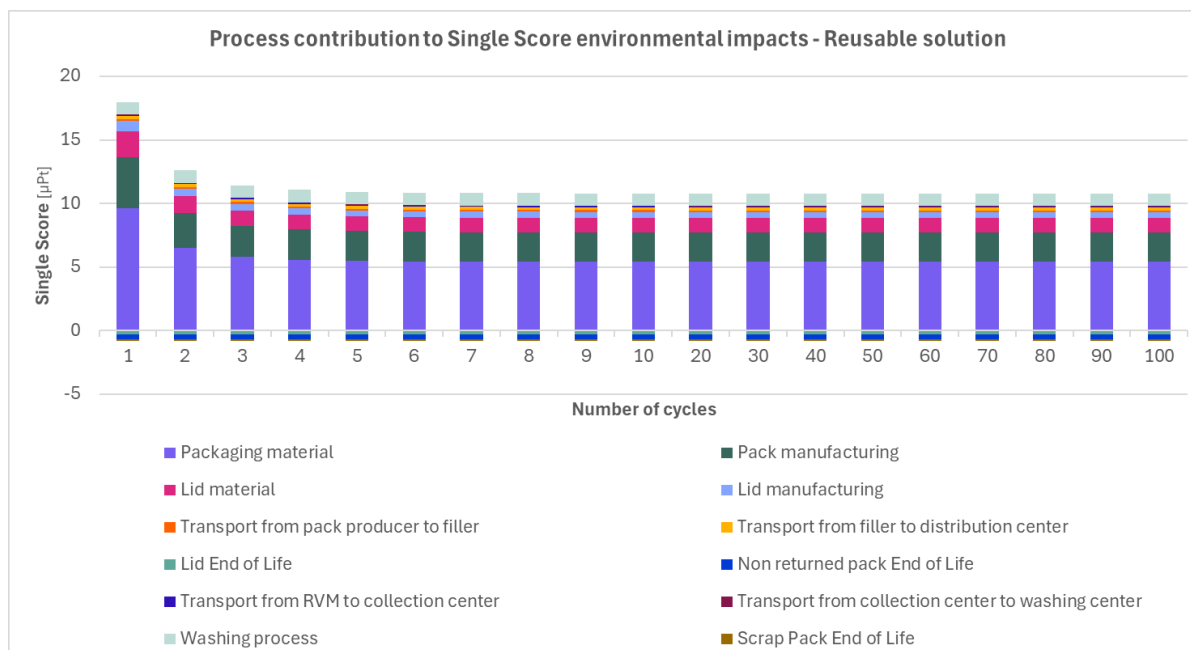


Figure 95: process contribution to life cycle impacts of product 10r1 with reusable lid, in return Scenario 1

What if...with reusable lid we reduce bucket packaging weight?

Following the previous results, where the reuse system with a reusable lid (Scenario 2 – 85.5% return rate) still showed a 4% higher impact (single score) than the state-of-the-art system at the 20th cycle, a further analysis was carried out to evaluate the influence of the bucket weight.

The hypothesis is that by reducing the bucket weight (per functional unit), it may be possible to reach the environmental break-even point.

Based on the dynamic calculation performed on the PRODUCT 10_1 (Petals saleè) 1 L bucket (Scenario 2 – 85.5% return rate), the break-even point can be reached by reducing the bucket weight (per functional unit) from the current 37 g (per Functional Unit) to approximately 35 g (per Functional Unit) — corresponding to a decrease of about 2 grams of packaging (per Functional Unit).

This result confirms that a relatively small weight optimization would be sufficient for the reuse system to achieve environmental parity with the single-use reference at the 20th cycle, assuming the lid weight remains unchanged.



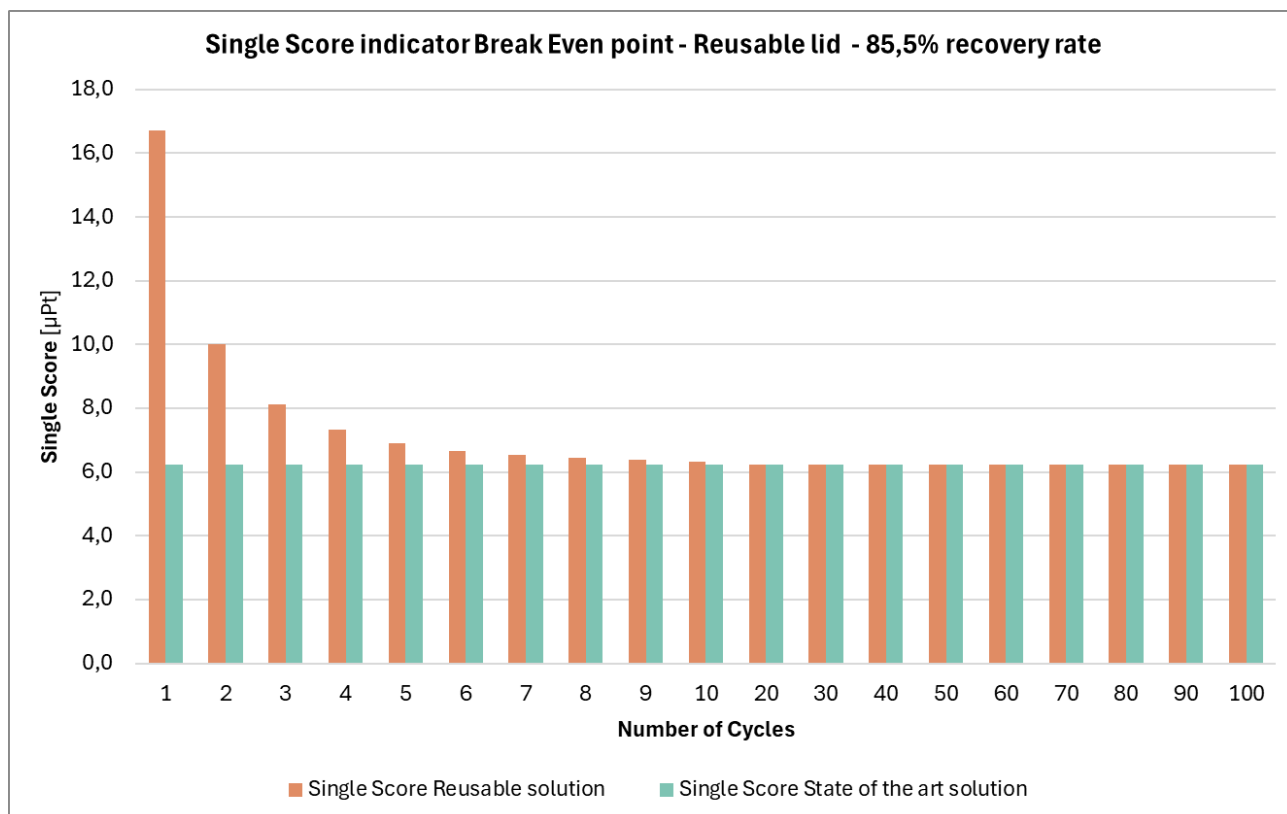


Figure 96: Break even point identification for product 10r1, with reusable lid, in Scenario 2, considering a bucket weight decrease from 37 to 35 grams

Note on the 10th Cycle Analysis

Although some stakeholders highlighted that 10 reuse cycles could represent a more realistic operational scenario for reusable plastic packaging, the main analysis was conducted at the 20th cycle, which corresponds to the median point of the flattening trend in the reuse impact (single score) curve.

As shown in the results, the curve starts flattening around the 7th cycle, and the difference between the 10th and 20th cycles is negligible, approximately producing an increase difference of 0,03% at a return rate of 64,6% and 1% at a return rate of 85.5%.

Therefore, performing a complete recalculation at the 10th cycle would not produce substantially different outcomes, as the environmental performance remains practically unchanged compared to the 20-cycle reference scenario already presented in this report.



3.Social Risks Assessment

The present study aims to assess the social hotspots of an alternative packaging system compared to the State of the art, single use system. The study was conducted following the *Guidelines for Social Life Cycle Assessment of Products and Organizations*.

The *Social Hotspots Database V.5 (SHDB)* (New Earth B, 2022) was used to provide information on potential social risks along global supply chains. The SHDB allows for the comparison of different scenarios and packaging alternatives within the product system, highlighting specific social risks and opportunities associated with each input, while avoiding the shifting of potential impacts between different life cycle stages.

The social hotspot analysis was not performed for all the products included in the R3PACK scope. Instead, a selection of representative cases was made based on material typologies and their relevance within the project's substitution and reuse scenarios. This approach allows the study to capture the main social dynamics associated with each material family (e.g., plastics, paper-based, glass), while avoiding redundancy among similar packaging systems.

In this context, representative packaging typologies have been selected within the R3PACK project to evaluate different material configurations and substitution scenarios. Among them, *Paper-based products with coatings (for Substitution)* were identified as a key case study (04-s) that represents the "Paper products" in general, and for the reuse packaging, different formats and materials have been selected:

Table 89: selected representative products

Food Category	Product	Format (State of the art)	Format (Alternative)	Company	LCA ID (SoA)	LCA ID (Alternative)
Yogurt	Greek Yogurt	PP Cup	Wet molded cellulose + PE	Yoplait	04	04-s
Yogurt	Greek Yogurt	PP Cup	PP Bucket + PP lid	Yoplait / System U / Carrefour	04	04-r
Ready meals	Salad	PET Tray	PP Tray + PP lid	LSDH / Sodebo / Floreale	02	02-r
Snacks	Pétales salées	OPP Sachet & Cardboard	PP Bucket 1L	Europe Snacks	10	10-r1
Juice	Orange Juice	Clear Bottle (50% recycled)	Glass Bottle 1L	LSDH	11	11-r
Condiments	Mayonnaise	Clear glass jar with metal closure	Clear glass jar with metal closure	Lesieur	17	17-r

The social hotspot assessment was performed using SimaPro software (v. 9.6.0.1) and the Social Hotspots Database (SHDB, v. 5). The SHDB is based on the Global Trade Analysis Project (GTAP), which provides trade and economic data for 57 industrial sectors across 140 countries (Bennema, Norri, & Benoit Norris, 2022).

The social risks and opportunities identified by the SHDB for each sector and country are classified into five main impact categories: *Working Conditions, Health and Safety, Human Rights, Governance, and Community*. Each category includes several subcategories (a total of 30), which are in turn associated with specific social indicators (160 in total) used to measure the potential social impacts corresponding to each subcategory.

The assessment conducted considered all impact categories, subcategories, and related social indicators, ensuring a comprehensive evaluation of potential social risks along the packaging life cycle.



DATA INVENTORY

Since it was not possible to collect primary inventory data, the information was developed based on the descriptive details of the different packaging solutions. Economic cost calculations for the various inputs were then derived from the environmental LCA inventory, taking into account material weights, energy consumption and transport distances. Price data were obtained from secondary sources, which are referenced in the report. The inventory phase and methodological approach were communicated to the project coordinator. All underlying assumptions are described in detail in the data inventory section.

For each input, the following data were collected:

- Associated sector (classified according to GTAP categories)¹
- Unit cost in local currency (EUR)
- Reference year
- Country of origin

All data were normalized to the functional unit defined for the packaging system under study: “The packaging required to contain, protect, and preserve 100 grams of food over the duration of the expected shelf life, to ensure food safety, quality, and integrity throughout the distribution chain”.

The Social Hotspots Database contains 160 social indicators categorized into 30 subcategories, 6 main impact categories, and 4 stakeholder groups: workers, local communities, value chain actors, and society. The database addresses pivotal social issues, including human rights, working conditions, health and safety, equality, governance, poverty, and environmental sustainability. It adheres to international frameworks such as the GRI, ISO 26000, and the UN Sustainable Development Goals. The Social Hotspots Index method assesses social impacts along the life cycle by combining social risk levels with labor intensity data and expressing the results in Medium Risk Hours Equivalent (MRHEQ). These values quantify social risks and opportunities by sector and country, enabling the identification of social hotspots within supply chains. Risk levels range from very high (factor 10) to low (factor 0.1). The SHI offers two life cycle impact assessment methods: one that weights the main categories equally and one that weights the subcategories equally. In the study, both methods were applied.

Monetary data have been updated using 2024 as the reference year. Since some cost information originally referred to 2021 values, an adjustment factor was applied to account for inflation. Unless otherwise specified in the inventory tables below, all monetary values should be considered as expressed in 2024 euros.

Material and processing costs were calculated for the defined functional unit (FU) based on the packaging weight. For reusable packaging, the same assumptions adopted in the environmental assessment were applied, considering identical life cycle stages. The mass of the packaging was distributed over multiple use cycles, accounting for system losses. The virtual mass composition was therefore aligned with that used in the environmental assessment, assuming a return rate of 64.6%.

1

GTAP

<https://www.gtap.agecon.purdue.edu/databases/contribute/concordinfo57.asp>



Table 90: Material and processes cost/kg

Materials and Processes	Material economic cost (euro/kg)	Economic cost process (euro/kg)
(PP) Plastic Injection Moulding	1,0395	13,5
(PET) Plastic Termoforming	1,0425	14,3
(Alu) Metal lamination	1,735	10,7
(Pulp) Pulping - Compression moulding	0,9365	14,7
(PE) Lamination - Extrusion	1,21	10,7
(PP) Plastic Injection Moulding	1,0395	13,5
(Alu) Metal lamination	1,735	10,7
Plastic Lamination - Extrusion	1,21	10,7
PET Blow Molding	1,0425	16,7
ALU sheet drawing	1,735	9,57
Glass Blow molding	1,305	8,39
*Source: Granta database, process data on 10.000 pieces		

Transportation costs have been obtained multiplying the cost g/km to the distance and mass of transportation for each phase.

Table 91: Transportation cost

Transports	Cost (euro/Km) ^{1,59} eur/km	Total transport Weight capacity (g)
Transport 1: Transport from producers to filler	1,59	24000000
Transport 2: Transport to distribution center	1,59	24000000
Transport 3: Distribution to Shop	1,59	24000000
Transport 4: RVM to sorter	1,59	24000000
Transport 5: Sorter to washer	1,59	24000000
Transport 6: Washer - Filler	1,59	24000000
	Source: Comité national routier, 2023 link	

End of life treatment cost have been calculated considering a recycling and an incineration scenario and the associated costs.

Table 92: End of life treatment flows and sectors involved

End of Life treatment	Recycling of light packaging	Recycle Paper	Recycle Glass	Incineration
Costs €/tonne recycled (France)	763	301	80	116
	Source: ADEME – Coût de référence SPGD 2024 (août 2023) (link) Source incineration cost: link			
% Recycle	27%	75%	66%	
% Inc+Land	73%	25%	34%	
	Source: “Plastics – the Facts 2022”, Plastic Europe, 2022	Source: Annex I, PEF Method, 2021	Source: Annex I, PEF Method, 2021	



3.1. Product 04 – Greek yogurt

The comparative analysis concerns the product ID 04, as state of the art referment, the product 04-s as paper-based substitution solution and 04-r as the solution for the reuse system. Below is presented an extract of the data employed in the analysis, calculated using the sources cited above.

Data inventory - ID04 – state of the art – single use system

Table 93: ID 04 product description

Product description ID 04 State of the art		
Pack Weight:	20,25	g
Food contained	450	g
Components	Weight per packaging unit (g)	Weight [g] su 100g FU
PP Cup	14	3,11
Alu Foil	1,25	0,28
PET Lid	5	1,11
Total	20,25	4,5

Table 94: ID 04 input list

Input N°	Description	COUNTRY where operations are carried	SECTOR INVOLVED (GTAP)	ECONOMIC COST (EURO 2024)	YEAR THE COST WAS INCURRED
INPUT 1	Polypropylene cup production	France	GTAP Code: 33 – Chemicals, Rubber, Plastics	0,045234	2021
INPUT 2	FOIL PRODUCTION	France	GTAP Code: nfm – Non-ferrous metals	0,003454167	2021
INPUT 3	PET lid production	France	GTAP Code: 33 – Chemicals, Rubber, Plastics	0,017047222	2021
INPUT 4	Transport 1: Transport from producers to filler	France	GTAP Code: 48 - Other Transport	5,10377E-05	Actualised to 2024
INPUT 5	Transport 2: Transport to distribution center	France	GTAP Code: 48 - Other Transport	8,30159E-05	Actualised to 2024
INPUT 6	Transport 3: Distribution to Shop	France	GTAP Code: 48 - Other Transport	1,91575E-05	Actualised to 2024
INPUT 7	Recycling of light packaging	France	GTAP 42 Recycle	0,000927045	2024
INPUT 8	Incineration	France	GTAP 56 Other Disposal	0,00038106	2024



Data inventory - ID04-s – substitution – single use system

Table 95: ID 04s product description

Product description ID 04-s Substitution		
Pack Weight:	10,74	g
Food contained	200	g
Components	Weight per packaging unit (g)	Weight [g] su 100g FU
moulded pulp	10	5,00
PE	0,74	0,37
Total	10,74	5,37

Table 96: ID 04s input list

Input N°	Description	COUNTRY where operations are carried	SECTOR INVOLVED (GTAP)	ECONOMIC COST (with VALUE indication) EURO	YEAR THE COST WAS INCURRED
INPUT 1	moulded pulp	France	GTAP Code: p_c – Paper products, publishing	0,0781825	2021
INPUT 2	PE	France	GTAP Code: crp – Chemical, rubber and plastic products	0,0044067	2021
INPUT 3	Transport 1: Transport from producers to filler	France	GTAP Code: 48 - Other Transport	6,0905E-05	Actualised to 2024
INPUT 4	Transport 2: Transport to distribution center	France	GTAP Code: 48 - Other Transport	9,90656E-05	Actualised to 2024
INPUT 5	Transport 3: Distribution to Shop	France	GTAP Code: 48 - Other Transport	2,28613E-05	Actualised to 2024
INPUT 6	Recycle Papier	France	GTAP 42 Recycle	0,00112875	2024
INPUT 7	Incenerition	France	GTAP 56 Other Disposal	0,000145	2024
INPUT 8	Recycling of light packaging	France	GTAP 42 Recycle	7,62237E-05	2024
INPUT 9	Incenerition	France	GTAP 56 Other Disposal	3,13316E-05	2024

Data inventory - ID04-r – reuse– reuse system

Table 97: ID 04r product description

Product description ID 04-r Reuse		
Pack Weight:	22,9	g
Food contained	500	g
Ratio con unit/FU	5	
Return Rate	0,644	
Components	Weight per packaging unit (g)	Weight [g] su 100g FU
PP bucket	17,3	3,46
PP Lid	5,6	1,12
Total	22,9	4,58



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Table 98: inputs list

Input N°	Description	COUNTRY where operations are carried	SECTOR INVOLVED (GTAP)	ECONOMIC COST (with VALUE indication) EURO	YEAR THE COST WAS INCURRED
INPUT 1	PP bucket	France	GTAP Code: crp – Chemical, rubber and plastic products	0,05030667	2021
INPUT 2	PP Lid	France	GTAP Code: crp – Chemical, rubber and plastic products	0,01628424	2021
INPUT 3	Transport 1: from producers to filler - BUCKET	France	GTAP Code: 48 - Other Transport	3,92424E-05	Actualised to 2024
INPUT 4	Transport 1: from producers to filler - LID	France	GTAP Code: 48 - Other Transport	1,27027E-05	Actualised to 2024
INPUT 5	Transport 2: Distribution Centre - ALL	France	GTAP Code: 48 - Other Transport	8,44917E-05	Actualised to 2024
INPUT 6	Transport 3: Distribution to Shop - ALL	France	GTAP Code: 48 - Other Transport	1,94981E-05	Actualised to 2024
INPUT 7	Transport 4: RVM to sorter - BUCKET	France	GTAP Code: 48 - Other Transport	3,76433E-05	Actualised to 2024
INPUT 8	Transport 5: Sorter to washer - BUCKET	France	"GTAP Code: 48 - Other " Transport	1,16905E-05	Actualised to 2024
INPUT 9	Transport 6: Washer – Filler - BUCKET	France	"GTAP Code: 48 - Other " Transport	0,000105214	Actualised to 2024
INPUT 10	RVM machine electricity	France	GTAP 46 Electricity	0,00038148	2024
INPUT 11	Recycling of light packaging - LID	France	GTAP 42 Recycle	0,000230731	2024
INPUT 12	Incenerition - LID	France	GTAP 56 Other Disposal	9,48416E-05	2024
INPUT 13	Recycling of light packaging - BUCKET	France	GTAP 42 Recycle	0,000253755	2024
INPUT 14	Incenerition BUCKET	France	GTAP 56 Other Disposal	0,000104305	2024



Results

Single Score products comparison

As shown in Figure 97, a comparison of social risks indicates that reuse (ID04-r) is the solution with the lowest associated risks. This is the most favourable scenario in 1st cycle scenario and subsequent ones, which show a gradual decrease in risk. Replacement with paper-based materials (ID 04s) proves to be the worst-case scenario. In addition to this, it is important to underline the notice out that in the substitution scenario (ID 04s), no data were provided regarding the lid composition. Impacts from the solution would subsequently further increase.

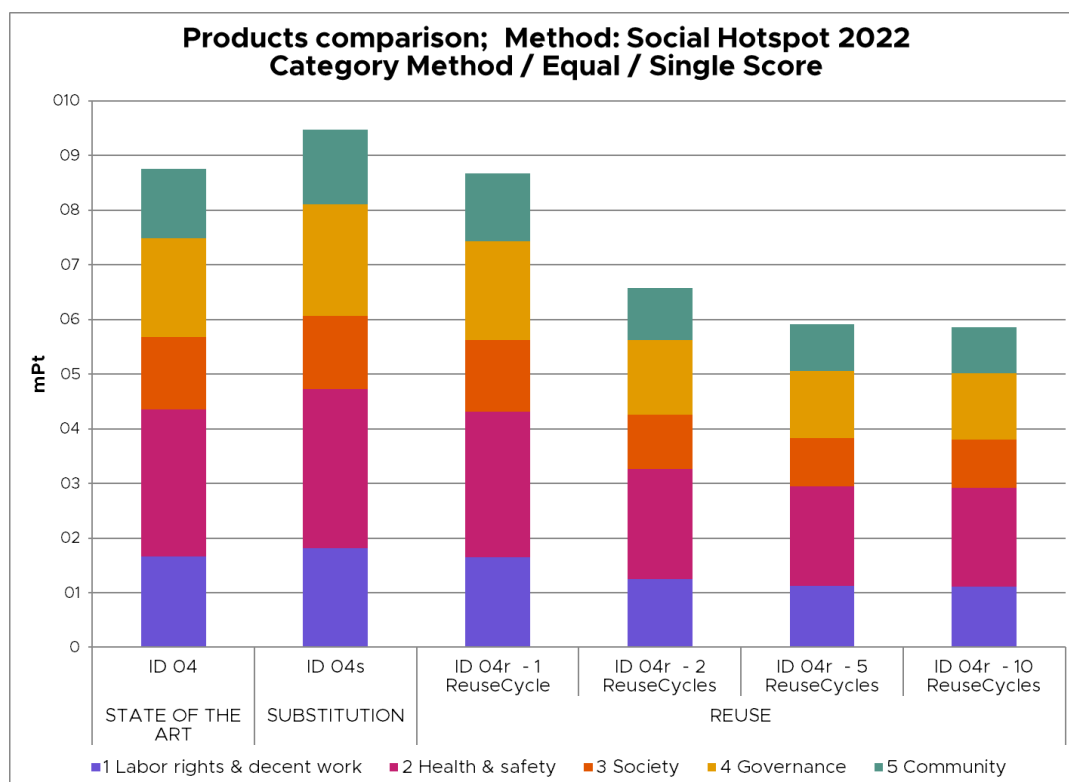


Figure 97: Single Score comparison between solutions and categories contribution



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Inputs contribution to life cycle impacts

PRODUCT 04 – STATE OF THE ART

As shown in Figure 98, the inputs that contribute most to the occurrence of social risks in the five categories indicated are related to materials (in order: PP cup, PET lid, Aluminium Foil) and their production, which are associated with the highest costs.

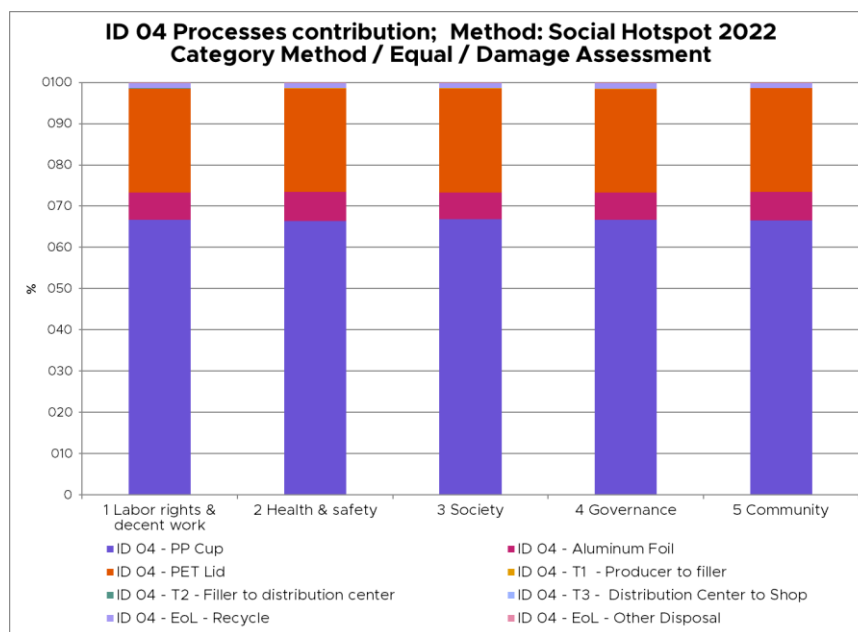


Figure 98: life cycle stages contribution to potential social impacts

PRODUCT 04-s – SUBSTITUTION

As shown in Figure 99, the inputs that contribute most to the occurrence of social risks in the five categories indicated are related to materials and their production (mostly Paper cup), which are associated with the highest costs.

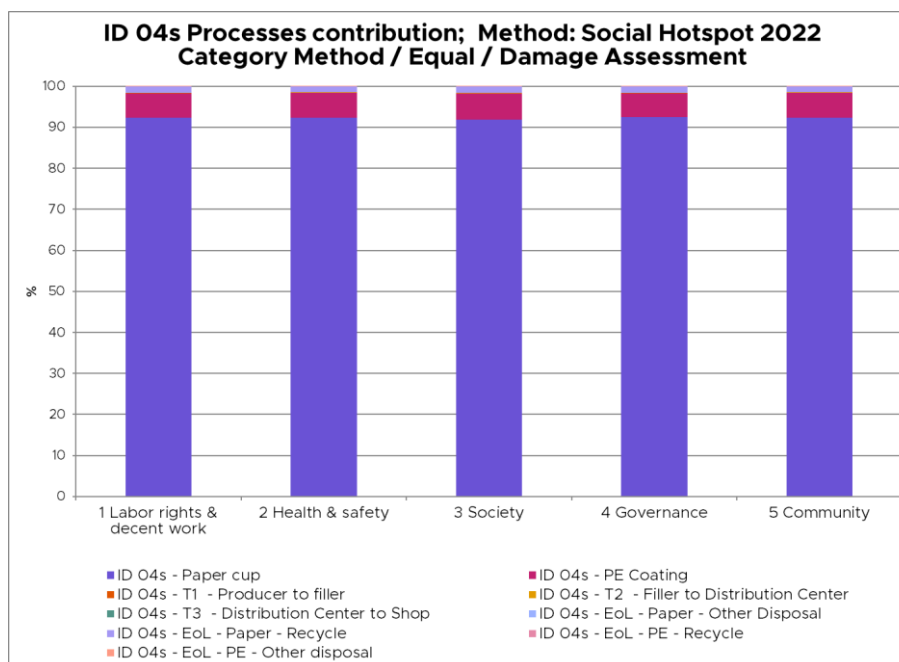


Figure 99: life cycle stages contribution to potential social impacts



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PRODUCT 04-r – REUSE

As shown in Figure 100, the inputs that contribute most to the occurrence of social risks in the five categories indicated are related to materials and their production components, which are associated with the highest costs.

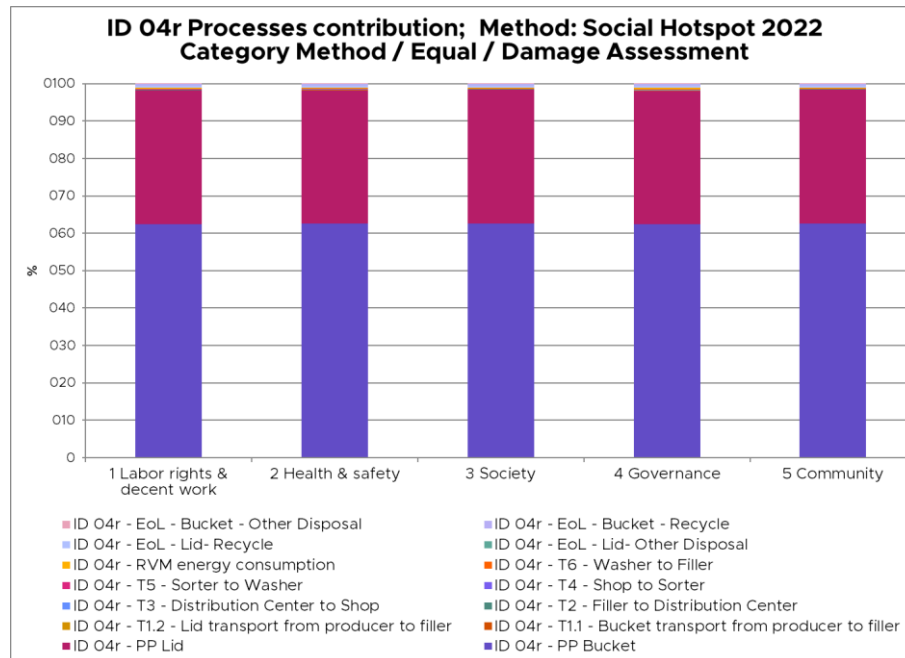


Figure 100: ID04r life cycle stages contribution to potential social impacts, calculated at 10th cycle, with a 64,6% return rate



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Impact sub-categories confrontation table

Table 99 shows in detail the social subcategories, that make up the categories, with the highest social potential risk when the products analyzed vary. In particular, the results were analyzed based on the percentage variation compared to the state of the art (ID-04), in order to quantify the extent of the potential benefits or limitations of the new solutions. Specifically, for product 04-s, the greatest potential risks are associated with: Wage assessment and Labor Laws/Conventions, while, for the reuse scenario (04-r) it can be seen a tie in the 1st cycle scenario and an improvement in all the sub-categories in the following cycles. Labor Laws and Conventions category assesses fairness based on national labor regulations and the ratification of ILO Conventions, which help estimate potential social risks across sectors. The Wage indicator calculates worker hours per dollar of output by dividing wage payments by country and sector specific average wages. It also assesses wage adequacy by comparing these wages to benchmarks such as Minimum Wages, Sweatfree wages, and Living Wages. (Bennema, Norri, & Benoit Norris, 2022). Using a controlled and ethical pulp fiber supply chain reduces exposure to risk situations, particularly in countries where labor protections are weak, as Madagascar and Caribbean regions.

Table 99: Potential impact sub-categories comparison

Impact categories	Impact Sub-categories	Unit	ID 04	ID 04s	ID 04r - 1 ReuseCycle	ID 04r - 2 ReuseCycles	ID 04r - 5 ReuseCycles	ID 04r - 10 ReuseCycles
1 Labor rights & decent work	1A Wage assessment	1A mrheq	2,10E-03	2,78E-03	2,09E-03	1,58E-03	1,43E-03	1,41E-03
	1C Workers in poverty	1C mrheq	1,86E-03	2,05E-03	1,85E-03	1,40E-03	1,26E-03	1,25E-03
	1D Child Labor	1D mrheq	1,70E-03	1,89E-03	1,71E-03	1,29E-03	1,16E-03	1,15E-03
	1E Forced Labor	1E mrheq	2,43E-03	2,44E-03	2,41E-03	1,82E-03	1,64E-03	1,63E-03
	1F Excessive WkTime	1F mrheq	2,13E-03	2,28E-03	2,09E-03	1,58E-03	1,43E-03	1,41E-03
	1G Freedom of Assoc	1G mrheq	1,61E-03	1,66E-03	1,60E-03	1,21E-03	1,09E-03	1,08E-03
	1H Migrant Labor	1H mrheq	1,43E-03	1,54E-03	1,43E-03	1,08E-03	9,74E-04	9,66E-04
	1I Social Benefits	1I mrheq	8,17E-04	7,62E-04	8,05E-04	6,10E-04	5,48E-04	5,44E-04
	1J Labor Laws/Convs	1J mrheq	5,16E-04	7,32E-04	5,14E-04	3,89E-04	3,50E-04	3,47E-04
	1K Discrimination	1K mrheq	2,15E-03	2,12E-03	2,13E-03	1,62E-03	1,45E-03	1,44E-03
2 Health & safety	1L Unemployment	1L mrheq	1,58E-03	1,67E-03	1,56E-03	1,18E-03	1,06E-03	1,05E-03
	2A Occ Tox & Haz	2A mrheq	2,38E-03	2,56E-03	2,35E-03	1,78E-03	1,60E-03	1,59E-03
	2B Injuries & Fatalities	2B mrheq	3,01E-03	3,28E-03	2,97E-03	2,25E-03	2,02E-03	2,01E-03
3 Society	3A Indigenous Rights	3A mrheq	8,58E-04	5,83E-04	8,65E-04	6,54E-04	5,88E-04	5,83E-04
	3B Gender Equity	3B mrheq	1,28E-03	1,27E-03	1,28E-03	9,70E-04	8,72E-04	8,65E-04
	3C High Conflict Zones	3C mrheq	1,60E-03	1,39E-03	1,61E-03	1,22E-03	1,10E-03	1,09E-03
	3D Non-Communicable Diseases	3D mrheq	2,89E-04	2,87E-04	2,87E-04	2,17E-04	1,95E-04	1,94E-04
	3E Communicable Diseases	3E mrheq	1,07E-03	1,12E-03	1,05E-03	7,97E-04	7,17E-04	7,11E-04
	3F Poverty and inequality	3F mrheq	1,91E-03	2,23E-03	1,87E-03	1,42E-03	1,28E-03	1,27E-03
	3G State of Env Sustainability	3G mrheq	2,22E-03	2,40E-03	2,21E-03	1,67E-03	1,50E-03	1,49E-03
4 Governance	4A Legal System	4A mrheq	1,89E-03	2,16E-03	1,88E-03	1,42E-03	1,28E-03	1,27E-03
	4B Corruption	4B mrheq	9,62E-04	1,14E-03	9,56E-04	7,24E-04	6,51E-04	6,46E-04
	4C Democracy & Freedom of Speech	4C mrheq	2,58E-03	2,85E-03	2,57E-03	1,94E-03	1,75E-03	1,73E-03
5 Community	5A Access to Drinking Water	5A mrheq	1,09E-03	1,24E-03	1,09E-03	8,28E-04	7,44E-04	7,39E-04
	5B Access to Sanitation	5B mrheq	1,66E-03	1,94E-03	1,65E-03	1,25E-03	1,12E-03	1,11E-03
	5C Children out of School	5C mrheq	1,52E-03	1,79E-03	1,50E-03	1,14E-03	1,02E-03	1,01E-03
	5D Access to Hospital Beds	5D mrheq	1,51E-03	1,73E-03	1,49E-03	1,13E-03	1,01E-03	1,00E-03
	5E Smallholder v Commercial Farms	5E mrheq	6,46E-04	5,33E-04	6,63E-04	5,02E-04	4,51E-04	4,48E-04
	5F Access to Electricity	5F mrheq	6,43E-04	5,61E-04	6,25E-04	4,74E-04	4,26E-04	4,22E-04
	5G Property rights	5G mrheq	1,75E-03	1,69E-03	1,71E-03	1,30E-03	1,17E-03	1,16E-03

3.2. Product 02 – Prepared salad

The comparative analysis concerns the product ID 02, as state of the art referment, and 02-r as the solution for the reuse system. Below is presented an extract of the data employed in the analysis, calculated using the sources cited above.

Data Inventory - ID02 – state of the art – single use system

Table 100: ID02 product description

Product description ID 02 State of the art		
Pack Weight:	30	g
Food contained	250	g
Components	Weight per packaging unit (g)	Weight [g] su 100g FU
PET Lid	10	4,00
PET Bowl	20	8,00
Total	30	12

Table 101: ID02 inputs list

Input N°	Description	COUNTRY where operations are carried	SECTOR INVOLVED (GTAP)	ECONOMIC COST (EURO 2024)	YEAR THE COST WAS INCURRED
INPUT 1	PET production bowl	France	GTAP Code: crp – Chemical, rubber and plastic products	0,12274	2021
INPUT 2	PET lid production	France	GTAP Code: crp – Chemical, rubber and plastic product	0,06137	2021
INPUT 3	Transport 1: Transport from producers to filler	France	GTAP Code: 48 - Other Transport	0,000136101	Actualised to 2024
INPUT 4	Transport 2: Transport to distribution center	France	GTAP Code: 48 - Other Transport	0,000221376	Actualised to 2024
INPUT 5	Transport 3: Distribution Shop	France	GTAP Code: 48 - Other Transport	5,10867E-05	Actualised to 2024
INPUT 6	Recycling of light packaging	France	GTAP 42 Recycle	0,00247212	2024
INPUT 7	Incineration	France	GTAP 56 Other Disposal	0,00101616	2024

Data Inventory - ID02-r – reuse– reuse system

Table 102: ID02r product description

Product description ID 02-r Reuse		
Pack Weight:	46,1	g
Food contained	250	g
Ratio con unit/FU	2,5	
Return Rate	0,644	
Components	Weight per packaging unit (g)	Weight [g] su 100g FU
PP tray	44,1	17,64
PP lid	2	0,80
Total	46,1	18,44



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Table 103: ID02r input list

Input N°	Description	COUNTRY where operations are carried	SECTOR INVOLVED (GTAP)	ECONOMIC COST (with VALUE indication) EURO 2024	YEAR THE COST WAS INCURRED
INPUT 1	PP tray	France	GTAP Code: crp – Chemical, rubber and plastic products	0,25647678	2021
INPUT 2	PP Lid	France	GTAP Code: crp – Chemical, rubber and plastic products	0,0116316	2021
INPUT 3	Transport 1: from producers to filler - tray	France	GTAP Code: 48 - Other Transport	0,000200068	Actualised to 2024
INPUT 4	Transport 1: from producers to filler - LID	France	GTAP Code: 48 - Other Transport	9,07338E-06	Actualised to 2024
INPUT 5	Transport 2: Distribution Centre - ALL	France	GTAP Code: 48 - Other Transport	0,000340181	Actualised to 2024
INPUT 6	Transport 3: Distribution to Shop - ALL	France	GTAP Code: 48 - Other Transport	7,85032E-05	Actualised to 2024
INPUT 7	Transport 4: RVM to sorter - TRAY	France	GTAP Code: 48 - Other Transport	0,000191916	Actualised to 2024
INPUT 8	Transport 5: Sorter to washer - TRAY	France	GTAP Code: 48 - Other Transport	5,96012E-05	Actualised to 2024
INPUT 9	Transport 6: Washer – Filler - TRAY	France	GTAP Code: 48 - Other Transport	0,00053641	Actualised to 2024
INPUT 10	RVM machine electricity	France	GTAP 46 Electricity	0,00076296	2024
INPUT 11	Recycling of light packaging - LID	France	GTAP 42 Recycle	0,000164808	2024
INPUT 12	Incenerition - LID	France	GTAP 56 Other Disposal	0,000067744	2024
INPUT 13	Recycling of light packaging - TRAY	France	GTAP 42 Recycle	0,00129371	2024
INPUT 14	Incenerition - TRAY	France	GTAP 56 Other Disposal	0,000531777	2024



Results

Single Score products comparison

As shown in Figure 101, a comparison of social risks indicates that the reuse system after the 2nd cycle is the solution with the lowest associated risks. The second cycle represents the “Break-even point” for the social risks associated with the solutions, which show a gradual decrease in risk with the following cycles.

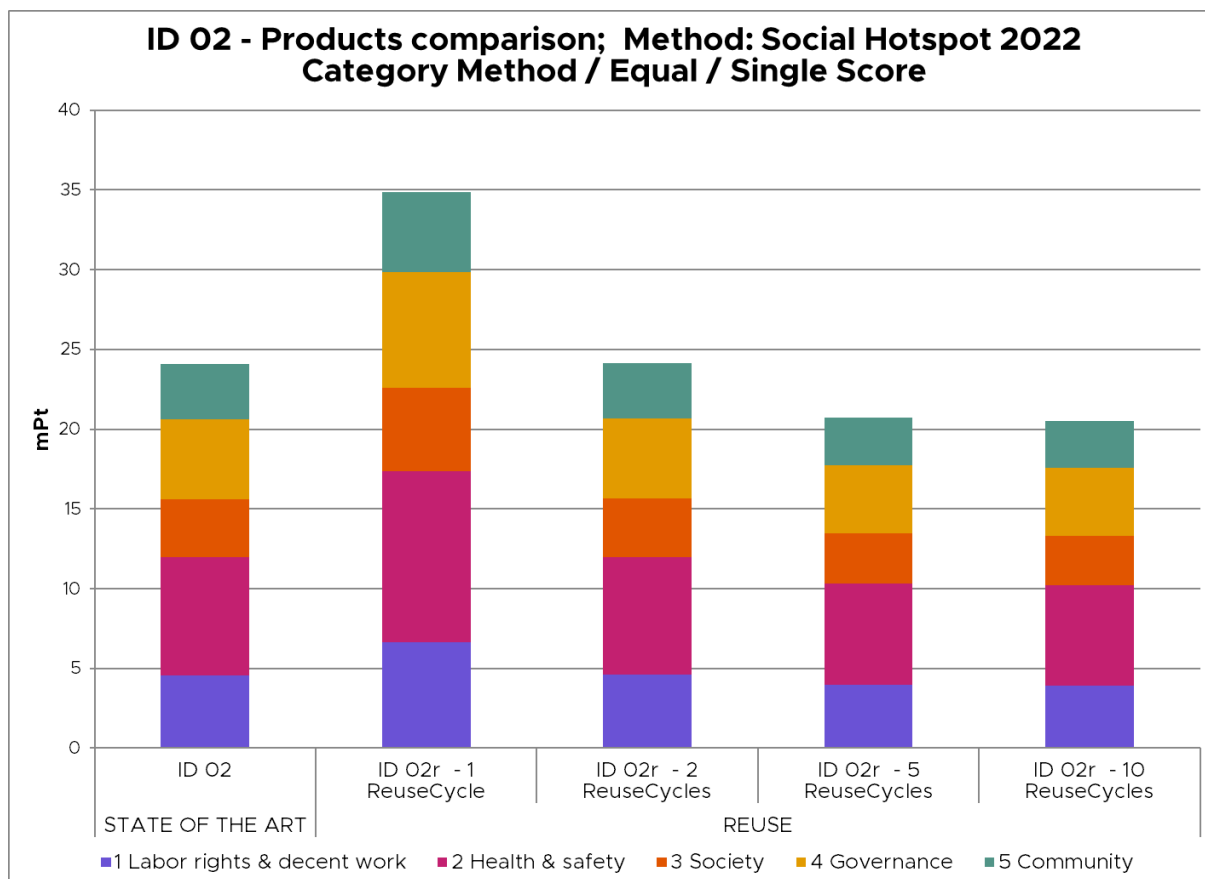


Figure 101: Single Score comparison between solutions and categories contribution

Inputs contribution to life cycle impacts

PRODUCT 02 – STATE OF THE ART

As shown in Figure 102, the inputs that contribute most to the occurrence of social risks in the five categories indicated are related to materials and their production components (PET tray, PET Lid), which are associated with the highest costs.

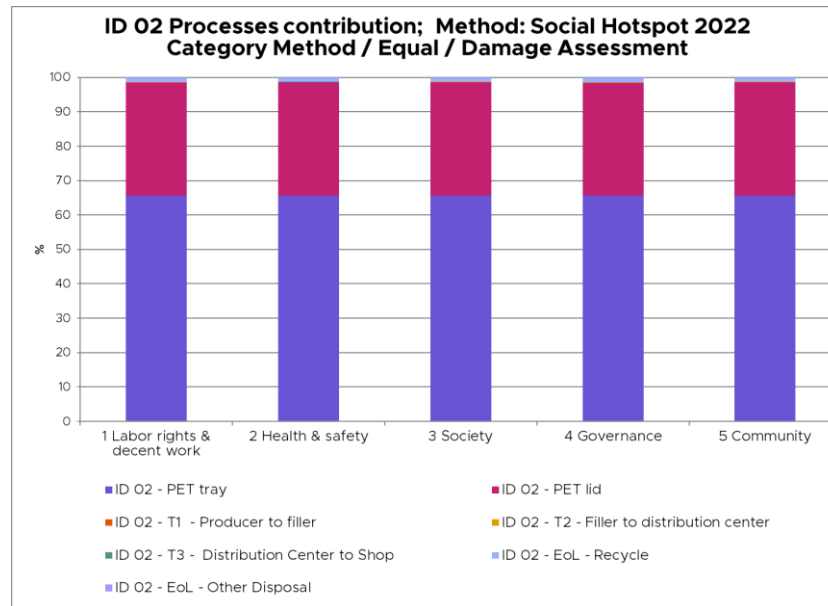


Figure 102: ID 02 life cycle stages contribution to potential social impacts

PRODUCT 02-r – REUSE (10 cycles)

As shown in Figure 103, the inputs that contribute most to the occurrence of social risks in the five categories indicated are related to materials and their production components (predominantly PP Bucket), which are associated with the highest costs.

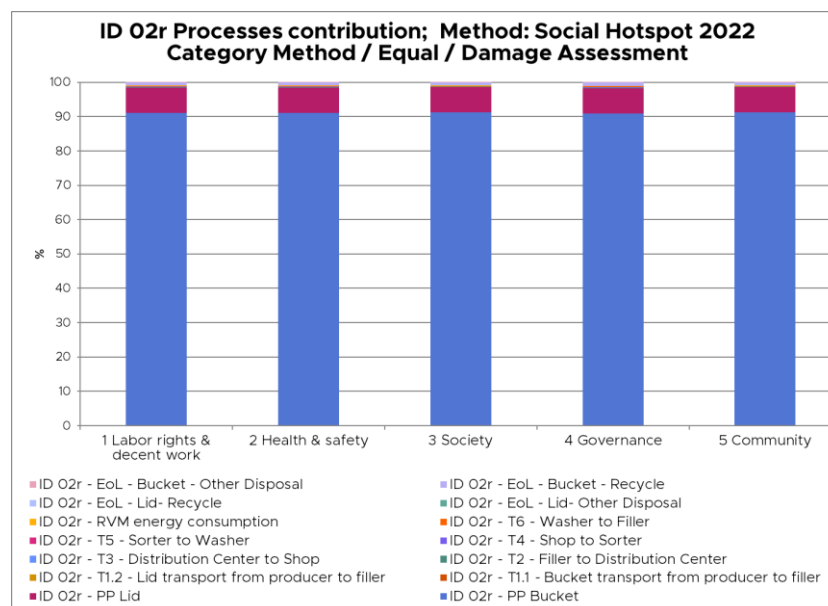


Figure 103: ID02r life cycle stages contribution to potential social impacts, calculated at 10th cycle, with a 64,6% return rate



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Impact sub-categories confrontation table

Table 104 shows the social subcategories that make up the categories with the highest social risk potential when the analyzed products vary. The results were analyzed based on percentage variation compared to the state of the art (ID-02) in order to quantify the extent of the potential benefits or limitations of the new solutions. Specifically, the results for product 02-r are not diversified for the sub-indicator, since the GTAP codes applied to plastics (PET or PP) are the same. A positive trend can be seen after the second reuse cycle, obtained by the spreading of the impacts related to the mass of the packaging on the reuse cycles.

Table 104 Potential impact sub-categories comparison

Impact categories	Impact Sub-categories	Unit	ID 02	ID 02r - 1 ReuseCycle	ID 02r - 2 ReuseCycles	ID 02r - 5 ReuseCycles	ID 02r - 10 ReuseCycles
1 Labor rights & decent work	1A Wage assessment	1A mrheq	5,80E-03	8,40E-03	5,82E-03	5,00E-03	4,95E-03
	1C Workers in poverty	1C mrheq	5,12E-03	7,41E-03	5,13E-03	4,41E-03	4,36E-03
	1D Child Labor	1D mrheq	4,74E-03	6,87E-03	4,75E-03	4,08E-03	4,04E-03
	1E Forced Labor	1E mrheq	6,68E-03	9,68E-03	6,70E-03	5,76E-03	5,69E-03
	1F Excessive WkTime	1F mrheq	5,80E-03	8,40E-03	5,82E-03	5,00E-03	4,94E-03
	1G Freedom of Assoc	1G mrheq	4,43E-03	6,41E-03	4,43E-03	3,81E-03	3,77E-03
	1H Migrant Labor	1H mrheq	3,97E-03	5,75E-03	3,98E-03	3,42E-03	3,38E-03
	1I Social Benefits	1I mrheq	2,24E-03	3,23E-03	2,24E-03	1,92E-03	1,90E-03
	1J Labor Laws/Convs	1J mrheq	1,43E-03	2,07E-03	1,43E-03	1,23E-03	1,22E-03
	1K Discrimination	1K mrheq	5,92E-03	8,58E-03	5,93E-03	5,10E-03	5,04E-03
2 Health & safety	1L Unemployment	1L mrheq	4,32E-03	6,25E-03	4,33E-03	3,72E-03	3,68E-03
	2A Occ Tox & Haz	2A mrheq	6,53E-03	9,45E-03	6,54E-03	5,62E-03	5,56E-03
3 Society	2B Injuries & Fatalities	2B mrheq	8,23E-03	1,19E-02	8,26E-03	7,10E-03	7,02E-03
	3A Indigenous Rights	3A mrheq	2,40E-03	3,47E-03	2,40E-03	2,06E-03	2,04E-03
	3B Gender Equity	3B mrheq	3,55E-03	5,15E-03	3,56E-03	3,06E-03	3,03E-03
	3C High Conflict Zones	3C mrheq	4,46E-03	6,46E-03	4,47E-03	3,84E-03	3,80E-03
	3D Non-Communicable Diseases	3D mrheq	7,95E-04	1,15E-03	7,96E-04	6,85E-04	6,77E-04
	3E Communicable Diseases	3E mrheq	2,92E-03	4,23E-03	2,93E-03	2,52E-03	2,49E-03
	3F Poverty and inequality	3F mrheq	5,20E-03	7,52E-03	5,21E-03	4,48E-03	4,43E-03
4 Governance	3G State of Env Sustainability	3G mrheq	6,13E-03	8,88E-03	6,14E-03	5,28E-03	5,22E-03
	4A Legal System	4A mrheq	5,22E-03	7,55E-03	5,23E-03	4,50E-03	4,45E-03
	4B Corruption	4B mrheq	2,65E-03	3,84E-03	2,66E-03	2,28E-03	2,26E-03
	4C Democracy & Freedom of Speech	4C mrheq	7,12E-03	1,03E-02	7,14E-03	6,14E-03	6,07E-03
5 Community	5A Access to Drinking Water	5A mrheq	3,03E-03	4,40E-03	3,04E-03	2,61E-03	2,58E-03
	5B Access to Sanitation	5B mrheq	4,58E-03	6,63E-03	4,58E-03	3,94E-03	3,90E-03
	5C Children out of School	5C mrheq	4,17E-03	6,04E-03	4,18E-03	3,59E-03	3,55E-03
	5D Access to Hospital Beds	5D mrheq	4,12E-03	5,97E-03	4,13E-03	3,55E-03	3,51E-03
	5E Smallholder v Commercial Farms	5E mrheq	1,84E-03	2,66E-03	1,84E-03	1,58E-03	1,56E-03
	5F Access to Electricity	5F mrheq	1,73E-03	2,51E-03	1,74E-03	1,49E-03	1,48E-03
	5G Property rights	5G mrheq	4,75E-03	6,88E-03	4,76E-03	4,09E-03	4,05E-03

3.3. Product 10 – Petals salée

The comparative analysis concerns the product ID 10, as state of the art referment, and 10-r1 as the solution for the reuse system. Below is presented an extract of the data employed in the analysis, calculated using the sources cited above.

Data Inventory - ID10 – state of the art – single use system

Table 105: ID10 product description

10 State of the art product description		
Pack Weight:	78,14086	g
Food contained	200	g
Components	Weight per packaging unit (g)	Weight [g] su 100g FU
carboard box	74,8	37,40
OPP film	2,92432	1,46216
Adhesive	0,41654	0,21
Total	78,14086	39,07043

Table 106: ID10 inputs list

Input N°	Description	COUNTRY where operations are carried	SECTOR INVOLVED (GTAP)	ECONOMIC COST (EURO 2024)	YEAR THE COST WAS INCURRED
INPUT 1	carboard box	France	GTAP Code: p_c – Paper products, publishing	0,5848051	2021
INPUT 2	Adhesive	France	GTAP Code: crp – Chemical, rubber and plastic products	0,002480496	2021
INPUT 3	OPP film	France	GTAP Code: crp – Chemical, rubber and plastic products	0,017414326	2021
INPUT 4	Transport 1: Transport from producers to filler	France	GTAP Code: 48 - Other Transport	0,000443126	Actualised to 2024
INPUT 5	Transport 2: Transport to distribution center	France	GTAP Code: 48 - Other Transport	0,00072077	Actualised to 2024
INPUT 6	Transport 3: Distribution to Shop	France	GTAP Code: 48 - Other Transport	0,000166332	Actualised to 2024
INPUT 7	Recycle Papier	France	GTAP 42 Recycle	0,008490067	2024
INPUT 8	Incenerition	France	GTAP 56 Other Disposal	0,00109064	2024
INPUT 9	Recycling of light packaging	France	GTAP 42 Recycle	0,00030122	2024
INPUT 10	Incenerition	France	GTAP 56 Other Disposal	0,000123816	2024



Data Inventory - ID10-r1 – reuse– reuse system

Table 107: ID 10r product description

10-r1 Reuse product description		
Pack Weight:	44,7 g	
Food contained	100 g	
Ratio con unit/FU	1	
Return Rate	0,644	
Components	Weight per packaging unit (g)	Weight [g] su 100g FU
PP bucket	37	37,00
PP Lid	7,7	7,70
Total	44,7	44,7

Table 108: ID10r inputs list

Input N°	Description	COUNTRY where operations are carried	SECTOR INVOLVED (GTAP)	ECONOMIC COST (with VALUE indication) EURO 2024	YEAR THE COST WAS INCURRED
INPUT 1	PP bucket	France	GTAP Code: crp – Chemical, rubber and plastic products	0,5379615	2021
INPUT 2	PP Lid	France	GTAP Code: crp – Chemical, rubber and plastic products	0,11195415	2021
INPUT 3	Transport 1: from producers to filler - BUCKET	France	GTAP Code: 48 - Other Transport	0,000419644	Actualised to 2024
INPUT 4	Transport 1: from producers to filler - LID	France	GTAP Code: 48 - Other Transport	8,73312E-05	Actualised to 2024
INPUT 5	Transport 2: Distribution Centre - ALL	France	GTAP Code: 48 - Other Transport	0,000824624	Actualised to 2024
INPUT 6	Transport 3: Distribution to Shop - ALL	France	GTAP Code: 48 - Other Transport	0,000190298	Actualised to 2024
INPUT 7	Transport 4: RVM to sorter - BUCKET	France	GTAP Code: 48 - Other Transport	0,000402544	Actualised to 2024
INPUT 8	Transport 5: Sorter to washer - BUCKET	France	GTAP Code: 48 - Other Transport	0,000125014	Actualised to 2024
INPUT 9	Transport 6: Washer – Filler - BUCKET	France	GTAP Code: 48 - Other Transport	0,001125124	Actualised to 2024
INPUT 10	RVM machine electricity	France	GTAP 46 Electricity	0,0019074	2024
INPUT 11	Recycling of light packaging - LID	France	GTAP 42 Recycle	0,001586277	2024
INPUT 12	Incenerition - LID	France	GTAP 56 Other Disposal	0,000652036	2024
INPUT 13	Recycling of light packaging - BUCKET	France	GTAP 42 Recycle	0,002713564	2024
INPUT 14	Incenerition BUCKET	France	GTAP 56 Other Disposal	0,001115405	2024



Results

Single Score products comparison

As shown in Figure 104, a comparison of social risks indicates that the reuse system after the 1st cycle is the solution with the lowest associated risks. The second cycle represents the “Break-even point” for the social risks associated with the solutions, which show a gradual decrease in risk with the following cycles.

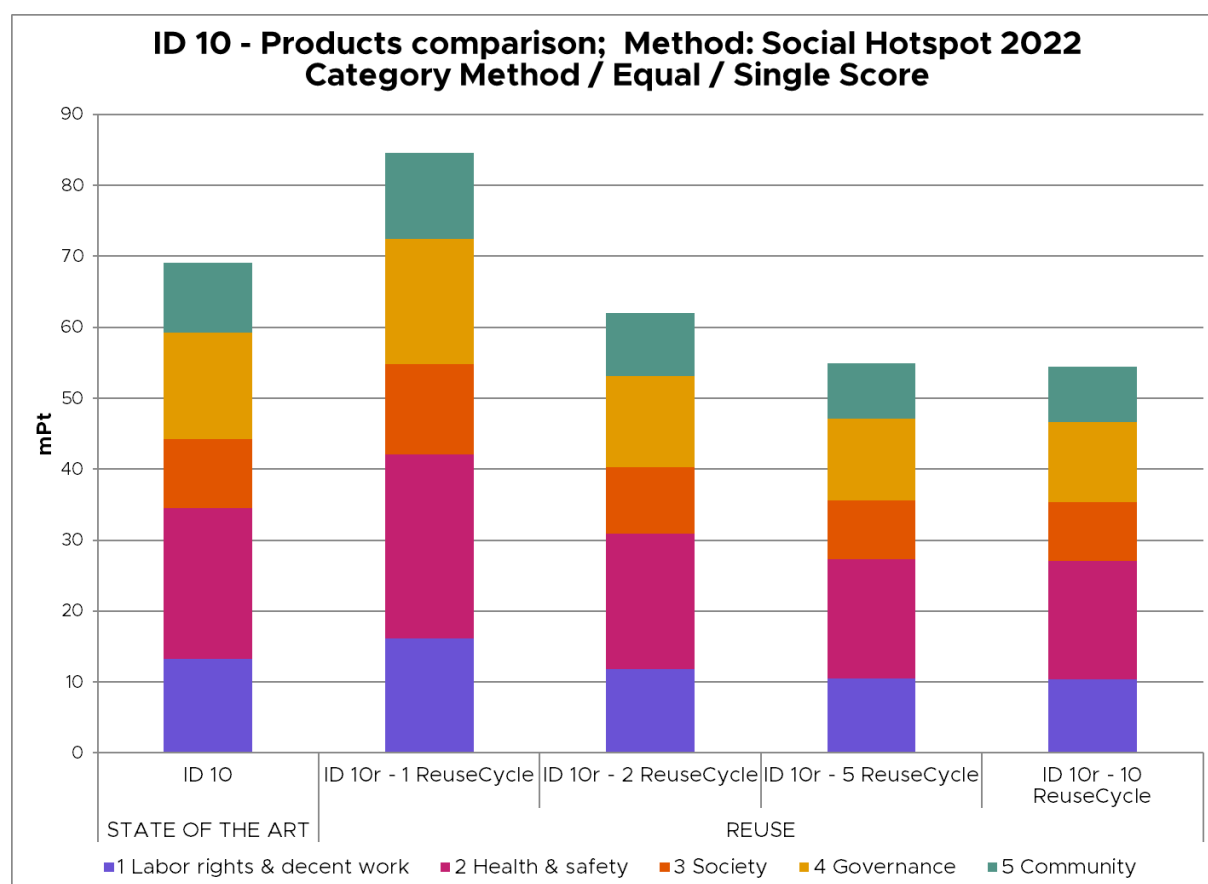


Figure 104: Single Score comparison between solutions and categories contribution



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Inputs contribution to life cycle impacts

PRODUCT 10– STATE OF THE ART

As shown in Figure 105, the inputs that contribute most to the occurrence of social risks in the five categories indicated are related to materials and their production components (predominantly cardboard box), which are associated with the highest costs.

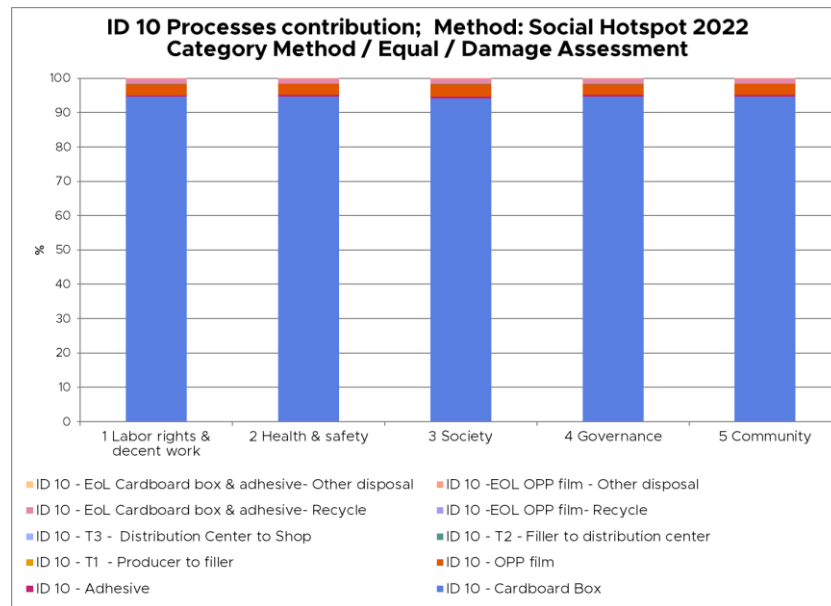


Figure 105: ID10 life cycle stages contribution to potential social impacts

PRODUCT 10r – REUSE

As shown in Figure 106, the inputs that contribute most to the occurrence of social risks in the five categories indicated are related to materials and their production components (PP bucket, PP lid), which are associated with the highest costs.

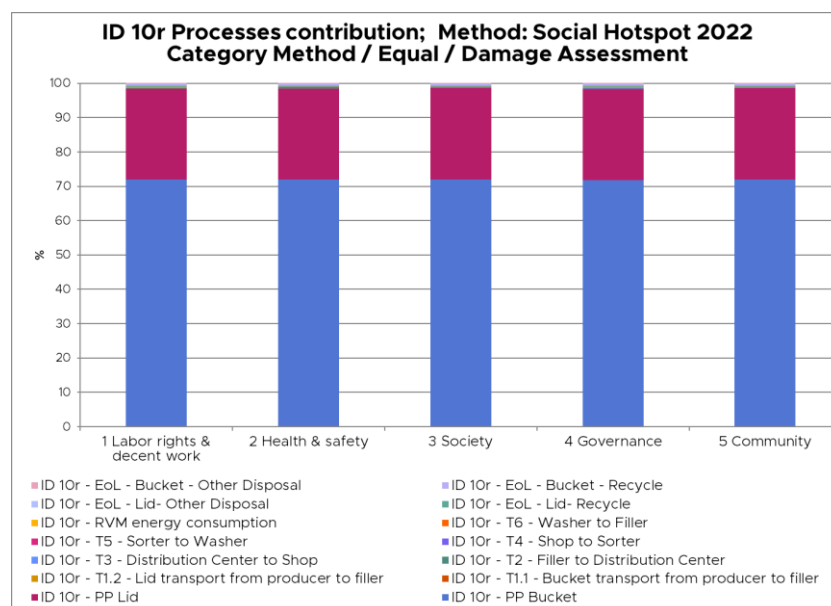


Figure 106: ID10r life cycle stages contribution to potential social impacts, calculated at 10th cycle, with a 64,6% return rate



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Impact sub-categories confrontation table

Table 109 shows in detail the social subcategories, that make up the categories, with the highest social potential risk when the products analyzed vary. In particular, the results were analyzed based on the percentage variation compared to the state of the art (ID 10). Specifically, for product 10-r1 at the 1st reuse cycle, the greatest potential risks are associated with: Indigenous rights and Smallholder v Commercial Farm, Access to Electricity, High conflict zones. The Indigenous Rights indicator measures the presence and share of indigenous peoples in each country, drawing on sources such as IWGIA, UNDESA, and the World Bank. It captures groups that are culturally distinct and self-identify as indigenous. The Smallholder vs. Commercial Farms indicator measures the distribution of smallholder and commercial farms using FAO data on landholding sizes and ILO data on family versus commercial labor. The Access to Electricity indicator measures the share of the population with electricity, using data from the World Bank's global electrification database. The High Conflict Zones indicator measures countries' exposure to conflict and state fragility, using data from the Heidelberg Institute for International Conflict Research, the Center for Systemic Peace, and Minority Rights Group International. Improvements to these indicators could come from stricter oversight of the polymer supply chain, particularly by ensuring safe and ethical sourcing of the components of the materials coming from high-risk regions, such as those in Africa. (Bennema, Norri, & Benoit Norris, 2022)

Instead, the subcategories that show an improvement from the 1st reuse cycle in comparison to the state-of-the-art system are Labor Laws/Conventions and Wage Assessment. For further explanation of these indicators, see the same section for product 04s. In this case, the differences are mainly due to the change in material, from paper-based to plastic-based, as can be seen from the previous graphs. From the second reuse cycle of the ID-10R1, there is a positive trend in favour of the reduction of associated potential risks in the reuse system.

Table 109: Potential impact sub-categories comparison

Impact categories	Impact Sub-categories	Unit	ID 10	ID 10r - 1 ReuseCycle	ID 10r - 2 ReuseCycles	ID 10r - 5 ReuseCycles	ID 10r - 10 ReuseCycles
1 Labor rights & decent work	1A Wage assessment	1A mrheq	2,04E-02	2,04E-02	1,50E-02	1,33E-02	1,31E-02
	1C Workers in poverty	1C mrheq	1,50E-02	1,80E-02	1,32E-02	1,17E-02	1,16E-02
	1D Child Labor	1D mrheq	1,38E-02	1,67E-02	1,22E-02	1,08E-02	1,07E-02
	1E Forced Labor	1E mrheq	1,78E-02	2,35E-02	1,72E-02	1,53E-02	1,51E-02
	1F Excessive WkTime	1F mrheq	1,66E-02	2,04E-02	1,50E-02	1,33E-02	1,31E-02
	1G Freedom of Assoc	1G mrheq	1,21E-02	1,56E-02	1,14E-02	1,01E-02	1,00E-02
	1H Migrant Labor	1H mrheq	1,13E-02	1,39E-02	1,02E-02	9,06E-03	8,98E-03
	1I Social Benefits	1I mrheq	5,54E-03	7,85E-03	5,76E-03	5,10E-03	5,05E-03
	1J Labor Laws/Convs	1J mrheq	5,38E-03	5,02E-03	3,68E-03	3,26E-03	3,23E-03
	1K Discrimination	1K mrheq	1,54E-02	2,08E-02	1,53E-02	1,35E-02	1,34E-02
2 Health & safety	1L Unemployment	1L mrheq	1,22E-02	1,52E-02	1,11E-02	9,86E-03	9,77E-03
	2A Occ Tox & Haz	2A mrheq	1,87E-02	2,29E-02	1,68E-02	1,49E-02	1,48E-02
3 Society	2B Injuries & Fatalities	2B mrheq	2,39E-02	2,90E-02	2,13E-02	1,88E-02	1,87E-02
	3A Indigenous Rights	3A mrheq	4,19E-03	8,43E-03	6,18E-03	5,47E-03	5,42E-03
	3B Gender Equity	3B mrheq	9,28E-03	1,25E-02	9,16E-03	8,11E-03	8,04E-03
	3C High Conflict Zones	3C mrheq	1,01E-02	1,57E-02	1,15E-02	1,02E-02	1,01E-02
	3D Non-Communicable Diseases	3D mrheq	2,09E-03	2,79E-03	2,05E-03	1,81E-03	1,80E-03
	3E Communicable Diseases	3E mrheq	8,21E-03	1,03E-02	7,53E-03	6,67E-03	6,61E-03
	3F Poverty and inequality	3F mrheq	1,63E-02	1,83E-02	1,34E-02	1,19E-02	1,18E-02
4 Governance	3G State of Env Sustainability	3G mrheq	1,75E-02	2,15E-02	1,58E-02	1,40E-02	1,39E-02
	4A Legal System	4A mrheq	1,58E-02	1,83E-02	1,35E-02	1,19E-02	1,18E-02
	4B Corruption	4B mrheq	8,32E-03	9,32E-03	6,84E-03	6,06E-03	6,00E-03
	4C Democracy & Freedom of Speech	4C mrheq	2,08E-02	2,50E-02	1,84E-02	1,63E-02	1,61E-02
5 Community	5A Access to Drinking Water	5A mrheq	9,09E-03	1,07E-02	7,82E-03	6,93E-03	6,86E-03
	5B Access to Sanitation	5B mrheq	1,42E-02	1,61E-02	1,18E-02	1,04E-02	1,04E-02
	5C Children out of School	5C mrheq	1,31E-02	1,46E-02	1,07E-02	9,52E-03	9,43E-03
	5D Access to Hospital Beds	5D mrheq	1,26E-02	1,45E-02	1,06E-02	9,41E-03	9,32E-03
	5E Smallholder v Commercial Farms	5E mrheq	3,85E-03	6,46E-03	4,74E-03	4,20E-03	4,16E-03
	5F Access to Electricity	5F mrheq	4,07E-03	6,09E-03	4,47E-03	3,96E-03	3,93E-03
	5G Property rights	5G mrheq	1,23E-02	1,67E-02	1,23E-02	1,09E-02	1,08E-02

3.4. Product 11 – Orange juice

The comparative analysis concerns product ID 11, as state of the art referment, and 11-r as the solution for the reuse system. Below is presented an extract of the data employed in the analysis, calculated using the sources cited above.

Data Inventory - ID11 – state of the art – single use system

Table 110: ID11 product description

ID11 State of the art product description		
Pack Weight:	6,4	g
Food contained	200	g
Components	Weight per packaging unit (g)	Weight [g] su 100g FU
HDPE Cap	0,6	0,30
OPP Foil	0,2	0,10
PET Bottle	5,6	2,80
Total	6,4	3,2

Table 111: ID11 inputs list

Input N°	Description	COUNTRY where operations are carried	SECTOR INVOLVED (GTAP)	ECONOMIC COST (EURO)	YEAR THE COST WAS INCURRED
INPUT 1	HDPE Cap	France	GTAP Code: crp – Chemical, rubber and plastic products	0,00436185	2021
INPUT 2	PET Bottle	France	GTAP Code: crp – Chemical, rubber and plastic products	0,049679	2021
INPUT 3	OPP Foil	France	GTAP Code: crp – Chemical, rubber and plastic products	0,001191	2021
INPUT 4	Transport 1: Transport from producers to filler	France	GTAP Code: 48 - Other Transport	3,62935E-05	Actualised to 2024
INPUT 5	Transport 2: Transport to distribution center	France	GTAP Code: 48 - Other Transport	5,90335E-05	Actualised to 2024
INPUT 6	Transport 3: Distribution to Shop	France	GTAP Code: 48 - Other Transport	1,36231E-05	Actualised to 2024
INPUT 7	Recycling of light packaging	France	GTAP 42 Recycle	0,000659232	2024
INPUT 8	Incenerition	France	GTAP 56 Other Disposal	0,000270976	2024



Data Inventory - ID11-r – reuse– reuse system

Table 112: ID11R product composition

11-r Reuse product description		
Pack Weight:	380 g	
Food contained	1000 g	
Pack weight /FU	10	
Return Rate	0,644	
Components	Weight per packaging unit (g)	Weight [g] su 100g FU
Twist-off capsule	5	0,50
Glass Bottle	375	37,50
Total	380	38

Table 113: ID11r inputs list

Input N°	Description	COUNTRY where operations are carried	SECTOR INVOLVED (GTAP)	ECONOMIC COST (with VALUE indication) EURO	YEAR THE COST WAS INCURRED
INPUT 1	Twist-off capsule	France	GTAP Code: nfm – Non-ferrous metals	0,0056525	2021
INPUT 2	Glass Bottle	France	GTAP Code: nmm – Non-metallic mineral products	0,3635625	2021
INPUT 3	Transport 1: from producers to filler - BOTTLE	France	GTAP Code: 48 - Other Transport	0,000425315	Actualised to 2024
INPUT 4	Transport 1: from producers to filler - LID	France	GTAP Code: 48 - Other Transport	5,67086E-06	Actualised to 2024
INPUT 5	Transport 2: Distribution Centre - ALL	France	GTAP Code: 48 - Other Transport	0,000701023	Actualised to 2024
INPUT 6	Transport 3: Distribution to Shop - ALL	France	GTAP Code: 48 - Other Transport	0,000161775	Actualised to 2024
INPUT 7	Transport 4: RVM to sorter - BOTTLE	France	GTAP Code: 48 - Other Transport	0,000407984	Actualised to 2024
INPUT 8	Transport 5: Sorter to washer - BOTTLE	France	GTAP Code: 48 - Other Transport	0,000126703	Actualised to 2024
INPUT 9	Transport 6: Washer – Filler - BOTTLE	France	GTAP Code: 48 - Other Transport	0,001140328	Actualised to 2024
INPUT 10	RVM machine	France	GTAP 46 Electricity	0,00019074	2024
INPUT 11	Recycling of light packaging - LID	France	GTAP 42 Recycle	0,000103005	2024
INPUT 12	Incenerition - LID	France	GTAP 56 Other Disposal	0,00004234	2024
INPUT 13	Recycle Verre - BOTTLE	France	GTAP 42 Recycle	0,00070488	2024
INPUT 14	Incenerition - BOTTLE	France	GTAP 56 Other Disposal	0,000526524	2024



Results

Single Score products comparison

As illustrated in Figure 107, a comparison of social risks indicates that the reuse system, even after 10 reuse cycles, is the solution with the highest associated risks. In this case, the switch of materials from plastic to glass (with the associated weights and costs per functional unit) represented an unfavourable change in terms of potential social risks.

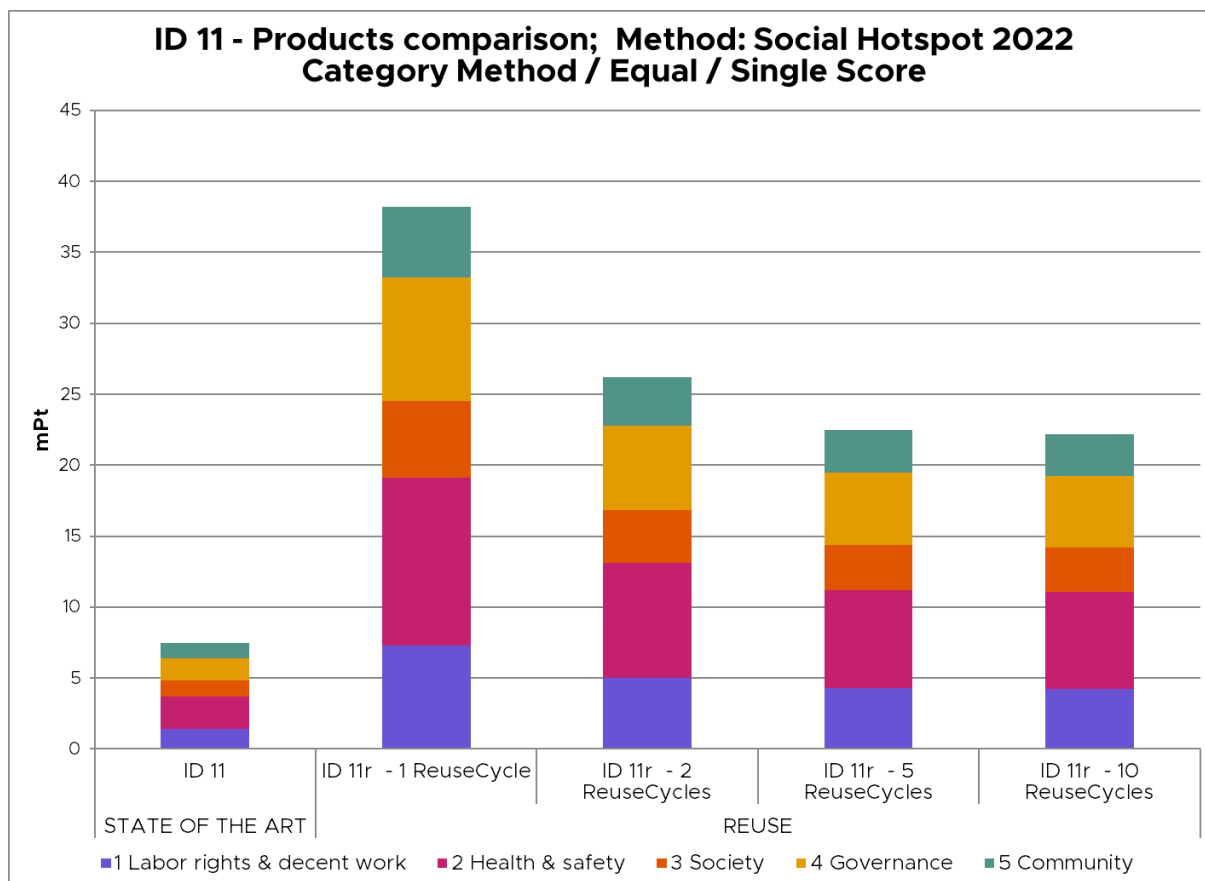


Figure 107: Single Score comparison between solutions and categories contribution



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Inputs contribution to life cycle impacts

PRODUCT 11 – STATE OF THE ART

As shown in Figure 108, the inputs that contribute most to the occurrence of social risks in the five categories indicated are related to materials and their production components (predominantly PET bottle), which are associated with the highest costs.

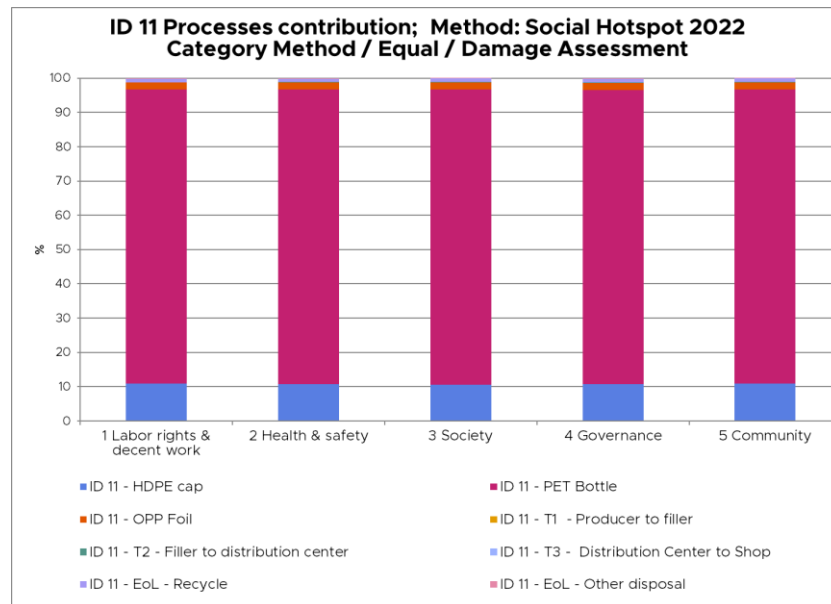


Figure 108: ID11 life cycle stages contribution to potential social impacts

PRODUCT 11r – REUSE

As shown in Figure 109, the inputs that contribute most to the occurrence of social risks in the five categories indicated are related to materials and their production components (predominantly Glass bottle), which are associated with the highest costs.

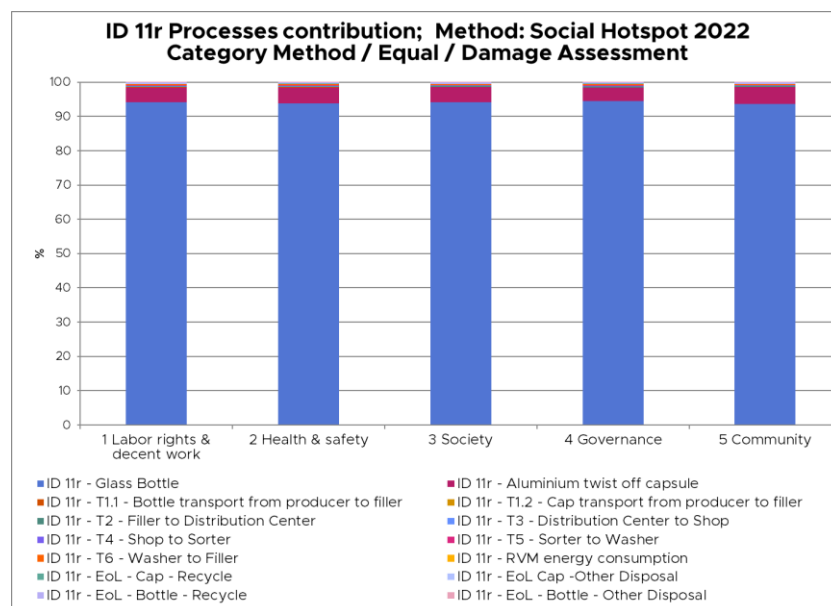


Figure 109: ID11r life cycle stages contribution to potential social impacts, calculated at 10th cycle, with a 64,6% return rate



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Impact sub-categories confrontation table

Table 114 shows in detail the social subcategories, that make up the categories, with the highest social potential risk when the products analyzed vary. In particular, the results were analyzed based on the percentage variation compared to the state of the art (ID 11). Specifically, for product 11-r. it can be seen a higher risk in all the subcategories. In this case, the differences are mainly due to the change in material, from plastic to glass (associated with a higher weight and cost per Functional Unit), as can be seen from the previous graphs.

Table 114 Potential impact sub-categories comparison

Impact categories	Impact Sub-categories	Unit	ID 11	ID 11r - 1 ReuseCycle	ID 11r - 2 ReuseCycles	ID 11r - 5 ReuseCycles	ID 11r - 10 ReuseCycles
1 Labor rights & decent work	1A Wage assessment	1A mrheq	1,81E-03	1,01E-02	6,89E-03	5,89E-03	5,82E-03
	1C Workers in poverty	1C mrheq	1,59E-03	7,85E-03	5,38E-03	4,61E-03	4,56E-03
	1D Child Labor	1D mrheq	1,47E-03	6,61E-03	4,53E-03	3,88E-03	3,83E-03
	1E Forced Labor	1E mrheq	2,07E-03	1,07E-02	7,33E-03	6,28E-03	6,20E-03
	1F Excessive WkTime	1F mrheq	1,79E-03	9,76E-03	6,70E-03	5,74E-03	5,67E-03
	1G Freedom of Assoc	1G mrheq	1,36E-03	6,96E-03	4,77E-03	4,09E-03	4,04E-03
	1H Migrant Labor	1H mrheq	1,23E-03	6,28E-03	4,31E-03	3,68E-03	3,64E-03
	1I Social Benefits	1I mrheq	6,87E-04	3,31E-03	2,27E-03	1,95E-03	1,92E-03
	1J Labor Laws/Convs	1J mrheq	4,43E-04	2,28E-03	1,57E-03	1,34E-03	1,32E-03
	1K Discrimination	1K mrheq	1,83E-03	9,09E-03	6,23E-03	5,33E-03	5,27E-03
2 Health & safety	1L Unemployment	1L mrheq	1,34E-03	7,14E-03	4,90E-03	4,19E-03	4,14E-03
	2A Occ Tox & Haz	2A mrheq	2,02E-03	1,02E-02	6,98E-03	5,97E-03	5,90E-03
3 Society	2B Injuries & Fatalities	2B mrheq	2,56E-03	1,35E-02	9,25E-03	7,92E-03	7,82E-03
	3A Indigenous Rights	3A mrheq	7,37E-04	2,97E-03	2,04E-03	1,74E-03	1,72E-03
	3B Gender Equity	3B mrheq	1,10E-03	5,02E-03	3,44E-03	2,94E-03	2,91E-03
	3C High Conflict Zones	3C mrheq	1,37E-03	6,57E-03	4,50E-03	3,85E-03	3,80E-03
	3D Non-Communicable Diseases	3D mrheq	2,46E-04	1,14E-03	7,84E-04	6,72E-04	6,64E-04
	3E Communicable Diseases	3E mrheq	9,04E-04	4,33E-03	2,98E-03	2,55E-03	2,52E-03
	3F Poverty and inequality	3F mrheq	1,61E-03	8,50E-03	5,84E-03	5,00E-03	4,94E-03
4 Governance	3G State of Env Sustainability	3G mrheq	1,89E-03	9,29E-03	6,37E-03	5,45E-03	5,39E-03
	4A Legal System	4A mrheq	1,62E-03	9,25E-03	6,34E-03	5,42E-03	5,36E-03
	4B Corruption	4B mrheq	8,24E-04	4,41E-03	3,02E-03	2,59E-03	2,56E-03
	4C Democracy & Freedom of Speech	4C mrheq	2,20E-03	1,24E-02	8,52E-03	7,29E-03	7,20E-03
5 Community	5A Access to Drinking Water	5A mrheq	9,45E-04	3,58E-03	2,46E-03	2,11E-03	2,08E-03
	5B Access to Sanitation	5B mrheq	1,42E-03	6,92E-03	4,75E-03	4,07E-03	4,02E-03
	5C Children out of School	5C mrheq	1,29E-03	6,32E-03	4,34E-03	3,71E-03	3,67E-03
	5D Access to Hospital Beds	5D mrheq	1,28E-03	6,20E-03	4,26E-03	3,65E-03	3,61E-03
	5E Smallholder v Commercial Farms	5E mrheq	5,67E-04	2,04E-03	1,39E-03	1,19E-03	1,17E-03
	5F Access to Electricity	5F mrheq	5,34E-04	2,83E-03	1,95E-03	1,67E-03	1,65E-03
	5G Property rights	5G mrheq	1,47E-03	7,26E-03	5,00E-03	4,28E-03	4,23E-03



3.5. Product 17 - Mayonnaise

The comparative analysis concerns the product ID 17, as state of the art referment considered in a single-use system and the same packaging solution considered in a reuse system: 17-r.

Data Inventory - ID17 – state of the art – single use system

Table 115: ID17 product description

17 State of the art product description		
Pack Weight:	472,6155	g
Food contained	475	g
Components	Weight per packaging unit (g)	Weight [g] su 100g FU
Twist off lid	15,504	3,26
Glass jar	457,1115	96,23
Total	472,6155	99,498

Table 116: ID17 inputs list

Input N°	Description	COUNTRY where operations are carried	SECTOR INVOLVED (GTAP)	ECONOMIC COST (EURO)	YEAR THE COST WAS INCURRED
INPUT 1	Twist off lid	France	GTAP Code: nfm – Non-ferrous metals	0,03689952	2021
INPUT 2	Glass jar	France	GTAP Code: nmm – Non-metallic mineral products	0,93298863	2021
INPUT 3	Transport 1: Transport from producers to filler	France	GTAP Code: 48 - Other Transport	0,001128478	Actualised to 2024
INPUT 4	Transport 2: Transport to distribution center	France	GTAP Code: 48 - Other Transport	0,001835537	Actualised to 2024
INPUT 5	Transport 3: Distribution to Shop	France	GTAP Code: 48 - Other Transport	0,000423585	Actualised to 2024
INPUT 6	Glass recycle	France	GTAP 42 Recycle	0,005081155	2024
INPUT 7	Other disposal glass	France	GTAP 56 Other Disposal	0,003795469	2024
INPUT 8	Recycling of light packaging	France	GTAP 42 Recycle	0,000672417	2024
INPUT 9	Incenerition	France	GTAP 56 Other Disposal	0,000276396	2024



Data Inventory - ID17-r – reuse– reuse system

Table 117: ID 17r product description

11-r Reuse product description		
Pack Weight:	472,6155 g	
Food contained	475 g	
Pack weight /FU	4,75	
Return Rate	0,644	
Components	Weight per packaging unit (g)	Weight [g] su 100g FU
Twist off lid	15,504	3,26
Glass jar	457,1115	96,23
Total	472,6155	99,498

Table 118: ID17r inputs list

Input N°	Description	COUNTRY where operations are carried	SECTOR INVOLVED (GTAP)	ECONOMIC COST (with VALUE indication) EURO	YEAR THE COST WAS INCURRED
INPUT 1	Twist off lid	France	GTAP Code: nfm – Non-ferrous metals	0,03689952	2021
INPUT 2	Glass jar	France	GTAP Code: nmm – Non-metallic mineral products	0,93298863	2021
INPUT 3	Transport 1: from producers to filler - JAR	France	GTAP Code: 48 - Other Transport	0,001091459	Actualised to 2024
INPUT 4	Transport 1: from producers to filler LID	France	GTAP Code: 48 - Other Transport	3,70194E-05	Actualised to 2024
INPUT 5	Transport 2: Distribution Centre - ALL	France	GTAP Code: 48 - Other Transport	0,001835537	Actualised to 2024
INPUT 6	Transport 3: Distribution to Shop - ALL	France	GTAP Code: 48 - Other Transport	0,000423585	Actualised to 2024
INPUT 7	Transport 4: RVM to sorter - JAR	France	GTAP Code: 48 - Other Transport	0,001046985	Actualised to 2024
INPUT 8	Transport 5: Sorter to washer - JAR	France	GTAP Code: 48 - Other Transport	0,000325151	Actualised to 2024
INPUT 9	Transport 6: Washer – Filler - JAR	France	GTAP Code: 48 - Other Transport	0,002926356	Actualised to 2024
INPUT 10	RVM machine	France	GTAP 46 Electricity	0,000401558	2024
INPUT 11	Recycling of light packaging	France	GTAP 42 Recycle	0,000672417	2024
INPUT 12	Incenerition	France	GTAP 56 Other Disposal	0,000276396	2024
INPUT 13	Recycle Verre	France	GTAP 42 Recycle	0,001808891	2024
INPUT 14	Incenerition	France	GTAP 56 Other Disposal	0,001351187	2024



Results

Single Score products comparison

As shown in Figure 110, a comparison indicates that the reuse system after the 1st cycle is the solution with the lowest associated risks. The second cycle represents the “Break-even point” for the social risks associated with the solutions, which show a gradual decrease in risk with the following cycles. In this case, being the packaging solution constant between the analysed scenarios, it can be seen that the additional phases that the reuse system includes do not have an influence on the results.

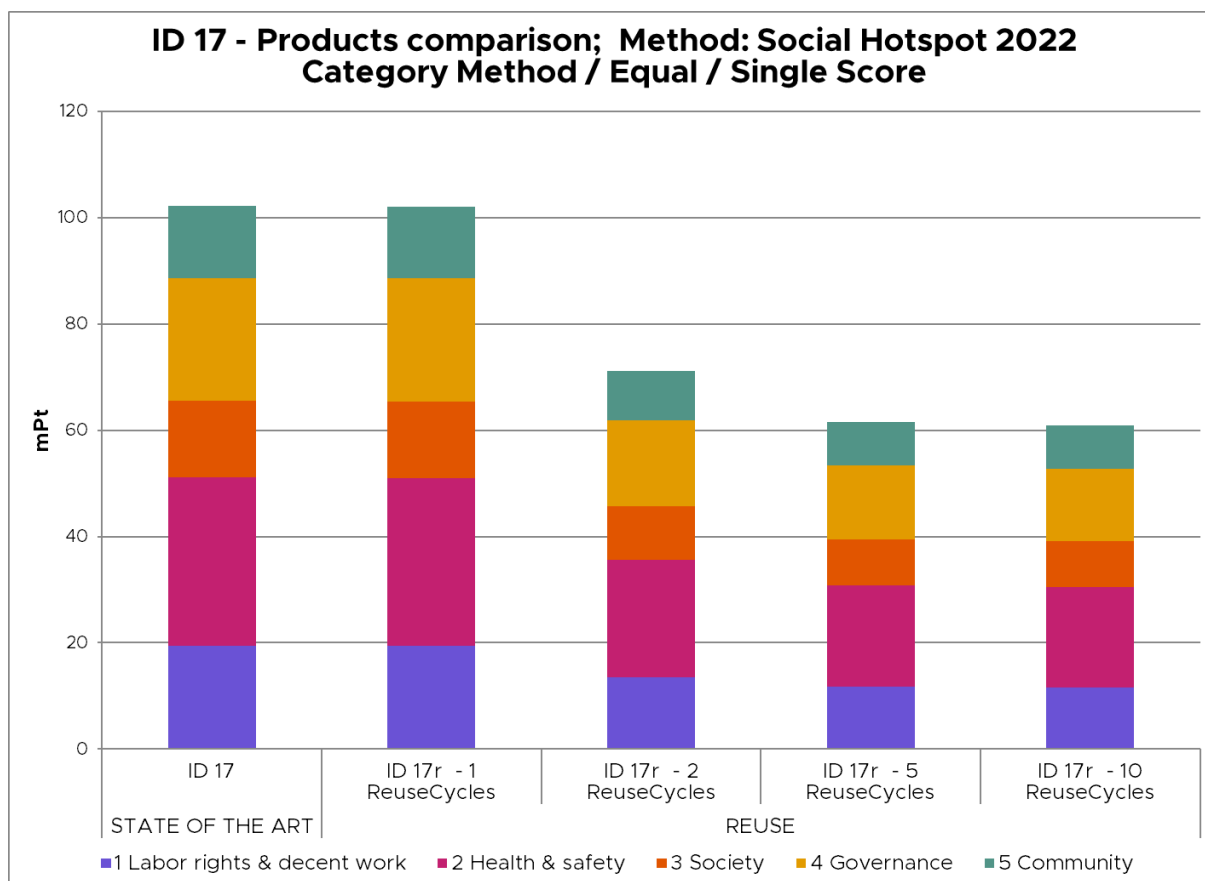


Figure 110: Single Score comparison between solutions and categories contribution



Inputs contribution to life cycle impacts

PRODUCT 17 – STATE OF THE ART

As shown in Figure 111, the inputs that contribute most to the occurrence of social risks in the five categories indicated are related to materials and their production components (predominantly Glass jar), which are associated with the highest costs.

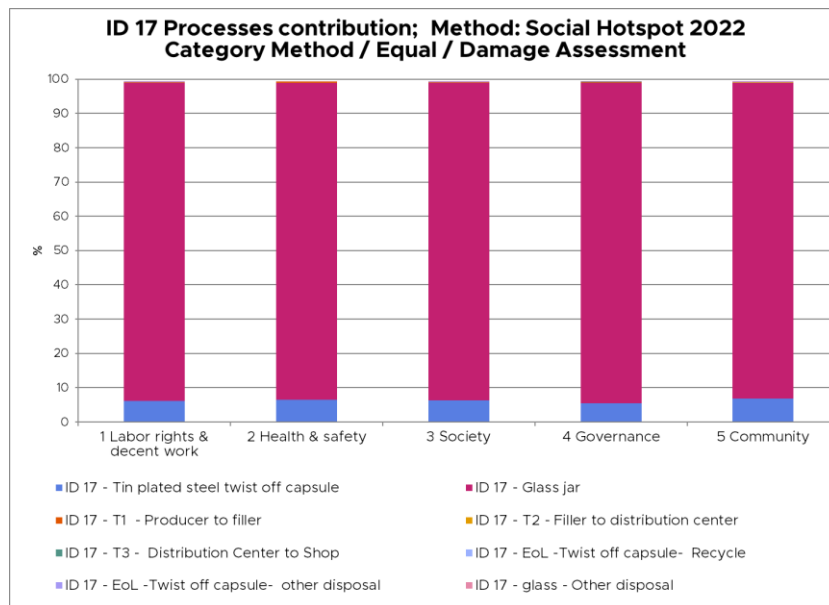


Figure 111: ID 17 life cycle stages contribution to potential social impacts

PRODUCT 17r – REUSE

As shown in Figure 112, the inputs that contribute most to the occurrence of social risks in the five categories indicated are related to materials and their production components (predominantly Glass jar), which are associated with the highest costs.

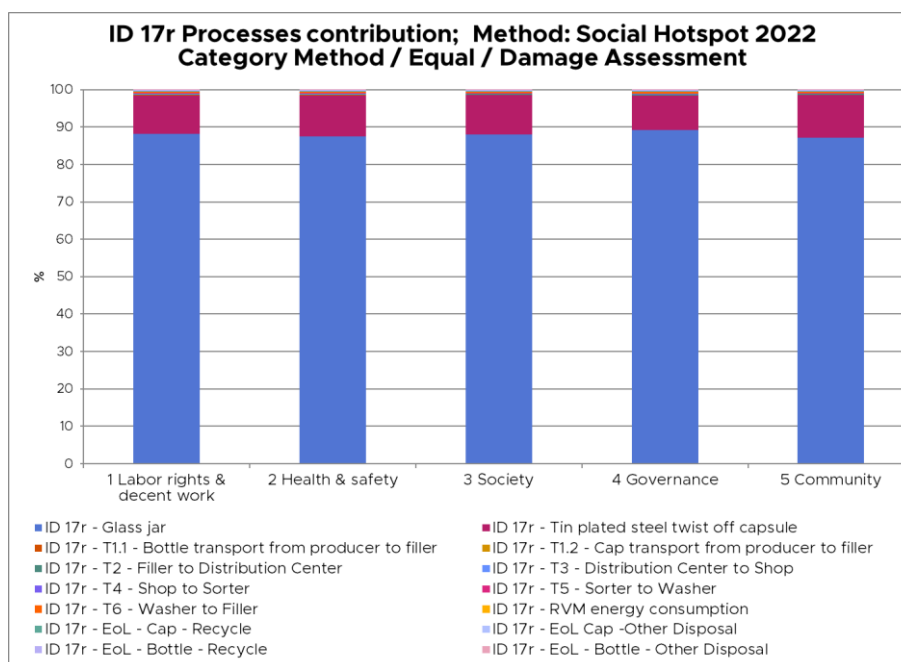


Figure 112: ID17r life cycle stages contribution to potential social impacts, calculated at 10th cycle, with a 64,6% return rate



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Impact sub-categories confrontation table

Table 119 shows in detail the social subcategories, that make up the categories, with the highest social potential risk when the products analyzed vary. In particular, the results were analyzed based on the percentage variation compared to the state of the art (ID 17). Specifically, for product 17-r. it can be seen a reduction of potential social risks across all the impact sub-categories due to the glass jar distribution of costs along the reuse cycles.

Table 119 Potential impact sub-categories comparison

Impact categories	Impact Sub-categories	Unit	ID 17	ID 17r - 1 ReuseCycle	ID 17r - 2 ReuseCycles	ID 17r - 5 ReuseCycles	ID 17r - 10 ReuseCycles
1 Labor rights & decent work	1A Wage assessment	1A mrheq	2,67E-02	2,67E-02	1,85E-02	1,60E-02	1,58E-02
	1C Workers in poverty	1C mrheq	2,10E-02	2,10E-02	1,46E-02	1,27E-02	1,25E-02
	1D Child Labor	1D mrheq	1,76E-02	1,76E-02	1,23E-02	1,06E-02	1,05E-02
	1E Forced Labor	1E mrheq	2,85E-02	2,85E-02	1,99E-02	1,72E-02	1,70E-02
	1F Excessive WkTime	1F mrheq	2,62E-02	2,61E-02	1,83E-02	1,58E-02	1,57E-02
	1G Freedom of Assoc	1G mrheq	1,86E-02	1,86E-02	1,30E-02	1,12E-02	1,11E-02
	1H Migrant Labor	1H mrheq	1,67E-02	1,67E-02	1,16E-02	1,00E-02	9,93E-03
	1I Social Benefits	1I mrheq	8,90E-03	8,88E-03	6,22E-03	5,39E-03	5,33E-03
	1J Labor Laws/Convs	1J mrheq	6,08E-03	6,08E-03	4,24E-03	3,66E-03	3,62E-03
	1K Discrimination	1K mrheq	2,43E-02	2,42E-02	1,69E-02	1,46E-02	1,44E-02
2 Health & safety	1L Unemployment	1L mrheq	1,91E-02	1,91E-02	1,33E-02	1,15E-02	1,14E-02
	2A Occ Tox & Haz	2A mrheq	2,72E-02	2,72E-02	1,90E-02	1,64E-02	1,63E-02
3 Society	2B Injuries & Fatalities	2B mrheq	3,60E-02	3,60E-02	2,51E-02	2,17E-02	2,15E-02
	3A Indigenous Rights	3A mrheq	7,95E-03	7,93E-03	5,53E-03	4,78E-03	4,73E-03
	3B Gender Equity	3B mrheq	1,34E-02	1,34E-02	9,31E-03	8,04E-03	7,95E-03
	3C High Conflict Zones	3C mrheq	1,75E-02	1,75E-02	1,22E-02	1,05E-02	1,04E-02
	3D Non-Communicable Diseases	3D mrheq	3,06E-03	3,06E-03	2,14E-03	1,85E-03	1,83E-03
	3E Communicable Diseases	3E mrheq	1,16E-02	1,16E-02	8,15E-03	7,05E-03	6,97E-03
	3F Poverty and inequality	3F mrheq	2,28E-02	2,28E-02	1,59E-02	1,38E-02	1,37E-02
4 Governance	3G State of Env Sustainability	3G mrheq	2,48E-02	2,48E-02	1,73E-02	1,49E-02	1,48E-02
	4A Legal System	4A mrheq	2,46E-02	2,46E-02	1,71E-02	1,47E-02	1,46E-02
	4B Corruption	4B mrheq	1,17E-02	1,17E-02	8,17E-03	7,05E-03	6,98E-03
	4C Democracy & Freedom of Speech	4C mrheq	3,30E-02	3,30E-02	2,30E-02	1,98E-02	1,96E-02
5 Community	5A Access to Drinking Water	5A mrheq	9,64E-03	9,63E-03	6,75E-03	5,85E-03	5,79E-03
	5B Access to Sanitation	5B mrheq	1,85E-02	1,85E-02	1,29E-02	1,12E-02	1,10E-02
	5C Children out of School	5C mrheq	1,69E-02	1,69E-02	1,18E-02	1,02E-02	1,01E-02
	5D Access to Hospital Beds	5D mrheq	1,67E-02	1,66E-02	1,16E-02	1,01E-02	9,97E-03
	5E Smallholder v Commercial Farms	5E mrheq	5,41E-03	5,38E-03	3,72E-03	3,19E-03	3,16E-03
	5F Access to Electricity	5F mrheq	7,64E-03	7,63E-03	5,36E-03	4,65E-03	4,60E-03
	5G Property rights	5G mrheq	1,96E-02	1,96E-02	1,37E-02	1,19E-02	1,18E-02

3.6. Comparative Results

The comparative assessment across products shows a consistent decrease in social risk potential for reusable packaging systems, once a certain number of use cycles is reached.

The break-even point where the reuse alternative achieves lower social risk than the single-use baseline varies by product and material type, typically after the 2nd reuse cycle.

- **Plastic-based reusable systems (IDs 02-r, 04-r, and 10-r1)**, show the lowest overall social risk levels after two or more reuse cycles. Risks associated with the production of the polymer are spread on the different reuse cycles.
- **Paper-based solutions (ID 10 and 04-s)** display higher social risk potentials, mainly due to the high risk in the supply chain coming from indicators as Wage assessment and Labor Laws and conventions. The paper pulp sector can be particularly exposed to these social risks in some countries, particularly in the case of the production of the fibres. Having a controlled and fair supply chain, can limit the exposure to this kind of risks.
- **Glass-based reuse systems (ID 11-r, 17-r)** show mixed results: although risk decreases along cycles, initial risks remain high because of higher material cost and energy intensity. In the comparison with PET, break-even point is not reached, mainly because the packaging weight per FU is strongly higher in the case of the glass solution. Nevertheless, for ID 17-r, where the same glass jar is reused, social risk improves substantially after the first cycle.



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