

4th Training

Life Cycle Assessment (LCA) for PFAS-Free Coatings:

Supporting Safe- and-sustainable-by-Design (SSbD) Decision-Making

September 30th, 2026

Online



BIO-SUSHY



Agenda

10:00 Opening Remarks and Introduction

- Welcome, housekeeping & BIO-SUSHY project intro.
- Goal of the training and overview. (10-15 min)



10:15 Common Misconceptions

- Interactive poll and key concept clarifications. (10 min)



10:25 Module 1: LCA Fundamentals

- ISO framework, four LCA phases & system boundaries. (35 min)



11:00 Module 2: LCA in BIO-SUSHY & SSbD

- Integration of LCA into SSbD & environmental hotspots. (35 min)



11:35 From LCA Results to Decision Making

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11:50 Wrap-up & Next Steps

- Summary of key takeaways.
- Closing remarks and acknowledgment. (10 min)



Introduction

PFAS, What?

PFAS (per and polyfluorinated alkyl substances) provide excellent **water** and **oil repellency** properties.

Why is it a problem?

PFAS are known as '**forever chemicals**' due to their resistance, widespread, and linked to **environmental** and **health problems** like cancer and decreased fertility.

How?

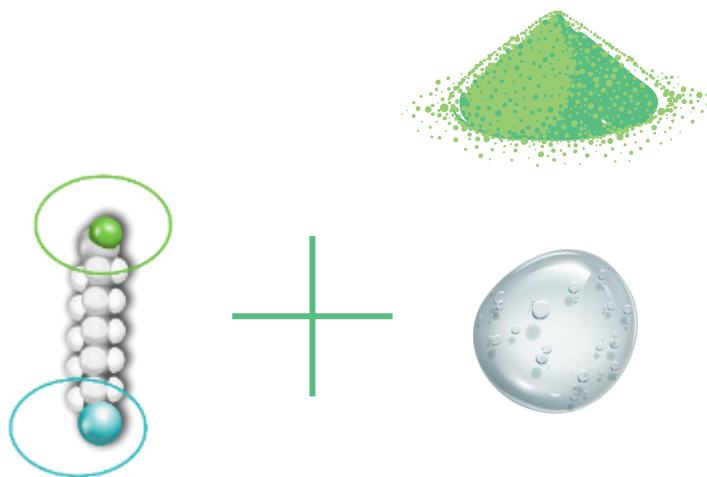
Exposure could happen through **eating, drinking, or using** consumer products containing PFAS.

You may have
assumed PFAS
without knowing it

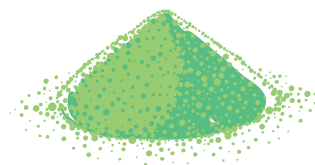


Objectives

Develop **3 PFAS-free bio-based coatings**



Hydro/oleophobic
additives



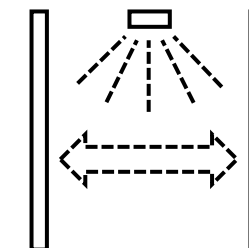
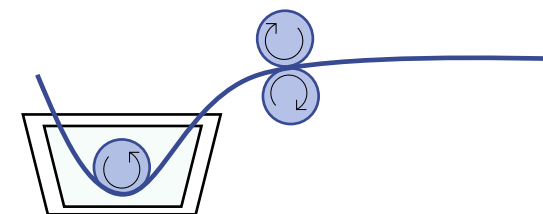
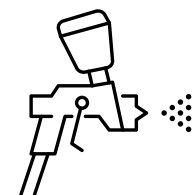
Thermoplastic bio-based **powder**



Water-based **hybrid sol-gel** organic



Solvent-based **hybrid sol-gel** inorganic





R&I Coating Development



TEXTILE COATING



FOOD PACKAGING



GLASS COSMETICS
PACKAGING

- Development of **3 novel SSbD coatings materials** with water and oil repellency
- **Validation** of coating materials with 3 case studies
 - Textile
 - Food packaging
 - Glass packaging

BIO-SUSHY Methodology – Based on 3 pillars



R&I COATING DEVELOPMENT

- Development of 3 novel SSbD coatings materials with water and oil repellency
- Validation of coating materials with 3 case studies (cellulose food trays, textile, glass packaging)



MODELING

- Development of the BIO-SUSHY set of computation tools for SSbD of coatings
- Development of integrated approaches supported by the BIO-SUSHY HUB for effective data management and sharing



SAFE AND SUSTAINABLE BY DESIGN

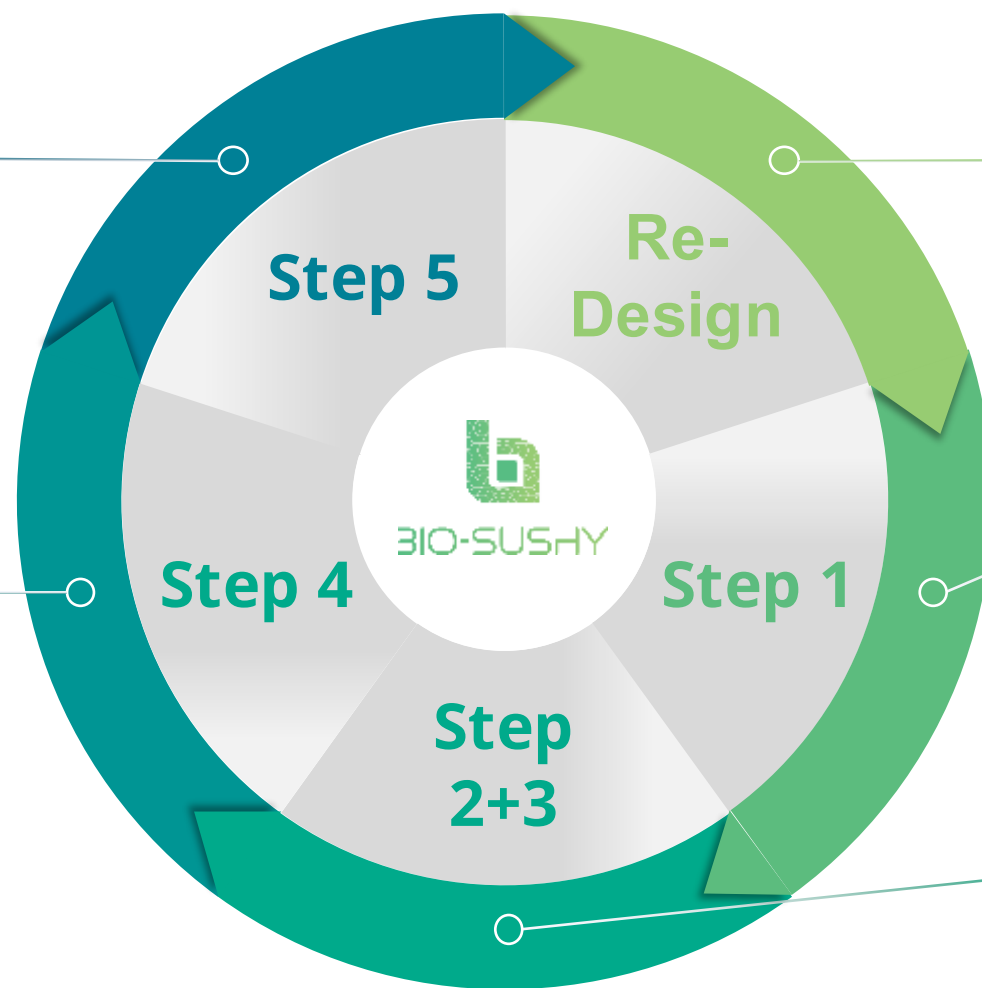
- Development of an SSbD Framework applied to PFAs-free coatings (safe by material design, safe by process design, toxicological studies, LCA, LCC, SLCA)
- Standardisation roadmap



The 5 steps SSbD framework

- Life Cycle Costing (LCC)
- Social-LCA

- LCA
- Circularity
- End of life



- Coating development
- Functional modelling
- Data mining
- Up-scaling

- Data mining
- QSAR

- Occupational monitoring
- Risk assessment
- Tox testing

Value Chain

BIO-SUSHY consortium combines **materials science, sustainability assessment, and industrial validation**

Materials & Technology Development

SSbD Methodology & Sustainable Assessment

Modelling & Computational Tools

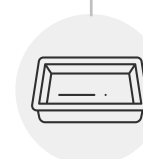
Social Acceptance

Industrial Validation

Market Entry, Dissemination & Standardization



Applications



Impacts



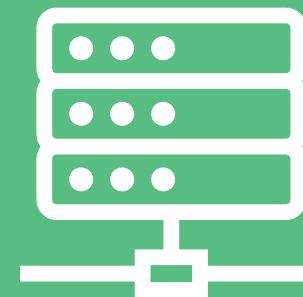
**25% reduction of
environmental
impact**



**Contribution to
SSbD criteria and
guiding principles**



**Reduction of PFAS
in the
environment**



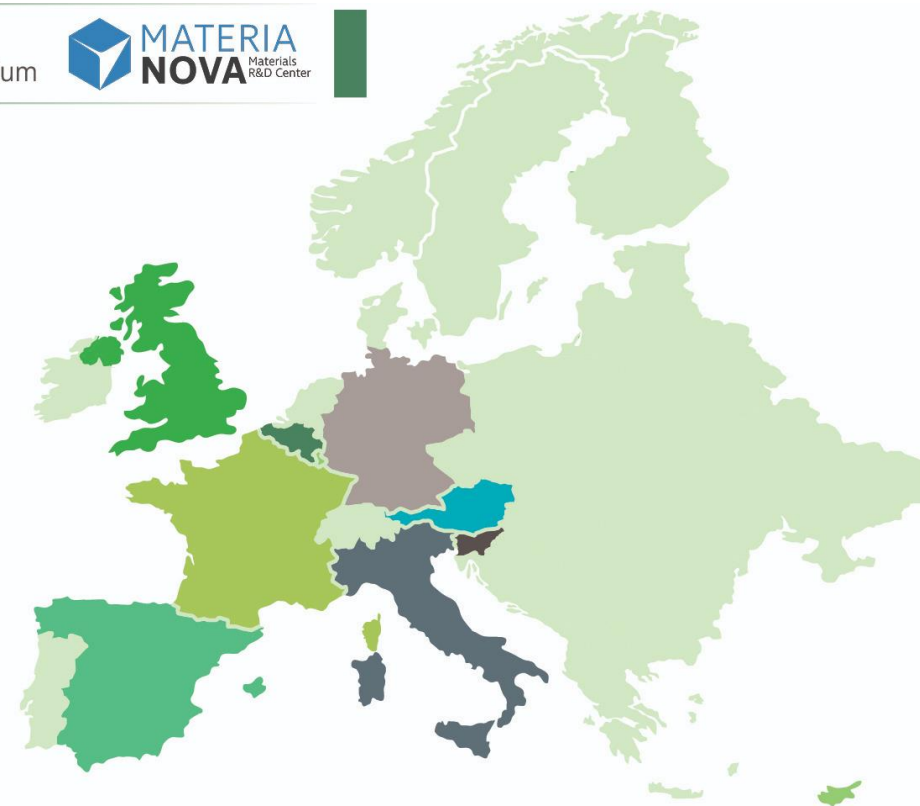
**Computational
tools to support
SSbD concepts**

Team

The **BIO-SUSHY** project is a collaboration between 14 partners from 7 EU countries and 1 EU-associated country: 6 RTDs, 6 SMEs, 1 university, and 1 national association.

BIO-SUSHY COORDINATOR:

Materia Nova, Av. Nicolas Copernic 3, 7000 Mons, Belgium



BIO-SUSHY SSbD Guidelines



SSbD Guidelines - Food Packaging



SSbD Guidelines - Glass Cosmetic Packaging



SSbD Guidelines - Textile

<https://www.bio-sushy.eu/dc-materials/>



SSbD Guidelines Infographic - Food Packaging



SSbD Guidelines Infographic - Glass Cosmetic Packaging



SSbD Guidelines Infographic - Textile

CEN Workshop Agreements (CWAs) BIO-SUSHY Kicked-off

CEN/WS BIO-SUSHY Kick-off Meeting took place, officially marking the start of the Workshop and the collaborative development of the three CEN Workshop Agreements (CWAs).

CEN Project Officer, introduced the CEN Workshop concept and provided guidance on the standardization process and requirements.

The three CWA drafts were presented by their respective leaders:

-  **WOOD K PLUS – Christoph Jocham & Ivana Burzic**
-  **MANO – Eric Khouzakoun**
-  **ULEEDS – Andrew Nelson**

Led and coordinated by the Spanish Association for Standardization (UNE), which is responsible for the organization of the CEN Workshop and its standardization process.



The target publication date for the three CWAs is **December 2026**.



 **MATERIA
NOVA** Materials
R&D Center

WORKSHOP

13 OCTOBER 2026

 Hotel Van der Valk

 Avenue M. Mercuri Mons (B)

HOW COATINGS
SUPPORT CIRCULARITY OF
MATERIALS

[Program](#)

[Registration](#)

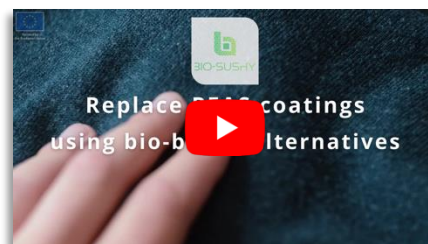


BIO-SUSHY Online Training #5

<u>Topic</u>	Application of QSAR Predictive Models in Toxicology: Supporting Safe-and-Sustainable-by-Design (SSbD) Assessment
<u>Partner</u>	ProtoQSAR
<u>Format</u>	Interactive Online Training (2 hours)

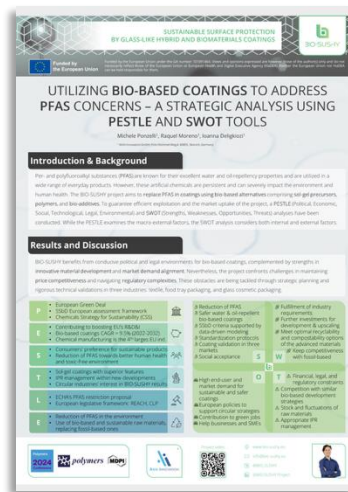


Stay up to date with our progress



www.bio-sushy.eu

info@bio-sushy.eu



@BIO-SUSHY Project



@BIO_SUSHY

Marion Bousser

Researcher

Materia Nova (MANO)



Benjamin Belloncle, PhD

Researcher

Materia Nova (MANO)



**MATERIA
NOVA** Materials
R&D Center

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partici.fi/03039472



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Marion Bousser

Researcher

Materia Nova (MANO)



SUSTAINABLE SURFACE PROTECTION BY GLASS-LIKE HYBRID AND BIOMATERIALS COATINGS

4th Training

Life Cycle Assessment (LCA) for PFAS-Free Coatings: Supporting Safe and Sustainable by Design (SSbD) Decision-Making



BIO-SUSHY

BIO-SUSHY SSbD workshop
September 30, 2026 – Teams

MATERIA NOVA

Benjamin Belloncle

Marion Bousser



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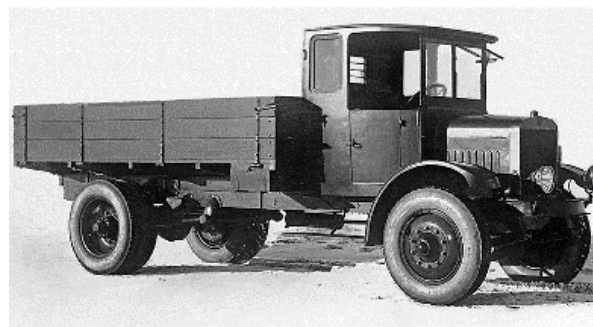
Life Cycle Assessment (LCA) in 5 minutes

LCA identifies all the life cycle steps of a system

Manufacture of
the product



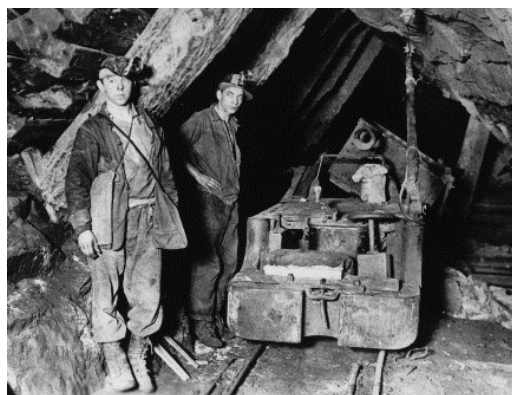
Transports



Use phase



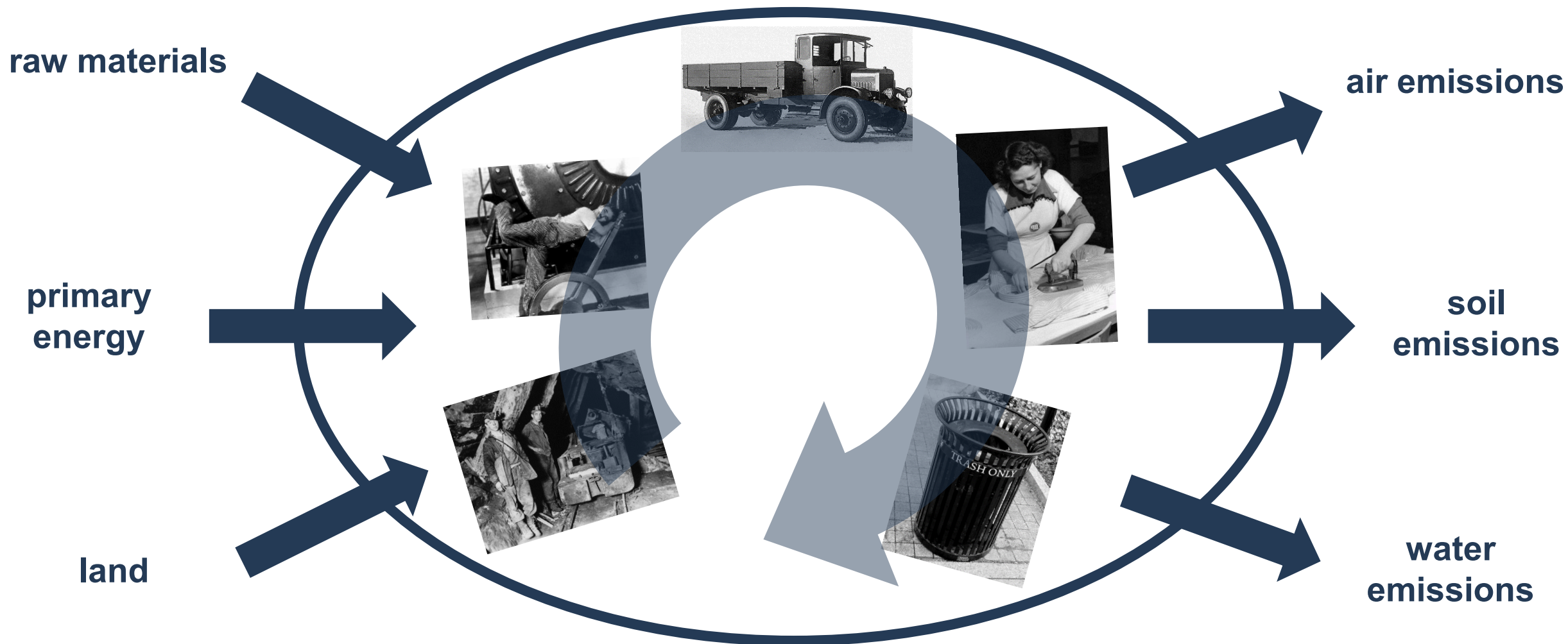
Raw materials
extraction



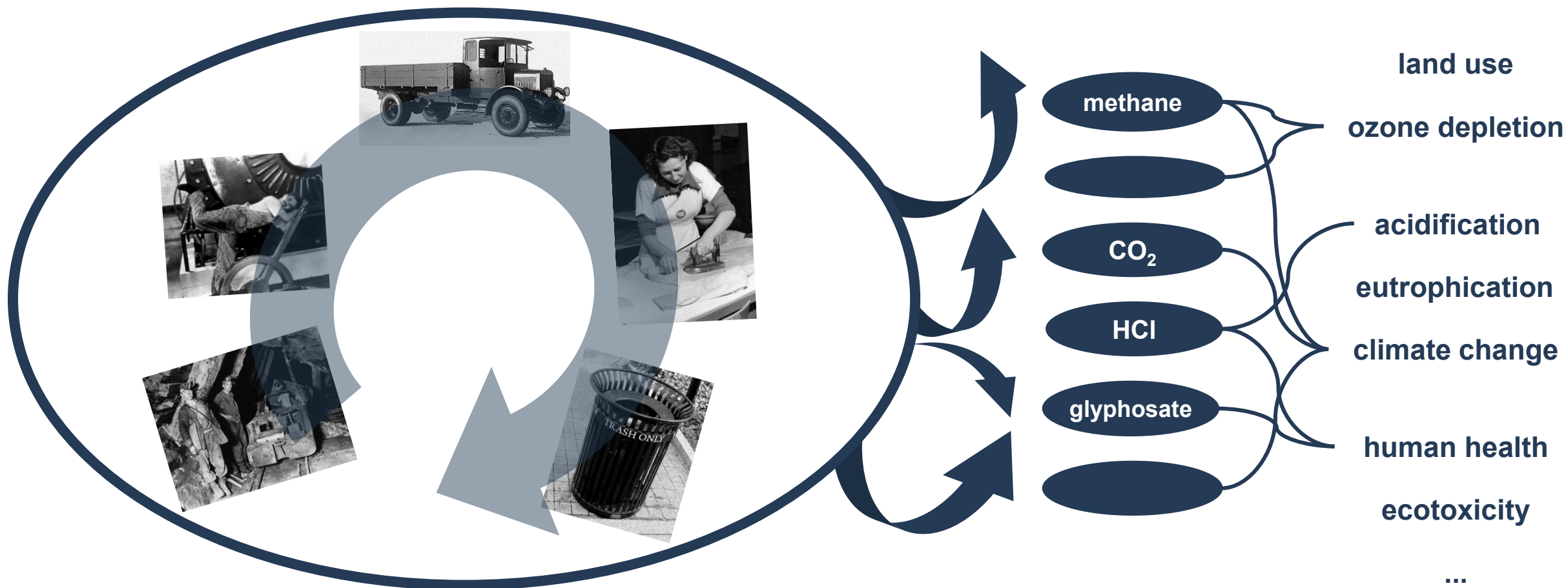
End of life
treatment



LCA quantifies flows exchanged between the system and the environment

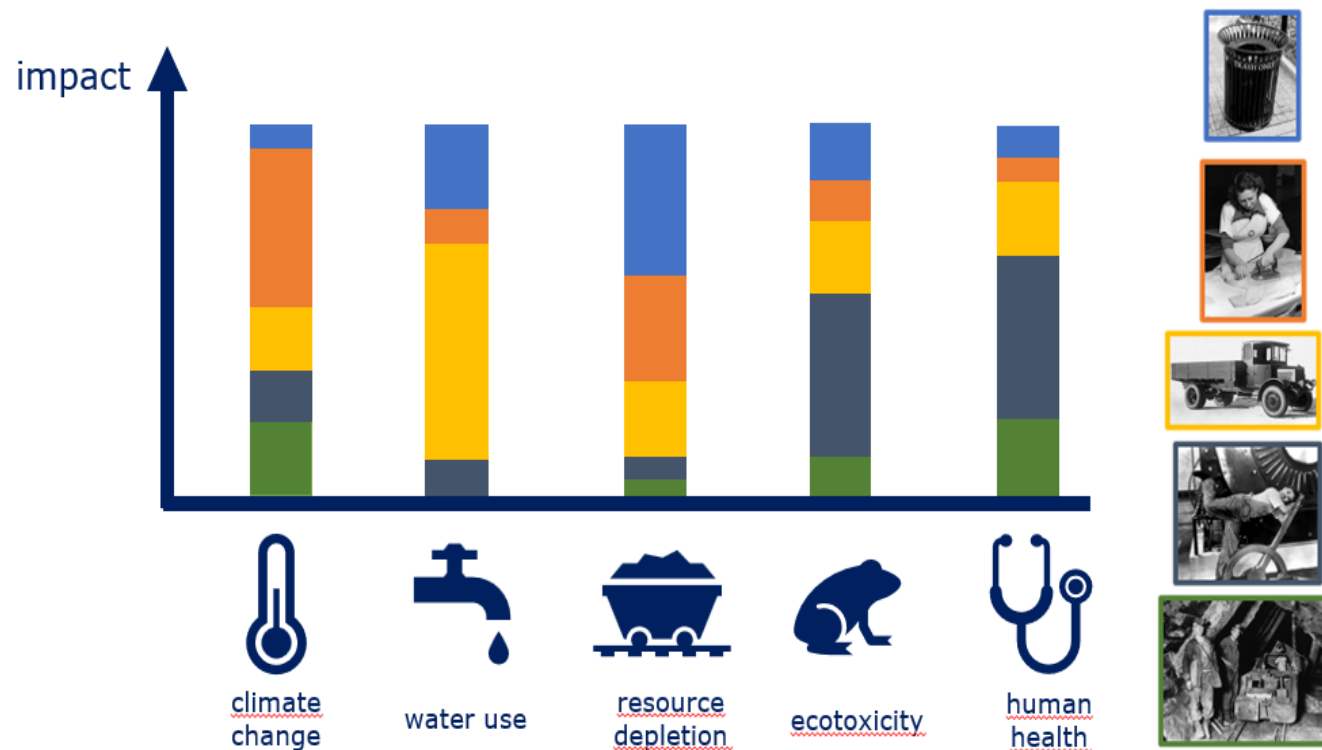


LCA makes links between these flows and environmental indicators

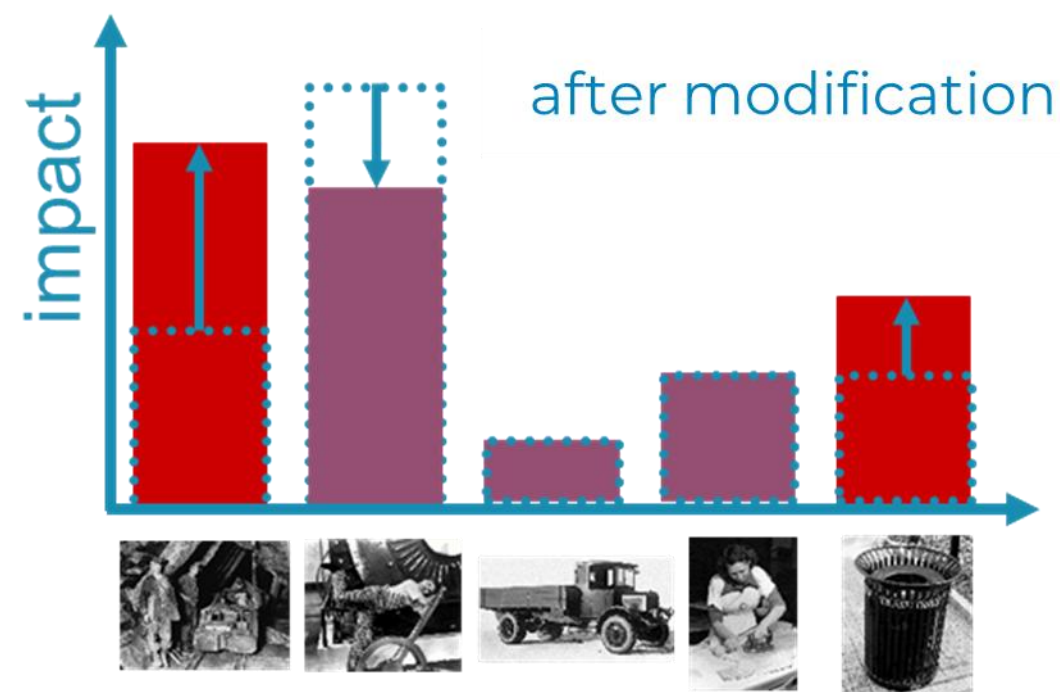
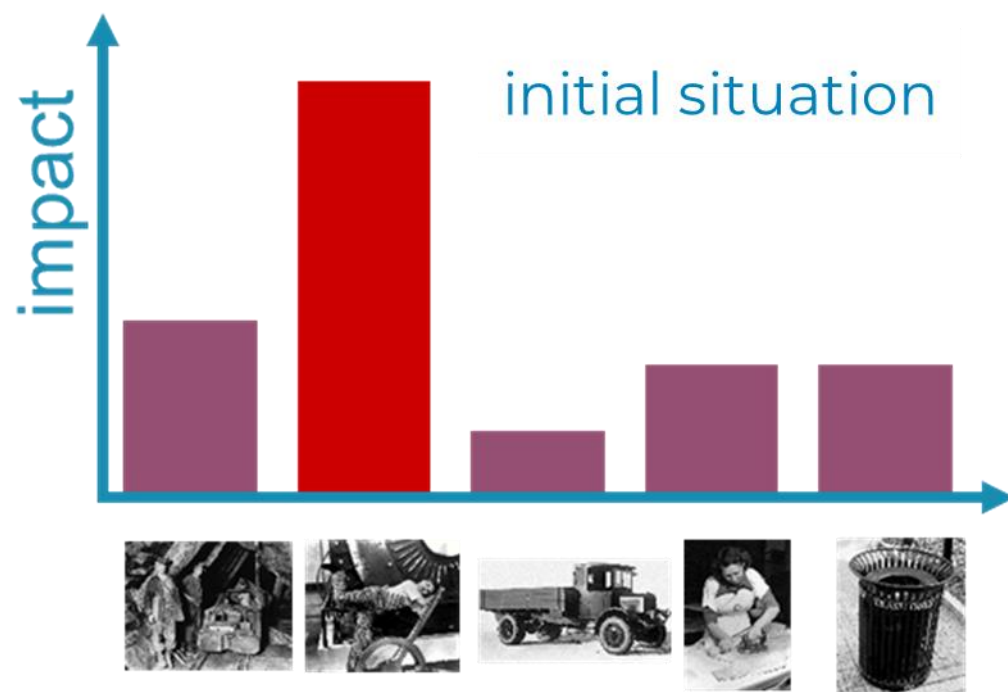


LCA translates these flows into environmental indicators

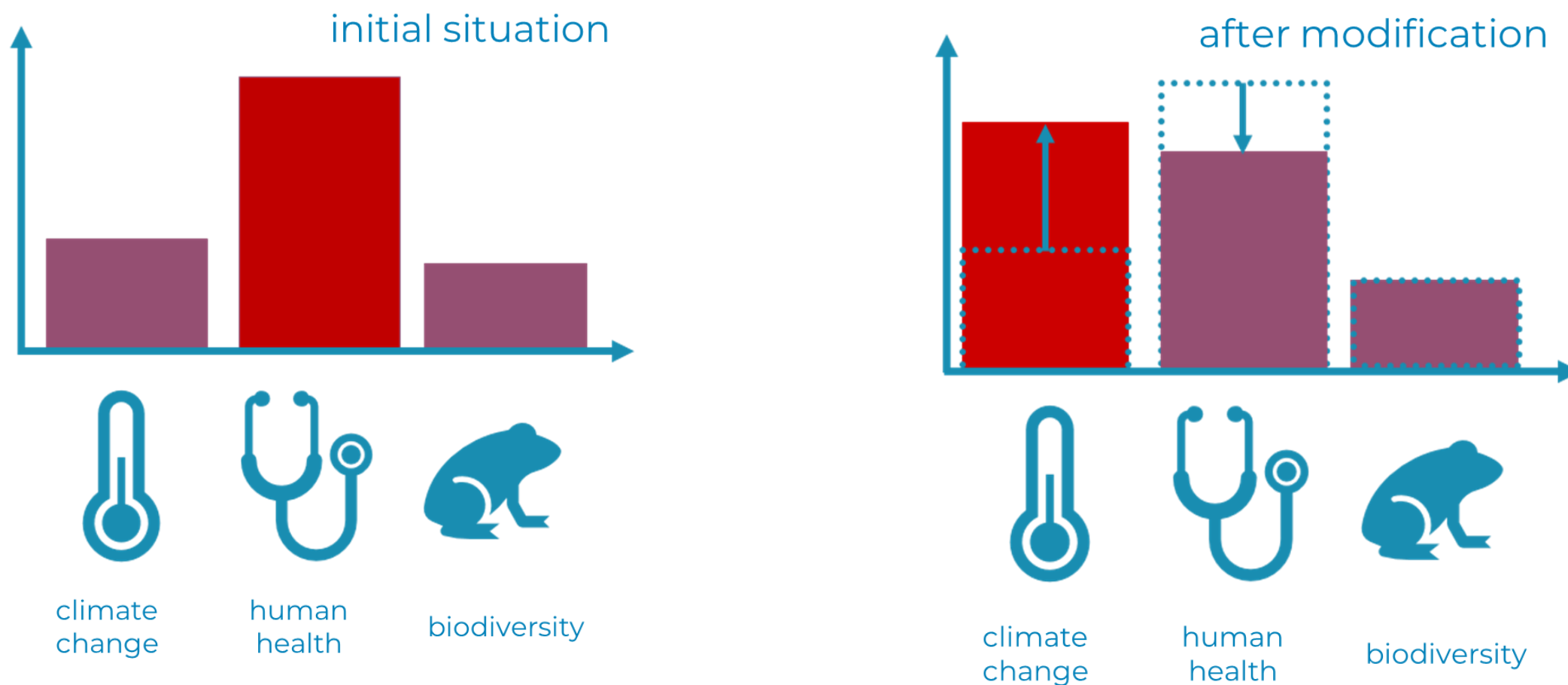
Contribution evaluation



Impact shift towards another life cycle step

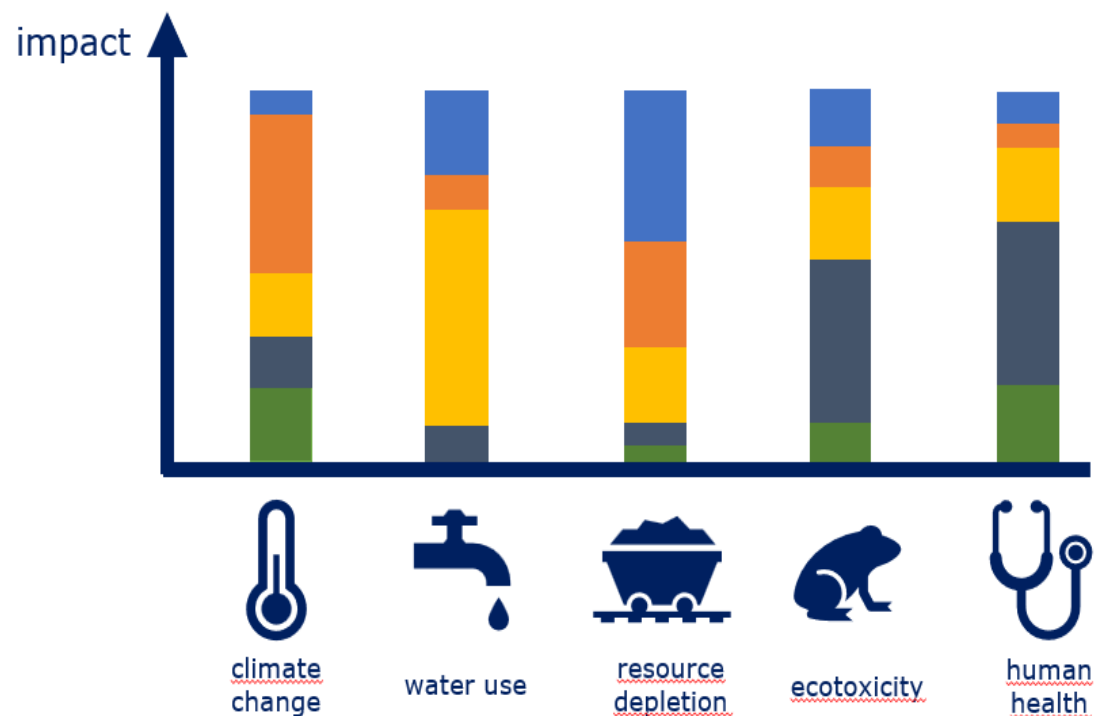


Impact shift towards another indicator

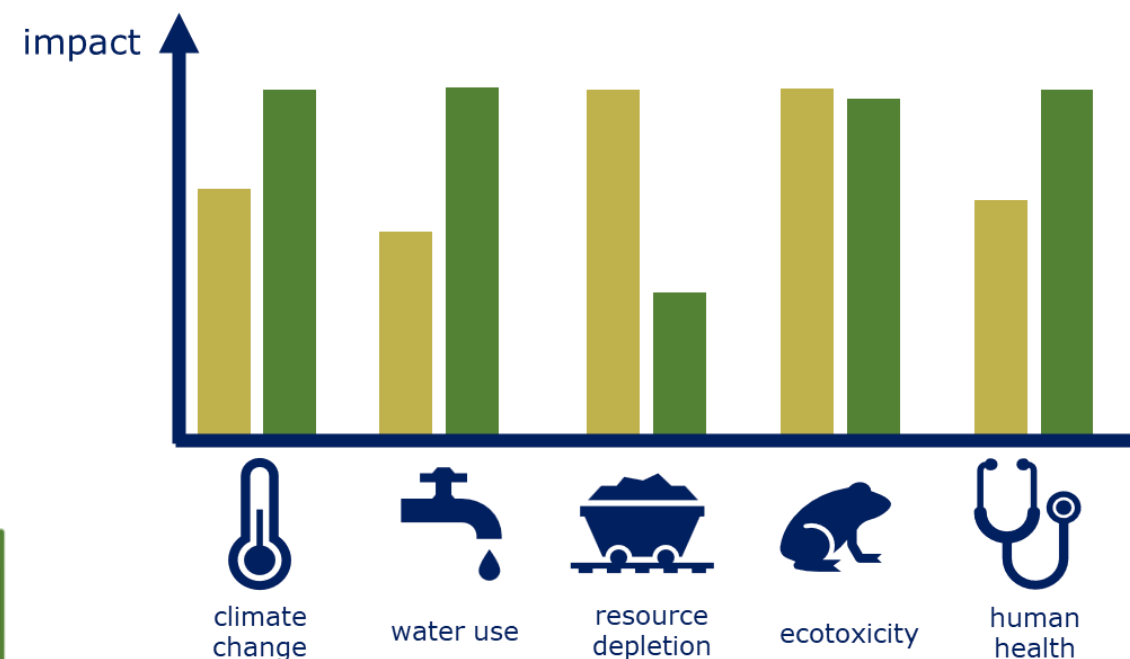


LCA translates these flows into environmental indicators

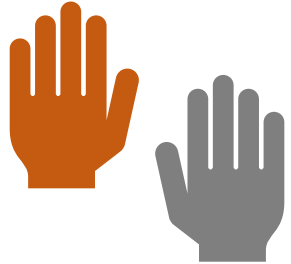
Contribution evaluation



Comparison



LCA compares systems on the basis of equivalent functionality



1 kg of **gloves A** vs. 1 kg of gloves B

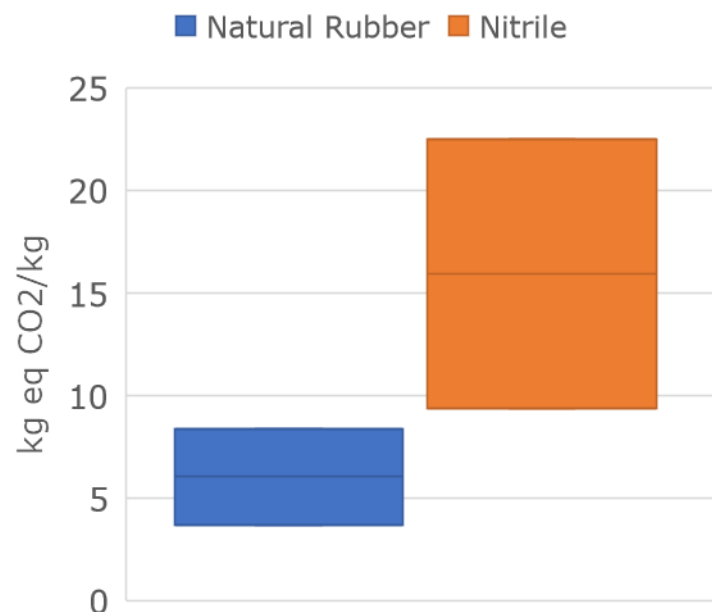


**use gloves for a 30 minutes operation in
a corrosive environment with type A or B
gloves**

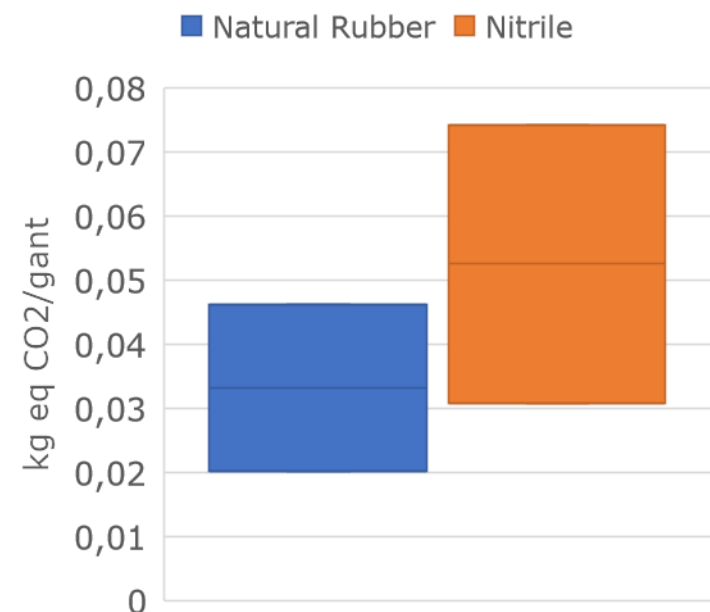


(this includes glove replacement rate during operation, mass of one glove... and other parameters that may vary between the two systems)

The choice of the functional unit can influence the results



Study on single use gloves – results by kg
MRGMA
2013



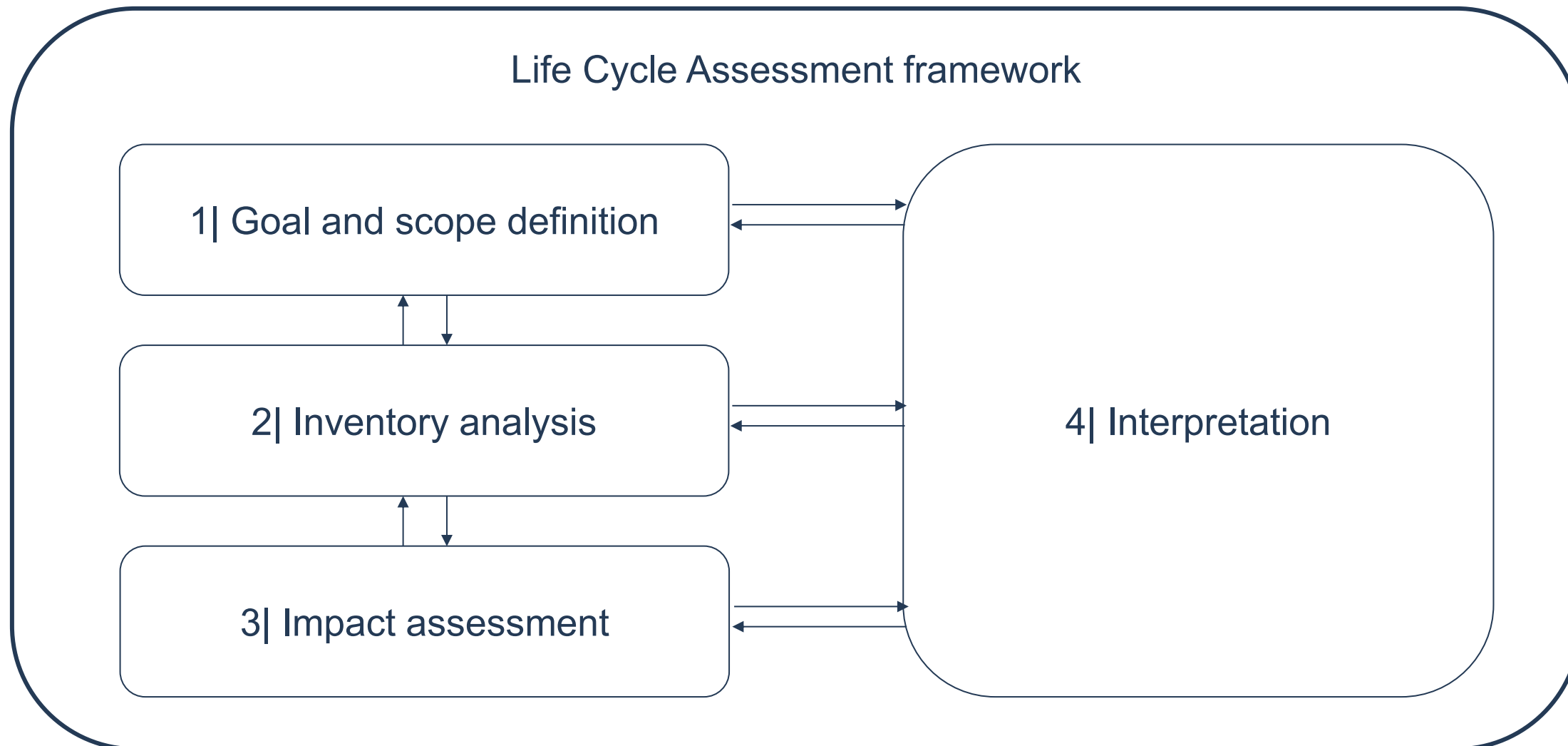
Study on single use gloves – taking into account the
functionality → impact of 1 glove
Materia Nova
2018



Life Cycle Assessment (LCA) in detail



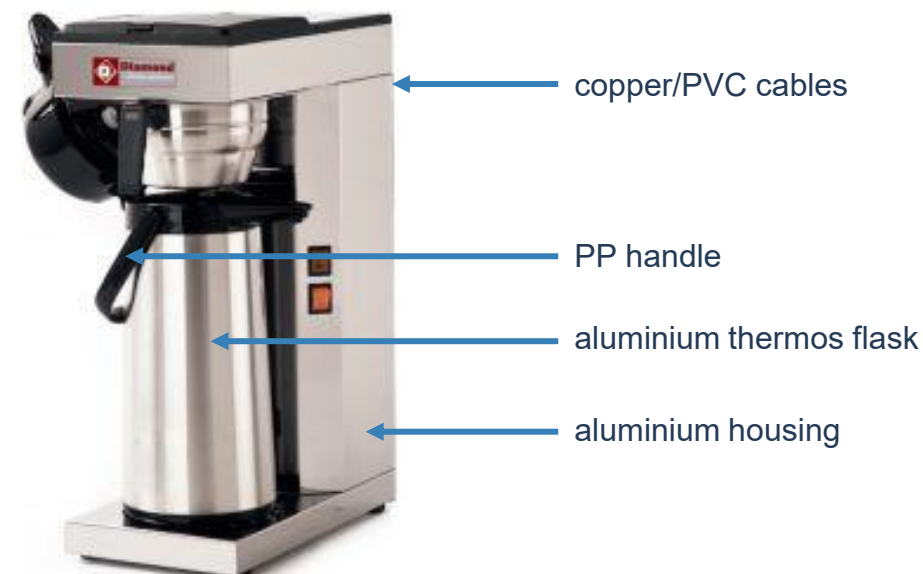
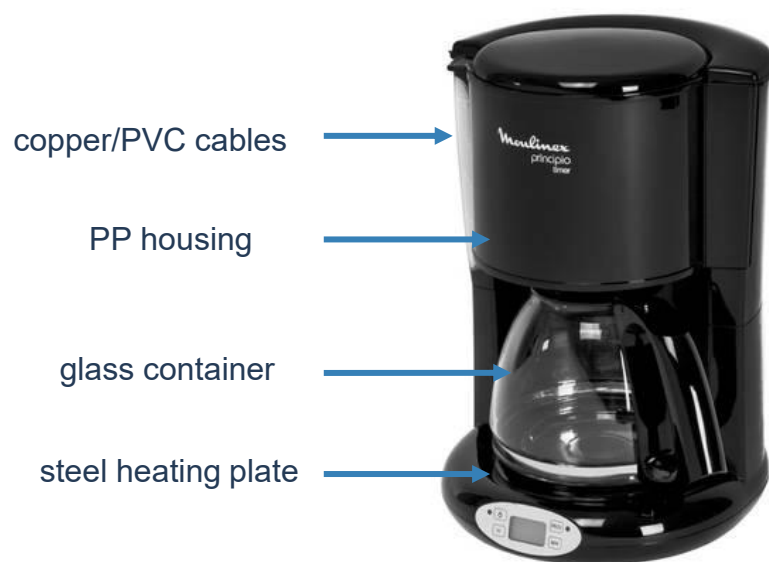
The 4 steps of LCA according to standards ISO 14040/14044



Step 1: Defining the goal and scope of the study



Case study: a coffee machine



Goal

Choose the less impacting model

System and function definition



System = coffee machine + consumables

Function: to produce 5 cups of coffee twice a day for 5 years, keep the coffee hot for 30 minutes



System and function definition



System = coffee machine + consumables

Function: to produce 5 cups of coffee twice a day for 5 years, keep the coffee hot for 30 minutes

Functional unit



How to define the functional unit?

The definition of the functional unit should answer the questions

What?	How much?	How long?	How well?
What is the service provided by the system?	Service quantity	Service duration	Service quality
Making coffee	5 cups twice a day	For 5 years	Keeping the coffee hot for 30 minutes

Reference flows

How much product is necessary to fulfil the function as defined in the FU?

To make 18250 coffees and keep them hot for 30 minutes over a 5-years period, you need:

n machines
p litres of water
x filters
y kg coffee beans
z kWh electricity

System boundaries

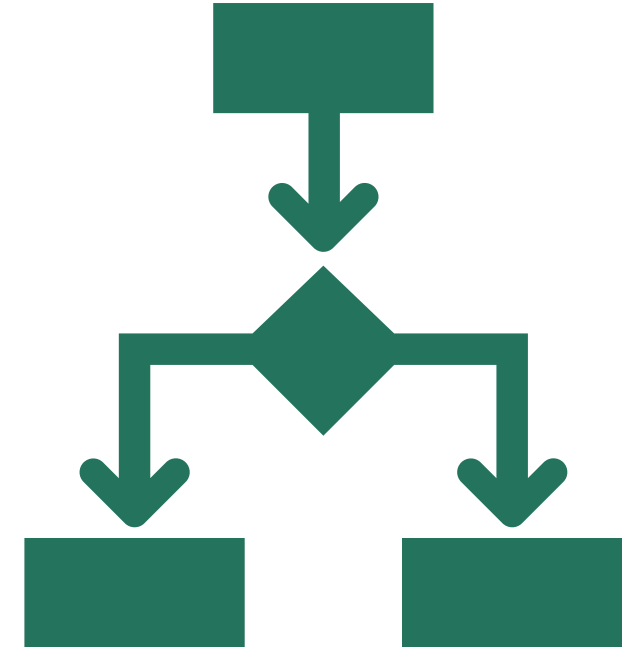
In such a comparative study, you can choose to exclude coffee production, which is common to both systems



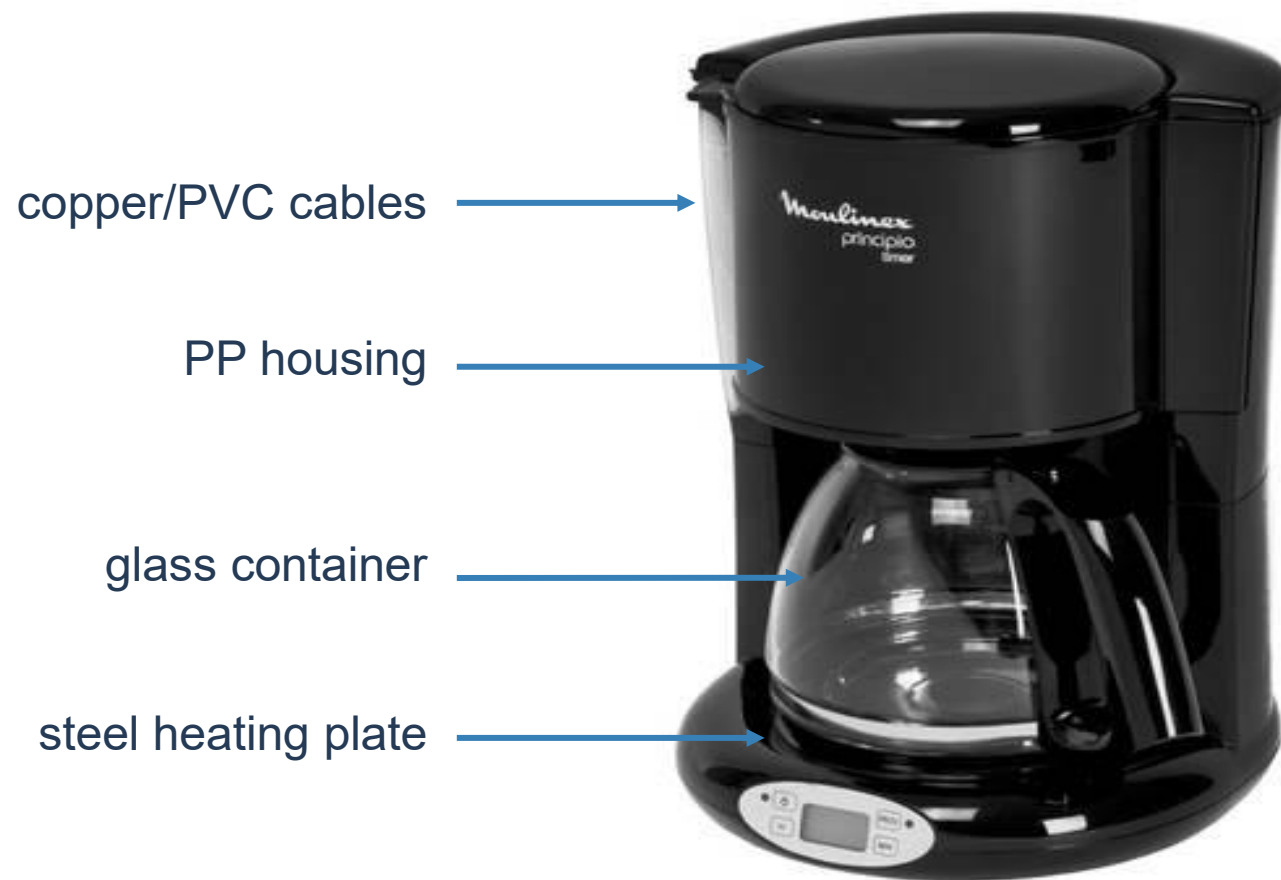
BUT then you will only compare the two systems, not determine the impacts of making coffee!

Process tree

After defining the system boundaries, a process tree can be established
(diagram of stages, inputs and outputs)



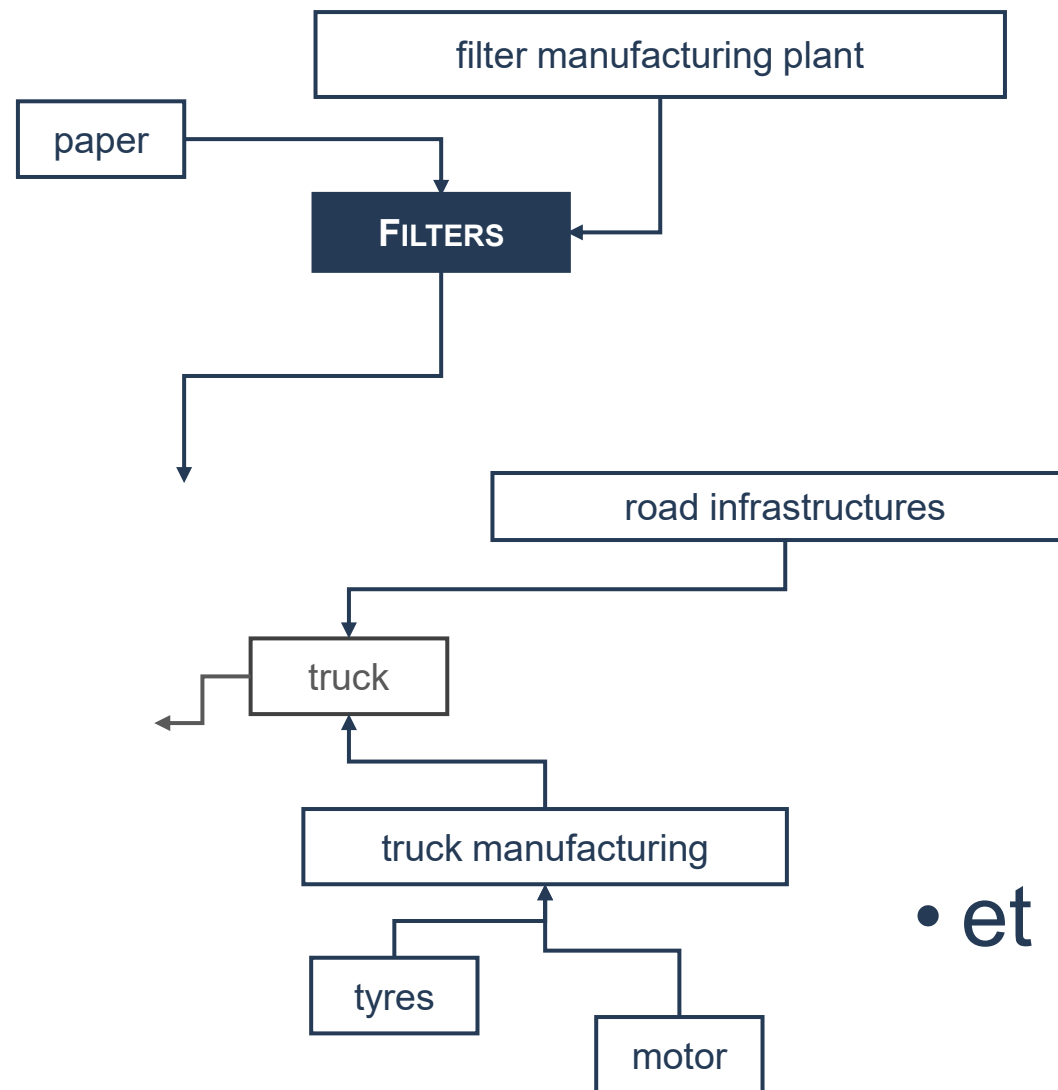
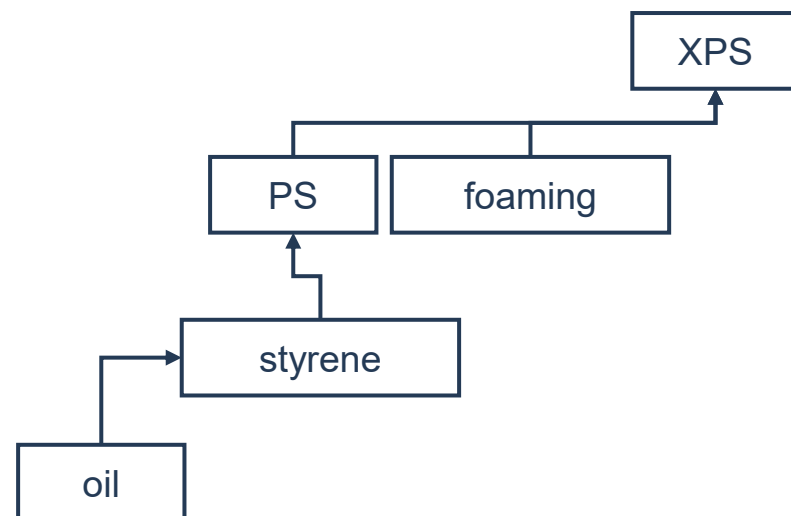
Process tree: coffee machine



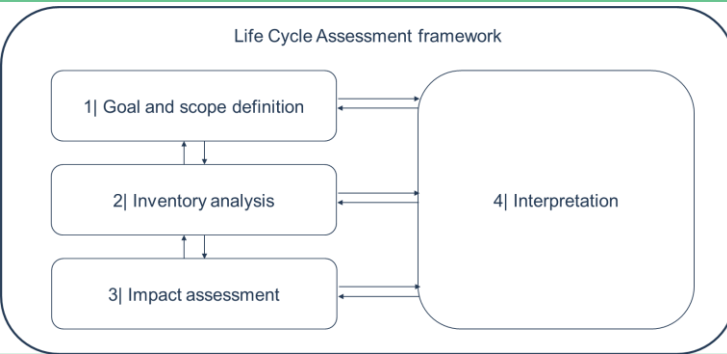




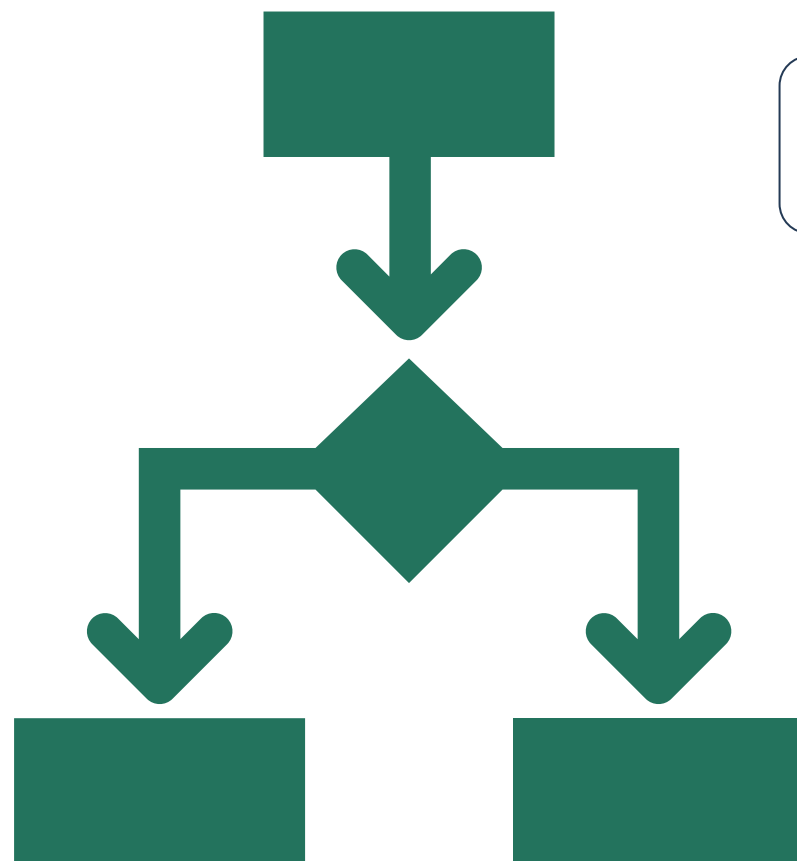
Process tree: coffee machine



• et cætera...



Step 2: Inventory analysis



Process tree

Identification of all process steps

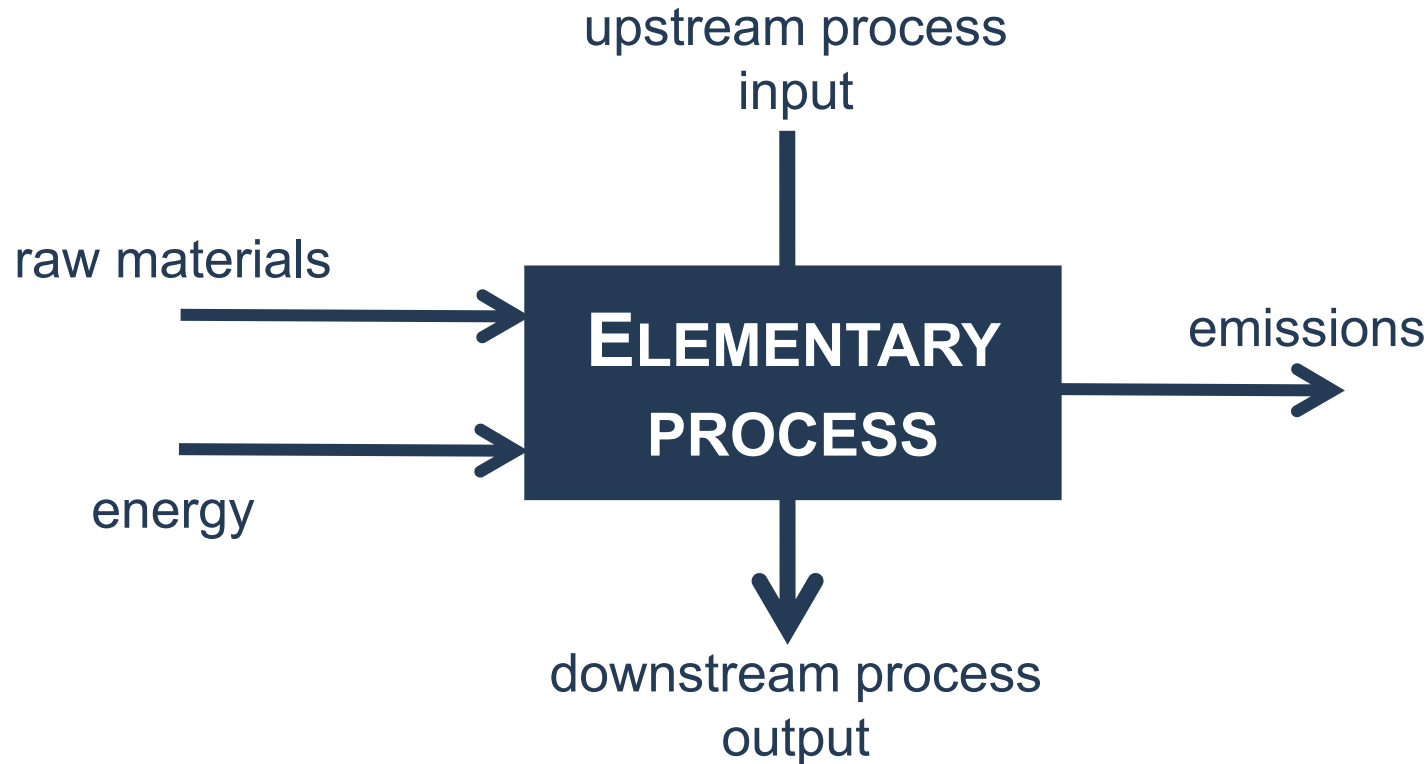
Quantifying elementary flows for each process

Water, air and soil emissions

Inputs from nature (raw materials, primary energy...)

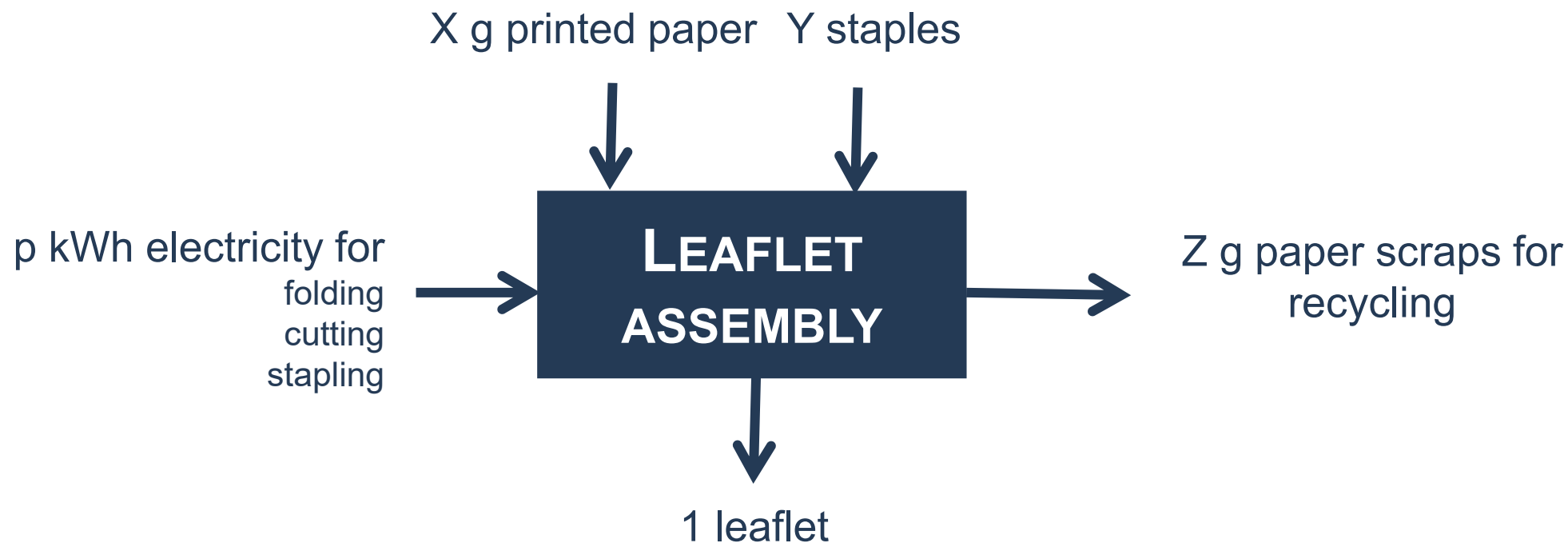
Value of links between processes (yields)

Decomposition of the tree into elementary processes



→ data collection for each elementary process

Decomposition of the tree into elementary processes



For each elementary process, a model is prepared including all the inputs and all the outputs.



PLA dataset in Ecoinvent

Produits					
Sortants connus vers la technosphère. Produits et co-produits	Quantité	Unité	Quantité	Affectatio	Typ
Polylactide, granulate {GLO} production Cut-off, U	1	kg	Mass	100 %	Bio
Entrées					
Entrées connues de la nature (ressources)	Sous-compartiment	Quantité	Unité	Distribution	Ecart Type^
Water, unspecified natural origin, GLO	in water	0,0032	m3	Lognormal	7,3891
Entrées connues de la technosphère (matériaux/carburants)		Quantité	Unité	Distribution	
Chemical factory, organics {GLO} market for Cut-off, U		4,0E-10	p	Lognormal	
Electricity, low voltage {GLO} market group for Cut-off, U		1,828			
Heat, district or industrial, natural gas {GLO} market group for Cut-off, U		17,537			
Maize grain {GLO} market for Cut-off, U		1,507	kg	Lognormal	
Naphtha {RER} m		0,0011875982803836	kg	Lognormal	
Sortants					
Émissions vers l'air	Sous-compartiment	Quantité	Unité	Distribution	Ecart Type^
NM VOC, non-methane volatile organic compounds, low. pop.		0,00252	kg	Lognormal	1,5639
Sortants connus vers la technosphère. Déchets et émissions pour traitement		Quantité	Unité		
Hazardous waste, for incineration {Europe without Switzerland} market for hazardous waste, for incin		0,0020608	kg		
Waste plastic, mixture {BR} market for waste plastic, mixture Cut-off, U		0,0001110610	kg		

name of product,
amount, unit

direct inputs from
nature, amount,
unit

statistical information on
the data

infrastructure

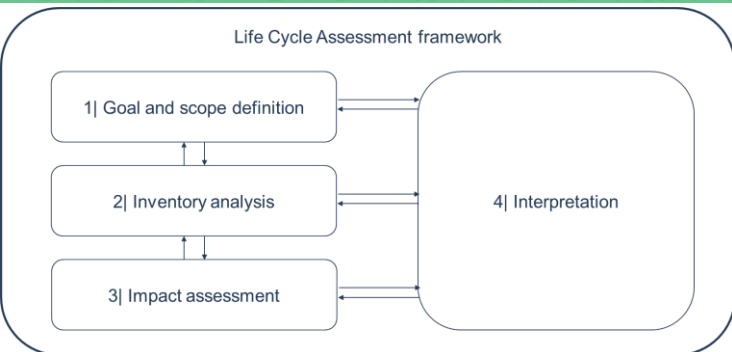
energy inputs

materials inputs

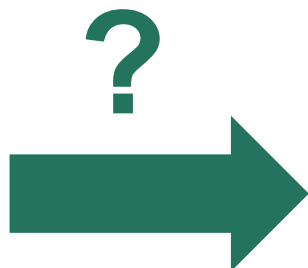
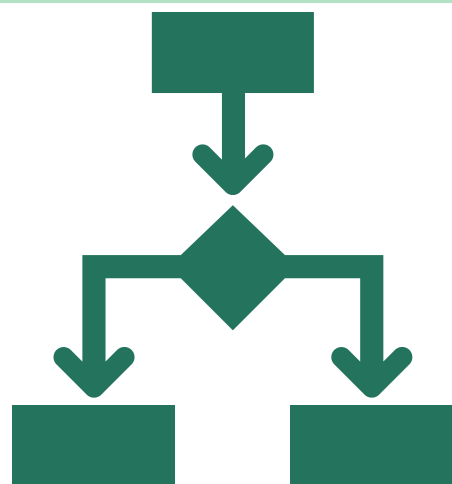
emissions to the
environment

waste for treatment

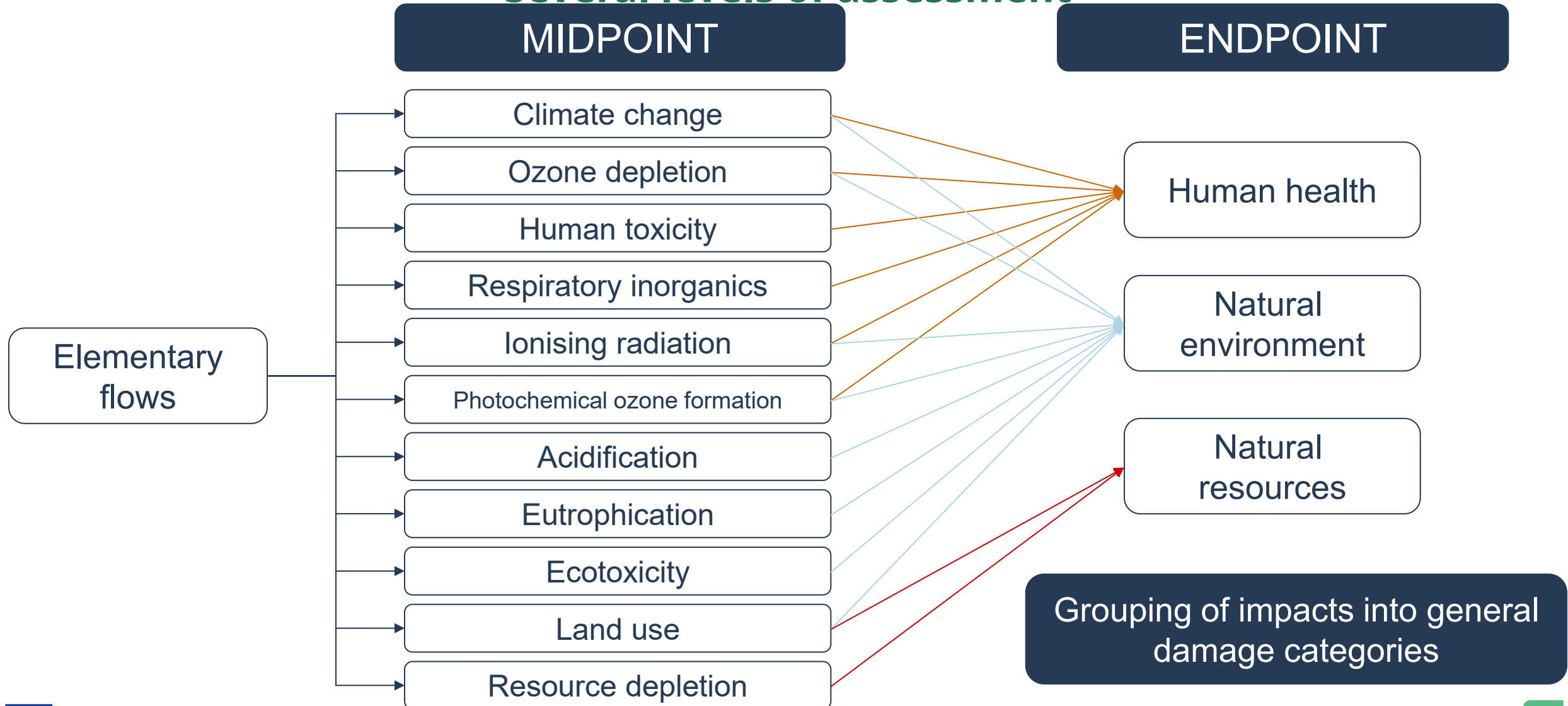
geographic
representativeness of
the data



Step 3: Calculating environmental impacts



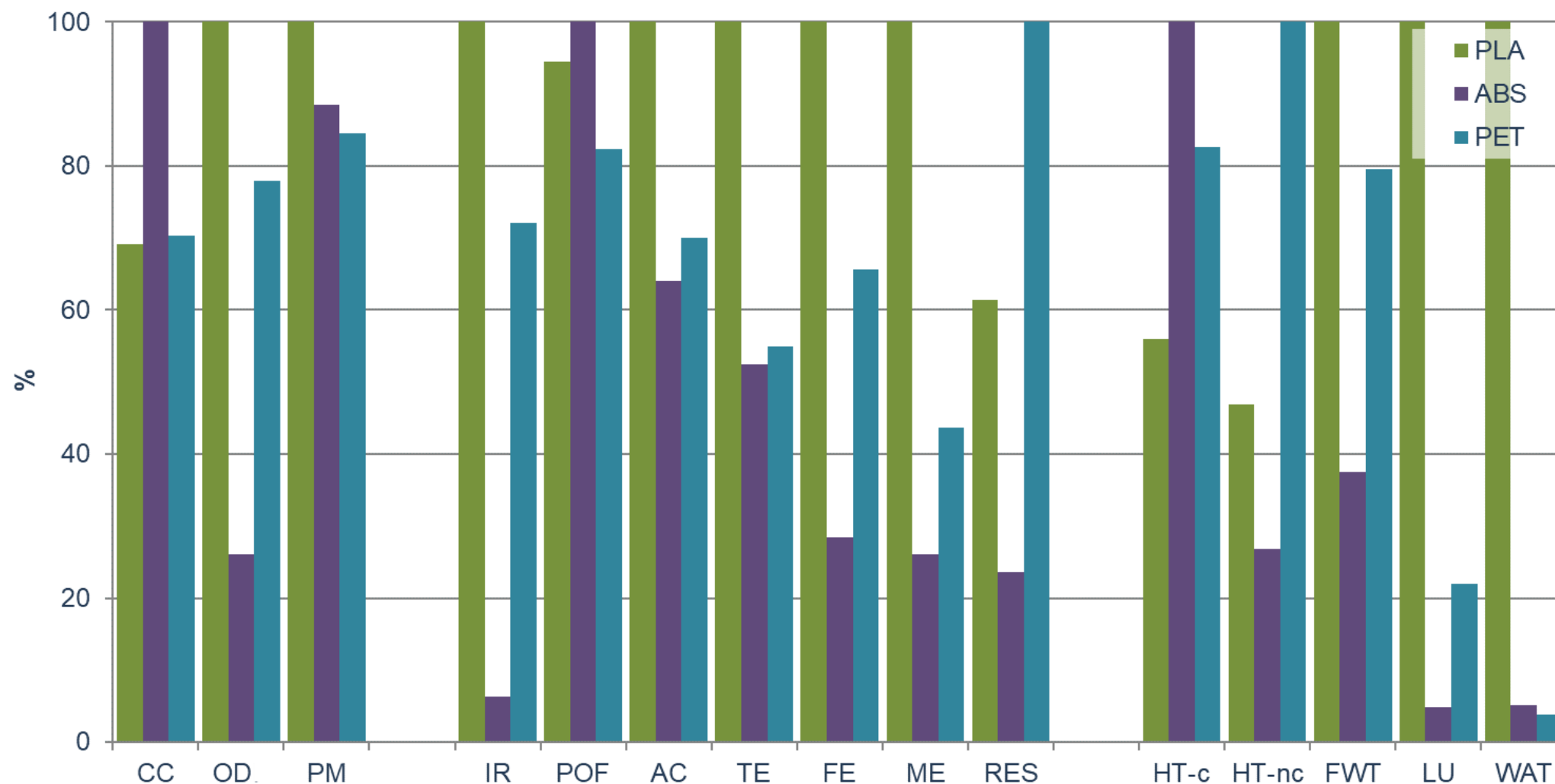
Several levels of assessment



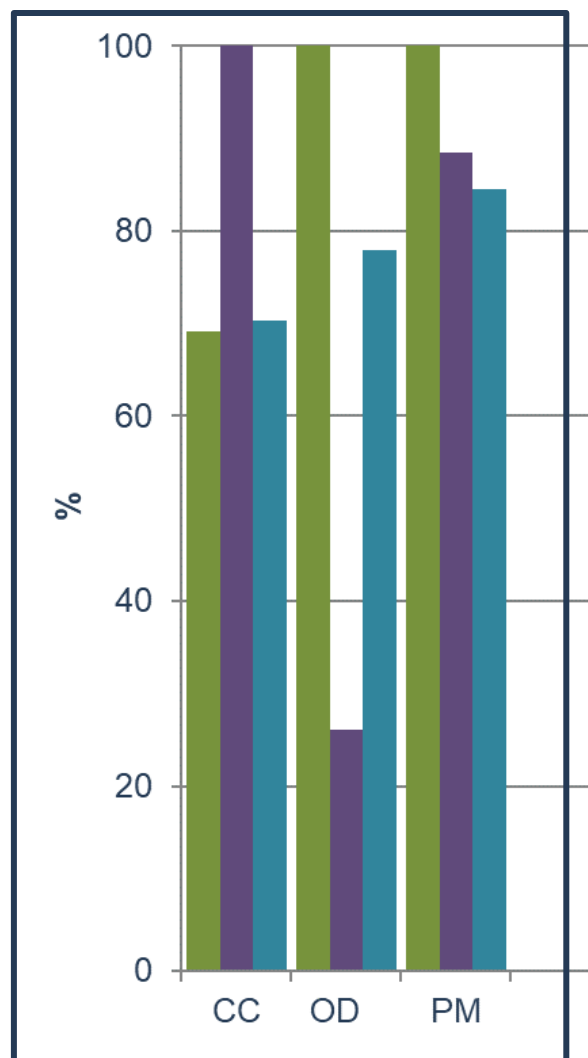
Levels of recommendation, ILCD referential

Ab.	Impact category	LCIA method	Midpoint unit	Class.
CC	Climate Change	Baseline model of 100 years of the IPCC	kg CO ₂ eq.	I
OD	Ozone Depletion	Steady-state ODPs 1999 as in WMO assessment	kg CFC-11 eq.	I
PM	Particulate Matter/Respiratory Inorganics	RiskPoll model	Disease incident	I
IR	Ionising Radiation, human health	Human health effect model	kBq ²³⁵ U eq. (to air)	II
POF	Photochemical Ozone Formation	LOTOS-EUROS model	kg NMVOC eq.	II
AC	Acidification	Accumulated Exceedance model	mol H ⁺ eq.	II
FE	Eutrophication, freshwater	EUTREND model	kg P eq.	II
ME	Eutrophication, marine	EUTREND model	kg N eq.	II
TE	Eutrophication, terrestrial	Accumulated Exceedance model	mol N eq.	II
WAT	Water Use	Available Water REmaining (AWARE)	m ³ water use related to local scarcity of water	III
LU	Land Use	Soil quality index based on LANCA (EC-JRC)	Dimensionless (pt)	III
RD, f	Resource depletion, energy carriers	CML 2002 - Abiotic resource depletion, fossil fuels	MJ	III
RD, m	Resource depletion, minerals and metals	CML 2002 - Abiotic resource depletion, ultimate reserves	kg Sb eq.	III
HT, nc	Human Toxicity, non-cancer effects	USETox 2.1 model	CTUh (Comparative Toxic Unit for humans)	III
HT, c	Human Toxicity, cancer effects	USETox 2.1 model	CTUh (Comparative Toxic Unit for humans)	III
FWT	Ecotoxicity for aquatic freshwater	USETox 2.1 model	CTUe (Comparative Toxic Unit for ecosystems)	III

Example: comparative results for 3 plastics



Interpretation of the results



Group I

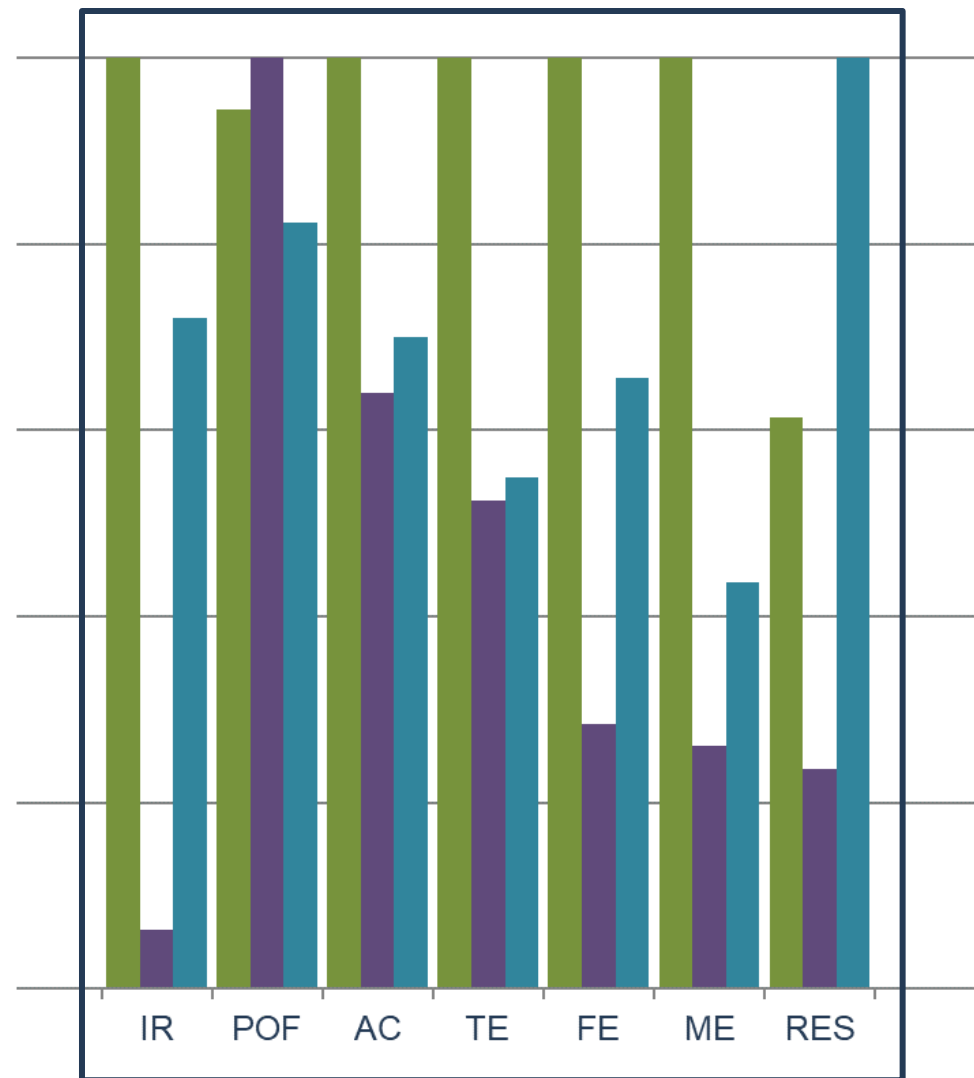
ILCD classification : I

If the inventories are reliable



interpretations can be made for gaps over
5-10%

Interpretation of the results



Group II : intermediate interpretability, a factor 2 or 3 will be significant

Interpretation of the results

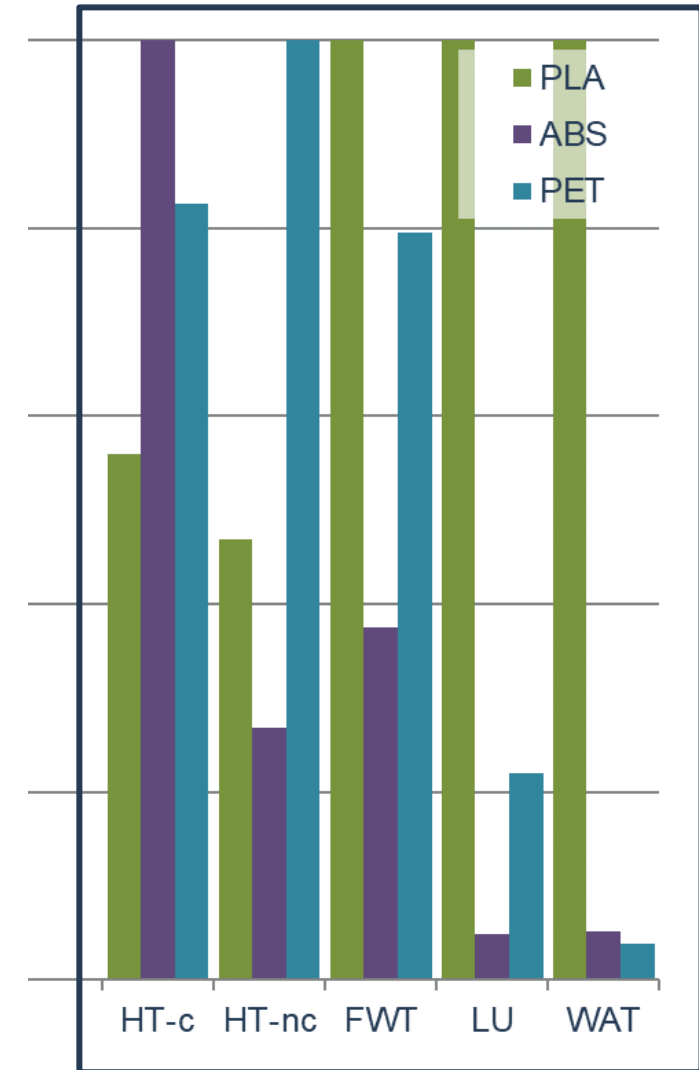
Group III

ILCD classification: II/III, III, interim

If the model is reliable



you can draw conclusions when results differ with a factor > 5-10



CHARACTERISATION (or contribution evaluation)



Value of the links between substance flows and impact categories

200 g glyphosate + 7 g cadmium = ☹ or ☹☹?



Comparing substances that have an effect on the same indicator

Général		Caractérisation		Normalisation et Pondération			
Impact category	Unit	Compa	Subc	Substance	CAS number	Facto /	Unit
Climate change	kg CO ₂ eq	Air		Methane, monochloro-, R-40	000074-87-3	13	kg CO ₂ eq / kg
Ozone depletion	kg CFC-11 eq	Air		Methane	000074-82-8	25	kg CO ₂ eq / kg
Human toxicity, non-cancer effects	CTUh	Air		Methane, biogenic	000074-82-8	25	kg CO ₂ eq / kg
Human toxicity, cancer effects	CTUh	Air		Methane, fossil	000074-82-8	25	kg CO ₂ eq / kg
Particulate matter	kg PM _{2.5} eq	Air		Chloroform	000067-66-3	31	kg CO ₂ eq / kg
Ionizing radiation HH	kBq U235 eq	Air		Ethane, 1,2-difluoro-, HFC-152	000624-72-6	53	kg CO ₂ eq / kg
Ionizing radiation E (interim)	CTUe	Air		Ether, nonafluorobutane ethyl-, HFE569sf2	163702-05-4	59	kg CO ₂ eq / kg
Photochemical ozone formation	kg NMVOC eq	Air		Ethane, 2,2-dichloro-1,1,1-trifluoro-, HCFC-	000306-83-2	77	kg CO ₂ eq / kg
Acidification	molc H ⁺ eq	Air		Methane, fluoro-, HFC-41	000593-53-3	92	kg CO ₂ eq / kg
Terrestrial eutrophication	molc N eq	Air		Ether, 1,1,2,3,3,3-Hexafluoropropyl methyl-	000382-34-3	101	kg CO ₂ eq / kg
Freshwater eutrophication	kg P eq	Air		Ether, 1,1,2,3,3,3-Hexafluoropropyl methyl-	000382-34-3	110	kg CO ₂ eq / kg
Marine eutrophication	kg N eq	Air		Propane, 3,3-dichloro-1,1,1,2,2-pentafluoroc	000422-56-0	122	kg CO ₂ eq / kg
Freshwater ecotoxicity	CTUe	Air		Ethane, 1,1-difluoro-, HFC-152a	000075-37-6	124	kg CO ₂ eq / kg
Land use	kg C deficit	Air		Ethane, 1,1,1-trichloro-, HCFC-140	000071-55-6	146	kg CO ₂ eq / kg
Water resource depletion	m ³ water eq	Air		Methane, dichlorofluoro-, HCFC-21	000075-43-4	151	kg CO ₂ eq / kg
Mineral, fossil & ren resource depleti	kg Sb eq	Air		Ether, 1,1,2,3,3,3-Hexafluoropropyl methyl-	000382-34-3	265	kg CO ₂ eq / kg
		Air		Ether, difluoromethyl 2,2,2-trifluoroethyl-, t	001885-48-9	286	kg CO ₂ eq / kg
		Air		1-Propanol, 3,3,3-trifluoro-2,2-bis(trifluorom	014117-17-0	297	kg CO ₂ eq / kg
		Air		Dinitrogen monoxide	010024-97-2	298	kg CO ₂ eq / kg
		Air		Ethane, 1-chloro-2,2,2-trifluoro-(difluorom	026675-46-7	350	kg CO ₂ eq / kg
		Air		Ethane, 1,1,2-trifluoro-, HFC-143	000430-66-0	353	kg CO ₂ eq / kg

characterisation
factor CF

one reference substance is
defined for each category

1 kg of methane emitted is equivalent to
25 kg of CO₂ in terms of global warming

Characterisation factors

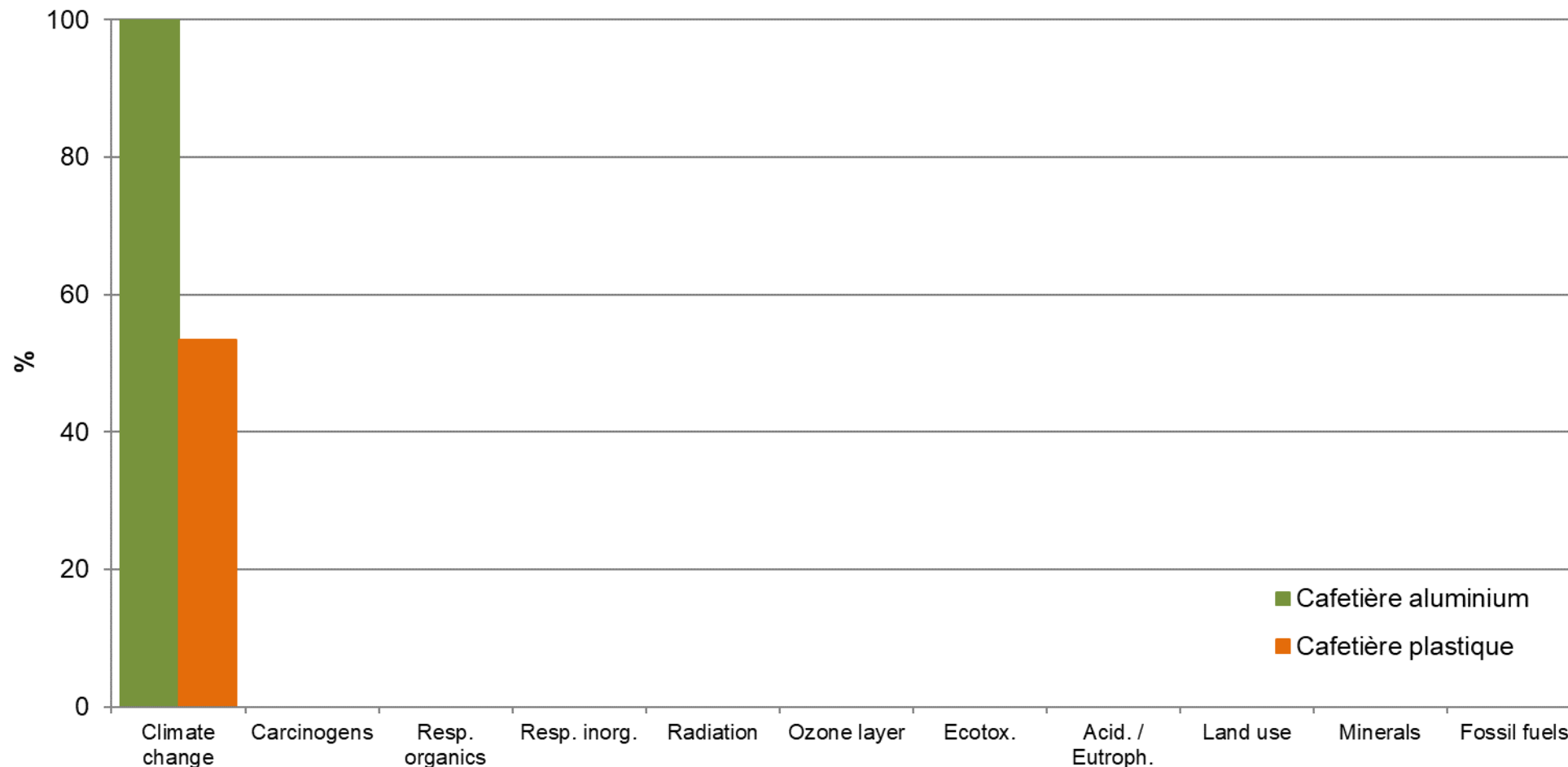


for climate change



for eutrophication

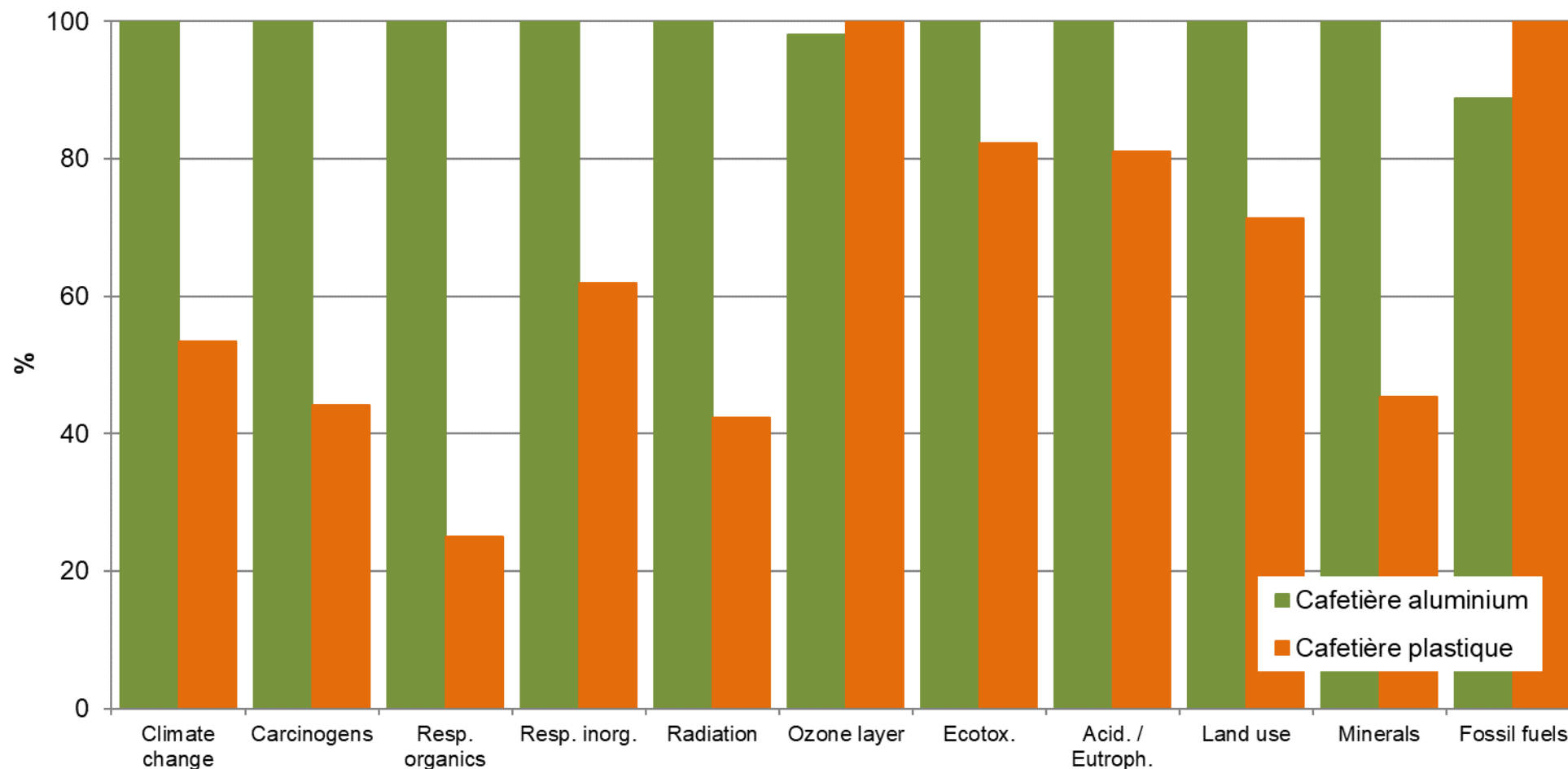
Characterisation results



Méthode: Eco-indicator 99 (H) V2.09 / Europe EI 99 H/A / Caractérisation

Comparison: base 100 for the most impactful system for each category.

Characterisation results



Méthode: Eco-indicator 99 (H) V2.09 / Europe EI 99 H/A / Caractérisation

No ranking of categories

NORMALISATION



Goal: To express results in relation to a benchmark, to measure the relative importance of impacts

Reference: impact category result for all activities in a region per capita for a year

Climate change

Characterisation

Normalisation

Result in eq. kg CO₂ / FU

Result in (european * year)/FU

Characterisation impact, per FU

climate change



eutrophication



Impact of an average European, per year

climate change



eutrophication



Normalised impact per FU

climate change : 0.25

eutrophication : 0.5

Normalisation factors (associated with a calculation method)

 Affichage méthode 'Recipe Midpoint (H) V1.07'

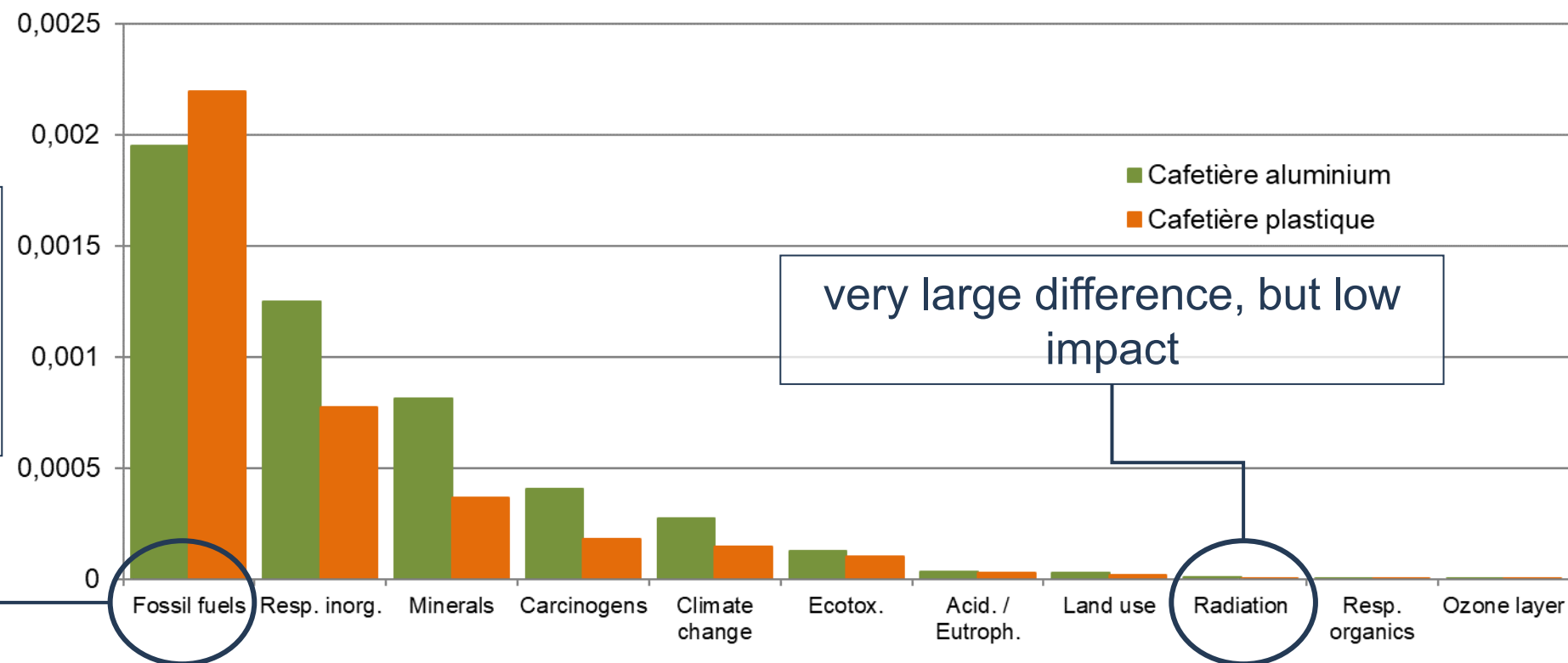
Général	Caractérisation	Normalisation
Ensemble de normalisati Europe ReCiPe H World ReCiPe H		
Catégorie d'impact		Normalisation
Climate change		8,92E-5
Ozone depletion		45,4
Terrestrial acidification		0,0291
Freshwater eutrophication		2,41
Marine eutrophication		0,0988
Human toxicity		0,00169
Photochemical oxidant formation		0,0188
Particulate matter formation		0,0671
Terrestrial ecotoxicity		0,122
Freshwater ecotoxicity		0,0919
Marine ecotoxicity		0,118
Ionising radiation		0,00016
Agricultural land occupation		0,000221
Urban land occupation		0,00246
Natural land transformation		6,19
Water depletion		0
Metal depletion		0,0014
Fossil depletion		0,000643

Normalised results

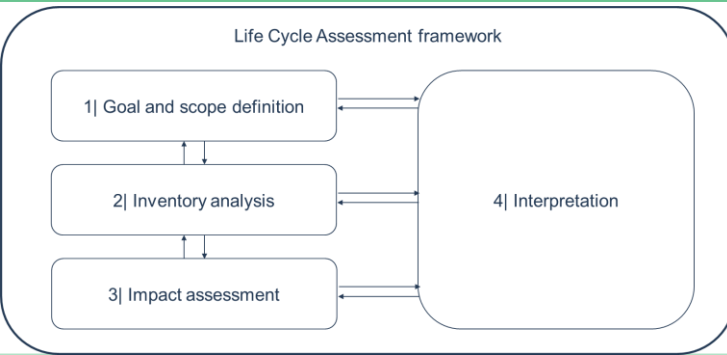
Production of the coffee machine



the only impact where plastic > alu is the most significant



Méthode: Eco-indicator 99 (H) V2.09 / Europe EI 99 H/A / Normalisation

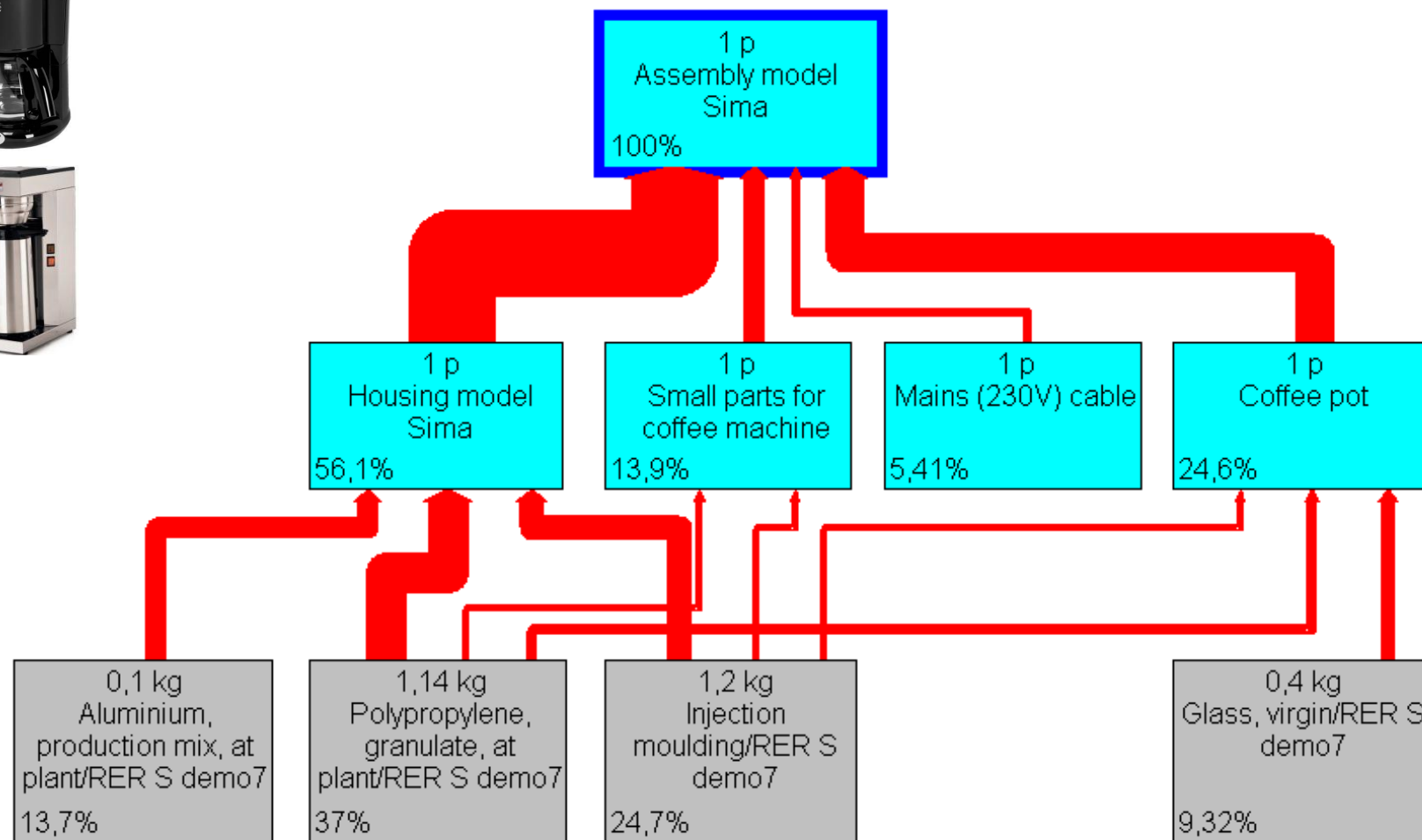


Step 4: Interpretation

Contribution study (identification of hotspots)



Contribution study

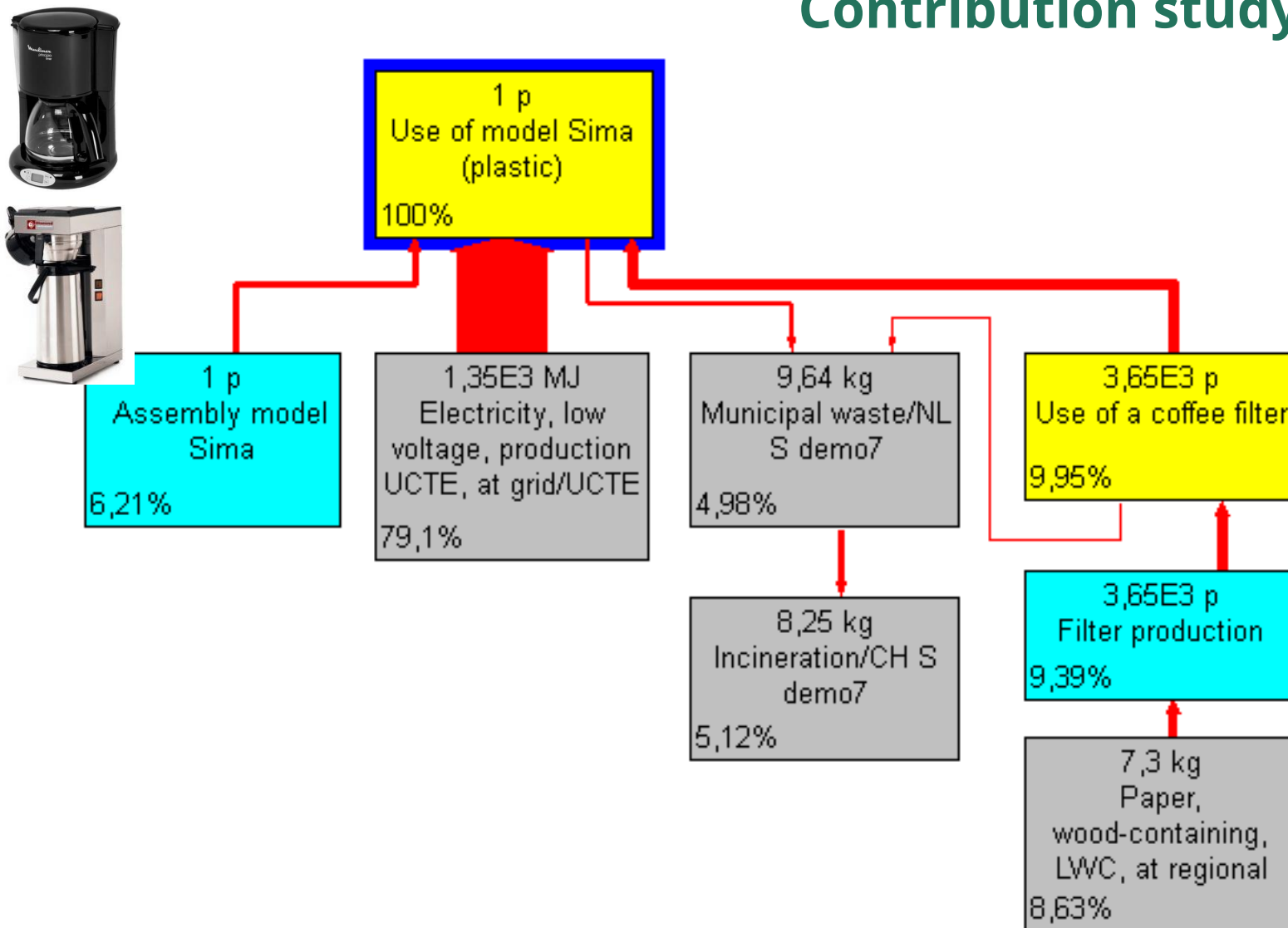


Identification of main contributors

Climate change
Plastic coffee machine production

Identification of relevant strategies → change PP
> reduce cable length?

Contribution study



Identification of main contributors

Most of the impact = electricity during use phase

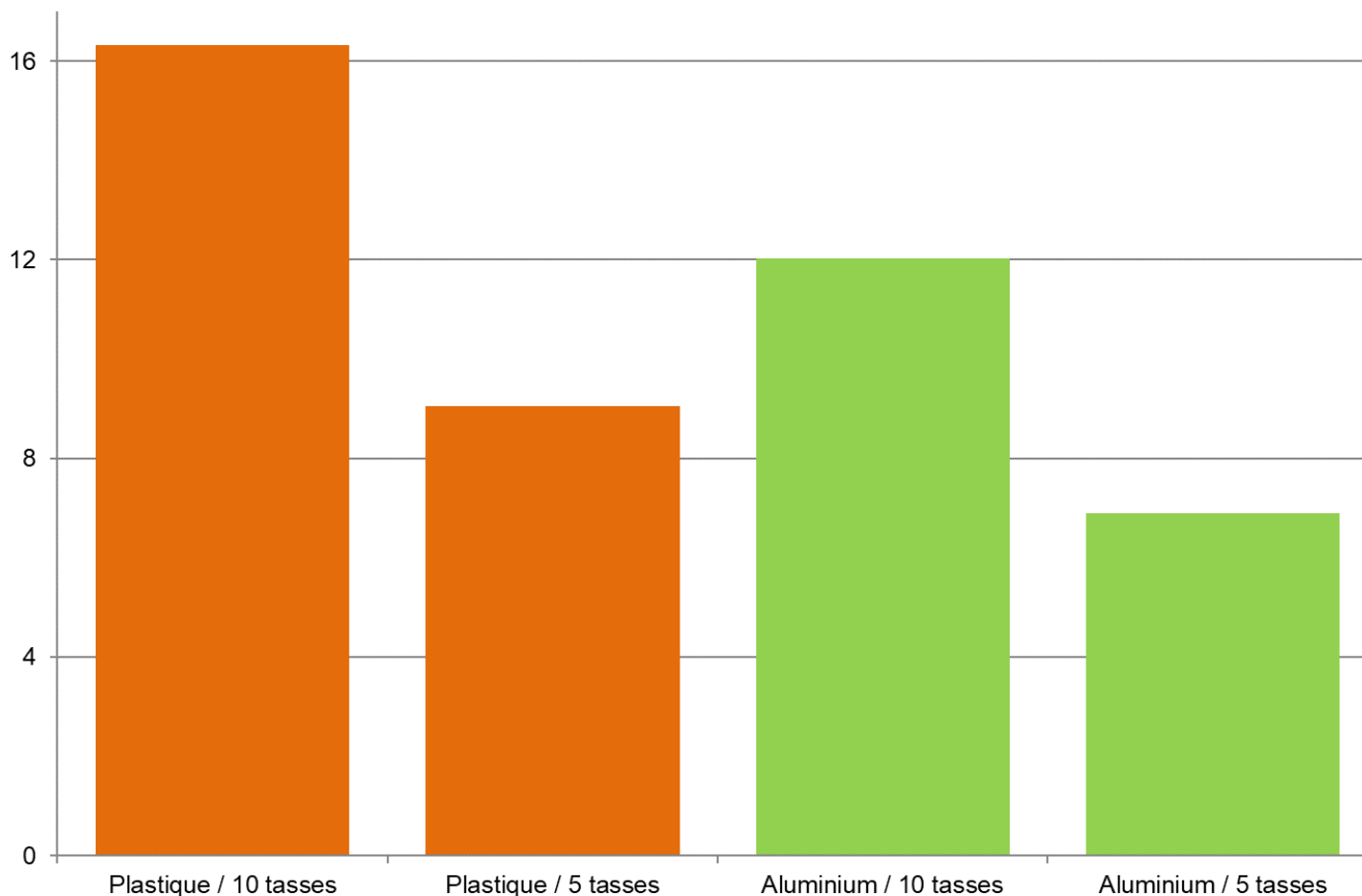


How relevant was the
choice of the functional
unit?



Sensitivity study

Sensitivity study



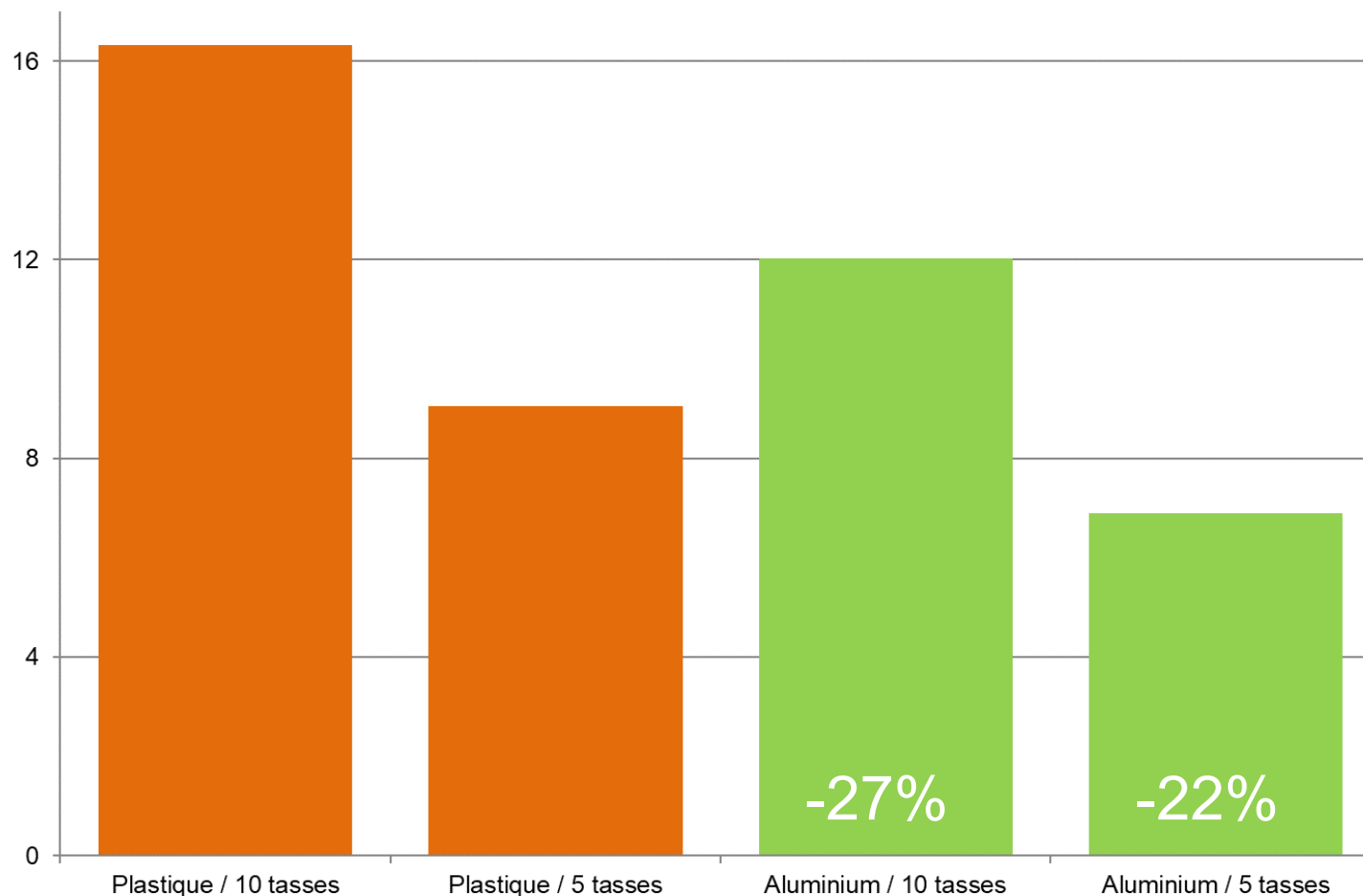
Méthode: Eco-indicator 99 (H) V2.09 / Europe EI 99 H/A / Score unique

Modification of FU

5 cups / day



Sensitivity study



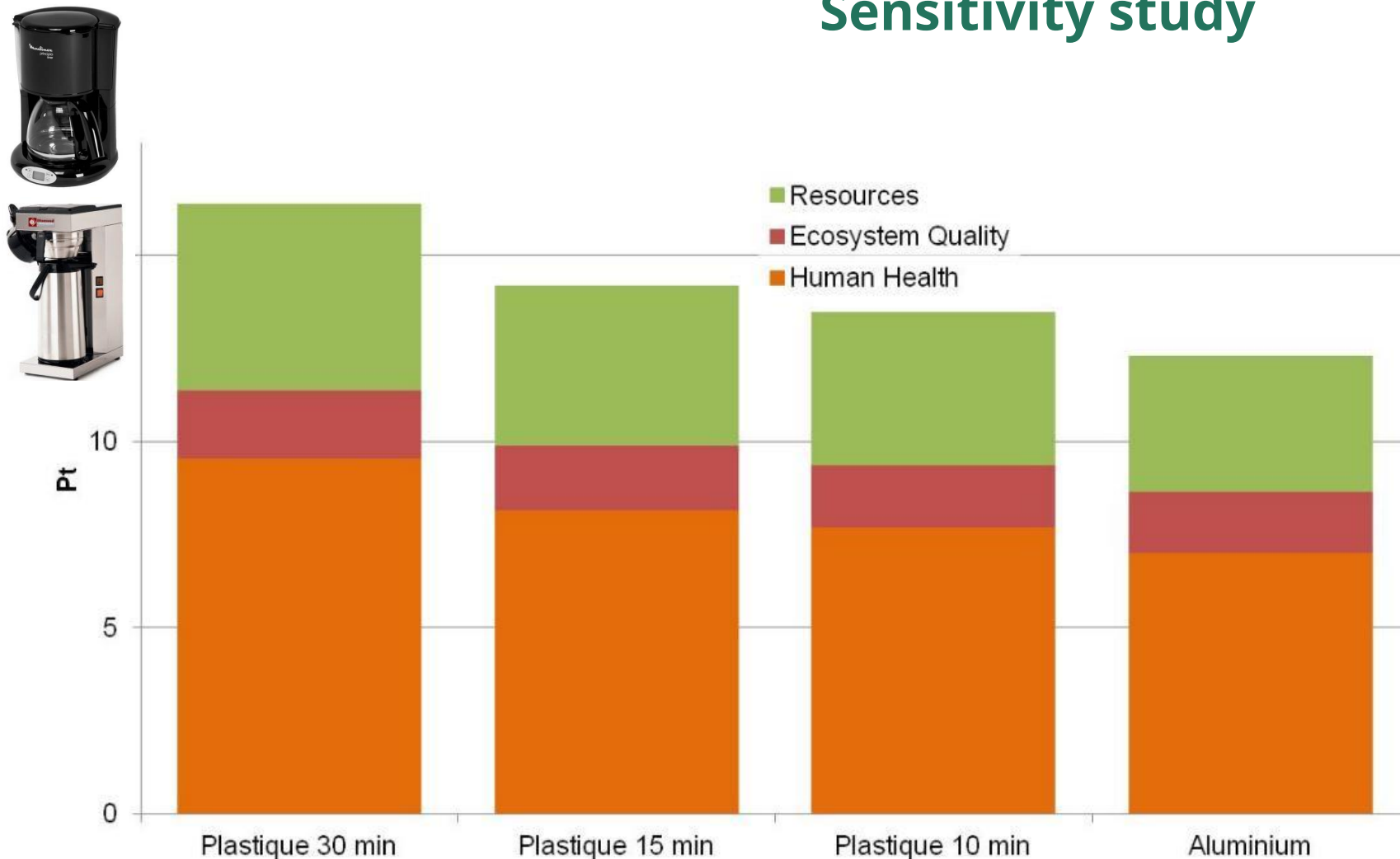
Méthode: Eco-indicator 99 (H) V2.09 / Europe EI 99 H/A / Score unique

Modification of FU

5 cups / day

Decrease in relative gap
→ sensitivity to FU choice

Sensitivity study



Modification of FU

Shortened warming time

Convergence of results →
sensitivity to the choice of
FU



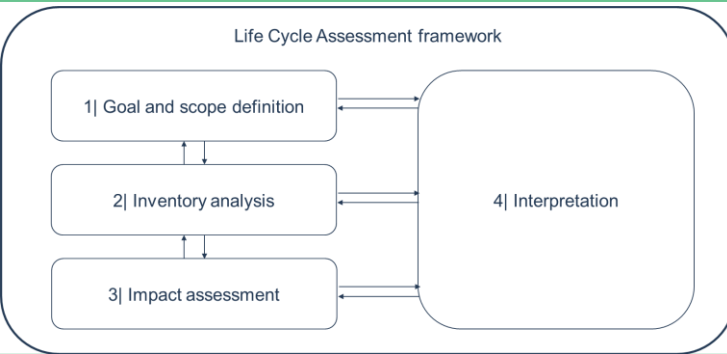
Conclusion on the case study

~~Plastic is bad, aluminium is good~~

~~Aluminium coffee machines are less impacting than plastic machines~~

~~This aluminium coffee machine is better than this plastic machine~~

If you want to make 10 coffees a day for 5 years and keep them hot for 30 minutes, this aluminium coffee maker with thermos has a lower environmental impact than this plastic coffee maker with glass jug and hot plate, taking into account the modelling assumptions and the reliability of the input data and calculation methods, and all other things being equal...



Third party critical review



Third party critical review

Goal: to guarantee the validity of the study and its conclusions from an external and expert perspective

Mandatory step according to the ISO standard if the aim is to communicate comparative results to the public

The remarks and recommendations of the critical review should be incorporated into the final report, together with the responses

Fields of inquiry of the critical review



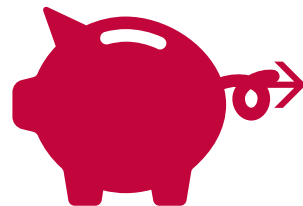
Several types of critical review

Experts panel

Single reviewer

**As an
accompaniment to
the study**

A posteriori



the critical review can significantly increase
the cost of a study



LCA: from results to applications

Life cycle assessment (LCA)

ISO 14040 / ISO 14044

Method used to quantify the potential environmental impacts associated with a product or system over its life cycle.

LCA results

Internal (to the company)

Decision support

- Product development & improvement - material selection, ecodesign
- Strategic planning - supply chain optimisation, benchmark comparison, investment in new production technology
- Supplier selection
- Decarbonisation
- Quantitative assessment of the true environmental impacts of circular, recycled, or bio-based alternatives

External (to the company)

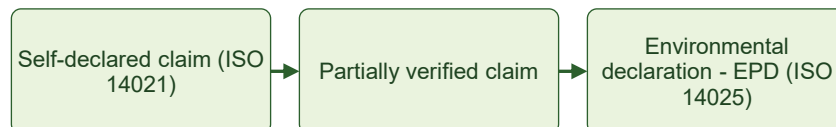
Decision support

Public policy

Others

Customer requirements, regulatory compliance

Communication & marketing



Also used for environmental reporting

EU Directive 2024/825

Applicable from 27 September 2026

Environmental claims aimed at consumers must be substantiated, transparent and not misleading.

LCA is one of the key methods for generating the evidence needed to substantiate an environmental claim.



BIO-SUSHY

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Questions ?

Agenda

10:00 Opening Remarks and Introduction

- Welcome, housekeeping & BIO-SUSHY project intro.
- Goal of the training and overview. (10-15 min)



10:15 Common Misconceptions

- Interactive poll and key concept clarifications. (10 min)



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- ISO framework, four LCA phases & system boundaries. (35 min)



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- Integration of LCA into SSbD & environmental hotspots. (35 min)



11:35 From LCA Results to Decision Making

- Summary of insights and open Q&A session. (15 min)



11:50 Wrap-up & Next Steps

- Summary of key takeaways.
- Closing remarks and acknowledgment. (10 min)



Benjamine Belloncle

Researcher

Materia Nova (MANO)



SUSTAINABLE SURFACE PROTECTION BY GLASS-LIKE HYBRID AND BIOMATERIALS COATINGS

4th Training

Life Cycle Assessment (LCA) for PFAS-Free Coatings: Supporting Safe and Sustainable by Design (SSbD) Decision-Making



BIO-SUSHY

BIO-SUSHY SSbD workshop
September 30, 2026 – Teams
MATERIA NOVA
Benjamin Belloncle



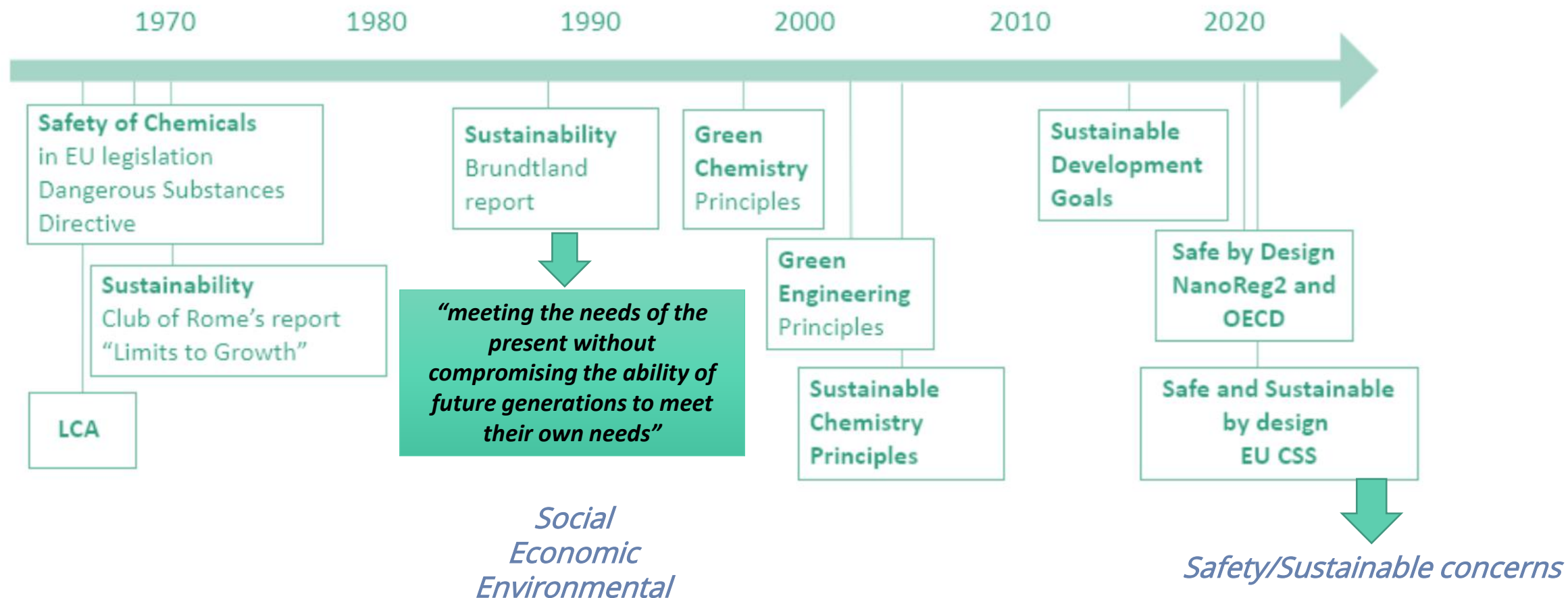
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Why SSbD?



Conceptual developments



SSbD Development



European Green Deal: European Commission aims to transform the EU's economy for a more sustainable future



CLIMATE



BIODIVERSITY



CIRCULARITY



HUMAN HEALTH



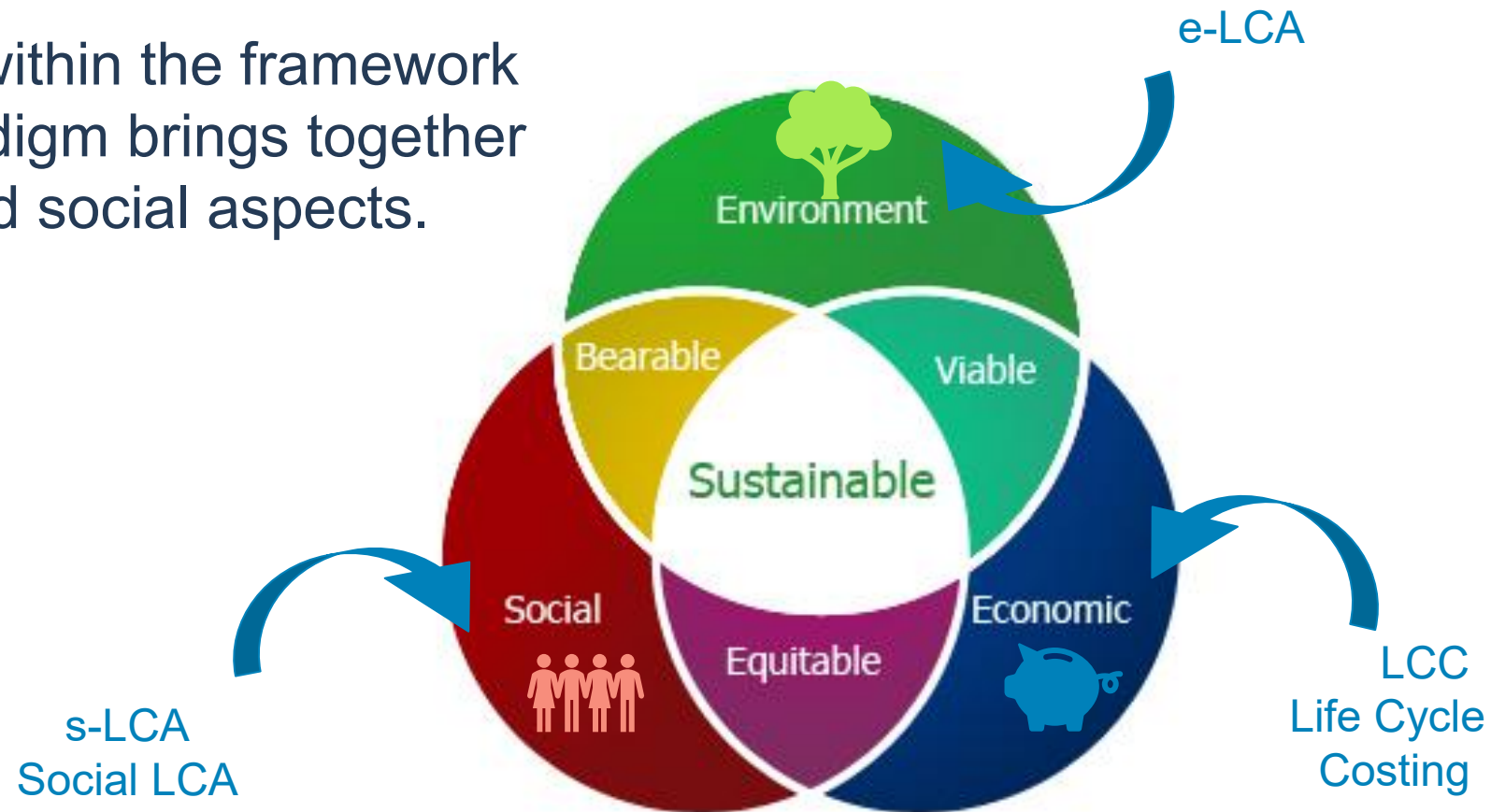
ENVIRONMENT



To achieve these objectives, the Chemicals Strategy for Sustainability (CSS) calls for the **transition to a Safe and Sustainable by Design (SSbD)** approach for chemicals

What is sustainability?

A sustainability assessment within the framework of the life-cycle thinking paradigm brings together environmental, economic, and social aspects.



Life Cycle Costing (LCC)

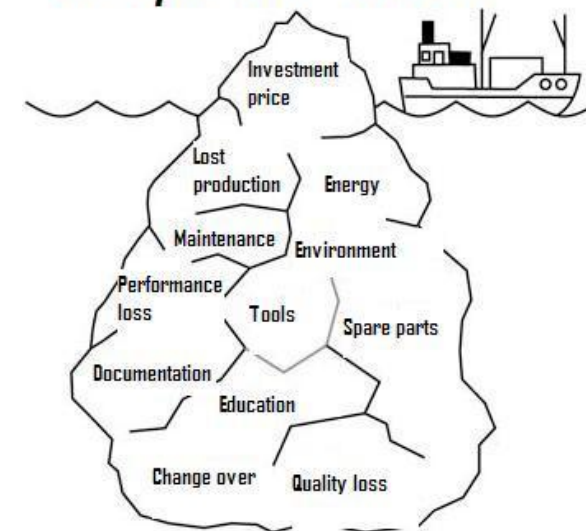
The economic pillar of a Safe and Sustainable by Design assessment

What is it?

A systematic accounting of **all the costs** generated by a product over its **entire life cycle** (from raw materials to end of life) and of who actually pays them: supplier, manufacturer, user, or society.

It is the economic counterpart of the LCA: same functional unit, same system boundaries, so **both results can be read side by side**.

Life Cycle Cost - LCC



Conventional LCC

Costs seen by one actor (usually the producer or the buyer). Classic cost accounting, no environmental link.

Environmental LCC

All costs along the value chain, for all actors, computed alongside an LCA. The reference practice in SSbD.

Societal LCC

Adds the monetised external costs borne by society (pollution, health). Still debated, risk of double counting.

Social Life Cycle Assessment (S-LCA)

The social pillar: who is affected, and how, along the value chain



What is it?

An assessment of the **social and socio-economic effects** of a product on the people involved in its life cycle: workers, communities, consumers,...

Same four-phase structure as the LCA (ISO 14040/44). The reference framework is the **UNEP Guidelines for S-LCA (2020)** and their Methodological Sheets (2021), with around 40 impact subcategories.

How it differs from an environmental LCA

Impacts depend on the conduct of the organisations involved: where and by whom the product is made, not only on physical flows. Indicators are largely qualitative or semi-quantitative, scored against reference scales rather than summed in kg.

Six stakeholder categories

Workers

Child & forced labour, fair salary, working hours, health & safety

Local communities

Safe living conditions, access to resources, local employment

Value chain actors

Fair competition, supplier relationships, promoting social responsibility

Consumers

Health & safety, transparency, privacy, end-of-life responsibility

Society

Contribution to development, corruption, technology development

Children

Education, child-specific exposure and rights

SSbD framework



The EU framework for chemicals and materials (revised by the JRC in 2025)

Ensure **safety** and **sustainability** throughout the entire life cycle of chemicals and products, and **steer innovation** so that chemicals, materials, processes and products are designed (or redesigned) by identifying safety issues, sustainability impacts and trade-offs as early as possible.

The 2022 framework was tested for two years by Member States, industry, academia and RTOs. The 2025 revision keeps the core concept but improves relevance, reliability and operability, including a simplified route for early-stage innovation and for SMEs.



What the 2025 revision introduces

Four SSbD principles stated explicitly as the backbone.

A structured entry step:
system, goal, actors,
decision rules.

Safety merged into one holistic part; socio-economic much expanded.

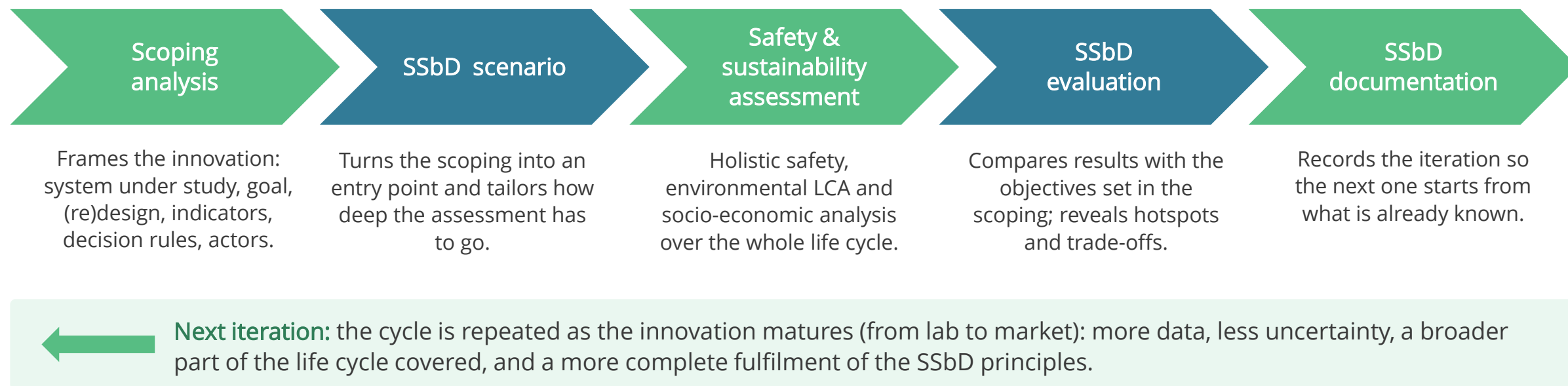
Trade-offs, uncertainty, and a dashboard to visualise results.

A template recording each iteration, for traceability.

How the framework is structured

A cycle repeated at every iteration of the innovation, not a one-off checklist

Entry point: an intended innovation: the design or redesign of a chemical, a material, a process or a product (incremental or breakthrough).



Applying design principles in the (re)design phase alone is not enough. An assessment is needed to unveil the hotspots and the trade-offs that the design choices actually produce: that is what the rest of the cycle is for.

Scoping analysis and the SSbD scenario

The new front end of the framework: decide what you are assessing, and how deeply

The scoping analysis in six questions

What is the chemical/material life cycle in which the innovation happens?

Why is the innovation happening? what is the goal?

What / where is the (re)design: molecular, process or product?

How will success be proved? which indicators and decision rules?

When is SSbD implemented? at which maturity of the innovation?

Who are the actors along the life cycle, and what are their responsibilities?

Output: the SSbD scenario : the entry point to the assessment

Simplified SSbD

One element of the system is defined in detail, the rest stays generic and conservative. A single innovation, a single practitioner.

Intermediate SSbD

Several elements are defined as far as reality allows. Collaborative innovation affecting neighbouring life cycle stages, several actors involved.

Full SSbD

The whole system is defined. Full life cycle innovation, all actors engaged, safety and sustainability performance ensured across the system.

Methodological criteria are the structured conditions that let a practitioner move from one scenario to the next, from a simplified implementation by a single actor towards a full SSbD covering the whole life cycle. The scenario is revisited at every iteration.

The safety assessment

Steps 1 to 3 of the 2022 framework are now merged into a single, holistic safety part



The common ground: intrinsic properties

Physico-chemical characterisation feeds both the safety and the sustainability assessment, including the transformation products that may be more hazardous than the parent chemical.

Problem formulation opens every iteration

It states what is assessed, why and how: the scope, the exposed populations and receptors, the endpoints, the type of assessment (qualitative, semi-quantitative or quantitative) and the data to be generated. Without it the assessment drifts.

Holistic safety: six complementary perspectives

Chemical / material safety

Process safety

Occupational safety

Consumer safety

Environmental safety

Product safety

Why merge the three former steps?

Because hazard alone says little. The revised framework evaluates the intrinsic properties together with occupational, consumer and environmental exposure, across the life cycle stages. A dedicated sub-chapter covers process-related safety, so that different routes to the same chemical/material can be compared.

The sustainability assessment

Two parts, both built on the life cycle of the chemical or material

Environmental sustainability

A function-based Life Cycle Assessment, following the Environmental Footprint (EF) method.

16 impact categories: EF 3.1 categories reported separately at characterisation level (climate change, toxicity, ecotoxicity, resource use, water, land, and the rest) so trade-offs stay visible instead of collapsing into one score.

A tiered LCA: Screening assessment → simplified → intermediate → full LCA, following the maturity of the innovation.

A reference to compare against: Proxy reference (generic reaction values) early on, then a benchmark (average performance) or a representative system; optionally a target set by the practitioner.

Classes of performance : Results are placed in classes CP5 to CP1, scored 0 to 4, from failing the criteria to a large improvement over the reference.

Socio-economic sustainability

Significantly expanded in 2025, and built on the same system definition and life cycle inventory as the LCA.

Pillar 1: social fairness: Human rights (child and forced labour), working conditions and quality of jobs (fair salary, working time, equal opportunity), health and safety.

Pillar 2: competitiveness: Contribution to economic development, supply chain vulnerabilities, skills shortages and technology potential.

Three complementary steps: Reference scale assessment (S-LCA, ISO 14075), identification of Critical Raw Materials along the life cycle, life cycle costs.

Not a financial analysis: It doesn't duplicate corporate accounting: it adds externalities and the financial risk attached to hazardous or poorly sustainable processes.

Safety and sustainability are assessed separately, then read together: they answer different questions and rely on different methods.

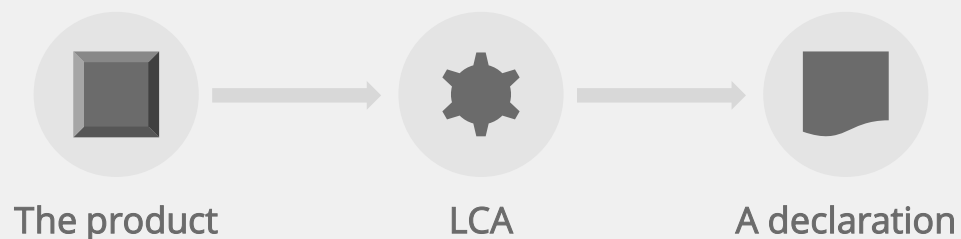
LCA in the SSbD framework



An LCA that feeds a design, not a claim

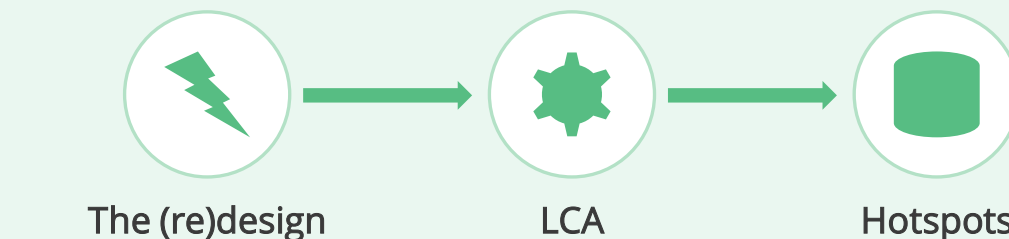
The same method as any LCA but a different question?

A CLASSICAL LCA STUDY



The study ends when the number is published.

AN LCA INSIDE SSbD (and R&D projects)

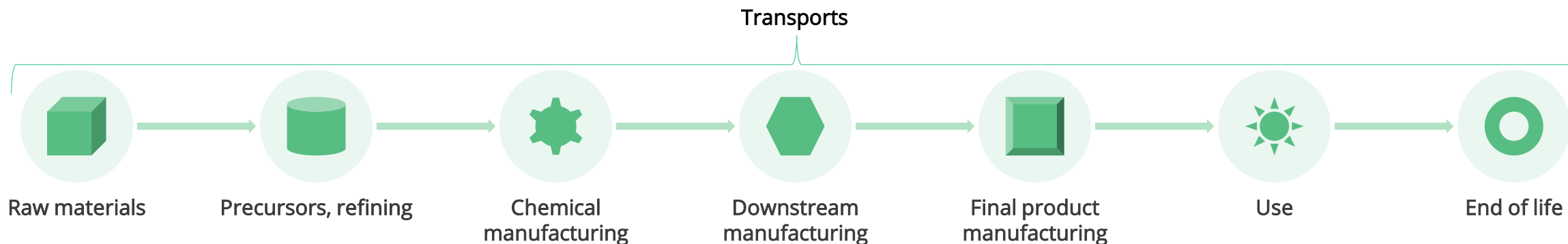


The result changes the next version of the design.

So the useful output is not “x kg CO₂ per kg”. It is: which impact category fails, at which life cycle stage, because of which flow, and therefore what to change next.

What we look at: the whole chain

The impact of a coating is rarely where you are standing in the chain



The SSbD system always covers the three elements: the chemical or material, the process that makes it, and the product it ends up in, with their life cycles.



Where you sit

A formulator sees the middle of the chain. A raw material supplier sees the left. Neither sees the whole impact.



Where the impact is

For many chemicals, most of the footprint sits upstream (in the precursors and the energy used to make them).



Why it matters here

Replacing a PFAS does not only change a molecule: it changes feedstocks, process conditions and service life.

From thousands of flows to sixteen indicators

What an LCA actually computes and why it stops at sixteen numbers

Thousands of elementary flows
energy, raw materials, emissions to air, water and soil, waste, for every process in the chain



16 impact categories
each flow is multiplied by a characterisation factor and summed per category



5 policy concerns
climate change · pollution · resources · ecosystems and biodiversity · toxicity

Why not one single number?

Two coatings can share the same overall score while one is a climate problem and the other a water problem. The design action is not the same.

So, in SSbD

The sixteen categories are kept separate, at characterisation level. Normalisation, weighting and the single score stay optional.



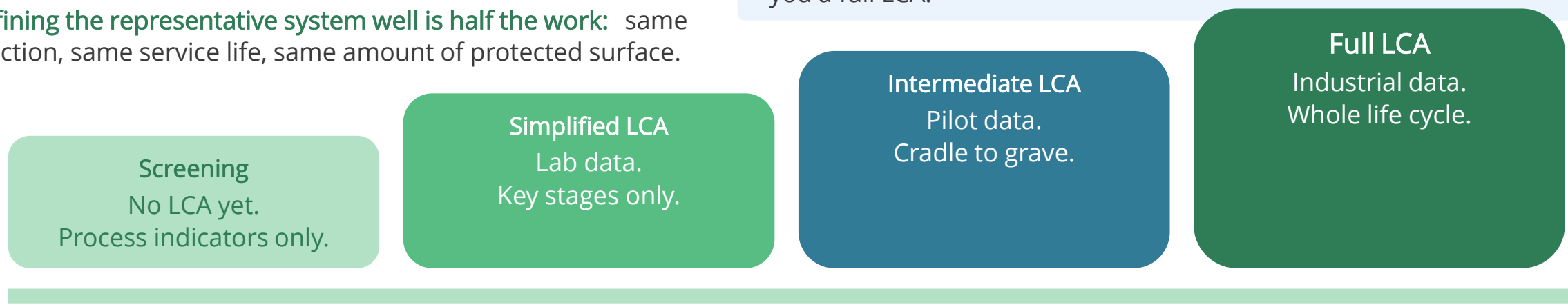
You do not need a full LCA on day one

The depth of the assessment climbs with the maturity of the innovation

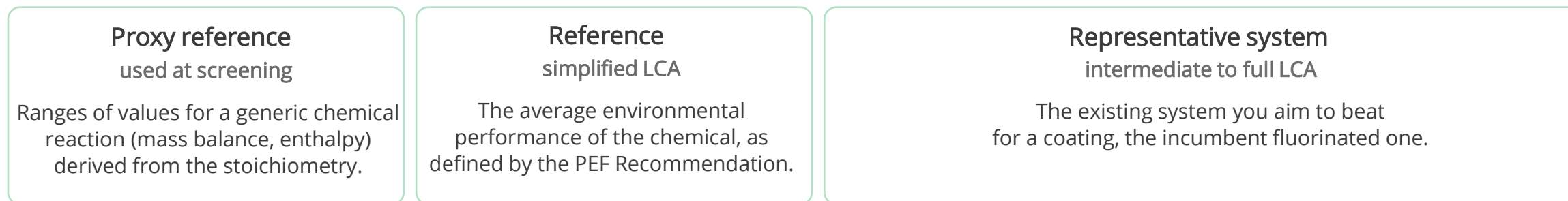
Uncertainty falls as you climb. Each tier reuses the previous one, nothing is thrown away, the model is refined.

Defining the representative system well is half the work: same function, same service life, same amount of protected surface.

Careful: two axes, not one. A mature product whose suppliers have given no data still sits in the middle tiers. Maturity alone does not buy you a full LCA.

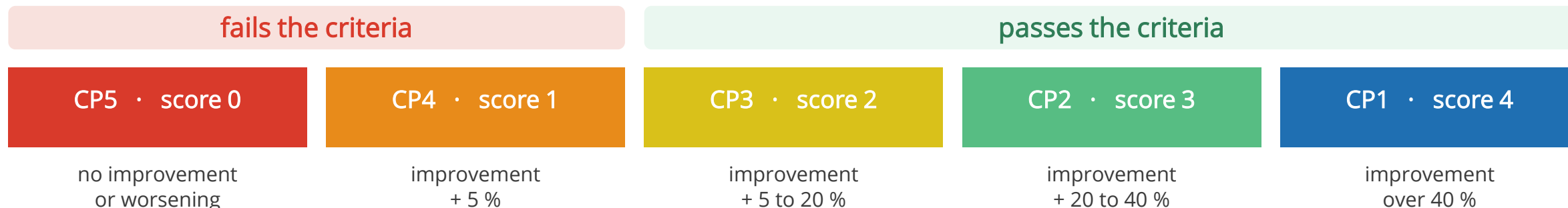


maturity of the innovation, and completeness of the data



Turning the number into a verdict

The same five-class ruler is applied to each of the sixteen categories



One verdict per category (illustrative profile on 5 impact categories)

Climate change						CP2
Water use						CP5
Resource use, fossils						CP1
Acidification						CP3
Human toxicity, cancer						CP4

How to read this

- A single product is rarely uniform: here it is excellent on fossil resources and fails on water use.
- Only the categories in CP5 and CP4 have to be acted upon that is the shortlist for the next iteration.
- The class boundaries are illustrative and should be set taking the uncertainty of the assessment into account.

Interpreting the results: close look to the hotspots

Three questions that turn an impact profile into a design action

1 Which impact categories perform worst?

Read the 16 categories against their classes of performance. The categories in CP5 and CP4 are where the innovation currently fails.

2 Which life cycle stages drive them?

Break each of those categories down by stage: raw materials, manufacturing, downstream processes, use, end of life.

3 Which flows are responsible?

Within those stages, identify the technical and elementary flows that carry the impact: a solvent, an energy carrier, a precursor, an emission.

... and then act on the innovation

→ Explore alternative options

Another feedstock, another synthesis route, another process configuration.

→ Run a sensitivity analysis

Test how much the conclusion depends on the uncertain flows and assumptions.

→ Change the design principles

Revisit which SSbD principles the (re)design is built on, and their indicators.

→ Expand the innovation

Extend the improvement to stages or aspects not covered by this iteration.

The output of the environmental assessment is therefore a shortlist of changes to try, carried into the next iteration of the scoping analysis.

Five things to remember

If the rest fades, keep these

The purpose is the design

An SSbD LCA is run to decide what to change next, not to publish a figure.

Start where you are

A screening on five process indicators beats waiting for data you will not have for two years.

Sixteen numbers, not one

Keep the impact categories separate; the single score hides the trade-off you need to see.

A result needs a reference

Define the representative system carefully: same function, same service life.

Say how sure you are

Uncertainty and the life cycle stage travel with every result, all the way to the dashboard.

And one habit: write down the assumptions, the data sources and the reference you used, in the iteration where you used them. The next iteration (and whoever reviews it) depends entirely on that record.

LCA in BIO-SUSHY



LCA in BIO-SUSHY: methodology

Comparing manufacturing routes before a process design even exists

1/ Define a benchmark (depends on the TRL of the project): for BIO-SUSHY the full LCA is taken into account

2/ Define a range of improvement
(here the scoring proposed in the framework)

Position to reference	Score	Colour code	
No improvement	0		Fail the criteria
Improvement + 5%	1		
Improvement + 5% to 20%	2		Pass the criteria
Improvement + 20% to 40%	3		
Improvement > 40%	4		

3/ Model the whole life cycles of the benchmark and the new products

4/ Compare the results for each impact category between the full life cycle of the benchmark and the new product → score SSbD

LCA in BIO-SUSHY: example of score

Comparing manufacturing routes before a process design even exists

Position to reference	Score	Colour code	
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Improvement + 5%	1		
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Improvement > 40%	4		

LCA Assessment level (max score)	Aspect	Score	Level
Toxicity ES1 (max 12)	Human Toxicity, cancer	3	X
	Human Toxicity non cancer	2	
	Ecotoxicity	1	



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- Summary of key takeaways.
- Closing remarks and acknowledgment. (10 min)

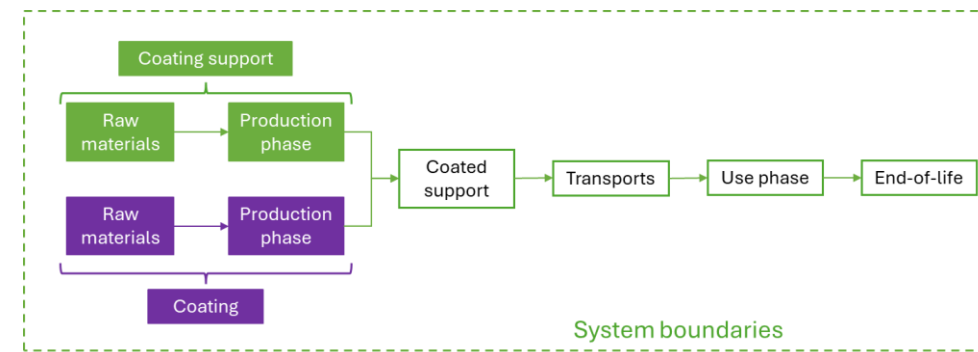


BIO-SUSHY Results



BIO-SUSHY case studies

Each case study corresponds to a full life cycle different and a different functional unit



1

FOOD PACKAGING CASE STUDY

FU: Paper based food tray used to deliver 200 g of hot food to canteens.
1 scenario defined with our industrial partner.



2

TEXTILE CASE STUDY

FU: Use of a tablecloth (150 x 200 cm), including 10 washings
2 scenarios: one European production vs worldwide production and use in Europe



3

GLASS PACKAGING CASE STUDY

FU: Use of 142.5 g of face cream
2 scenarios vs benchmark: single use glass packaging and reuse of the packaging





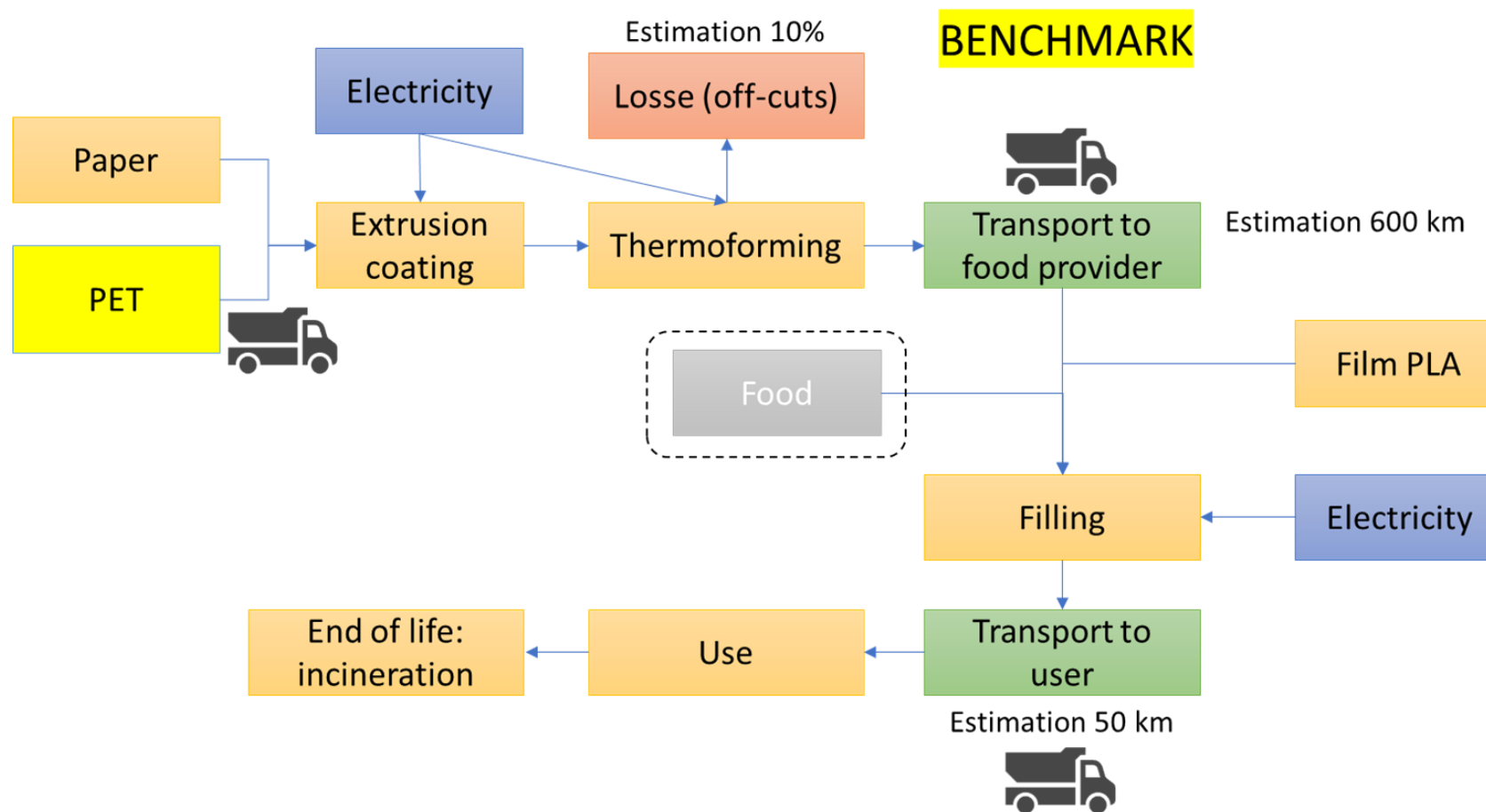
BIO-SUSHY

FOOD TRAYS



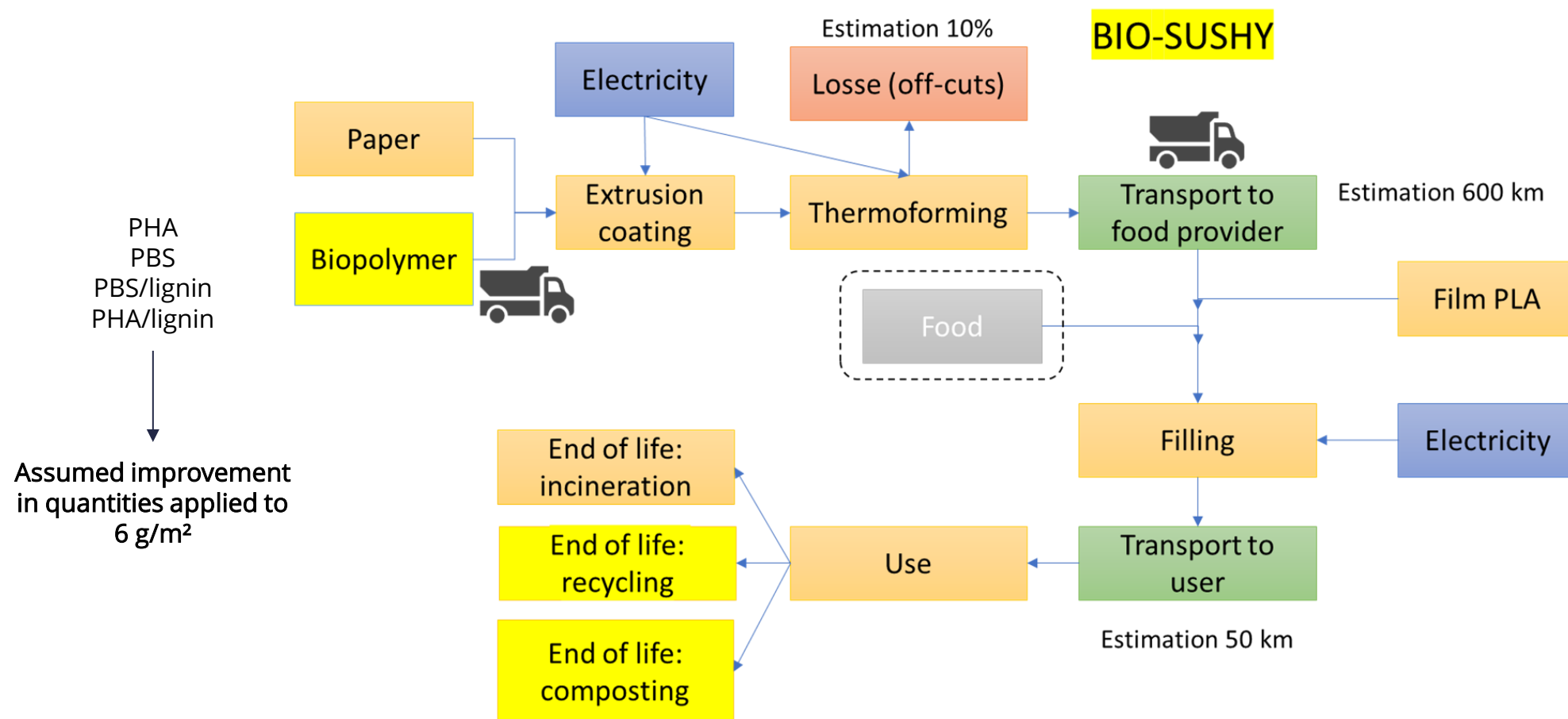
BIO-SUSHY: Food tray case study

Definition of the benchmark full life cycle



BIO-SUSHY: Food tray case study

Definition of the BIO-SUSHY full life cycle

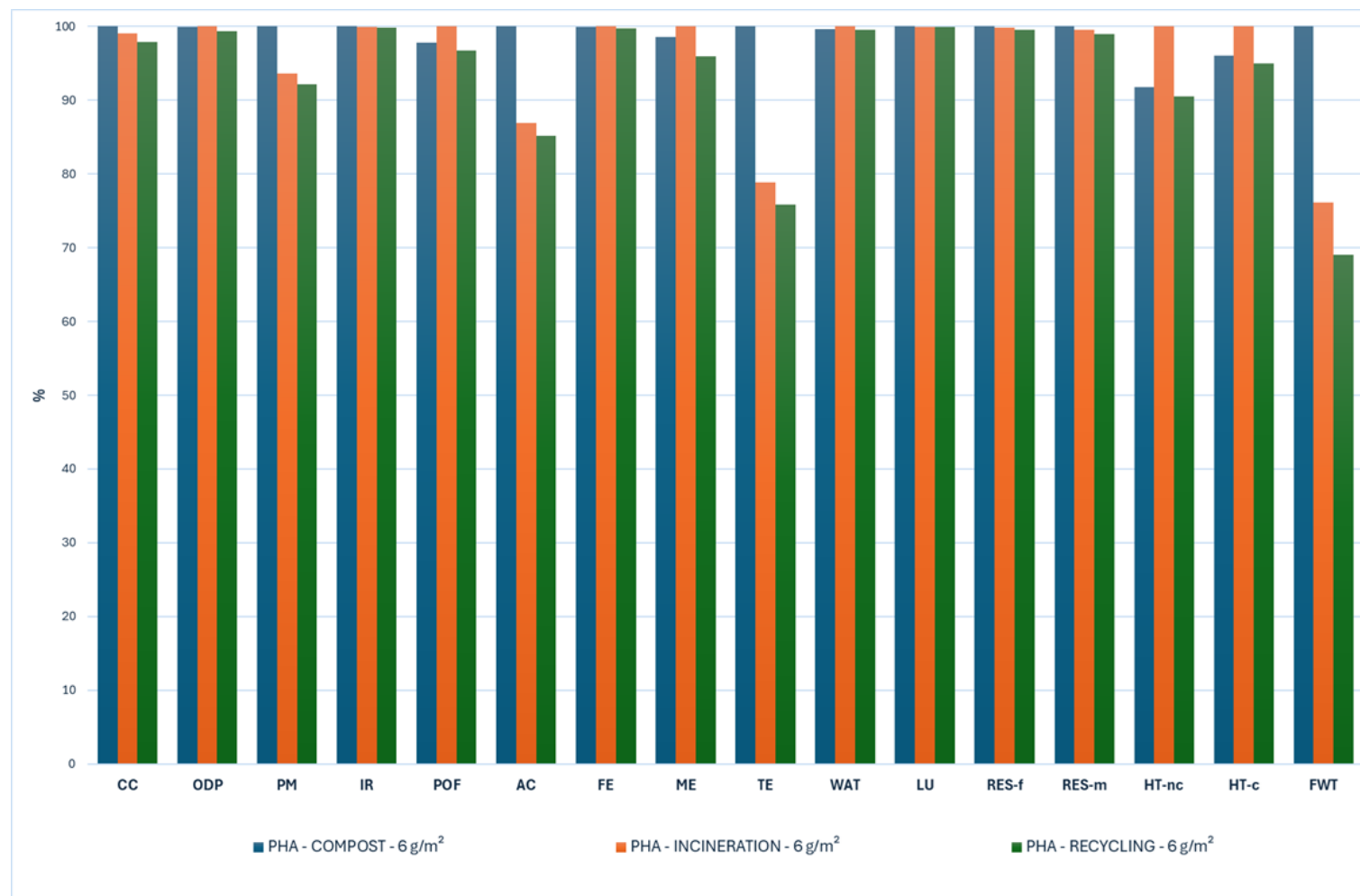


BIO-SUSHY: Food tray case study

Comparison of the end-of-life

Recycling is the less impactant end-of-life
(in comparison with incineration and
composting)

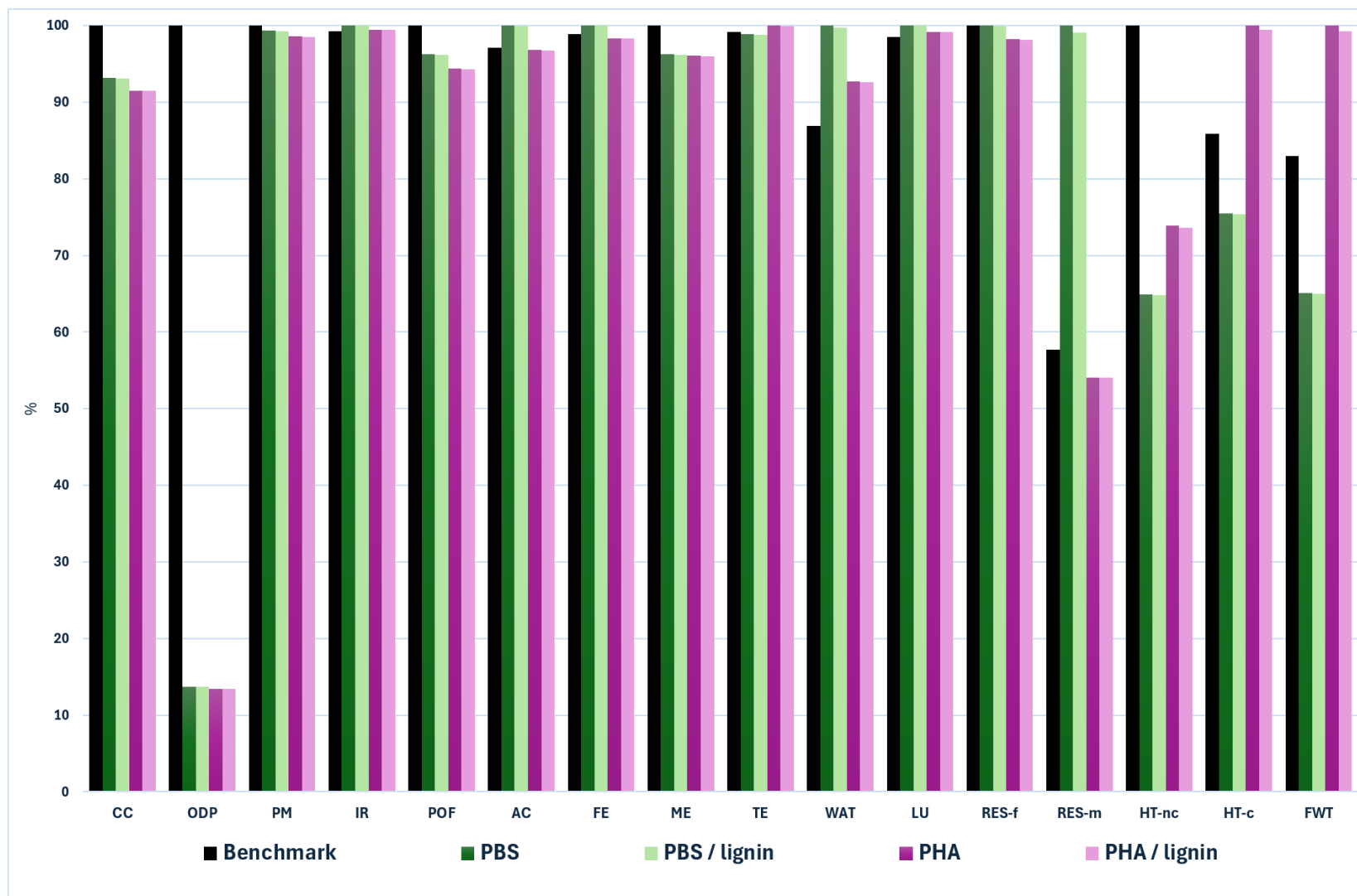
Same trends are observed for PBS



BIO-SUSHY: Food tray case study

Comparison of the full life cycles

PHA is less impactant than PBS on most of the impact categories.



BIO-SUSHY: Food tray case study

1st SSbD scoring

The **biopolymer model** developed based on the **literature**, which relies on lab-scale experiments, involves **uncertainties**.

→ It is **difficult to suggest ways to improve results**, because the problem stems from the model itself (industrial data would be needed, but the relevant stakeholders are very reluctant to provide it).

Position to reference	Score	Colour code	
No improvement	0		Fail the criteria
Improvement + 5%	1		
Improvement + 5% to 20%	2		Pass the criteria
Improvement + 20% to 40%	3		
Improvement > 40%	4		

LCA Assessment level (max score)	Aspect	PBS / lignin	PBS	PHA / lignin	PHA
Toxicity ES 1 (max 12)	HT, NC				
	HT, C				
	Ecotoxicity				
Climate Change ES 2 (max 4)	Climate Change				
Pollution ES 3 (max 32)	Ozone Depletion				
	Particulate matter/ Respiratory inorganics				
	Ionisation radiation, human health				
	Photochemical ozone formation				
	Acidification				
	Eutrophication, terrestrial				
	Eutrophication, aquatic freshwater				
	Eutrophication, aquatic marine				
Resources ES 4 (max 16)	Land use				
	Water use				
	Resource use, minerals and metals				
	Resource use, energy carriers				

BIO-SUSHY: Food tray case study

1st SSbD scoring

Change of the scoring system to take into account the uncertainties.

Position to reference	Score	Color code	
-10% <	0		Fail the criteria
No improvement -5 to -10%	1		
No improvement -5 to improvement 5%	2		Pass the criteria
Improvement + 5% to 20%	3		
Improvement > 20%	4		

LCA Assessment level (max score)	Aspect	PBS / lignin	PBS	PHA / lignin	PHA
Toxicity ES 1 (max 12)	HT, NC				
	HT, C				
	Ecotoxicity				
Climate Change ES 2 (max 4)	Climate Change				
Pollution ES 3 (max 32)	Ozone Depletion				
	Particulate matter/ Respiratory inorganics				
	Ionisation radiation, human health				
	Photochemical ozone formation				
	Acidification				
	Eutrophication, terrestrial				
	Eutrophication, aquatic freshwater				
	Eutrophication, aquatic marine				
Resources ES 4 (max 16)	Land use				
	Water use				
	Resource use, minerals and metals				
	Resource use, energy carriers				



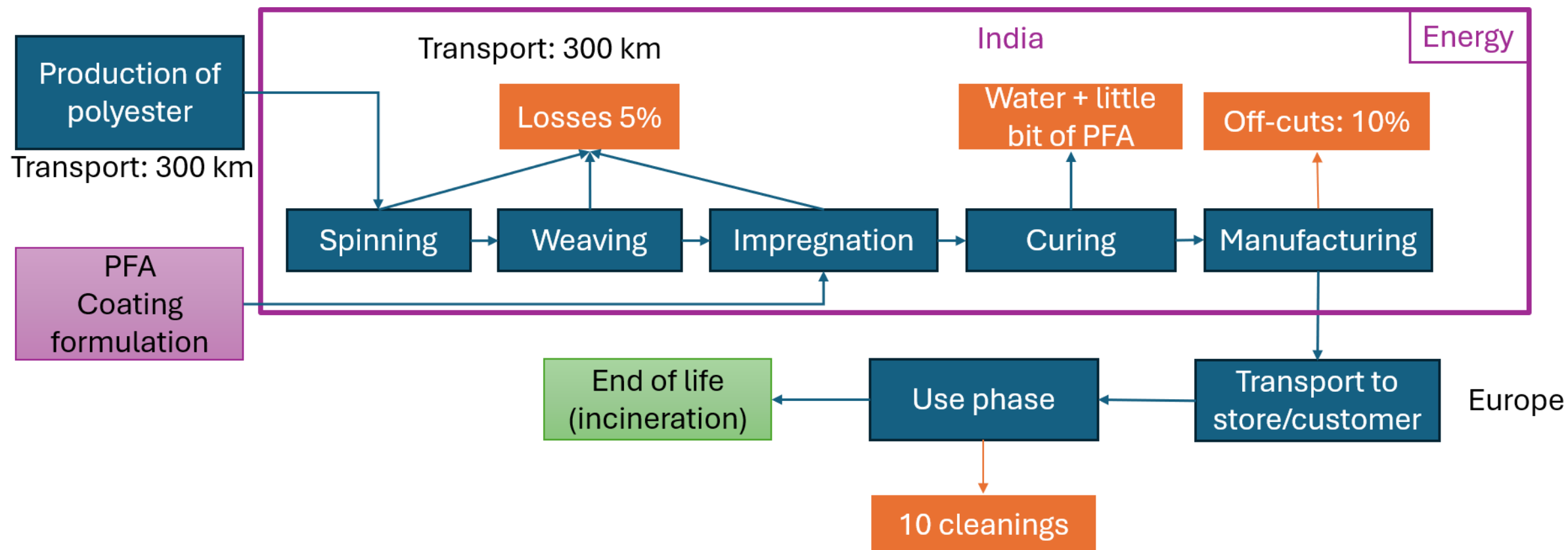
BIO-SUSHY

TEXTILE



BIO-SUSHY: Textile case study

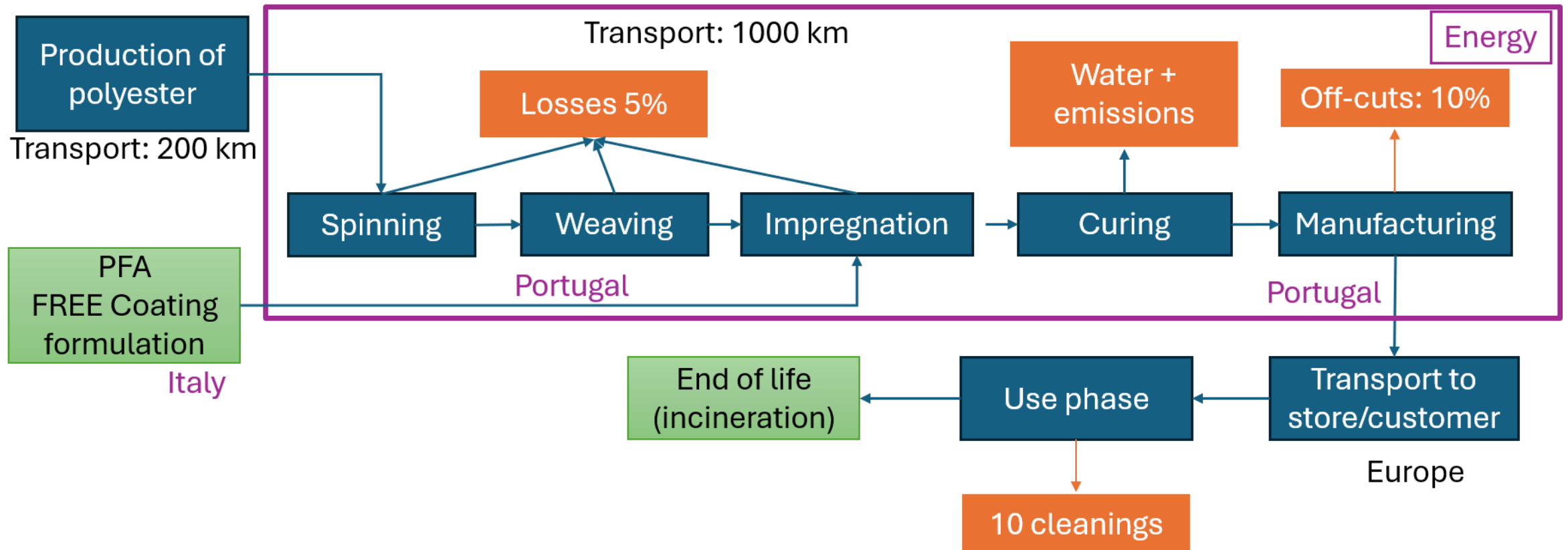
Definition of the benchmark full life cycle



BIO-SUSHY: Textile case study

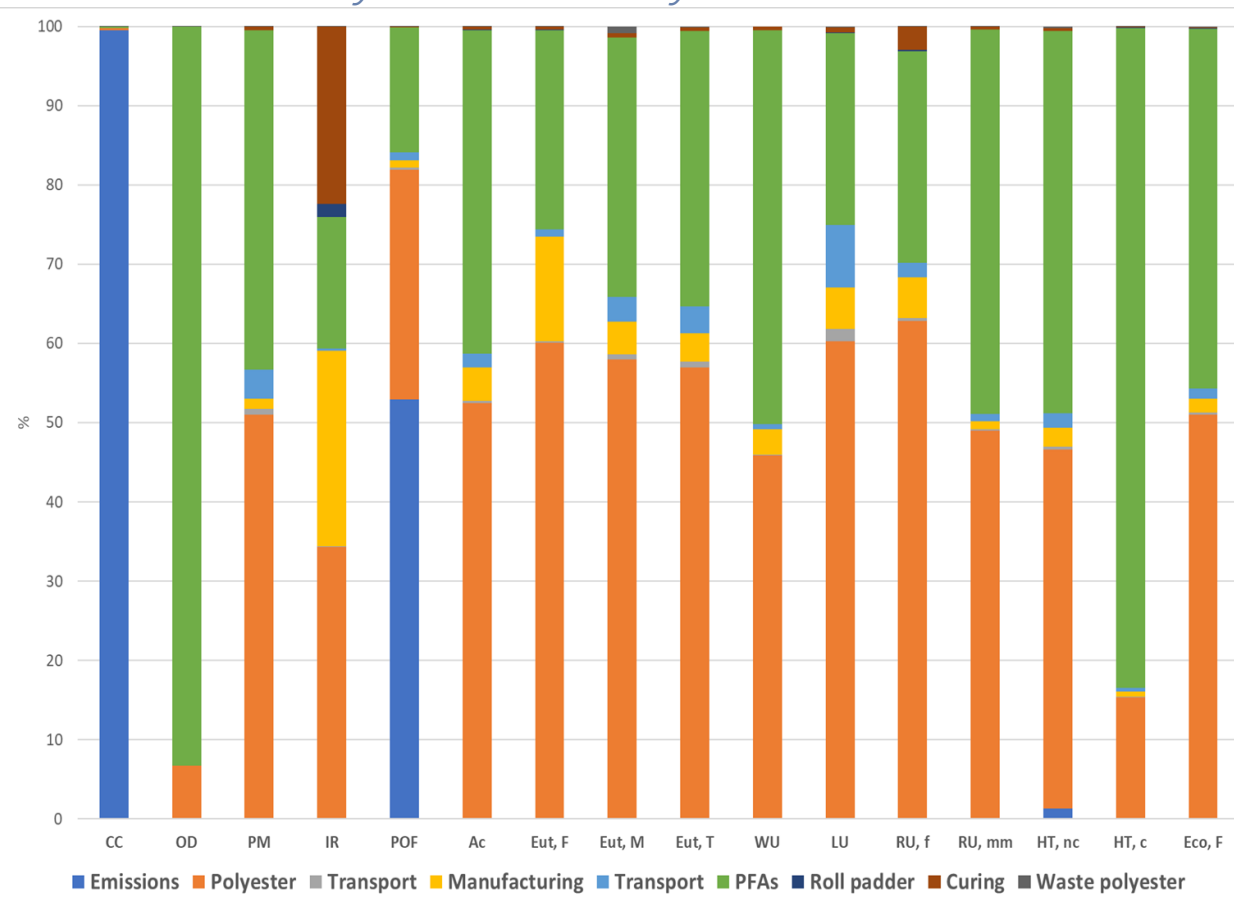
Definition of the BIO-SUSHY full life cycle

Two scenarios: Europe or Worldwide



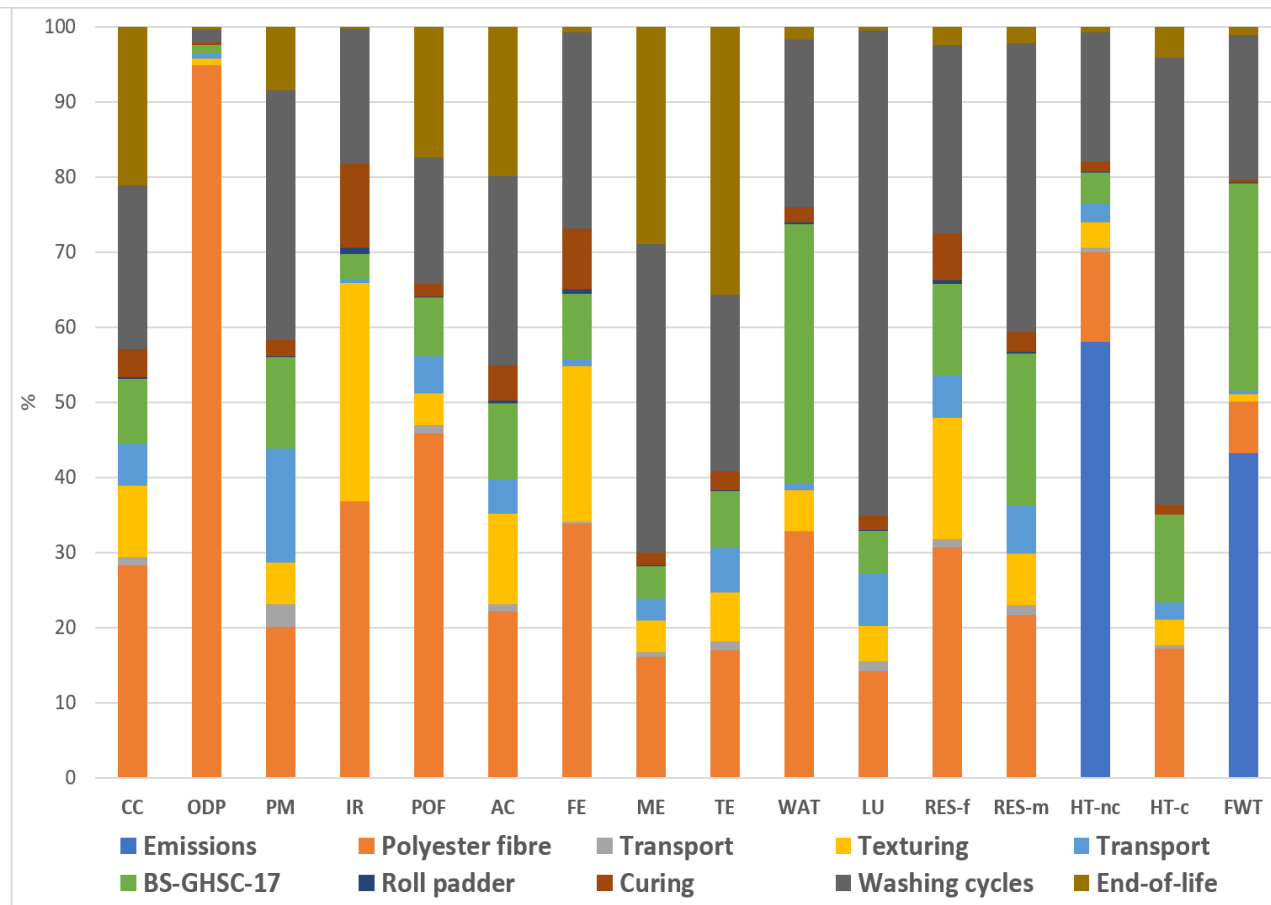
BIO-SUSHY: Textile case study

Contribution analysis of the full life cycles



Evaluation of benchmark full life cycle:

Main contributors: Polyester, Emissions during washing step (on CC and POF), PFAs



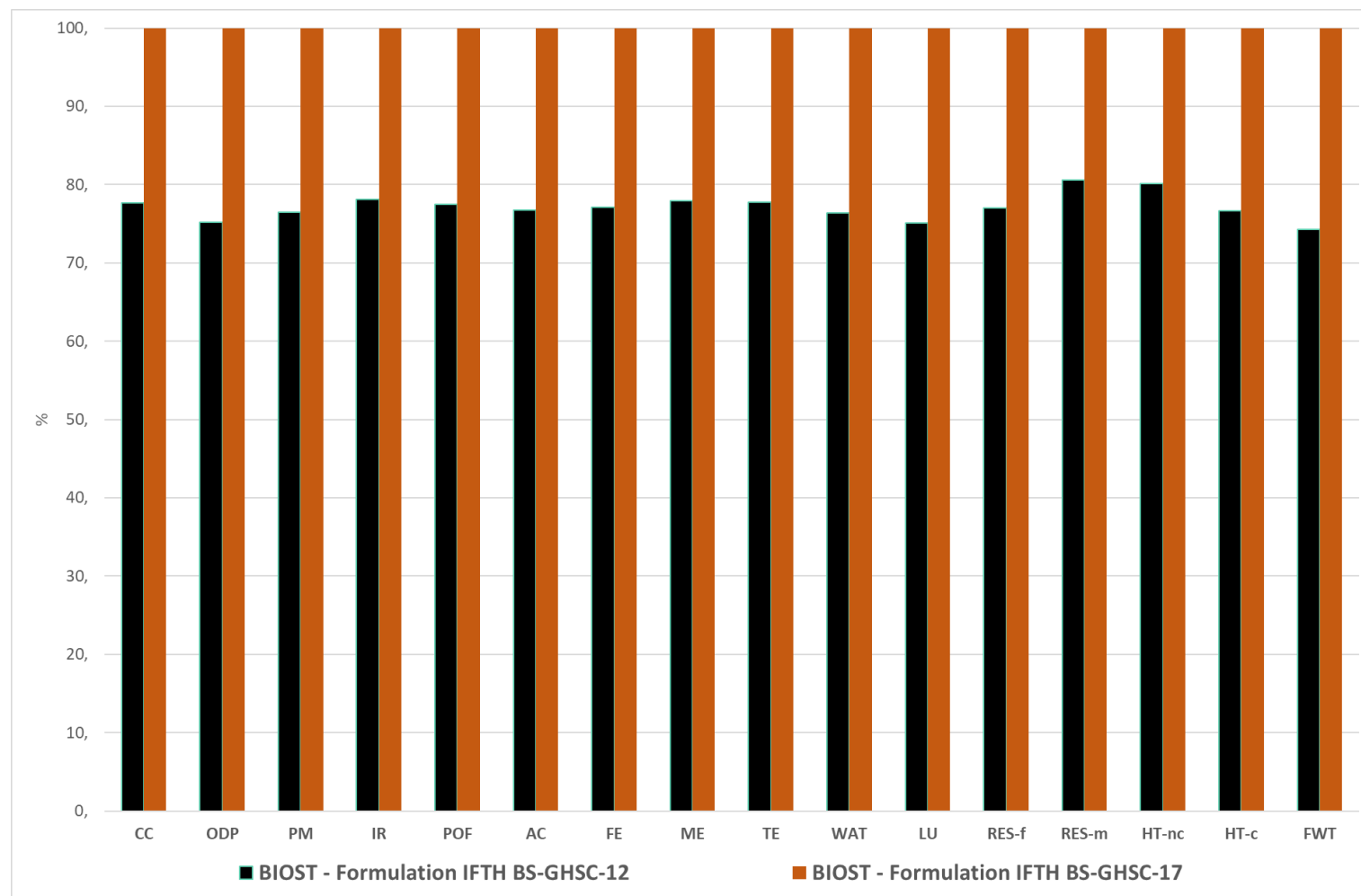
Evaluation of BIO-SUSHY full life cycle:

Main contributors: Polyester, emissions (on HT,nc and FWT), washing cycles

BIO-SUSHY: Textile case study

Comparison of the formulations

Formulation 17 has the highest impacts when considering the formulation only.

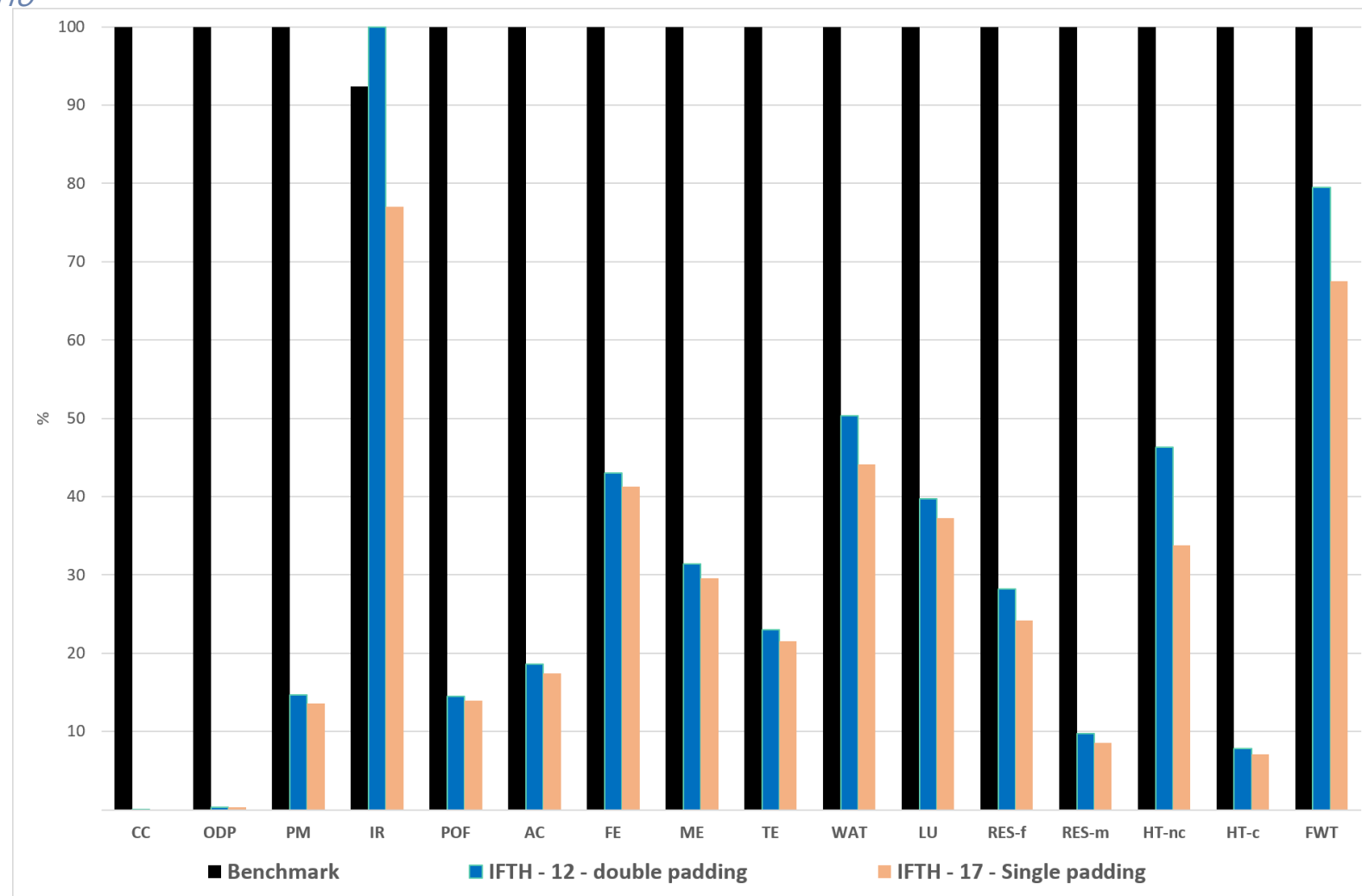


BIO-SUSHY: Textile case study

Comparison of the full life cycles - European scenario

Formulation 17 has the lowest life-cycle impacts in all impact categories.

Formulation 12 performs well over the entire life cycle compared to the reference, except for IR.



BIO-SUSHY: Textile case study

SSbD scoring

Position to reference	Score	Colour code	
No improvement	0		Fail the criteria
Improvement + 5%	1		
Improvement + 5% to 20%	2		Pass the criteria
Improvement + 20% to 40%	3		
Improvement > 40%	4		

LCA Assessment Level (max score)	Aspect	IFTH 12 - double		IFTH - 17 single	
		Scoring	Level	Scoring	Level
Toxicity	Human Toxicity, cancer		✓		✓
	Human Toxicity, non cancer				
	Ecotoxicity				
Climate Change	Climate Change		✓		✓
Pollution	Ozone Depletion		✗		✓
	Particulate Matter				
	Ionising Radiation				
	Photochemical Ozone Formation				
	Acidification				
	Eutrophication, terrestrial				
	Eutrophication, aquatic freshwater				
Resources	Eutrophication, aquatic marine				
	Land Use		✓		✓
	Water Use				
	Resource use, minerals and metals				
	Resource use, energy carriers				

Only the formulation 17 is passing all the criteria in the European scenario.

For Indian scenario, also a problem on the Ecotoxicity impact category



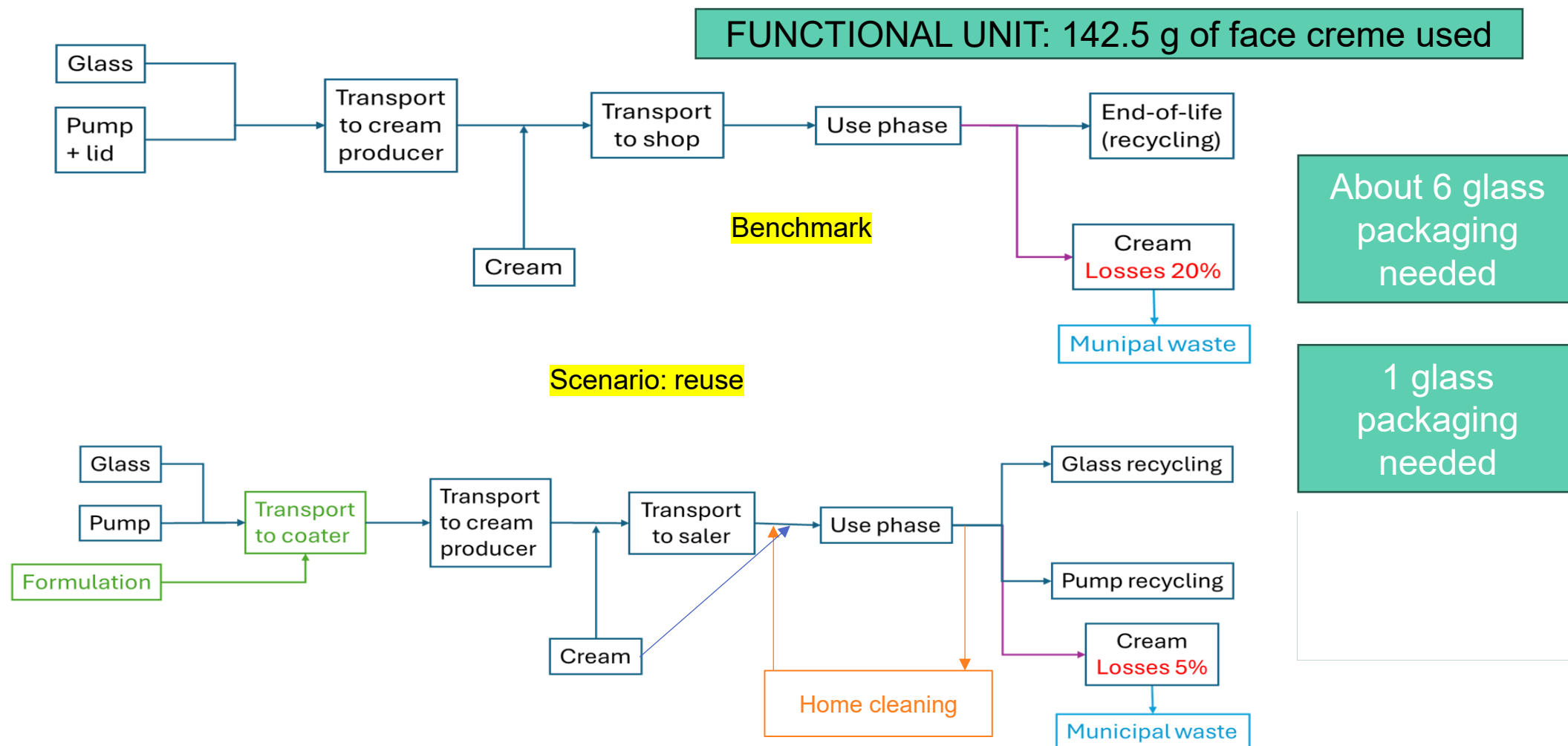
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GLASS PACKAGING



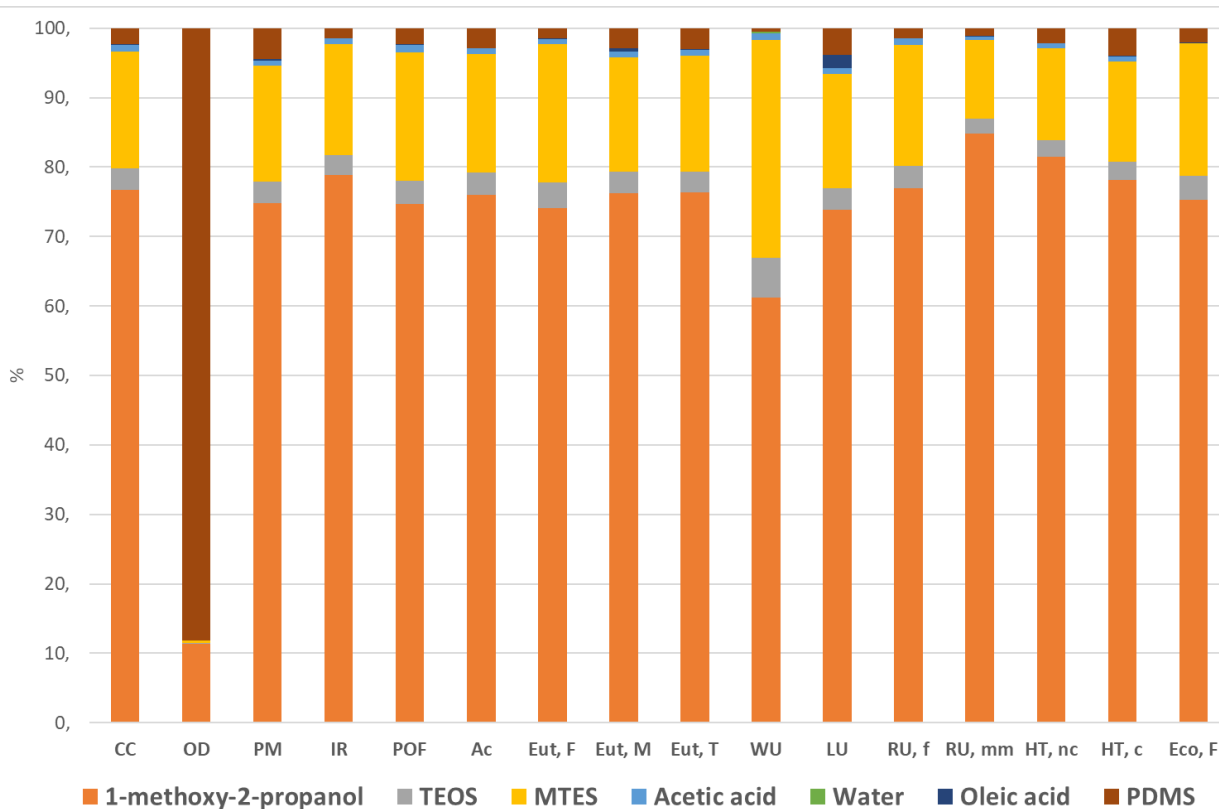
BIO-SUSHY: Glass packaging case study

Definition of the benchmark's full life cycle vs single use and reuse scenarios

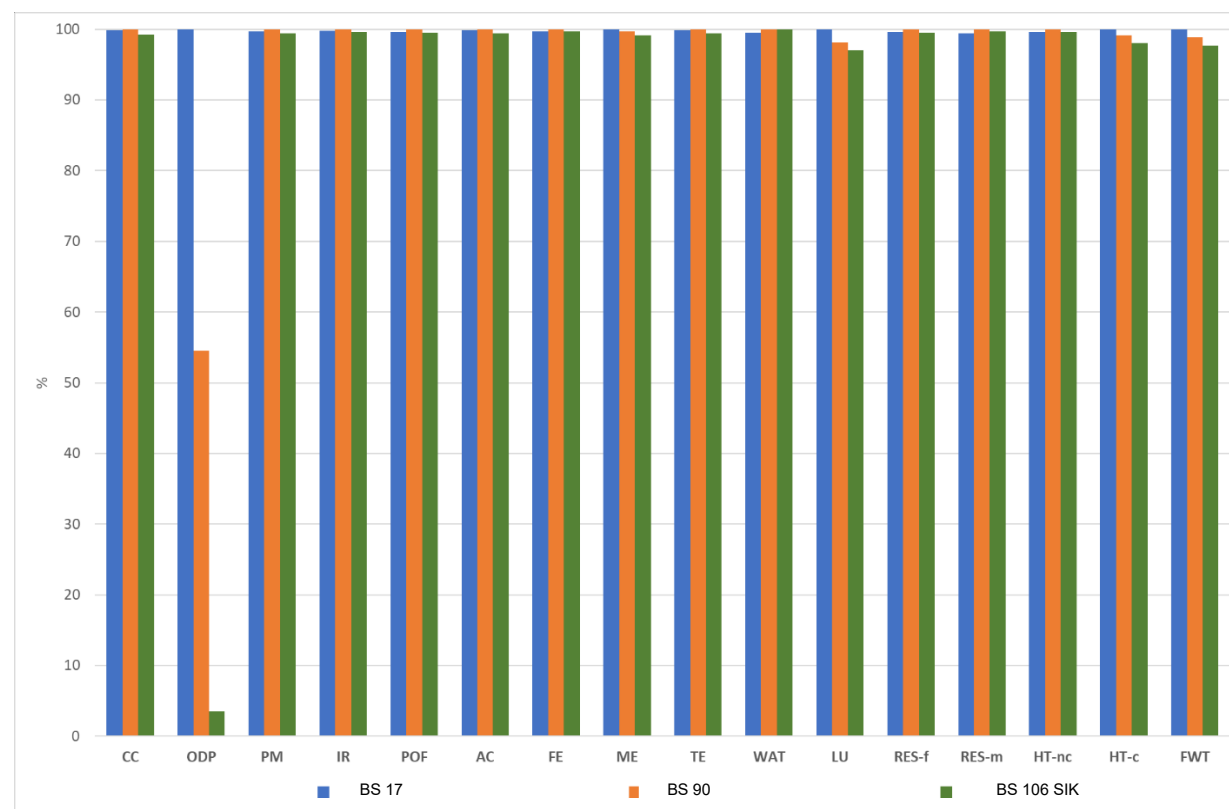


BIO-SUSHY: Glass packaging case study

1st evaluation of formulation, and use of SSbD to redesign



PDMS was identified as impactant during the 1st LCA evaluation (BS17) on OD.



Several formulations (to keep good properties) were tested :
 → BS90 (containing PDMS but in a lower quantity)
 → BS106 SIK for which the PDMS is replaced by a cellulosic compound.

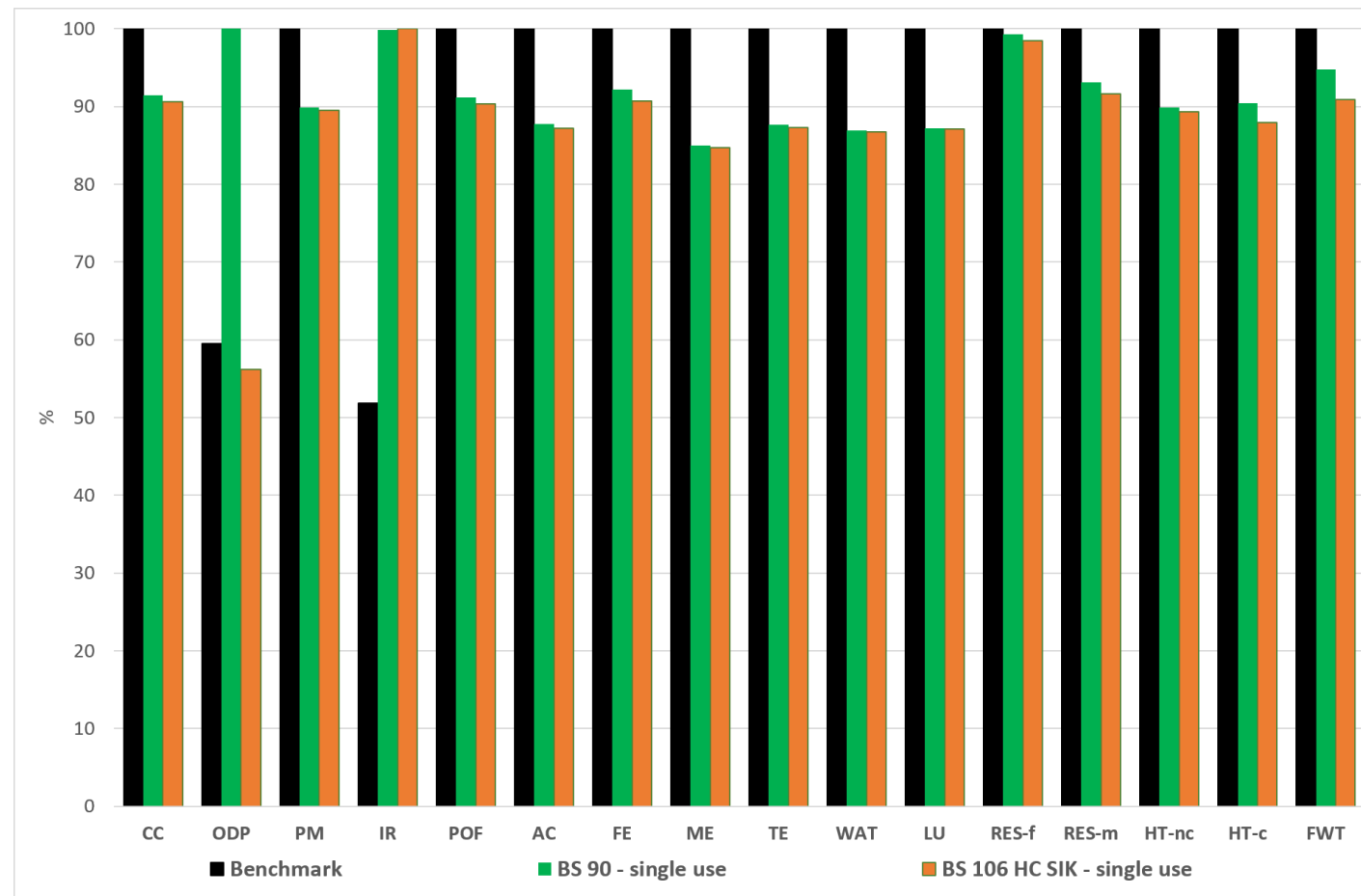
BIO-SUSHY: Glass packaging case study

Comparison of single use scenarios (full life cycle)

BIO-SUSHY coatings outperform the benchmark for the **single use**, particularly the BS106 SIK, except on IR due to the energy consumption required for the process

Position to reference	Score	Colour code	
No improvement	0		Fail the criteria
Improvement + 5%	1		
Improvement + 5% to 20%	2		Pass the criteria
Improvement + 20% to 40%	3		
Improvement > 40%	4		

LCA Assessment Level (max score)	Aspect	BS 90	BS 106 HC SIK
Toxicity	Human Toxicity, cancer		
	Human Toxicity, non cancer		
	Ecotoxicity		
Climate Change	Climate Change		
Pollution	Ozone Depletion		
	Particulate Matter		
	Ionising Radiation		
	Photochemical Ozone Formation		
	Acidification		
	Eutrophication, terrestrial		
	Eutrophication, aquatic freshwater		
	Eutrophication, aquatic marine		
Resources	Land Use		
	Water Use		
	Resource use, minerals and metals		
	Resource use, energy carriers		



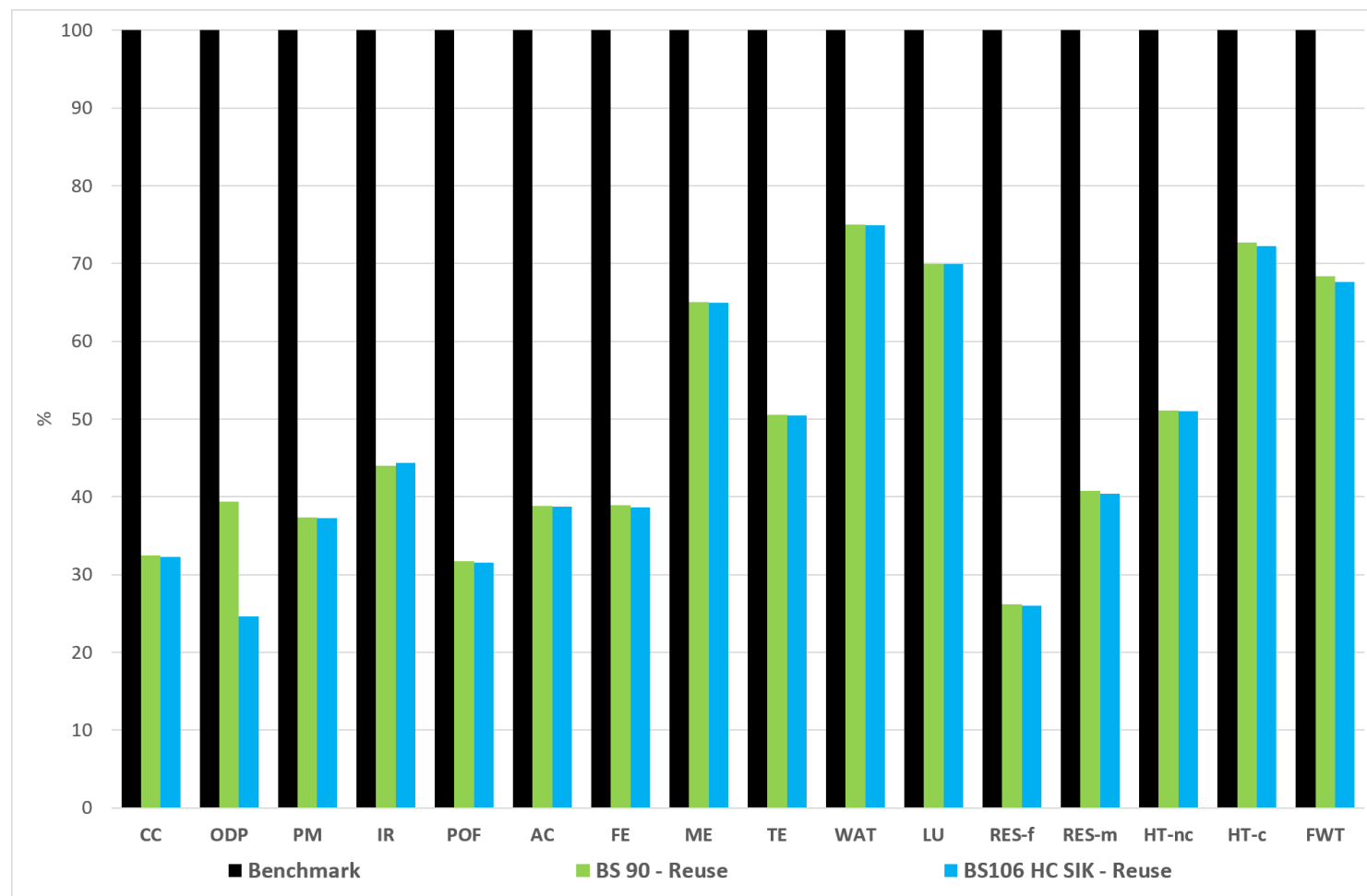
BIO-SUSHY: Glass packaging case study

Comparison of the reuse scenarios

Position to reference	Score	Colour code	
No improvement	0		Fail the criteria
Improvement + 5%	1		
Improvement + 5% to 20%	2		Pass the criteria
Improvement + 20% to 40%	3		
Improvement > 40%	4		

Same trends but here all the impact categories are passing the SSbD criteria.

LCA Assessment Level (max score)	Aspect	BS 90	BS 106 HC SIK
Toxicity	Human Toxicity, cancer		
	Human Toxicity, non cancer		
	Ecotoxicity		
Climate Change	Climate Change		
Pollution	Ozone Depletion		
	Particulate Matter		
	Ionising Radiation		
	Photochemical Ozone Formation		
	Acidification		
	Eutrophication, terrestrial		
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	Water Use		
	Resource use, minerals and metals		
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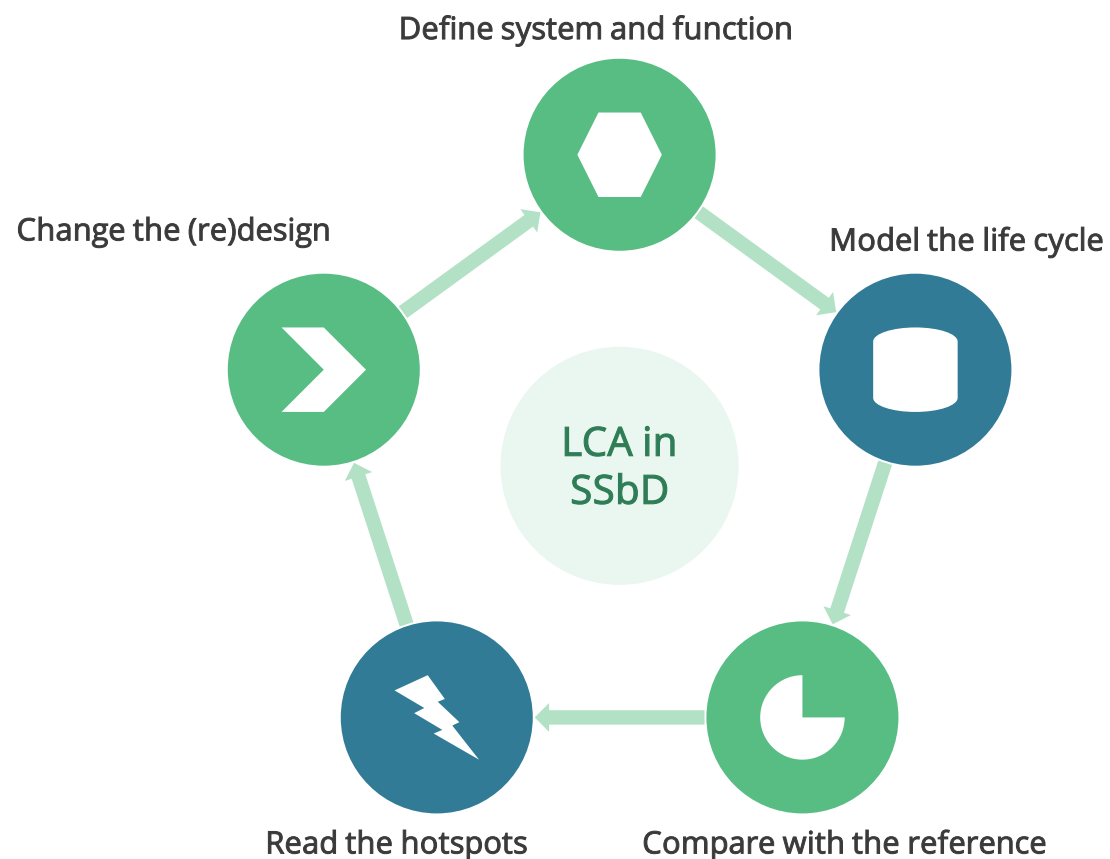


Key takeaways



The whole thing is a loop

Five moves, repeated at every iteration of the innovation



- 1 **Same function, same boundaries**
as the safety and socio-economic parts of the SSbD assessment.
- 2 **At the tier you can afford**
screening, simplified, intermediate or full.
- 3 **Against a reference**
proxy, benchmark, representative system, or a target.
- 4 **Sixteen categories, kept apart**
with their class of performance and their uncertainty.
- 5 **And back to the scoping**
the next iteration starts from what you just learned.

The four SSbD principles

The backbone of the framework, everything else serves these

Assess the entire SSbD system

Chemicals and materials, the processes that make them and the products they end up in, together with their life cycles. Never a substance in isolation.

Iterative and tiered throughout the innovation

SSbD is applied at each iteration to the level of detail the available data allow, and deepened as the innovation matures.

Iterative: at each loop SSbD is applied to the level of detail the data allow. It is not static: it evolves with new information on hazards and uses.

Engage the actors along the life cycle

Suppliers, manufacturers, downstream users, waste operators and in-house experts from several disciplines. Most of the information needed is not held by one actor.

Transparency and traceability

Every assumption, method and decision is documented, so the fulfilment of the principles can be traced across iterations.

Tiered: uncertainty is reduced gradually: each iteration identifies the information still missing and generates or collects the data to close the gap.

Agenda

10:00 Opening Remarks and Introduction

- Welcome, housekeeping & BIO-SUSHY project intro.
- Goal of the training and overview. (10-15 min)



10:15 Common Misconceptions

- Interactive poll and key concept clarifications. (10 min)



10:25 Module 1: LCA Fundamentals

- ISO framework, four LCA phases & system boundaries. (35 min)



11:00 Module 2: LCA in BIO-SUSHY & SSbD

- Integration of LCA into SSbD & environmental hotspots. (35 min)



11:35 From LCA Results to Decision Making

- Summary of insights and open Q&A session. (15 min)



11:50 Wrap-up & Next Steps

- Summary of key takeaways.
- Closing remarks and acknowledgment. (10 min)





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THANK YOU!