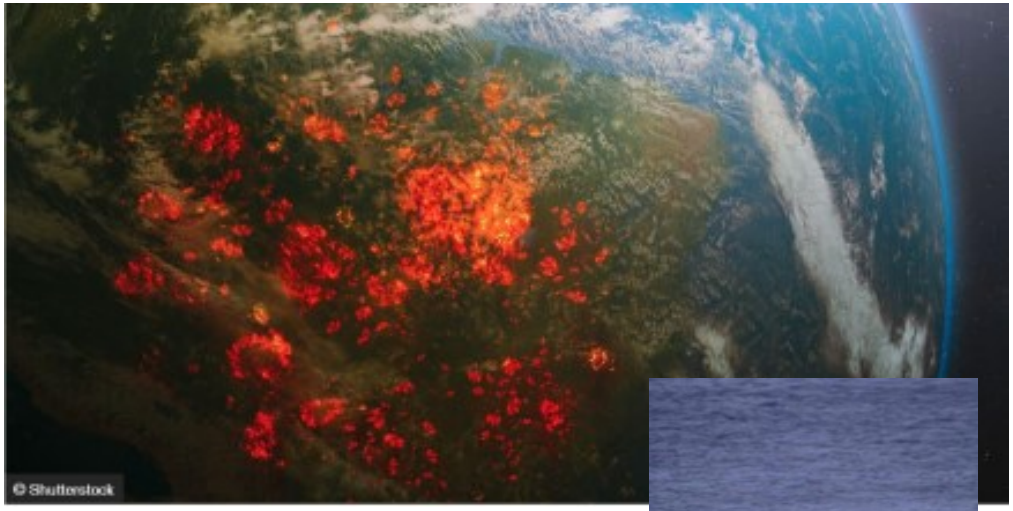
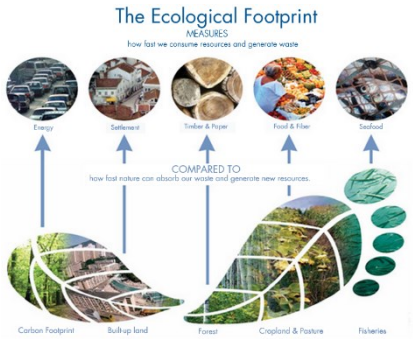
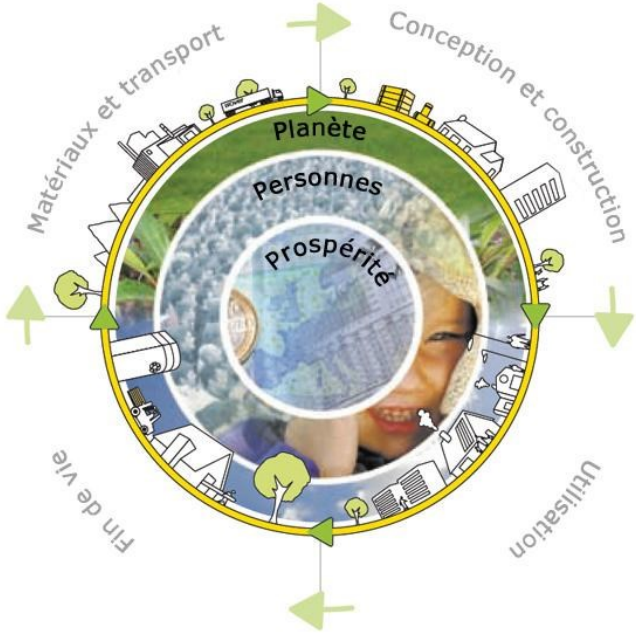
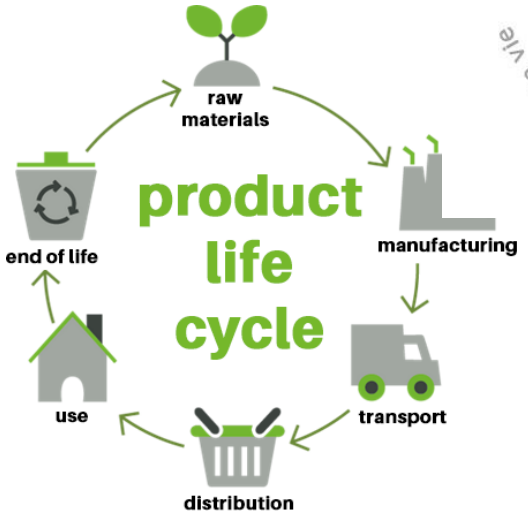


ECOLOGICAL FOOTPRINT







EPD®

ENVIRONMENTAL PRODUCT DECLARATION

Life Cycle Assessment, an environmental and scientific compass for objective evaluation & communication

Dr Ir Sylvie GROSLAMBERT

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LIÈGE université
Chemical Engineering

PEPs
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Agenda

- Context
- What is Life cycle assessment (LCA)?
- How to make an LCA?
  + example
- Environmental communication
- Conclusion

Agenda

- Context
- What is Life cycle assessment (LCA)?
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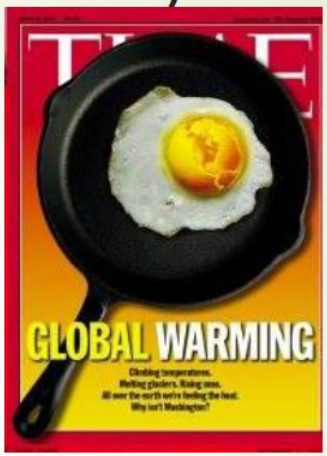
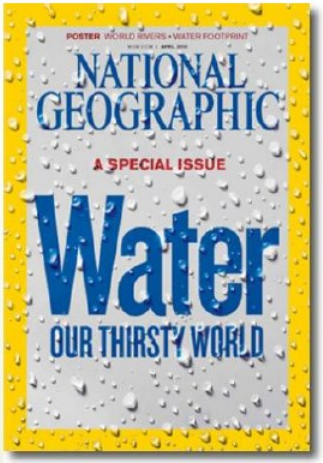
Context

Major global challenges of today





Source = S. Valdivia

"Sustainable development" concept

- 1987 – United Nations World Commission on Environment and Development (Montreal) - "Brundtland report"
- 2015 : UN summit (USA)

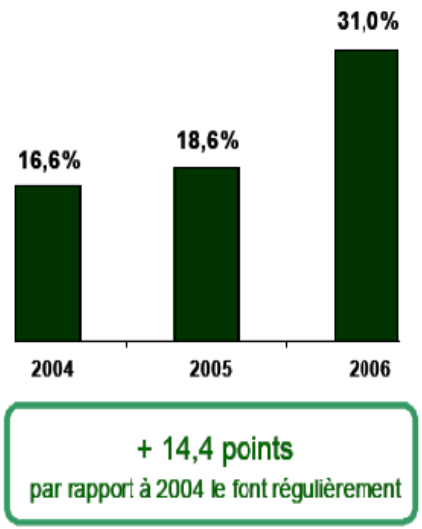
https://macaulay.cuny.edu/eportfolios/akurry/2011/12/21/sustainable-development/

https://cifal-flanders.org/focus/sustainable-development-goals/

Context

- Environmental considerations ➡ essential!
- Increasing demand from consumers

« I choose environmental-friendly products »



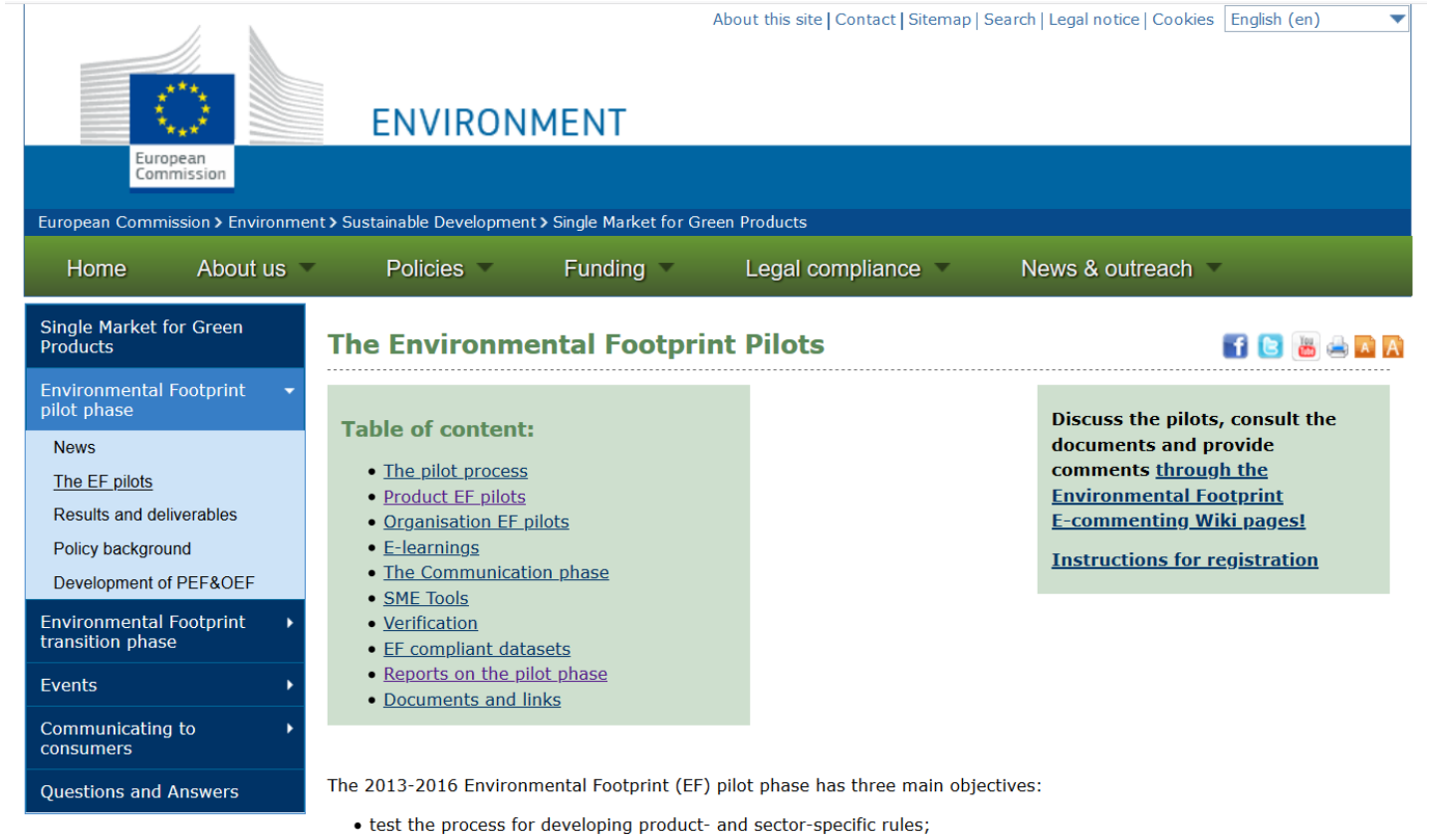
31% of consumers would like to buy a product depending on the environmental performance

16,6% 2 years before (2004)

Source : ADEME / ETHICITY

Context

- Environmental considerations ➡ essential!
- Political focus

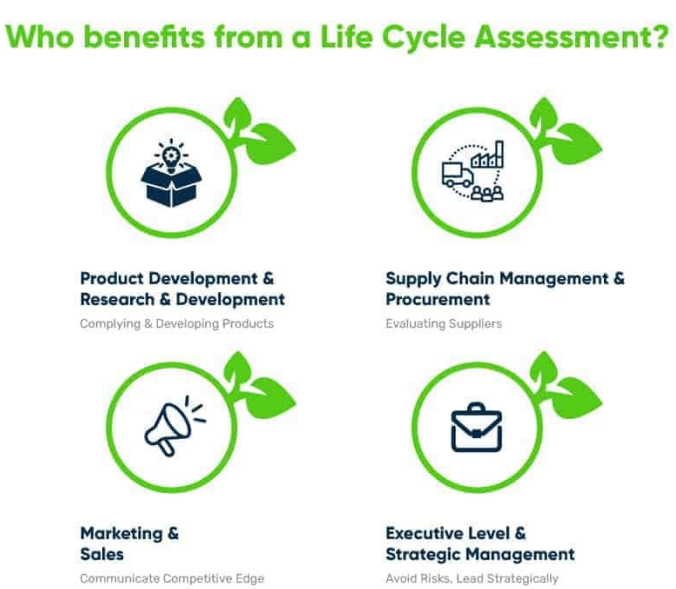


Environmental management

- Environmental considerations ➡ essential!
  - Companies, public services, ...
  - Research programmes

Interreg Europe
European Union | European Regional Development Fund

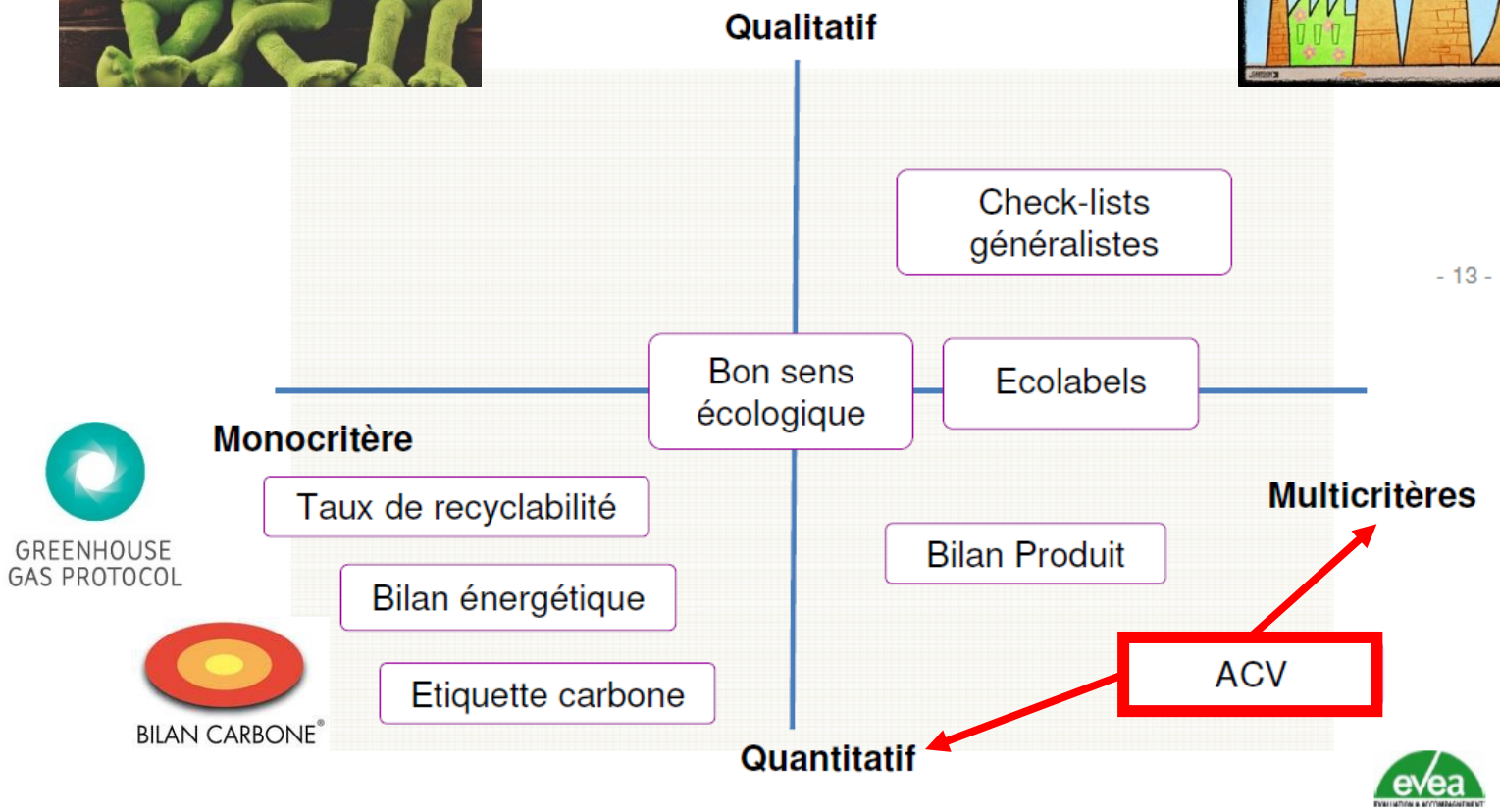
BBI JU



GREEN WIN FROM INNOVATION TO BUSINESS

➡ Objective characterisation tool!

Objectivising environmental impact



Eco-Conception : Principes et outils, J.-B. Puyou, 5ème rencontres des Eco-industries, Niort, 25-26 novembre 2009.

Agenda

- Context
- What is Life cycle assessment (LCA)?
- How to make an LCA?
  + example
- Environmental communication
- Conclusion

History

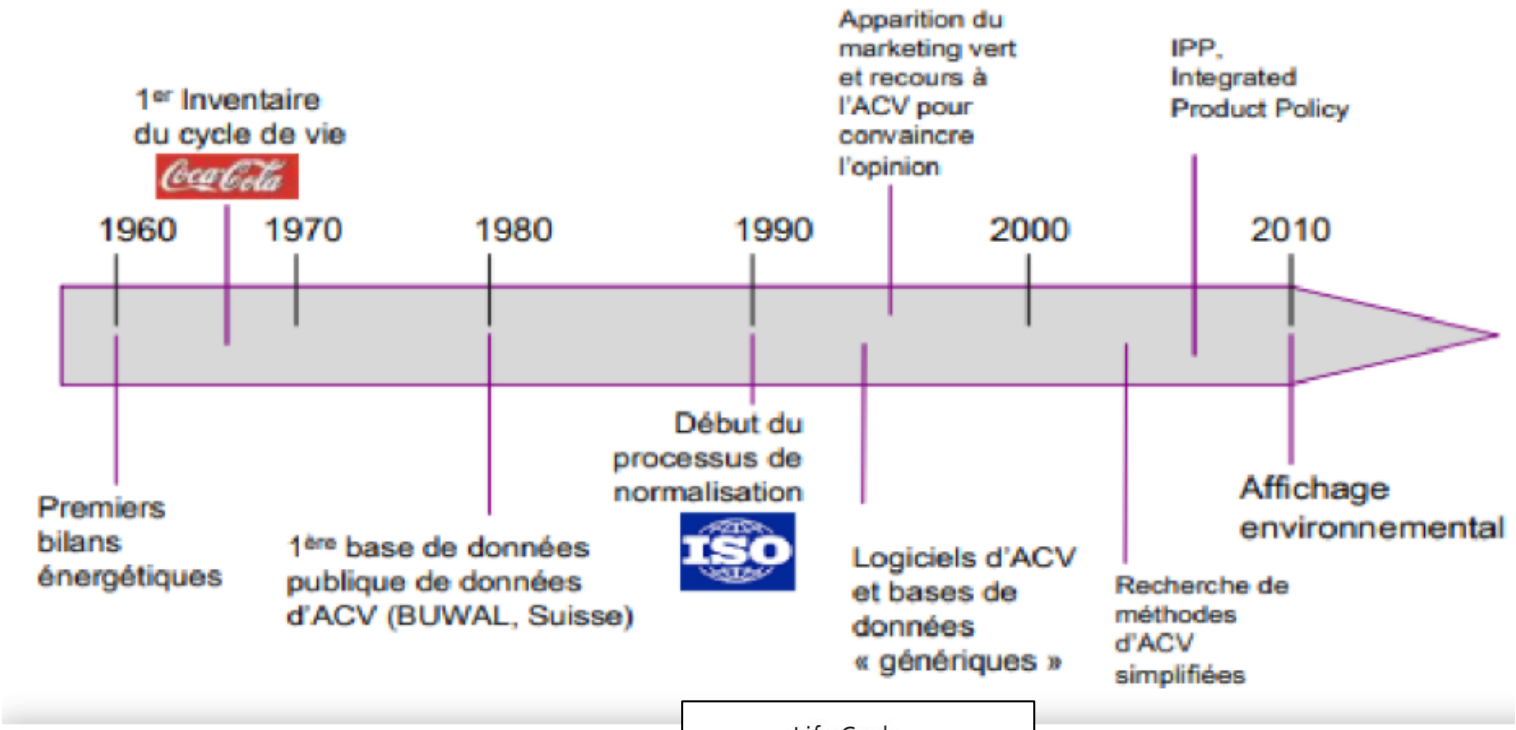


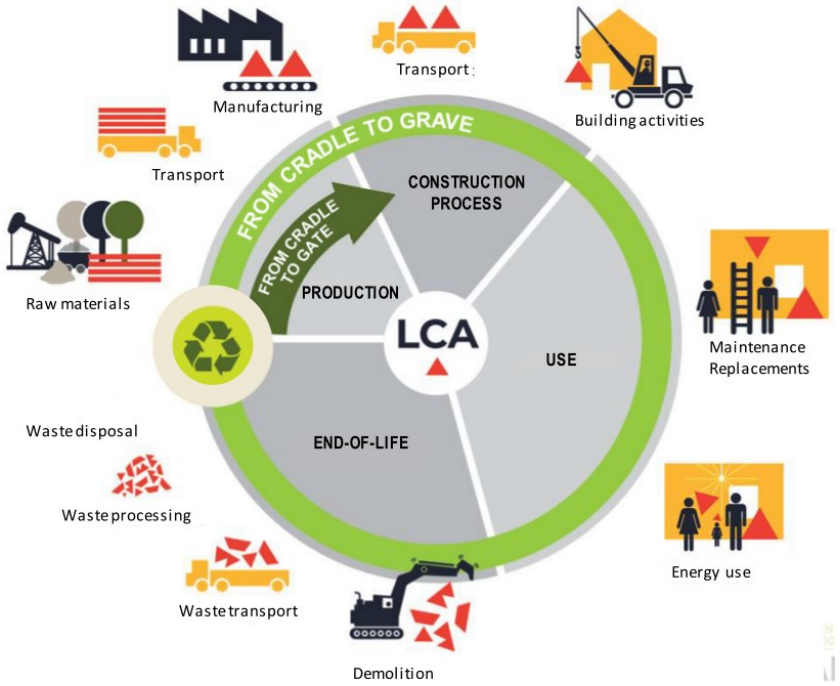
Figure 1 : Historique de de l'ACV(Merad et Guillet, 2014)

UNEP (PNUE) = United Nations Environment Programme
Programme des Nations Unies pour l'Environnement au service du développement
SETAC = The Society of Environmental Toxicology and Chemistry

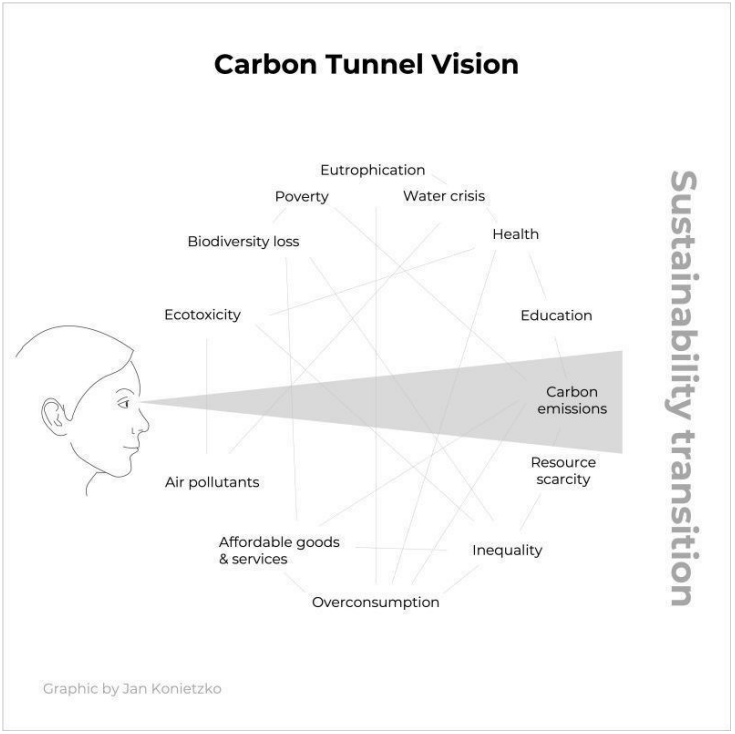
Life cycle assessment (LCA)

Life cycle assessment – ISO 14040/44:2006

- environmental aspects & potential **environmental impacts**
- throughout a **product life cycle**



Carbon footprint ↔ LCA



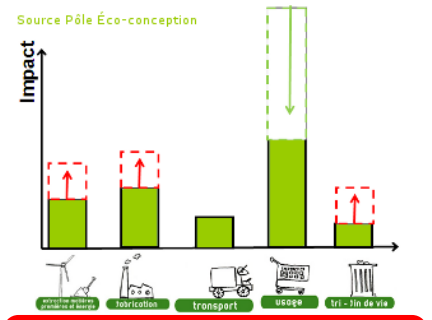


Illustration du transfert d'impact d'une étape du cycle de vie à d'autres étapes.

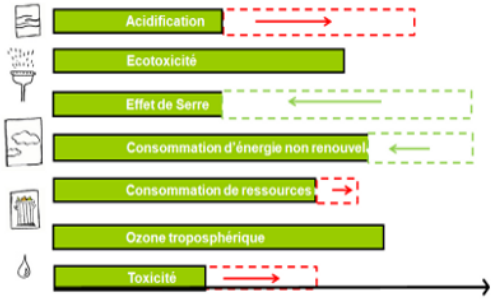


Illustration du transfert d'impacts à d'autres impacts environnementaux

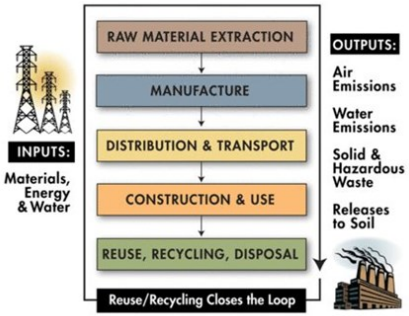
What is LCA?

1. Goal & Scope

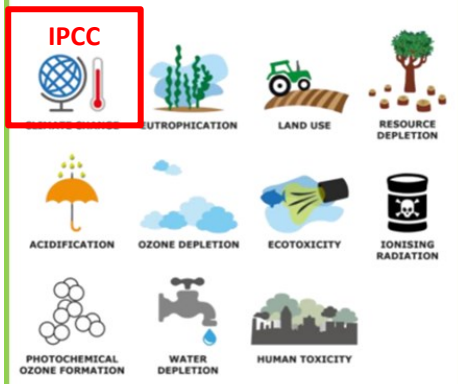
2. Inventory

Primary data ↔ Partners Database(s)

ecoinvent



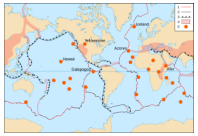
3. Impact Assessment



Method

4. Interprétation

Identification



Verification

Explanation

Conclusions & Recommandations

SimaPro

GaBi Software PRODUCT SUSTAINABILITY

openLCA

https://ecochain.com/knowledge/life-cycle-assessment-lca-guide/
https://www.researchgate.net/figure/Stages-of-products-life-cycle-4_fig1_312073799

Different levels of details for LCA

- **Life cycle thinking = qualitative discussion**
  - Answers with no number
  - Quick study to identify important steps

- **Simplified LCA**
  - Study based on the global life cycle but using generic data for some points (example: generic data for transport or energy)
  - Environmental impacts quantification

Different levels of details for LCA

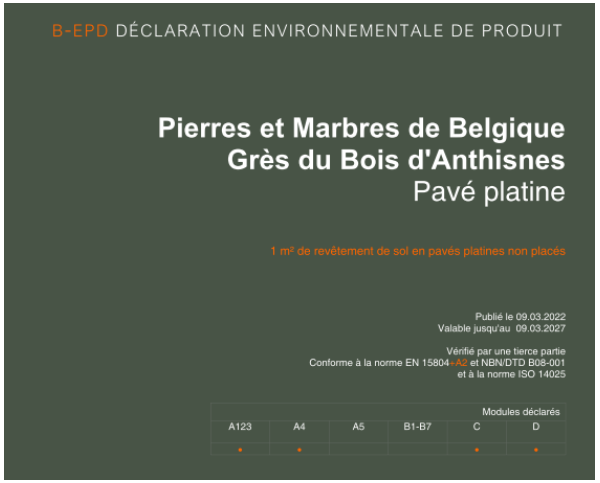
- **Detailed LCA**
  - Detailed inventory and specific data use
  - Iterative definition of the scope
  - Consideration of all important impacts
  - Full and long study

Life Cycle Assessment: why?

Internal	**Strategy** • Identification of potential environmental impacts due to a product • Investment decision support	**R & D products/processes** • Early identification of problems/opportunities • Help in project choice • Help in objectives definition
External	**Marketing** • Product or service comparative assessment • Promotion of the most eco-efficient solutions (impacts on environment + costs)	**Policy** • Better information to leaders, authorities, consumers, etc. (regulation/ecolabel/…) • Comparative assessments

Objectives of an LCA

- **Diagnostic**: what is
  - Picture of environmental impacts
  - ⇒ Environmental communication
- **Ecodesign**: what will be
  - New product (from scratch)
  - Improvement


B-EPD DÉCLARATION ENVIRONNEMENTALE DE PRODUIT

Pierres et Marbres de Belgique
Grès du Bois d'Anthisnes
Pavé platine

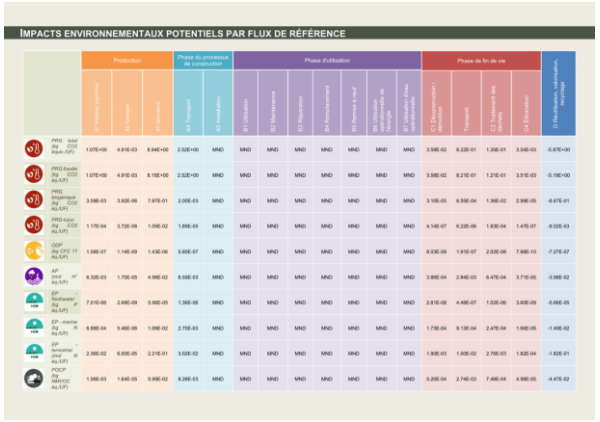
1 m² de revêtement de sol en pavés platines non placés

Publié le 09.03.2022
Valable jusqu'au 09.03.2027

Vérifié par une tierce partie
Conforme à la norme EN 15804+A2 et NBN/DTD B08-001
et à la norme ISO 14025

Modules déclarés

A123	A4	A5	B1-B7	C	D
•	•			•	•



- Identify the areas where environmental impacts are most significant
  - human health, climate change, etc.
- Rank the life cycle stages according to their environmental impact
- Identify the "guilty parties"

Life Cycle Assessment: limits

- LCA = decision **support** tool

  ≠ decision tool

  - LCA: environmental impacts only
  - Other aspects: economic (→ LCC), social (→ SLCA), operational, ...
  - The results depend on the model and input data

➡ Need for **transparency** of studies (inventories, models, hypotheses, ...)

- to understand the results
- to compare studies

- Validation by an objective external viewpoint
  → critical review (by experts)

Agenda

- Context
- What is Life cycle assessment (LCA)?
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  + example
- Environmental communication
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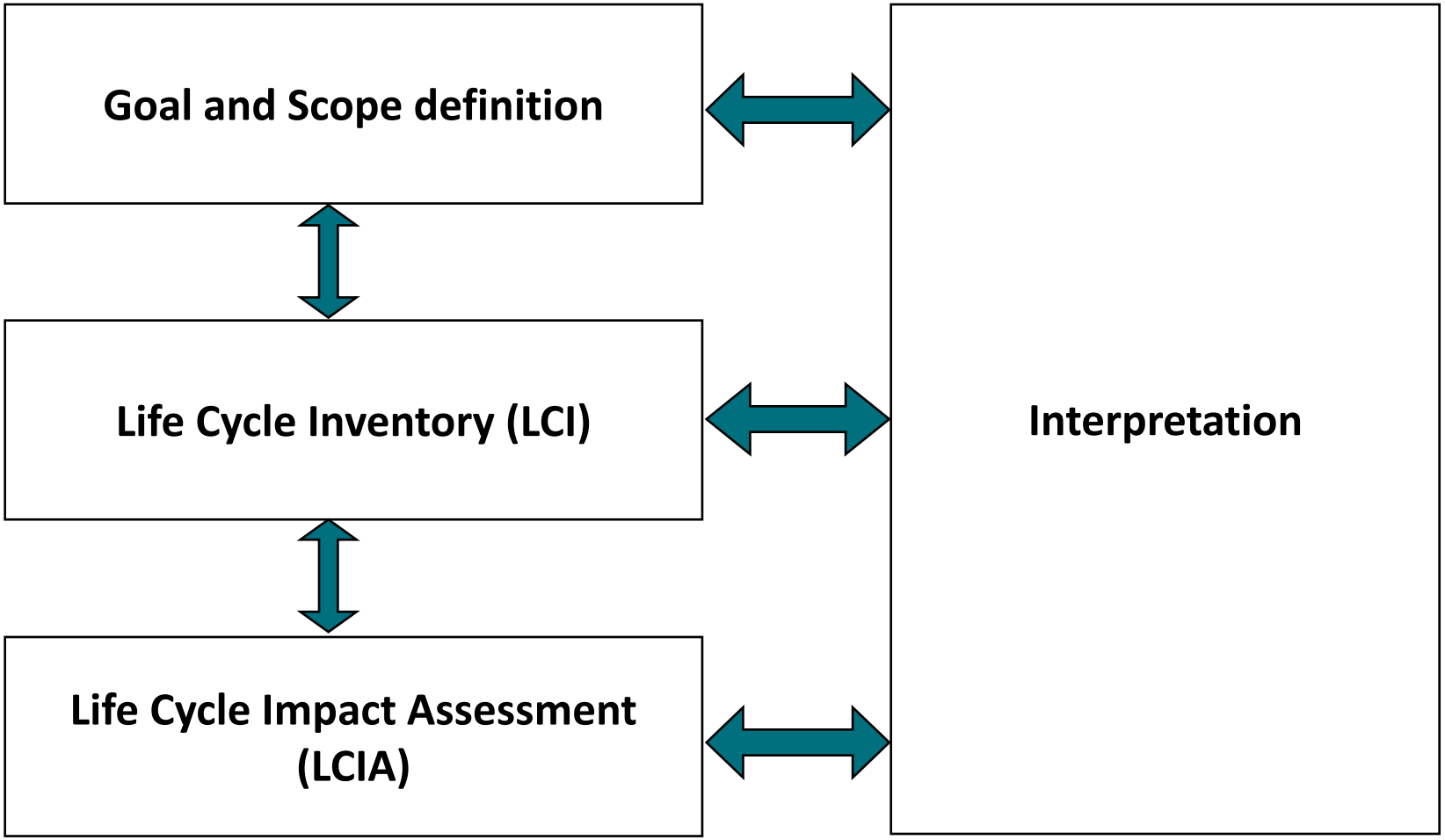
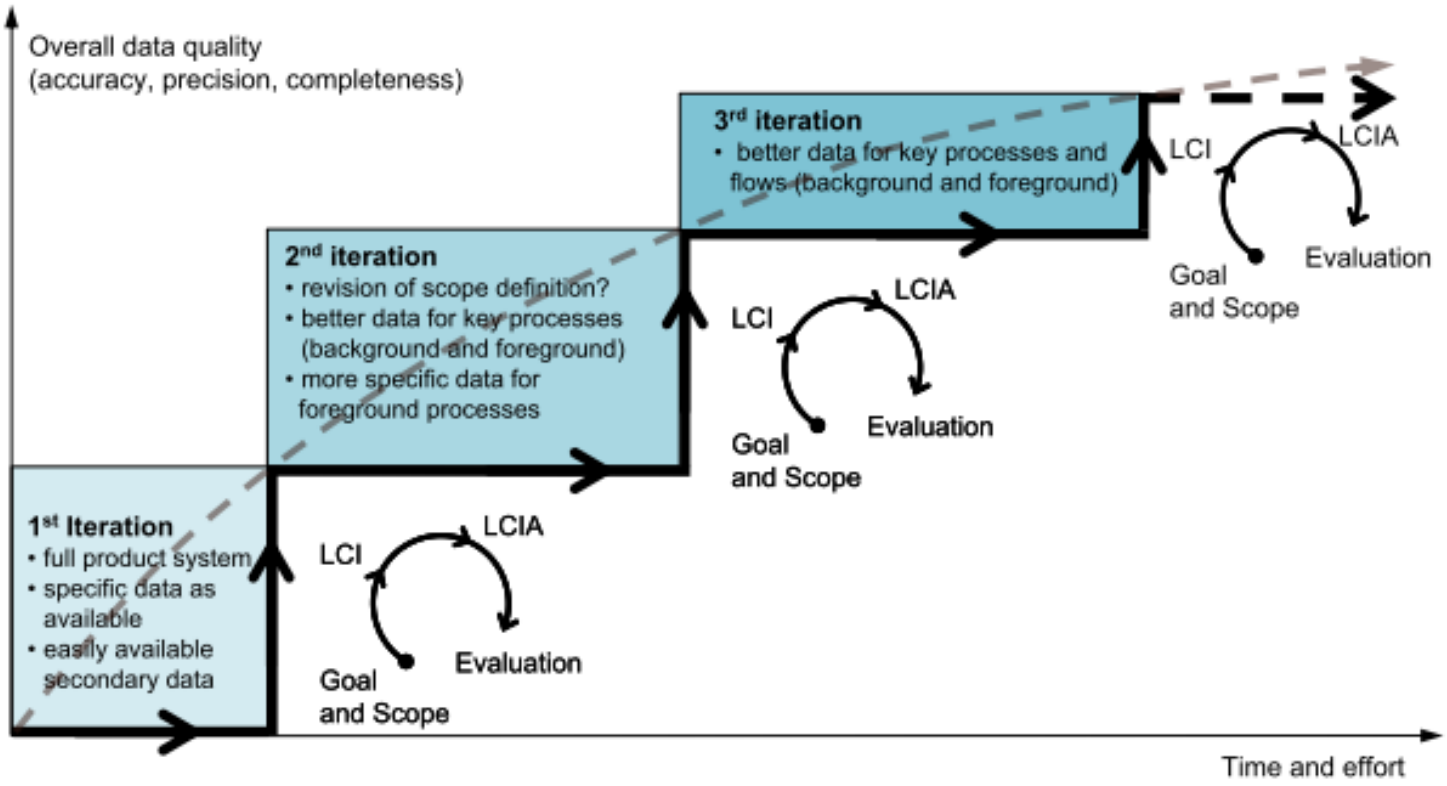
Four stages of an LCA study

- ISO 14040 – 14044:2006 standards



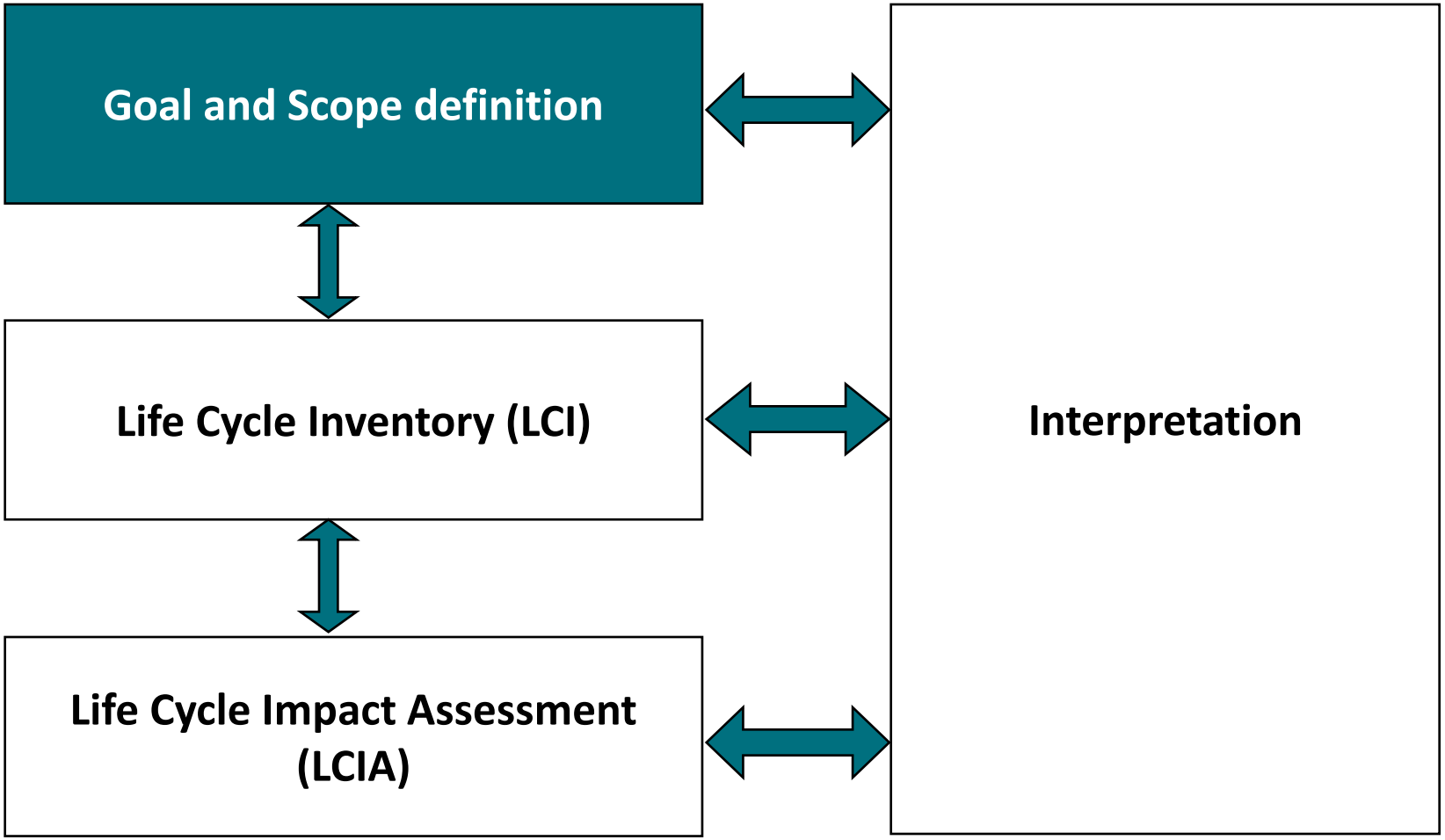
Four stages of an LCA study

- An iterative process



Four stages of an LCA study

- ISO 14040 – 14044:2006 standards



1. Goal(s)

- Application/reason of the study $\Rightarrow$ **Why?**
  - Week point analyze
  - Ecodesign
  - Comparison
  - Etc.
- Target audience $\Rightarrow$ **Who?**
  - Internally? For customers? For government? Publication?

1. Goal(s)

- Partner
  - Who are the concerned stakeholders?
  - Where the information will come from?
- Critical review?
- Results depend on the goal of the study
  - Country
  - Current or future technology
  - Target audience

➡ **Results can rarely be extrapolated!**

1. Scope

- Functional unit (FU) = performance characteristic
  - Example:
    - Mobile phone : to communicate
    - Painting: to cover an area
  - ➡Reference flow
- Boundaries
  - Which step are included and why?
- (Impact categories selection)
- Criteria to include inputs and outputs

➡**Objectives**

Functional unit

- Comparaison:
  - Comparison: systems of the **same function**!
  - Different functions are possible for a same product
    - Mobile – to look smart, to go on the internet, to play, videos, photos, etc.
    - Painting – to protect, to be nice, etc.
    - Soap – ……..
  - If the second function differs, pay attention to the validity of the comparison!

Functional unit

- Functional unit
  - **What:** Which function/service is given by the product?
  - **How much:** What is the needed amount of the required product to fill the function?
  - **How long**: What is the lifetime of the function?
  - **How**: What is the expected level of quality?

Functional unit

- Functional unit (FU)
  - Value quantifying the system function which is the basis to compare scenarios
  - Should not be the real capacity
    - Mobile phone
      - What: communication
      - How much? 1000 h
    - Painting
      - What: cover on area
      - How much? 10 m^2
      - How long? 10 years
      - How: stay nice
    - Soap – ……..
    - Cobbles: cover an alley

Functional unit

- If a component is studied, the functional unit is relative to the general function
  - Example: phone battery
  - FU = batteries numbers to perform 1000 hours of communication

Reference flows

- Quantity of needed products to fill the function for the defined FU

- What is bought to perform the function
  - Mobile phone – 1 phone, electricity to charge
  - Painting – painting and brushes to paint 1 m^2 area
  - Soap – ……..

- Lifetime and reuse are taken into account
  - If the lifetime of the mobile is about 500 hours, 2 phones will be needed to fill the funtional unit

- Lifetime, numbers of reuse = key parameters

Example: scope

Product	**Painting A**	**Painting B**
Function	• **Cover a wall** • **Protection**	
Functional unit	**To cover a wall of 10 m²**	
Reference flows	**1,5 L**	**2,1 L**

1. Wrap up

- **Goals** = study objectives, target audience and applications

- **Scope** of the study: functional unit, reference flow and system boundaries
  - Functional unit
    - ≠ unit!
    - What?
    - How much?
    - How long?
    - How?
  - Reference flows
    - Quantity of needed products to fill the function for the defined FU

1. Goal and Scope

Goal

- LCA of flat cobblestones (Platines) (for a B-EPD)
  = "pavé platine" (PP)

- Cobblestone: 15 x 15 x 8.5 cm
- Quarry of the Grès du Bois d'Anthisnes (GBA) (Poulseur)

PIERRES & MARBRES WALLONIE

CARRIERE GBA Grès du Bois d'Anthisnes

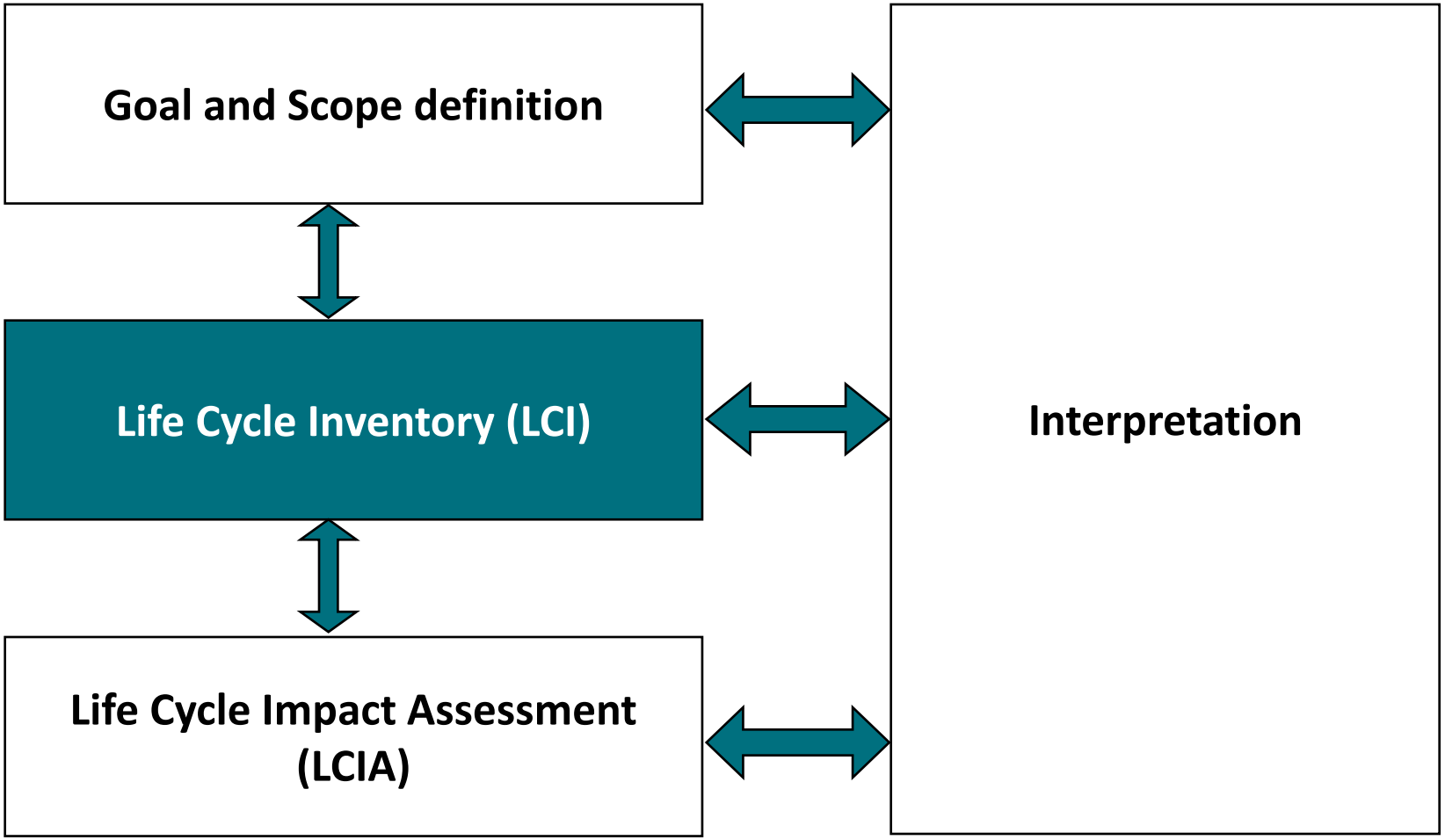
Scope

- Functional unit (FU): To cover 1 m^2 with flat cobblestones (15 x 15 x 8.5 cm), without installation
  1 FU = 196 kg of cobblestones
- Boundaries: cradle to gate + End of life
  (A1-A3 ; C1-C4 ; D)
  Modules non declared: A4-A5 (intallation), B1-B7 (use)
- Reference service life: 60 ans (mandatory!)
  → several hundred years, reuse 6 x

- Suggested installation but not included: on stabilised sand, with cement joints (1 cm wide)

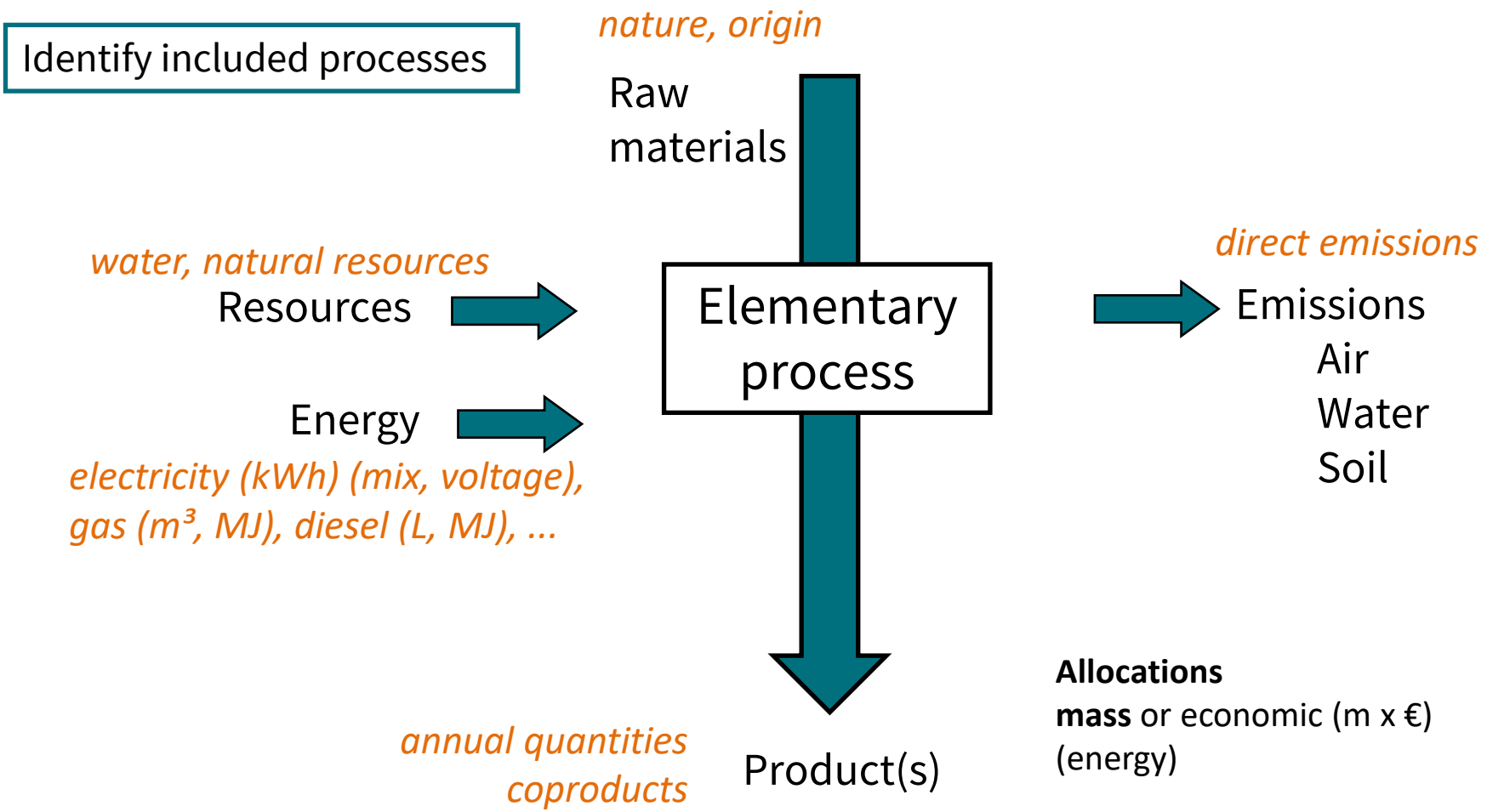
Four stages of an LCA study

- ISO 14040 – 14044:2006 standards

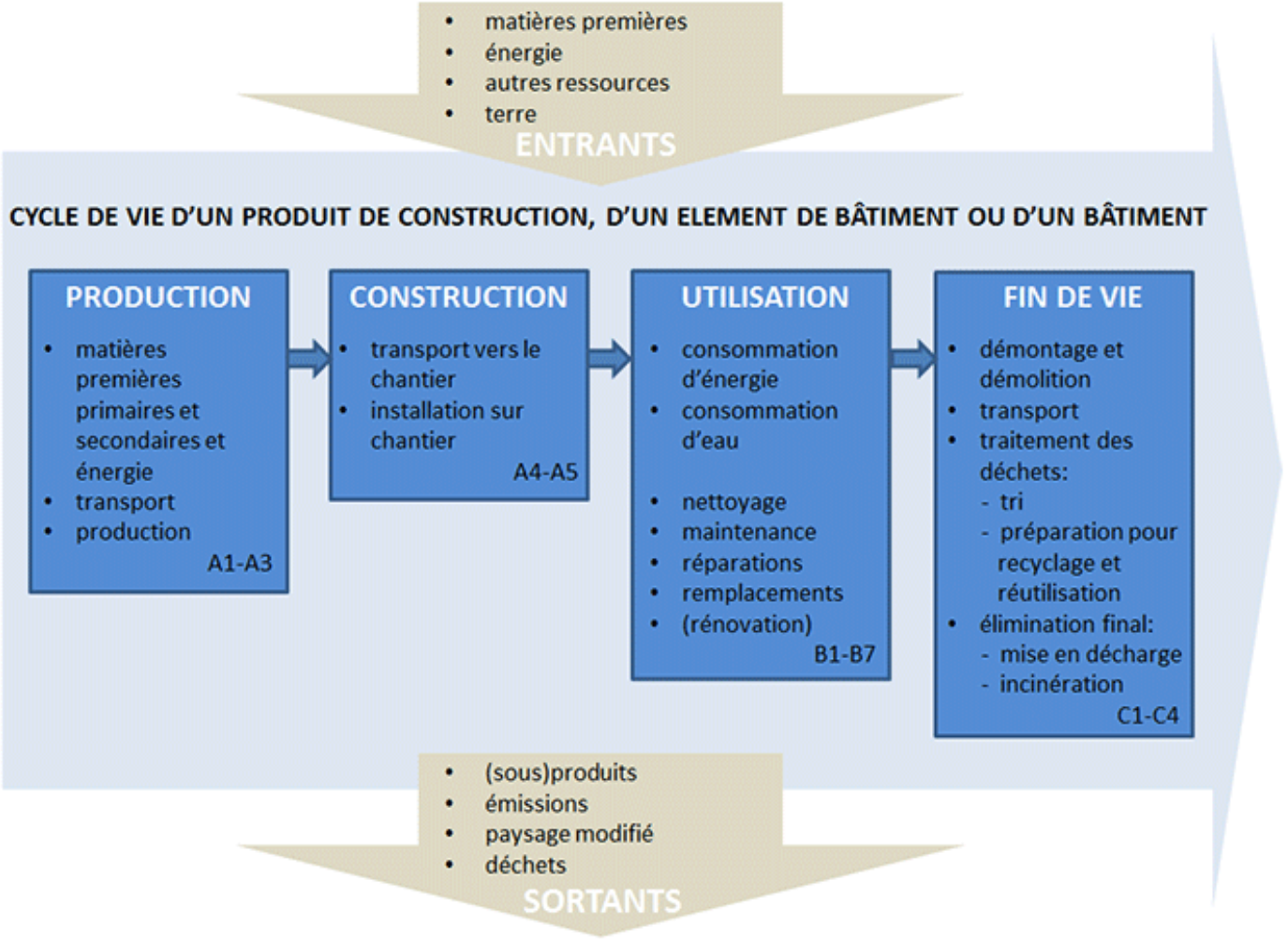


2. Inventory

- Quantification of flows → Mass and Energy balances



2. Inventory


• matières premières
• énergie
• autres ressources
• terre
ENTRANTS
CYCLE DE VIE D'UN PRODUIT DE CONSTRUCTION, D'UN ELEMENT DE BÂTIMENT OU D'UN BÂTIMENT
PRODUCTION
• matières premières primaires et secondaires et énergie
• transport
• production
A1-A3
CONSTRUCTION
• transport vers le chantier
• installation sur chantier
A4-A5
UTILISATION
• consommation d'énergie
• consommation d'eau
• nettoyage
• maintenance
• réparations
• remplacements
• (rénovation)
B1-B7
FIN DE VIE
• démontage et démolition
• transport
• traitement des déchets:
- tri
- préparation pour recyclage et réutilisation
• élimination final:
- mise en décharge
- incinération
C1-C4
• (sous)produits
• émissions
• paysage modifié
• déchets
SORTANTS

2. Inventory

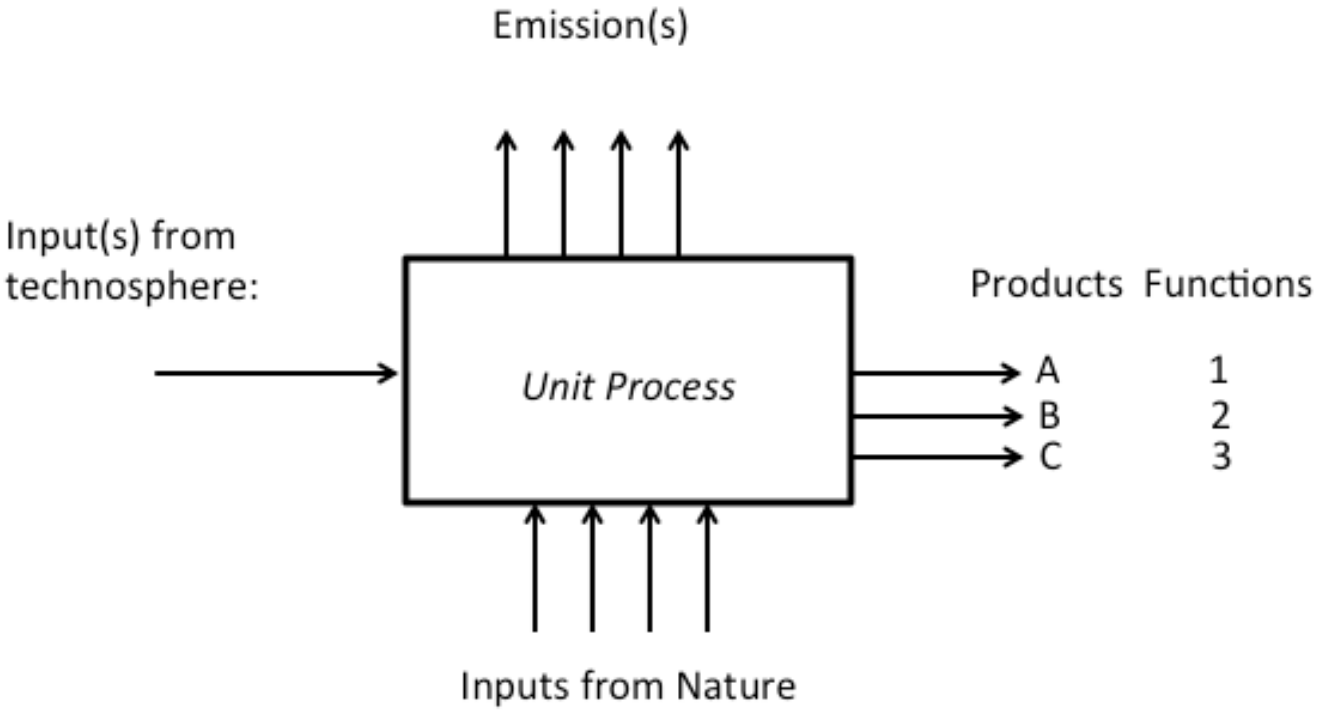
- What is needed
  - Accurate description of processes
  - Collection of available data
    - Technical data, simulation, …
  - Definition and justification of calculation assumptions

2. Inventory

- Types of data
  - **Activity factors**
    (transport distance, kg of cardboard, electricity consumption, …)
  - **Emissions factors**
    (emissions of GHG or PM2.5 per kWhe, per km, per activity, …)
- Data sources
  - **Primary data**: collected directly on site
  - **Secondary data**: from generic databases (Ecoinvent, GaBi, national databases, industrial sector, Agribalyse, Agri-Footprint, …)
  - **Specific data**: THE modelled process
  - **Generic data:** data from a similar process
    (from Universities, research centers, literature, ...)
- Importance of data quality (verifications, ...)

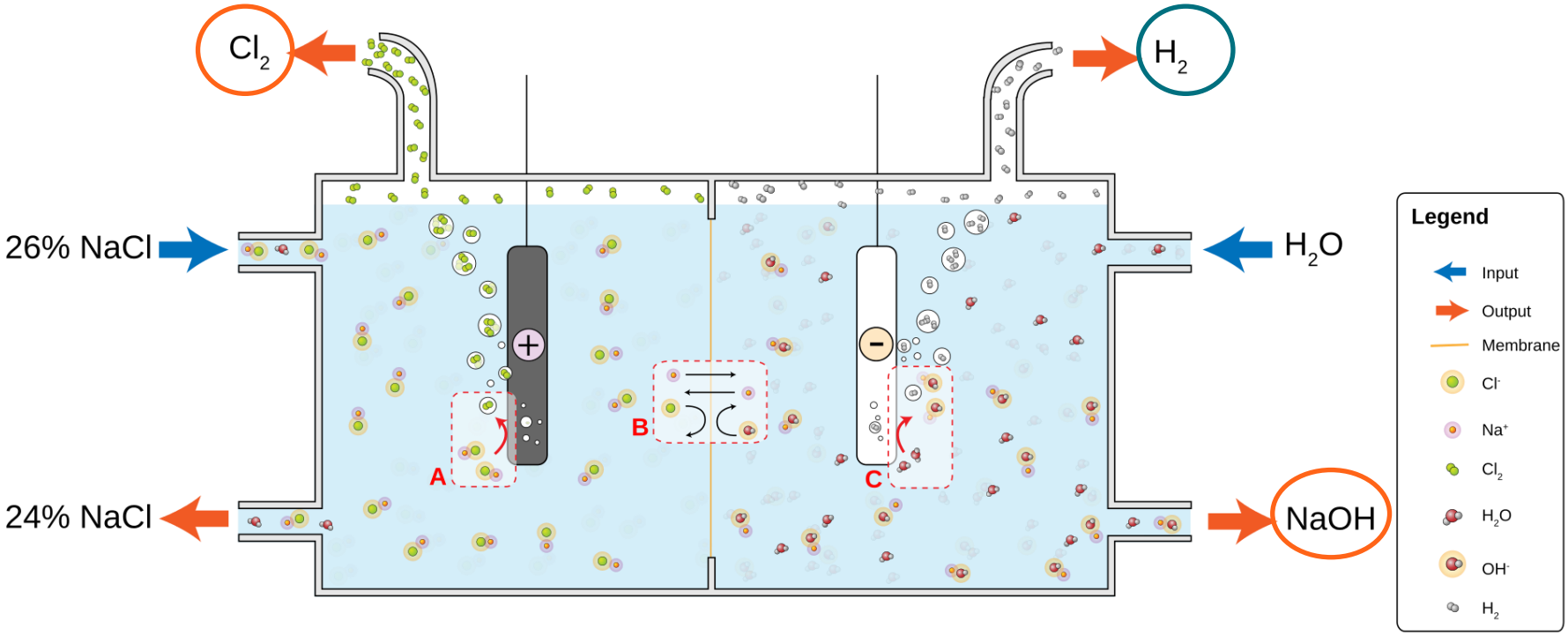
Data inventory

- Inventory distribution
  - Overall emissions and consumptions quantities by functional unit
  - How to divide them if process leads to several products?
  - **Allocation rules**



Allocations

- Inventory distribution
  - Some processes lead to several products
    - NaCl electrolysis



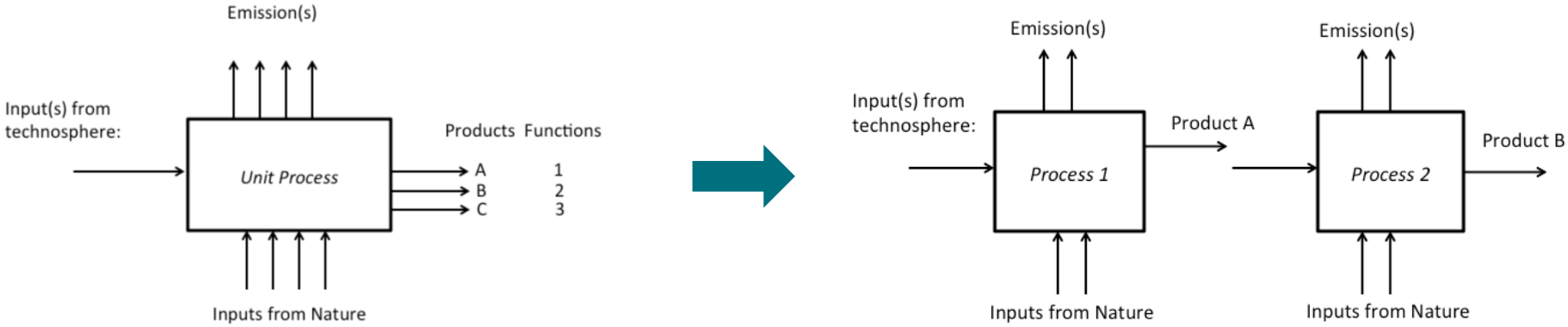
Allocations

Inventory distribution

- Some processes lead to several products
  - NaCl electrolysis $\rightarrow$ NaOH, Cl_2 and H_2
- During an electrolysis, there is an emission of X g of CO_2. Which product should take this impact?
  - Environmental load to divide between products
- Need of allocation rules:
  - Mass allocation
  - Economic allocation: mass x market price (cf. main product $\leftrightarrow$ co- or sub-product)
  - (Energy allocation)

Allocations

- To avoid allocation by dividing elementary process in several sub-processes (not always possible)

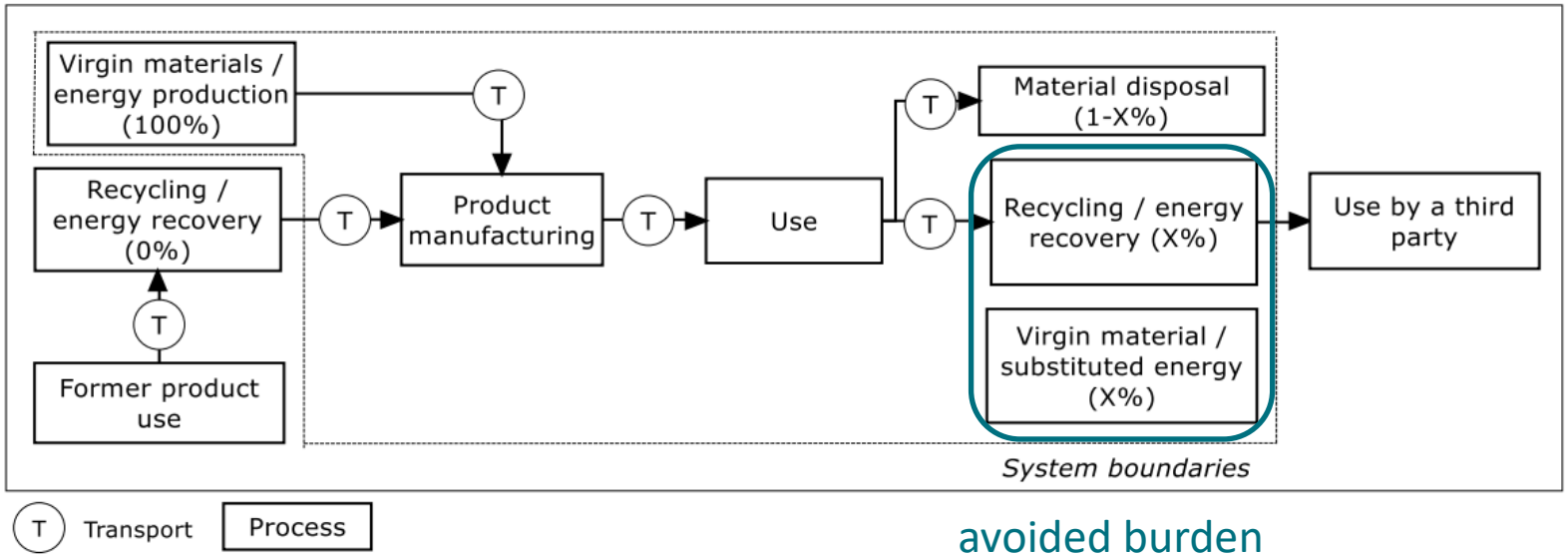


figures from: Life Cycle Assessment: Quantitative Approaches for Decisions That Matter – lcatextbook.com

Allocations – End of life and "waste"

- Recycling of waste → secondary material or energy production
- Who gets the benefits? ⇒ allocation of the recycling of waste
- Definition of system boundaries

- The **producer** gets the benefits
- System expansion (extention) approach or avoided burden

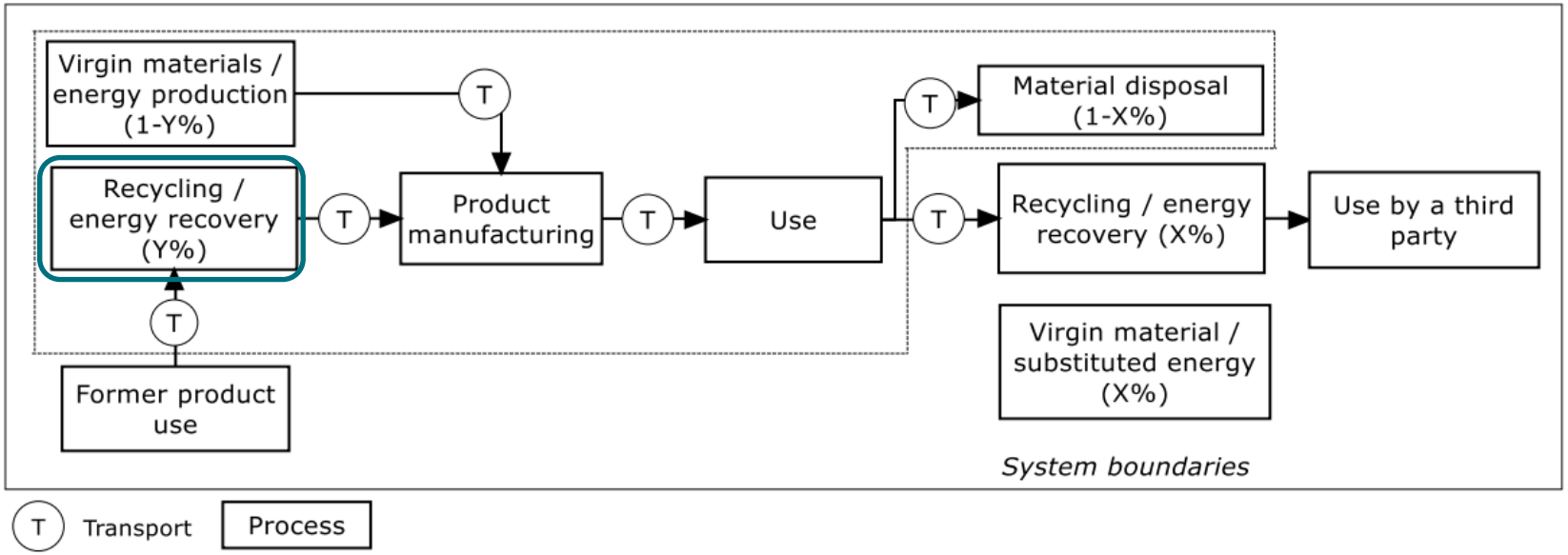


avoided burden

image: Quantis

Allocations – End of life and "waste"

- The **user** gets the benefit
- Cut-off approach: waste is "free" (not its processing or transport)

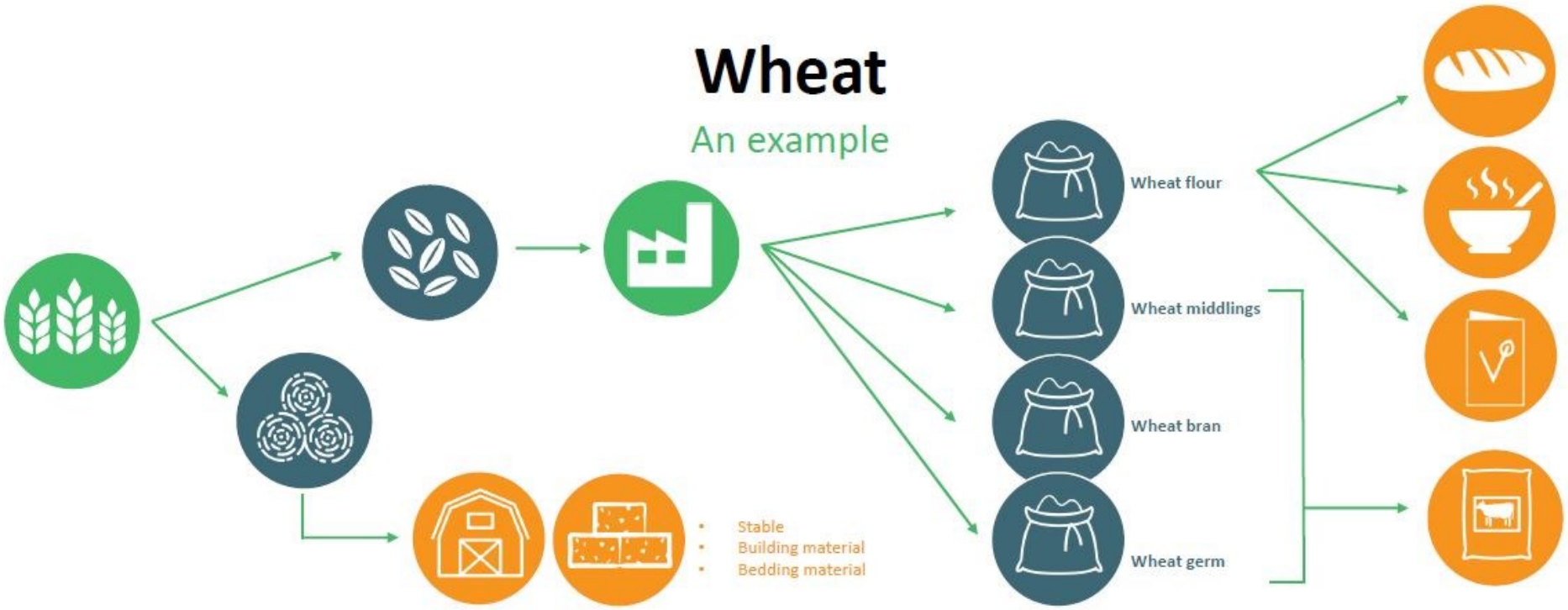


"processing" of waste

- **50/50** between producer and user (PEF)

image: Quantis

Allocation: wheat cultivation

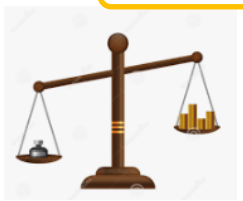


Allocations (Mass, **Economic**, etc)

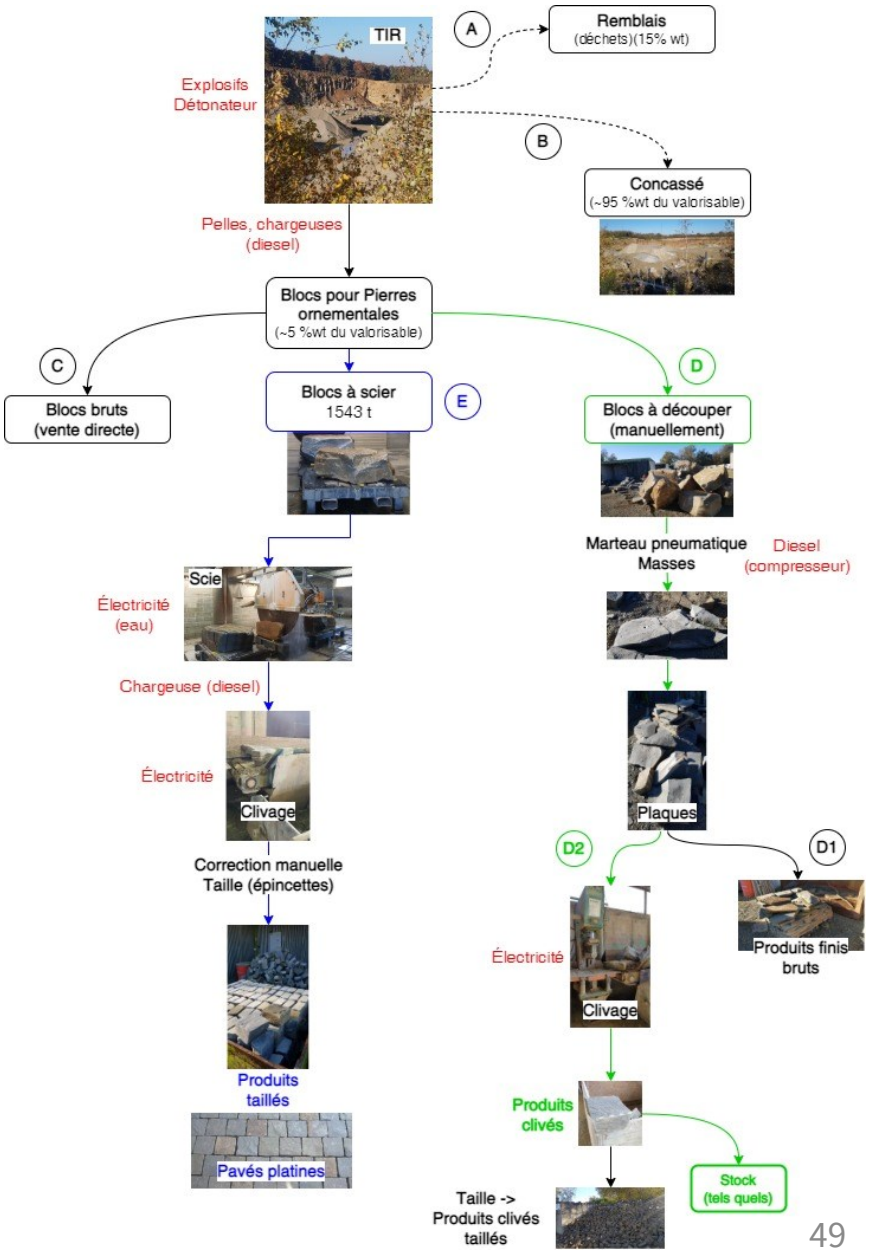
2. Inventory – PP: A1-A3: Production

- Several products with ≠ values
- Allocation of impacts?

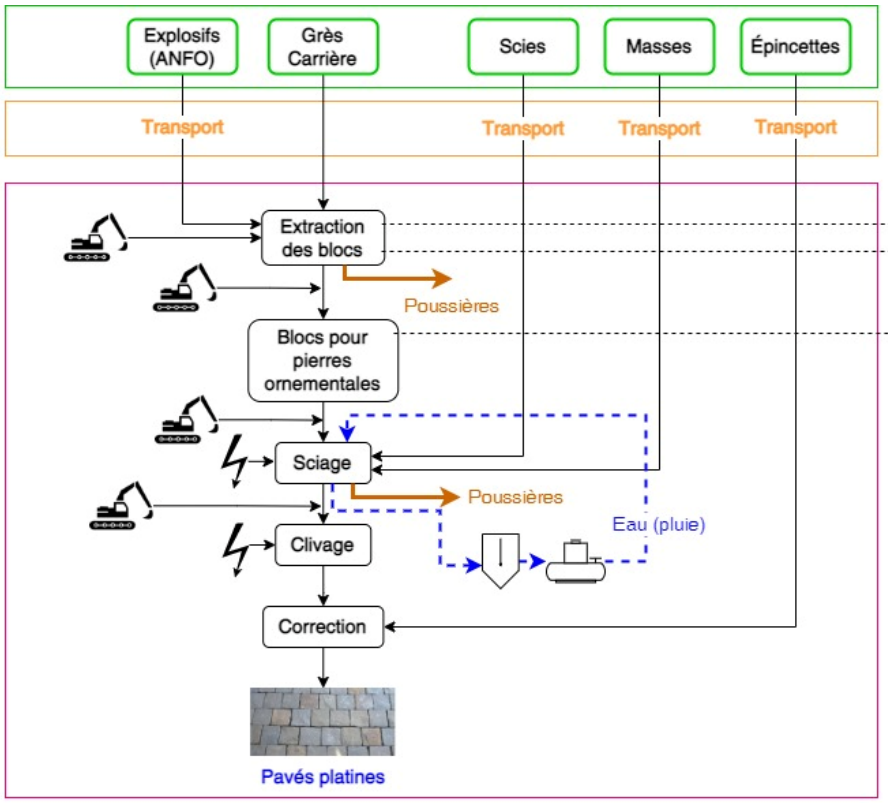
- Physical (mass) ↔ economis (revenues)



- Weighting :
  mass (kg) x selling price (€/kg)
- → Economic allocation: € PP / € total



2. Inventory – PP: A1-A3: Production



- Likewise for End of life (EoL) (dismantling → reuse, recycling) (C, D)
- End of life:
  - 85% cobblestones reused
  - 15% crushed → natural aggregates (with 5% losses) (→ concrete)

2. Inventory

- Ecoinvent database
- Example of insulation materials

Produit	Quantité	Unité	Projet
Cellulose fibre, inclusive blowing in, at plant/CH U	1	kg	Ecoinvent unit processes
Cork slab, at plant/RER U	1	kg	Ecoinvent unit processes
Foam glass, at plant/RER U	1	kg	Ecoinvent unit processes
Glass wool mat, at plant/CH U	1	kg	Ecoinvent unit processes
Polystyrene foam slab, 100% recycled, at plant/CH U	1	kg	Ecoinvent unit processes
Polystyrene foam slab, 45% recycled, at plant/CH U	1	kg	Ecoinvent unit processes
Polystyrene foam slab, at plant/RER U	1	kg	Ecoinvent unit processes
Rock wool, at plant/CH U	1	kg	Ecoinvent unit processes
Urea formaldehyde foam slab, hard, at plant/CH U	1	kg	Ecoinvent unit processes

2.Inventory: wrap up

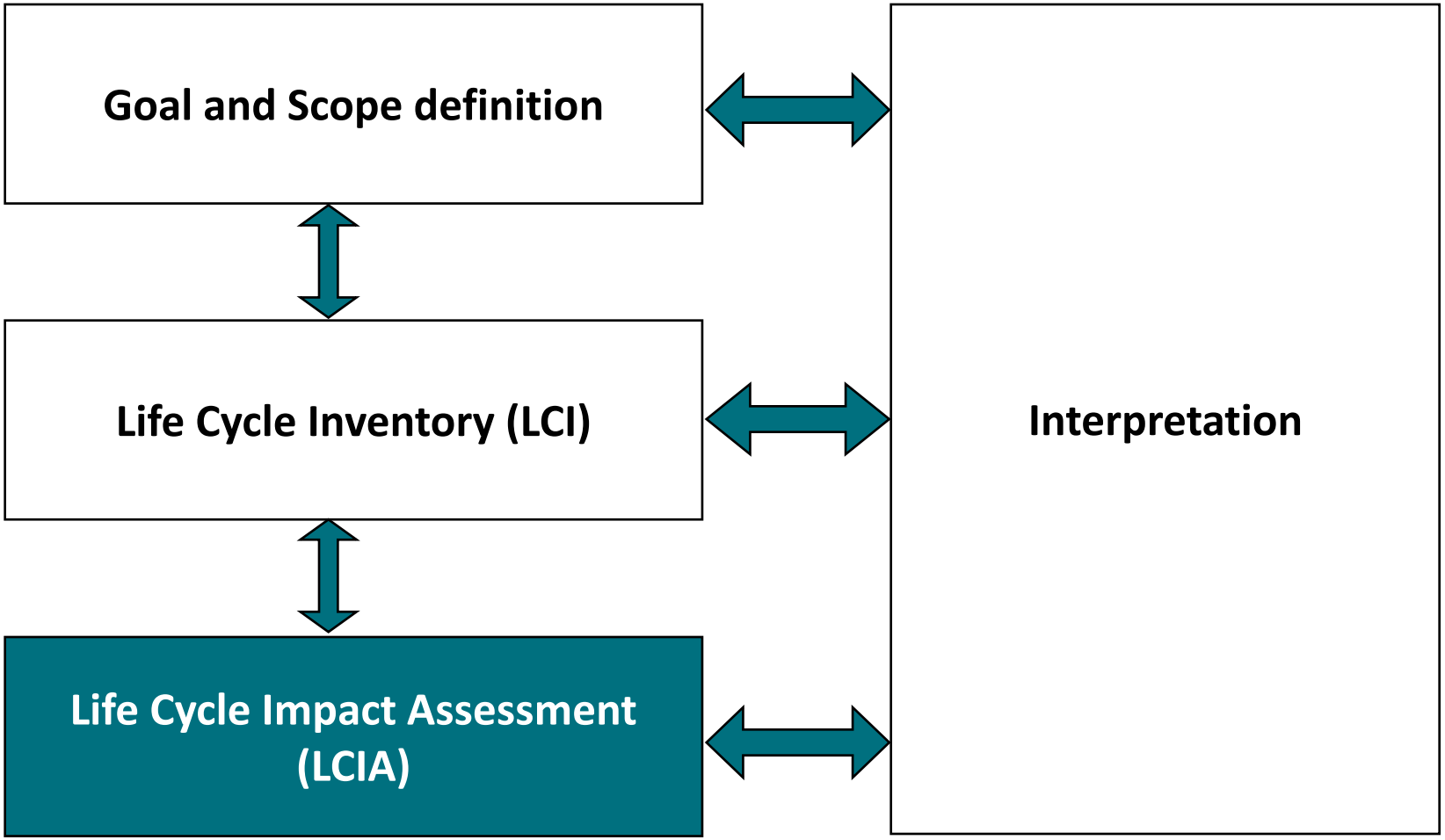
- Balance of inputs (consumptions) and outputs (emissions)
- List of emissions in the air, in the water, in the soil and resources use
- Only an inventory, not yet environmental impacts
- Mass Balance!
- Allows a first interpretation
- Gestion of boundaries (limits, allocations)

- Different units $\Rightarrow$ difficulty of comparison

➡Evaluation of impacts

Four stages of an LCA study

- Defined by ISO 14040 – 14044 standards



3. Impact assessment

- To assess environmental impacts related to data inventory
- To express environmental impacts in an understandable way
- Goal and scope guide the used methods and the choice of studied impacts
- Mandatory and optional items are given by ISO 1404X standards

3. Impact assessment: tools

Software

and database(s)

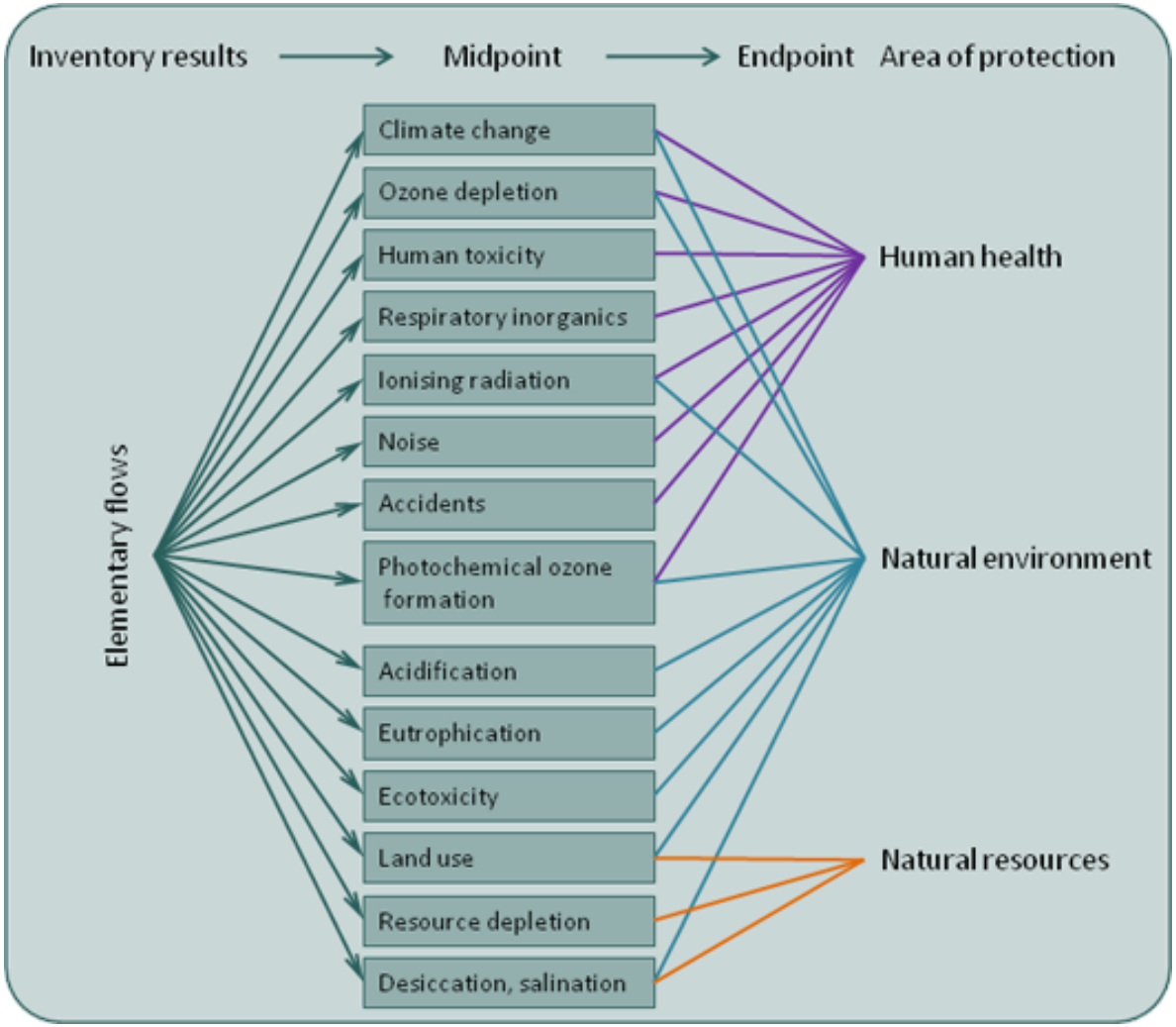
- **GaBi**: Thinkstep (DE)
  - proprietary database + Ecoinvent (CH) + ...
- **SimaPro**: PRé Sustainabillity (NL)
  - Ecoinvent (CH) + ...
- **OpenLCA**: open source, **free**
  - Ecoinvent (CH) + ...

Industry data LCA library

3. Impact assessment

- 6 steps
  - Mandatory
    - Impact categories
    - Classification
    - Characterisation
  - Optional
    - Normalisation
    - Grouping
    - Weighting

3. Impact assessment: categories



http://lct.jrc.ec.europa.eu/assessment

3. Impact assessment: categories

Depending on the magnitude/scale

- World

- Continent (< 1000 km)

3. Impact assessment: categories

Depending on the magnitude/scale

- Region (< 100 km)

- Local (< 5 km)

Impact assessment

- 6 steps:
  - Mandatory
    - Impact categories, indicators and methods selection
    - Classification
    - Characterization
  - Optional
    - Normalization
    - Grouping
    - Weighting

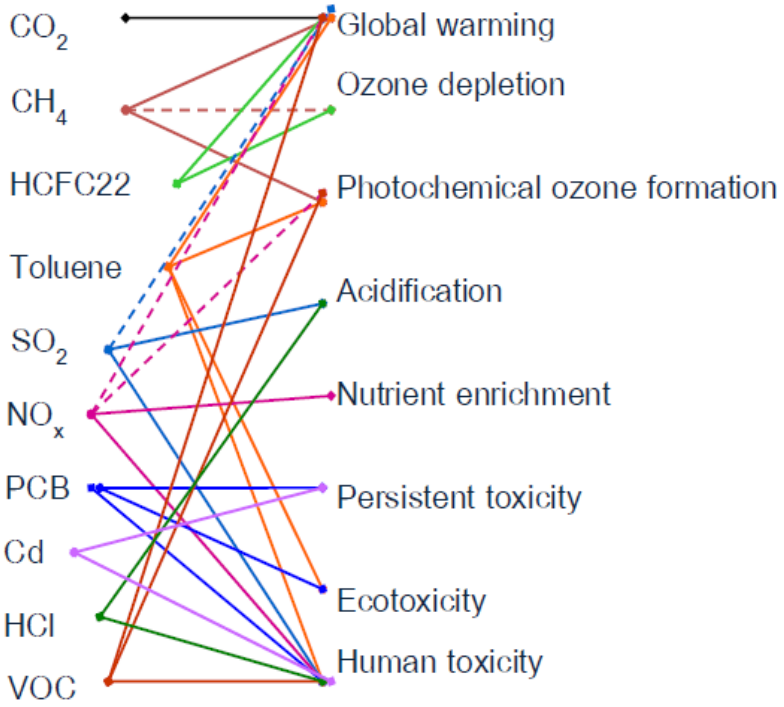
3. Impact assessment: classification

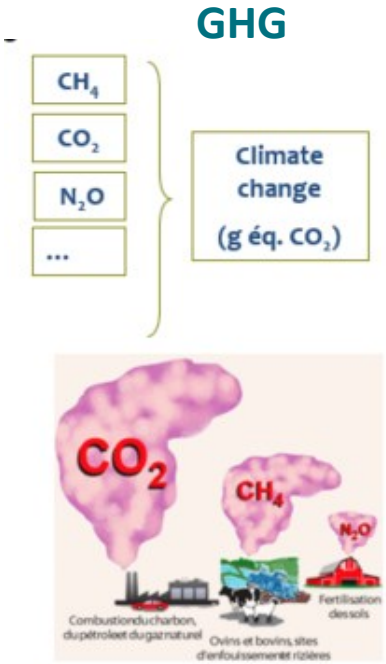
Preliminary step

- Inventary $\Rightarrow$ Input and Output flows
  (substance/energy consumed or emitted, produced)
- "Breakdown" $\Rightarrow$ "list" of everything that goes in/out in elementary flows & affectation to impact categories
- Use of databases (generic records)

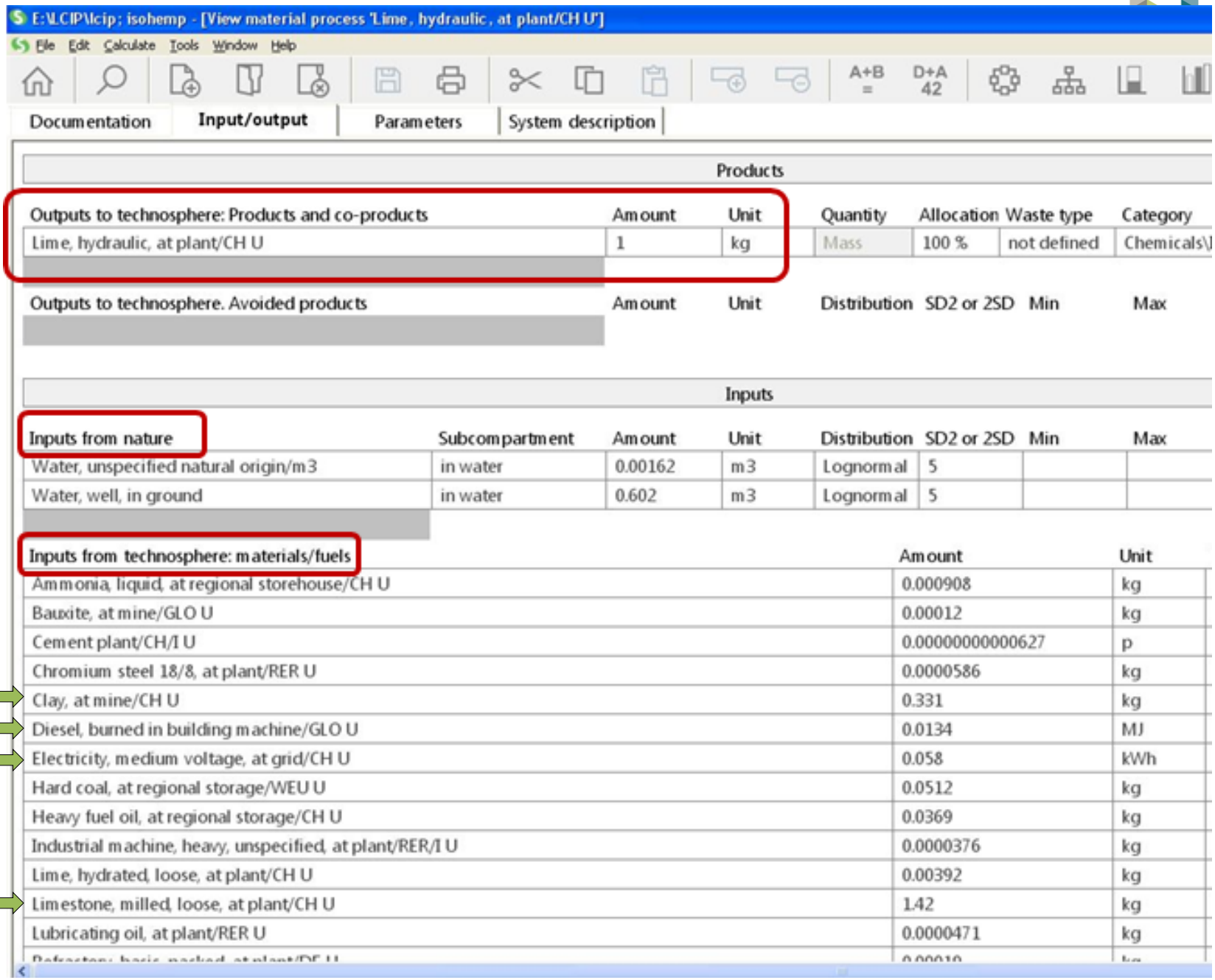
3. Impact assessment: classification

- Goal = to class inventory results in impact categories





- No influence of the user in this step



E:\LCIP\lcip; isohemp - [View material process 'Lime, hydraulic, at plant/CH U']

File Edit Calculate Tools Window Help

Documentation | Input/output | Parameters | System description

Products

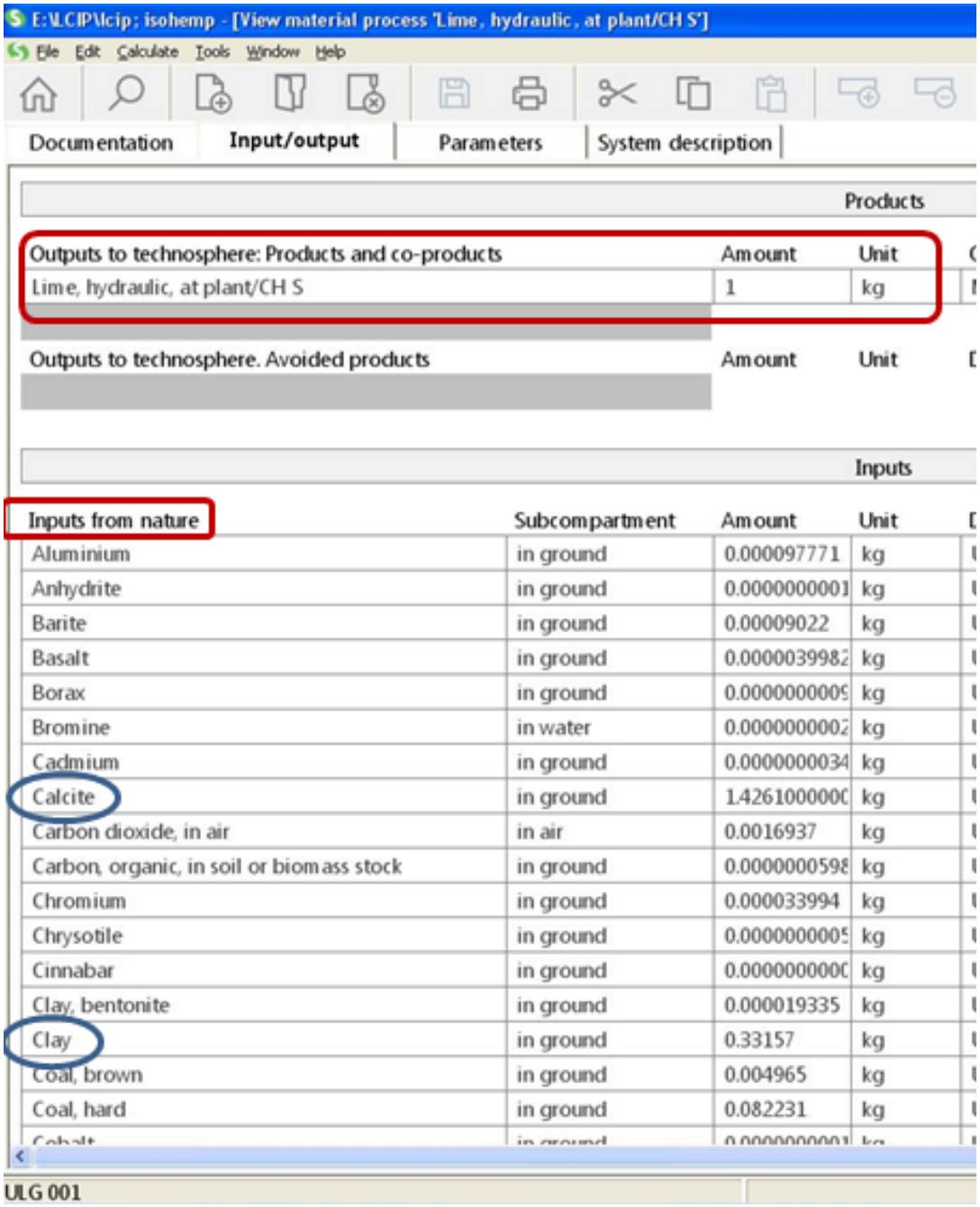
Outputs to technosphere: Products and co-products	Amount	Unit	Quantity	Allocation	Waste type	Category
Lime, hydraulic, at plant/CH U	1	kg	Mass	100 %	not defined	Chemicals\I

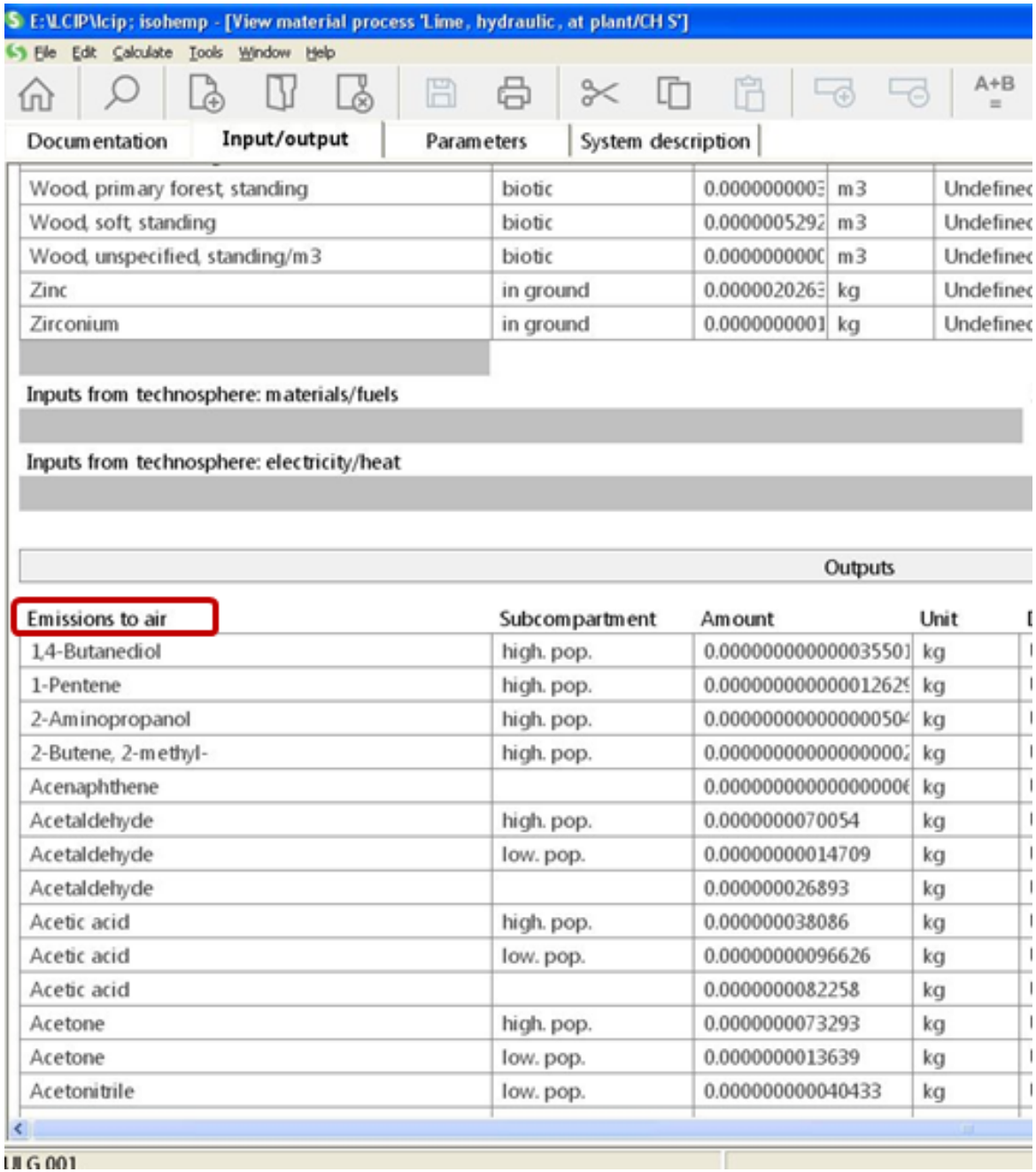
Outputs to technosphere. Avoided products	Amount	Unit	Distribution	SD2 or 2SD	Min	Max

Inputs

Inputs from nature	Subcompartment	Amount	Unit	Distribution	SD2 or 2SD	Min	Max
Water, unspecified natural origin/m3	in water	0.00162	m3	Lognormal	5		
Water, well, in ground	in water	0.602	m3	Lognormal	5		

Inputs from technosphere: materials/fuels	Amount	Unit
Ammonia, liquid, at regional storehouse/CH U	0.000908	kg
Bauxite, at mine/GLO U	0.00012	kg
Cement plant/CH/I U	0.00000000000627	p
Chromium steel 18/8, at plant/RER U	0.0000586	kg
Clay, at mine/CH U	0.331	kg
Diesel, burned in building machine/GLO U	0.0134	MJ
Electricity, medium voltage, at grid/CH U	0.058	kWh
Hard coal, at regional storage/WEU U	0.0512	kg
Heavy fuel oil, at regional storage/CH U	0.0369	kg
Industrial machine, heavy, unspecified, at plant/RER/I U	0.0000376	kg
Lime, hydrated, loose, at plant/CH U	0.00392	kg
Limestone, milled, loose, at plant/CH U	1.42	kg
Lubricating oil, at plant/RER U	0.0000471	kg


E:\LCIP\lcip; isohemp - [View material process 'Lime, hydraulic, at plant/CH S']
File Edit Calculate Tools Window Help
Documentation
Input/output
Parameters
System description
Products
Outputs to technosphere: Products and co-products
Amount
Unit
Lime, hydraulic, at plant/CH S
1
kg
Outputs to technosphere. Avoided products
Amount
Unit
Inputs
Inputs from nature
Subcompartment
Amount
Unit
Aluminium in ground 0.000097771 kg
Anhydrite in ground 0.0000000001 kg
Barite in ground 0.00009022 kg
Basalt in ground 0.0000039982 kg
Borax in ground 0.000000000 kg
Bromine in water 0.000000000 kg
Cadmium in ground 0.000000003 kg
Calcite in ground 1.426100000 kg
Carbon dioxide, in air in air 0.0016937 kg
Carbon, organic, in soil or biomass stock in ground 0.000000059 kg
Chromium in ground 0.000033994 kg
Chrysotile in ground 0.000000000 kg
Cinnabar in ground 0.000000000 kg
Clay, bentonite in ground 0.000019335 kg
Clay in ground 0.33157 kg
Coal, brown in ground 0.004965 kg
Coal, hard in ground 0.082231 kg
ULG 001

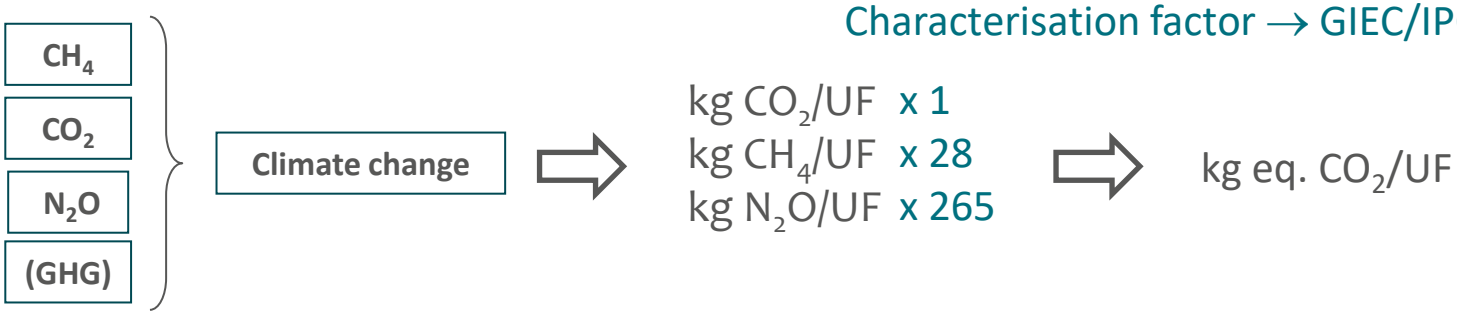

E:\LCIP\lcip; isohemp - [View material process 'Lime, hydraulic, at plant/CH S']
File Edit Calculate Tools Window Help
Documentation
Input/output
Parameters
System description
Wood, primary forest, standing | biotic | 0.000000000 | m3 | Undefined
Wood, soft, standing | biotic | 0.0000005292 | m3 | Undefined
Wood, unspecified, standing/m3 | biotic | 0.000000000 | m3 | Undefined
Zinc | in ground | 0.000002026 | kg | Undefined
Zirconium | in ground | 0.000000001 | kg | Undefined
Inputs from technosphere: materials/fuels
Inputs from technosphere: electricity/heat
Outputs
Emissions to air | Subcompartment | Amount | Unit
1,4-Butanediol | high. pop. | 0.00000000000003550 | kg
1-Pentene | high. pop. | 0.00000000000012625 | kg
2-Aminopropanol | high. pop. | 0.00000000000000504 | kg
2-Butene, 2-methyl- | high. pop. | 0.00000000000000007 | kg
Acenaphthene | | 0.00000000000000006 | kg
Acetaldehyde | high. pop. | 0.0000000070054 | kg
Acetaldehyde | low. pop. | 0.00000000014709 | kg
Acetaldehyde | | 0.000000026893 | kg
Acetic acid | high. pop. | 0.000000038086 | kg
Acetic acid | low. pop. | 0.00000000096626 | kg
Acetic acid | | 0.0000000082258 | kg
Acetone | high. pop. | 0.0000000073293 | kg
Acetone | low. pop. | 0.0000000013639 | kg
Acetonitrile | low. pop. | 0.000000000040433 | kg

3. Impact assessment

- 6 steps
  - Mandatory
    - Impact categories
    - Classification
    - Characterisation
  - Optional
    - Normalisation
    - Grouping
    - Weighting

3. Impact assessment: characterisation

- Aim = To express the different pollutants of a same category in equivalent amount of a same pollutant

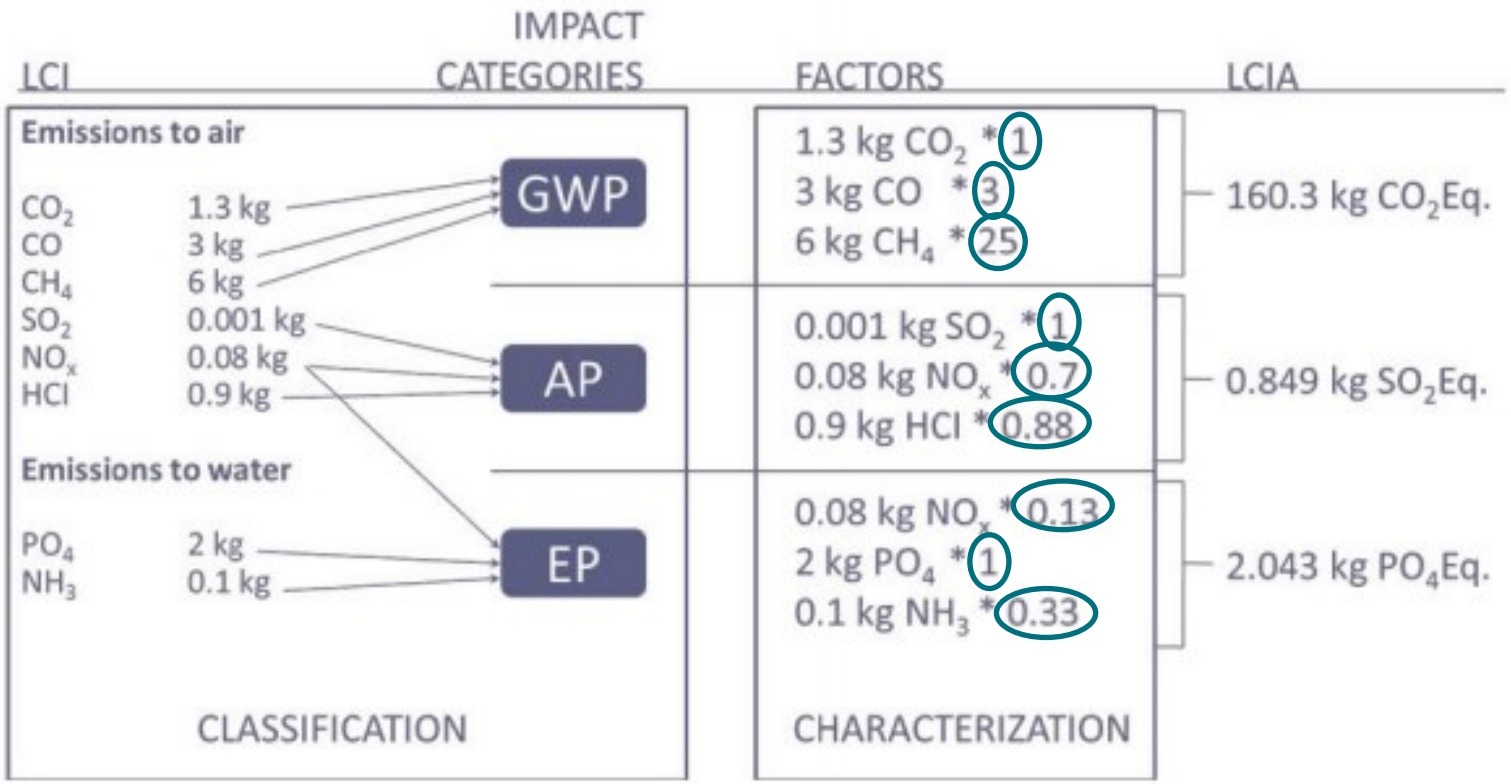


- Impact indicator =
  Inventory data x Characterisation Factor (CF)

$$\mathrm{IS}_c = \sum_i (\mathrm{CF}_i \cdot E_i)$$

- Characterisation Factors (CF): depend on the models
  (No CF = no impact!)

3. Impact assessment: characterisation



GWP = Global Warming Potential
AP = Acidification Potential
EP = Eutrophication Potential

3. Impact assessment: characterisation

- Method = set of specific models for each impact category

- No unique reference method for impact assessment
- Depends on the willing goal and method characteristics
- ISO standard allows scientifically recognized methods
- Examples
  - CML-IA (EN15804+A2:2019)
  - ReCiPe 2008/2016
  - ILCD 2011
  - Impact 2002+ ; ImpactWold+
  - Eco-Indicator 99
- Models: different level of maturity
  $\Rightarrow$ JRC

JRC TECHNICAL REPORTS

LCA standards

- LCA standards: ISO 14040 et 14044
  - ISO 14040:2006 Principles and framework
  - ISO 14044:2006 Requirements and guidelines

- Defines the 4 steps of an LCA
  - Lot of freedom degrees

- Defines the critical review

LCA standards

- JRC = Joint Research Centre
  The European Commission's science and knowledge service which employs scientists to carry out research in order to provide independent scientific advice and support to EU policy.
  https://ec.europa.eu/jrc/en

- EPLCA = European Platform on Life Cycle Assessment
  The EU's knowledge base that responds to business and policy needs for social and environmental assessments of supply chains and end-of-life waste management, otherwise known as life cycle assessments.
  https://eplca.jrc.ec.europa.eu/index.html

LCA standards

- EPLCA $\Rightarrow$ ILCD International Life Cycle Data system
  - Guidance and standards for greater consistency and quality assurance
  - ILCD handbook(s)

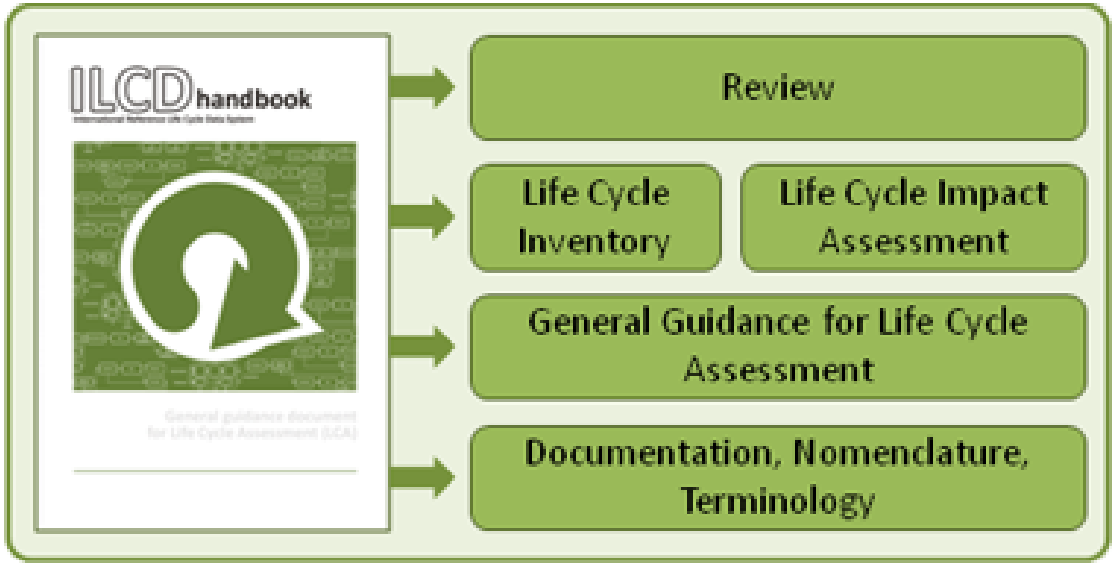
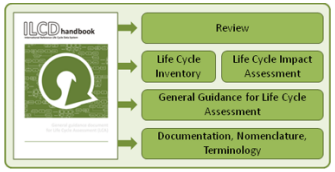


Table 1 Recommended methods and their classification at midpoint

	Recommendation at midpoint		
Impact category	**Recommended default LCIA method**	**Indicator**	**Classification**
Climate change	Baseline model of 100 years of the IPCC	Radiative forcing as Global Warming Potential (GWP100)	I
Ozone depletion	Steady-state ODPs 1999 as in WMO assessment	Ozone Depletion Potential (ODP)	I
Human toxicity, cancer effects	USEtox model (Rosenbaum et al, 2008)	Comparative Toxic Unit for humans (CTU_h)	II/III
Human toxicity, non-cancer effects	USEtox model (Rosenbaum et al, 2008)	Comparative Toxic Unit for humans (CTU_h)	II/III
Particulate matter/Respiratory inorganics	RiskPoll model (Rabl and Spadaro, 2004) and Greco et al 2007	Intake fraction for fine particles (kg PM2.5-eq/kg)	I
Ionising radiation, human health	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)	Human exposure efficiency relative to U^{235}	II
Ionising radiation, ecosystems	No methods recommended		Interim
Photochemical ozone formation	LOTOS-EUROS (Van Zelm et al, 2008) as applied in ReCiPe	Tropospheric ozone concentration increase	II
Acidification	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	Accumulated Exceedance (AE)	II
Eutrophication, terrestrial	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	Accumulated Exceedance (AE)	II
Eutrophication, aquatic	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe	Fraction of nutrients reaching freshwater end compartment (P) or marine end compartment (N)	II
Ecotoxicity (freshwater)	USEtox model, (Rosenbaum et al, 2008)	Comparative Toxic Unit for ecosystems (CTU_e)	II/III
Ecotoxicity (terrestrial and marine)	No methods recommended		
Land use	Model based on Soil Organic Matter (SOM) (Milà i Canals et al, 2007b)	Soil Organic Matter	III
Resource depletion, water	Model for water consumption as in Swiss Ecoscarcity (Frischknecht et al, 2008)	Water use related to local scarcity of water	III
Resource depletion, mineral, fossil and renewable[6]	CML 2002 (Guinée et al., 2002)	Scarcity	II



Impact assessment methods: diversity

LCIA Methods	CML	EDIP	EF	EPD	ILCD	IMPACT	ReCiPe	TRACI
References	[3]	[4]	[43]	environdec.com (accessed on 2 April 2021)	[5]	[44]	[6]	[7]
Region	Europe	Europe	Europe	Global	Europe	Europe	Global	North America
Version	IA-baseline	2003	2.0	2018	2001 Midpoint+	2002+	2016 Midpoint(H)	2.1
Approach	Mid	Mid	Mid/End	Mid	Mid	Mid/End	Mid	Mid
Global warming	kg CO_2 eq	kg CO_2 eq	kg CO_2 eq	kg CO_2 eq	kg CO_2 eq	kg CO_2 eq	kg CO_2 eq	kg CO_2 eq
Acidification	kg SO_2 eq	m^2	mol H+ eq	kg SO_2 eq	mol H^+ eq	kg SO_2 eq	kg SO_2 eq	kg SO_2 eq
Ozone depletion	kg CFC-11 eq	kg CFC-11 eq	kg CFC-11 eq	kg CFC-11 eq	kg CFC-11 eq	kg CFC-11 eq	kg CFC-11 eq	kg CFC-11 eq
Eutrophication	kg PO_4 eq	kg P	kg P eq	kg PO_4 eq	kg P eq	kg PO_4 P-lim	kg P eq	kg N eq
Energy consumption	MJ		MJ	MJ		MJ primary	kg oil eq	MJ surplus
Resource	kg Sb eq	PR2004	kg Sb eq	kg Sb eq	kg Sb eq		kg Cu eq	
Smog	kg C_2H_4 eq	per.ppm.h	kg NMVOC eq	kg NMVOC	kg NMVOC eq	kg C_2H_4 eq	kg NO_x eq	kg O_3 eq
Water depletion			m^3 depriv.	m^3 eq	m^3 water eq		m^3	
Human toxicity (Cancer)	kg 1,4-DB eq	person	CTUh		CTUh	kg C_2H_3Cl eq	kg 1,4-DCB	CTUh
Human toxicity (Non-Cancer)	kg 1,4-DB eq	person	CTUh		CTUh	kg C_2H_3Cl eq	kg 1,4-DCB	CTUh
Particulate matter			disease inc.		kg PM2.5 eq	kg PM2.5 eq	kg PM2.5 eq	kg PM2.5 eq
Ecotoxicity (Freshwater)	kg 1,4-DB eq	m^3	CTUe		CTUe	kg TEG water	kg 1,4-DCB	CTUe
Land use			Pt		kg C deficit	m^2org.arable	m^2a crop eq	
Ionizing radiation			kBq U-235 eq		k Bq U235 eq	Bq C-14 eq	kBq Co-60 eq	

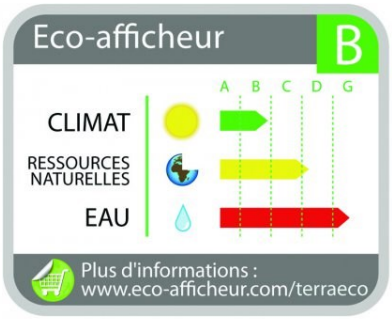
Note: Mid: midpoint approach; End: endpoint approach. EF and IMPACT2002+ include midpoint and endpoint indicators for different impact categories. "eq" refers to equivalent.

Dong, Yahong & Hossain, Md & Hongyang, Li & Liu, Peng. (2021). Developing Conversion Factors of LCIA Methods for Comparison of LCA Results in the Construction Sector. Sustainability. 13. 9016. 10.3390/su13169016.

Agenda

- Context
- What is Life cycle assessment (LCA)?
- How to make an LCA?
  + example(s)
- Environmental communication
- Conclusion


Certified
B Corporation
RSPO
NSF
USDA CERTIFIED BIOBASED PRODUCT
GREENGUARD
Carbonfree
ENERGY STAR LISTED
RIOS
US Composting Council
SGP
FAIRTRADE
paper profile
WaterSense
sourcemap
PEFC
floor score
TERRACYCLE
UTZ CERTIFIED Good inside
QCS
eco-certified SUSTAINABLE TRAVEL
ECO CERT
ups
CARBON NEUTRAL SHIPMENT
WHOLE TRADE
VERMONT ORGANIC CERTIFIED
CCOF
Certified GREEN
SALMON
SAFE
VCS
OREGON TILTH
PROTECTED HARVEST
Certified GREEN by TRA Certification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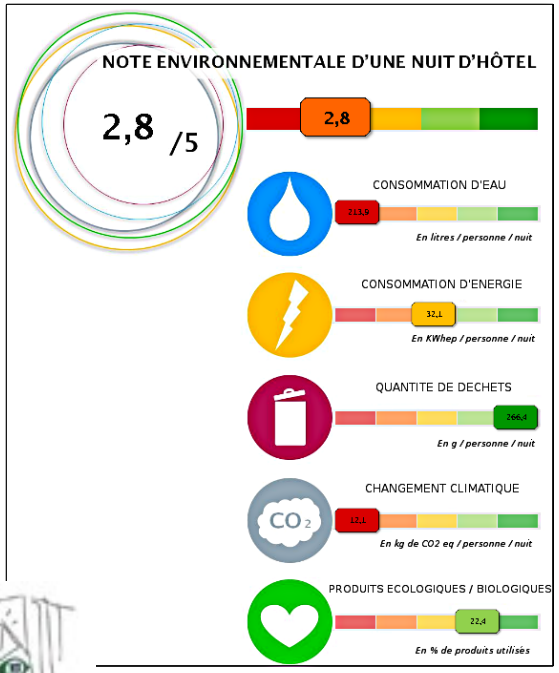
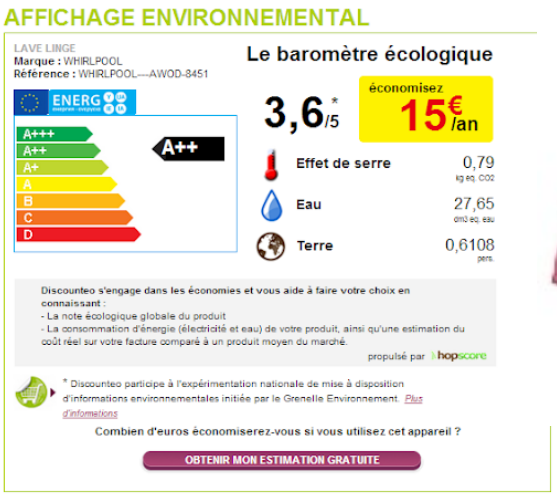
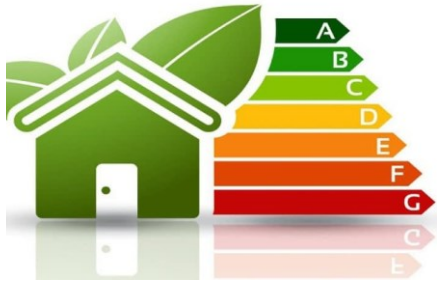
Plus d'informations :
www.eco-afficheur.com/terraeco


NOTE ENVIRONNEMENTALE D'UNE NUIT D'HÔTEL
2,8 /5
2,8
CONSOMMATION D'EAU
213,9
En litres / personne / nuit
CONSOMMATION D'ENERGIE
32,1
En KWhep / personne / nuit
QUANTITE DE DECHETS
266,4
En g / personne / nuit
CHANGEMENT CLIMATIQUE
CO2
12,1
En kg de CO2 eq / personne / nuit
PRODUITS ECOLOGIQUES / BIOLOGIQUES
22,4
En % de produits utilisés


AFFICHAGE ENVIRONNEMENTAL
LAVE LINGE
Marque : WHIRLPOOL
Référence : WHIRLPOOL---AWOD-8451
ENERG
A+++
A++
A+
A
B
C
D
A++
Le baromètre écologique
3,6/5 *
économisez 15€ /an
Effet de serre 0,79 kg eq. CO2
Eau 27,65 dm3 eq. eau
Terre 0,6108 pers.
Discounteo s'engage dans les économies et vous aide à faire votre choix en connaissant :
- La note écologique globale du produit
- La consommation d'énergie (électricité et eau) de votre produit, ainsi qu'une estimation du coût réel sur votre facture comparé à un produit moyen du marché.
propulsé par hopscore
* Discounteo participe à l'expérimentation nationale de mise à disposition d'informations environnementales initiée par le Grenelle Environnement. Plus d'informations
Combien d'euros économiserez-vous si vous utilisez cet appareil ?
OBTENIR MON ESTIMATION GRATUITE


A
B
C
D
E
F
G

Three types of labels

ISO 14021 – Type 2
Self declaration
Fast, partial (mono criteria)
One or two criteria One step (end of life, …)

http://stockage.univ-valenciennes.fr/MenetACVBAT20120704/acvbat/chap05/co/ch05_010_acv_2.html

Three types of labels

ISO 14024 – Type 1	ISO 14021 – Type 2
Ecolabel	Self declaration
Criteria fixed by a competent agency	Fast, partial (mono criteria)
Multi steps Multi criteria LCA not mandatory	One or two criteria One step (end of life, …)

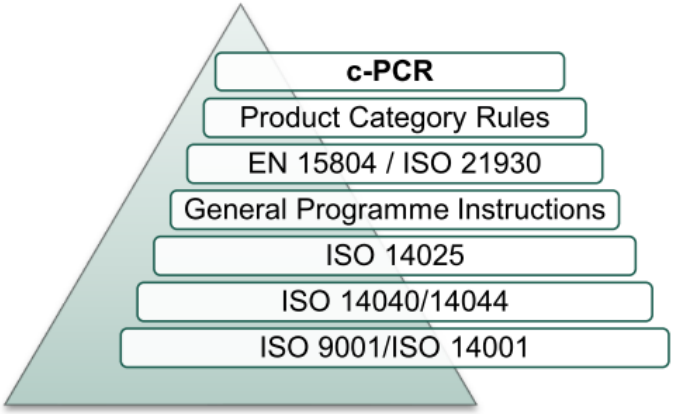
http://stockage.univ-valenciennes.fr/MenetACVBAT20120704/acvbat/chap05/co/ch05_010_acv_2.html

Three types of labels

ISO 14024 – Type 1	ISO 14021 – Type 2	ISO 14025 – Type 3
Ecolabel	Self declaration	Environmental declaration Ecoprofile
Criteria fixed by a competent agency	Fast, partial (mono criteria)	Complex and complete
Multi steps Multi criteria LCA not mandatory	One or two criteria One step (end of life, …)	LCA = mandatory

http://stockage.univ-valenciennes.fr/MenetACVBAT20120704/acvbat/chap05/co/ch05_010_acv_2.html

EPD – Type III (Environmental Product Declaration)



Norme belge

EN 15804:2012+A2:2019

NBN EN 15804:2012+A2:2019

NBN

Contribution des ouvrages de construction au développement durable - Déclarations environnementales sur les produits - Règles régissant les catégories de produits de construction

EPD®

THE INTERNATIONAL EPD® SYSTEM

JRC TECHNICAL REPORTS

Suggestions for updating the Product Environmental Footprint (PEF) method

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2019

European Commission

Product Environmental Footprint

PEF

epd-norge.no

The Norwegian EPD Foundation

PRODUCT CATEGORY RULES

EN 15804

NPCR 018 version 1.0

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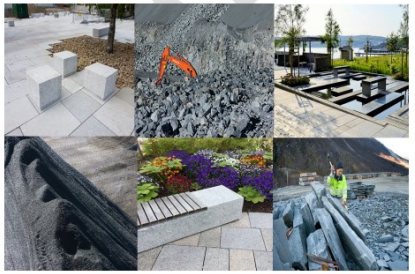
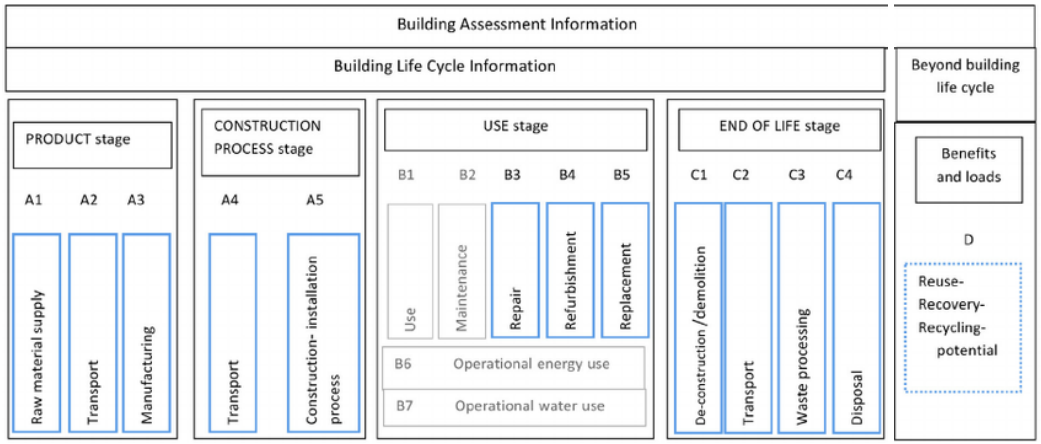
PCR-Part B for natural stone products, aggregates and fillers



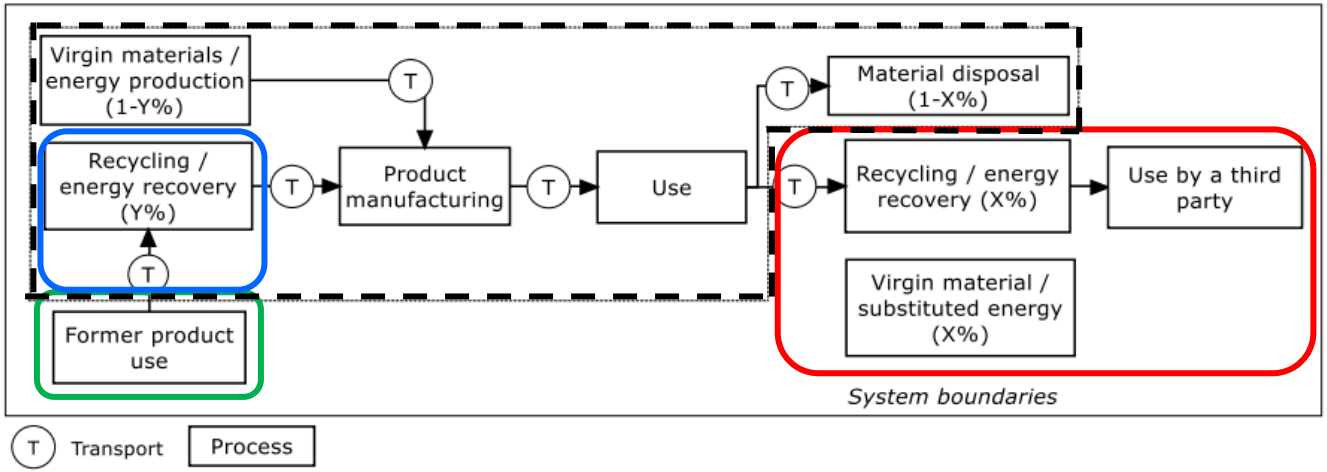
DRAFT NPCR 018:2020 Part B for natural stone products, aggregates and fillers 1

Allocation rules

- EN15804+A2:2019
- "Cut-off"



- Recycled = "free"
- BUT ~~recycling~~ at the EoL
- ⇒ Module D → cobbles reused and recycled at their EoL



3. Impact assessment

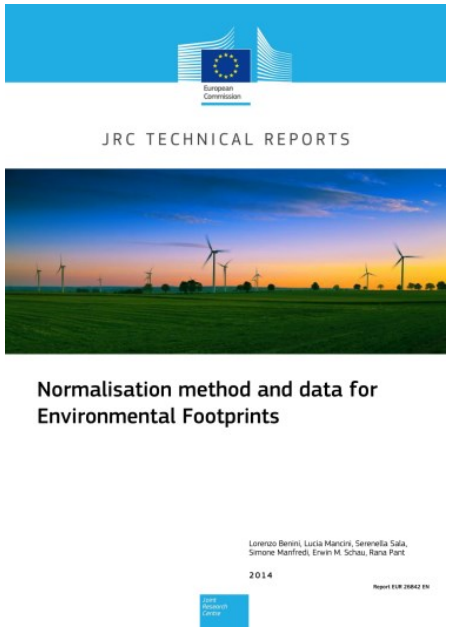
- 6 steps
  - Mandatory
    - Impact categories
    - Classification
    - Characterisation
  - Optional
    - Normalisation
    - Grouping
    - Weighting

3. Impact assessment: normalisation

- Goal = to express results comparing to a reference
- Reference
  - Impact category results for all activities of a region per inhabitant during one year

Table 26 Normalisation factors (NF) for EU-27 (2010) using domestic inventories

Impact category	Unit	Domestic	Normalisation Factor per Person (domestic)	Overall Robustness
Climate change	kg CO_2 eq.	4.60E+12	9.22E+03	Very High
Ozone depletion	kg CFC-11 eq.	1.08E+07	2.16E-02	Medium
Human toxicity - cancer effect	CTUh	1.84E+04	3.69E-05	Low
Human toxicity- non -cancer effect	CTUh	2.66E+05	5.33E-04	Low
Acidification	mol H^+ eq.	2.36E+10	4.73E+01	High
Particulate matter/Respiratory Inorganics	kg $PM_{2.5}$ eq.	1.90E+09	3.80E+00	Very High
Ecotoxicity for aquatic fresh water	CTUeq.	4.36E+12	8.74E+03	Low
Ionising radiations – human health effects	kBq U^{235} eq.	5.64E+11	1.13E+03	Medium
Photochemical ozone formation	kg NMVOC eq.	1.58E+10	3.17E+01	Medium
Eutrophication - terrestrial	mol N eq.	8.76E+10	1.76E+02	Medium
Eutrophication - freshwater	kg P eq.	7.41E+08	1.48E+00	Medium to Low
Eutrophication - marine	kg N eq.	8.44E+09	1.69E+01	Medium to Low
Land use	kg C deficit	3.74E+13	7.48E+04	Medium
Resource depletion - water	m^3 water eq.	4.06E+10	8.14E+01	Medium to Low
Resource depletion - mineral, fossil & renewable	kg Sb eq.	5.03E+07	1.01E-01	Medium



- Allows to measure the relative magnitude of environmental impacts (ranking)

3. Impact assessment

- 6 steps
  - Mandatory
    - Impact categories
    - Classification
    - Characterisation
  - Optional
    - Normalisation
    - Grouping
    - Weighting

3. Impact assessment: grouping

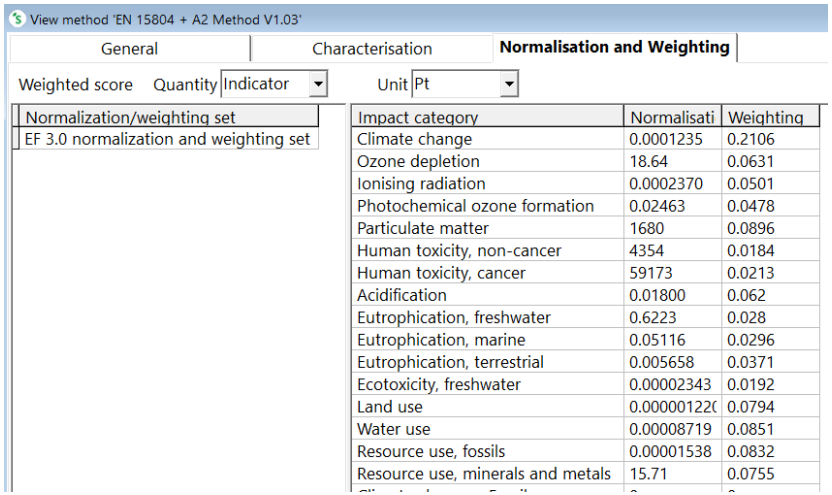
- Goal = Classify categories in general category
- Depends on methods
  - Carcinogens substances, summer smog, etc. → Human health
  - Fossil fuels resources, mineral resources → Resources

3. Impact assessment

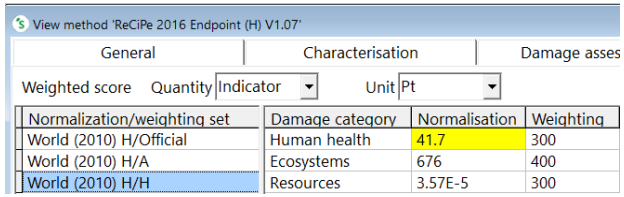
- 6 steps
  - Mandatory
    - Impact categories
    - Classification
    - Characterisation
  - Optional
    - Normalisation
    - Grouping
    - Weighting

3. Impact assessment: weighting

- Forbidden item by the ISO standards when results are used for a publicy comparison
- BUT... evolution and used by TOTEM and PEF (EF 3.0) (cf. standardisation by JRC)

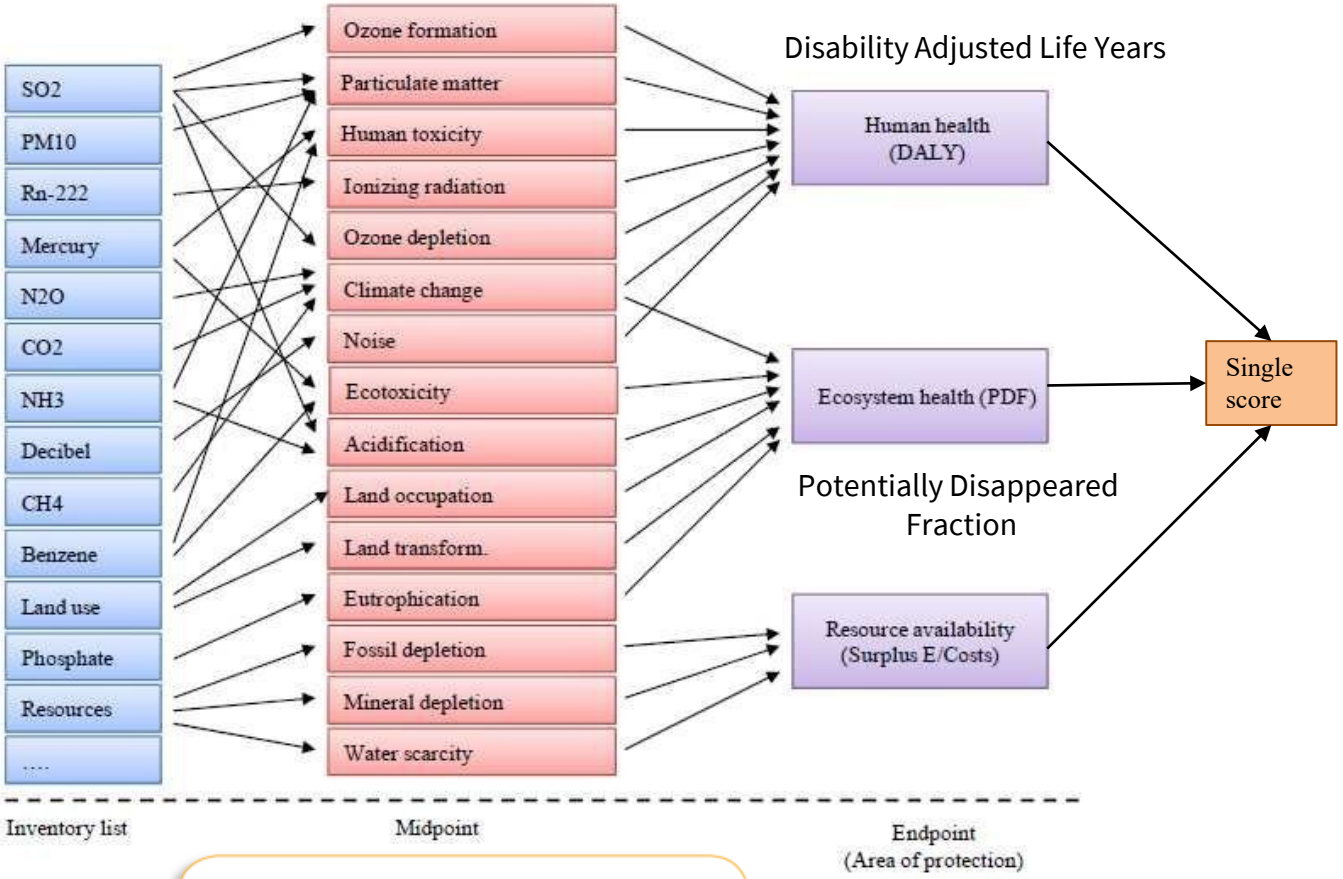


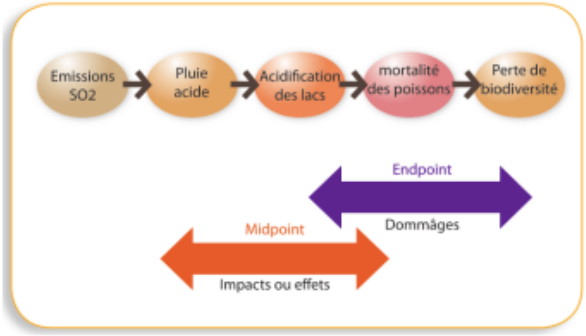
- Based on value choices
- Subjectivity!
- Obtention of a single score



High score ⇒ important environmental impact

3. Grouping/Weighting: MP & EP





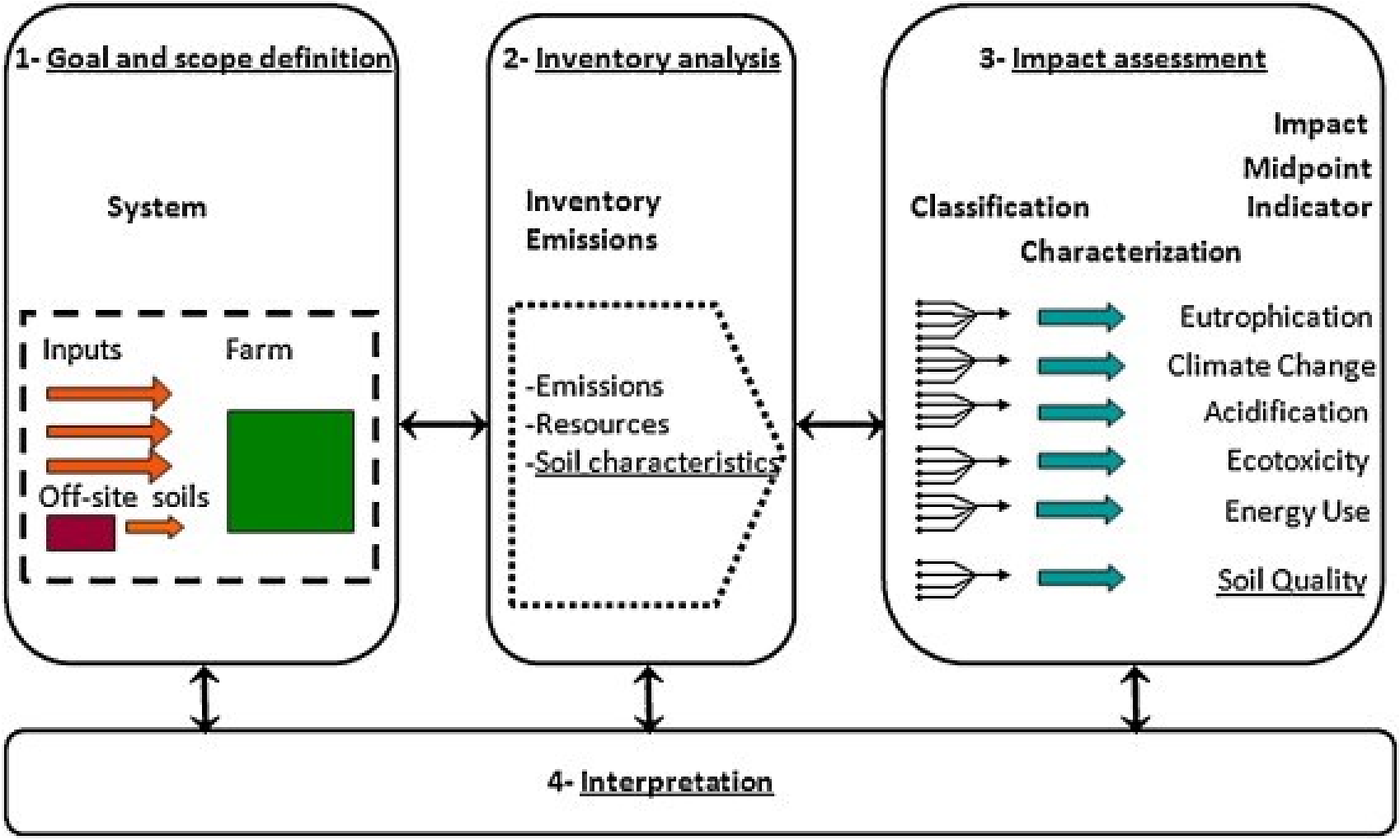
Level of characterisation

Scientific robustness

https://www.researchgate.net/figure/List-of-impact-categories-for-characterization-at-midpoint-and-endpoint-level-5_fig2_326418521

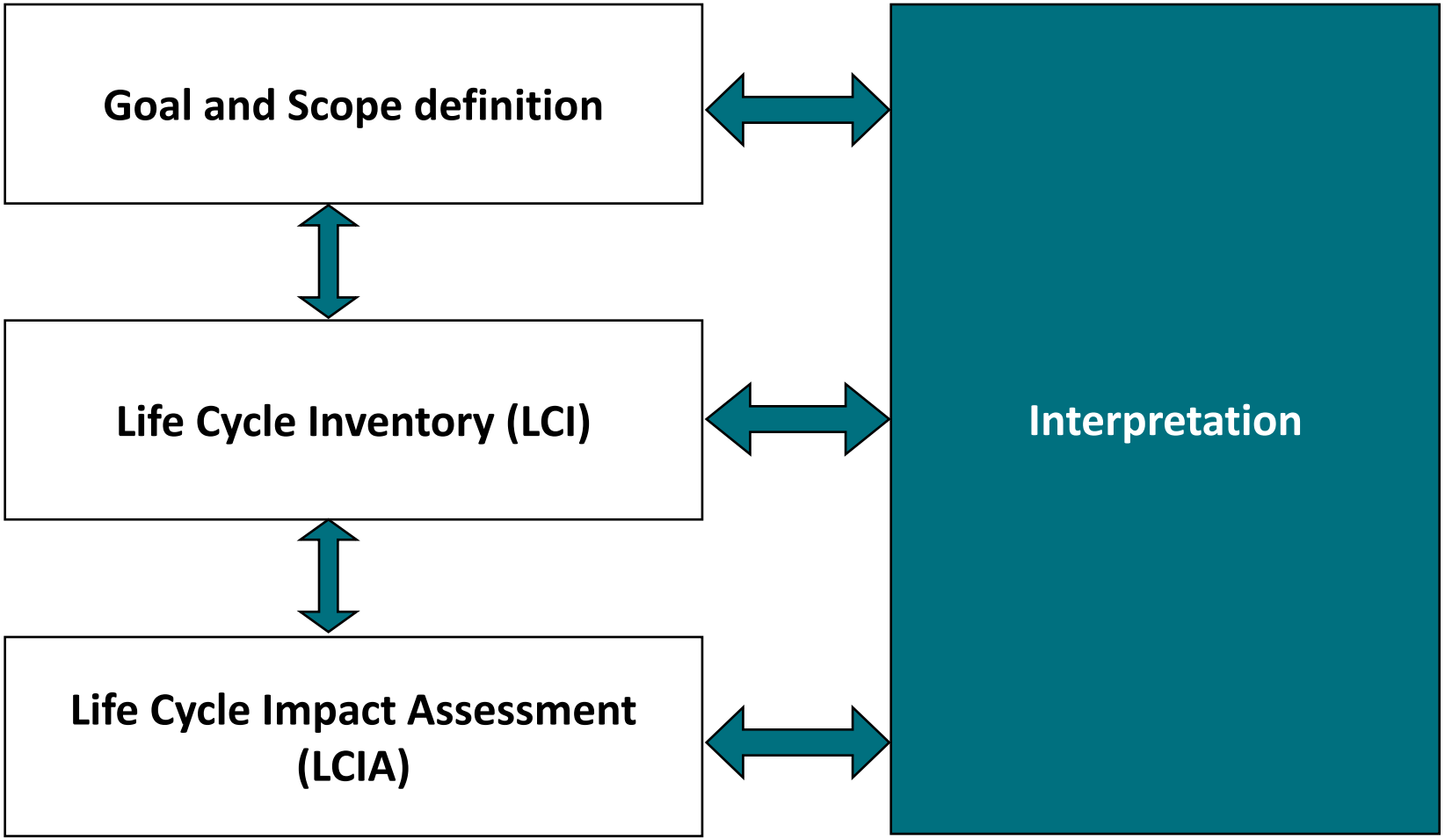
Eggermont, D. (2013). Méthodes d ' analyse environnementale - Analyse de cycle de vie , Bilan CO2 , Empreinte, 30.

3. Impact assessment: wrap up



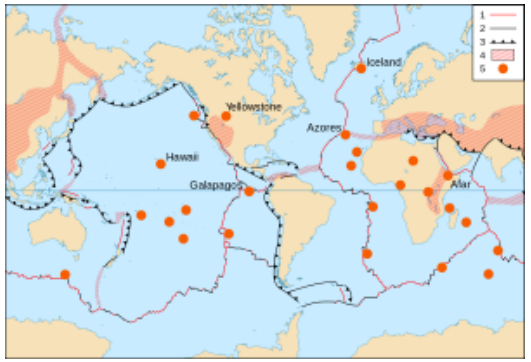
Four stages of an LCA study

- Defined by ISO 14040 – 14044 standards



4. Results interpretation

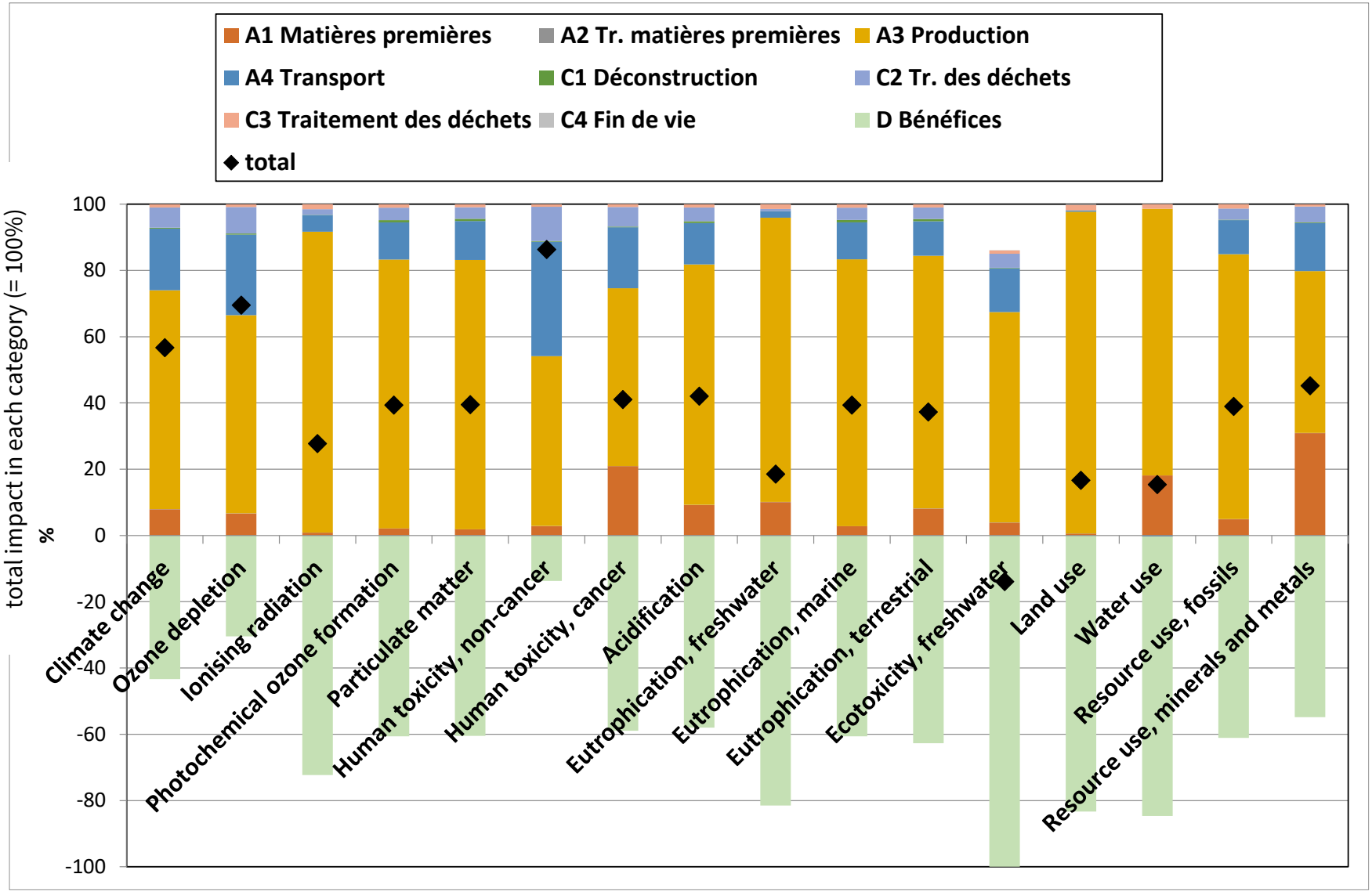
- Identification of significant results
  → ranking of categories, steps, key consumptions and/or emissions, ...
- ⇒ Hotspots



- Verification: identification of potential issues
  - Check completeness, sensitivity and consistency for theses issues
- Limitations explanation
  - **Transparency**, hypotheses, ...
- Conclusions and recommendations
- Expertise required!

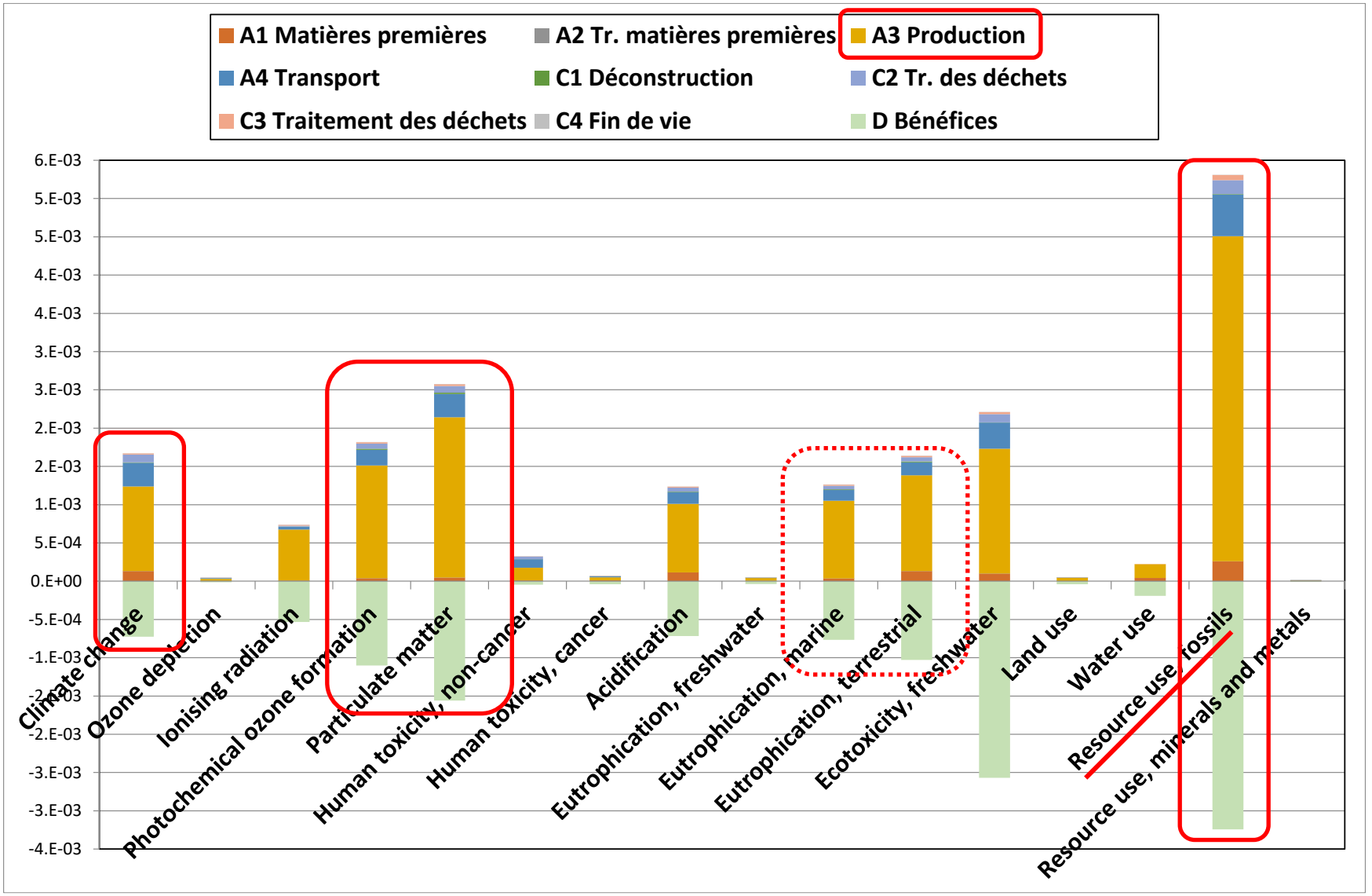
3. Evaluation - 4. Interpretation

FU = 1 m^2 of cobbles - **Characterisation** – EN15804+A2:2019



3. Evaluation - 4. Interpretation

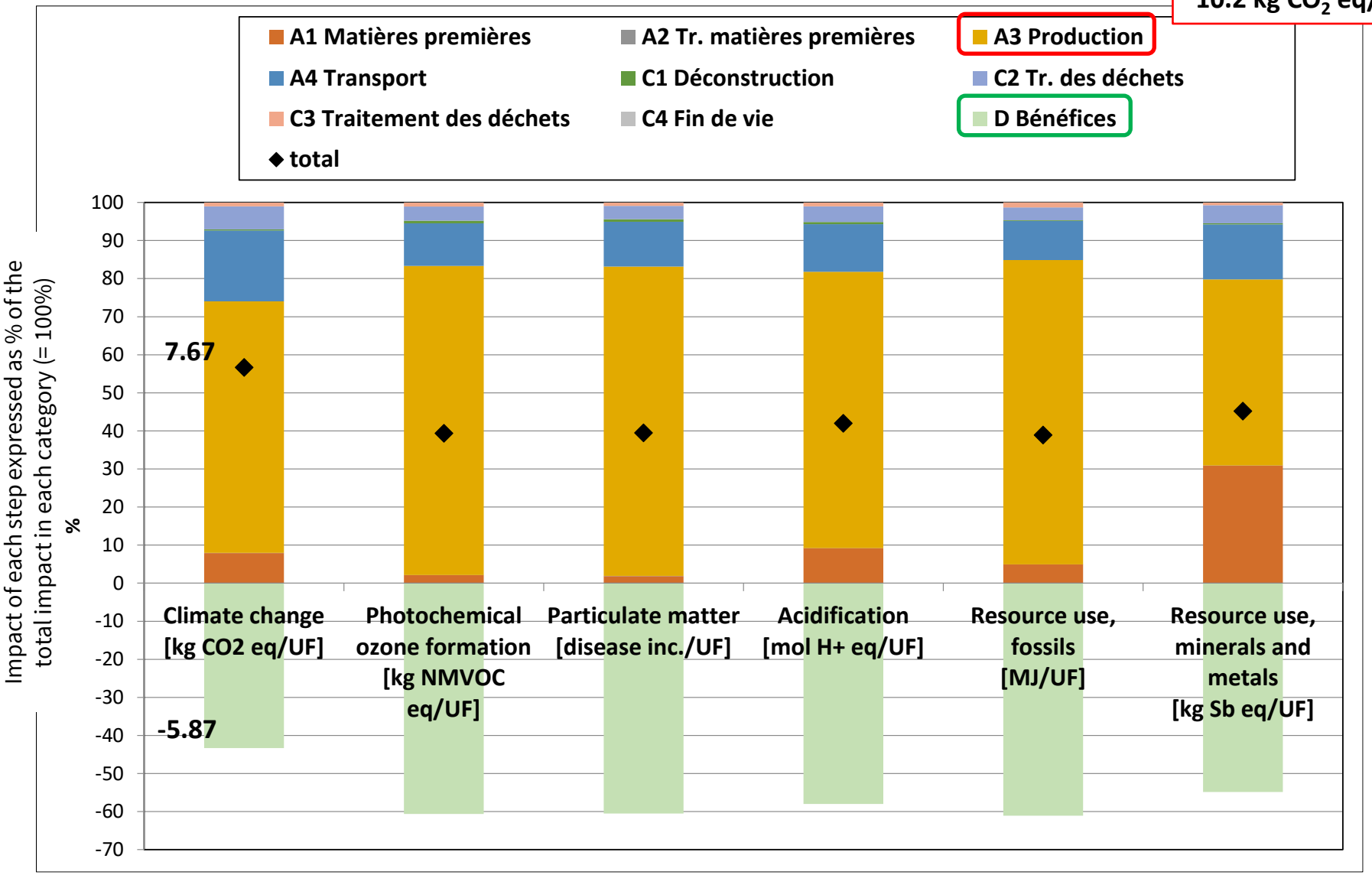
FU = 1 m^2 of cobbles - **Normalisation** – EN15804+A2:2019/EF 3.0



3. Evaluation - 4. Interpretation

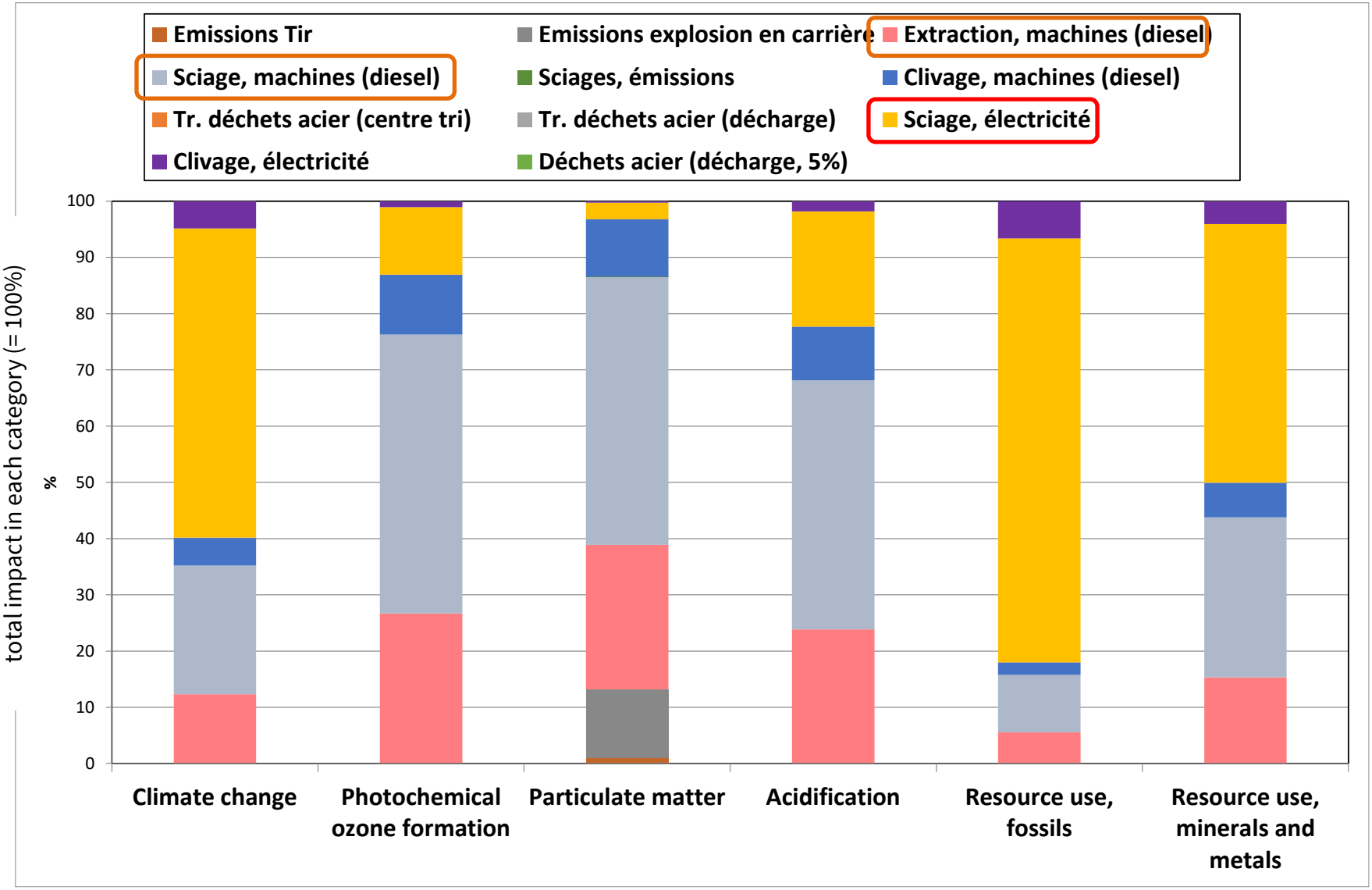
FU = 1 m² of cobbles - **Characterisation** – EN15804+A2:2019

A1-A3
10.2 kg CO_2 eq/FU



3. Evaluation - 4. Interpretation

FU = 1 m^2 of cobbles - **Characterisation Production A3** – EN15804+A2:2019



Conclusions – Sandstone cobbles

- Most impacting step: production of the cobbles (A1-**A3**)

- Most impacted categories
  - Resource use - fossils (RU-F)
  - Particulate matters (PM)
  - Photochemical ozone formation (POF)
  - Climate change (CC - GWP)

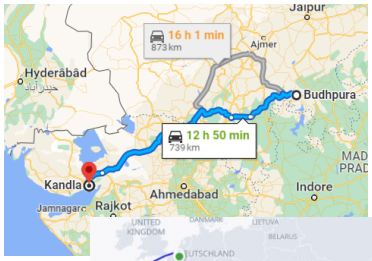
- A3: electricity (sawing) & diesel (quarry work, sawing)

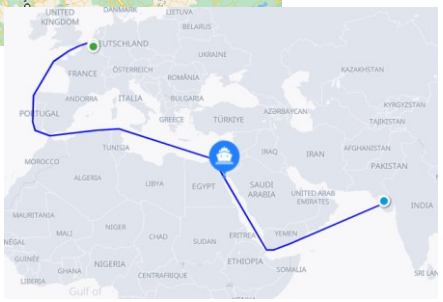
➡ Renewable electricity / on site production

- D: important benefit thanks to the reuse (85%) and recycling (as natural aggregates) of the cobbles

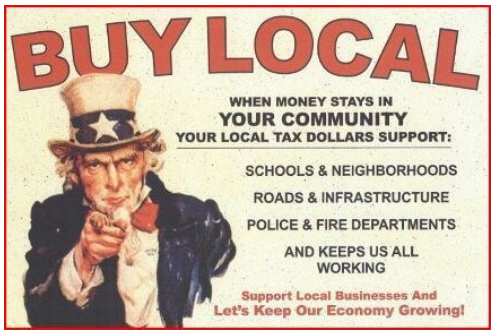
Discussion – Sandstone cobbles

- Transport (to client)? (A4)
- Default value for B-EPD
  - Lorry ⇒ **GWP = 2.52 kg CO_2 eq/FU**





- Inde (Rajastan) : concurrent (NB : quality?)
  - Lorry/Container ship/ (~ 740/11 500 km) / Lorry
    ⇒ **GWP = 42.25 kg CO_2 eq/FU**
  - + Electricity mix!
    Belgium : 0.248 kg CO_2 eq/kWh
    Inde (Eastern) : 1.83 kg CO_2 eq/kWh / Inde (Western) : 1.63 kg CO_2 eq/kWh



DNSH

- = Do Not Significant Harm
- EU (green) taxonomy

CLIMATE CHANGE MITIGATION

CLIMATE CHANGE ADAPTATION

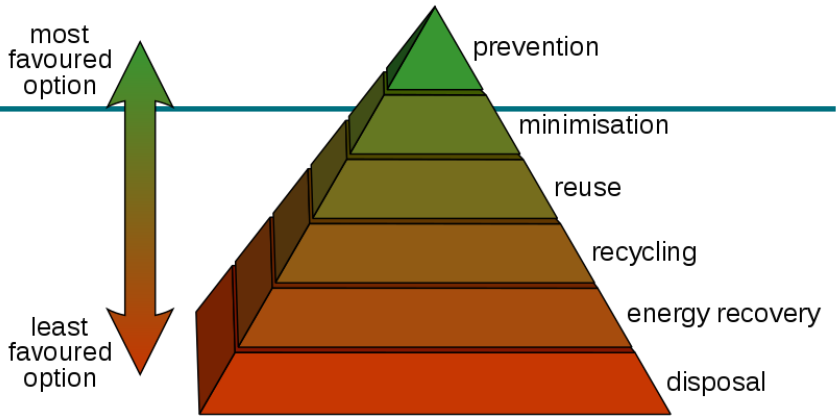
SUSTAINABILITY AND PROTECTION OF WATER AND MARINE SOURCES

TRANSITION TO CIRCULAR ECONOMY

POLLUTION AND PREVENTION CONTROL

PROTECTION AND RESTORATION OF BIODIVERSITY AND ECOSYSTEMS

Reversibility

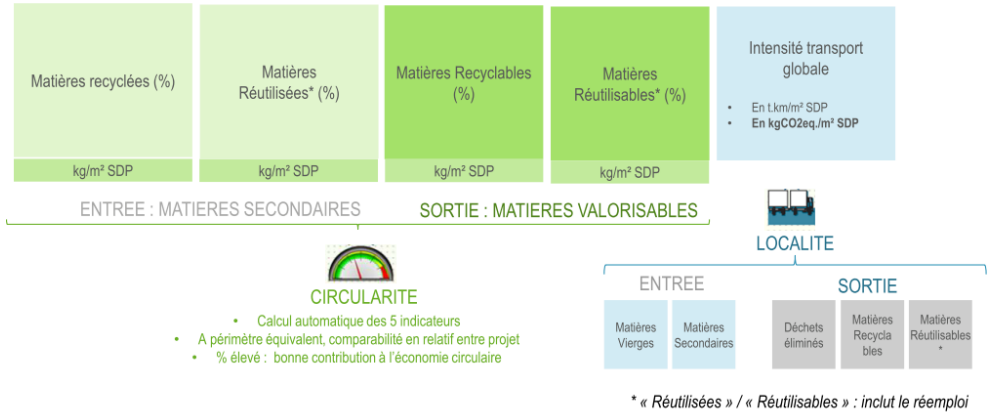


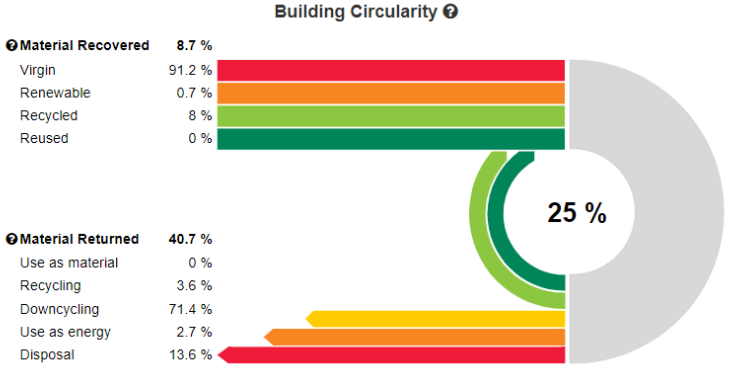
INFORMATIONS ADDITIONNELLES SUR LA RÉVERSIBILITÉ

Description	Type of fixing	Level of reversibility	Simplicity of disassembly	Speed of disassembly	Ease of handling (size and weight)	Robustness of material (material resistance to disassembly)	Comment
Describe to what element or other product the product is connected to at building level (e.g. wooden frame, metal frame, brickwork, ...)	Describe the ancillary material and way of connecting. One line per way of connecting. See table below for options.	Indicate the level of reversibility based on the table below **per type of fixing**. – Reversible connections – Reversible connections with light repairable damage – Reversible connections with non-repairable damage – Non reversible connections	per type of connection, choose from – simple – no specific dismantling tools required – Simple – requires the use of specific though common tools – Simple, but collecting the material is a bit more intensive (ex. bulk material) – More complex - requires specific tools and/or skills	Per type of connection choose from - speedy disassembly - Speedy, lightweight material – Speedy, material loosely laid / in bulk – Rather speedy disassembly – Speed of disassembly varies from quick to slow depending on element dimensions – Speed of disassembly varies from quick to slow depending on element dimensions and number of fixations per distance unit – Disassembly is slow (due to dimensions, weight and/or fixation method)	Per type of connection choose from – Easy to manipulate (by hand (small size and limited weight): one worker should be sufficient – Material easy to manipulate by hand, one to two workers required depending on dimensions – Can be handled manually, but due to size, weight and/or tools two or more workers are required – At least two workers and additional specific equipment are needed – Comes in a manipulable size, but the whole is rather heavy to manipulate.	Per type of connection choose from – The material resists well during disassembly – Disassembly is possible but should be done carefully in order not to generate any damage – Material with a long lifespan, disassembly is possible but the material should be handled with care in order to prevent damaging it – Disassembly is possible but can cause damage to the material due to the type of assembly or fixing used. – Disassembly is possible but will likely cause damage to the material due to the type of assembly or fixing used – Disassembly is possible but will likely cause damage to the material due to the type of assembly or and tools used and the presence of additional layers. –	
Pavés posés sur le sol en tant que revêtement, sur une couche de sable stabilité et avec un joint en mortier de ciment	Loose laid but with cement mortar joints (Rjoint < Rmat) (Pose libre mais avec joints en mortier de ciment (Rjoint < Rmat))	Reversible connections with light repairable damage (Connexions réversibles avec dommages léger : nettoyage des pavés après dépose)	Simple – no specific dismantling tools required (Simple – pas d'outil de démontage spécifique nécessaire))	Rather speedy disassembly (Démontage assez rapide)	Easy to manipulate (by hand (small size and limited weight): one worker should be sufficient (Facile à manipuler (à la main) (petite taille et poids limité) : un seul ouvrier devrait suffire)	The material resists well during disassembly (Le matériau résiste très bien durant de démontage)	Rjoint < Rmat cf. grès plus dur que le mortier (option non disponible dans la table de référence) Les pavés en grès sont très durs et résistent très bien au démontage (85% de réutilisation possible – voir D)

Circularity index

Résultats : Indicateurs de circularité et de localité calculés automatiquement





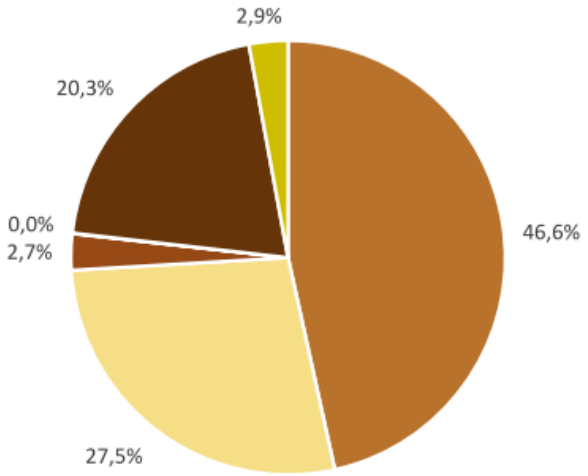
https://www.oneclicklca.com/fr/construction/building-circularity/

Electricity mix 2019

2.2. Production brute d'électricité en 2019

Électricité		TWh
Nucléaire		43,5
Gaz naturel		25,7
Combustibles fossiles solides et gaz sidérurgiques		2,5
Produits pétroliers		0,0
Énergies renouvelables		19,0
Autres sources*		2,7
Total		**93,5**

*Les autres sources comprennent l'hydroélectricité pompée, la chaleur de récupération, les déchets non renouvelables et autres.



EN15804+A2:2019

Uranium = Ressource use, fossils

ReCiPe (2016)

Uranium = Mineral resource scarcity

(Fossiles = "C fossile" only)

SPF Économie – Energy key data, juillet 2020

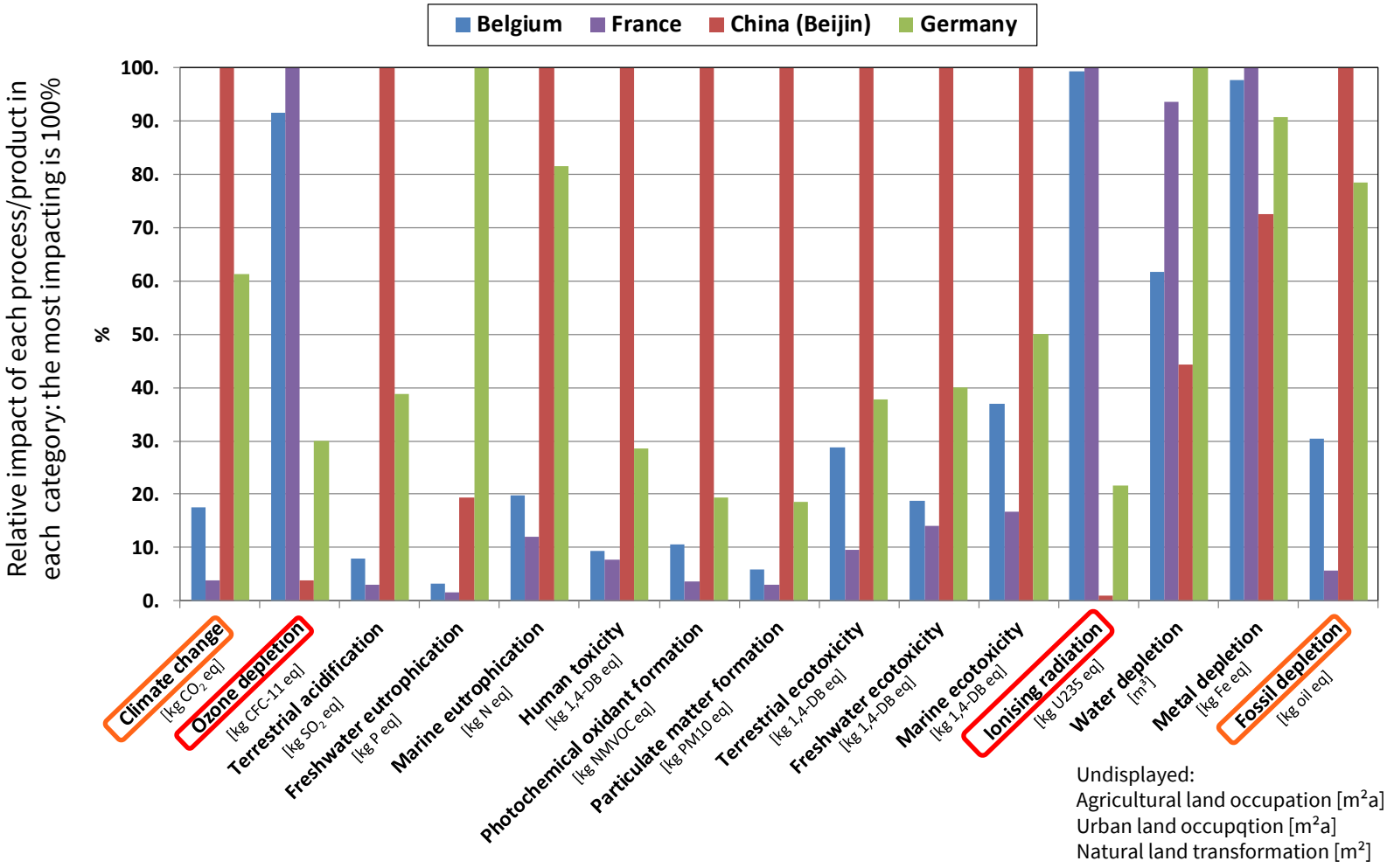
Influence of grid mix (2014, EI 3.4)

Source (%)	Belgium	France	China(Beijin)	Germany
Coal	3.7	1.7	93.4	19.4
Lignite				27.5
Hydraulic	2.7	13.1	3.0	5.0
Natural gas	16.1	0.6	2.3	1.7
Nuclear	56.3	80.3	0.0	18.2
Oil		0.1	0.1	0.2
Wind	8.1	3.1	1.2	11.3
Cogen Biogas	0.5	0.1		6.2
Cogen Natural gas	10.0	0.9		5.6
Cogen Coal				2.4
Cogen Lignite				0.8
Cogen Wood	2.6	0.1		1.5
Blast furnace gas			0.1	

Fossil fuel **Renewable**

Grid mix (2014) – ReCiPe 2008

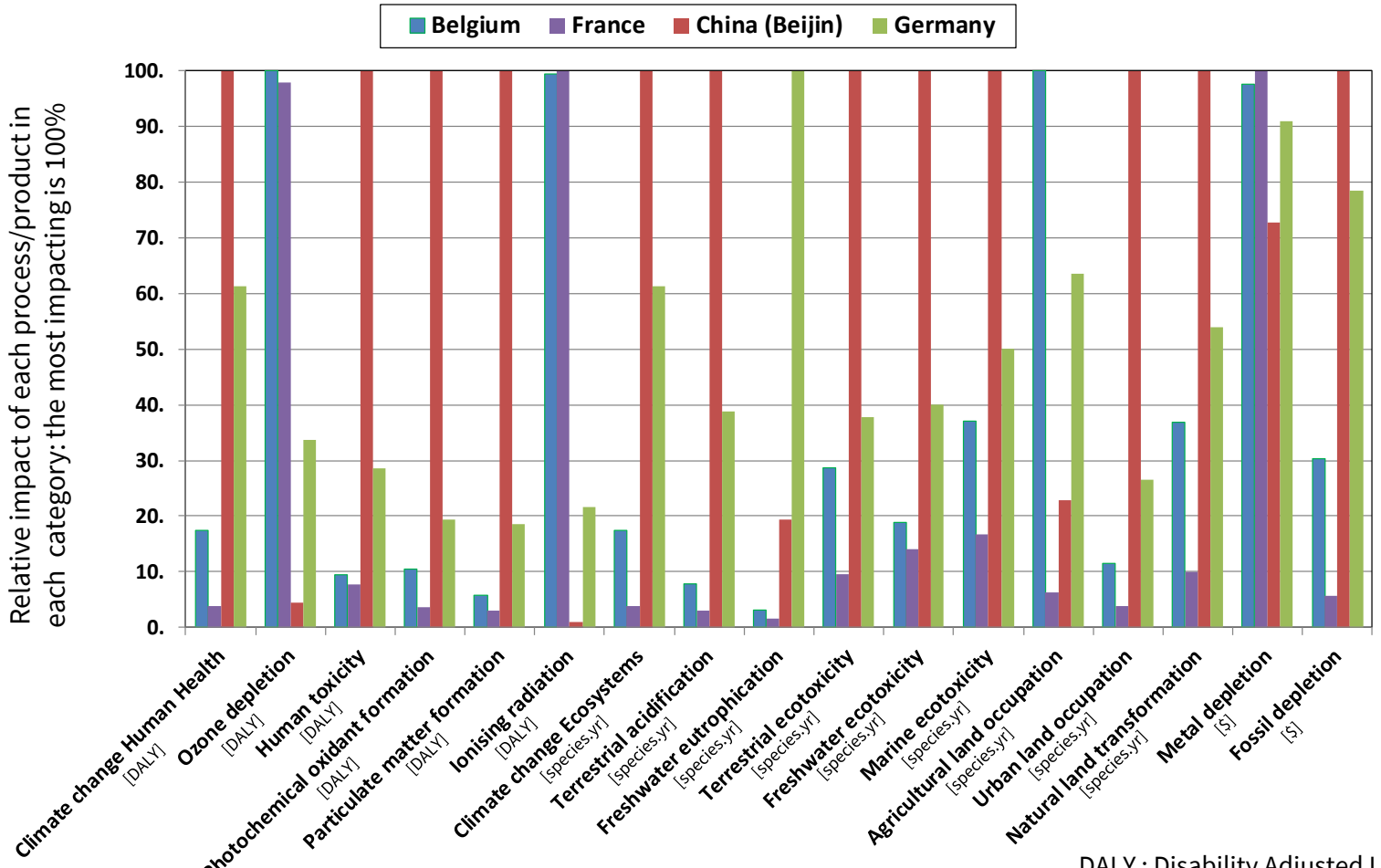
- Characterisation / Midpoint



Undisplayed:
Agricultural land occupation [m^2a]
Urban land occupqtion [m^2a]
Natural land transformation [m^2]

Grid mix (2014) – ReCiPe 2008

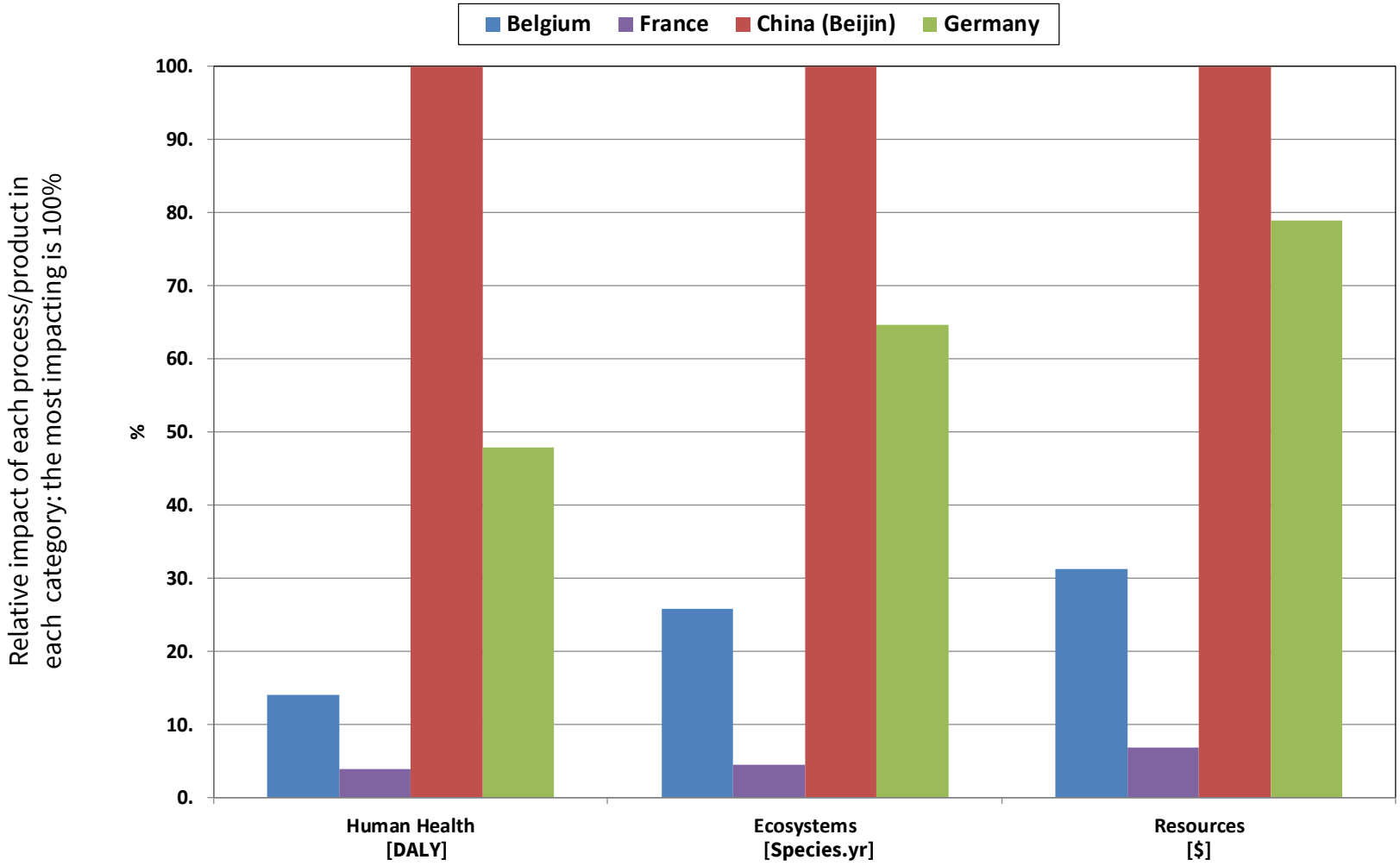
- Characterisation by impact category / Endpoint



DALY : Disability Adjusted Life Years
One DALY = one lost year of "healthy" life

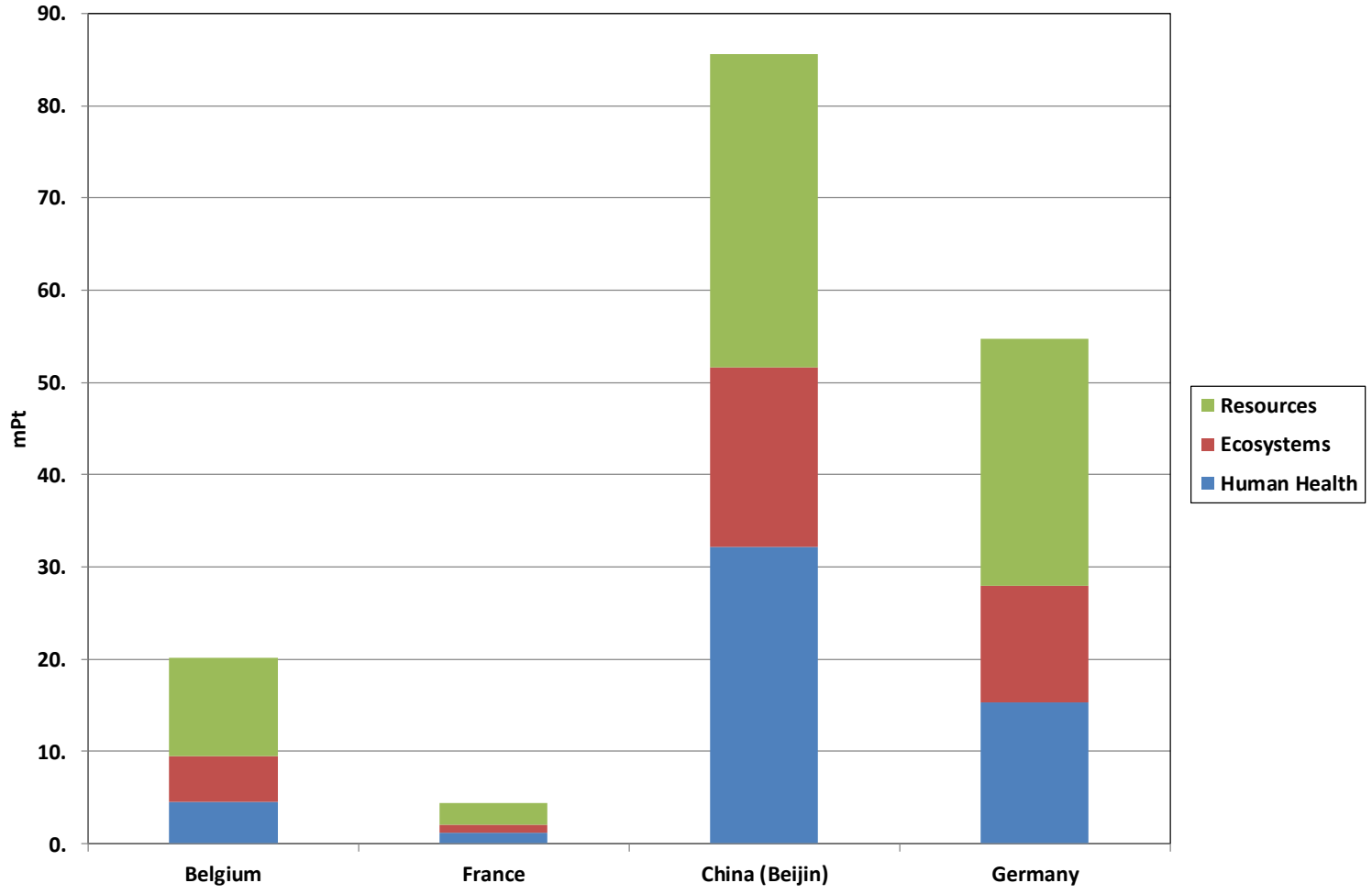
Grid mix (2014) – ReCiPe 2008

- Characterisation by damage category / Endpoint



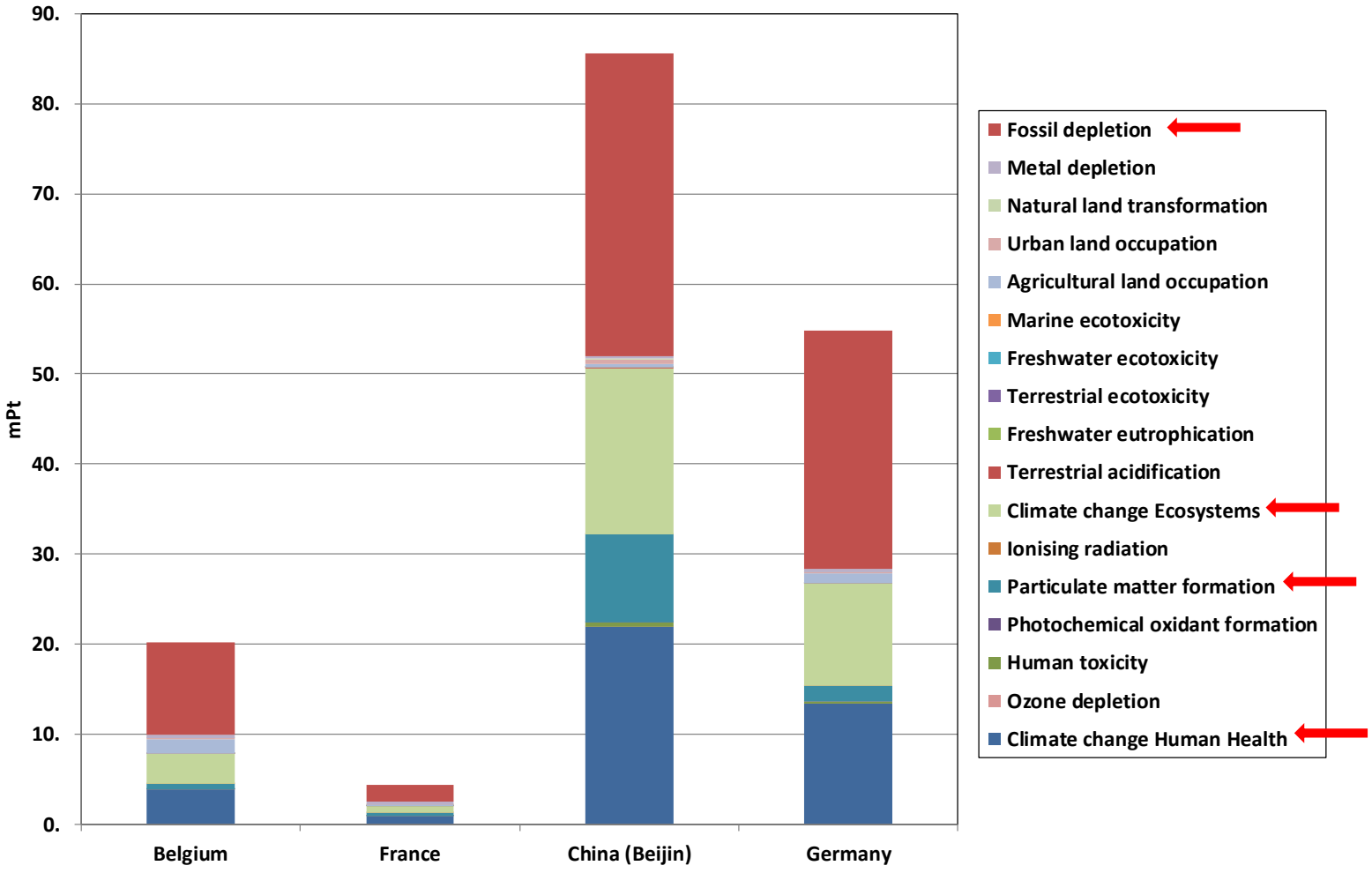
Grid mix (2014) – ReCiPe 2008

- Single score by damage category / Endpoint

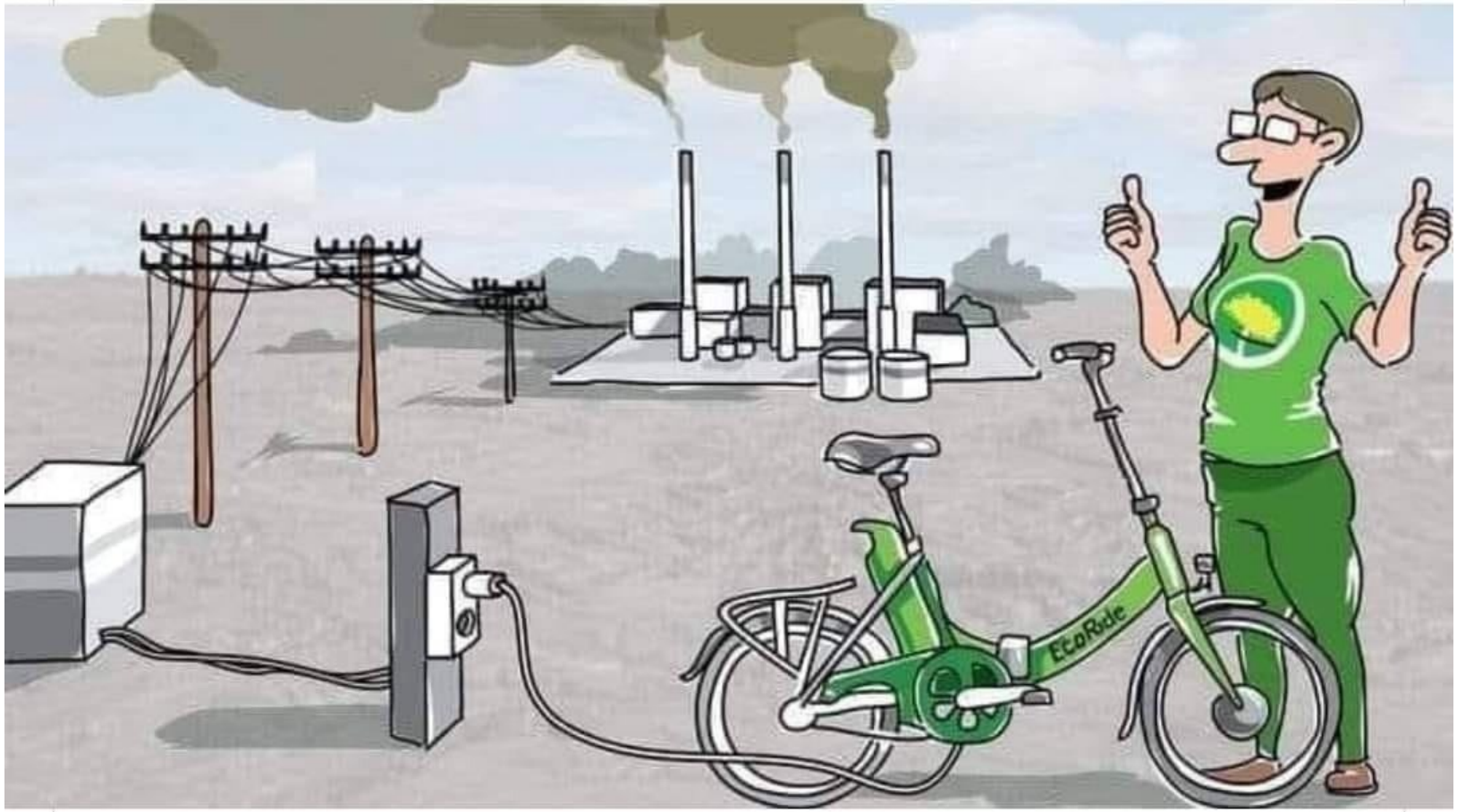


Grid mix (2014) – ReCiPe 2008

- Single score by impact category/ Endpoint



Grid mix (2014) – ReCiPe 2008



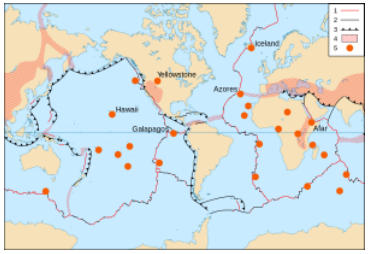
Agenda

- Context
- What is Life cycle assessment (LCA)?
- How to make an LCA?
  + example(s)
- Environmental communication
- Conclusion

Conclusion

LCA helps to answer the questions

- **What** is the impact of my product on environment?
- **Which** steps are the most impacting?
- **Which** are the key parameters?
- **What** are the limits of the study?



- Where and how can I act to improve my product/process to reduce its impacts?

- What are the expected results?

Conclusion

- LCA = tool for determining the environmental impacts of a product (service, process)
  - Framed by standards (ISO, EN)
  - Scientifically based (models, JRC)
  - As objective as possible (transparency requirement, specific standards - PCR)
- To be handled with care
  - Complexity of end of life management / recycling
  - Choice of allocations / attributions
  - ➡ Transparency in assumptions and choices made (models, data, ...)
  - ➡ Validation by external experts
- Requires good data and databases

Limits of LCA

- Impact $\leftrightarrow$ Characterization factor (CF)
  (for a substance in inventory)

- No CF $\Rightarrow$ no impact!
- Not in database and/or not in inventory $\Rightarrow$ no impact!

➡ Importance of collaboration and data sharing with (technical) partners in a project

Limits of LCA

- Model: responsability of developpers
- Inventory: responsability of practitioners

- LCA: fairly "young" science-based discipline
- In development

- Need of standardisation
- International conferences, working groups, JRC, CEN/TC, ...

Conclusion


Pulco citronnade
Pulco
NUTRI-SCORE
NOVA SCORE
4
SYNTHESE
INGREDIENTS
NUTRITION
MES IMPACTS
SANTE
6
SOCIAL
0
PLANETE
4


BE
CAREFUL
THIS MACHINE
HAS NO BRAIN
USE YOUR OWN

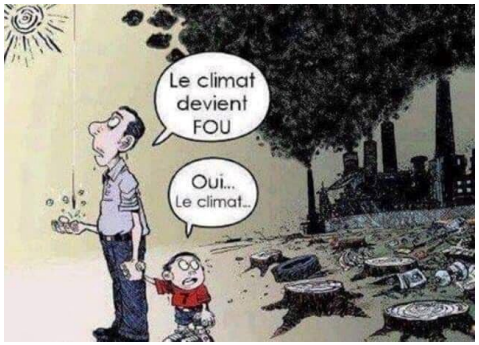
Take home message

Life cycle assessment (LCA) is ...

- A complex tool but
  - Quantitative & Objective
  - Multi-criteria (including climate change)
  - Multi-stage

- Decision support tool ≠ decision tool

- A tool for Improvement - what is – and Ecodesign - what will be ...



« We do not inherit the earth from our fathers, we are borrowing it from our children… »
Antoine de Saint-Exupéry