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Centre interuniversitaire de recherche sur le cycle de vie des produits, procédés et services

Week 2

Goal and scope according to ISO, function, functional unit, reference flows, product system and system boundary

POLYTECHNIQUE MONTRÉAL

WORLD-CLASS ENGINEERING

On the agenda today

- Reminder:
  - **select/define LCA project and groups**
  - **basic concepts of the LCA framework**
- Definition of the scope of the study
  - **List of ISO 14044 elements to include in the « scope »**
  - **Functional unit**
  - **Reference flows and key parameters**
  - **Product system and process tree**
- Case studies
- Homework

Quick reminder form last week

BASIC CONCEPTS

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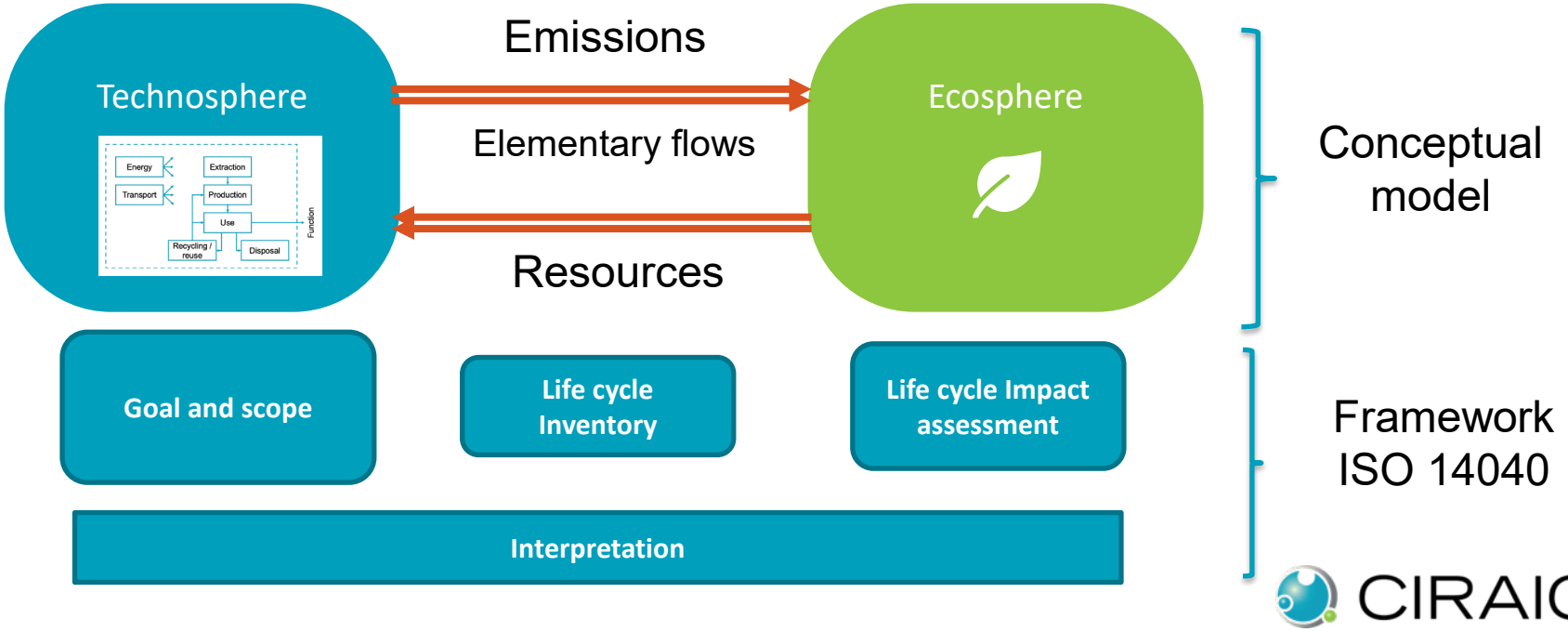
Conceptual model and framework of analysis ISO 14040

In sum, an LCA consists of…

1. **Defining the product system (activities related to a product/service)**
2. **Calculating all the exchanges between the product-system and the environment (environmental flows)**
3. **Calculating the potential environmental impacts related to these elementary flows**
4. **… without forgetting to interpret the results in relation to the goals of the study (ISO 14040)**



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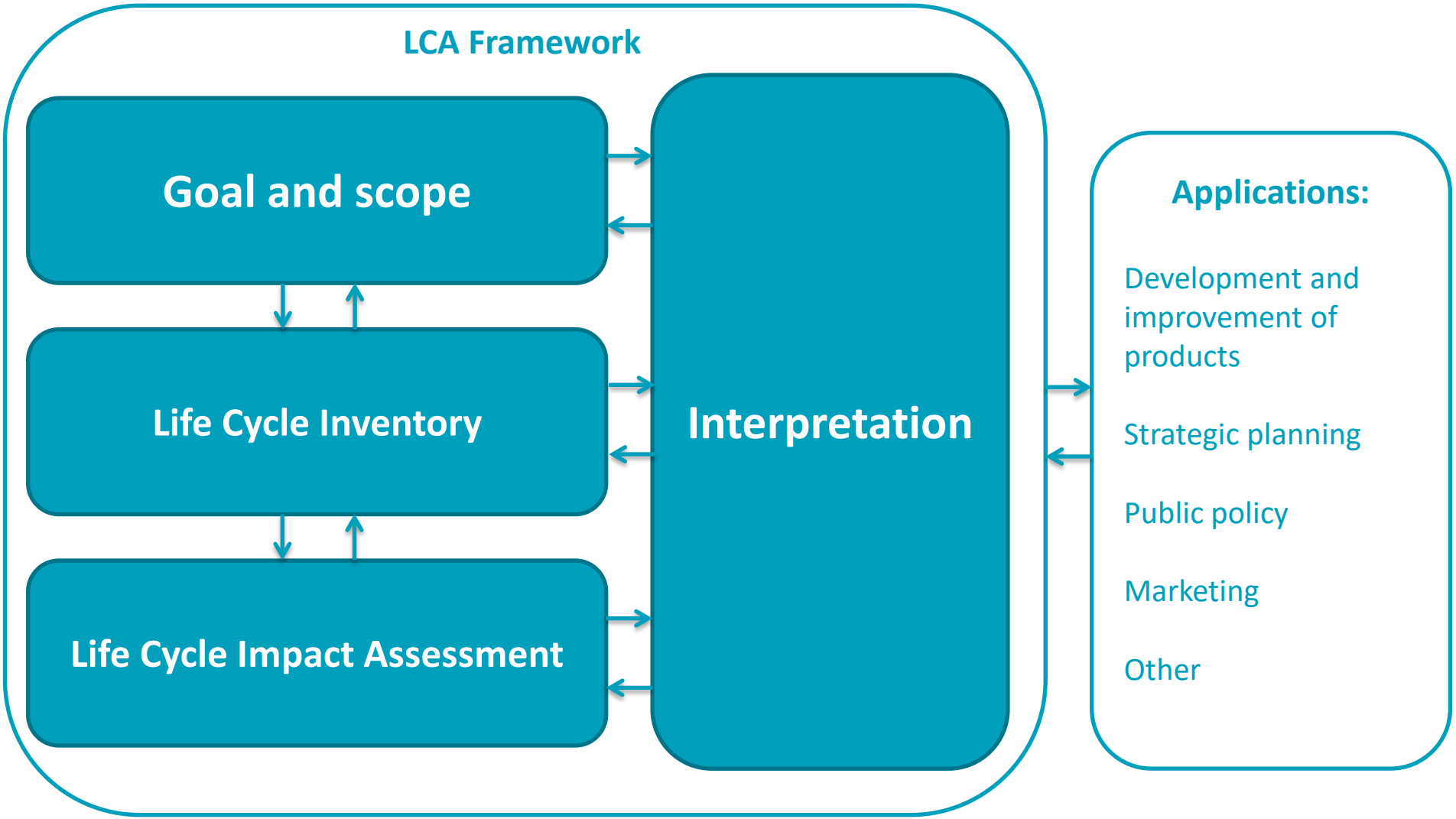
LCA Framework and applications (ISO 14040)



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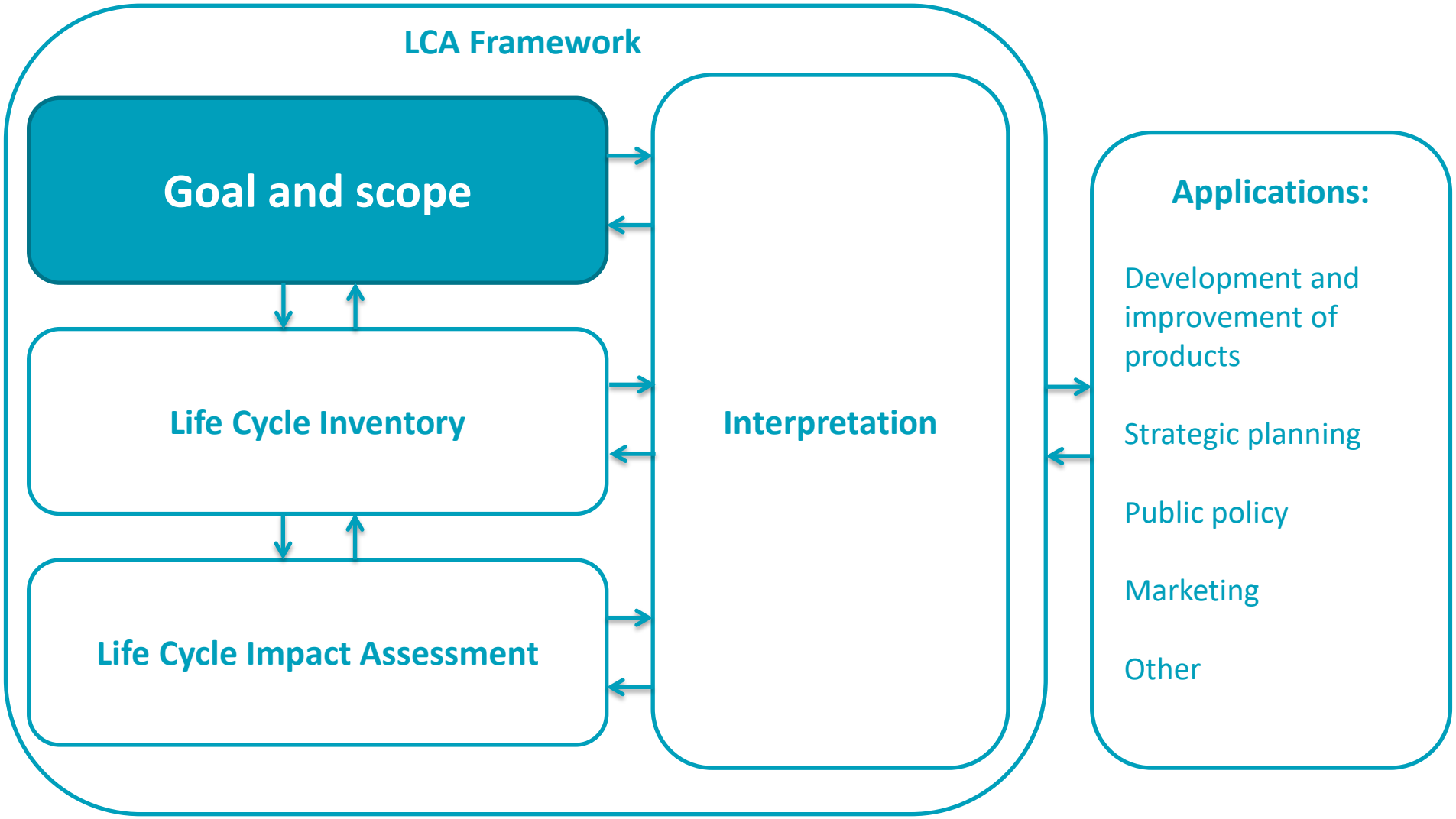
LCA Framework and applications (ISO 14040)



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Goal and scope

DEFINITION OF THE GOAL OF THE STUDY

Goal of the study:

The commissioner of the study and those executing it need to define:

Why?	For whom?	For what purpose?
the reasons for carrying out the study	the intended audience	The intended application

Defining the goal: Why - the reasons for carrying out the study

Why?

- The reasons to conduct an LCA stuyd can be multiple.

  Some example:

  - **Determine the potential environmental impacts of a product, service or technology**
  - **Identify the environmental hotspots along its whole life cycle**
  - **Compare the environmental performances of two products, services or technologies**
  - **Improve the design of a product, service or technology**
  - **Élaboration of environmental policies and/or assess the conseqences of a policy on environmental impacts**
  - **Prove the environmental superioty of a material towards an other materials**
  - **And many more…!**

Of course, the why, the whom and the what purpose are closely interconected

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Defining the goal: For whom - intended audience

- The intended audience:

To whom?

  - **Internal: the sole commissioner has access to results (e.g. engineers, designers)**
  - **« External, restricted »: the results will be disseminated to identified actors, (e.g. a supplier or a client)**
  - **Public: any interested party will have access to the results, or the result will be part of a marketing strategy.**

Will the public be "technical" or "non-technical"? Communication may need to be tailored to the target audience.

→ Third party report

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Defining the goal: For whom - intended audience

The specific case of comparative LCA to be disclosed to the public

Comparative assertion?

For this specific case:

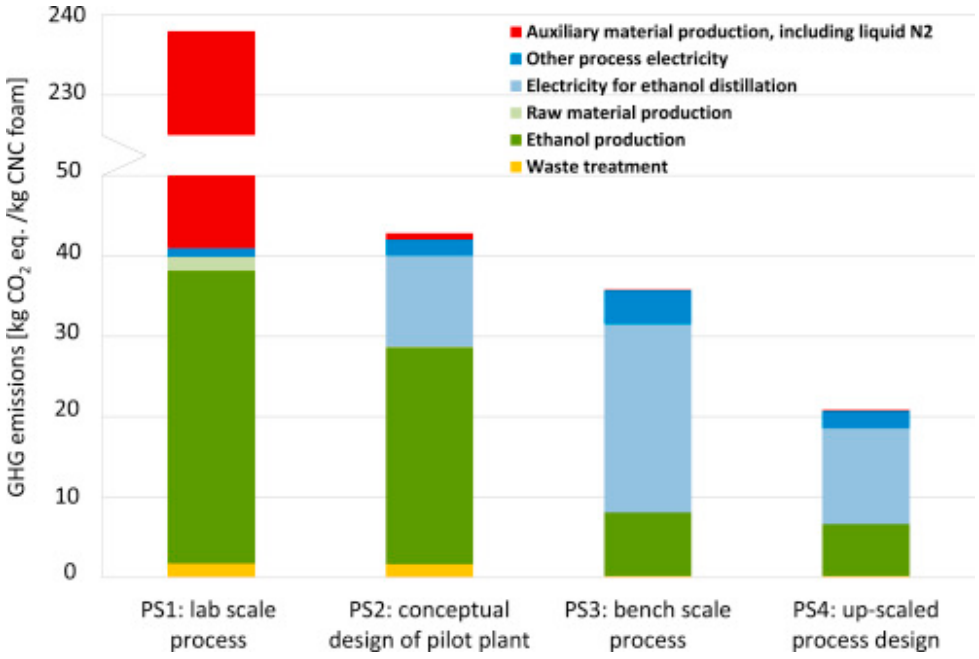
- **« environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function»**

The ISO14040 standard will need special requirements (documentation, external critical review, etc.)

Defining the goal: For what purpose - intended applications

For what purpose?

- **Improving products/services**
  - Identifying performance indicators
  - Prioritising changes to a process or product (« hot spots analysis »)
  - Ecodesign, design-for-recycling



cellulose nanocrystals (CNC) foam at different development stages

(Tan, L., et al. (2018). "Combining ex-ante LCA and EHS screening to assist green design: A case study of cellulose nanocrystal foam." Journal of Cleaner Production **178**: 494-506.)

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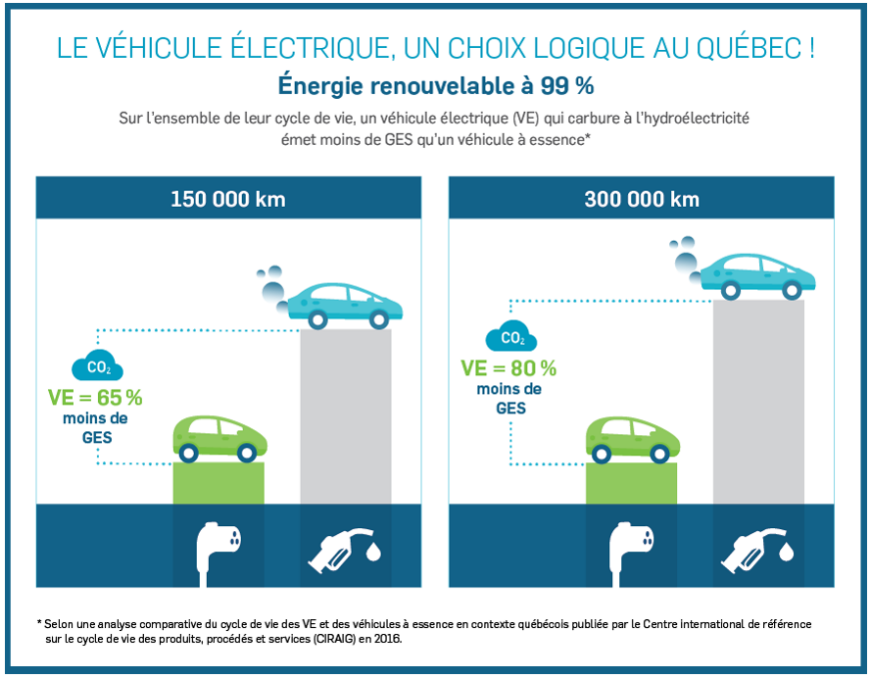
Defining the goal: For what purpose - intended applications

- **Comparison of products/services**
  - Product A vs product B,
  - Technology A vs technology B
  - Comparison to a competitor average
  - Choice of a supplier

For what purpose?



http://www.hydroquebec.com/developpement-durable/centre-documentation/acv-vehicule-electrique.html

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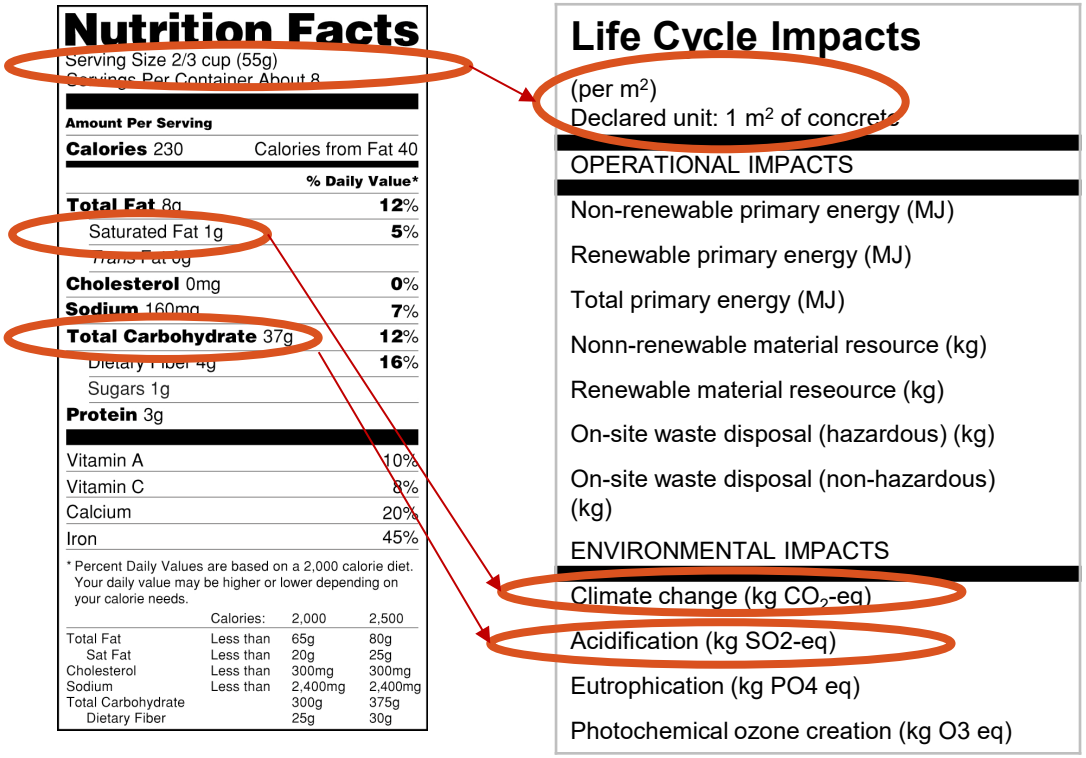
Defining the goal: For what purpose - intended applications

For what purpose?

- **Communication B2C**
  - Provide information for ecolabels
  - Communicate the environmental profile on several env. indicators »



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Defining the goal: For what purpose - intended applications

For what purpose?

- **Communication B2C**
  - Provide information for ecolabels
  - Communicate the environmental profile, on serveral env. indicators

Exemple d'étiquetage sur le marché de l'hygiène/beauté

Defining the goal: For what purpose - intended applications

- **Communication**
  - Provide information for ecolabels
  - Communicate the environmental profile, on serveral env. indicators
  - Need of Product category rules (PCR) and Environmental Product Declarations (EPD)

For what purpose?

Eurobarometer

Home | Browse all surveys | Browse by category | About Eurobarometer

Attitudes of Europeans towards building the single market for green products

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Abstract

According to this survey, most Europeans would be prepared to change their purchasing habits and buy more environmentally-friendly products, but many feel they lack information and distrust manufacturers' environmental claims. The survey also indicates that 77% of respondents are willing to pay more for environmentally-friendly products if they were confident that the products are truly environmentally-friendly. However, only 55% feel informed about the environmental impacts of the products they buy and use.

https://europa.eu/eurobarometer/surveys/detail/1048

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Defining the goal: For what purpose - intended applications

- **Communication**
  - Provide information for ecolabels
  - Communicate the environmental profile, on serveral env. indicators
  - Need of Product category rules (PCR) and Environmental Product Declarations (EPD)

For what purpose?

Green Business

Environmental Footprint methods

The European Commission has proposed the Product Environmental Footprint and Organisation Environmental Footprint methods as a common way of measuring environmental performance.

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Overview

Companies that wish to market a product as environmentally friendly in the EU face a range of choices of methods and initiatives. Without a reliable, state of the art, life cycle assessment, companies are not able to make the right decision to improve their environmental performance. This results in costs for companies, lack of clarity for consumers and potentially a missed opportunity to promote truly sustainable products that are respectful of the environment.

In December 2021, the Commission adopted a revised Recommendation on the use of Environmental Footprint methods, helping companies to calculate their environmental performance based on reliable, verifiable and comparable information. It also allows other actors (public administrations, NGOs, business partners, for example) to have access to such information. The European Commission's Joint Research Centre has been driving the scientific and technical developments to ensure robustness and impartiality.

https://green-business.ec.europa.eu/environmental-footprint-methods_en

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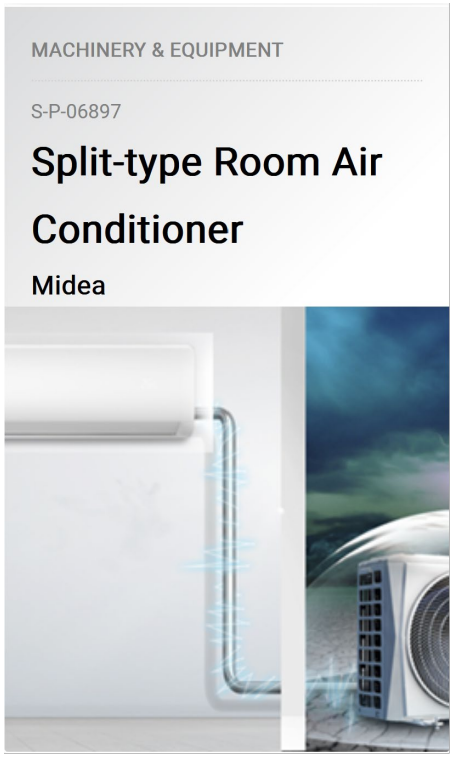
Defining the goal: For what purpose - intended applications

For what purpose?

- **Communication B2B**
  - Provide information for ecolabels
  - Communicate the environmental profile, on serveral env. indicators
  - Need of Product category rules (PCR) and Environmental Product Declarations (EPD)



Further examples
https://www.environdec.com/library

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Defining the goal: For what purpose - intended applications

For what purpose?

- **Support policy making**
  - Analysis and prospective for technologies (energy, electricity, water, waste treatment, transport, etc.)
  - Identifying groups of products to maximize the reduction of environmental impacts

641.611

Ordonnance sur l'imposition des huiles minérales (Oimpmin)

Swiss mineral oil tax regulation

du 20 novembre 1996 (Etat le 1er janvier 2017)

Le Conseil fédéral suisse,
vu la loi du 21 juin 1996 sur l'imposition des huiles minérales (Limpmin[1])[2],
arrête:

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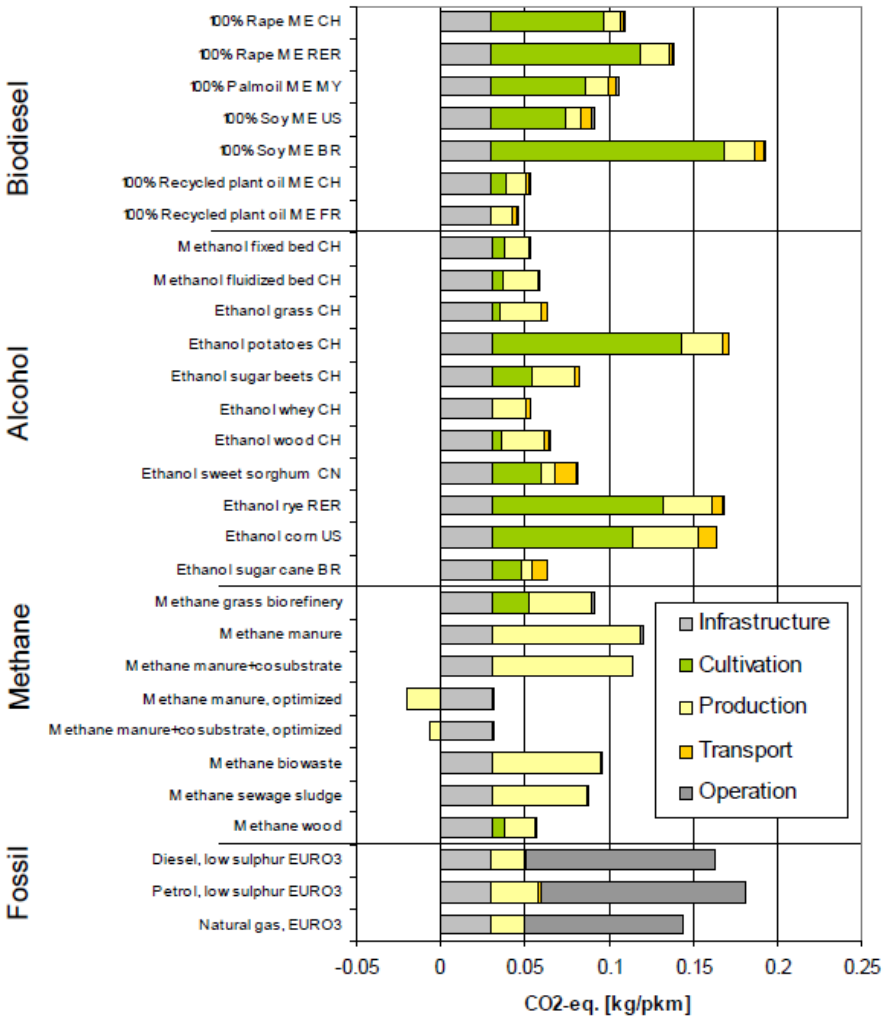
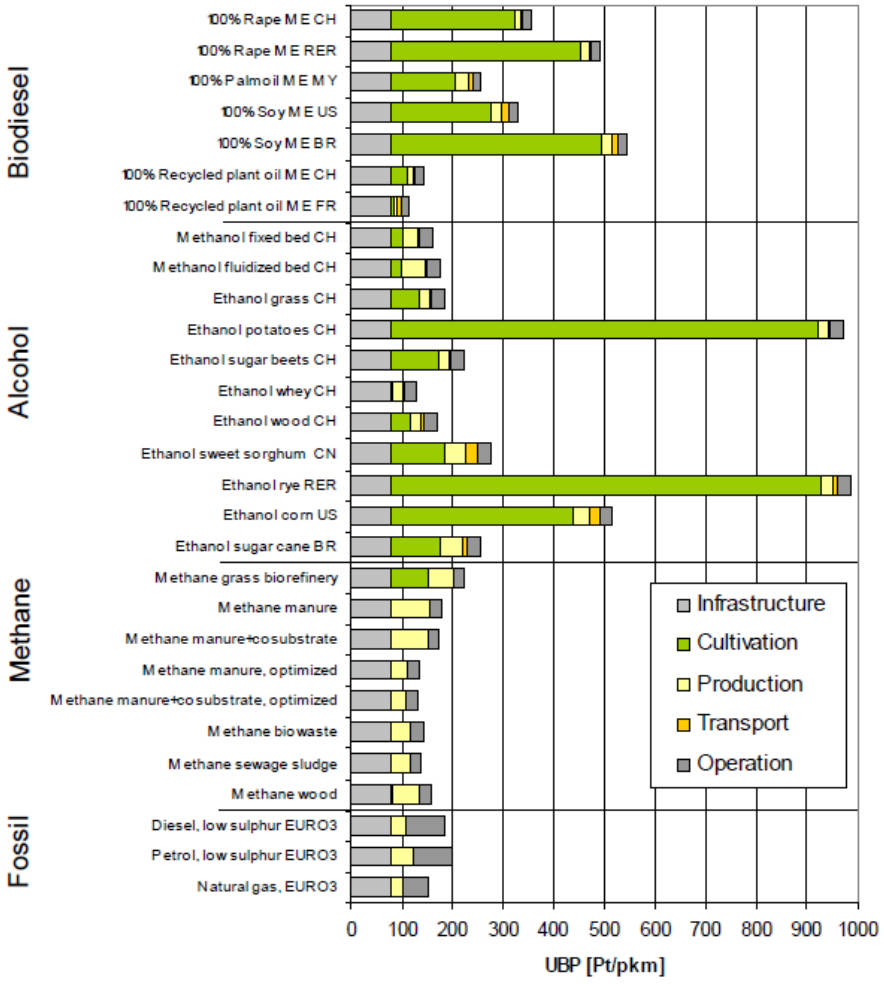
Life cycle assessment of biofuels vs. fossil fuels





(Zah, et al. 2007. Life cycle assessment of energy products: environmental impact assessment of biofuels. BFE, BAFU, BLW. https://www.osti.gov/etdeweb/servlets/purl/21208801

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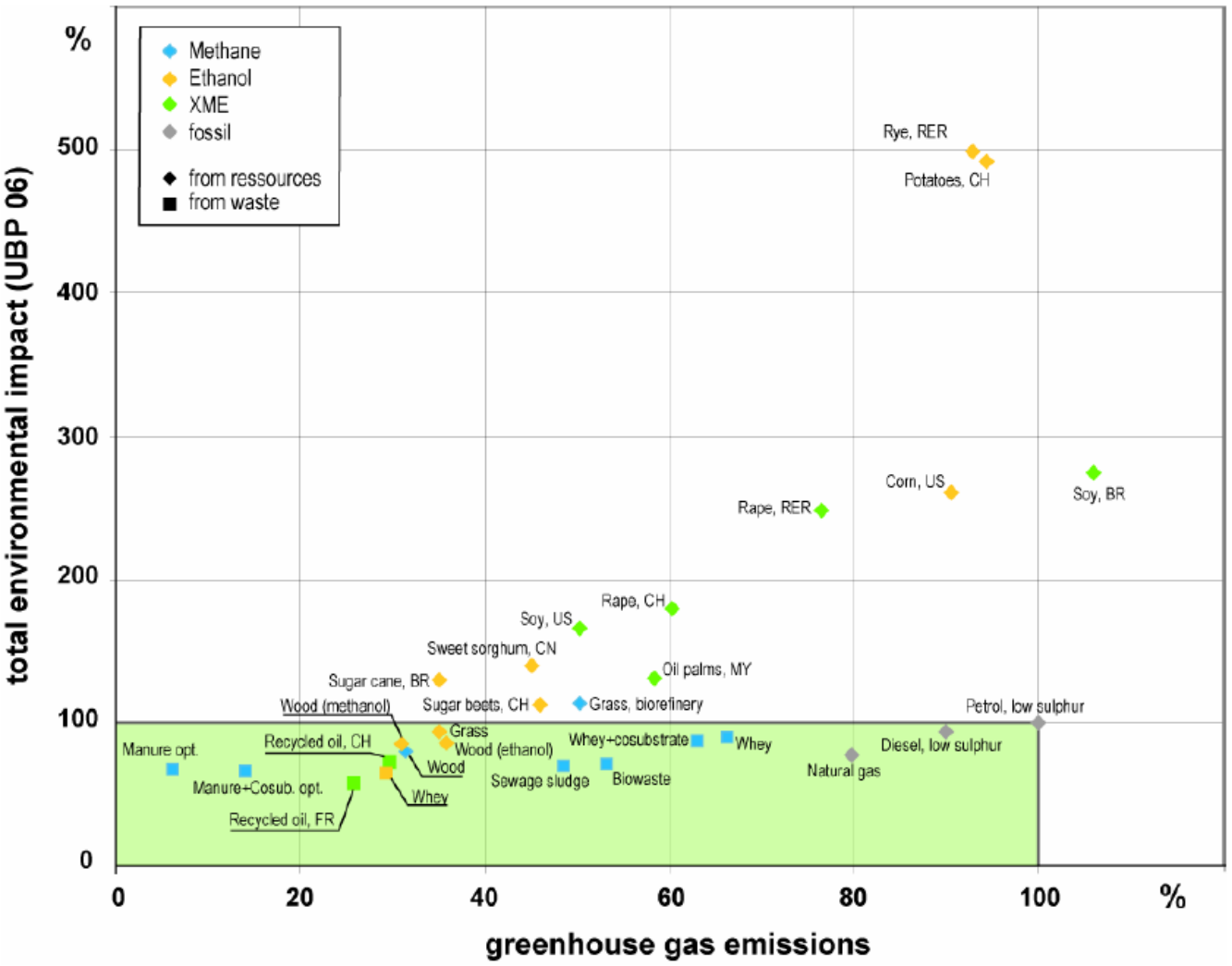
Life cycle assessment of biofuels vs. fossil fuels



(Zah, et al. 2007. Life cycle assessment of energy products: environmental impact assessment of biofuels. BAFU)

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Defining the goal: For what purpose - intended applications

- **Support policy making**

For what purpose?

Ordonnance sur l'imposition des huiles minérales (Oimpmin)

tax relief for biofuels

Art. 19*b* Allégement fiscal pour les biocarburants

L'allégement fiscal pour les biocarburants est accordé sur demande conformément au tarif figurant à l'annexe 2.

Art. 19*c* Exigences écologiques

[1] Les exigences visées à l'art. 12*b*, al. 1, let. a à c, Limpmin (exigences écologiques) sont remplies:

release less than 40% of GHG

a. si, depuis la production des matières premières jusqu'à leur utilisation, les biocarburants émettent au moins 40 % de gaz à effet de serre en moins que l'essence fossile;

do not globally harm the environment more than 25%

b. si, depuis la production des matières premières jusqu'à leur utilisation, les biocarburants ne nuisent globalement pas à l'environnement de plus de 25 % que l'essence fossile, et

do not not generate land use change

c. si les matières premières n'ont pas été produites sur des surfaces ayant fait l'objet d'un changement d'affectation après le 1er janvier 2008 et ayant présenté avant le changement d'affectation un important stock de carbone ou une grande diversité biologique.

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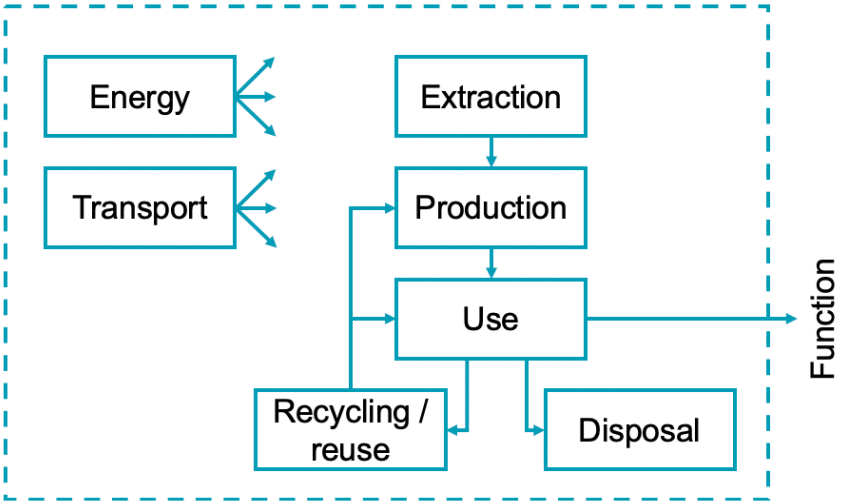
Function, Functional unit and reference flows

DEFINITION OF THE SCOPE OF THE STUDY

Defining the scope

- « Scope » in « goal and scope »
  - **Goal: « why are we analysing? »**
  - **Scope: « what are we analysing and how will we analyse it? »**
- We define the following elements:
  - **The product system to study**
  - **Functions of the system**
  - **The functional unit**
  - **Reference flows**
  - **The system boundary**
  - **Allocation rules (week 6)**
  - **The type of question (attributional vs consequential)**



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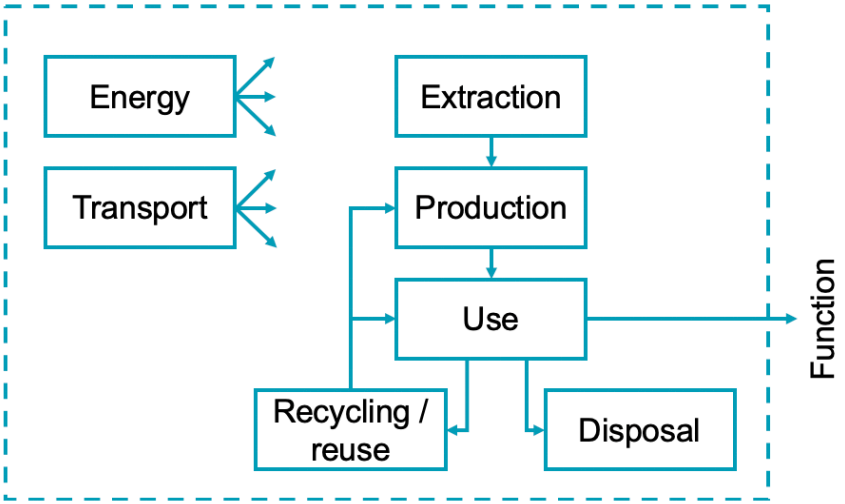
Defining the scope

- We define the following elements (continuation):
  - **The impact categories & indicators, as well as the impact assessment methods used (weeks 8-9)**
  - **Requirements for data sources and quality**
  - **Assumptions**
  - **Limitations**
  - **Type of critical review**
  - **Format of the report (deliverables)**



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Defining the scope

IMPORTANT

The conclusions of an LCA are only valid inside the defined scope of the study. It is dangerous to extrapolate for other technologies, use profiles, geographical contexts, years, etc.

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Defining the scope: function and functional unit

Function (qualitative)

One needs to ask the following questions:

- For what is the product useful?
- How is it actually used by consumers?
- What is the service provided?
- Must be consistent with the goals of the study
- Mandatory properties vs. Optional properties

In LCA, the comparaison is based on a functional unit in order to allow compareing different product systems on a common basis

Function of a product system

… it is traditionally defined by an **action verb**

Define the function of those 3 different products:

- For what is the product useful?
- How is it actually used by consumers?
- What is the service provided?
- Must be consistent with the goals of the study
- Mandatory properties vs. Optional properties

Function of a product system

… it is traditionally defined by an **action verb**

Define the function of those 3 different products:

- For what is the product useful?
- How is it actually used by consumers?
- What is the service provided?
- Must be consistent with the goals of the study
- Mandatory properties vs. Optional properties

Funct.: sit & rest confortable
(+ sleep function?)

FU: to serve
(hot?) drink

FU: protect the feet
(+ protect from the cold?
+ protect from water?)

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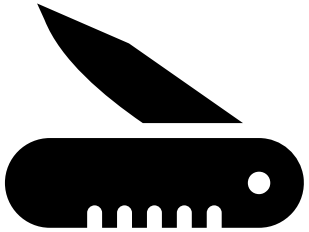
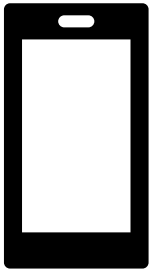
Defining the scope: function and functional unit

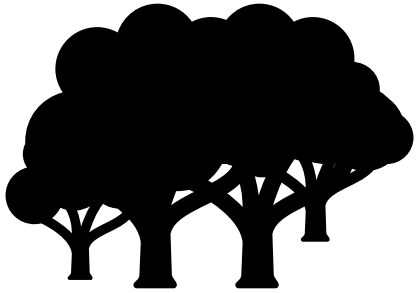
« Multifunctional » products

- Some products provide other functions in addition to the « primary function »
- It is important to understand the importance of these secondary functions to determine if the different options considered are actually comparable.

(week 6)







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Functional unit (FU): definition

Measure quantifying the function of the system

- **Mesurable and additive**
- **Basis on which scenarios are compared**

"quantified performance of a product system for use as a reference unit" in a LCA (ISO 14044)

The **Functional unit** is normally complemented with:

- **« perfomance characteristics » as required**
- **a place and time to describe the context of the study**

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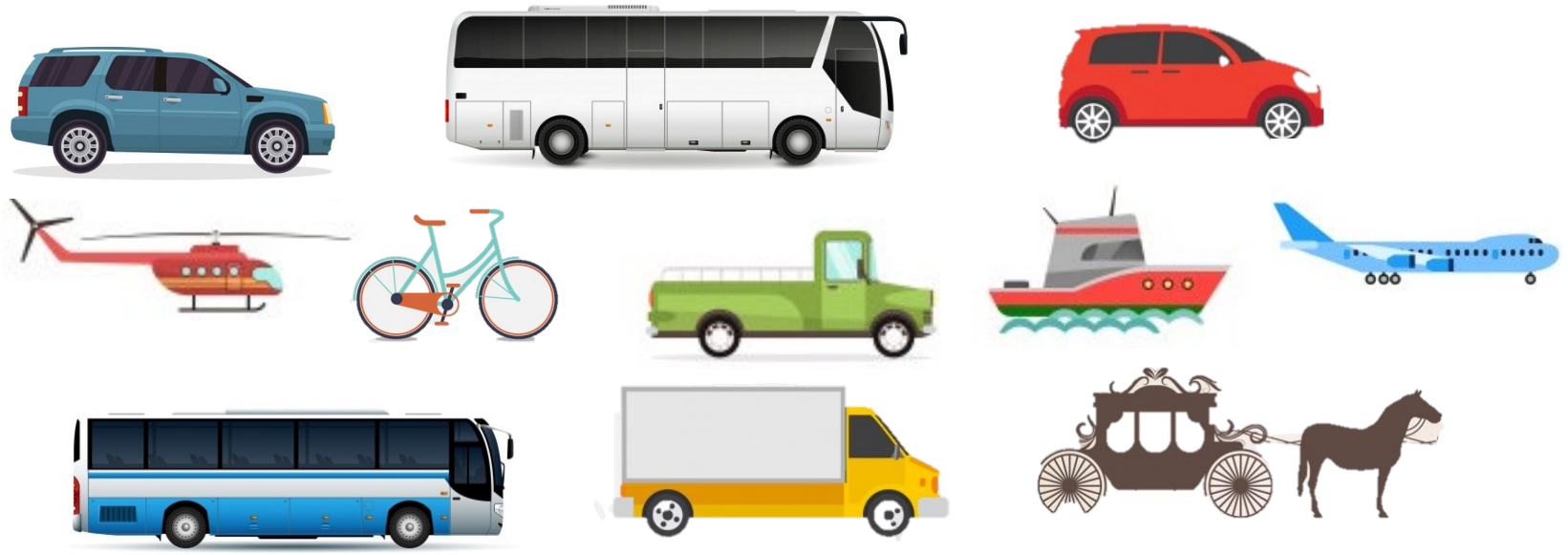
Example: function and functional unit

Function: Transport

Functional unit:

Important: be specific when defining the fonctional unit



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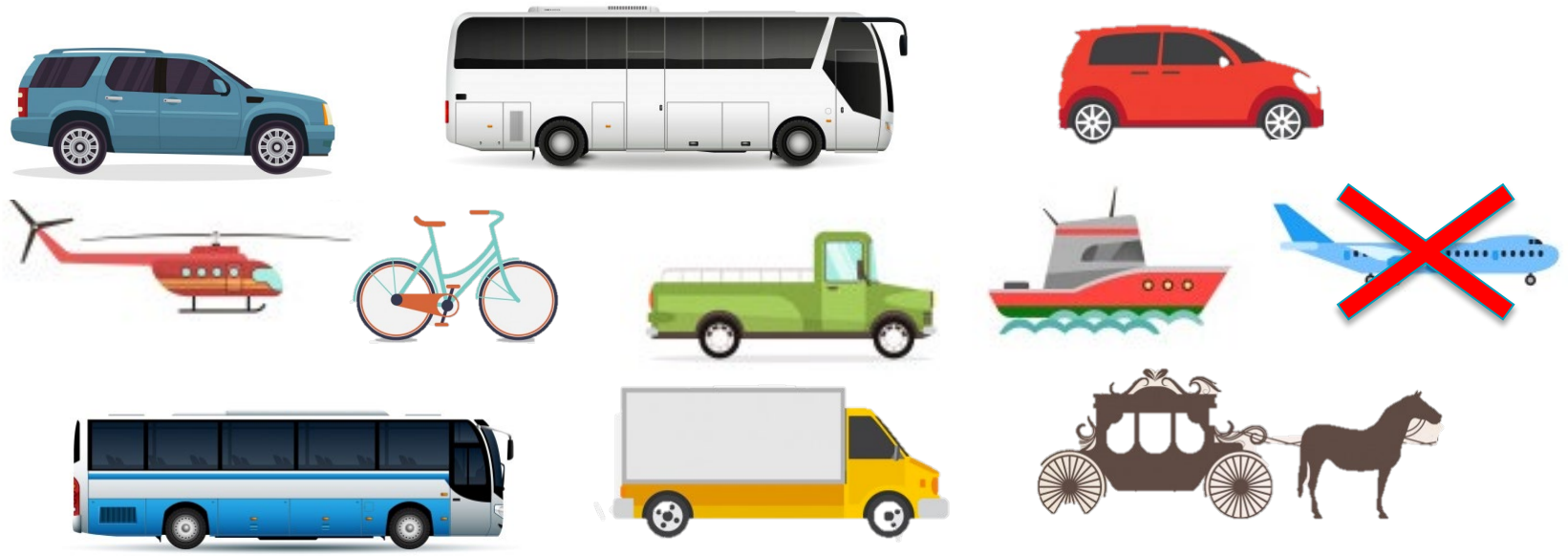
Example: function and functional unit

Function: *Transport*

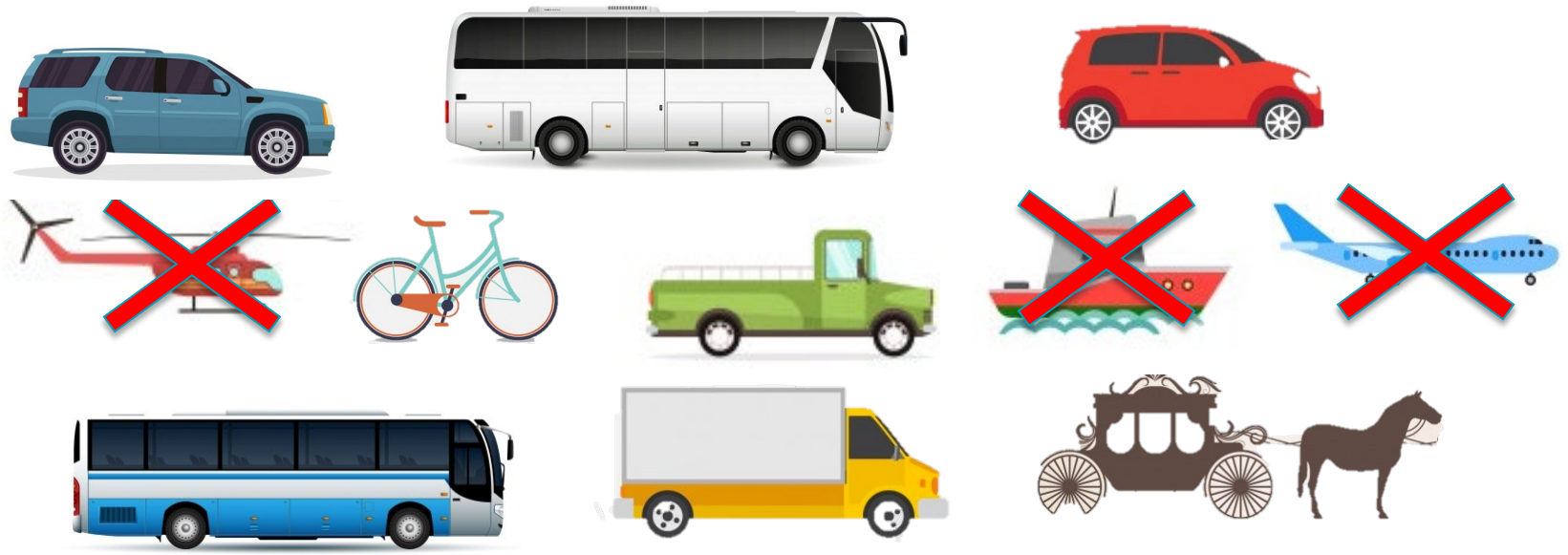
Functional unit: *Transport over 5 km*



Example: function and functional unit

Function: Ground t*ransportation*

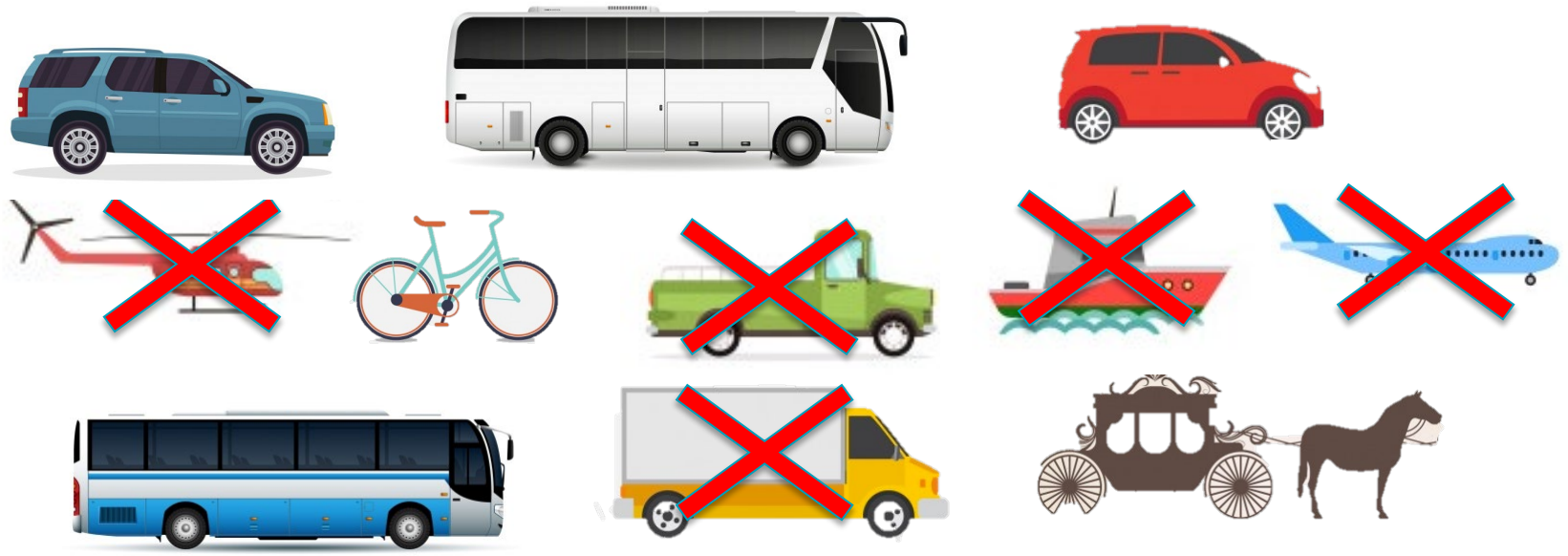
Functional unit: *Ground transportation over 5 km*



Example: function and functional unit

Function: Ground t*ransportation of a person*

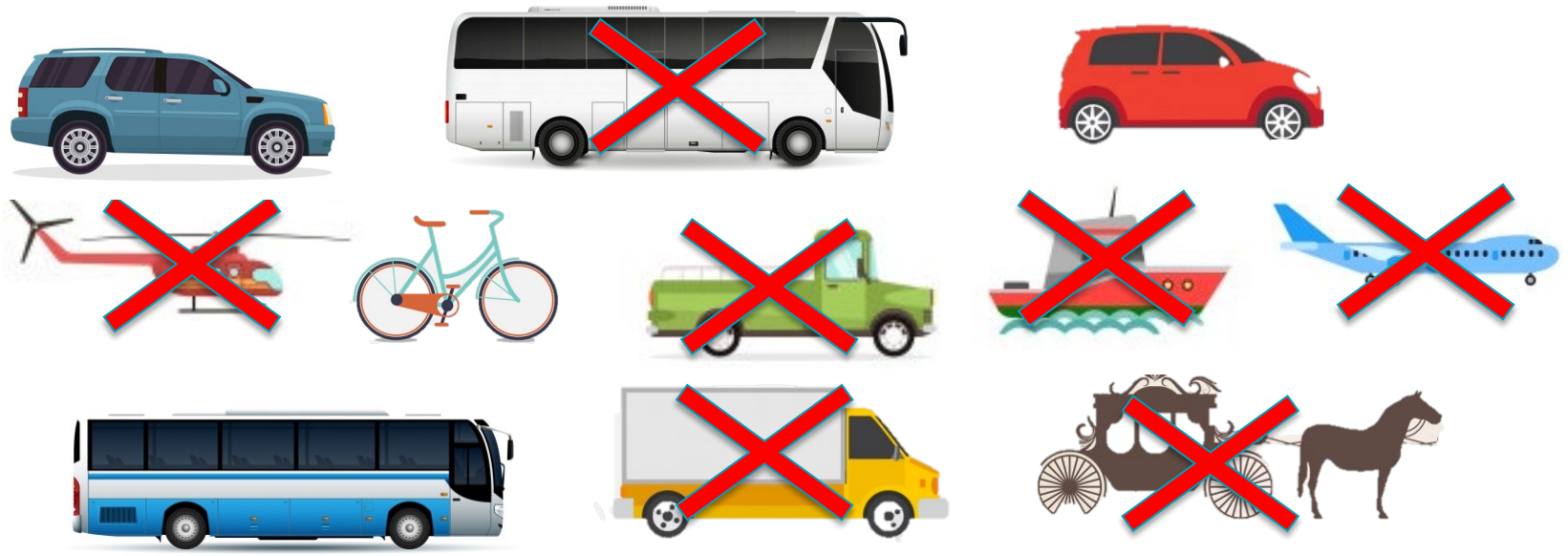
Functional unit: *Ground transportation over 5 km a person*



Example: function and functional unit

Function: Ground t*ransportation of a person commuting*

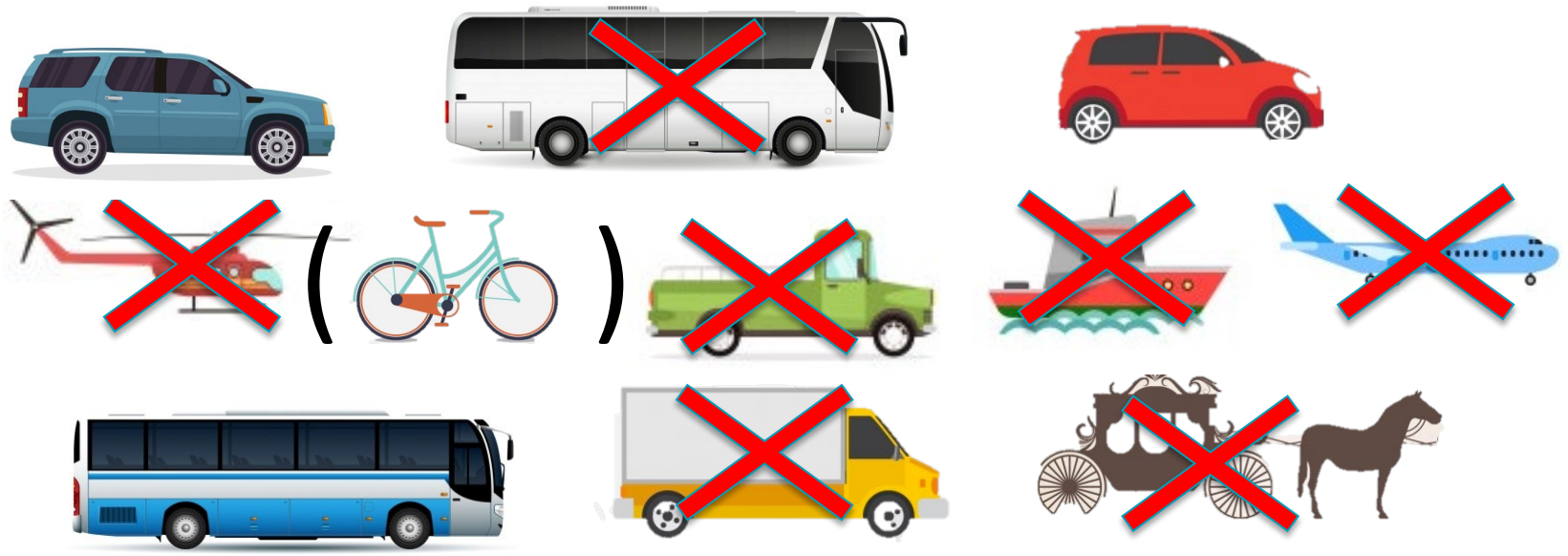
Functional unit: *Ground transportation over 5 km a person commuting*



Example: function and functional unit

Function: Ground t*ransportation of a person commuting in Montréal in 2023*

Functional unit: *Ground transportation over 5 km a person commuting in Montreal during one year in 2023*



Example: Functional unit ground transportation for commuting

()

Functional unit:

Ground transportation of a person commuting in Montreal over 5 km during one year in 2023

= 1 person * 5km/trip x 2 trips/days * 220 days = 2200 person*km

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Defining the functional unit

The FU should answer the following questions:

- **What?**
- **How much? Which quantity?**
- **For how long/ For how many times?**
- **Where?**
- **When?**
- **With what quantity / performance characteristics?**

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Defining the functional unit

The FU should quantify the different dimensions of the service rendered:

- **Does the usefulness of your product scale with the passing of time? FU should include a time dimension (e.g. m^2 x year)**
- **The different dimensions are typically *multiplied*.**
- **Not an intensive property (km/h, kg/m^3, etc.) These are properties that do not measure the amount of service delivered. They can be exclusion criteria.**

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Functional unit

… it is traditionally defined by an **action verb**

… it describes the function **quantitatively**

Define the functional unit of those 3 different products:

How much of what is provided for how long / times?
Where? When? Wich performance characteristics?

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Functional unit

… it is traditionally defined by an **action verb**

… it describes the function **quantitatively**

Define the functional unit of those 3 different products:

How much of what is provided for how long / times?
Where? When? Wich performance characteristics?

*FU: 2h/d*7d/w*52w/yr*10yr*
= Support 730h of rest

FU: serve 1 hot bewerage (3dl) daily over 1 yr
= 365 bewerages of 3dl
*(or 3dl/day*365day= 1095dl)*

*FU: 8h/day*365d/yr*2yr*
= 5'840h of feet protection

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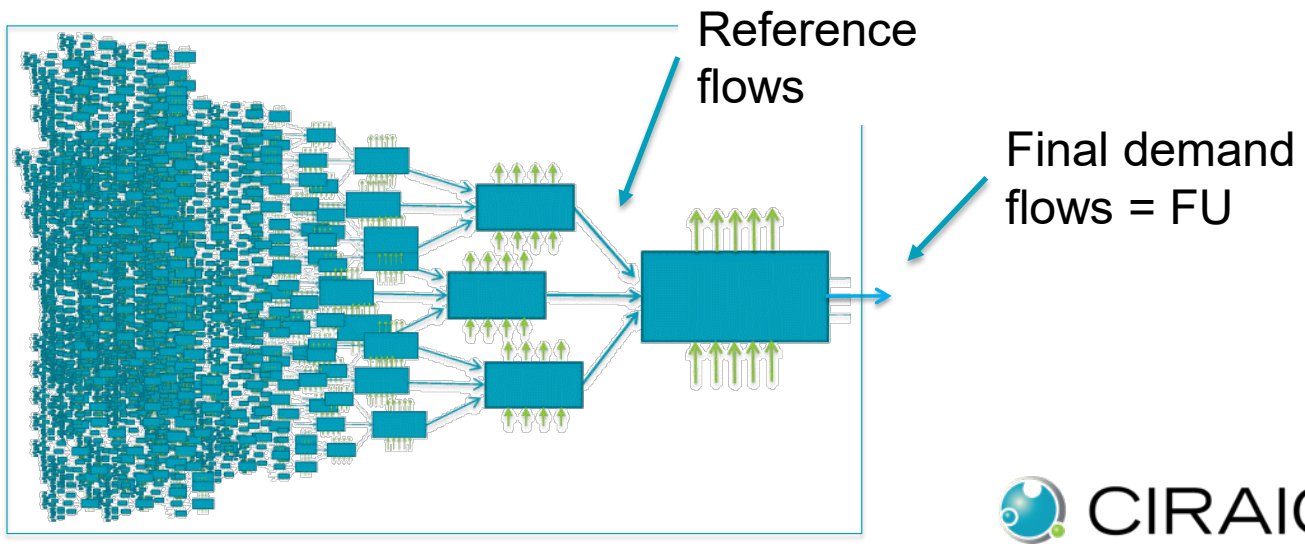
Scope of the study - Definitions

Final demand flows: economic flows that provide the functional unit

Reference flows (RF): product (or intermediary) flows necessary to provide the final demand flow.
Expressed in *Quantity of product/Functional unit*

Key parameters (KP): Data used to *calculate* the reference flows



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Example to calculate a reference flow

function :
Protect the feet

Shoe A (good quality)	Comparison	Shoe B (low quality)
functional unit : To protect the feet (8 hours per day) during 1 year (= 2920 hours)		
Lifespan shoes: 4 years	Key parameter -	Lifespan shoes: ½ year
1/4 pairs of shoe A	Reference flows: -	2 pairs of shoe B

45 *RF_A = 1yr/FU * 1 p.shoes/4yr = ¼ p.shoes*

*RF_B = 1yr/FU * 1 p.shoes/0.5 yr = 2 p.shoes*

Example : cups

Function:
Serve (hot) bewerages

Functional unit:

Serve 1 (hot) bewerage of 3dl daily during 1 yr
= 365 bewerages of 3dl

Key parameters:

Reference flows:

Example : cups

Function:
Serve (hot) bewerages

Functional unit:

Serve 1 (hot) bewerage of 3dl daily during 1 yr
= 365 (hot) bewerages (of 3dl)

Lifetime : 500 servings/cup
Nb. washes/serving: 1
(Vol: 3dl/cup)

Key parameters:

Lifetime: 1 serving/cup
(Vol: 3dl/cup)

Reference flows:

*RF_{cup}: 365 serv./UF *1 cup/500 serv.*
= 0.73 cups (ceramic)
*RF_{wash}: 365 serv./UF * 1 washes/serv.*
= 365 washes
$RF_{disposal}$: disposal of 0.73 ceramic cups (ceramic)

*RF_{cup}: 365 serv./UF *1 cup/serv.*
= 365 cups (cardboard)
$RF_{disposal}$: disposal of 365 cups (cardboard)

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Example: transport

Function:
Commuting people

Functional unit:
Commuting 1 person over 5km in Montreal during one year in 2023
= 2200 pkm

Key parameters:

Reference flow:

Example: transport

Function:
Commuting people

Functional unit:

Commuting 1 person over 5km in Lausanne during one year in 2023
= 2200 pkm

Key parameters:

Consumption: 0.08 L/vkm
Lifetime: 180kkm
Occupancy rate: 1.2 p/v

Consumption: 0.75 lt/vkm
Lifetime: 800kkm
Occupancy rate: 15 p/v

Reference flow:

*$RF_{vehicles}$: 2200pkm/UF *(1.2 p/v)$^{-1}$ * 1/180kkm*
= 0.01 vehicles (car)
*RF_{fuel}: 2200pkm/UF * (1.2 p/v)$^{-1}$ *0.08 L/vkm*
= 147 L
$RF_{disposal}$: disposal of 0.01 vehicles

*$RF_{vehicles}$: 2200pkm/UF *(15 p/v)$^{-1}$ * 1/800kkm*
= 0.00018 vehicles (bus)
*RF_{fuel}: 2200pkm/UF * (15 p/v)$^{-1}$ *0.75 L/vkm*
= 110 L
$RF_{disposal}$: disposal of 0.00018 vehicles

Reference flow

Definition : **Product flows necessary to provide the final demand flow that provide the functional unit**

Alternative definition:

« Quantities of products needed and purchased to fill a given functional unit »

(Jolliet et al. 2019)

A reference flow is generally « tested by the consumer »

« what needs to be bought to provide the service of the FU »

Keep in mind that in the case of product/service comparisons, the functional units are the same, but the reference flows are different

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Definition: key parameters

"Key parameters are the quantities necessary to calculate the reference flows starting from the functional unit »

Examples:

- **Lifespan**
- **Number of re-uses possible**
- **Quantity of material / energy used by a service rendered**
- **Efficiency**
- **…**

Sometimes we need more than one key parameter to link a reference flow to the functional unit

Ex.: reference flow calculation - # of tiles per functional unit

FU = Cover 50 m^2 of a wall over 10 years.

= 50m^2 x 10 years = 500 m^2.year.

one ceramic tile lasts 10 years and covers 0.01 m^2.

RF_tiles = (500 m^2.year)/FU x (1 tile/0,01m^2) x (1/10 years) = 5000 tiles / FU

functional unit

key parameter

reference flow

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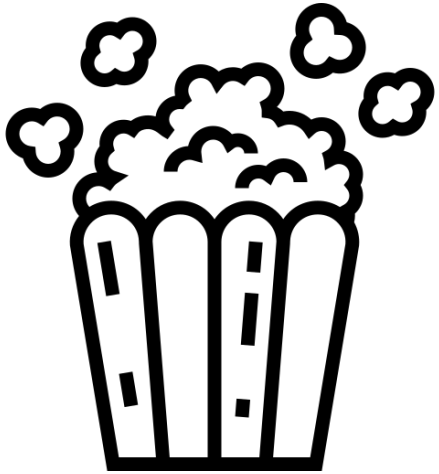
Importance to define the right functional unit

EXAMPLE ON PACKAGING

Popcorn vs polystyrene as a packaging material



VS

Which is the environmentally preferable solution?

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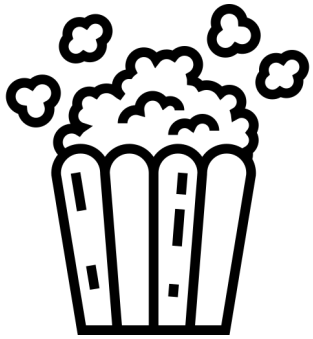
Popcorn vs polystyrene as a packaging material

Traditional scenario: expanded polystyrene « chips »

- -
- -

Alternative scenario studied: popcorn

- -
- -
- -



Adapted from Jolliet, Saadé et Crettaz (2005).
Analyse du cycle de vie: Comprendre et réaliser un écobilan.

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Popcorn vs polystyrene as a packaging material

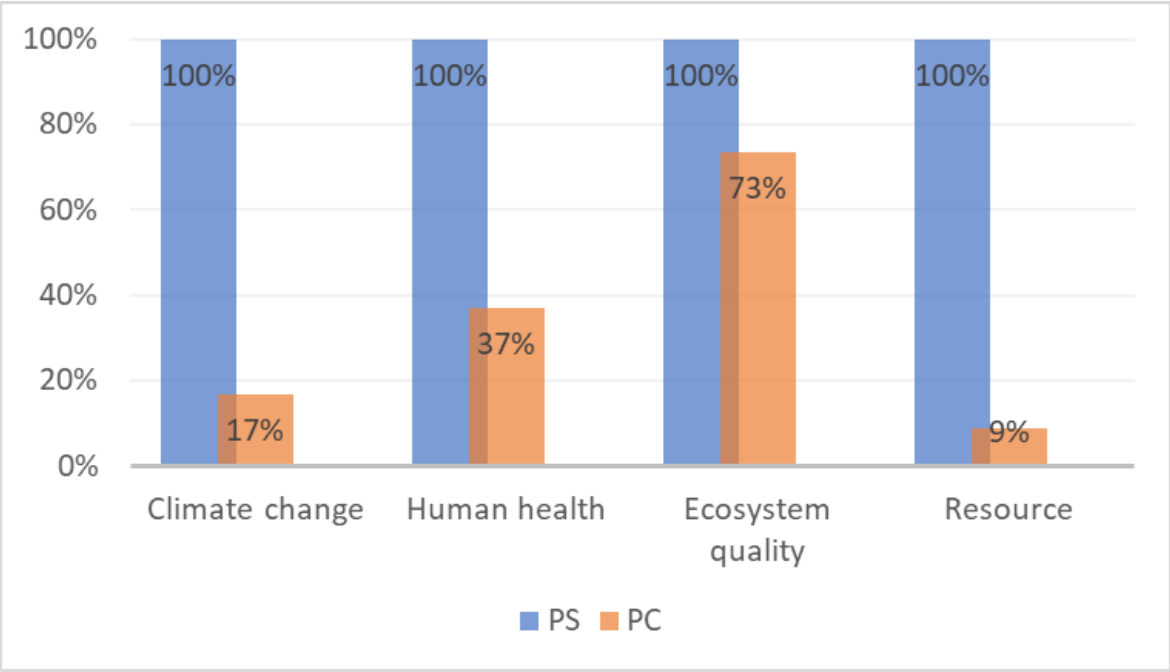
Functional unit: 1 kg packaging material

Emission	Popcorn	Polystyrène
CO_2	570 g	3440 g
CH_4	2 g	34 g
N_2O	0.53 g	0.03 g
Particle matter	0.5 g	1 g
NH_3	1.5 g	0.07 g
Nitrates	14 g	0.45 g
Non renewable energy	9 MJ	103 MJ

+ hundreds of other elementary flows

Popcorn vs polystyrene as a packaging material

Functional unit: 1 kg of material



popcorn is the most prefered option?

Per kg of materials, popcorn is the preferred solution across all the impact categories

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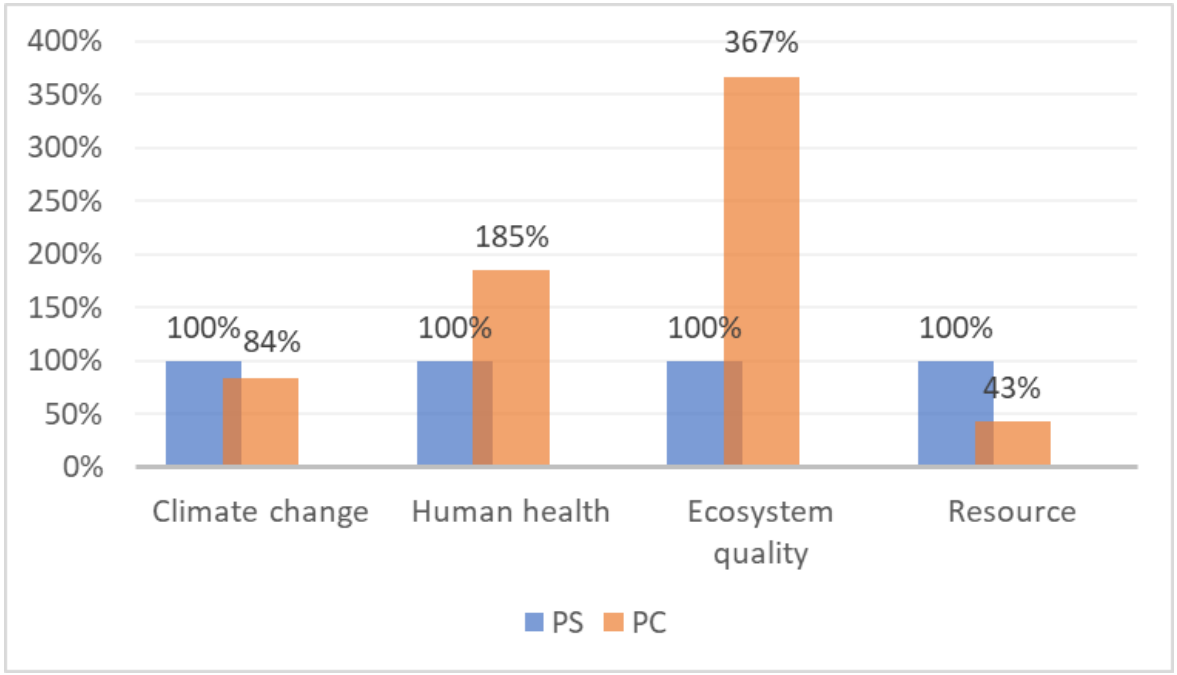
Example: pop corn VS polystyrene

Problem: function not defined properly!

- The function of the packing material is to fill in a volume
  - example of a functional unit: fill in 1 m^3
- The comparison of the materials on the base of their mass doesn't make sense in the present context.
- Popcorn density is 5 times higher than polystyrene

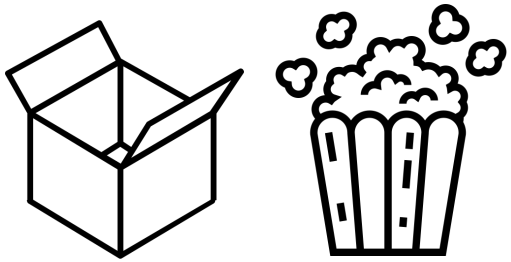
Example: pop corn VS polystyrene

Functional unit: fill in $1m^3$



popcorn impacts are augmented by a factor 5

Results are nuanced



By comparing PC and PS on a functional unit expressed in terms of volume, the impacts of popcorn are directly multiplied by a factor of 5

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Example: pop corn VS polystyrene

The advantage of polystyrene becomes even more important when we consider that this material is easier to reuse than popcorn.

If we reuse the polystyrene chips 4 times and popcorn once, we would have to divide the impacts of these materials respectively by a factor 4 and 1, further increasing the gap between these two materials.

- For a consumption product, this may not be true, but in a B2B context, reuse is the norm.
- We should have probably specified this in the goal & scope
- « Renewable » ≠ « lower impacts »

Example: pop corn VS polystyrene

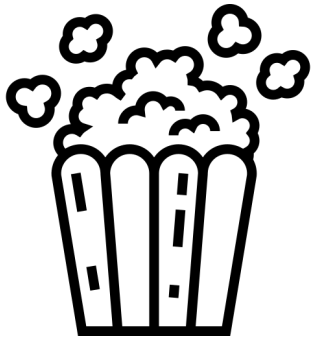
Proper definition of FU key parameters and reference flows

FU = 1 m^3

$$\frac{1\ m^3}{UF} * \frac{7\ kg}{m^3} * \frac{1}{4\ ut} = \frac{2\ kg\ polystyrène}{UF}$$

Key parameters Reference flows

$$\frac{1\ m^3}{UF} * \frac{35\ kg}{m^3} * \frac{1}{1\ ut} = \frac{35\ kg\ pop\ corn}{UF}$$



Material density

uses

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Product system & boundaries

DEFINITION OF THE SCOPE OF THE STUDY

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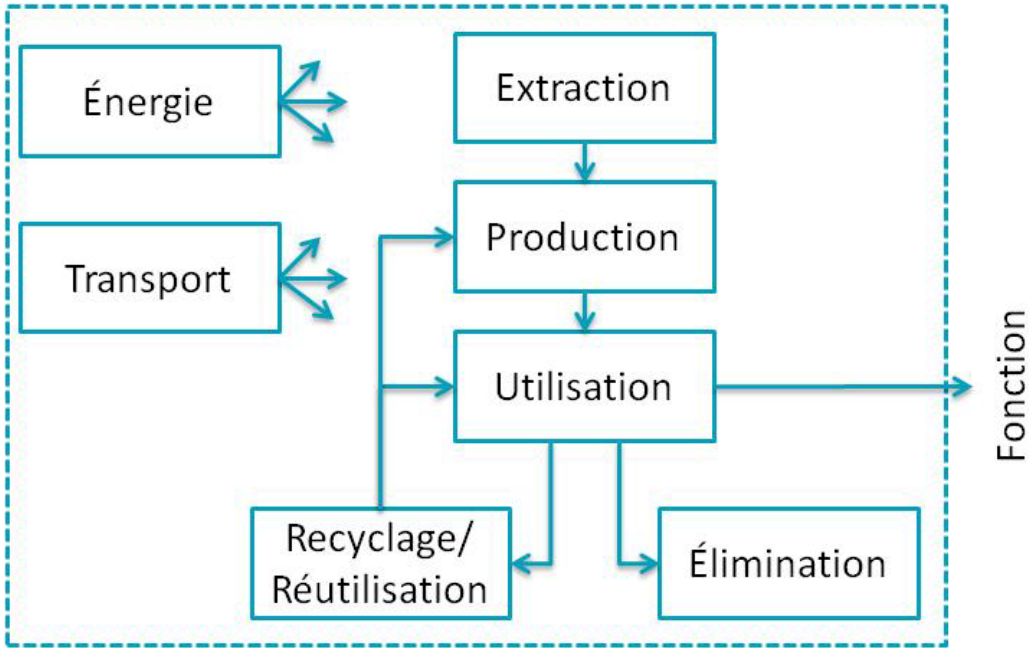
Simplified representation of a « product system »



"collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product"
(ISO 14044)

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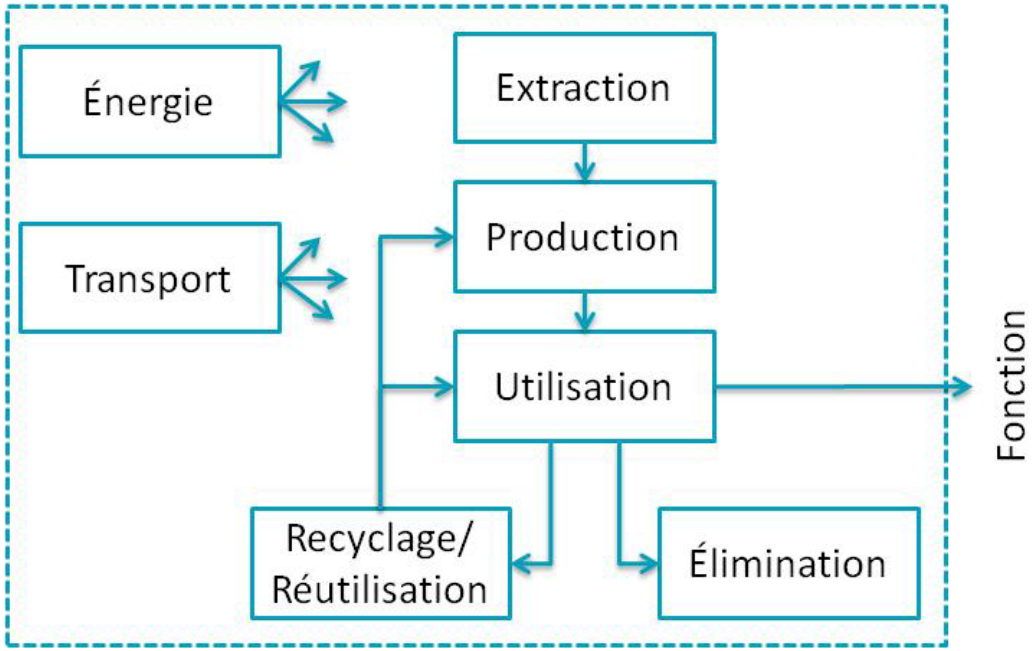
Definition of a product system

Basic elements of a product system: unit processes

- Black boxes describing activities like extraction, production, consumption, etc.



"smallest element considered in the life cycle inventory analysis for which input and output data are quantified" (ISO 14044)

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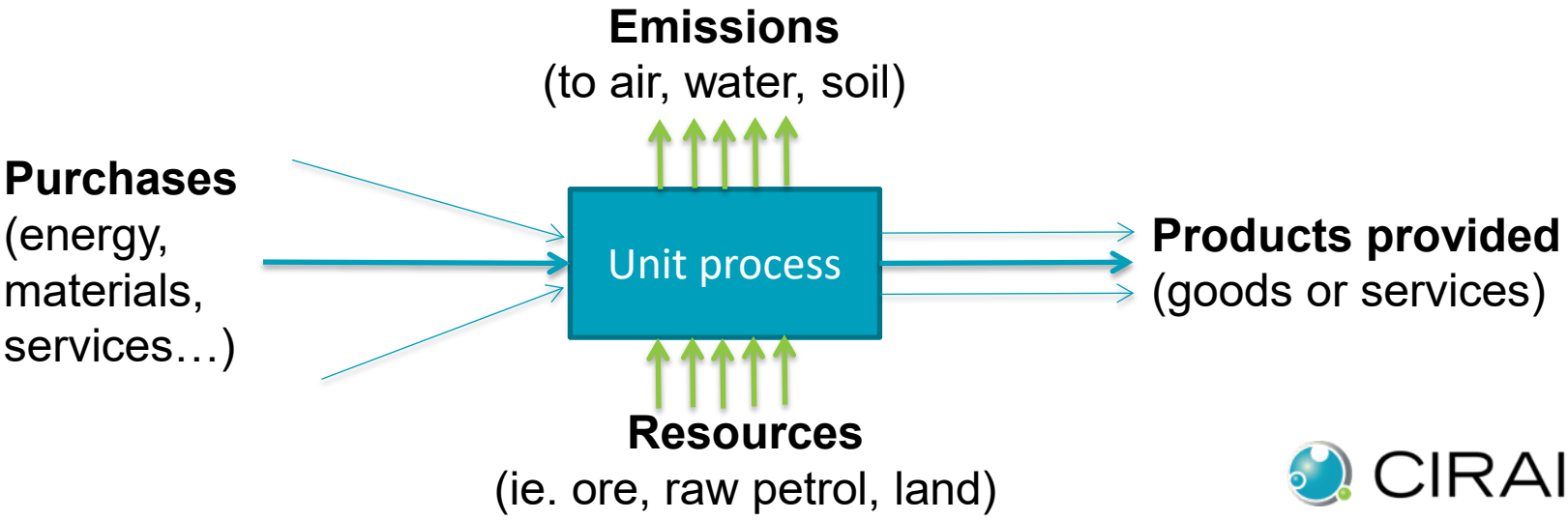
Definition of a product system

Basic elements of a product system: unit processes

- Black boxes describing activities like extraction, production, consumption, etc.
  - **Elementary flows: emissions/resources exchanged directly with the environment**
  - **Intermediary flows: products and services→ Links with other unit processes OR to the function of the study**



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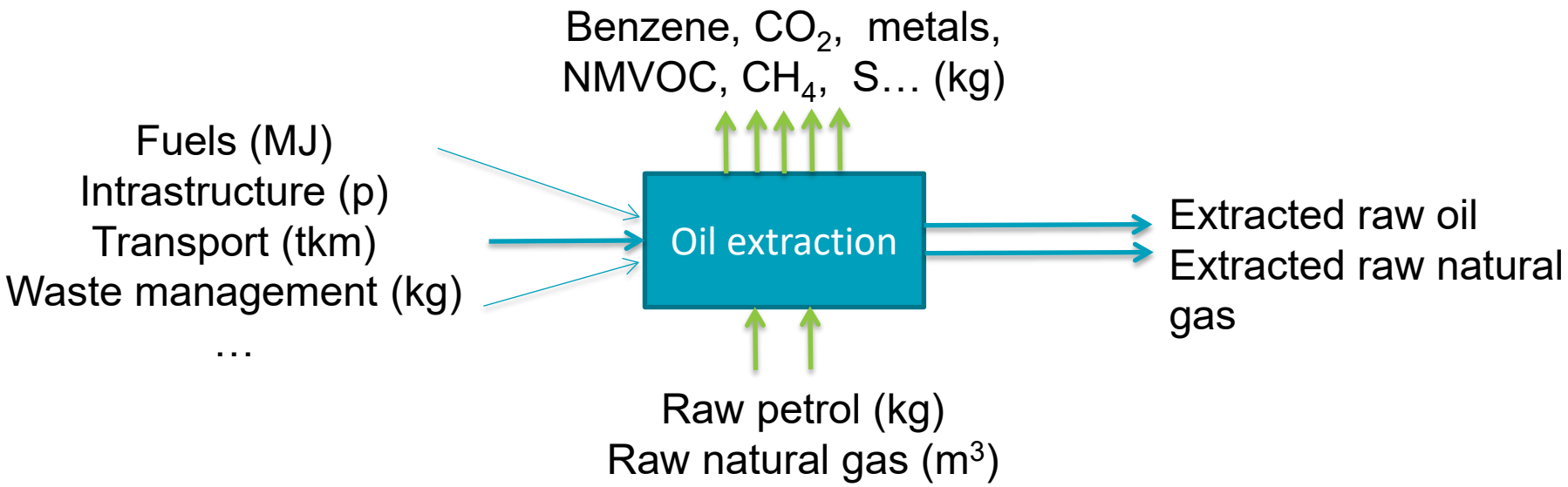
Unit processes

- Black boxes describing activities
- Examples:



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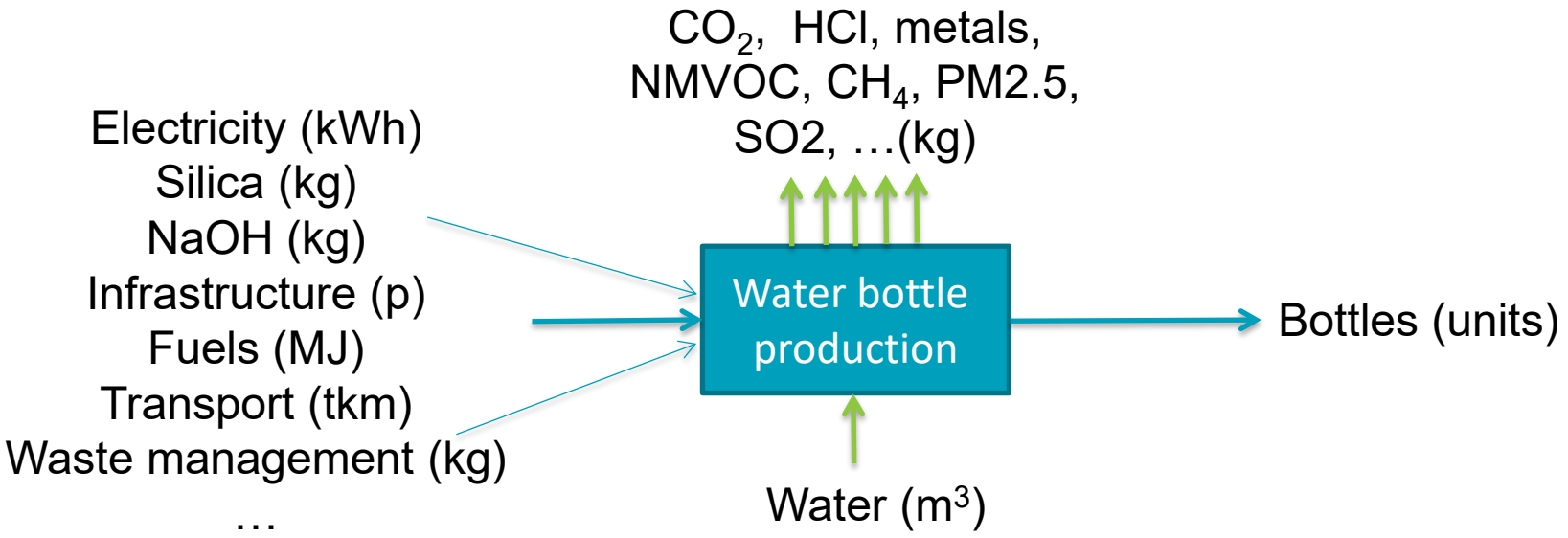
Unit processes

- Black boxes describing activities
- Examples:



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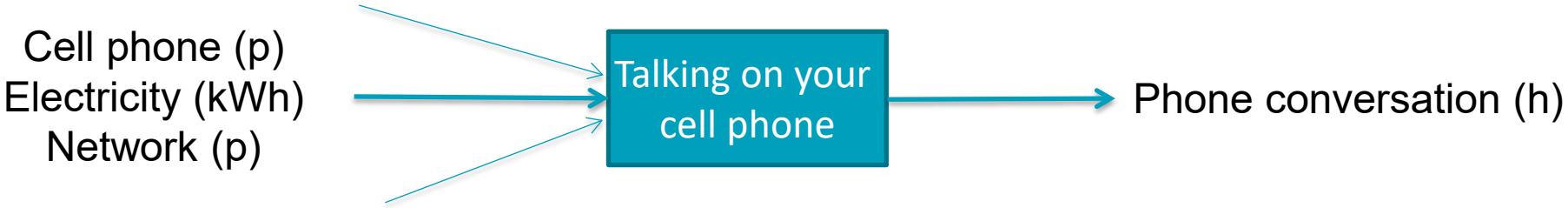
Unit processes

- Black boxes describing activities
- Examples:



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Recap

Unit process, intermediary flow or elementary flow?

- A beam of steel
- Iron ore from the ground
- Water from the tap
- Water from the river
- CO_2 added to water to make sparkling water
- Producing sparkling water
- Emission of CO_2 from a sparkling water factory
- Waste sent to a landfill site
- Land use to practice agriculture

Unit processes– Notes

- We often use « unit process » or « elementary process » or « activity ». They are all synonyms, but ISO only uses « unit process ».

- In the course, we will use the terms « economic flows » or « intermediary flows »
  - **in ISO and Jolliet et al.: intermediary flow**
  - **in openLCA: product flow**
  - **in SimaPro: technosphere flow**
  - **in ecoinvent: intermediary exchange**
  - **in Brightway: exchange from the technosphere**

Synonymes!

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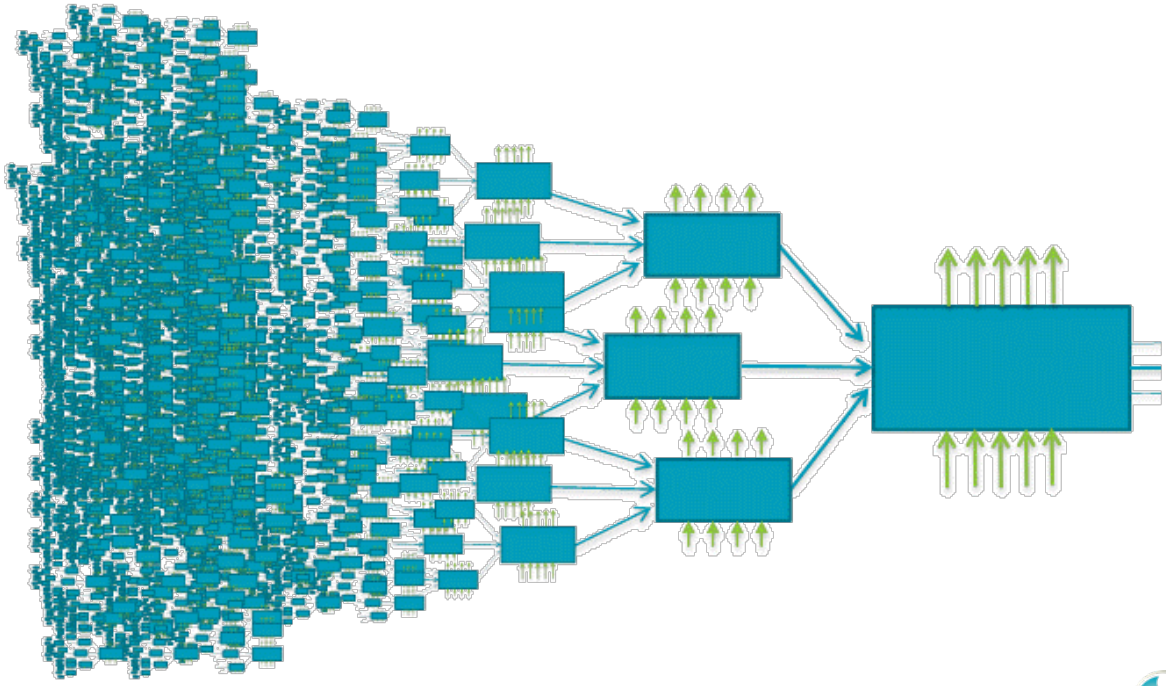
A product system

Product system:

- Model of the life cycle of a product
- Encompass all unit processes involved in the product life cycle
- Each unit process needs the intermediary flows of other unit processes…



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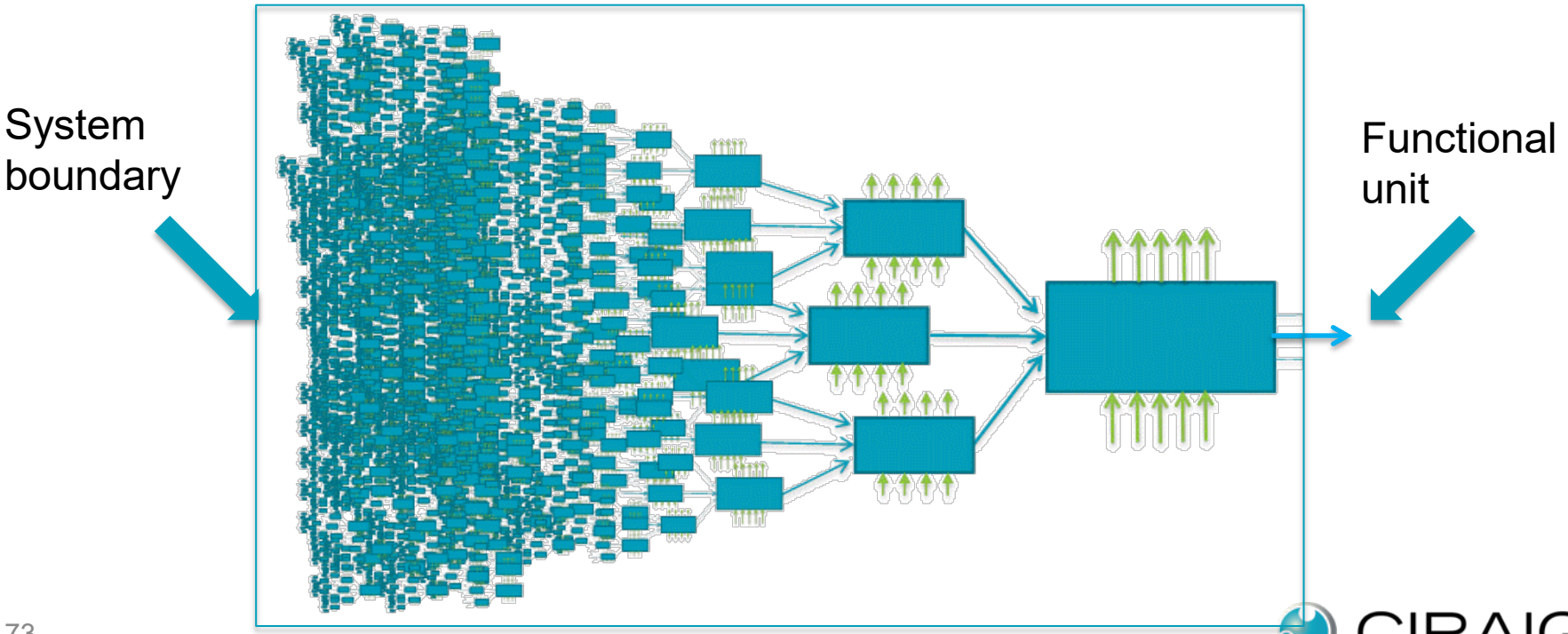
A product system

Product system:

- Model of the life cycle of a product
- Encompass all unit processes involved of the product life cycle
- Only ONE intermediary flow leaves the **system boundary**: the flow associated to the FU (final demand)



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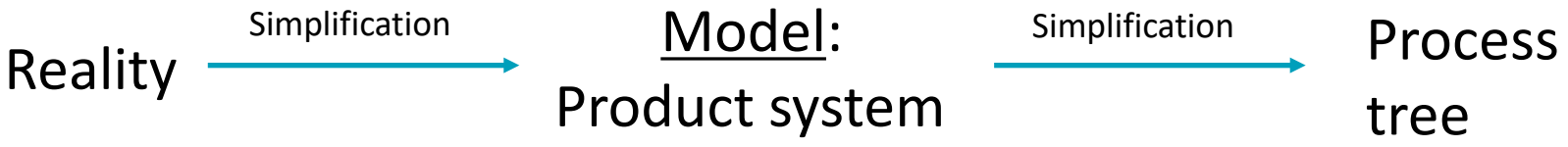
A product system

Product system:

- Usually what's included in the system boundary:
  - Extraction of raw materials and production of components and energy transformation
  - Capital goods such as infrastructure, machines. etc.
  - Logistic: Transportation, distribution
  - Main manufacturing/production stage
  - Use phase of products (including maintenance)
  - Waste treatment (landfill, valorisation, reuse, recycling…)

Process tree – a simplified representation of a product system



The process tree is a simplified representation of a product system

- You have lots of freedom to create your process tree, but stick to the following principles:
  - **Simple enough to be legible**
  - **Complete enough to understand what is overall included in the study**
  - **Activities (or group of) are identified as a box and flows as arrows**
  - **Be consistent in the direction of the intermediary flows (arrows)**
- There are no calculations to be done to make a process tree. It's a qualitative representation of the product system.

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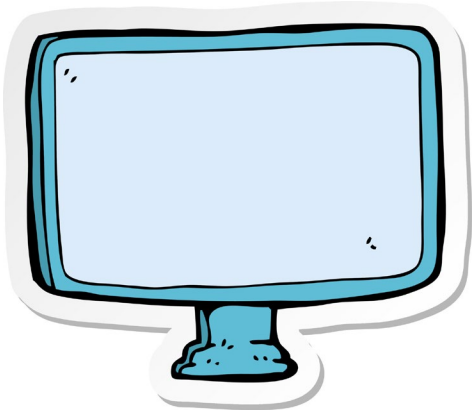
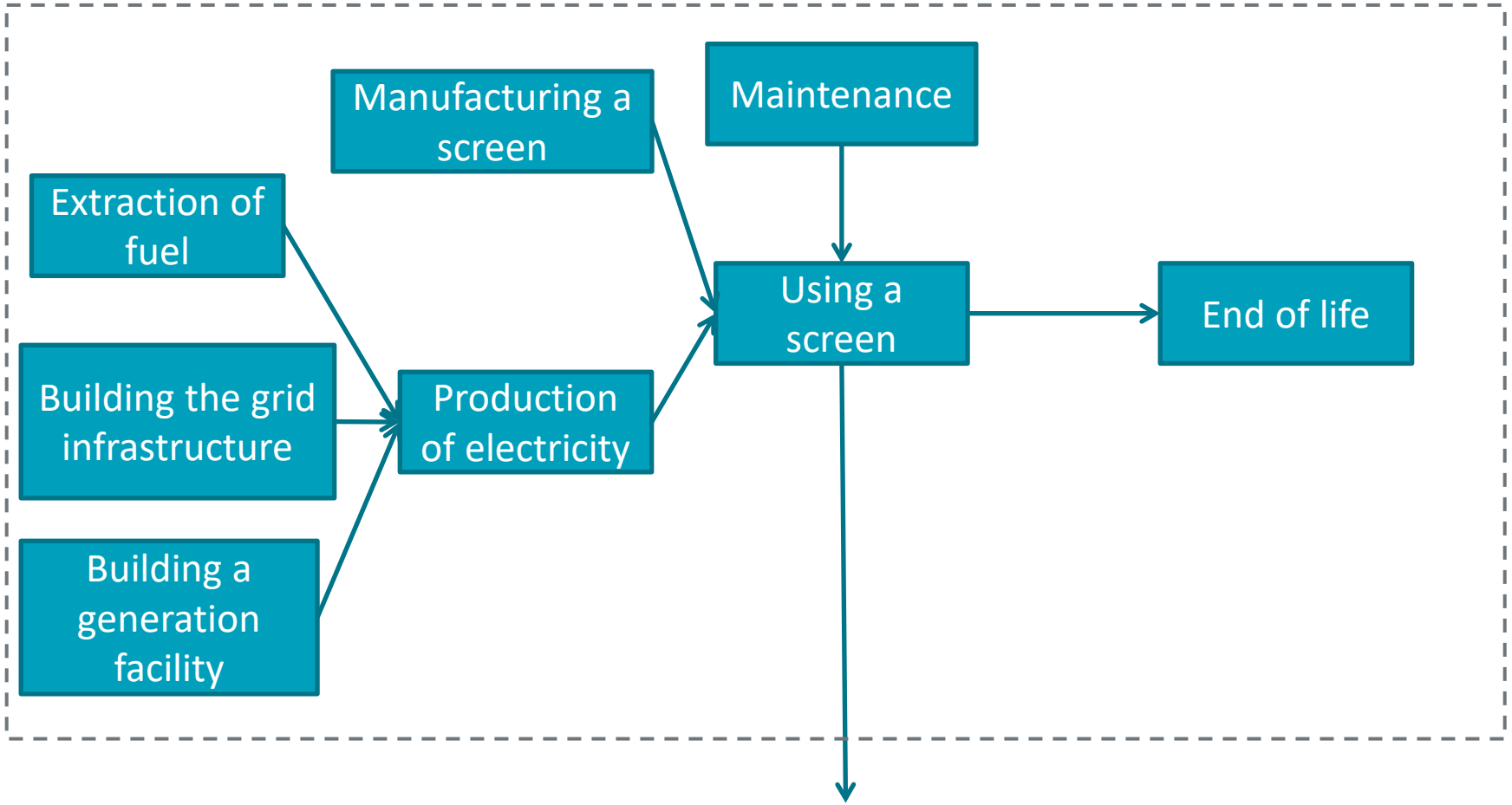
Example of using a computer screen

- Function, functional unit and reference flows
  - **Funtion: displaying information sent by a computer**
  - **UF: Displaying information sent by a computer on a screen for 1 hour (size, image quality, etc. should be specified here)**
  - **RF: screen, electricity, maintenance (cleaning products), scrap**



Example of product system: using a computer screen



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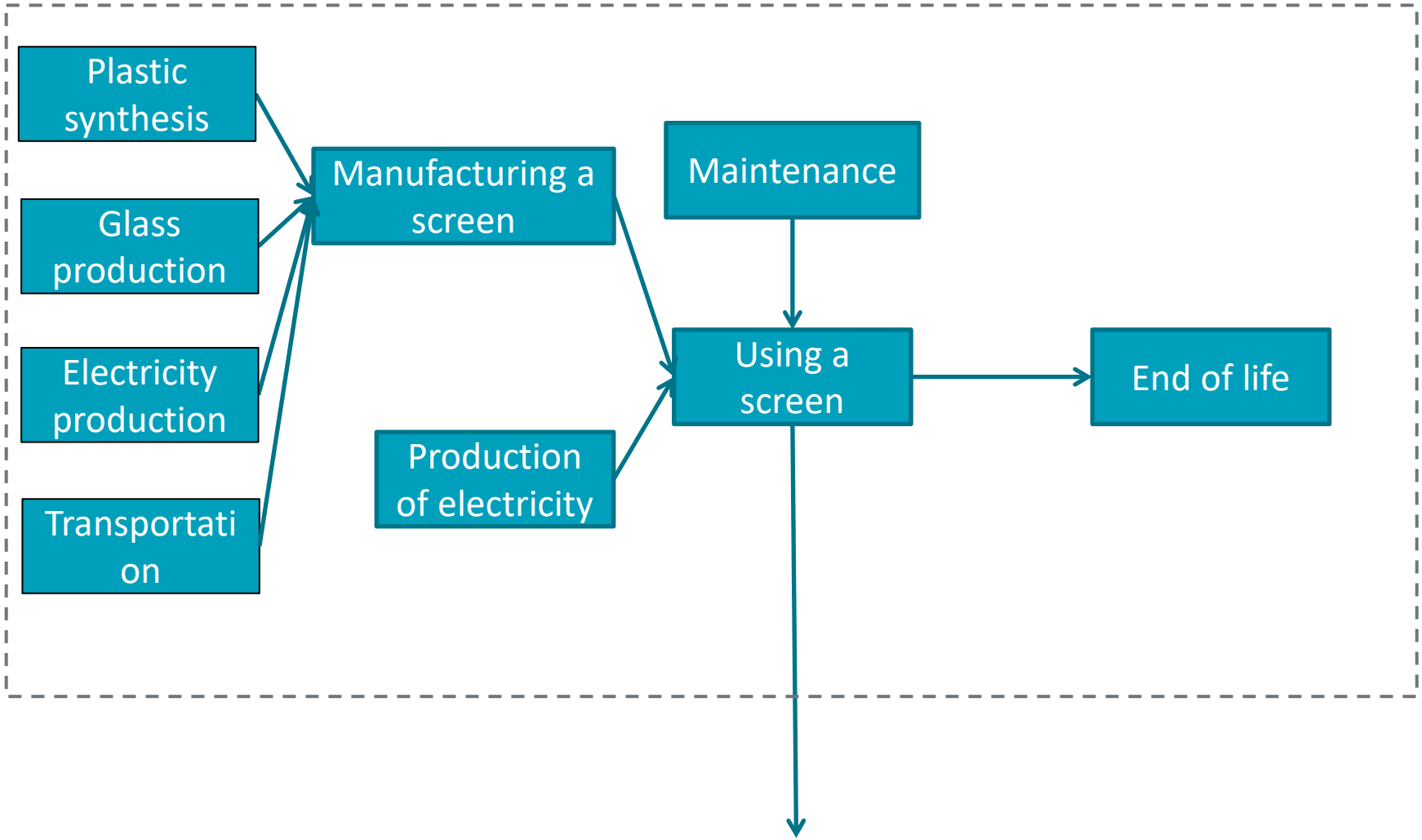
Example of product system: using a computer screen



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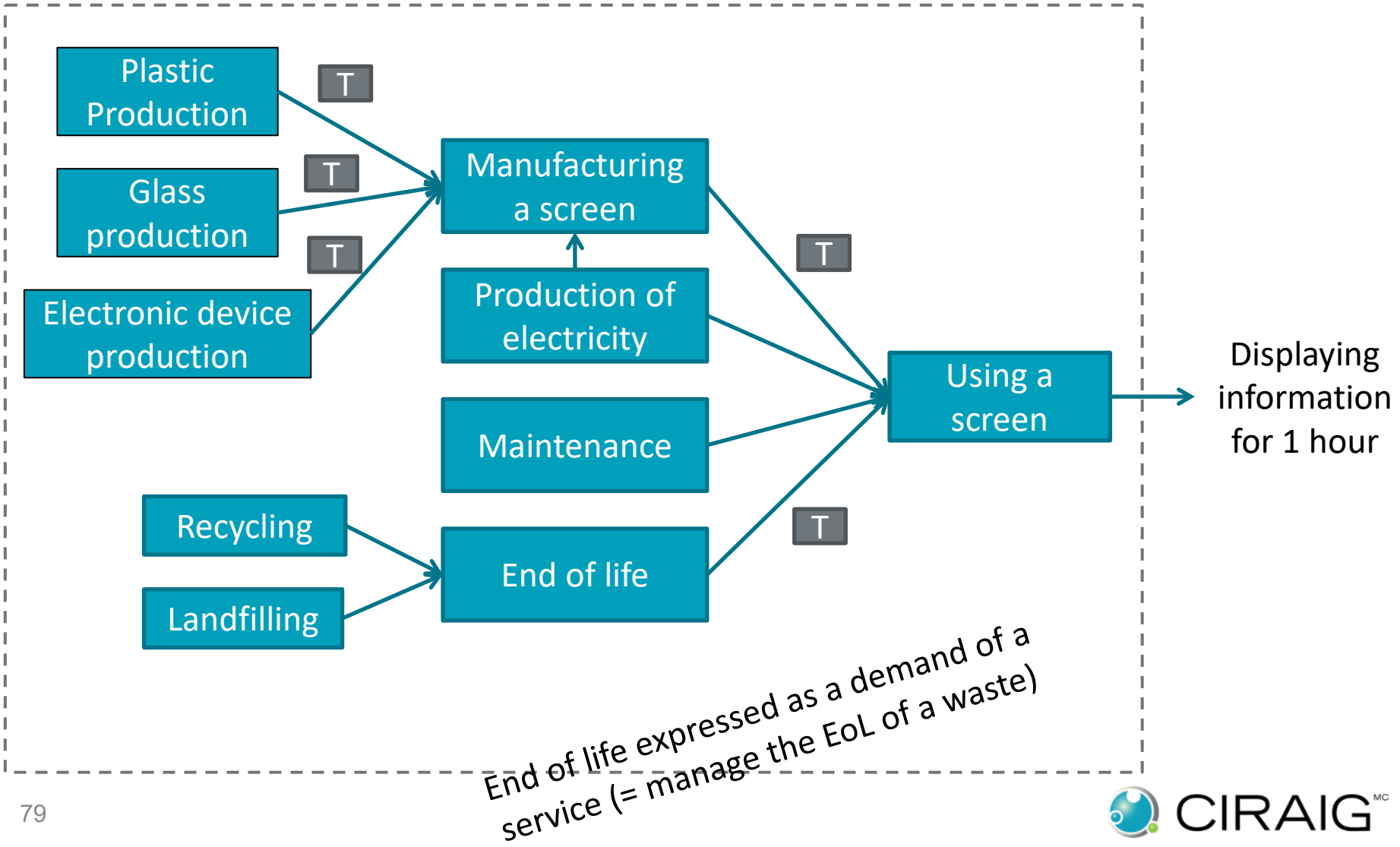
Example of product system: using a computer screen



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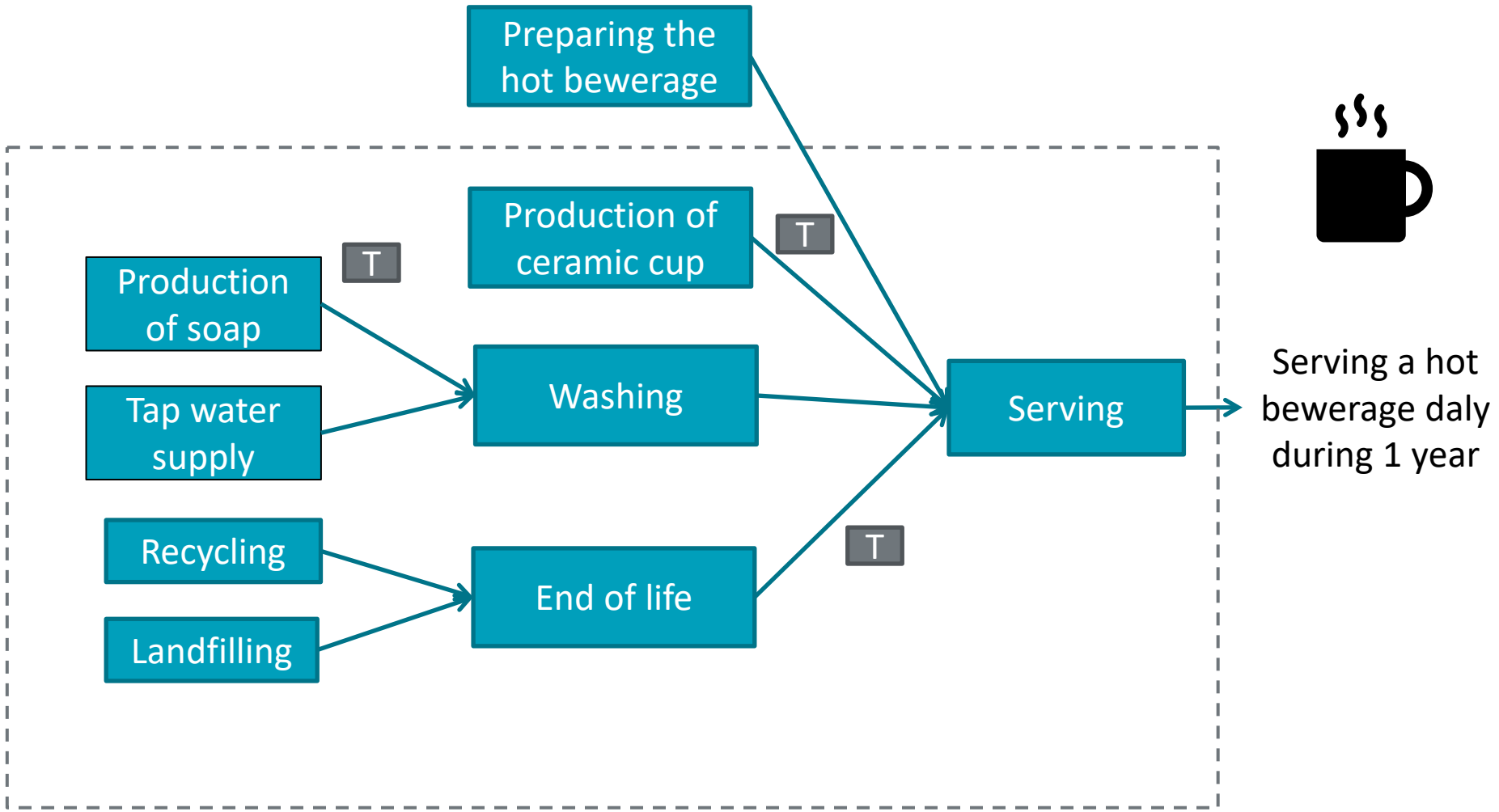
The process tree is useful to visualize the product system and to communicate the results

- <u>You cannot draw everything in your process tree</u>
- You will need to put what is important, and group of processes (activities) in bigger classes
  - **Ie. A box « aluminum production » implicitly contains extraction of bauxite, transportation, production of alumine, and productino of all intermediary products necessary...**
- Note that boxes are processes (activities) not products (result of an activity). You can write the products or the elementary flows on the arrows if there is enough space

Example of product system: serving hot bewerages during 1 year



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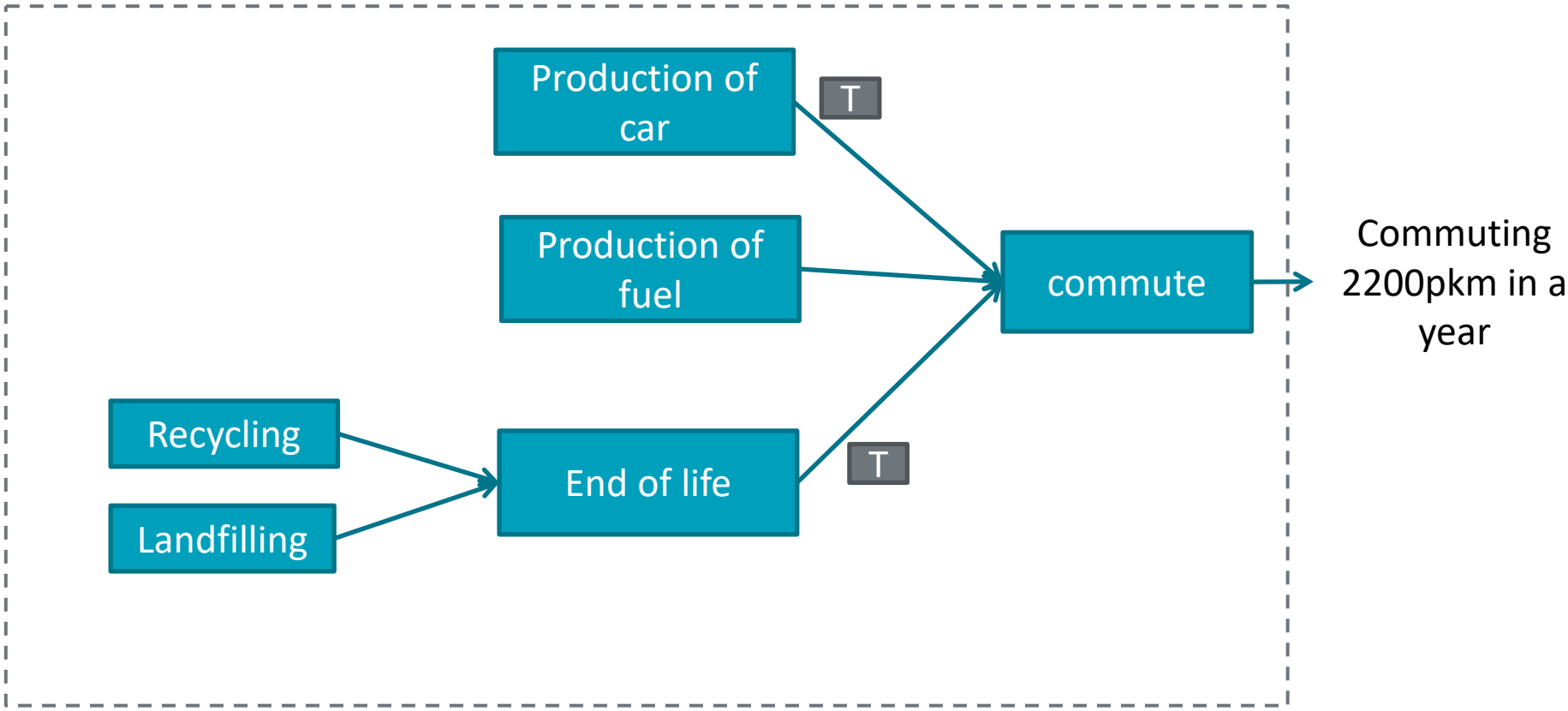
Example of product system: commuting 2200 pkm in a year



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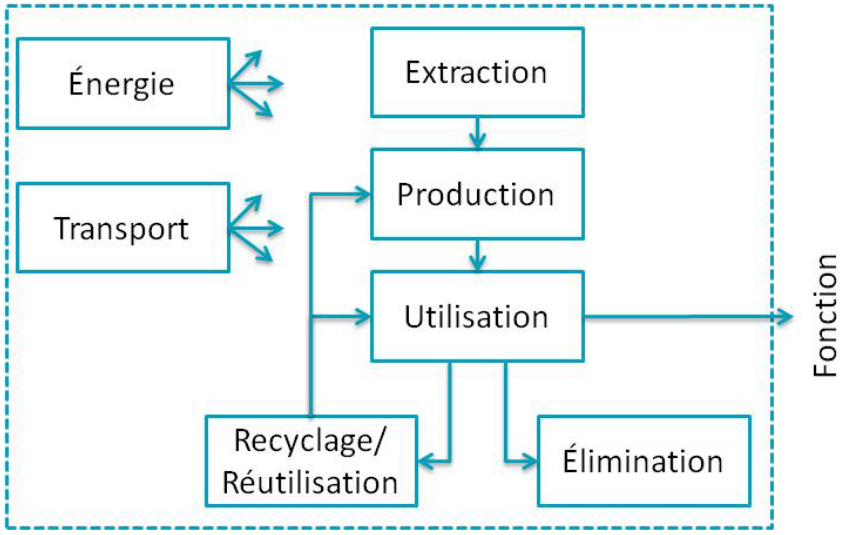
Three important rules for defining the system boundary



1. The system boundary must cover the same functional reality in all scenarios

2. Identical steps in all scenarios may be excluded only if it doesn't affect the functional equivalence between the scenarios

3. The included processes must contribute above the cut-off criteria

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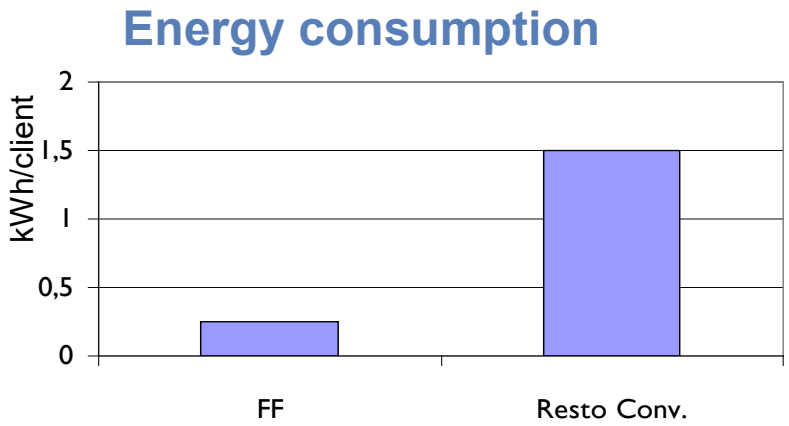
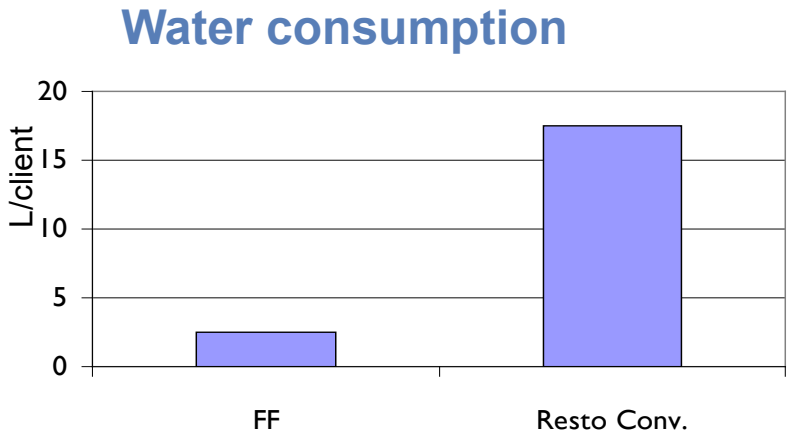
Rule 1: Same functional reality

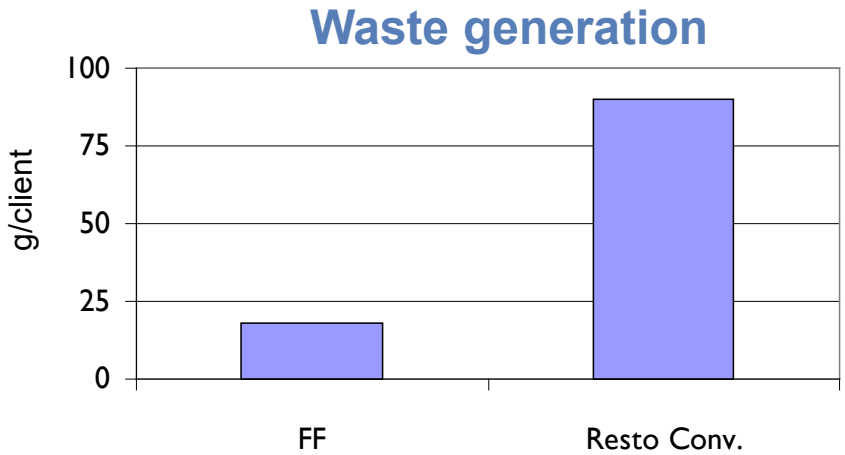
- The compared alternatives must cover the same functional reality in all scenarios = deliver the same quantity & quality of *function*
- Not comparable:
  - 1 pair of shoes with a lifespan of 4 years vs. 1 pair of shoes with a lifespan of 6 months (**quantity of function is different**)
  - Meal in a 5-star restaurant vs. Meal in a fast-food restaurant (**quality is too different**, unless we define a FU strictly in terms of nutritional value)
  - Landfill of 1kg of waste vs. Incinerating 1kg of waste (heat as **supplementary function** in the case of incineration)
- The product system must include all the activities so that the functions covered by both systems are equivalent

Rule 1: Same functional reality

- Example of an error with regards to Rule 1 (same functional reality)
- According to a study performed in 1990, a fast-food restaurant consumes **less energy**, **less water** and produces **less waste** than a conventional restaurant.







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Rule 1: Same functional reality

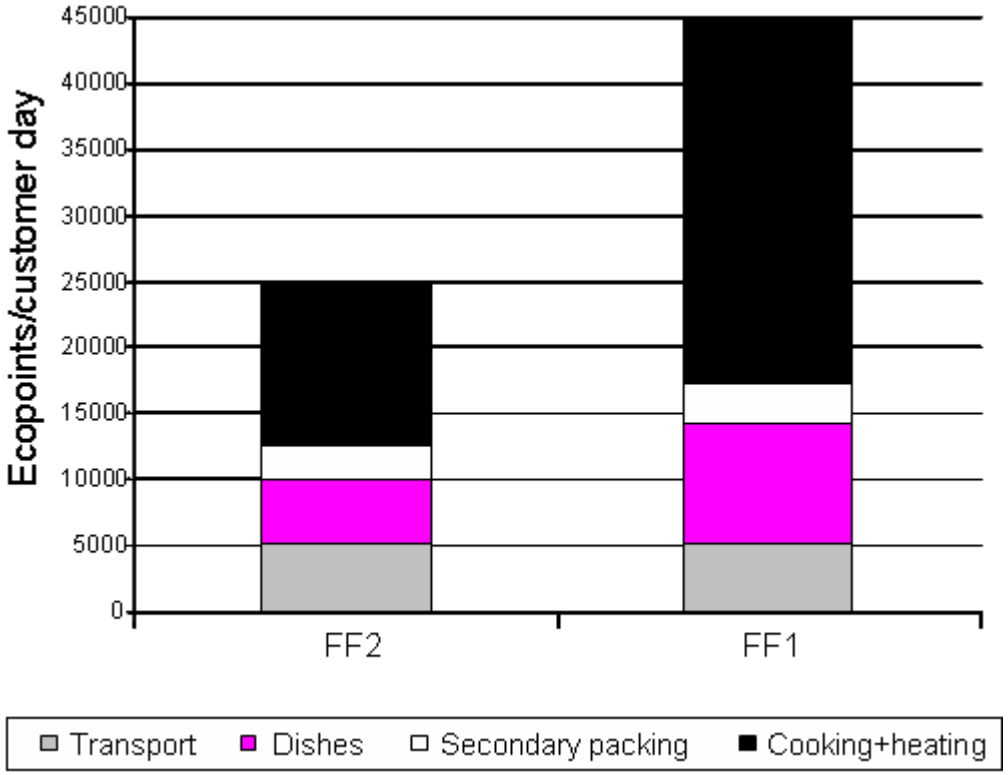
- The system boundaries considered for both restaurants were within the walls of the restaurant (do not cover the same functional reality)
- The only processes occurring within the restaurant walls were compared
  - **The *fast-food restaurant* receives much more food conditionned externally**
  - **A conventional restaurant has much more preparation and dishes are cleaned**

Fast-food	Restaurant conventionnel
Agro food supply chain	Chaîne de production agronomique
Transport	Transport
Centralized food conditioning (hamburger preparation, salad, etc.)	
Disposable tableware production	Ceramic dishes to be cleaned
Cooking	Food conditioning and cooking
leaning, heating, lighting of the restaurant	leaning, heating, lighting of the restaurant
Management of packaging and food waste	Management of packaging and food waste

Rule 1: Same functional reality

The study was redone by other analysts (Lang et al., 1994)

The fast-food in study 1 (FF1) was compared to another fast-food restaurant where the food was served in reusable plates when the client attend the restaurant (FF2) encompassing the full life cycle



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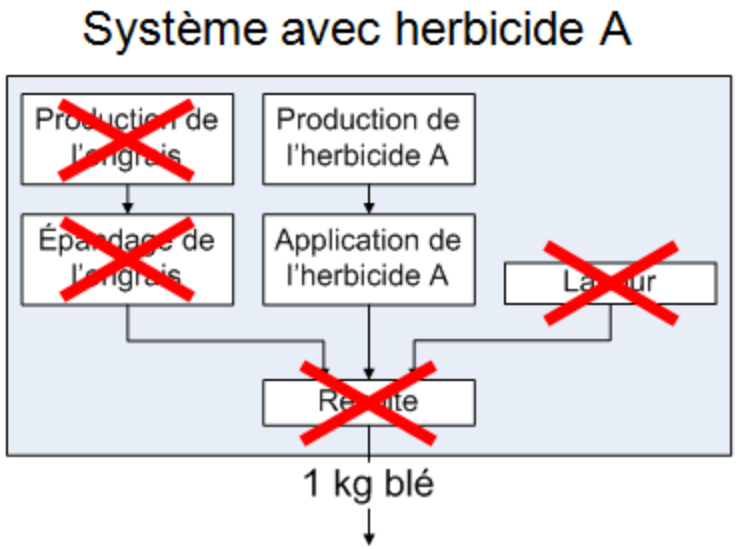
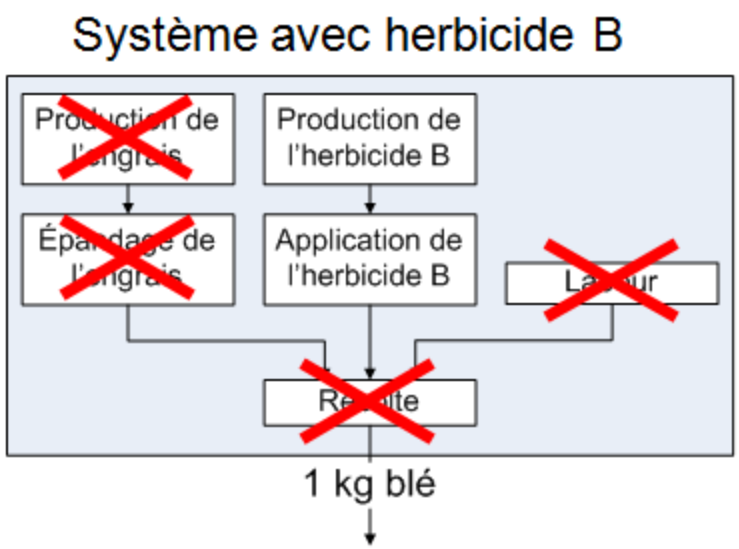
Rule 2: identical steps may be excluded

- Identical steps in all scenarios may be excluded **at the condition that** the reference flows affected by these processes are exactly the same (conservation of functional equivalence between the scenarios)
- Examples
  - **Comparision of two herbicides for wheat production**
  - **Cradle-to-gate LCA**
  - **Gate-to-grave LCA**

Rule 2: identical steps may be excluded
Example of comparison of two herbicides for wheat production

- Why not exclude the production and spraying of fertilizer, as well as labour and harvesting since all of these steps are in both systems?
- Simplification is possible IF AND ONLY IF the crop yield is identical with both herbicides!





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Rule 2: identical steps may be excluded
Example of comparison of two herbicides for wheat production

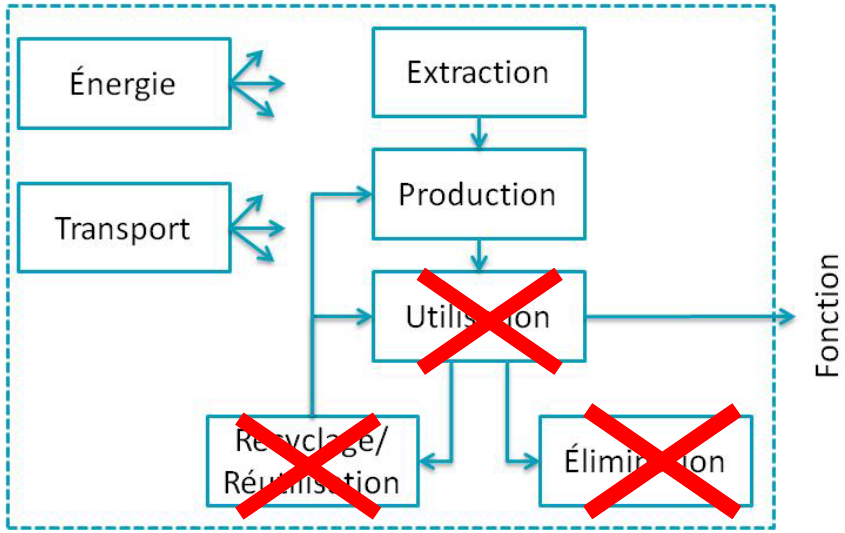
- If the choice of herbicide changes the yield
  - **Herbicide A: 4000kg/ha. Herbicide B: 5000kg/ha**

- The production of 1kg of wheat therefore needs
  - **25% more land using herbicide A rather than herbicide B**
  - **25% more area of spraying fertilizer, labour and harvesting is needed!**

- Since reference flows and emissions per functional unit are different, all of these processes must be included

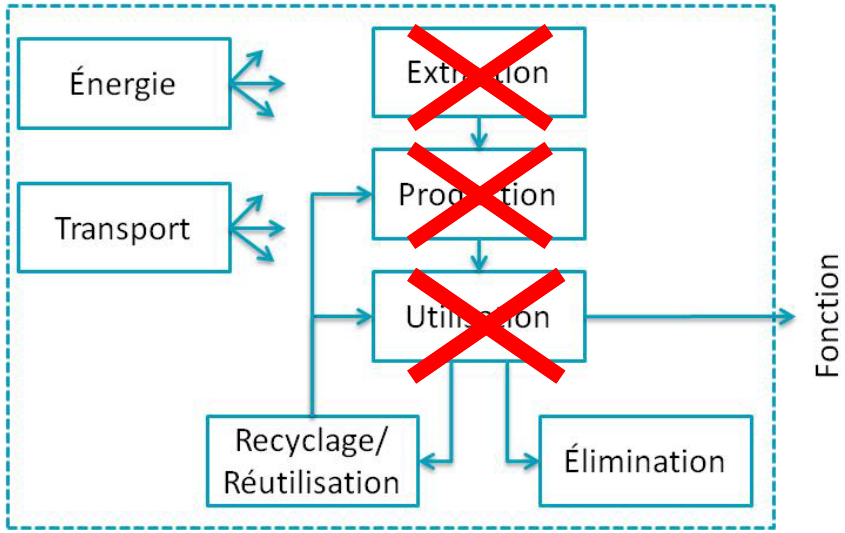
Rule 2: excluding identical steps « cradle-to-gate »

- LCA comparing different processes to manufacture the same product
  - **so that their use phase and end of life would be equivalent**
- LCA aiming to evaluate the production of a given material



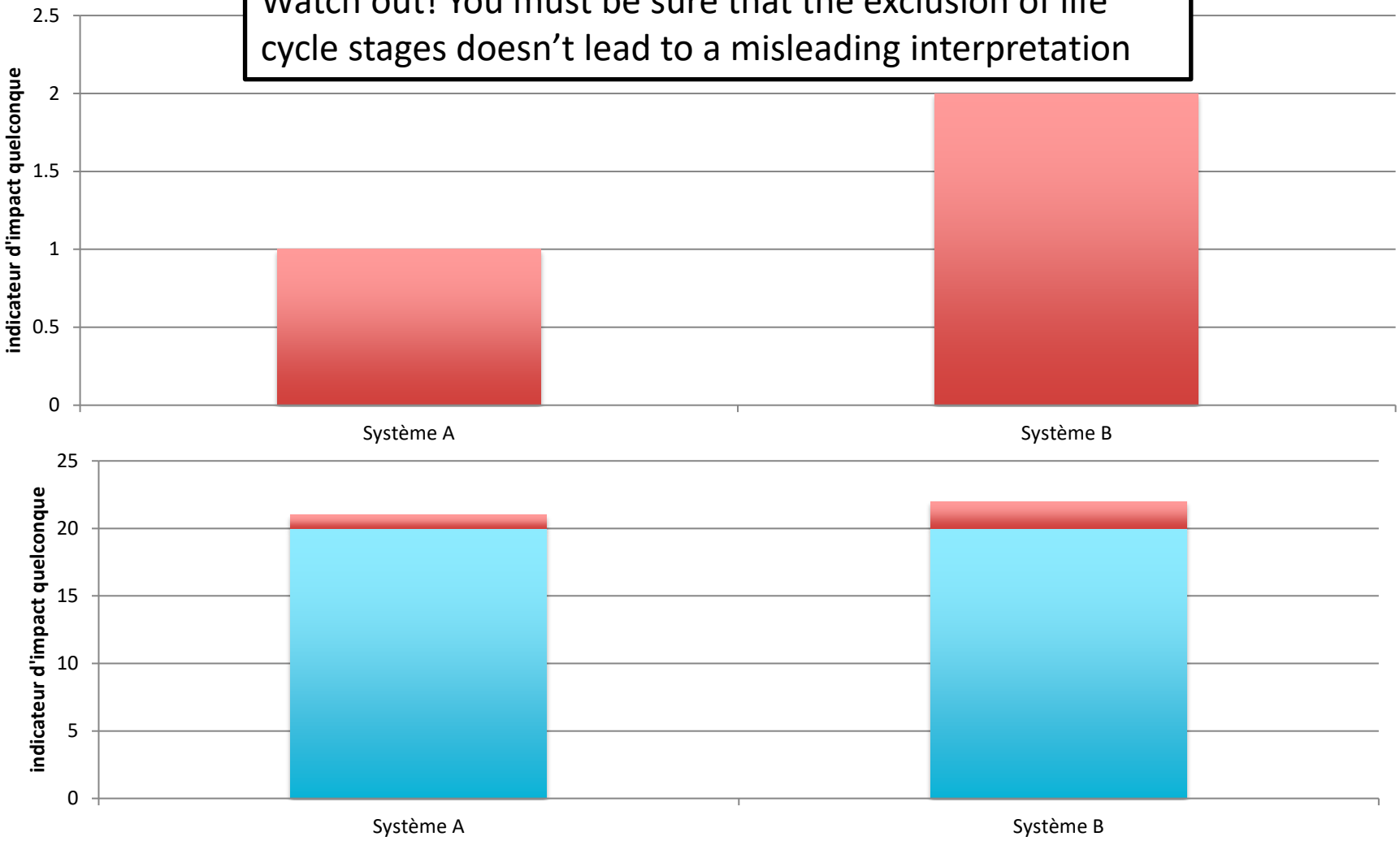
Rule 2: excluding identical steps « gate-to-grave »

- LCA comparing different means of managing waste at the end of life
  - **The steps preceding disposal won't have an influence on the comparison**



System boundary: excluding identical steps

Watch out! You must be sure that the exclusion of life cycle stages doesn't lead to a misleading interpretation



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Rule 3: Cut-off criteria

- The chosen processes contribute at least to…
  - **x% of the mass of inputs**
  - **x% of the energy consumption**
  - **x% of the environmental relevance**

  where x is a threshold defined beforehand

- This rule is difficult to use in practice
  - **To know if a unit process contributes less than x% of impacts, we need to evaluate its contribution.**
  - **If the effort necessary to evaluate these impacts is already done, there isn't any reason to exclude it.**
  - **In practice, we use proxies and/or judge by experience**

  → This exclusion must be mentioned in the LCA report

CONCLUSION

Conclusion

The goal and scope is the first step to conduct a LCA. It is important to well define well the different requirements, because it will have a big influence on all the study.

- Goal
  - **Why?**
  - **To whom?**
  - **For what purpose?**
- Scope
  - **Functions of the system**
  - **The functional unit**
  - **Reference flows (calculated form key parameters)**
  - **The product system to study**
  - **…**
  - **Allocation rule (week 6)**
  - **…**