



DDI8003E – Week 6 ecoinvent, multifunctionality and recycling

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POLYTECHNIQUE
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On the agenda today

- Project's midterm presentations → next week
- Ecoinvent
- Multifunctionality
- Recycling approaches
- Lab 3

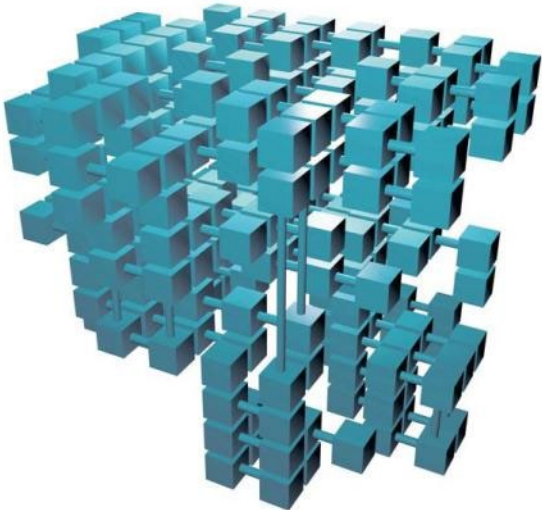
ECOINVENT (INVENTORY DATABASE)

90s	Demand for LCI data growing in Switzerland Data development in many institutions Non-centralized data, sometimes contradictory No one institution is sufficiently strong to maintain a complete LCI-DB of good quality
1997	Creation of the NGO « Centre ecoinvent »: ETH Zurich, EPF Lausanne, PSI, EMPA, ART Financed by the Swiss government Goal: create and maintain the ecoinvent LCI-DB Harmonisation Characteristics aimed for: scientifically solid and transparent data All revenues reinvested in the LCI-DB
1999-2007	ecoinvent 1.0-1.3 (~2500 datasets) Integration in main software Starts gaining momentum (particularly in research community)
2007-2013	ecoinvent 2.0-2.2 (~4000 datasets) Work started on ecoinvent v3
2013-now	ecoinvent v3 (> 15000 datasets)

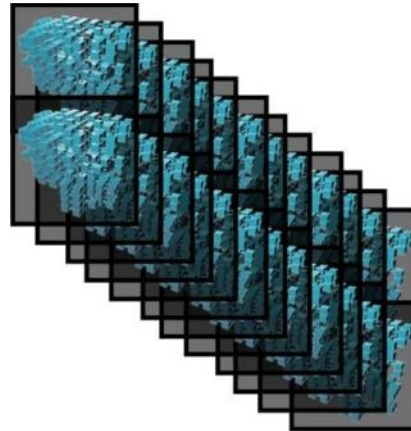
ecoinvent : some characteristics

Transparency

- Datasets available in disaggregated version (gate-to-gate) and aggregated (pre-calculated inventories)
- Exhaustive documentation (datasets, hypotheses)



ecoinvent version
« Unit process » (U)



ecoinvent version
« System process » (S)

Note: some datasets are only available in « S », e.g. plastics, for confidentiality reasons imposed by industry associations

ecoinvent : some characteristics

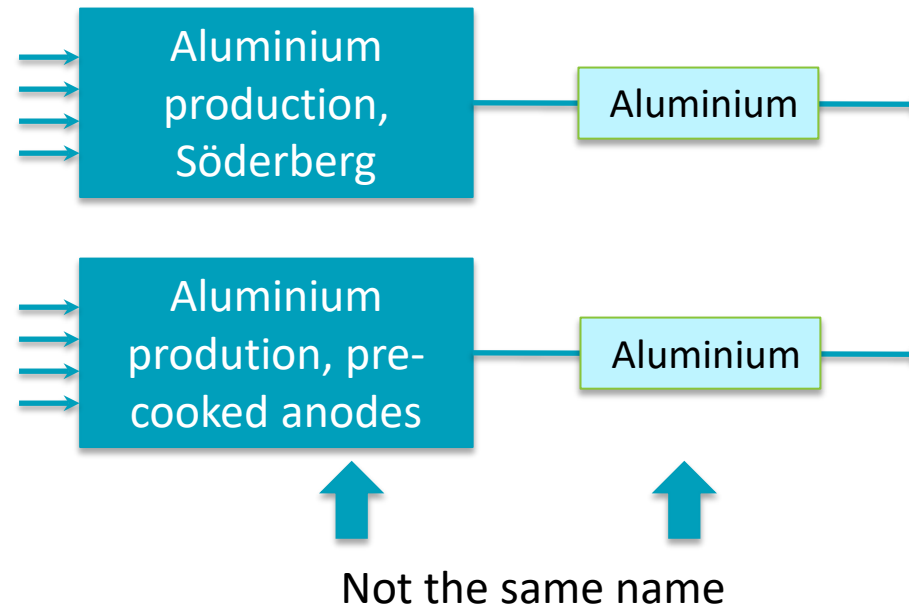
Comprehensiveness

- Elementary flows
 - All extraction/emissions included, even if the substances are not yet associated to a characterisation factor
- Intermediary flows
 - Effort to cover as many intermediary flows as possible (no exclusion criteria)
 - Infrastructure, transport, packaging, etc.
- Industry sectors
 - Extraction of resources, agriculture, production and transformation of materials, energy, end of life, transport
- Geography
 - More countries, especially since v3 – noted with abbreviations

Data integration on *uncertainty* of flows

ecoinvent v3

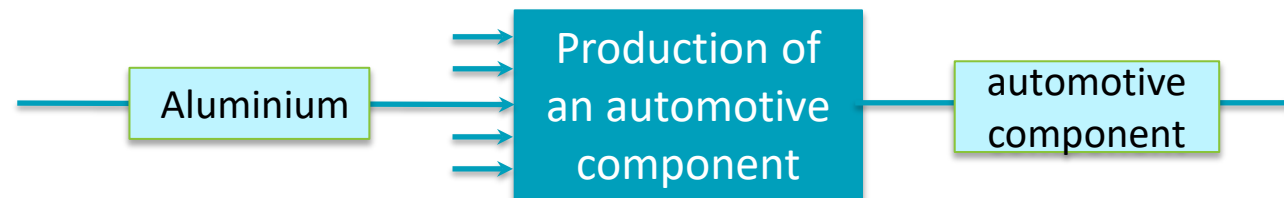
1. Distinction between the nomenclature of products (flows) and processes (activities/providers)



ecoinvent v3 – Technical differences

2. Distinction between processes of *transformation* and *market*

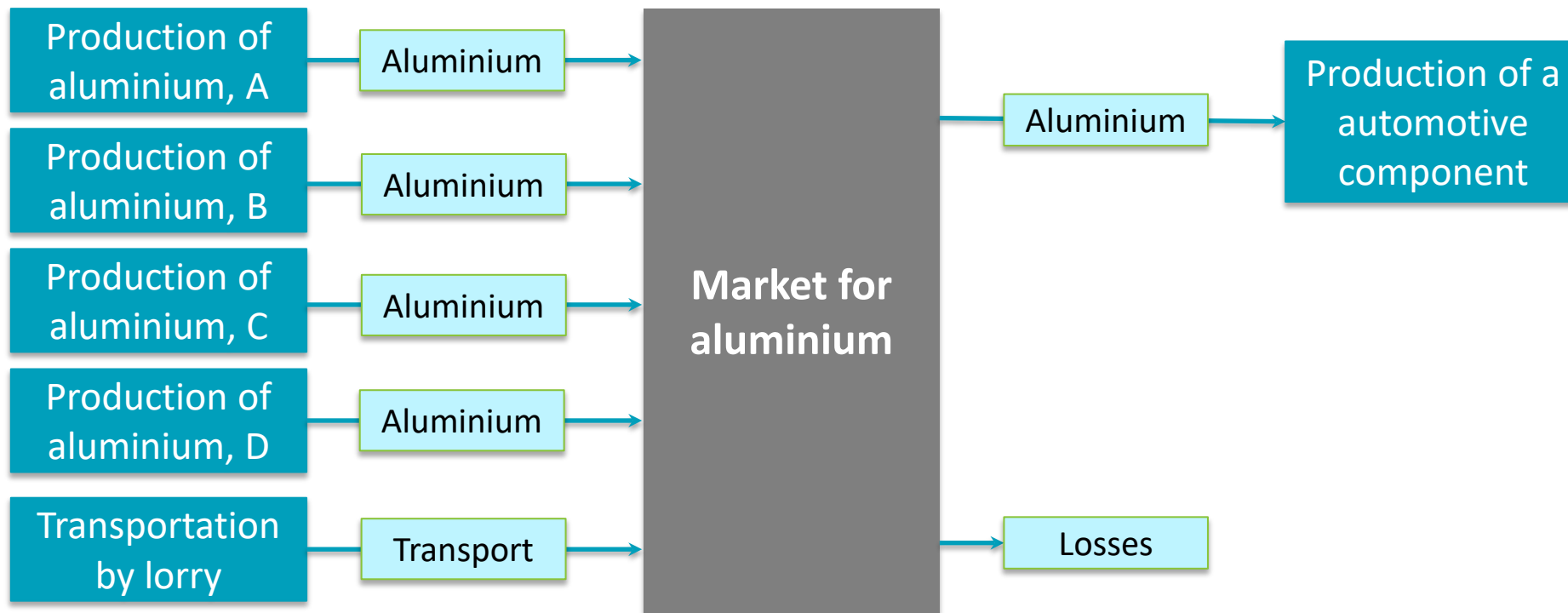
- Transformation process, inputs \neq outputs



ecoinvent v3 – Technical differences

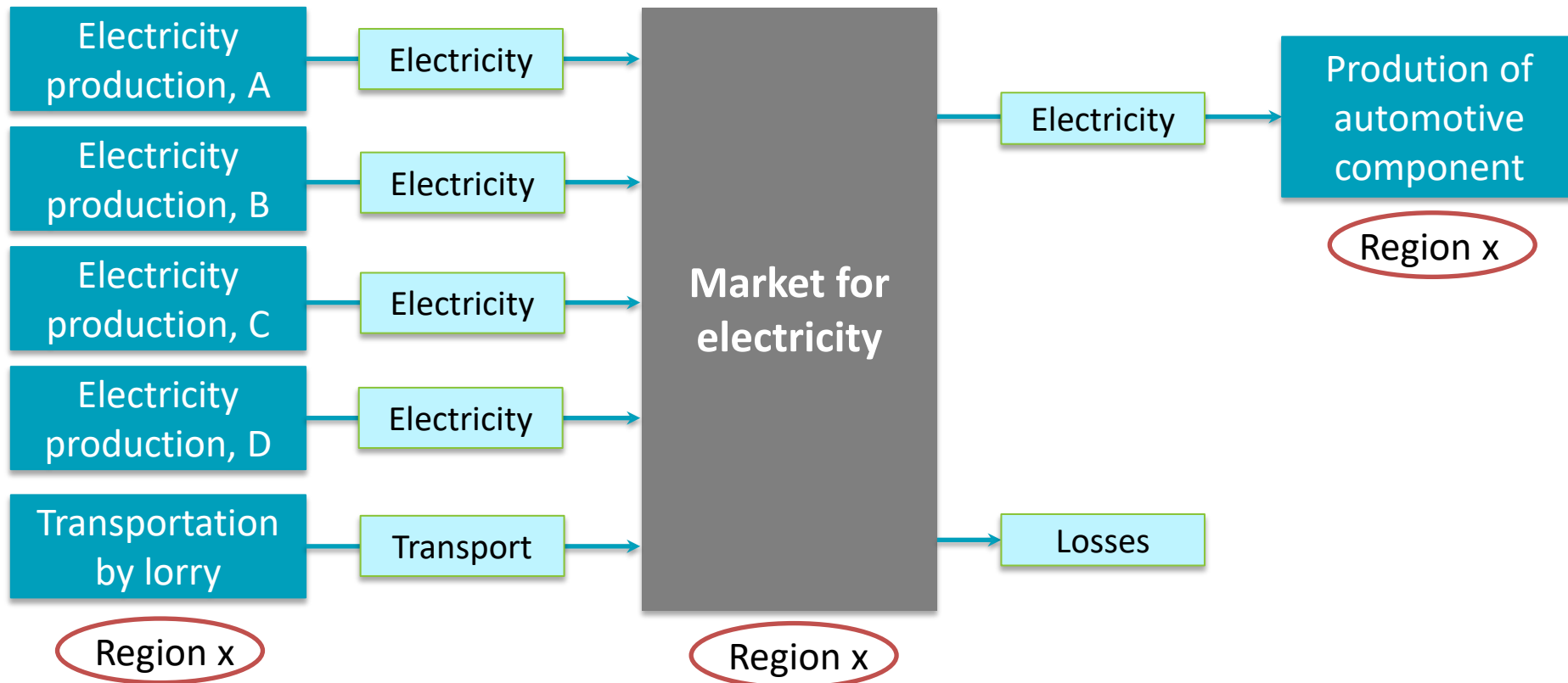
2. Distinction between processes of *transformation* and *market*

- **Market process, inputs = outputs**



ecoinvent v3 – How it works

Automatic links between producers, market and suppliers, based on location



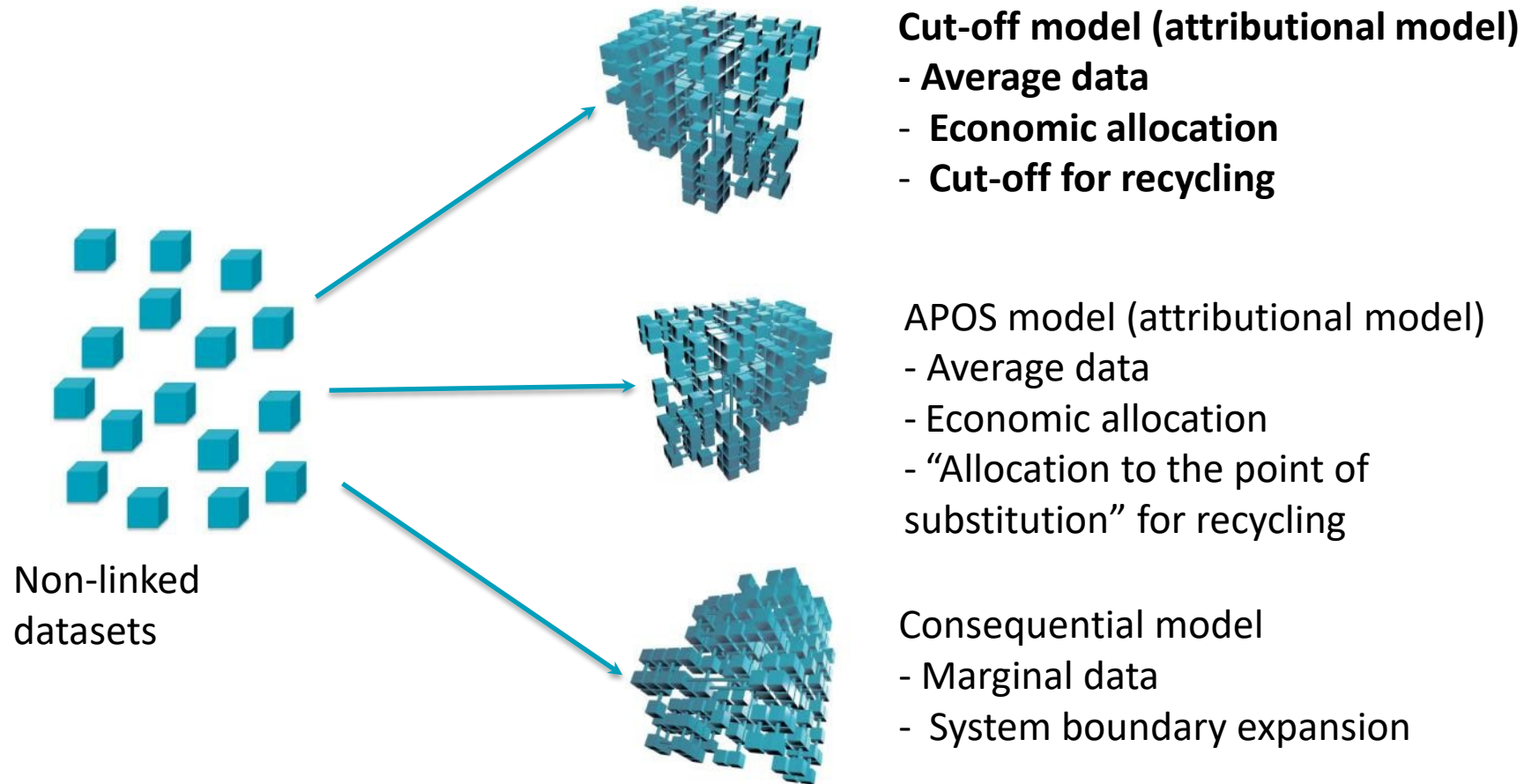
ecoinvent v3 – How it works

Automatic links between producers, market and suppliers, based on location

- *Some important details:*
 - Default region = global (GLO)
 - When a region < GLO is defined, another region « rest of world» (RoW) is created
 - The more regions created, the more the production volume of RoW is reduced

ecoinvent v3 – How it works

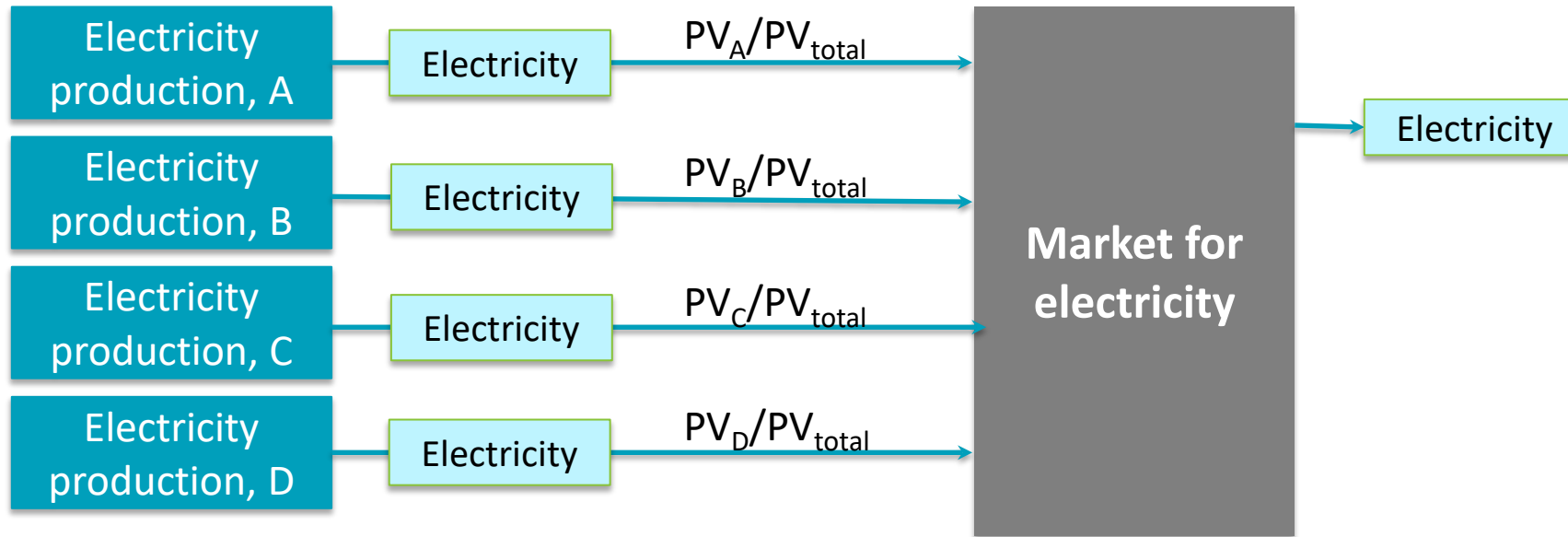
A group of disaggregated unit processes, many system models



In your projects,
by default

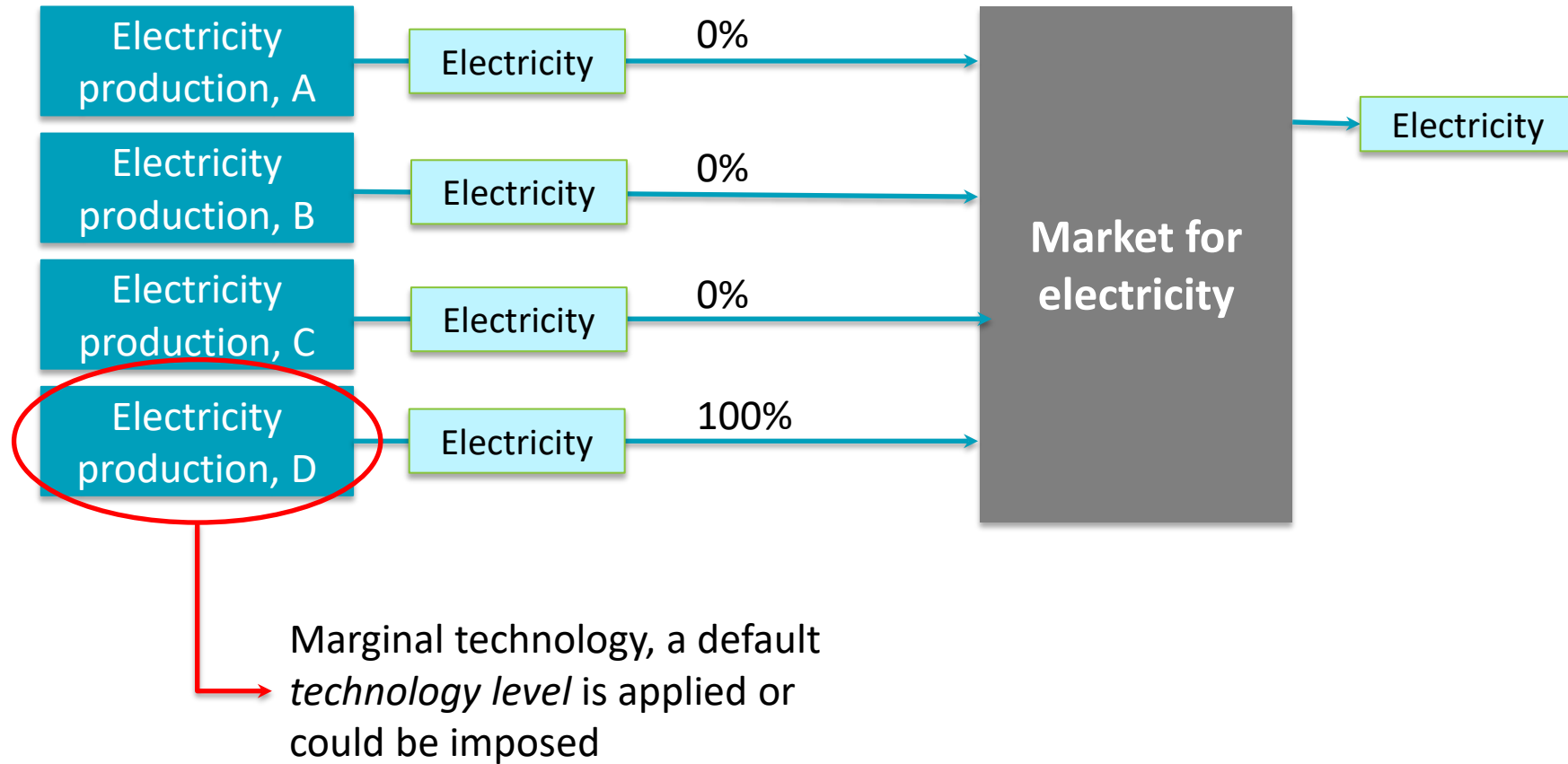
ecoinvent v3 – How it works

Attributional model



ecoinvent v3 – How it works

Consequential model



Ecoinvent v3.6

You have access to the ecoinvent version 3.6 for this course

- <https://support.ecoinvent.org/ecoinvent-version-3.6>
- 18000+ activities
- Should not be used externally → delete it after the course

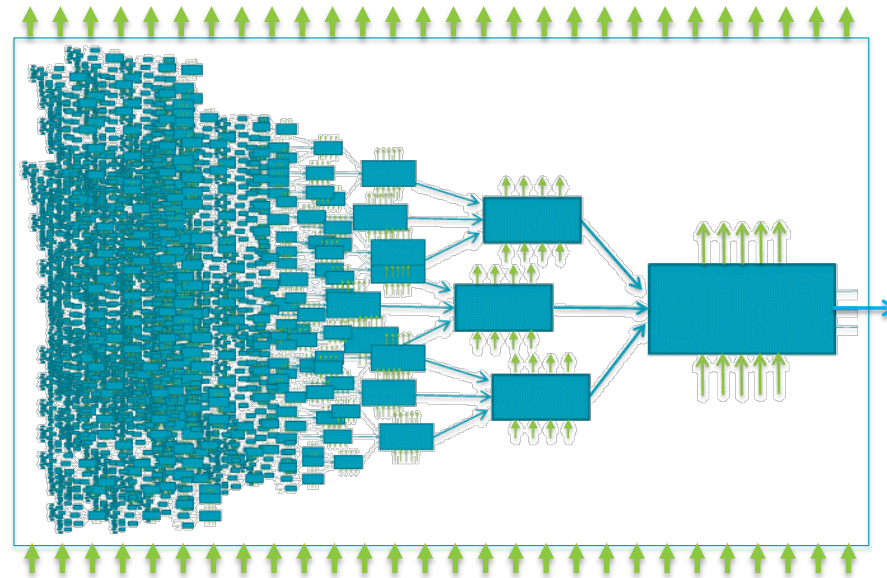
Resources

- Definitions: <http://www.ecoinvent.org/support/glossary/glossary.html>
- Frequently asked questions: <http://www.ecoinvent.org/support/faqs/faqs.html>
- Short presentation: <http://www.ecoinvent.org/support/documents-and-files/documents-and-files.html>
- Webinar: https://www.youtube.com/channel/UC4Ma_pX9r1-DoNi2D2Fd6g

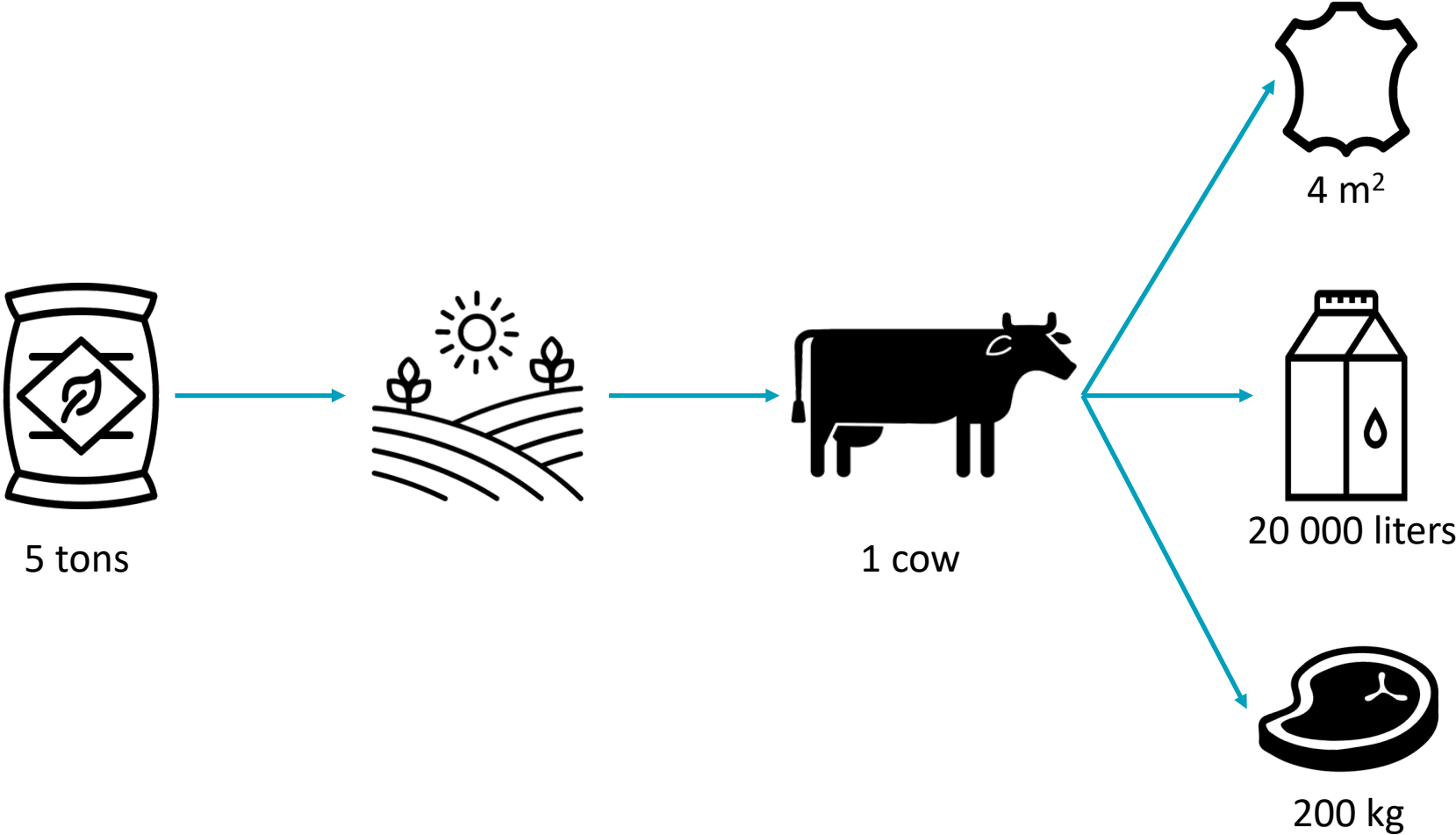
MULTIFUNCTIONALITY

Recap: System boundary

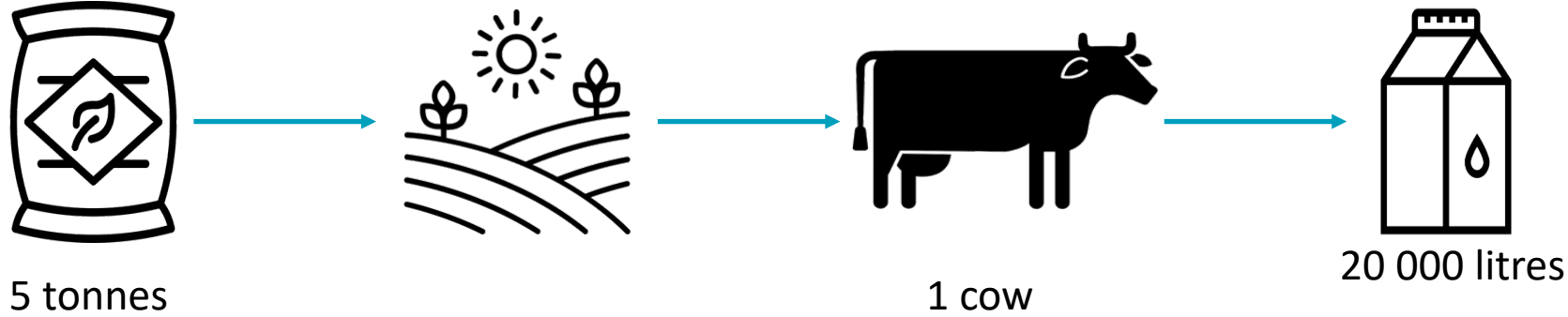
- In theory, the only economic flows that cross the system boundary in the study are directly associated to the function (**final demand flow**)
- The other economic flows are entirely consumed by the other unit processes (fundamental assumption: **market balance** assumption)
- All other flows that cross the system boundary are elementary flows



Multifunctional processes – the example of a cow

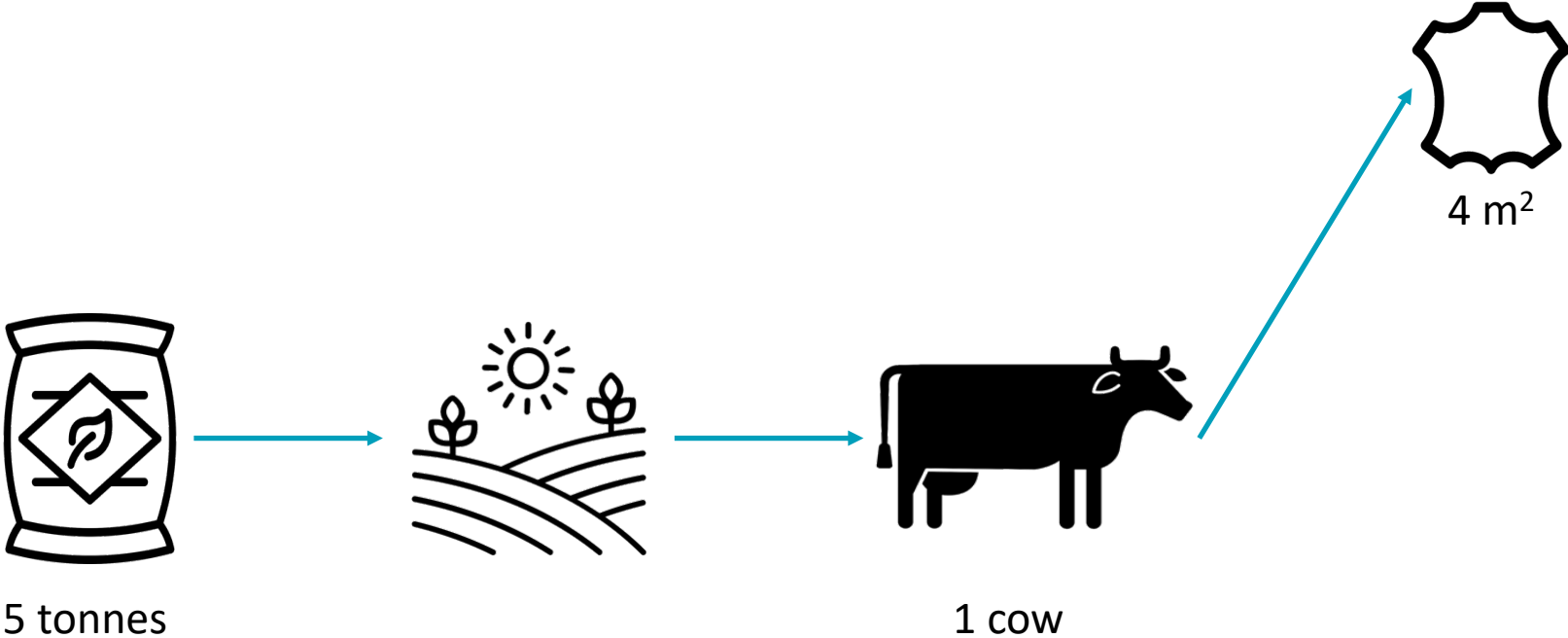


Multifunctional processes



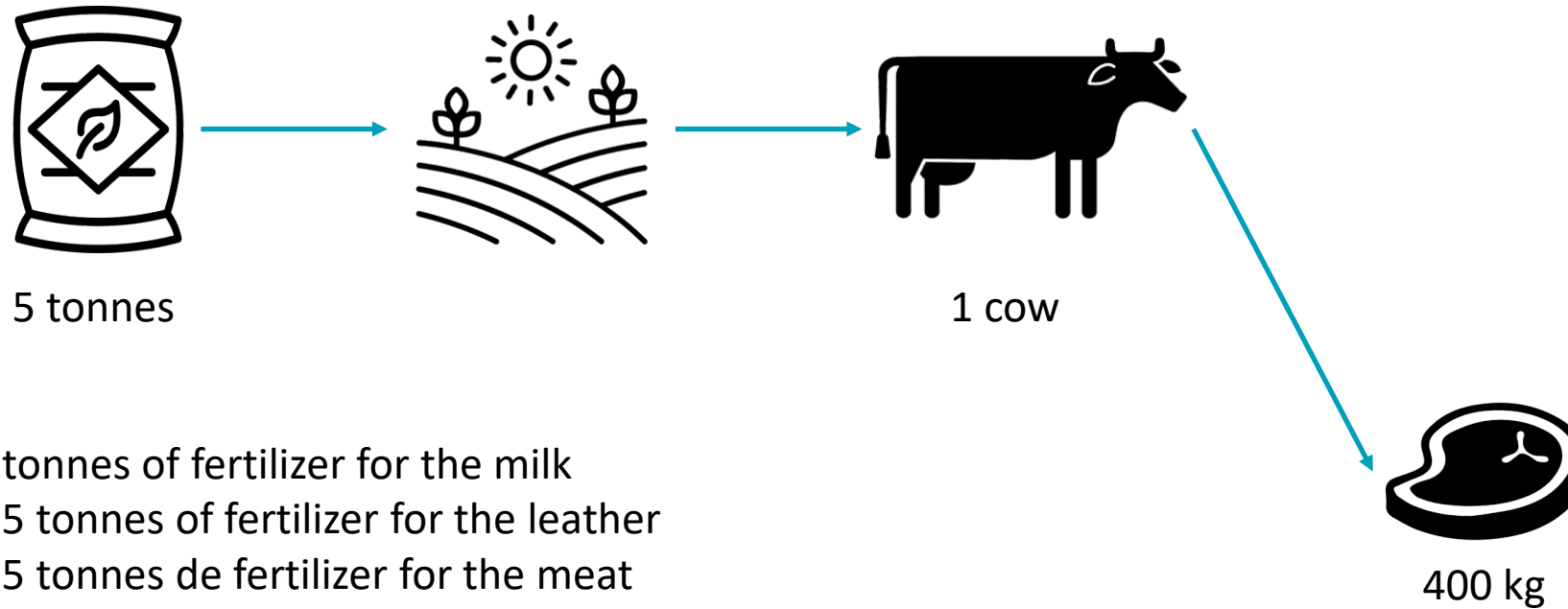
5 tonnes of fertilizer for the milk

Multifunctional processes



5 tonnes of fertilizer for the milk
+ 5 tonnes of fertilizer for the leather

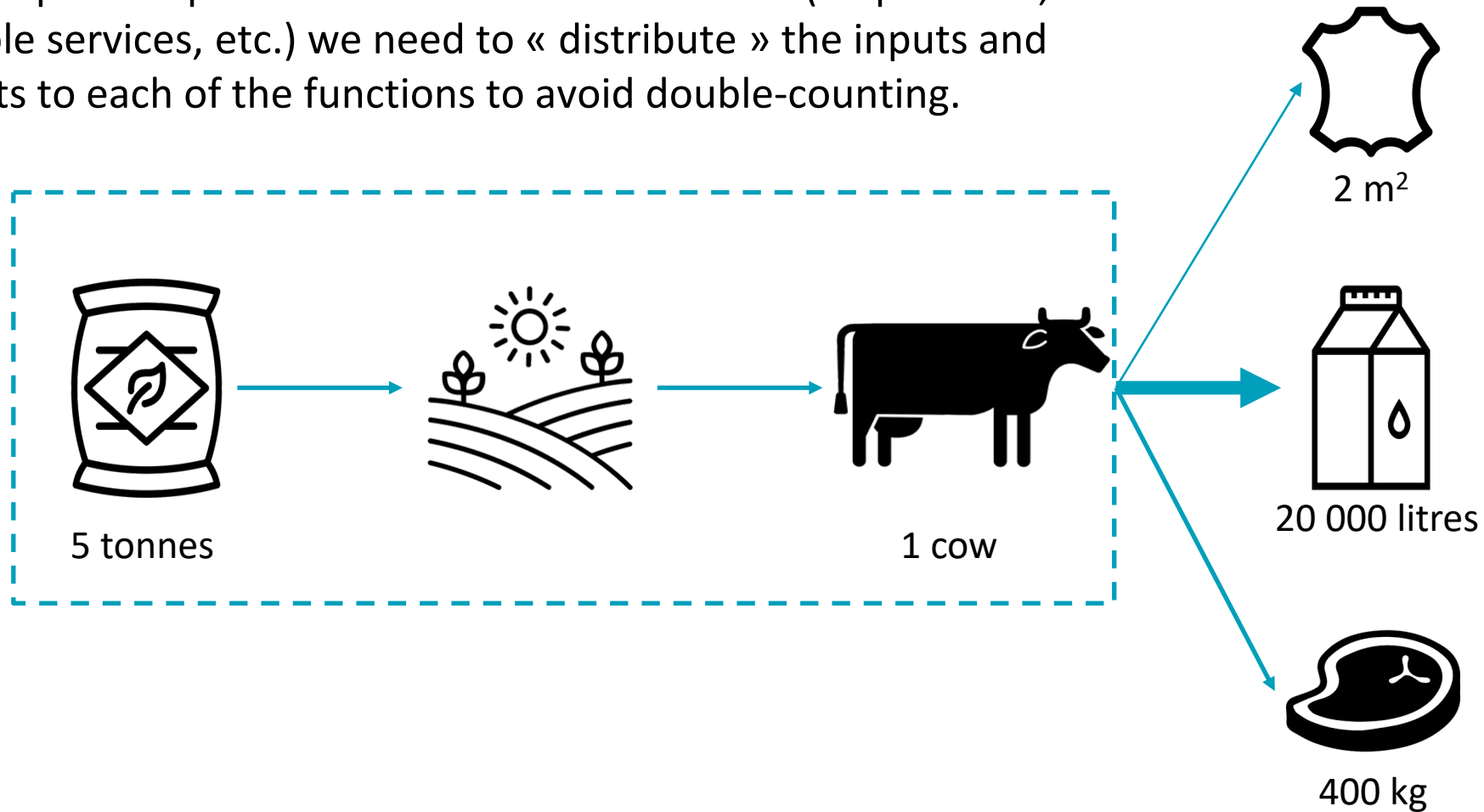
Multifunctional processes



5 tonnes of fertilizer for the milk
+ 5 tonnes of fertilizer for the leather
+ 5 tonnes de fertilizer for the meat
= 15t!! → **ERROR! Double counting**

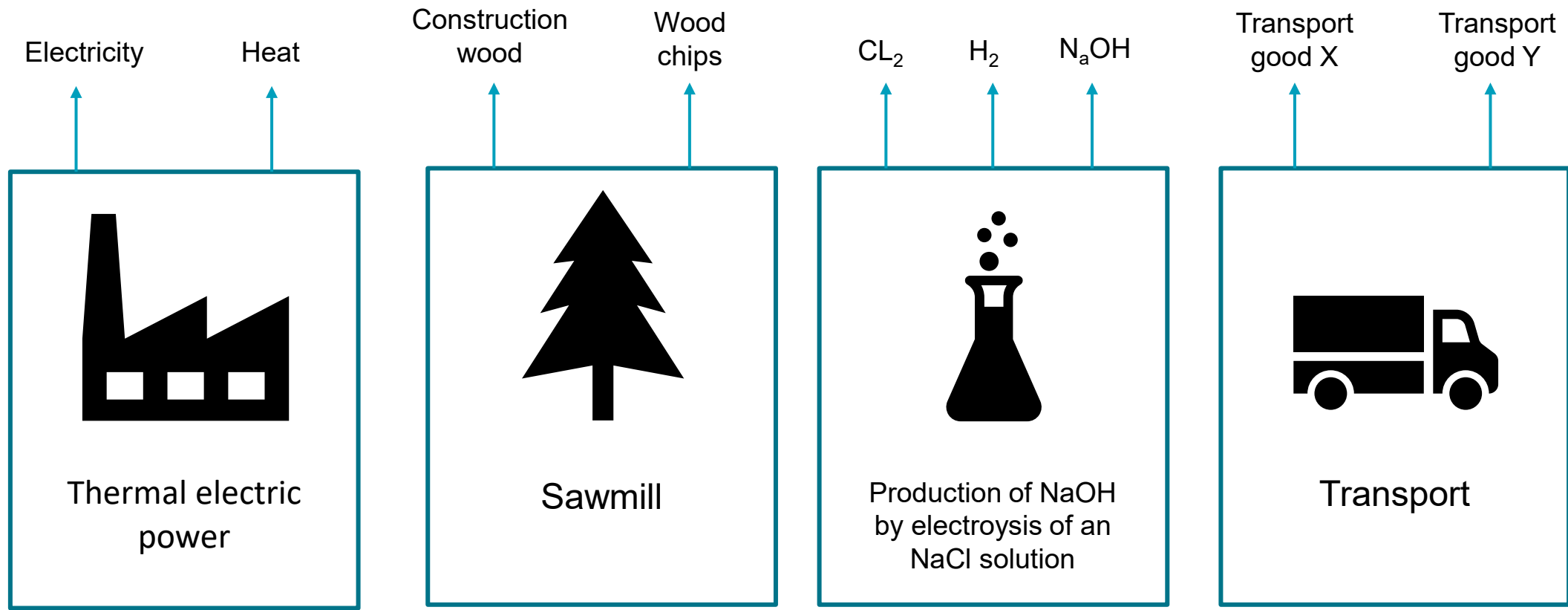
Multifunctional processes

- When a process provides more than one function (co-products, multiple services, etc.) we need to « distribute » the inputs and outputs to each of the functions to avoid double-counting.



Multifunctional processes

- These processes are omnipresent:



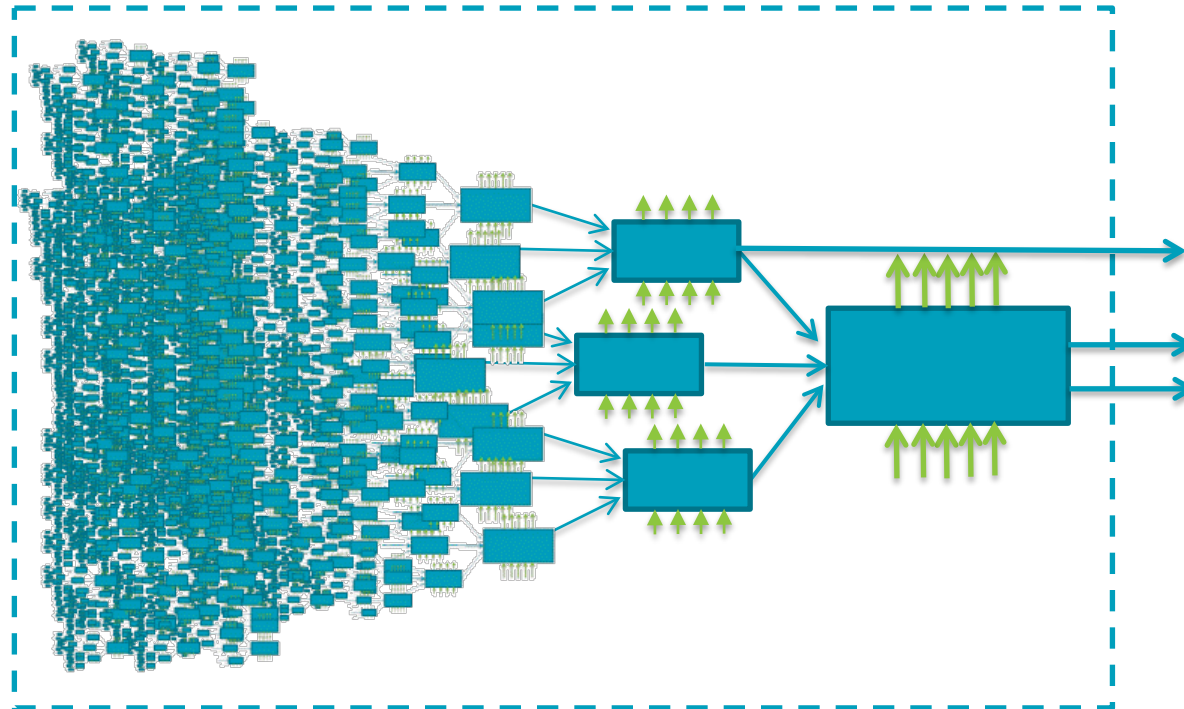
Multifunctional processes

- Different levels of **technological linkage** between coproducts (are they always coproduced in the same ratio? Does the production of one force the production of the other?):
 - **Refining petroleum: jetfuel (aviation fuel), gasoline, diesel, propane, bitumen, etc.**
 - **Wheat cultivation: straw, wheat grain**
 - **Raising cows: meat, milk, leather**
 - **Thermal electric power plant: electricity, heat**
 - **Sawmill: construction wood, wood chips for paper production, wood waste for energy production**
 - **Production of NaOH by electrolysis of an NaCl solution: NaOH, Cl₂, H₂**
 - **Transportation: many products transported in the same truck**

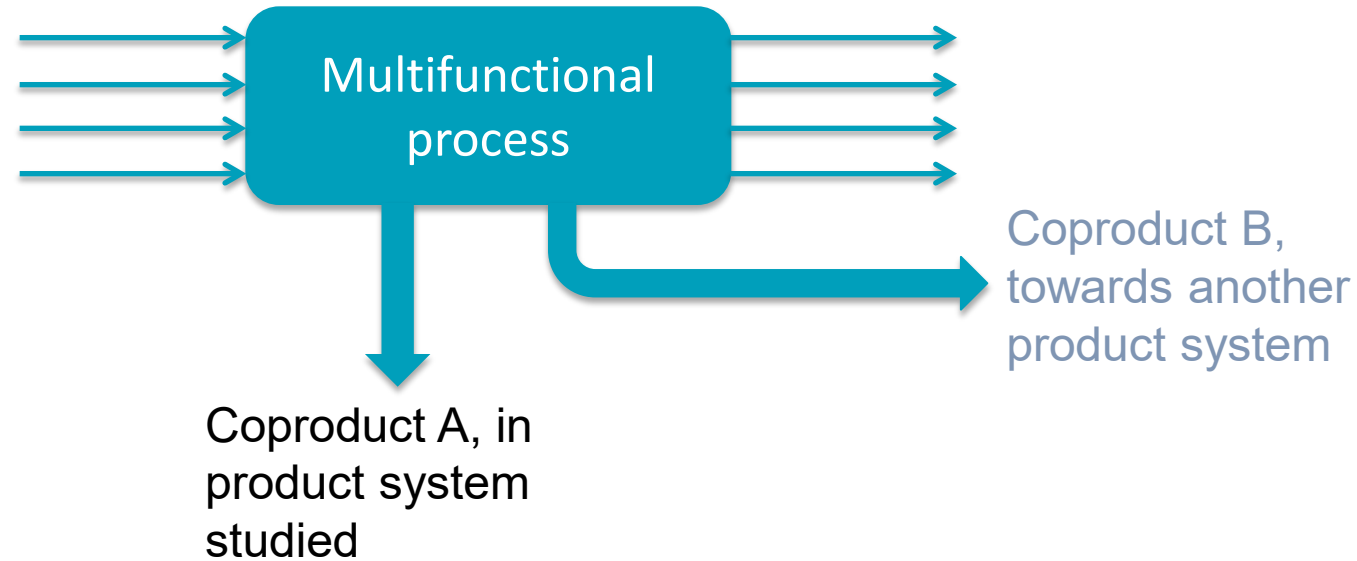
Why multifunctionality is a problem?

Problem of « double counting »

Only one intermediary flow can cross the system boundary



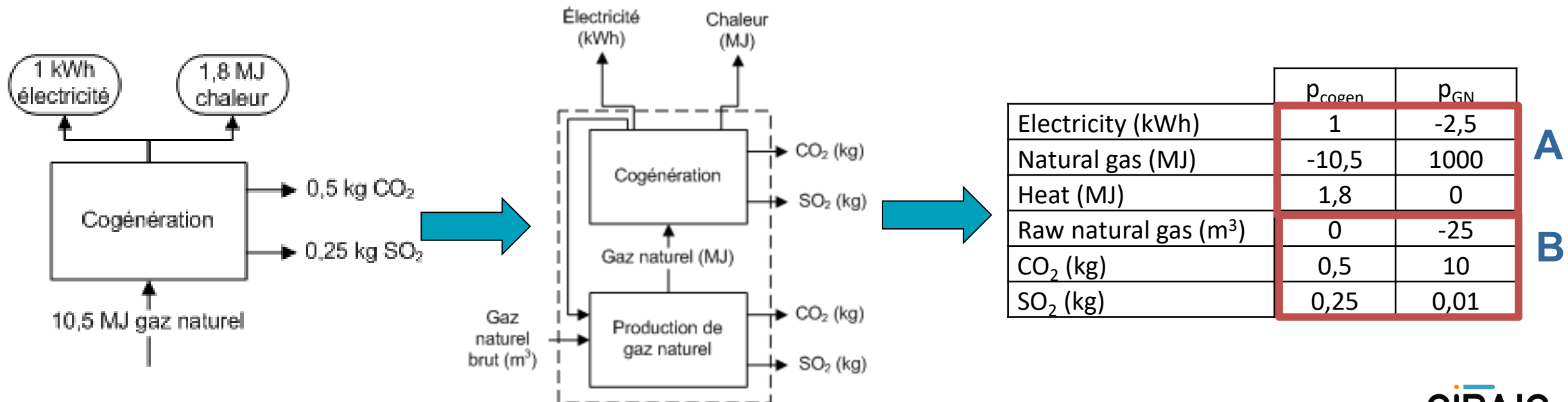
Multifunctionality problem



Problem: What proportion of impacts associated to the inputs and outputs of the multifunctional process should be attributed to coproduct A?

Multifunctional processes

- With multifunctional processes, more than one economic flows cross the system boundary: the system has more than one function
- With multifunctional processes, we will also have non-inversible **A** matrices (not square)...



How to solve multifunctionality in LCA?

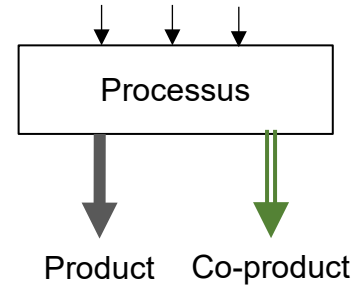
Subdivision

System
expansion

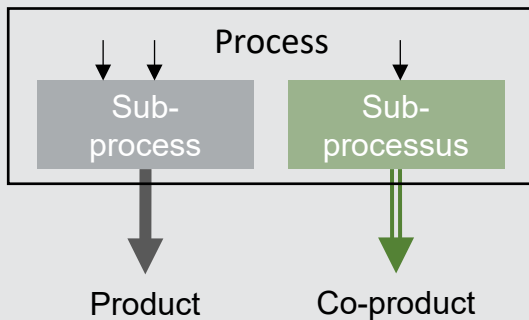
Allocation based on
underlying physical
relationship

Allocation based on
other relations

Overview of approaches to deal with multifunctionality

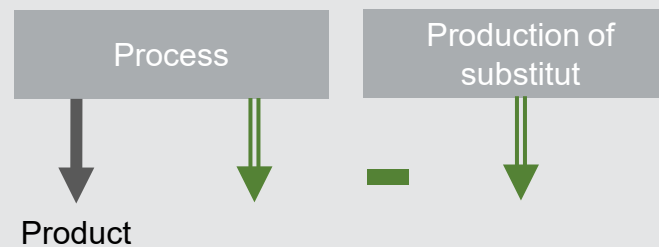


Subdivision

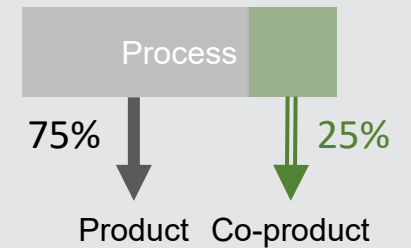


System expansion

Substitution



Allocation



- Allocation based on underlying physical relationship
- Allocation based on other relationship (economic, massic, energetic, etc.)

Multifunctional processes and ISO 14044

ISO 14044, section 4.3.4.2: The study must identify the processes shared with other product systems and follow the step-by-step procedure presented here:

Step 1: Avoid allocation as much as possible by:

- **Subdividing the unit process by creating two sub-processes or more;**
- **Extend the system boundary of the product system**

Step 2: Allocate the inputs and outputs in a way that reflects underlying physical relationships existing between them.

Step 3: Allocate inputs and outputs in a way that reflects other mutual relationships (mass, economic, etc.)

Multifunctional processes and ISO 14044

ISO 14044, section 4.3.4.2: The study must identify the processes shared with other product systems and follow the step-by-step procedure presented here:

Step 1: Avoid allocation as much as possible by:

- **Subdividing** **Subdivision** **creating two sub-processes or more;**
- **Extend the** **System expansion** **of the product system**

Step 2: Allocate the inputs and outputs in a way that reflects underlying physical relationships existing between them **Allocation – Underlying physical relationship**

Step 3: Allocate inputs and outputs in a way that reflects other mutual relationships (mass, economic, etc.) **Allocation – Other relationship**

**ISO calls them steps, but they are in fact
4 mutually exclusive options ranked by priority order**

How to solve multifunctionality in LCA?

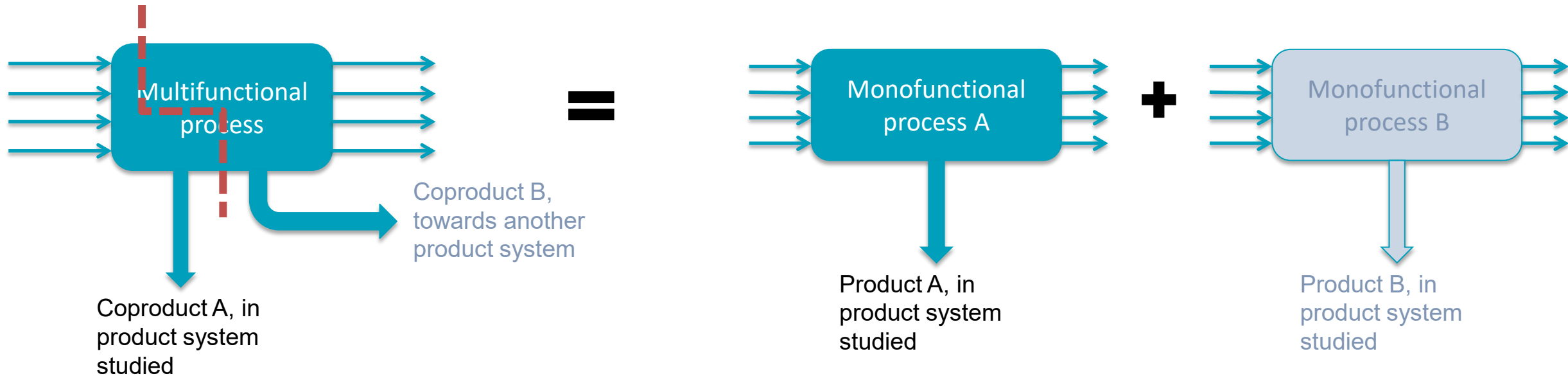
1. Subdivision

2. System expansion

3. Allocation based on underlying physical relationship

4. Allocation based on other relations

ISO 14044 Procedure– Step 1a: Subdivision



Step 1.1: Divide the process in sub-processes

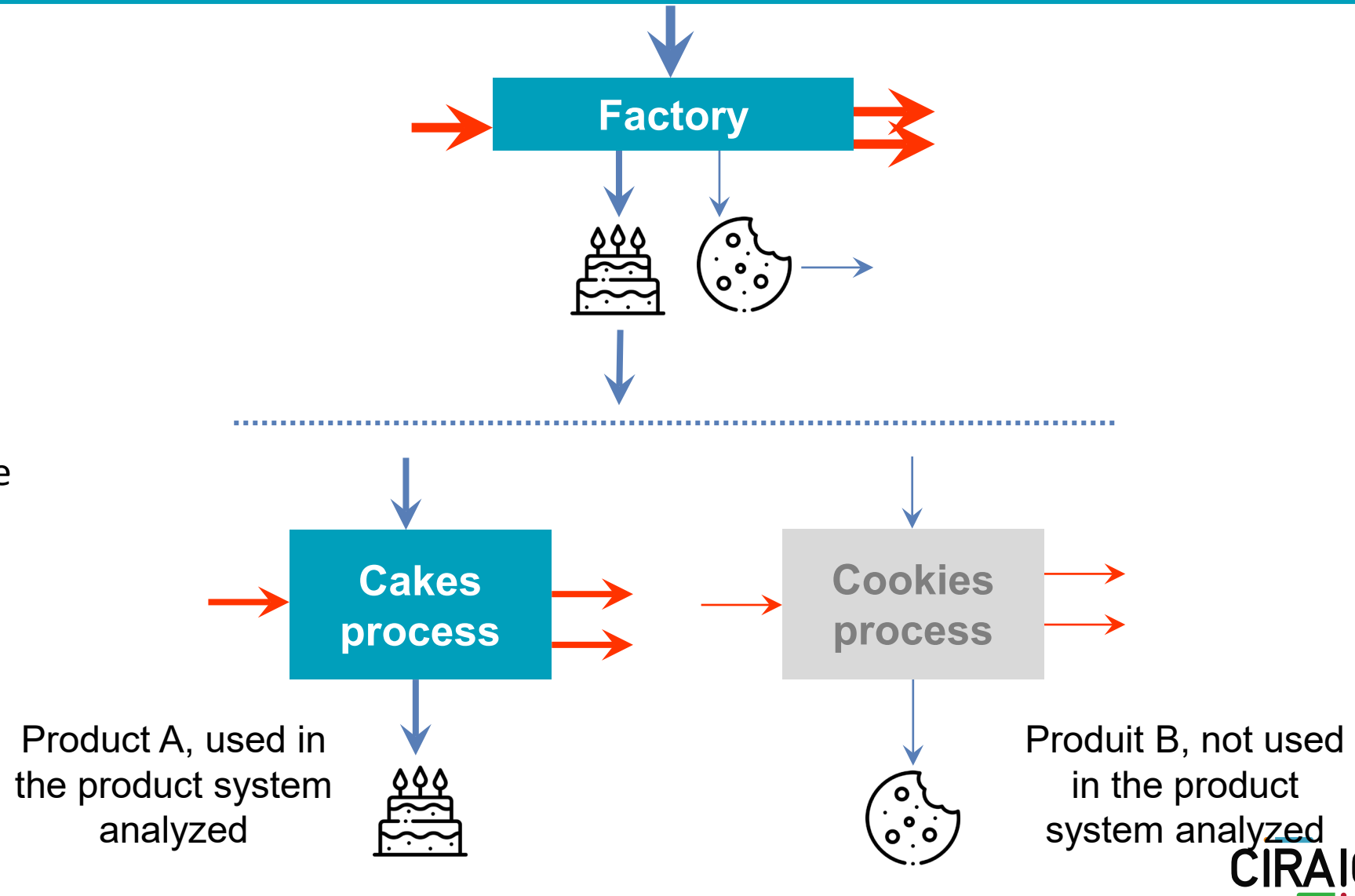
Note: only applicable if the process isn't actually multifunctional : no technological linkage between coproducts (combined production)

ISO 14044 Procedure– Step 1a: Subdivision

- Example: LCA of cakes.

We have data for all inputs and outputs of a factory producing two products: cakes and cookies.

The data collection could be refined to distinguish the processes in the factory that are used for the cake and those used for the cookies.



How to solve multifunctionality in LCA?

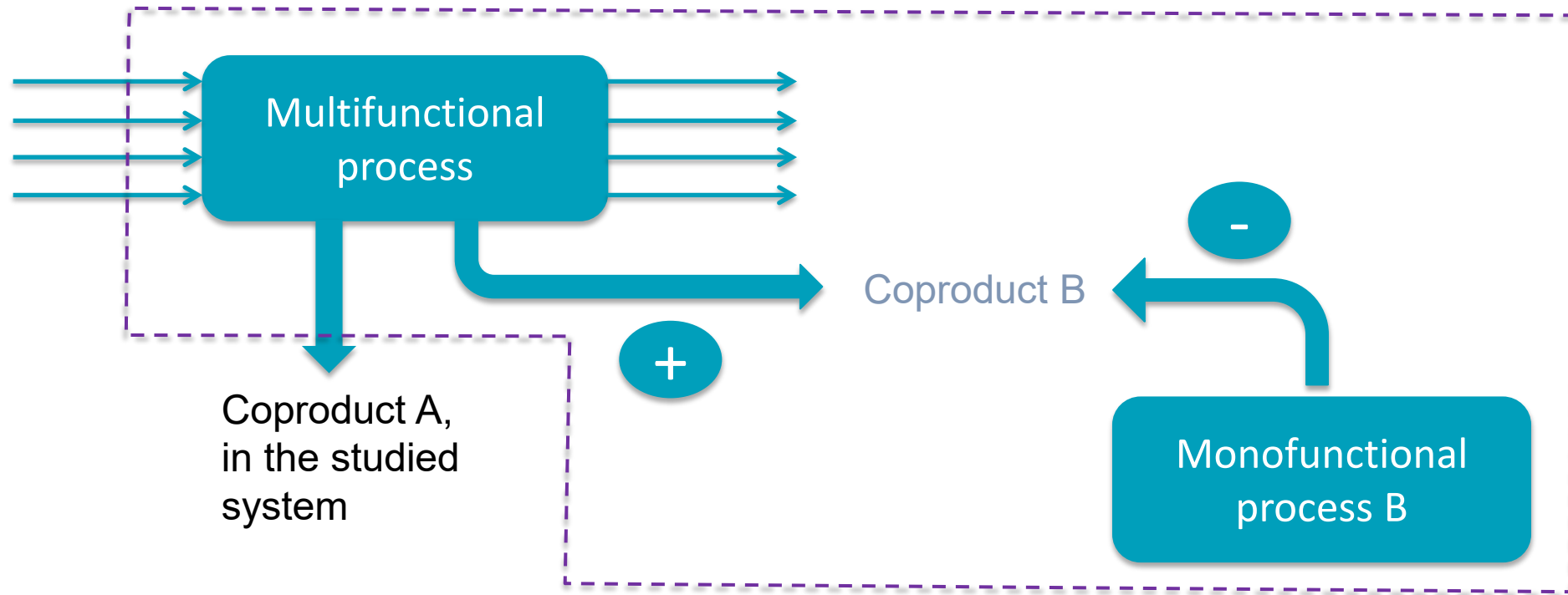
1. Subdivision

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ISO 14044 Procedure– Step 1b: Expanding the system boundary

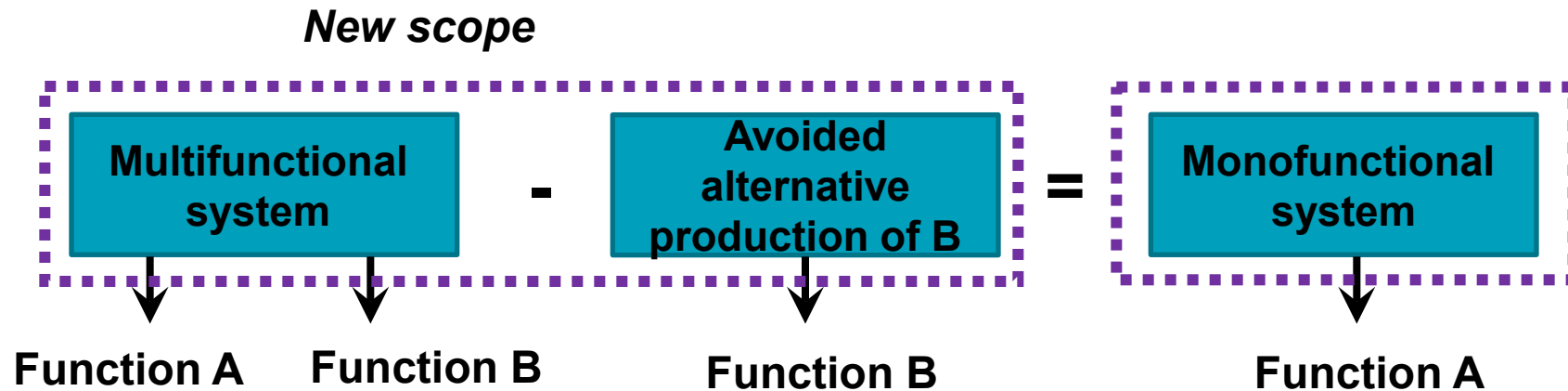


Step 1.2: Expand the system boundary

Note: Only applicable if there is a process producing a functionally equivalent product to product B

ISO 14044 Procedure– Step 1b: Expanding the system boundary

- In this approach, the product system is expanded to include avoided unit processes
 - LCA on function A, product system A and B
 - We take into account the avoided (negative) **alternative way to produce B**
 - substitution, displacement, avoidance
 - We consider then that the expanded system is equivalent to a product system that doesn't have function B as an output



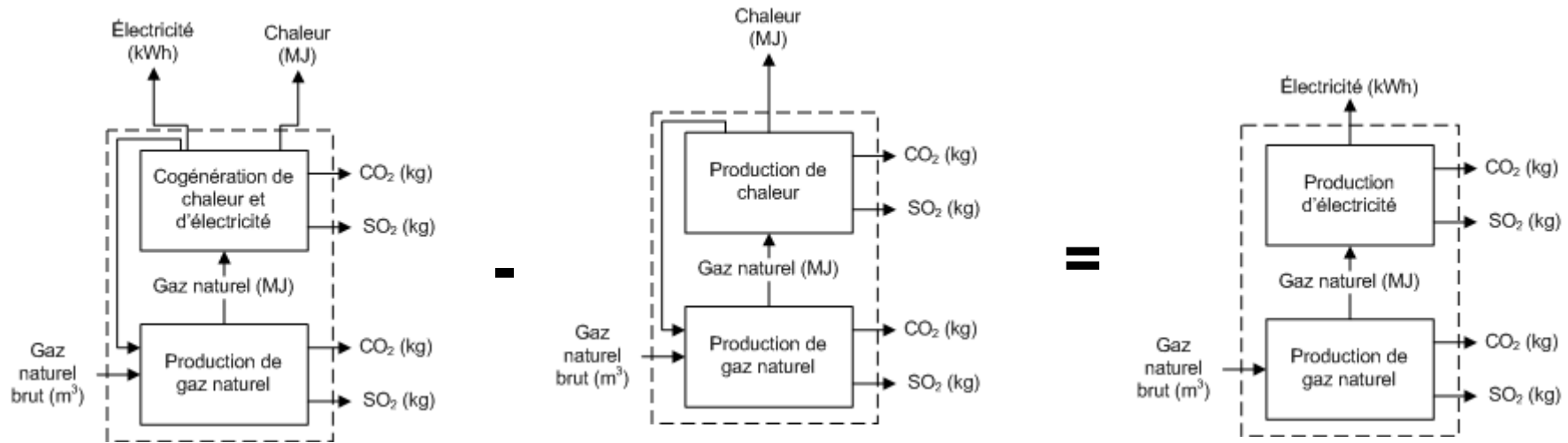
ISO 14044 Procedure– Step 1b: Expanding the system boundary



To use system expansion:

- 1) We need to be able to identify a **competing primary producer** of the co-product that doesn't interest us
 - Could be especially challenging for prospective modeling, when alternative way to produce do not exist yet
- 2) We should pay attention to substitutability ratio which is not always 1:1
 - Accounting for the efficiency of the co-product and its alternative to provide the same function

ISO 14044 Procedure– Step 1b: Expanding the system boundary



	p_{cogen}	p_{GN}	p_{chaleur}
Electricity (kWh)	1	-2,5	0
Natural gas (MJ)	-10,5	1000	-1.05
Heat (MJ)	1,8	0	1
Raw natural gas (m ³)	0	-25	0
CO ₂ (kg)	0,5	10	0,06
SO ₂ (kg)	0.25	0.01	6e-7

A → square!

B

How to solve multifunctionality in LCA?

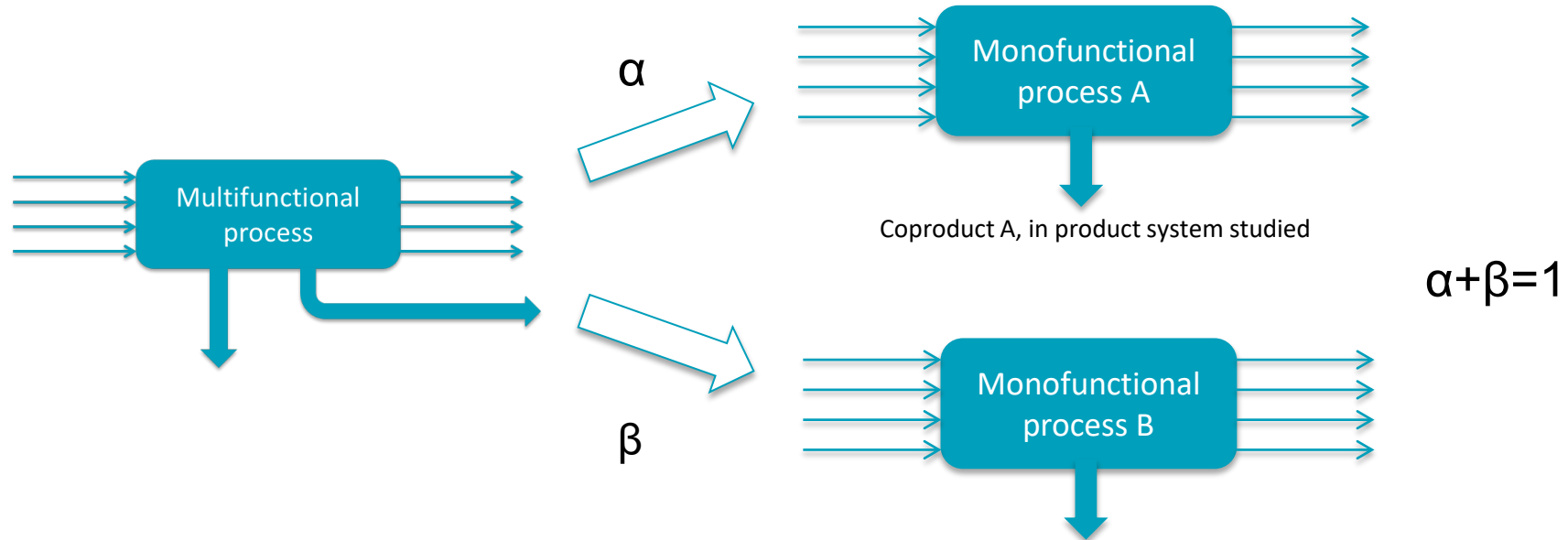
1. Subdivision

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3. Allocation based on underlying physical relationship

4. Allocation based on other relations

ISO 14044 Procedure – Step 3: Other relationship



Step 3: Attribute according to other mutual relationship (economic value, mass, surface, exergy, etc.)

Note: Useful for joint production. Results in process where conservation laws only works for the chosen relationship.

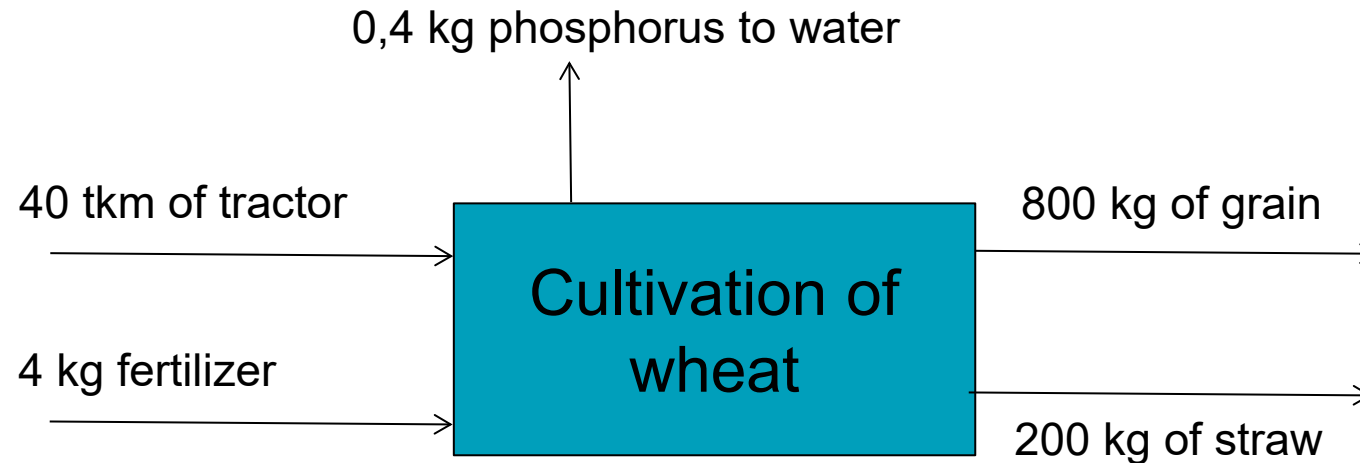
ISO 14044 Procedure – Step 3: Other relationship

→ Applies to **joint productions**

- The inputs and outputs are divided between the different products
 - According to a physical property (e.g. mass, energy, surface)
 - According to economic value of the co-products
 - According to another valuable relationship
- **Causality principle : the factors used to allocate a flow to a product should reflect the degree of responsibility of the product for generating that flow**

ISO 14044 Procedure – Step 3: Other relationship

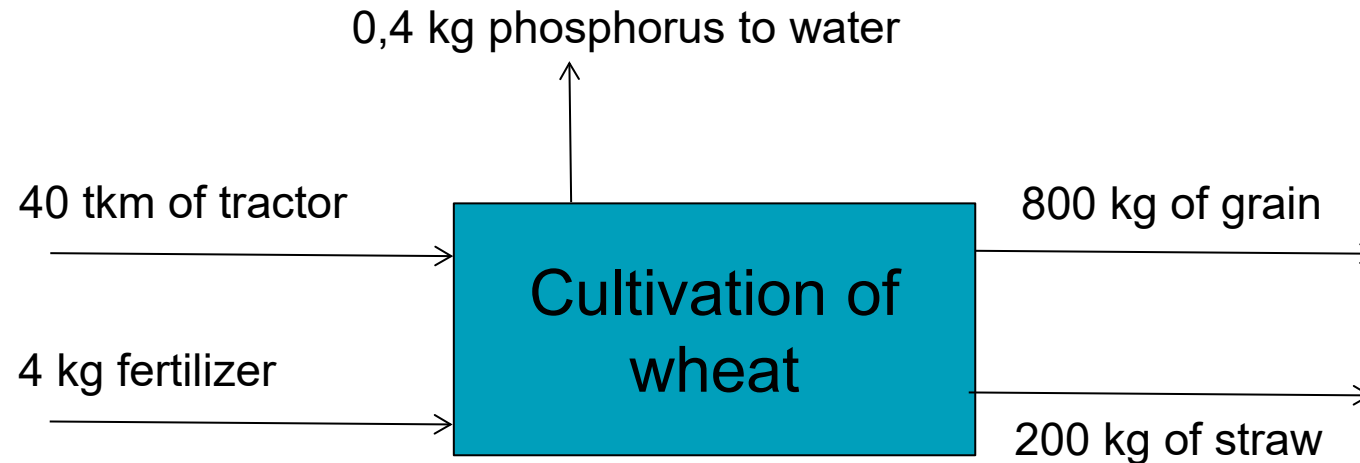
- Allocation example



- Choice of allocation basis: mass
- The two products are measured by their mass

ISO 14044 Procedure – Step 3: Other relationship

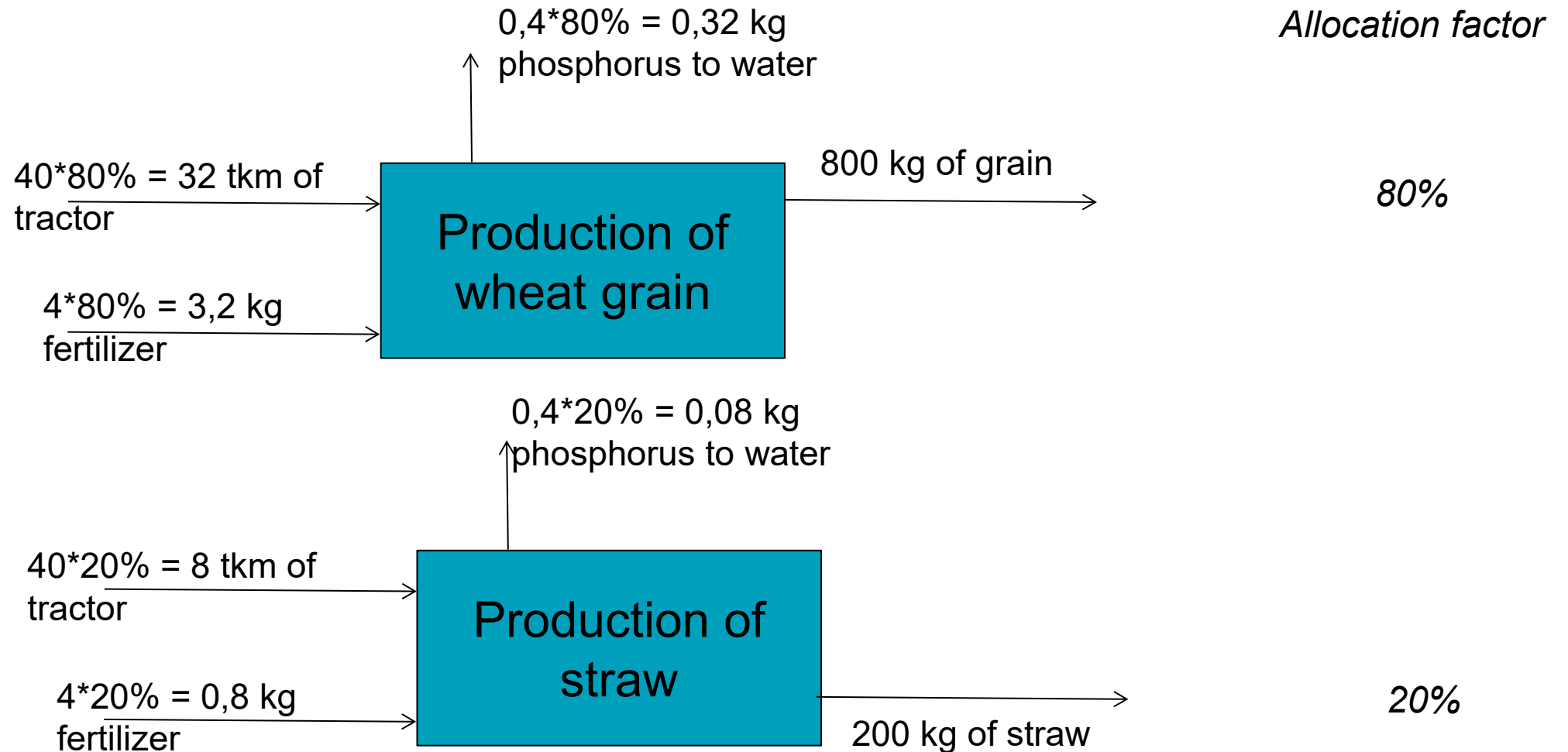
- Allocation example: mass



- Total mass produced: $800 + 200 = 1000$ kg
- Allocation factor for grain = $800/1000 = 80\%$
- Allocation factor for straw = $200/1000 = 20\%$

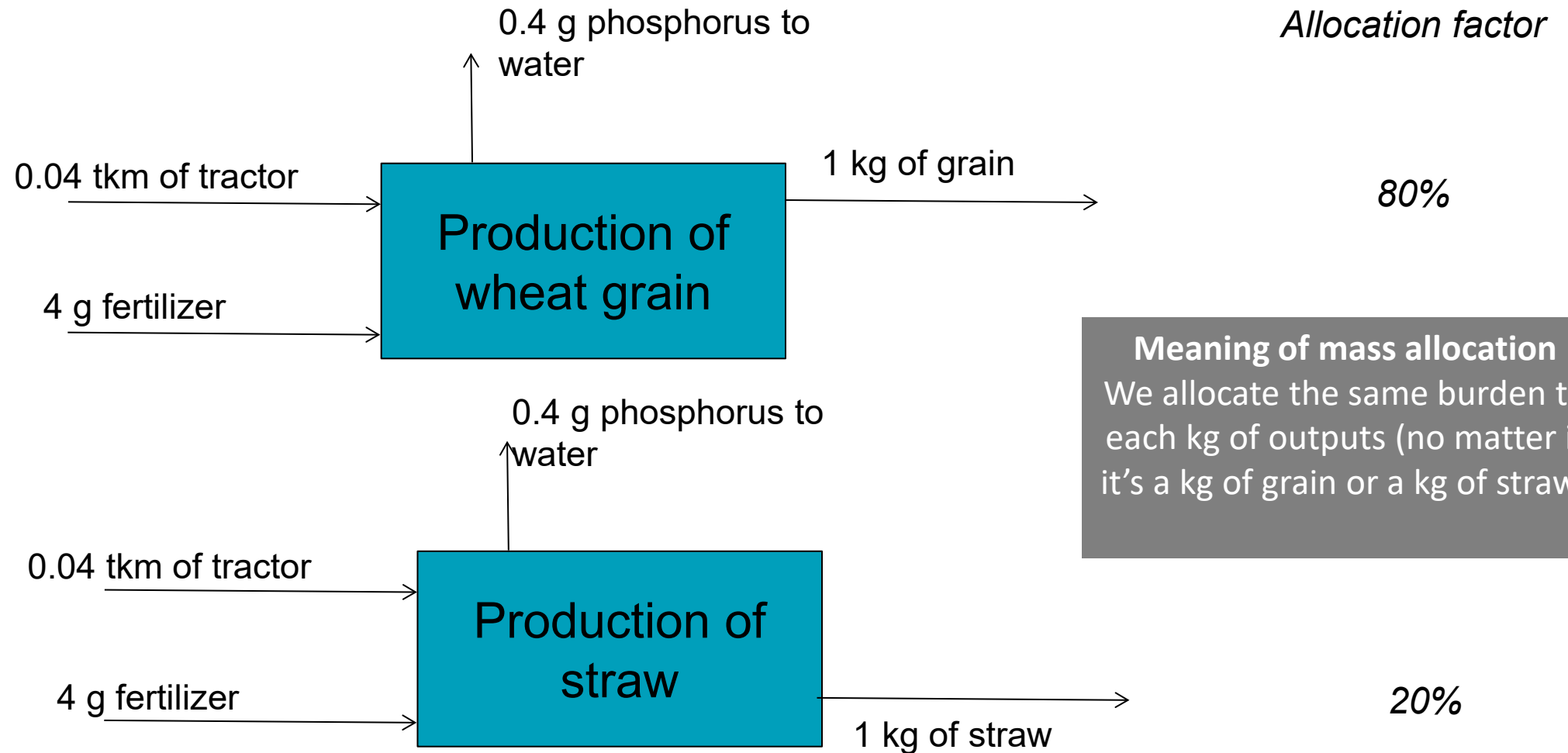
ISO 14044 Procedure – Step 3: Other relationship

- Allocation example: mass



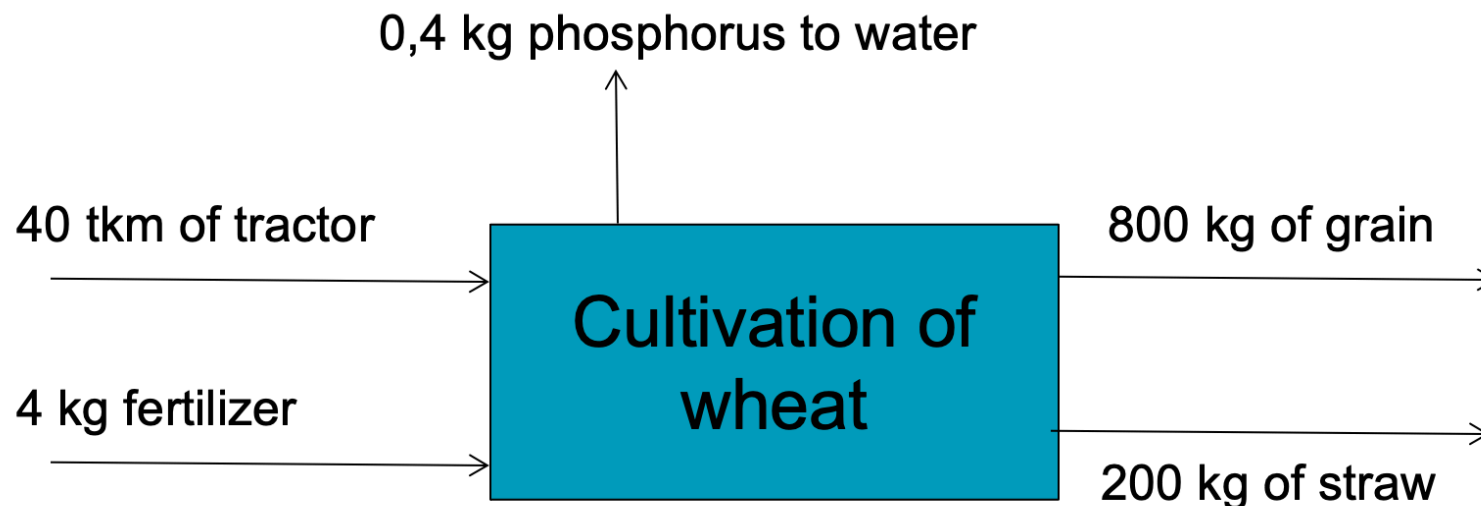
ISO 14044 Procedure – Step 3: Other relationship

- Allocation example: mass



ISO 14044 Procedure – Step 3: Other relationship

- Example of economic allocation
 - **Let's take the same process, but let's use an economic allocation**
 - **Let's suppose the following prices:**
 - Wheat grains: 0,25\$/kg
 - Straw: 0,1\$/kg

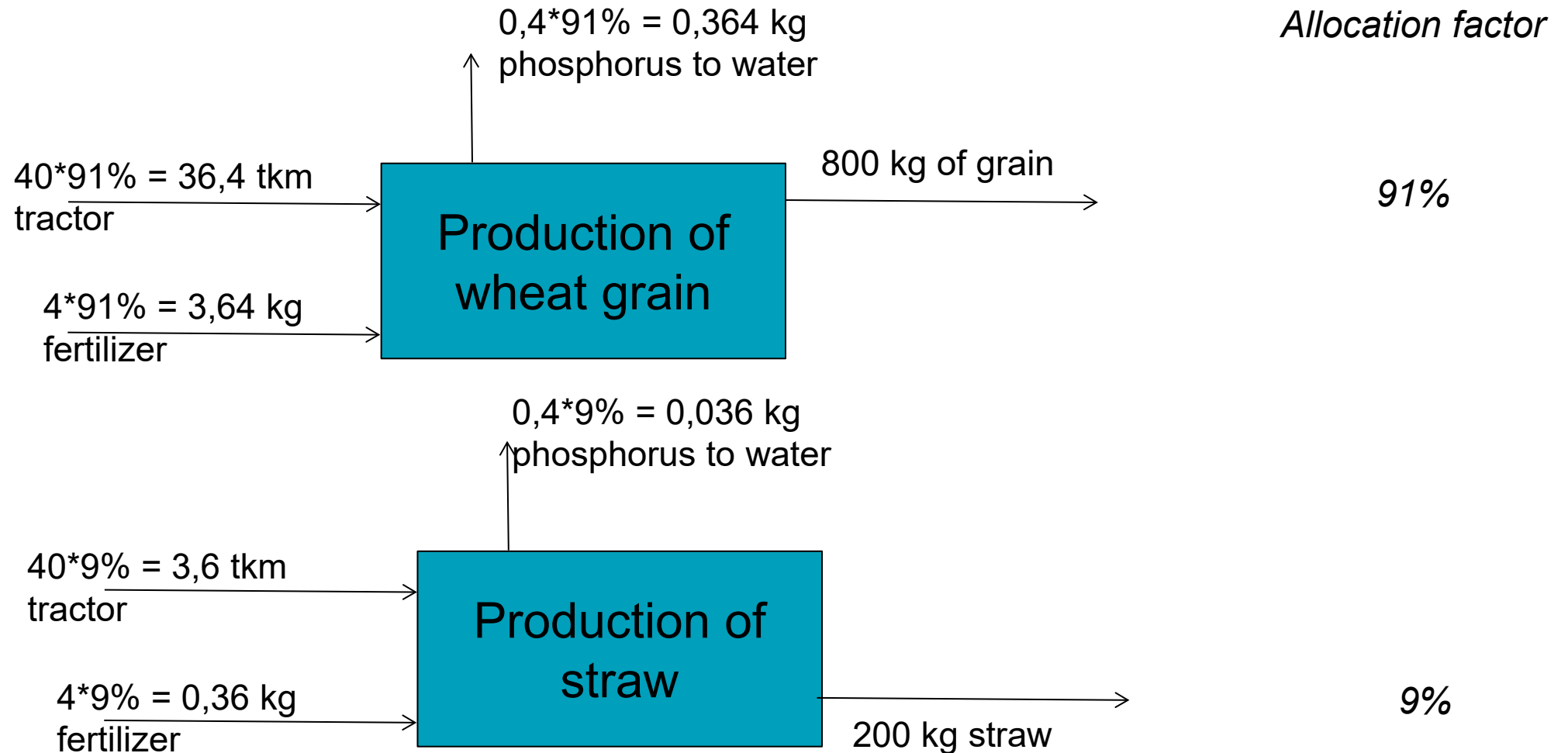


ISO 14044 Procedure – Step 3: Other relationship

- Example of economic allocation
 - **Let's take the same process, but let's use an economic allocation**
 - **Let's suppose the following prices:**
 - Wheat grains: 0,25\$/kg
 - Straw: 0,1\$/kg
- **Total revenue:** $800 \text{ kg} * 0,25 \text{ \$/kg} + 200 \text{ kg} * 0,1 \text{ \$/kg} = 220\text{\$}$
- Allocation factor for grain = $200/220 = 91\%$
- Allocation factor for straw = $20/220 = 9\%$

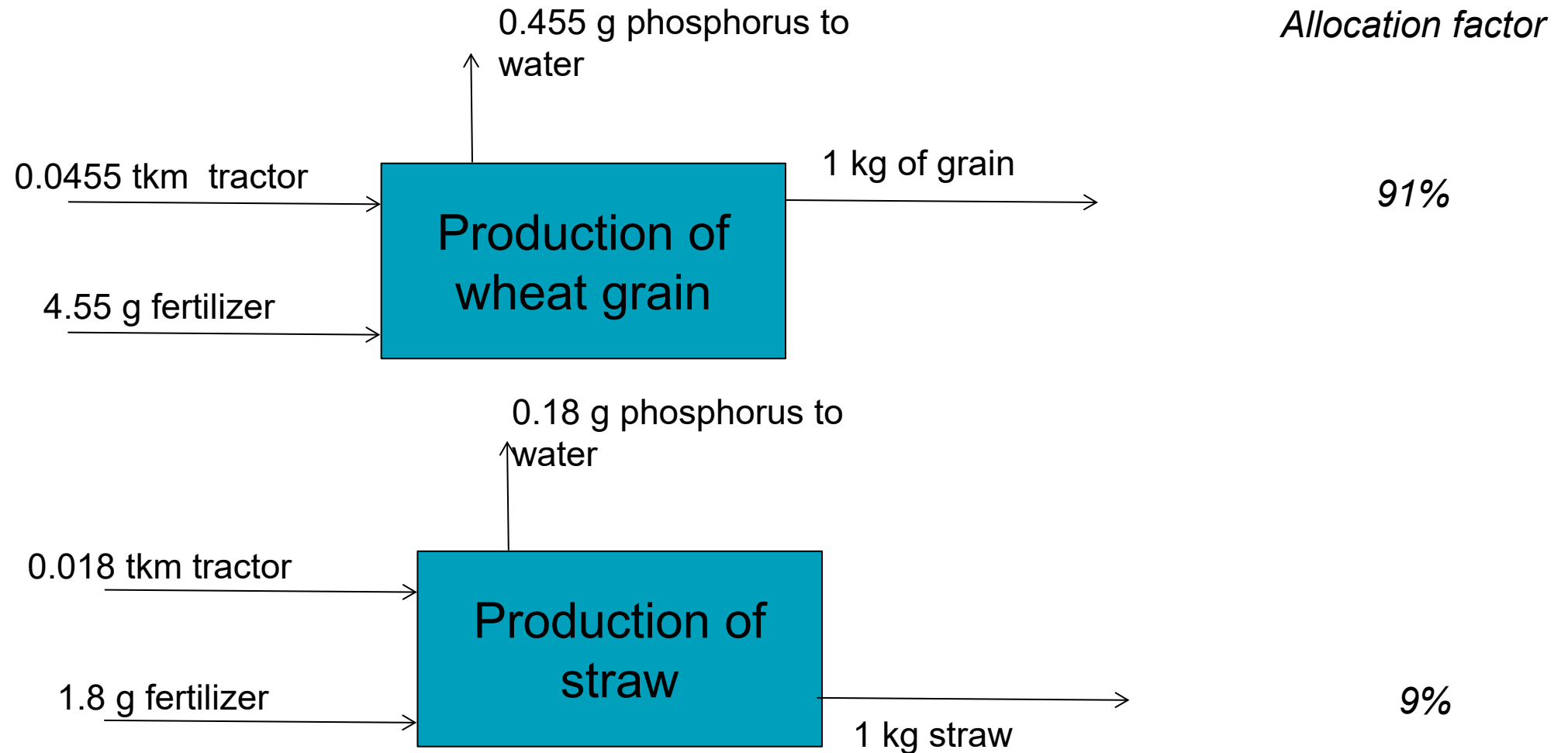
ISO 14044 Procedure – Step 3: Other relationship

- Allocation example: economic



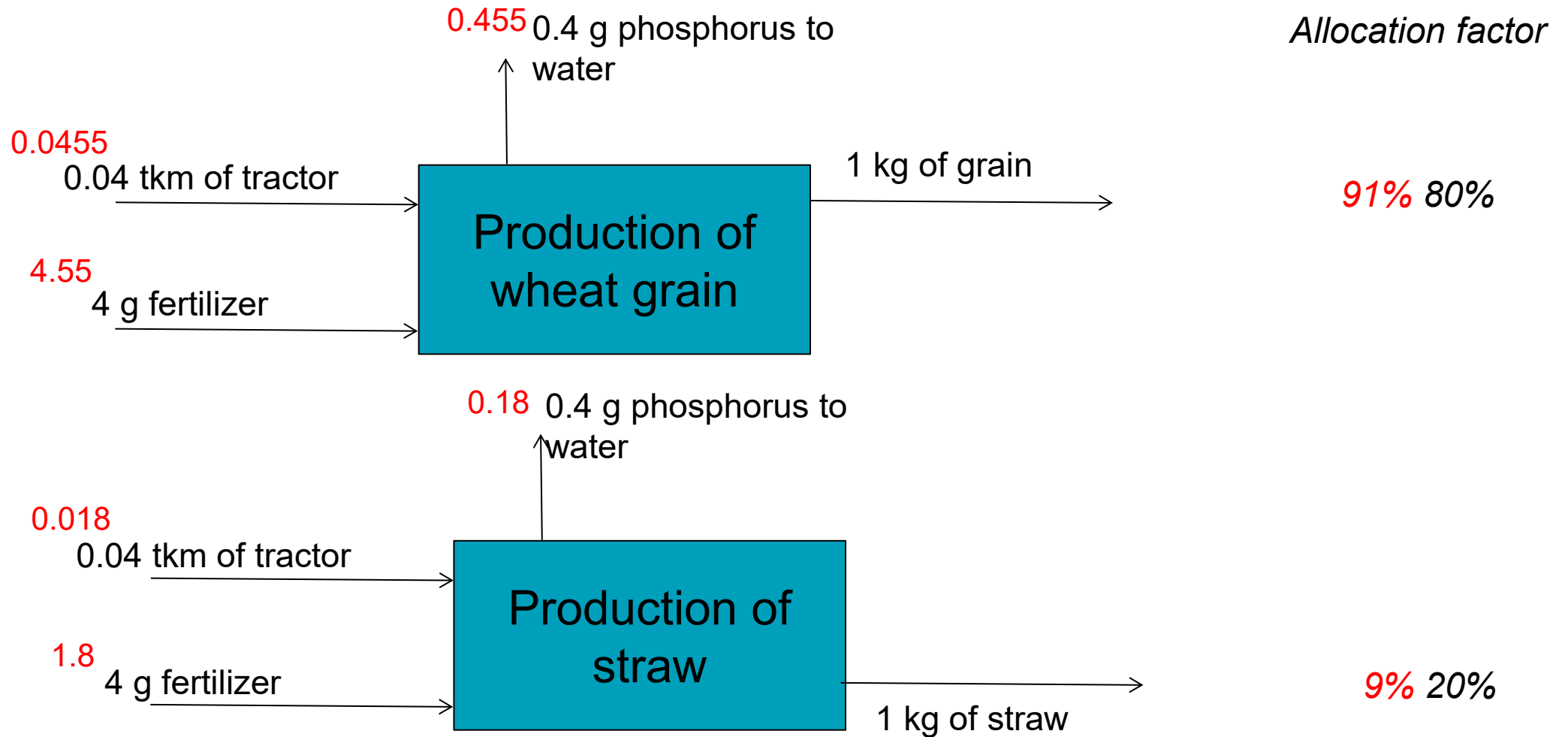
ISO 14044 Procedure – Step 3: Other relationship

- Allocation example: economic



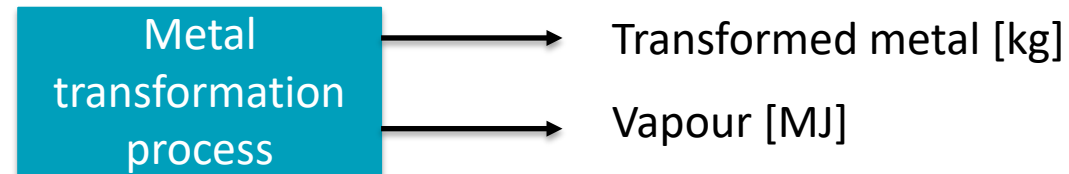
ISO 14044 Procedure – Step 3: Other relationship

- Allocation example: mass vs economic



ISO 14044 Procedure – Step 3: Other relationship

- Another example of economic allocation



- A factory transforms metal with a process using heat. A heat recovery machine produces steam that is sold to a factory nearby.
- Inconsistent data properties → economic allocation
- The factory sells metal at a price of 45 \$/kg, and steam at 5 \$/MJ
- Allocation factor for metal: $45 / (45 + 5) = 90\%$?
 - **NO!!!!!! We cannot add the prices, but we could add the revenues.**
- Over one year, the factory produces 300 tonnes of metal and 800 GJ of steam

ISO 14044 Procedure – Step 3: Other relationship

- Example of economic allocation
 - The factory sells metal at a price of 45 \$/kg, and steam at 5 \$/MJ
 - Over one year, the factory produces 300 tonnes of metal and 800 GJ of steam

Product	Quantity	Price	Revenues	Allocation factor
Metal	300E3 kg	45\$/kg	13500 k\$	77,1%
Steam	800E3 MJ	5\$/MJ	4000 k\$	22,9%

ISO 14044 Procedure – Step 3: Other relationship - examples



ISO 14044 Procedure – Step 3: Other relationship - examples



- Volumic allocation would make no sense!
- Economic value? Calorific value?



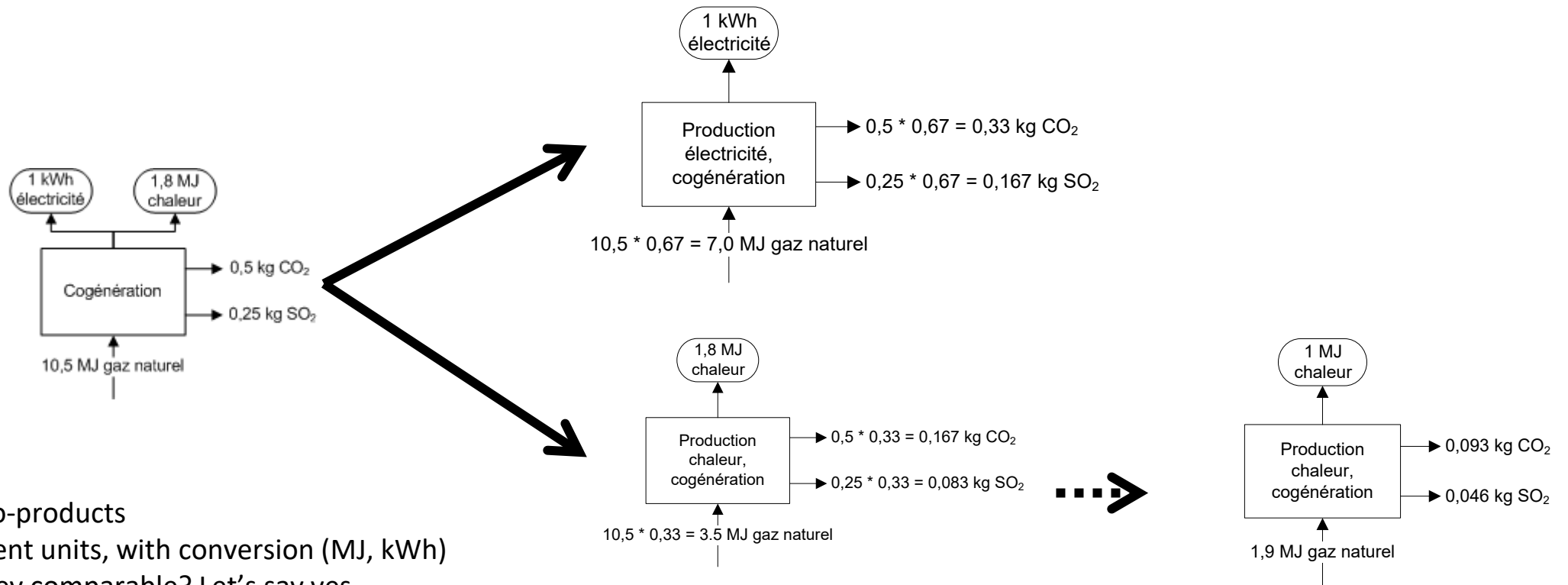
- Economic allocation: Diamond exploitation is the existing reason of the process (high added value)!

ISO 14044 Procedure – Step 3: Other relationship - examples

How to do it?

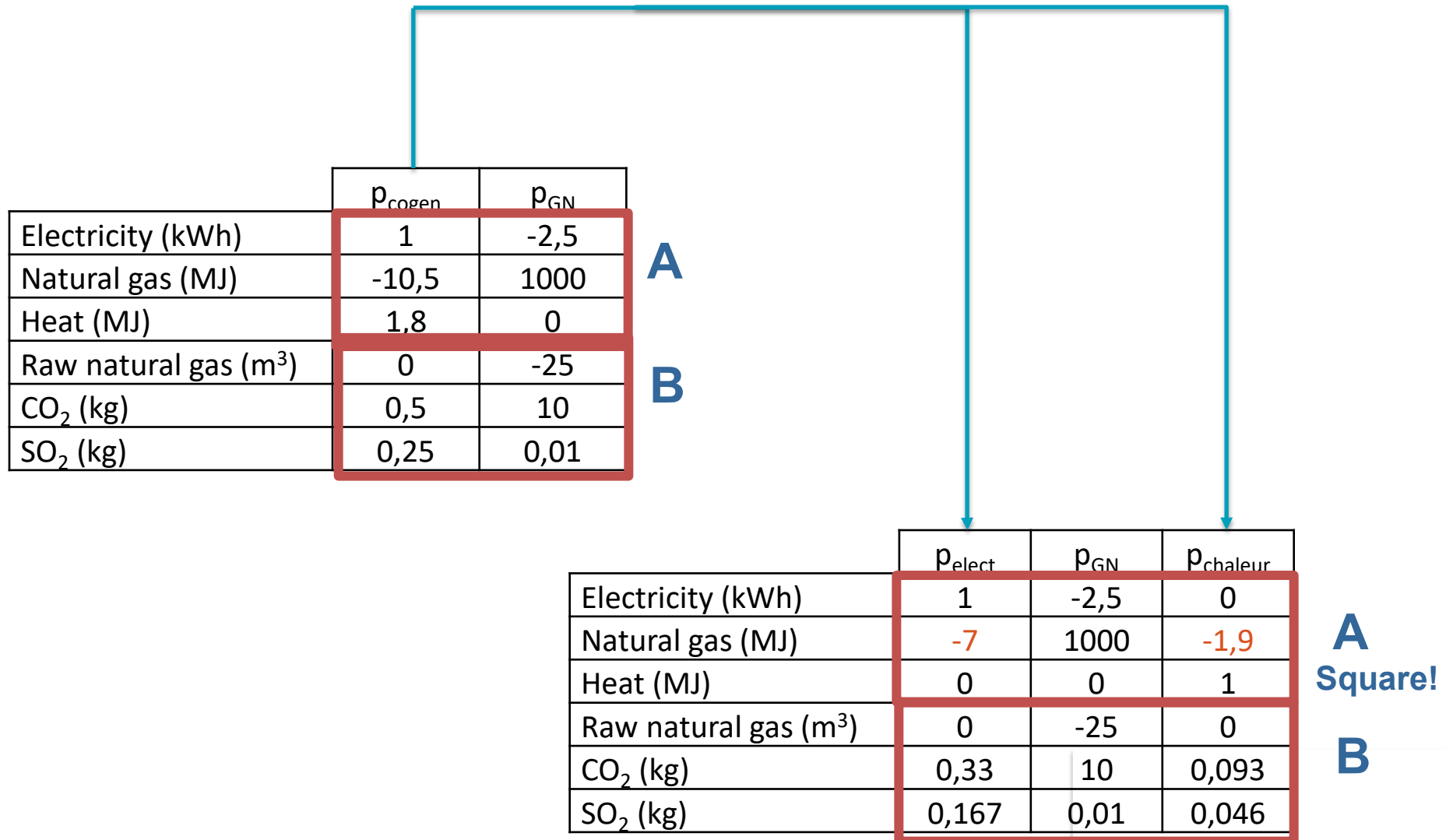
1. Identify all co-products and the quantities produced
2. Look at the units of the co-products: are they consistent?
3. Is there something common, comparable to all the co-products? Do you think that the impacts of the co-products would be proportional to this basis? (mass, volume, energy, surface area, price, time, etc.). Which basis would better reflect the degree of responsibility of each product? We need to think about the process for answering this question.
4. Choose the allocation basis, name it and justify it.
5. Calculate an allocation factor for each co-product.
6. Apply the factor to each flow (elementary and economic) except for product and co-product flows.
7. Exception: are there any flows that you can fully impute to certain co-products?
8. Create a new elementary process for each co-product.
9. Optional: Scale up each elementary process to obtain 1 unit of product.

ISO 14044 Procedure – Step 3: Other relationship



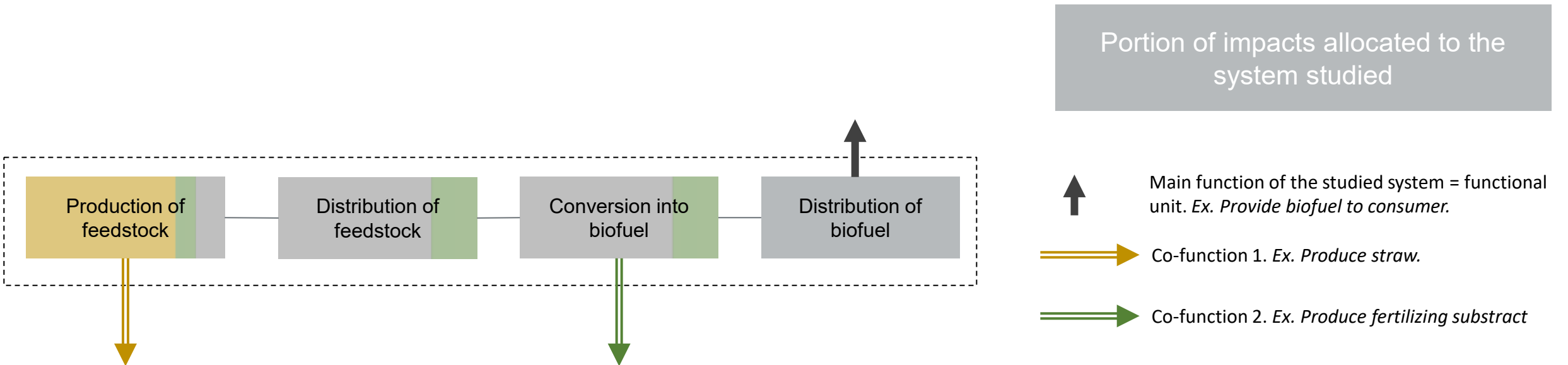
- Two co-products
- Coherent units, with conversion (MJ, kWh)
- Are they comparable? Let's say yes...
- Basis of allocation chosen: Energy. We suppose that heat and electricity are both useful to do work (which is not necessarily true... → exergy would be a better metric)
- Calculating the allocation factors:
 - **Total energy: 1 kWh * (3,6 MJ/kWh) + 1,8 MJ = 5,4 MJ**
 - **Allocation factor electricity: 3,6/5,4 = 0,67**
 - **Allocation factor heat: 1,8/5,4 = 0,33**
- Apply the factors
- Re-normalize, if needed

Multifunctional processes - Allocation



Handling multifunctionality with allocation all along the product system

We usually have more than one co-products in a product system.



How to solve multifunctionality in LCA?

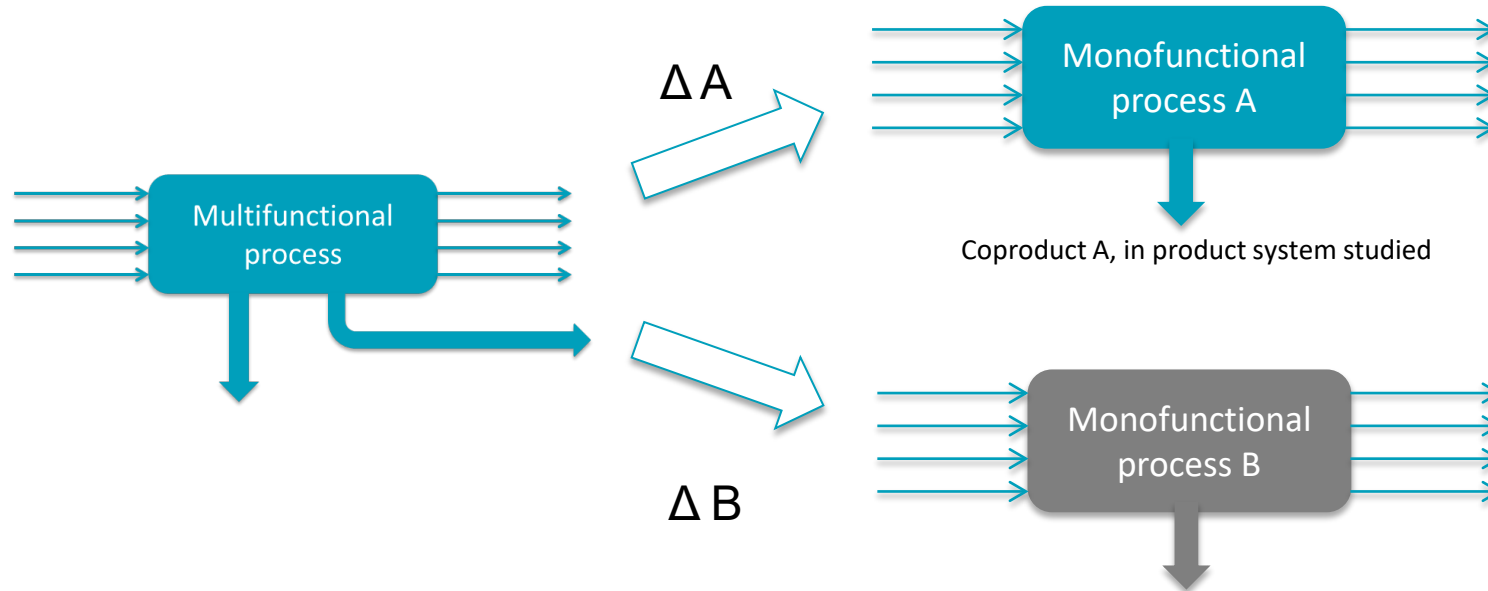
1. Subdivision

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4. Allocation based on other relations

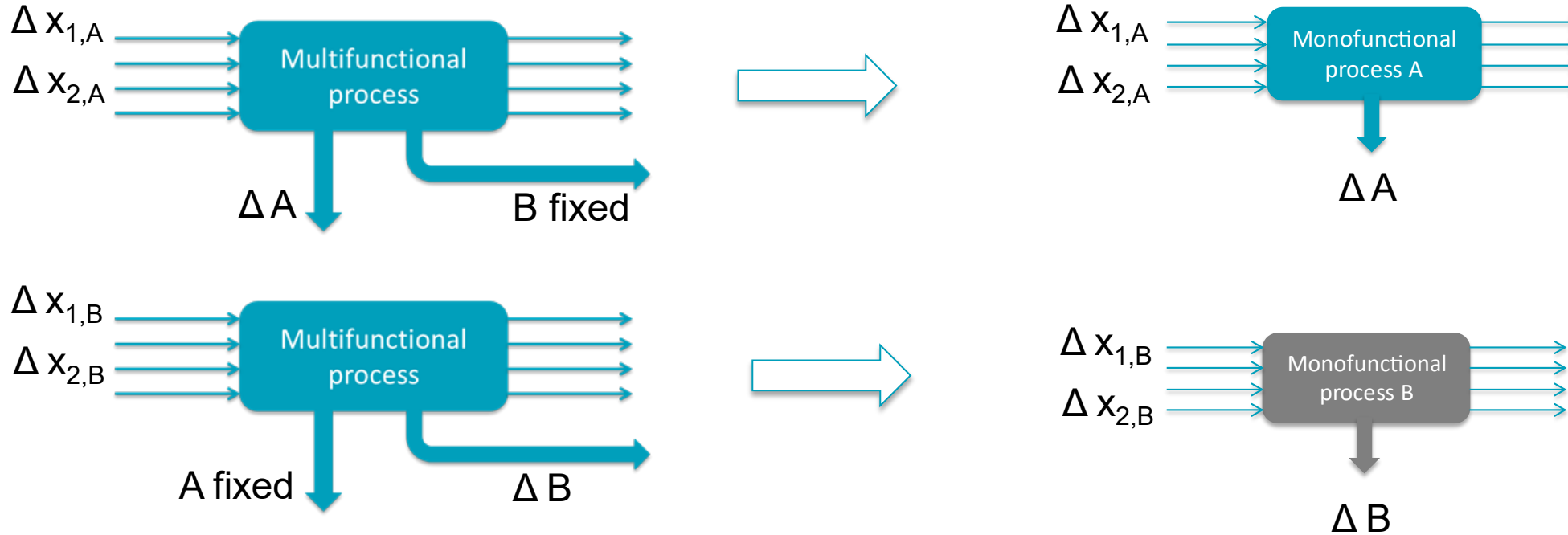
ISO 14044 Procedure – Step 2: underlying physical relationships



Step 2: Allocate between products in a way that reflects underlying physical relationships existing between them

Note: only applicable if we can vary the co-products independently (combined production)

ISO 14044 Procedure – Step 2: underlying physical relationships



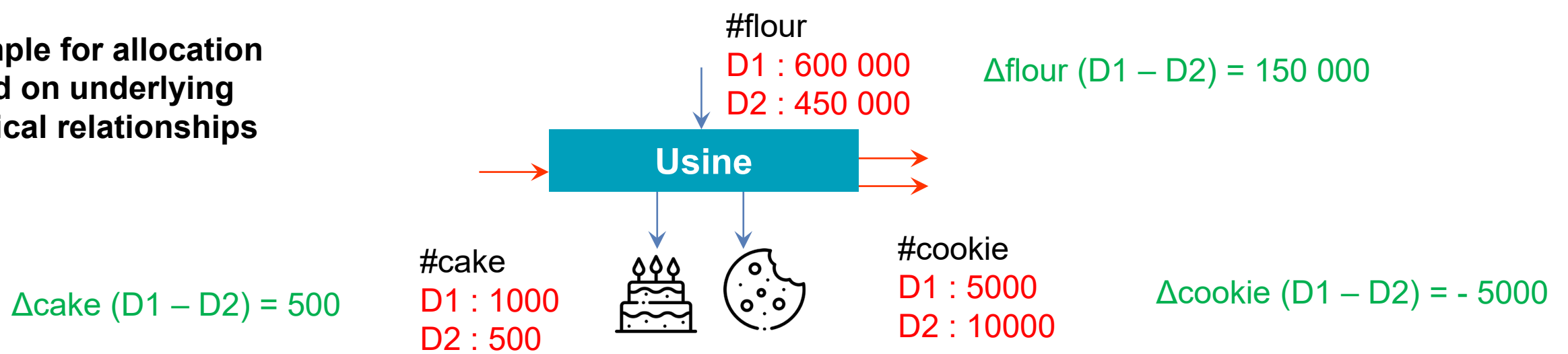
This method allows us to determine how the inputs and outputs are affected by an increase in production of one of the co-products → This information is used to estimate the inputs and outputs associated to one co-product only

Note: only applicable if we can vary the co-products independently (combined production)

ISO 14044 Procedure – Step 2: underlying physical relationships

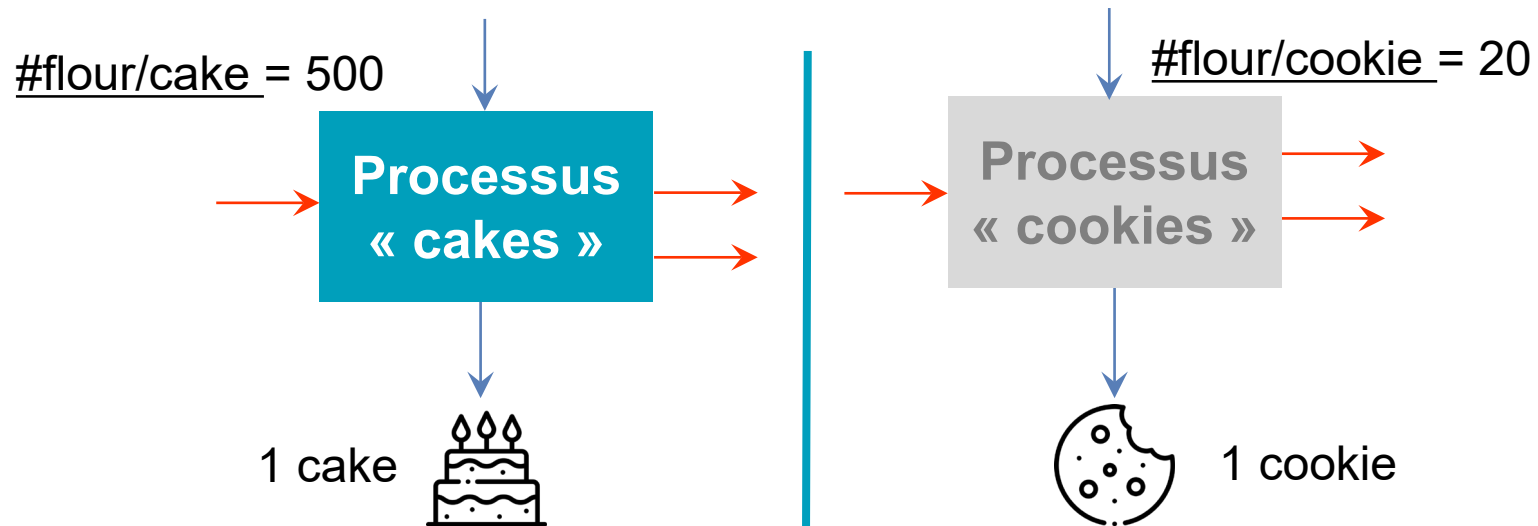
- Examples of **combined productions** where the quantity of co-products can vary independently
 - **A chemical reaction where the proportion of products can be controlled according to the proportions of reactants in input is an example of combined production with independently varying amounts of co-product. In this case, the quantities of inputs and outputs allocated to each reaction product are based on stoichiometric ratios.**
 - **Another example is the allocation of the amount of fuel needed to transport a product between the product itself and its packaging based on the payload used. Indeed, it is possible to vary the packaging quantity regardless of the product quantity.**
- Coming back to LCA example of the factory producing cakes and cookies:
 - **If it's impossible to simply attribute the different unit processes inside the factory to those producing cakes, we could vary the quantity of cakes produced: this would affect the inputs and outputs of the factory**
 - **In this way, we could determine which inputs are directly attributable to cakes**
- **Not to be confused with applying an allocation based on a physical property like mass!**

Example for allocation based on underlying physical relationships



Equation system to be solved to find #flour/cake and #flour/cookie

- For D1 (ou D2) : $\text{\#flour} = \text{\#cake} \times \text{\#flour/cake} + \text{\#cookie} \times \text{\#flour/cookie}$
- For D1-D2 : $\Delta\text{flour} = \Delta\text{cake} \times \text{\#flour/cake} + \Delta\text{cookie} \times \text{\#flour/cookie}$



How to choose the approach to address multifunctionality?

1. Subdivision

2. System expansion

3. Allocation based on underlying physical relationship

4. Allocation based on other relations

Debate in the LCA community

Validity framework, strenghts and weaknesses of each approach

Approach	Framework of validity of the approach	Potential reasons for non-applicability of the approach	Advantages of the approach	Disadvantages of the approach
Subdivision	<ul style="list-style-type: none"> Combined production of co-products (non-joined): quantities of co-products vary independently 	<ul style="list-style-type: none"> Processes are too intertwined to be separated If detailed information on the different processes are not available 	<ul style="list-style-type: none"> Represents the real situation in a very detailed manner Avoid subjective choices 	<ul style="list-style-type: none"> Data requirement is very high and can be confidential
System expansion / substitution	<ul style="list-style-type: none"> Joint production of co-products: quantities of co-products vary in a dependent manner 	<ul style="list-style-type: none"> No avoided product can be identified No access to data on substitute pathway 	<ul style="list-style-type: none"> Reflects the physical and economic implications of co-product generation Conservation of mass, energy or other content balances 	<ul style="list-style-type: none"> Need for additional LCI data Substitution pathways can be difficult to identify and model Choice of substitution pathways can greatly influence results The degree of substitutability between a product and its substitute should be taken into account
Allocation based on underlying physical relationship	<ul style="list-style-type: none"> Combined production of co-products (non-joined): quantities of co-products vary independently 	<ul style="list-style-type: none"> No access to data to determine the physical causality 	<ul style="list-style-type: none"> Less subjective because based on natural science 	<ul style="list-style-type: none"> Can misrepresent the reasons for operating a process, especially when co-products have very different economic values Often confused with an allocation based on a common physical property between co-products, such as mass or energy content
Economic allocation	<ul style="list-style-type: none"> Joint production of co-products: quantities of co-products vary in a dependent manner 	<ul style="list-style-type: none"> No access price data to calculate the allocation factor, especially if co-products at the point of allocation do not yet have a market value. 	<ul style="list-style-type: none"> Reflects the reasons for operating a process Differentiates similar products with different qualities 	<ul style="list-style-type: none"> Prices are highly variable over time (volatility), between regions, between different market players and according to market conditions (monopolies, regulations, subsidies). Economic allocation factors can therefore be unstable. Price choice can greatly influence results (value choice) Price data for intermediate products or for prospective scenarios can be difficult to estimate. Non-conservation of mass balances
Mass allocation	<ul style="list-style-type: none"> If a co-product avoids the production of another product 	<ul style="list-style-type: none"> If not all co-products from the same multifunctional process have a directly defined mass. E.g. heat co-production 	<ul style="list-style-type: none"> Often easy to apply Conservation of mass balances 	<ul style="list-style-type: none"> May misrepresent the reasons for operating a process, especially when co-products have very different economic values
Energetic allocation			<ul style="list-style-type: none"> Allows allocation of products with no directly defined mass. e.g. heat in the form of steam Conservation of energy balances 	<ul style="list-style-type: none"> May misrepresent the reasons for operating a process when not all co-products are used for their energy content Non-preservation of mass balances Does not reflect the useful energy of co-products if exergy is not the energy property used



How to choose the approach to address multifunctionality?

According to the
UNEP Life Cycle Initiative (2016) ...

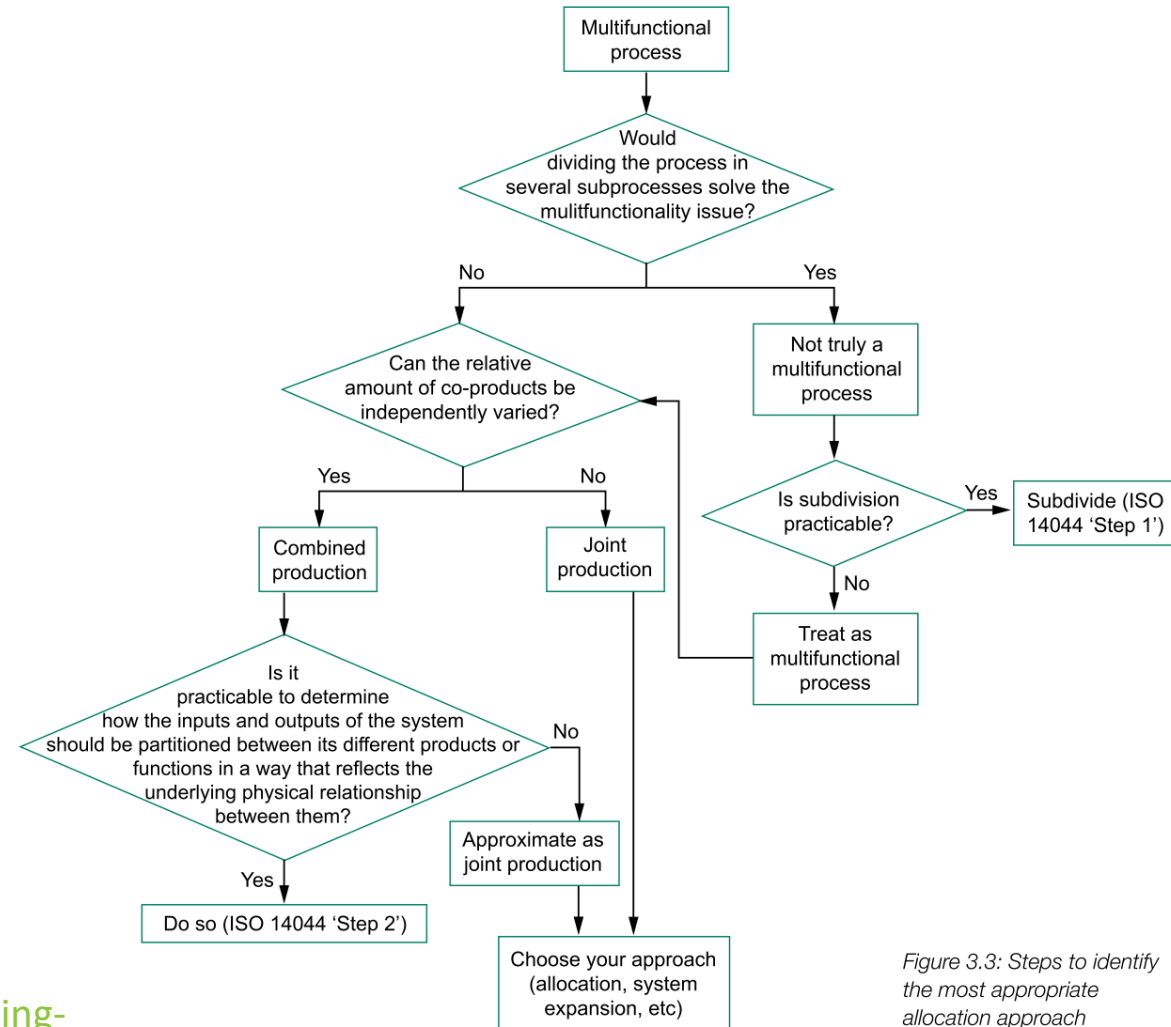


Figure 3.3: Steps to identify the most appropriate allocation approach

Life Cycle Initiative. (2016)
Steps to identify the most
appropriate allocation approach.

Retrieved from: <https://www.lifecycleinitiative.org/training-resources/global-guidance-principles-ggp-on-life-cycle-assessment-data-and-databases/>

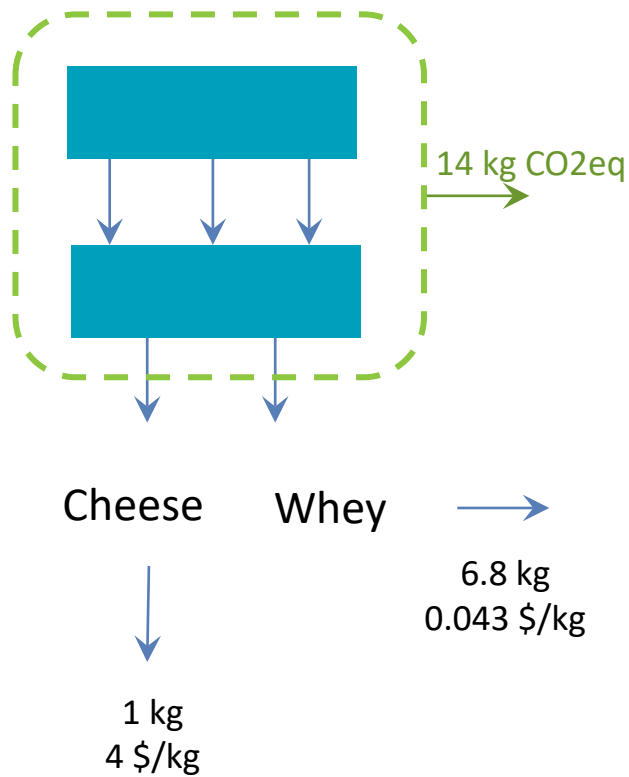
ISO 14044 Procedure - multifunctionality

- « Attributing impacts » to a co-product is entirely imaginary. In reality, the co-products will always be manufactured together. For this reason, allocation is an arbitrary operation subject to debate.

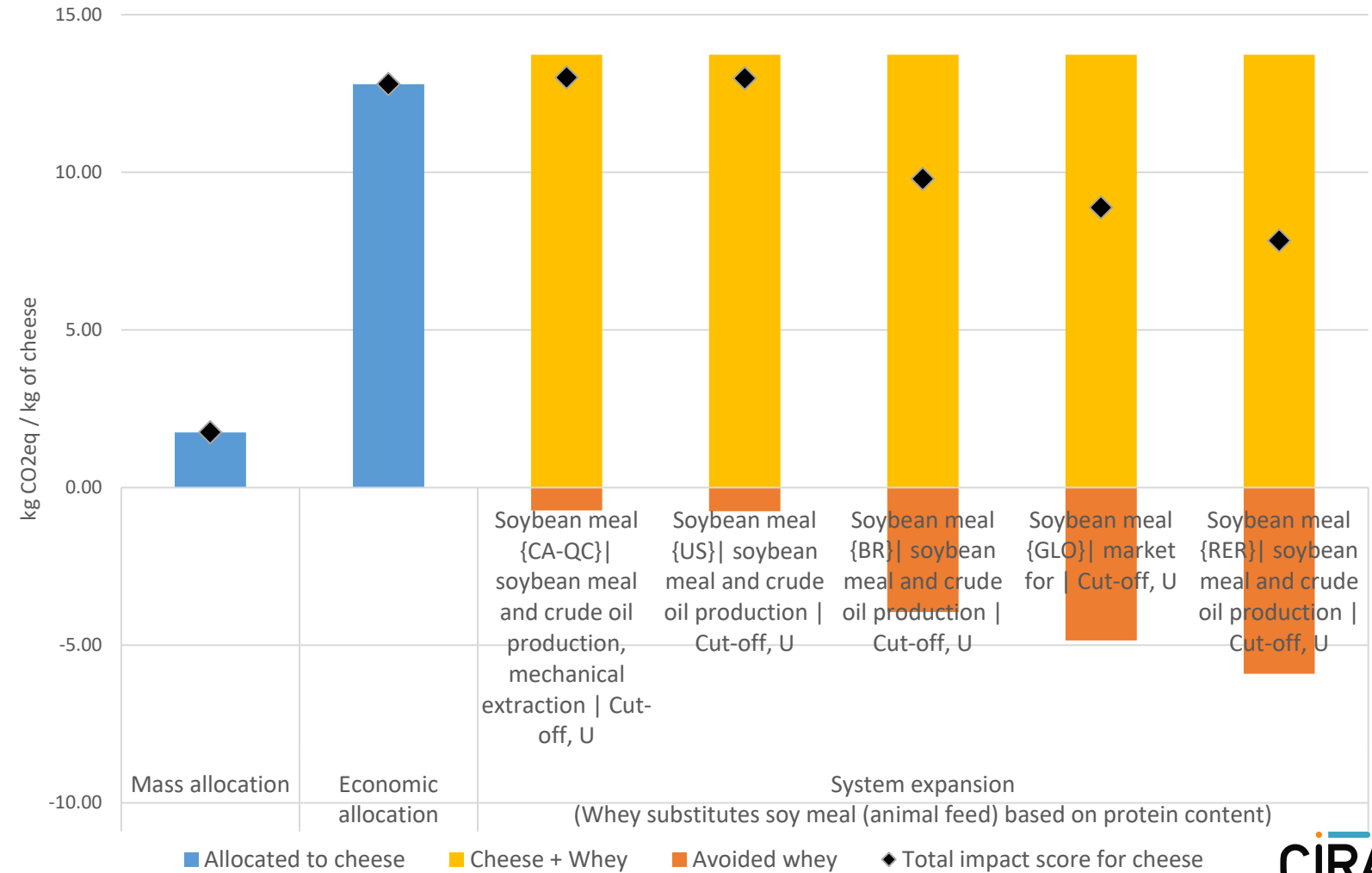
The choice of allocation approach can change the results and the conclusion of a study!!!

- Like anytime, there are assumptions in LCA, transparency is necessary.
- When in doubt, or if controversy arises on the best method to use, perform a scenario/sensitivity analysis

Influence of the choice of the approach to address multifunctionality

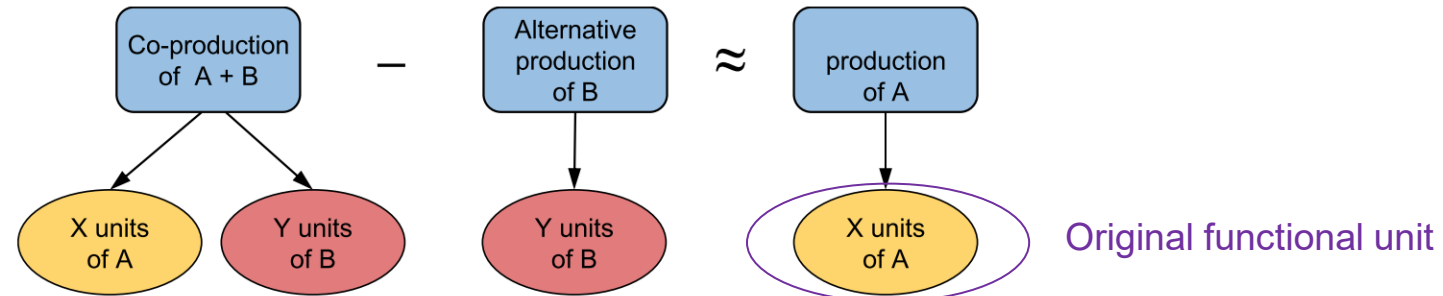


Carbon footprint of cheese

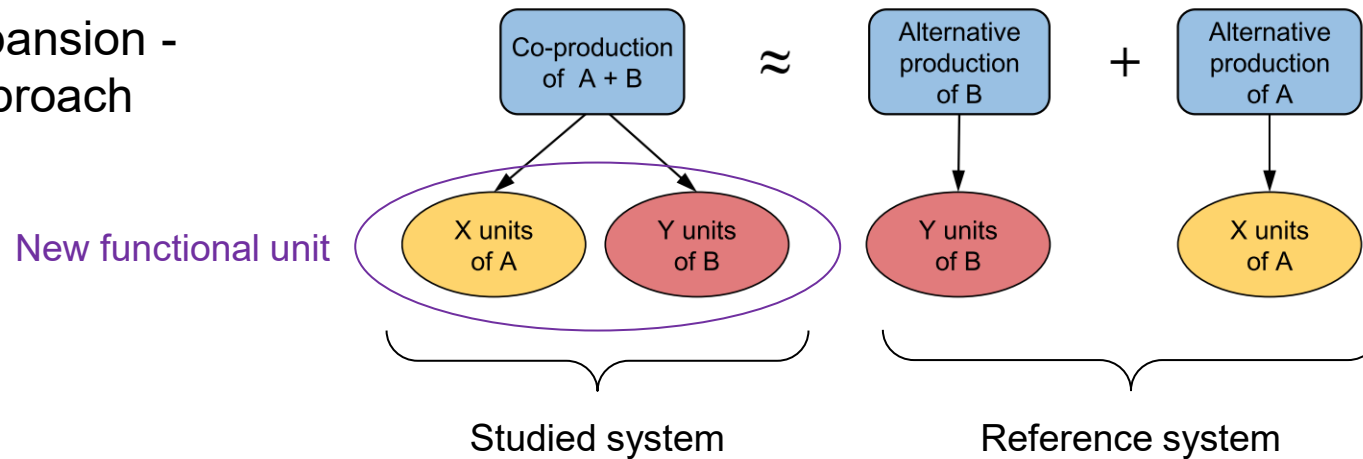


Avoidance of allocation by defining the functional unit differently (additive system expansion)

System expansion -
substitution approach

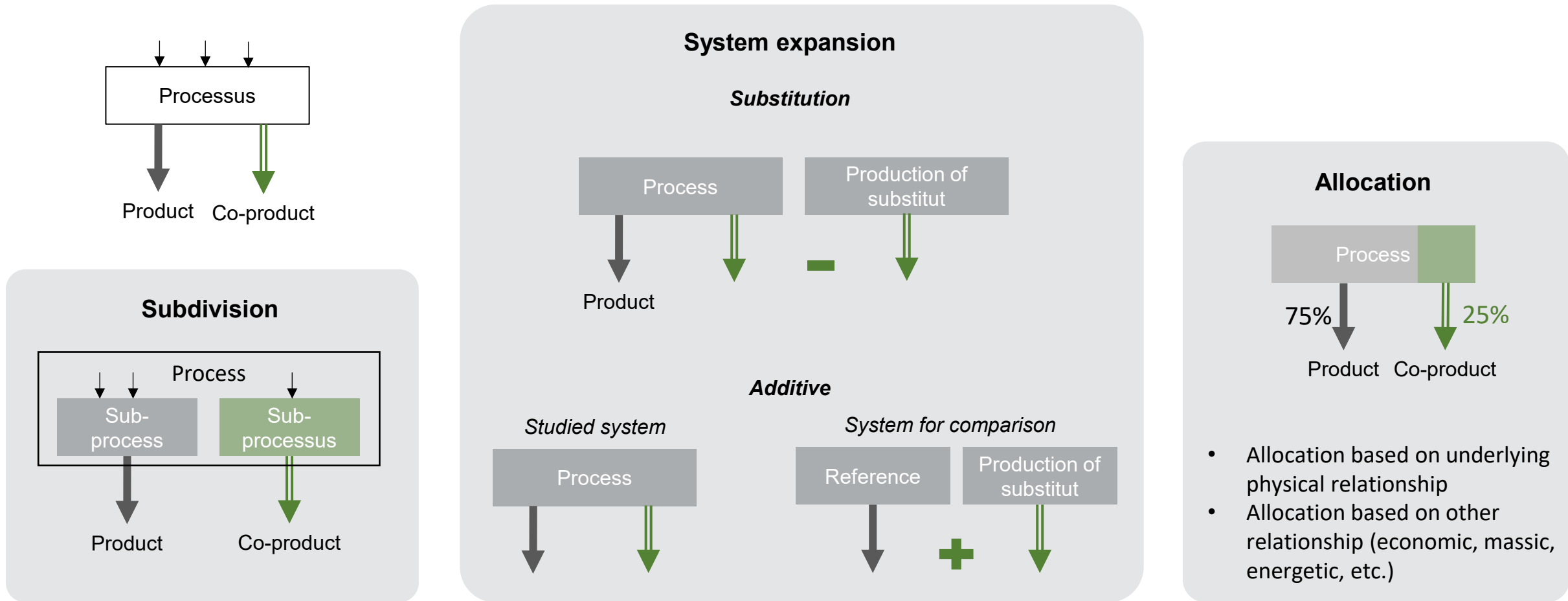


System expansion -
additive approach



- Avoids allocation and its uncertainties
- BUT functional unit can become too complex and lose interpretability

Overview of approaches to deal with multifunctionality



MULTIFUNCTIONALITY AND RECYCLING

Open-loop recycling

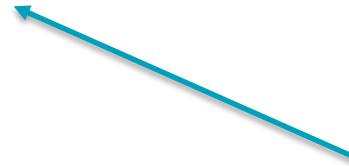
Open-loop recycling has two functions, each associated to its respective product system



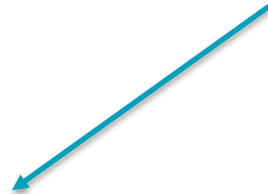
Elimination of waste from
product system A



Recycled material used in
product system B

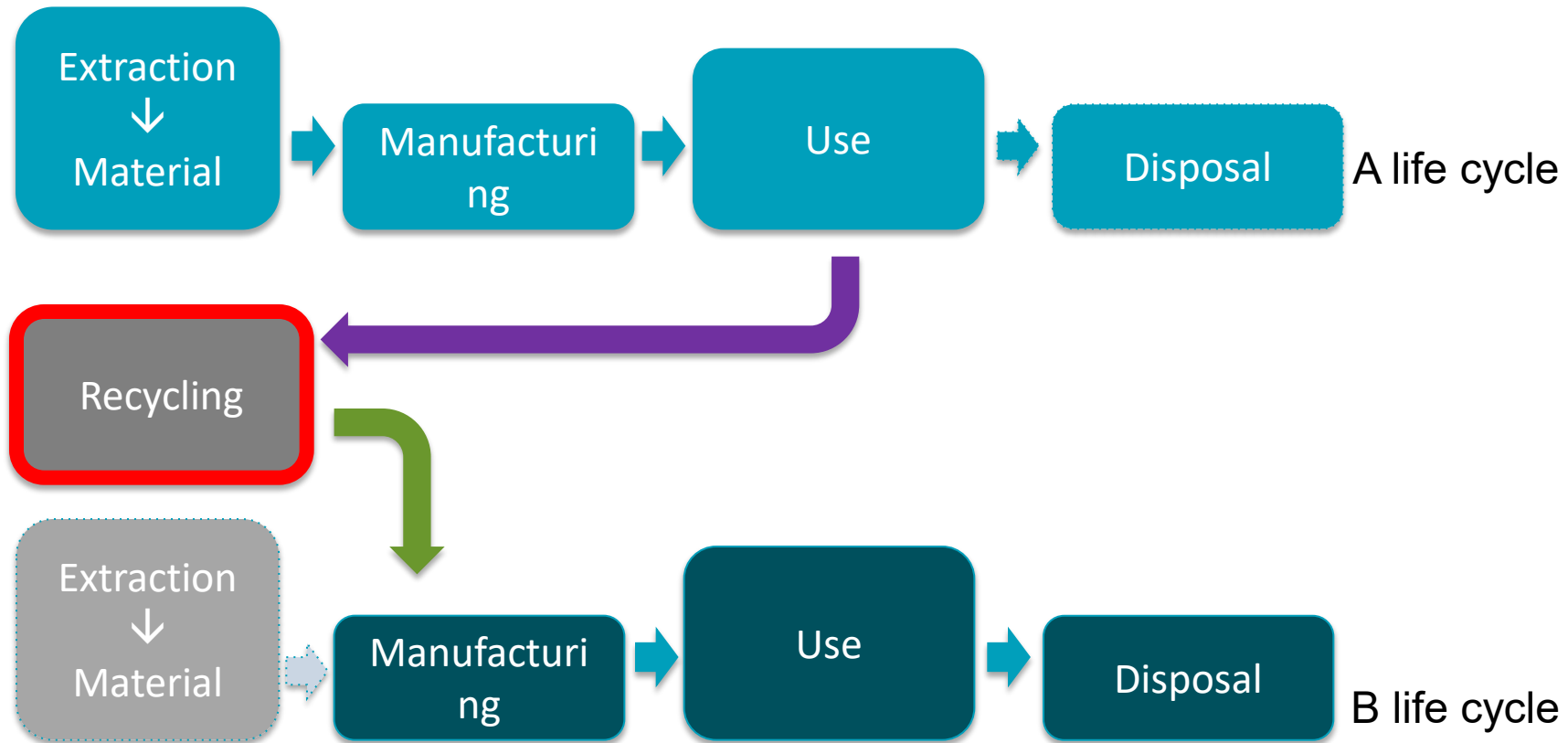


For a study we can
generate waste that
will be recycled
AND/OR use recycled
material



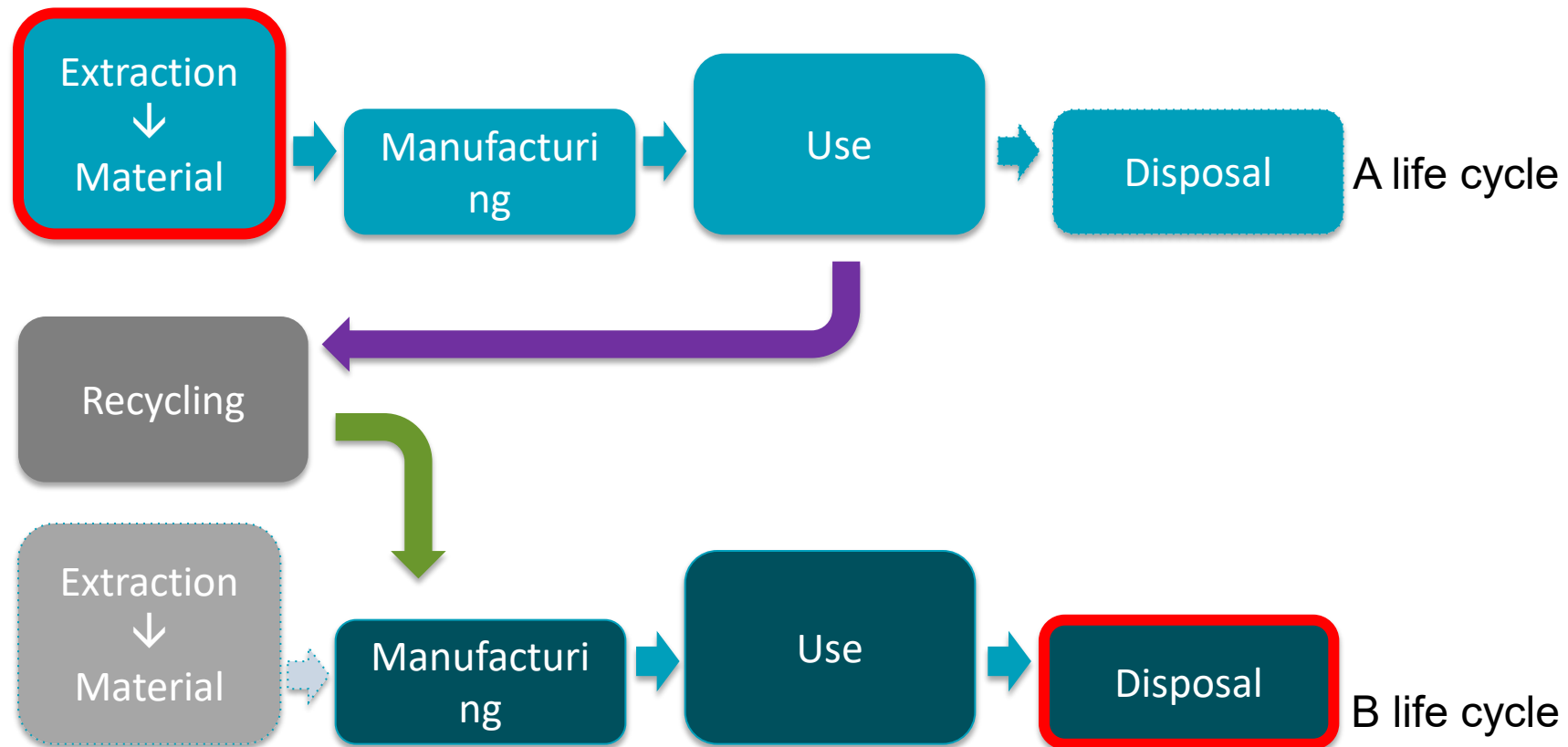
Open-loop recycling

Who is responsible for the impacts of recycling?



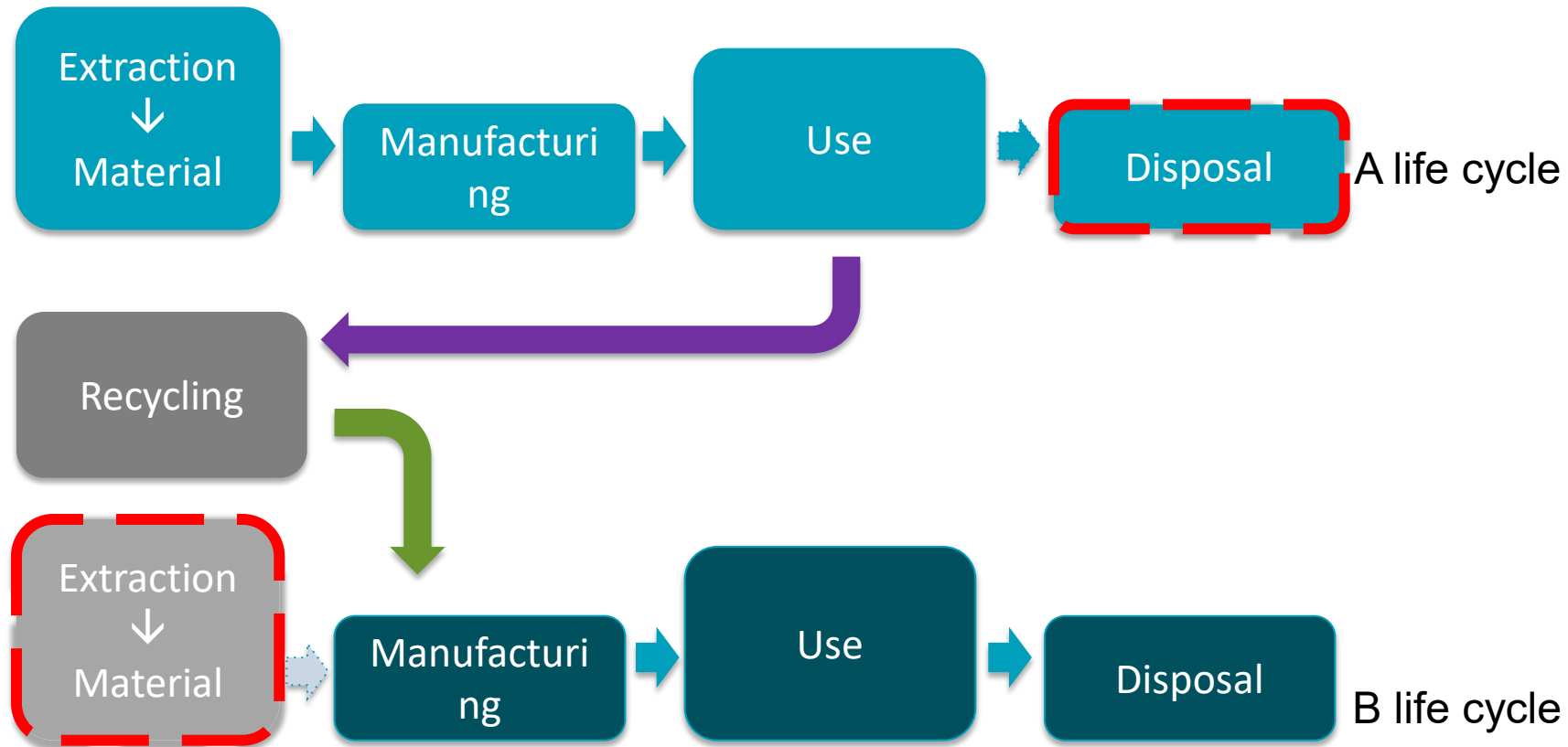
Open-loop recycling

Who is responsible for the impacts of the production of initial virgin material?
Who is responsible for the impacts of final disposal?



Open-loop recycling

Who takes credits for the avoided impacts of disposal?
Who take credits for the avoided impacts of the production of virgin raw material?



Most common approaches

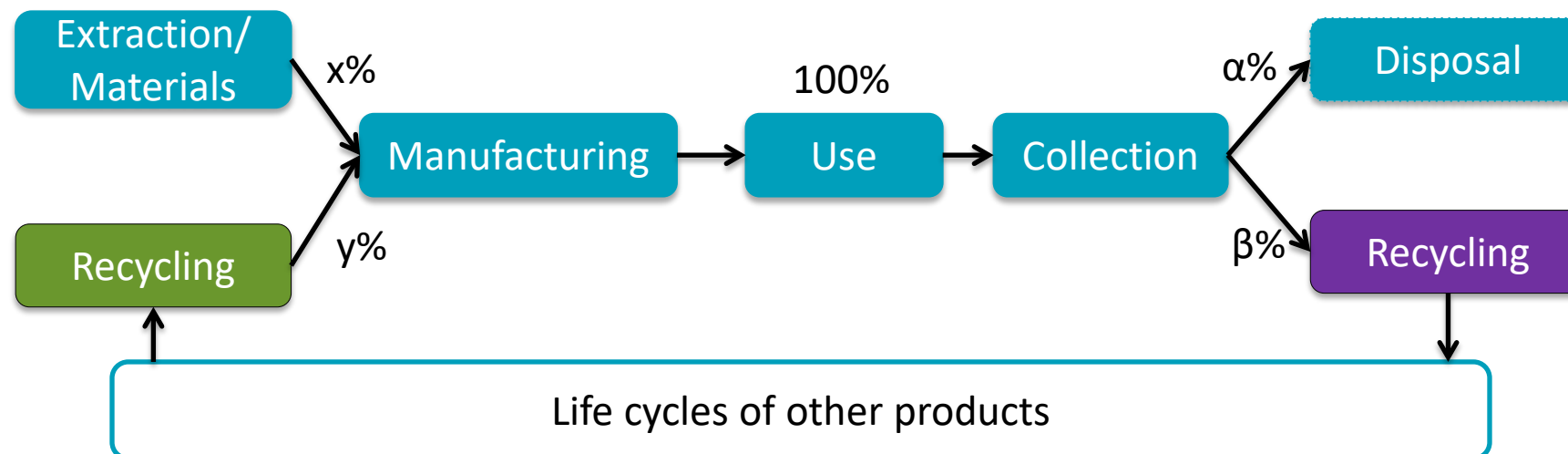
- **Recycled content method**
- **End of life recycling method**
- There are more:
 - **Circular Footprint Formula (CFF)**
https://ec.europa.eu/environment/eussd/pdf/Webinar%20CFF%20Circular%20Footprint%20Formula_final-shown_8Oct2019.pdf
 - **Method of number of uses (usually used for paper, but not covered in this course)**
 - **Methods based on the quality of the recycled material**
 - **50-50 method**
 - ...

Example: description

- Let's assume a product composed of 1kg of material
 - Is manufactured from $x\%$ virgin material and $y\%$ recycled material
 - At the end of its life, $\alpha\%$ of the collected material goes to final disposal (e.g. landfill) and $\beta\%$ is recycled

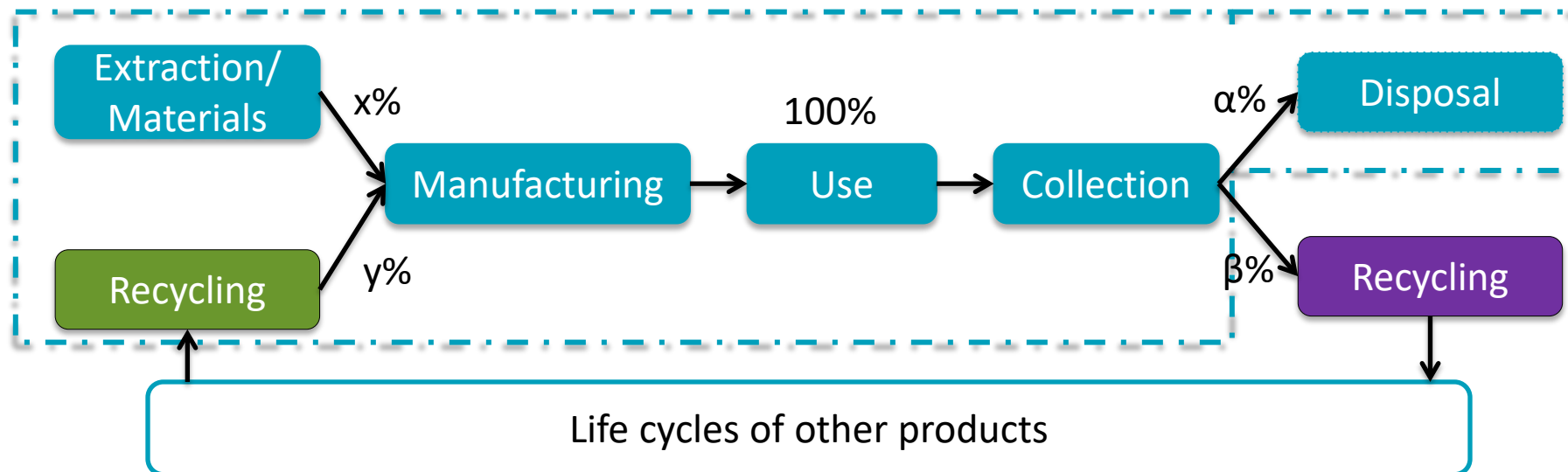
*Using recycled material
as input*

*Recycling of residual
materials as output*



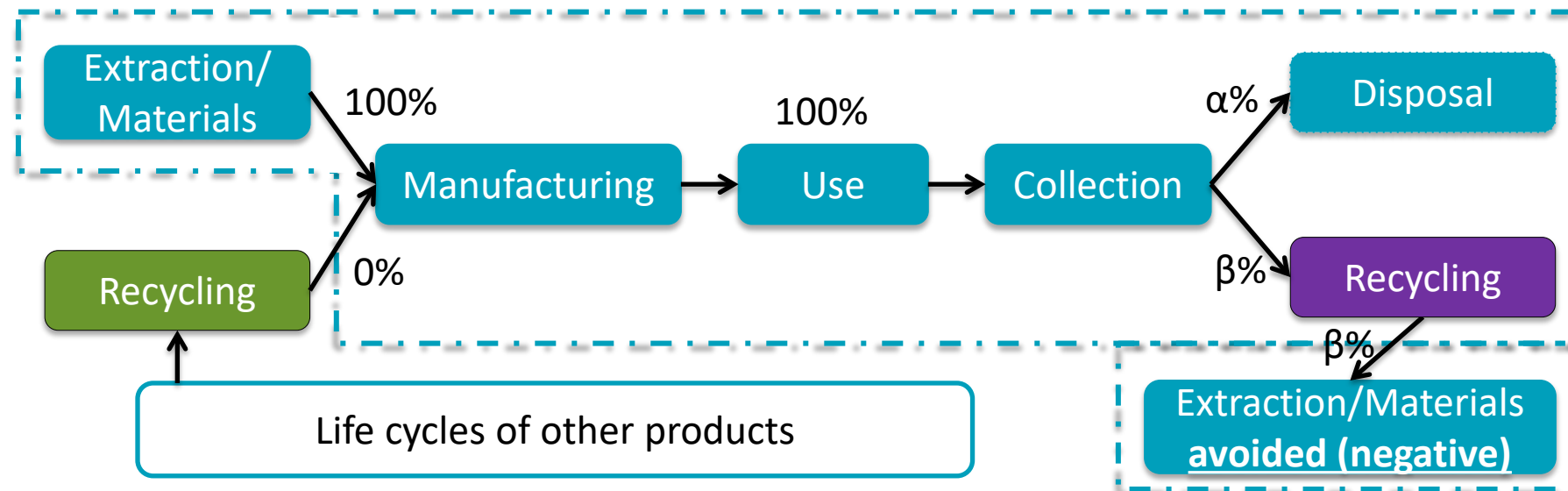
Example: “Recycled content” approach

- Recycled content approach (cut-off):
 - **Recycling impact is attributed to the life cycle that uses the recycled material**
 - **Recycling impact at end of life is simply excluded from the system (no credits, but no impacts of end of life treatment either)**



Example: “End of life recycling” approach

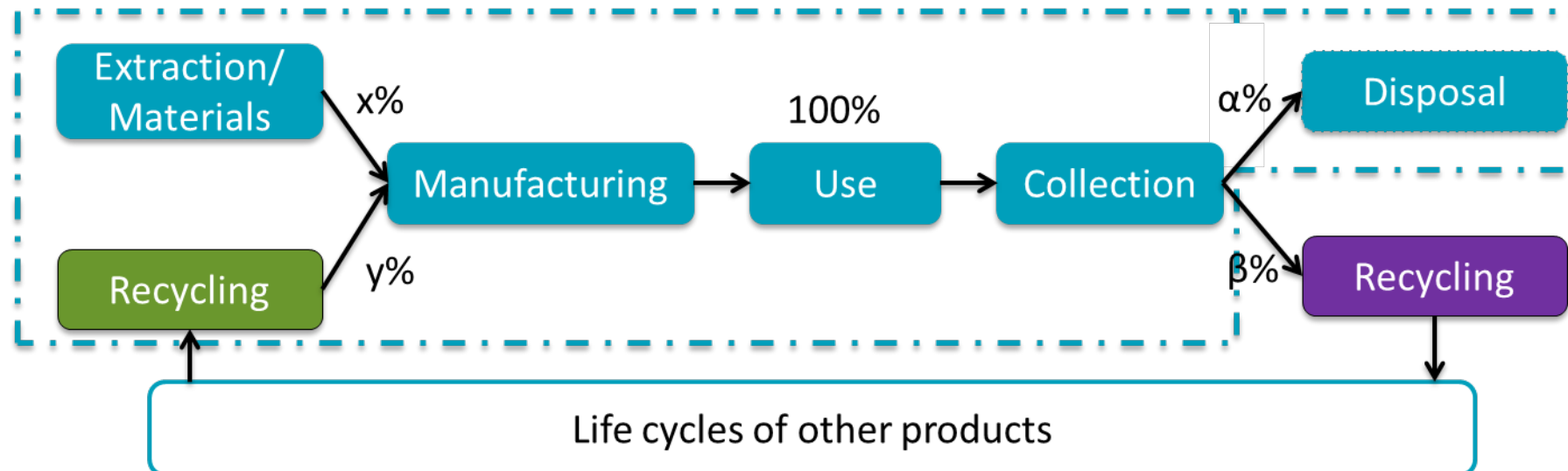
- End of life recycling approach
 - **Materials used by the life cycle are assumed as virgin, regardless of the recycled content**
 - **Recycling at the end of life avoids producing raw materials (substitution, system boundary expansion)**



Main approaches – what do they imply?

Recycled content approach:

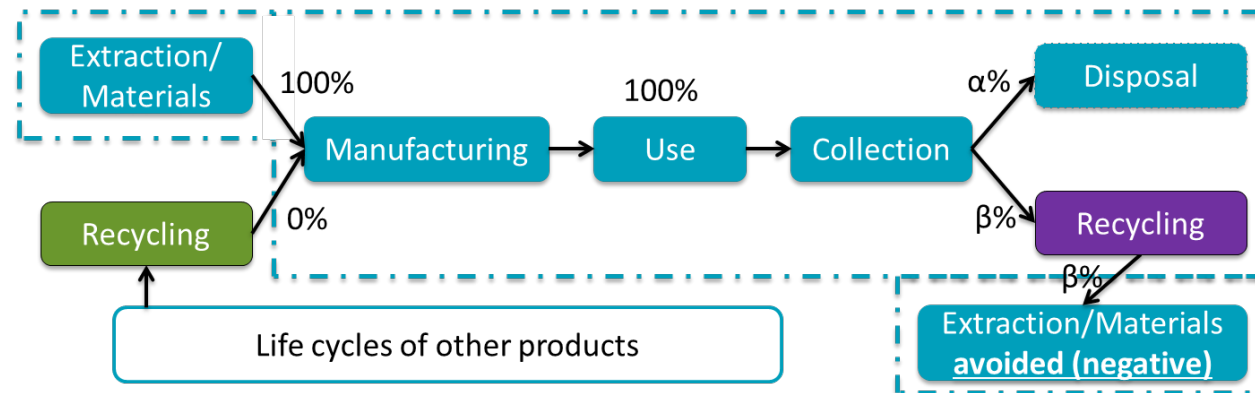
- **Boosts use of recycled materials**
 - If impacts of recycling < impacts of initial production of virgin materials
- **Encourages (though weak) recycling at the end of life**
 - Recycled material isn't associated to impacts of final disposal



Main approaches – what do they imply?

End of life recycling approach:

- **Doesn't encourage the use of recycled materials**
 - All input materials are associated to impacts of virgin materials, regardless of their recycled content
- **Encourages recycling at end of life (Design for Recycling)**
 - Recycling → « credit »
 - (must obviously take into account the modification of inherent properties of the materials)
- **Discourages dissipation of materials**
 - If they can't be collected, it's impossible to recycle them



Choice of a recycling approach

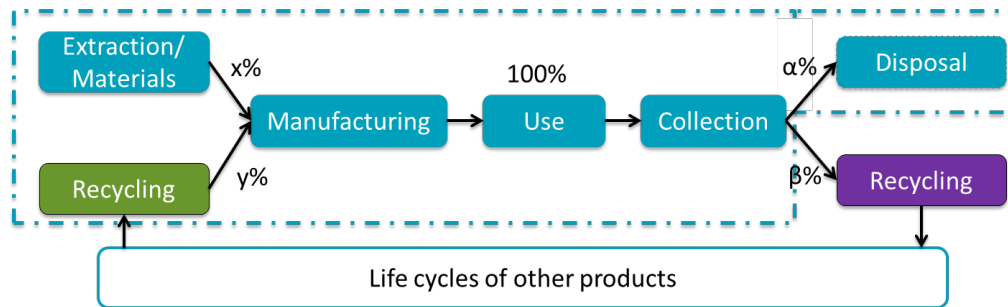
Depends on the state of the market for recycled material

Supply > Demand

Ex : glass in QC

Low demand, so using recycled material

- contributes to reducing the amount of recycled material waiting to be used
- avoids production of virgin material



High supply, so producing recycled material

- contributes to increasing the amount of recycled material waiting to be used
- does not avoid production of virgin material

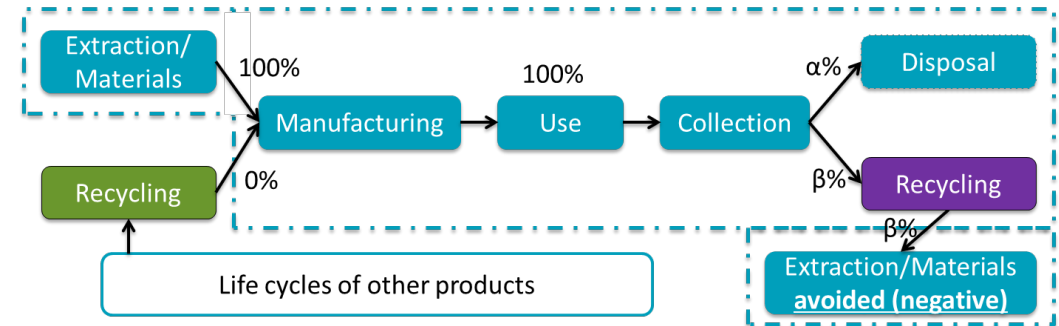
Recommended approach
« Recycled content (cutoff) »

Supply < Demand

Ex : steel

High demand, so using recycled material

- deprives users of access to recycled material
- does not avoid production of virgin material



Low supply, so producing recycled material

- Promotes access to recycled material for other users
- Avoids production of virgin material

Recommended approach
« End of life recycling »

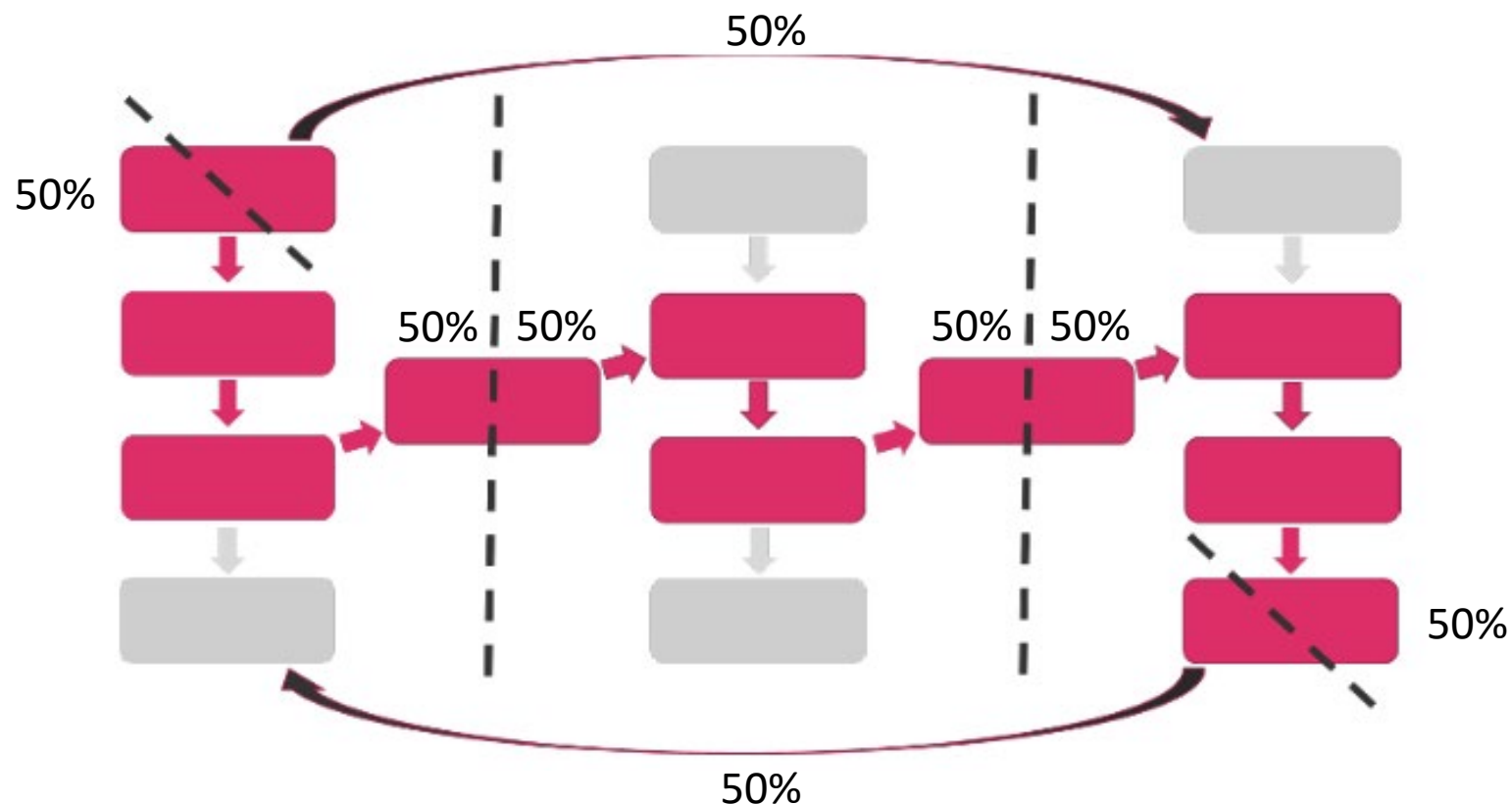
Concretely, for your projects

For “significant” multifunctional processes and for recycling:

- **Choose, justify and document your approach**
- **Identify the other justifiable approaches**
- **Perform a sensitivity analysis with alternative allocation approaches**

To go further in modeling recycling in LCA

50/50 Approach for recycling: The lesser of the two evils?



Ekvall, T., Björklund, A., Sandin, G., Jelse, K., Lagergren, J., & Rydberg, M. (2020). Modeling recycling in life cycle assessment. Retrieved from https://www.lifecyclecenter.se/wp-content/uploads/2020_05_Modeling-recycling-in-life-cycle-assessment-1.pdf

The PEF approach: introducing the single end-of-life formula?

Introducing the single Environmental Footprint end-of-life formula

<https://pre-sustainability.com/articles/pef-series-end-of-life-modelling/>

→ The Circular Footprint Formula (CFF) approach



The Circular Footprint Formula (CFF) and its practical application

Training; Environmental Footprint (EF) transition phase

10 November 2020

Trainer:

Marc-Andree WOLF
maki Consulting GmbH

Quality assurance:

Kirana (CHOMKHAMRSRI) WOLF
maki Consulting GmbH

Hannes PARTL
Sphera Solutions GmbH

Project officers:

Alicia BOYANO-LARRIBA, Lionel THELLIER
European Commission, DG ENV

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https://ec.europa.eu/environment/eusds/mgmp/pdf/TrainingCFF%20Circular%20Footprint%20Formula10Nov2020_final_corr.pdf