INNOMAT

LEARNING & TRAINING PACKAGES

LCA PRACTICAL GUIDE

David Sanjuan Delmás (Ghent University)

- Introduction to LCA
- Goal and scope
- Inventory analysis
- Impact assessment
- Interpretation
- Use of LCA
- Example

We start with a personal question:

Suppose you need a new pair of trousers, blue jeans. You go to the shop and you see two Diesel jeans. Both they have the same cut, the fabric has the same feel and touch, and the same colour. Suppose the quality is the same, and one of the two has a green sticker with a statement of Diesel that this jeans has been produced greener than the other jeans of Diesel.

Suppose that you believe Diesel, and suppose that both pairs of jeans have the same price. Who of you will buy the jeans with the green sticker?

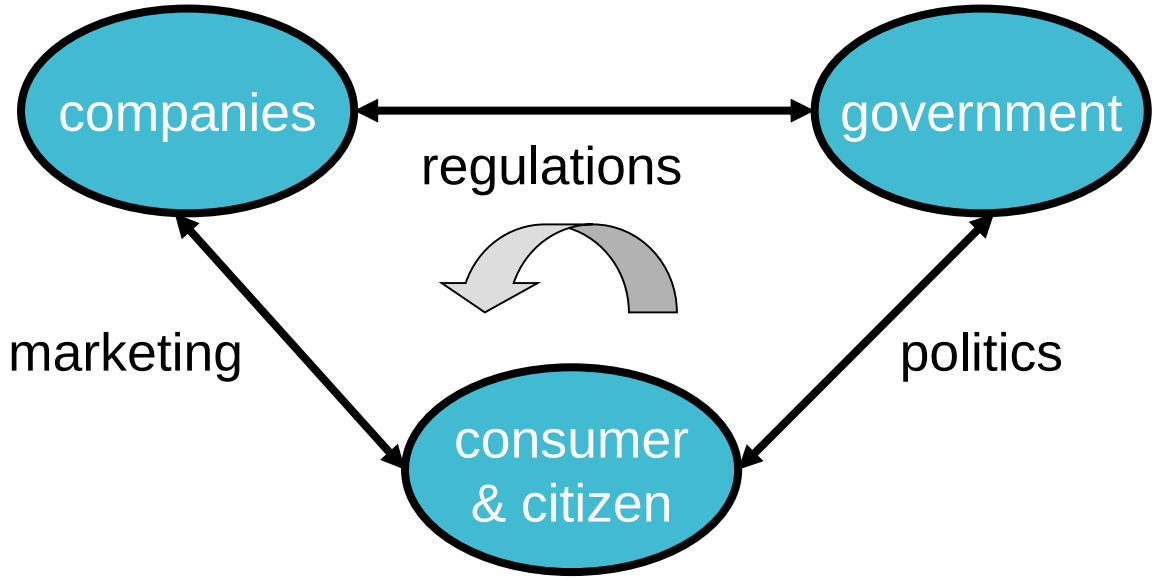
Suppose the normal jeans costs 80 euro and green jeans will costs 85 euro. Who of you will still buy the jeans with the green sticker? (please be honest)

Suppose the green jeans costs 90 euro. Who of you will still buy the jeans with the green sticker?

Enquiries in Western Europe show:

- 75 – 80 % of the people care for the environment, however
- 2 – 5 % of the people are prepared to pay more for a ‘green’ product
- About 50% of the students do not buy green labels:
  - regard it as ‘green washing’
  - mistrust the quality when the price is the same

The road towards Sustainability: the interaction of the 3 stakeholders



The road towards sustainability:

- Clients buy products in shops on the basis of quality/price ratio (sustainability is unimportant in the shop)
- However, clients act also a citizen in politics: a majority asks the government to set strickter regulations
- Companies accept regulations when they are ‘level playing field’

Source: Vogtlander J.G. et al. 2014. Eco-efficient Value Creation, Second edition, Delft Academic Press

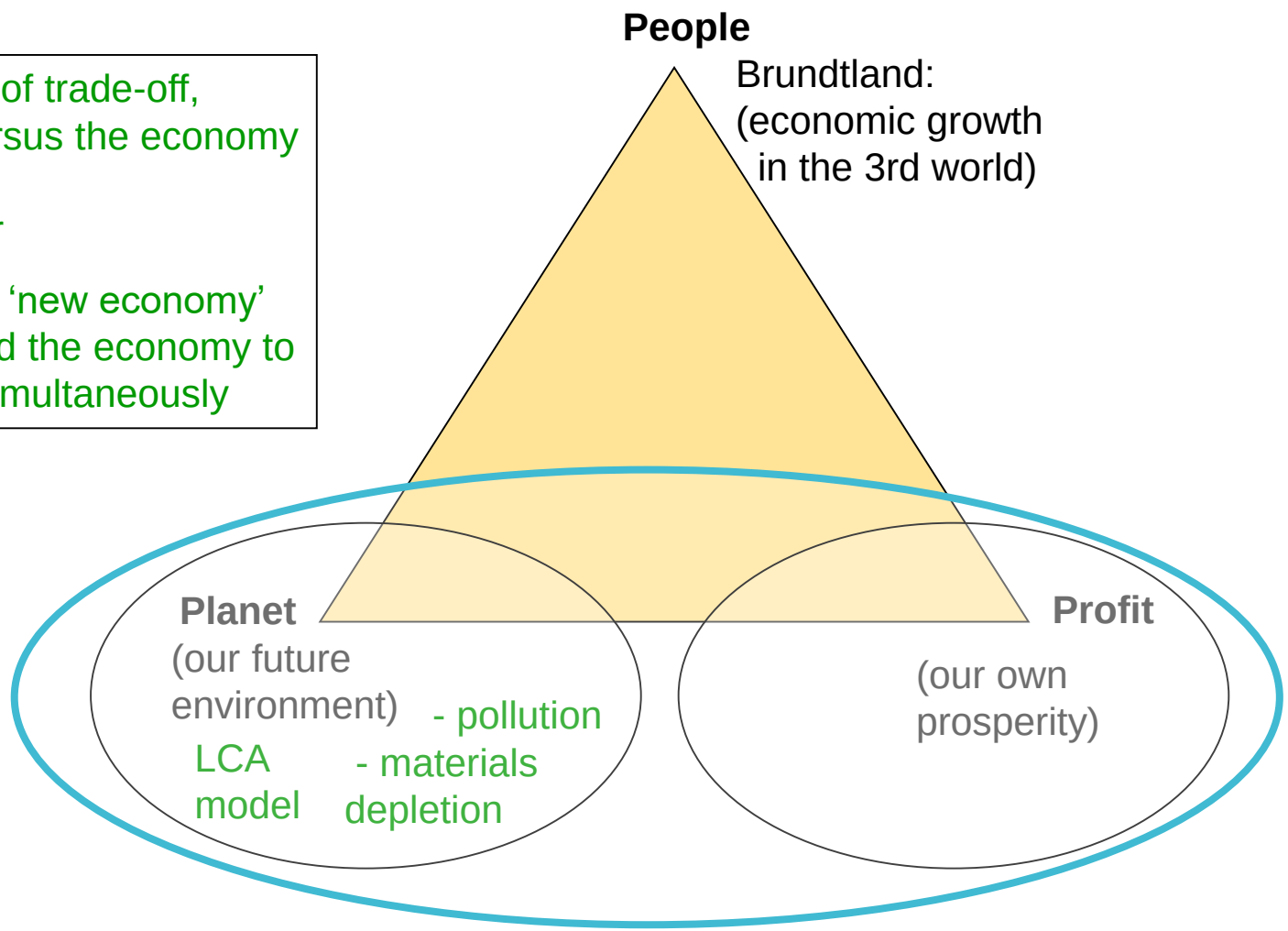
INNOMAT 3
LEARNING & TRAINING PACKAGES

The basics of Sustainability: the 'Triple P' of Planet, People, and Profit

Is it a matter of trade-off,
i.e. the ecology versus the economy

or

is it a matter of a 'new economy'
i.e. the ecology and the economy to be improved simultaneously



Circular business models and eco-efficient value creation

Source: Vogtlander J.G. et al. 2014. Eco-efficient Value Creation, Second edition, Delft Academic Press

Sustainability according Brundtland and Elkington

- Brundtland (1987) looked at the relationship between the poor environmental situation and poverty in 3rd world countries
- Elkington (1994) looked at business strategies, and proposed a more balanced trade-off in business:
  - saving our **planet,**
  - care for **people** :a better distribution of wealth
  - **profit** of your own company

INNOMAT 4
LEARNING & TRAINING PACKAGES

The key question: Which of these products is the most sustainable? How to decide it?

Paper bag

Reusable plastic bag

A key issue in our modern world: "what is true and what is not true?"

- Many companies are marketing by 'window dressing', since they want to be perceived greener than that they are.
- NGOs tend to spread alarming 'guts feel' news since they belief that people should be made aware, but adhere to marketing strategies that avoid the real complexity of issues.
- Who can we trust anymore?

The key question: Which of these products is the most sustainable? How to decide it?

DIFFICULT DECISION

- What is the **lifespan** of these products?
- How impacting is their **manufacturing**?
- How will they be treated at their **end of life**?

Etc.

Paper bag

Reusable plastic bag

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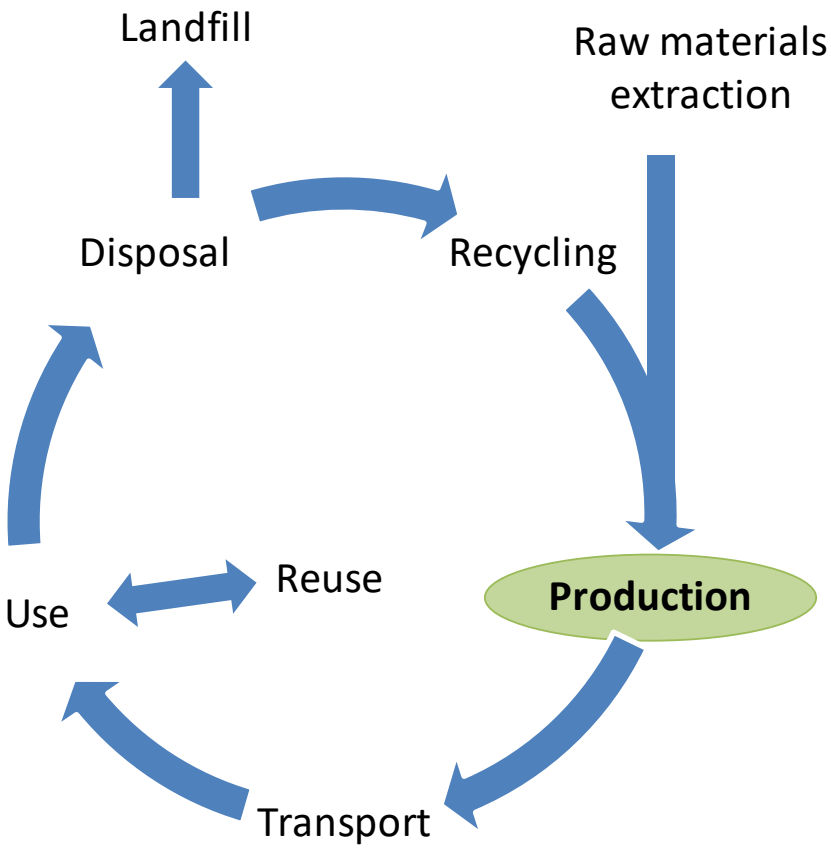
Paper bag

Reusable plastic bag

we need **LCA** to perform this analyses in a comprehensive way

What is Life Cycle Assessment – LCA ?

"Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system (good or service) throughout its life cycle, from the extraction of raw material to product disposal"



Life Cycle Assessment is about mass- and energy balances

- Considers the **entire life cycle** of a product
- Quantifies **resources** consumed as well as **emissions** into the **air, water and soil** that can be attributed to the product.
- **Provides indicators** of the product's contribution to environmental problems such as climate change, toxicity (human and eco-systems) and resource scarcity

What is Life Cycle Assessment used for?

1. Product comparison

Examples:

- Alkaline battery vs rechargeable battery?
- Fossil vs bio-based plastic?
- Centralized vs decentralized wastewater treatment?
- Concrete vs wood?

What is Life Cycle Assessment used for?

1. Product comparison
2. Product design and improvement

Example: the LCA of a knife

LCA results

- *Material consumption largest impact: steel*
- *Use phase varies: maintenance (handwashing vs. dishwasher)*

→ *Design strategy example*

- *Reduction of blade's thickness + use of recycled PP in handle*
- *Communication to user about best maintenance (handwashing vs. dishwasher)*
- *…*

↳ *Quantification of impact reduction*

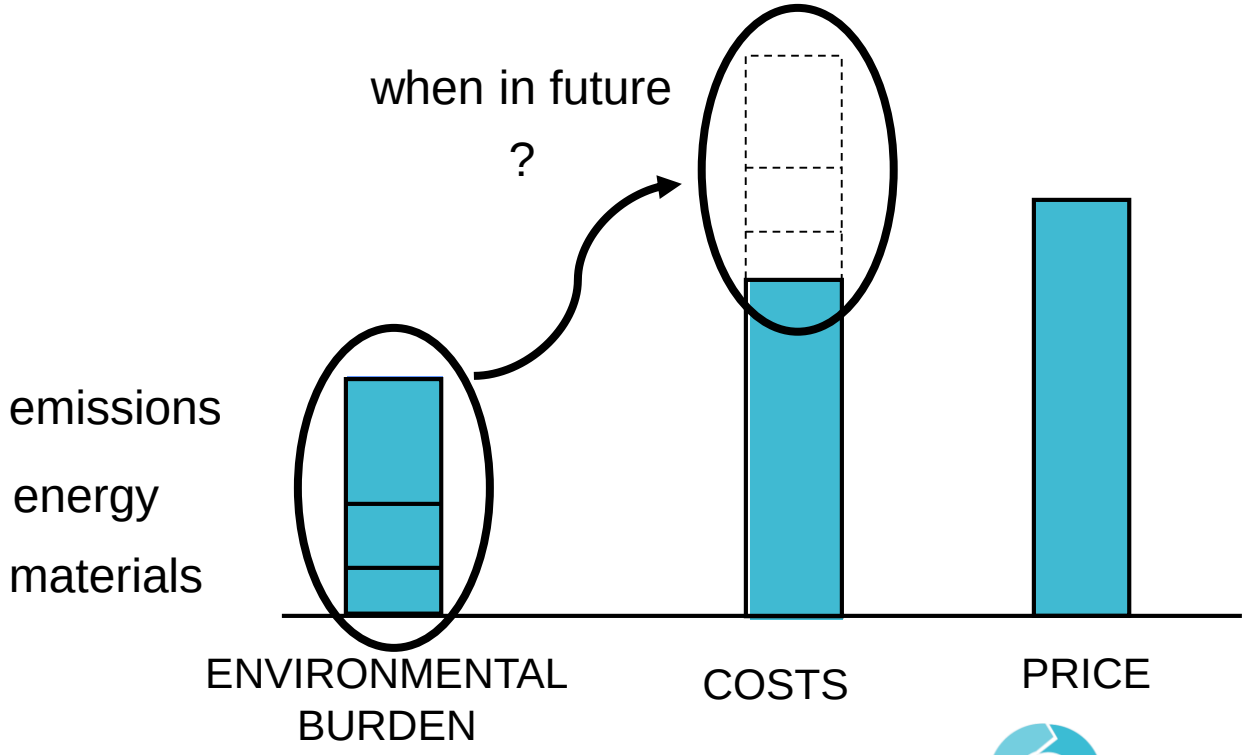
What is Life Cycle Assessment used for?

1. Product comparison
2. Product design and improvement
3. Environmental Product Declarations, EPDs

- EPDs are product descriptions with environmental information, in a well organised, trustable, and transparent certification system
- It is available in the building industry, and becomes available in the European food industry as well
- It is supposed to make an end to the ever increasing mess of labels

What is Life Cycle Assessment used for?

1. Product comparison
2. Product design and improvement
3. Environmental Product Declarations
4. Strategic planning of product innovation
   - LCA accounts for “external costs” in addition to the “internal costs”
   - Regulations may “internalize” external costs via: taxes to be paid, tradable emission right prices, required Best Available Technology (not at excessive costs)
   - When it will happen is not known, but that it happens is quite certain



Source: Vogtlander J.G. et al. 2014. Eco-efficient Value Creation, Second edition, Delft Academic Press

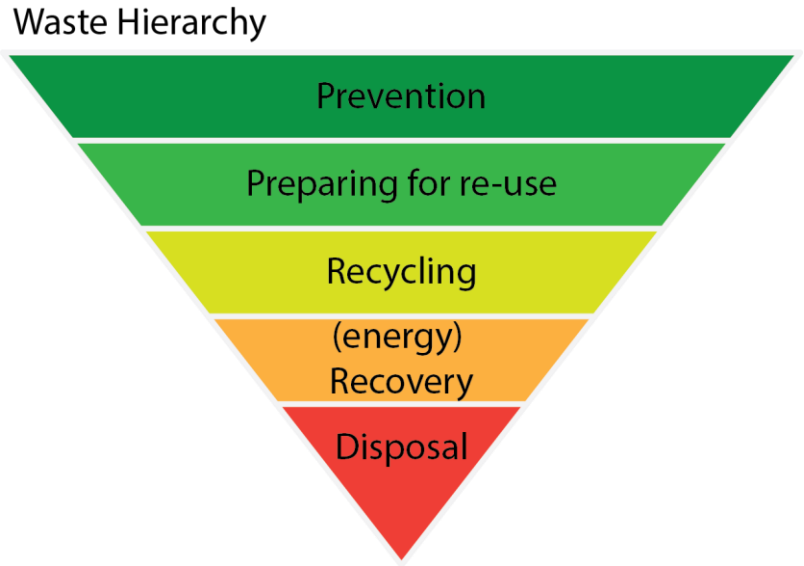
What is Life Cycle Assessment used for?

1. Product comparison
2. Product design and improvement
3. Ecolabelling
4. Strategic planning
5. Policy usage
    - Helping to develop long-term policy
    - Evaluating effects of alternative techniques
    - Providing environmental impact information to broad public

Important element of European environmental policy

What is Life Cycle Assessment used for?

1. Product comparison
2. Product design and improvement
3. Ecolabelling
4. Strategic planning
5. Policy usage
6. Comparison of alternative treatment processes of waste materials, waste water, etc.

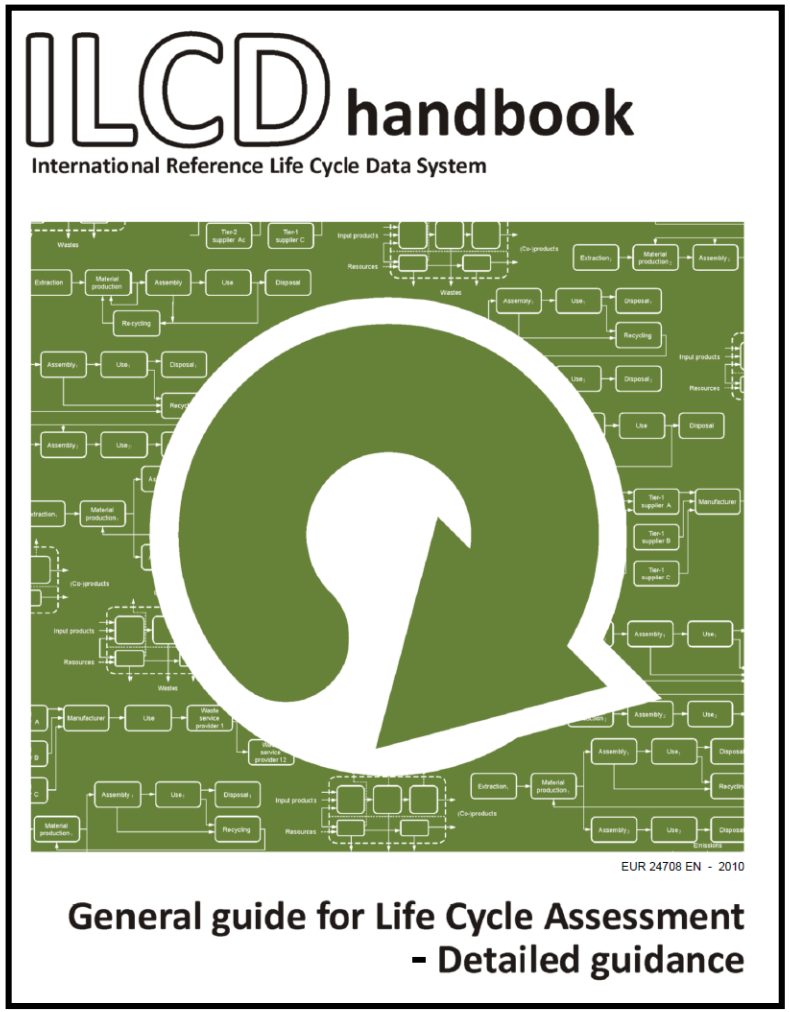


Note: LCA studies on "waste treatment processes" have different system definitions and system boundaries (compared to "product LCAs").

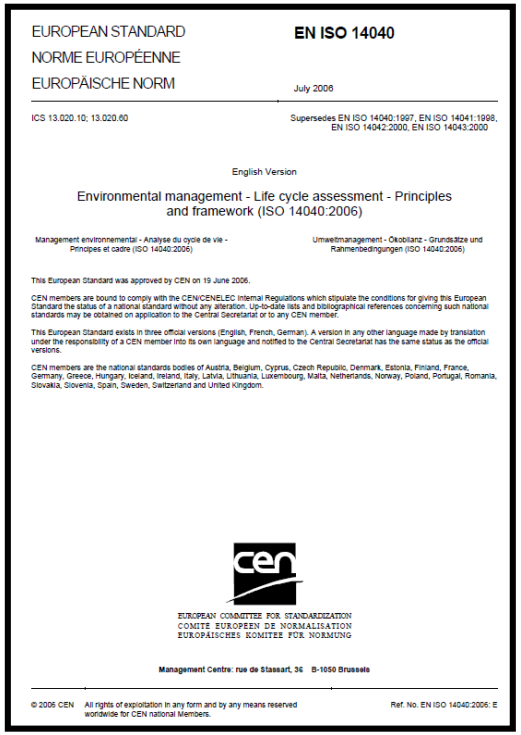
Life Cycle Assessment is well specified:

- Norms and definitions
- Scientific papers
- Handbooks
- Databases

Detailed guidelines in the ILCD handbook and other literature



International Organization for Standardization


EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN ISO 14040

July 2006

ICS 13.020.10; 13.020.60

Supersedes EN ISO 14040:1997, EN ISO 14041:1998, EN ISO 14042:2000, EN ISO 14043:2000

English Version

Environmental management - Life cycle assessment - Principles and framework (ISO 14040:2006)

Management environnemental - Analyse du cycle de vie - Principes et cadre (ISO 14040:2006)

Umweltmanagement - Ökobilanz - Grundsätze und Rahmenbedingungen (ISO 14040:2006)

This European Standard was approved by CEN on 19 June 2006.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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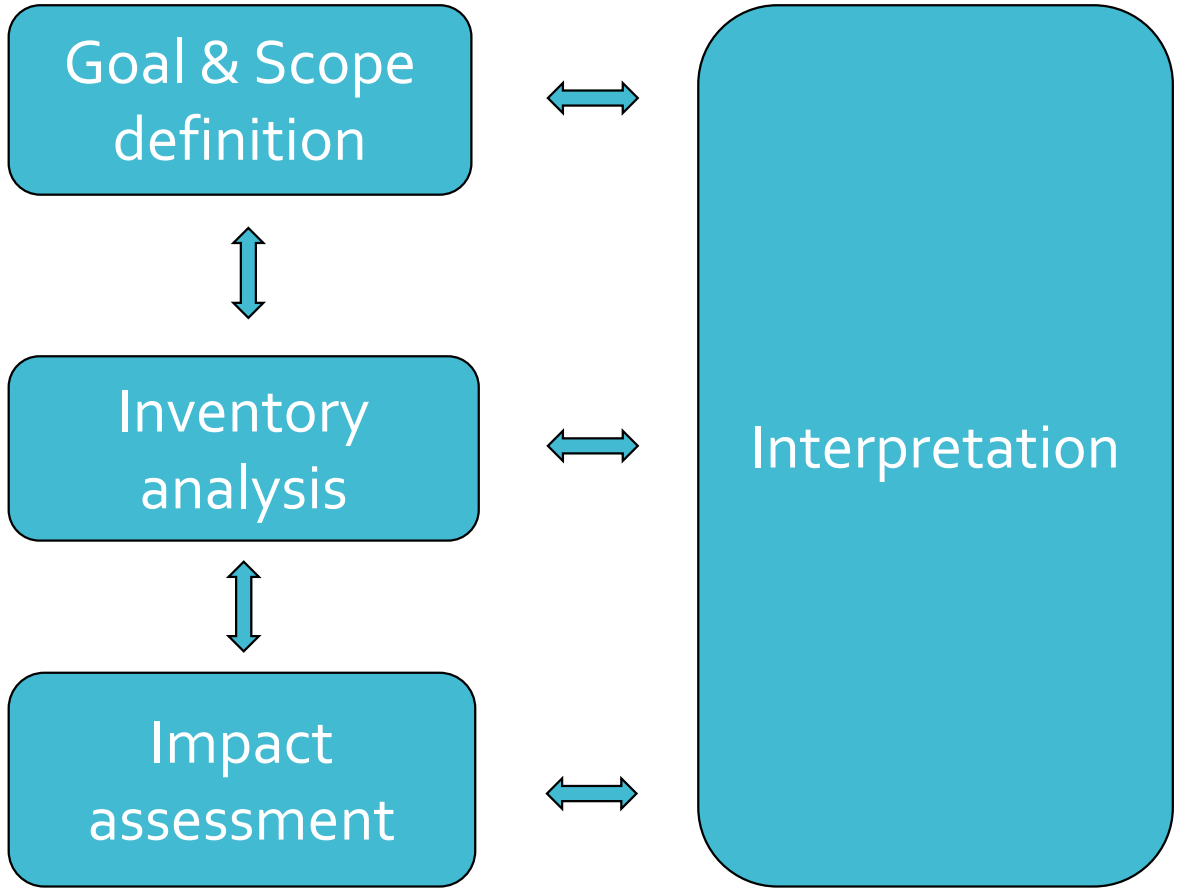
The stages of and LCA study



Goal & Scope definition must include at least:

- Aim of the study, e.g.
  (1) a comparison of 2 or more products, **or** improvement of the environmental characteristics of a product chain
  (2) for internal **or** external use
  (3) choice of the relevant indicator(s) **or** single indicator system

- Scope of the study, e.g.
  (1) system description including flow diagram
  (2) system boundaries
  (3) what is included or excluded
  (4) transport scenarios
  (5) life time assumptions (technical or economic)

- The “Functional Unit”

The 'functional unit' in LCA: the delivery

The **functional unit**

- The reference unit for the study (**the delivery**)
- What? How much? How long? Which quality?

COMPARISONS MUST BE FAIR

Examples:

- *Supply of 100.000 lumen lighting during one year (= 90h)*
- *Plastic or paper bag for shopping :10 kg weight max, 15 litre volume (35 cm x 35 cm x 15 cm): how many times re-usable? (or calculate per shopping session)*
- *Treatment of 1 m^3 of wastewater*
- *Production of 1 kg steel (is called 'declared unit')*

System description and system boundaries of an LCA for a product

ENERGY, MATERIALS

FUNCTION TO OUR SOCIETY

EMISSIONS TO AIR, WATER, SOIL

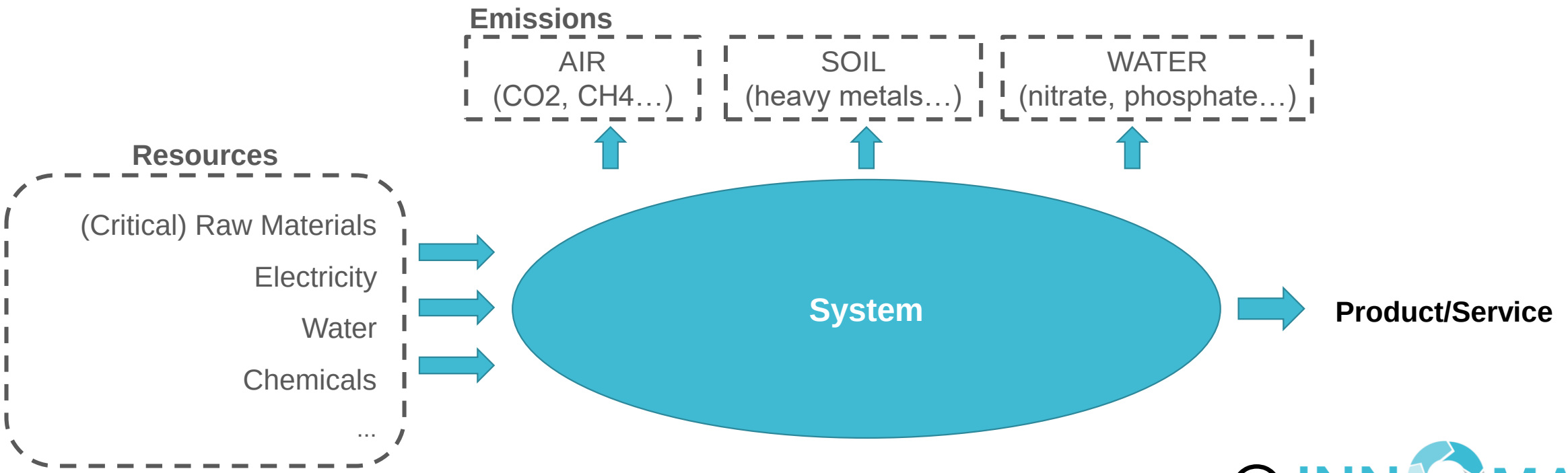
- **Excluding** a stage or element should be properly **justified**

  Example:
  - Not important for the decision-making (e.g. in a comaprison: subsystems which are the same for both systems)
  - Not relevant impacts (e.g. below 1 or 2 %)

- **Cradle to gate**
- **Cradle to cradle**

Life Cycle Inventory (LCI): Gathering all the necessary data to conduct the LCA

Once the LCA is defined, **we must collect the necessary data:**



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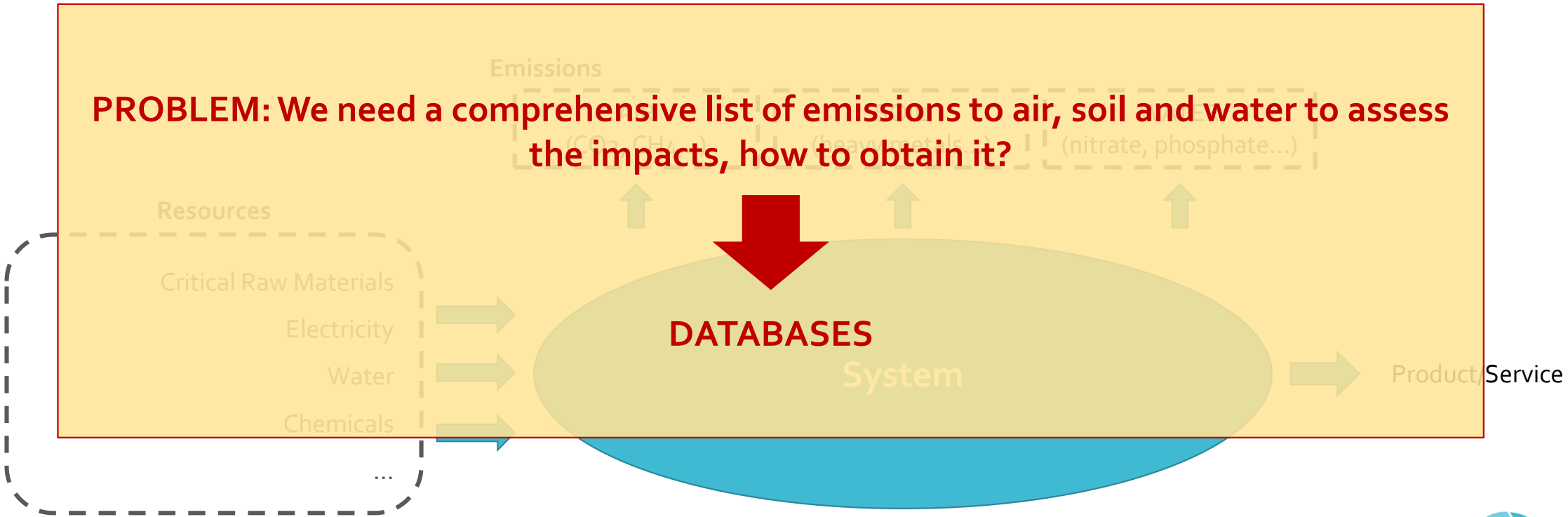
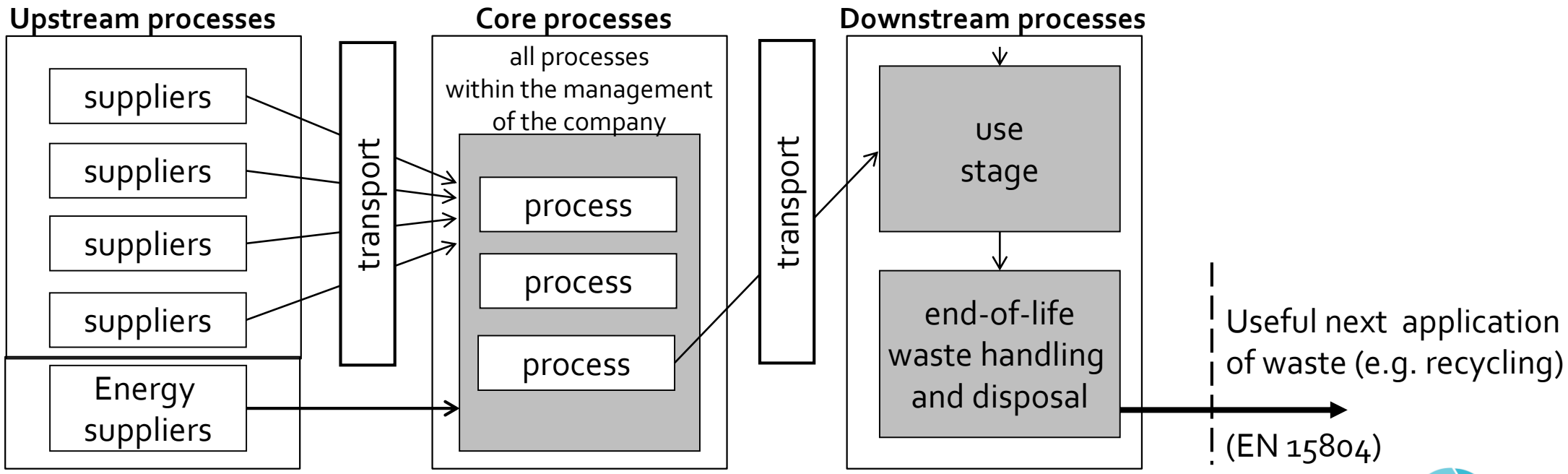


The foreground system and background systems, a practical consideration

Background systems
Processes for production of materials and other supplies
Generic data

Foreground system
Core processes under direct control or decisive influence
Specific/primary data

A mix of Foreground and Background Systems



Potential sources for the Life Cycle Inventory (LCI)

FOREGROUND SYSTEM (main system)

EXAMPLES
- Direct emissions from the process

DATA SOURCES
- Measurements on production site
- Surveys/inquiries
- Literature data (bibliographic research)
- Modeling/calculations

BACKGROUND SYSTEM (supply chain)

EXAMPLES
- Emissions transportation
- Emissions electricity generation
- Materials required (kg)

DATABASES WITH ENVIRONMENTAL INFORMATION

Ecoinvent database

Agri-footprint database

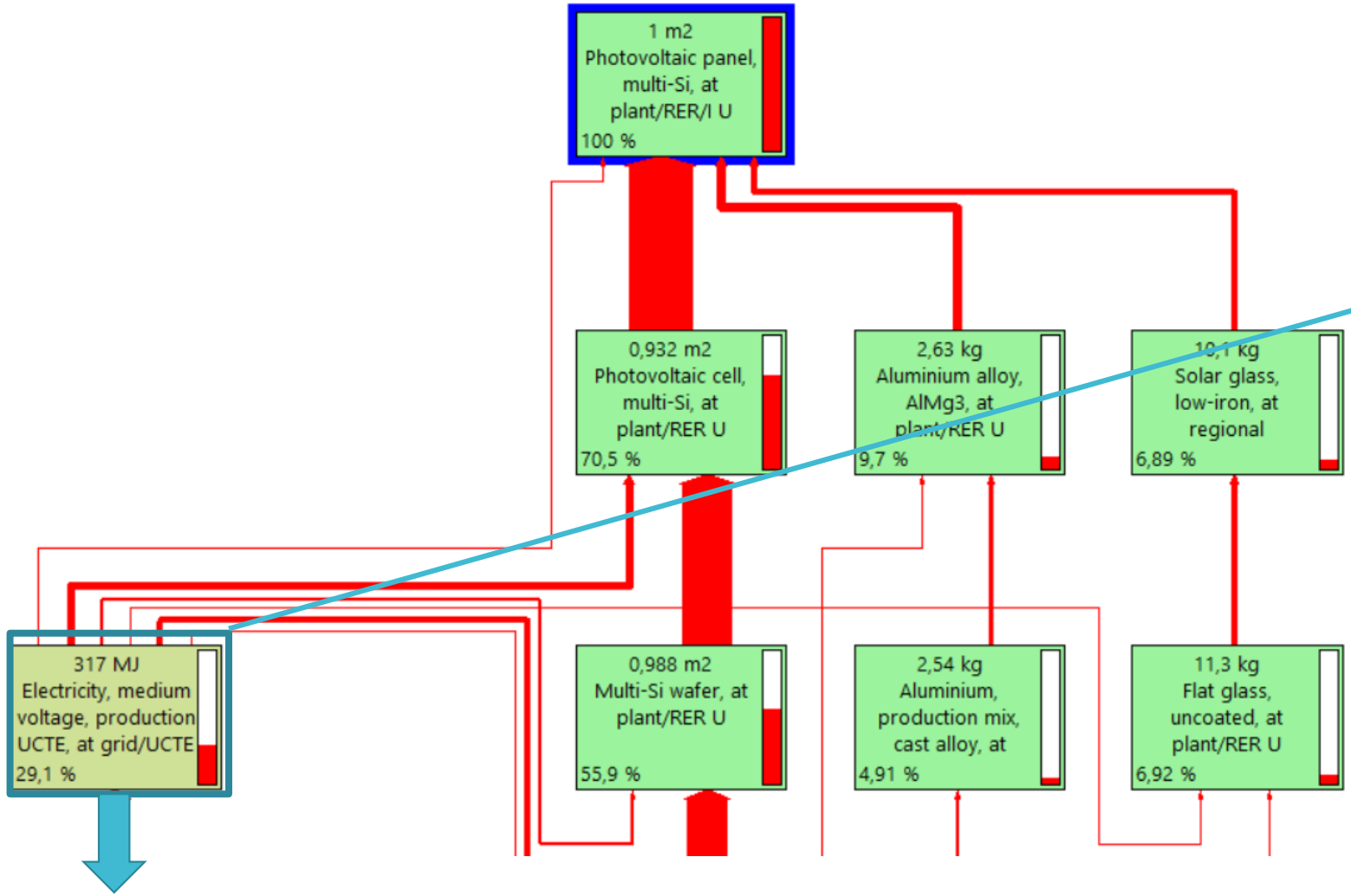
thinkstep GaBi

TU Delft Delft University of Technology

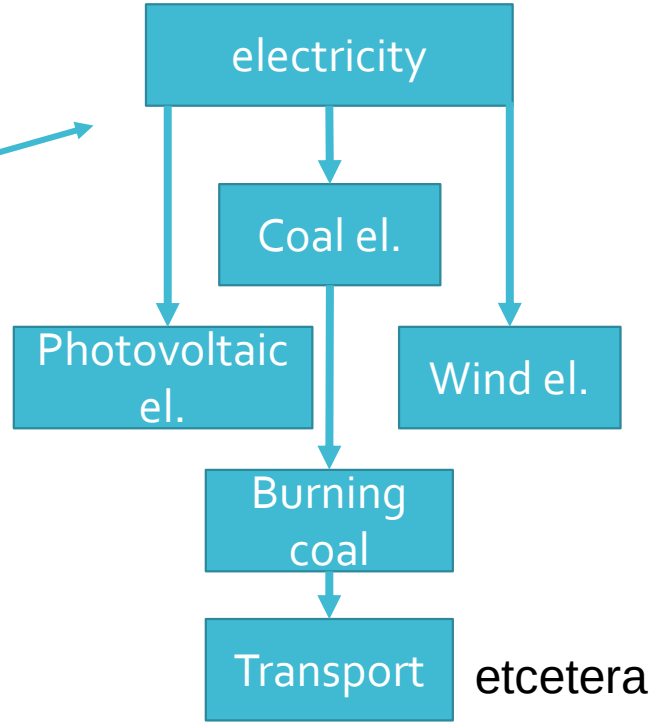
↓ data on effects of toxicity and scarcity

↓ Idemat and Idematapp data

"The Tree" in LCA: assembly of existing background processes lead to new LCAs of new products



You can dig deeper and deeper, for instance:



etcetera

Even a simple system can have hundreds or thousands of emissions!

EXAMPLE: **1 kg steel** – list of emissions 719 different emissions to the environment!!

No	Substance	Compartment	Unit	Steel, low-alloyed, at plant/RER S
1	1-Butanol	Air	pg	13.342
2	1-Butanol	Water	ng	142.58
3	1-Pentanol	Air	pg	169.57
4	1-Pentanol	Water	pg	406.96
5	1-Pentene	Air	pg	128.14
6	1-Pentene	Water	pg	307.53
7	1-Propanol	Air	ng	11.545
8	1-Propanol	Water	pg	625.24
•••				
714	Zinc-65	Air	nBq	384.12
715	Zinc-65	Water	µBq	947.68
716	Zirconium	Raw	µg	1.8466
717	Zirconium	Air	µg	14.051
718	Zirconium-95	Air	nBq	375.46
719	Zirconium-95	Water	µBq	10.974

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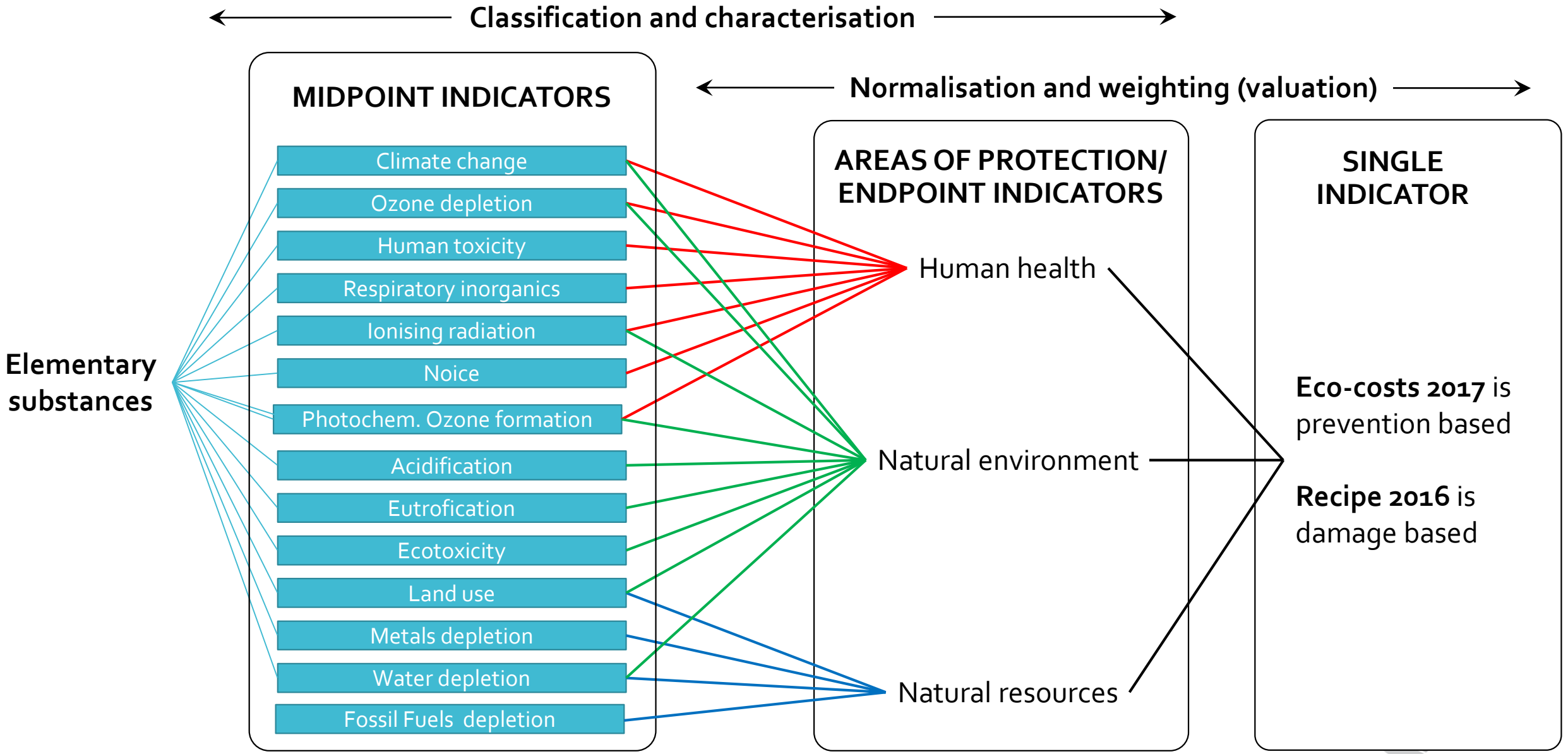
PROBLEM: How to address all these emissions? Which ones are important? How do we decide which ones to use when comparing products?

We need Life Cycle Impact Assessment (LCIA)

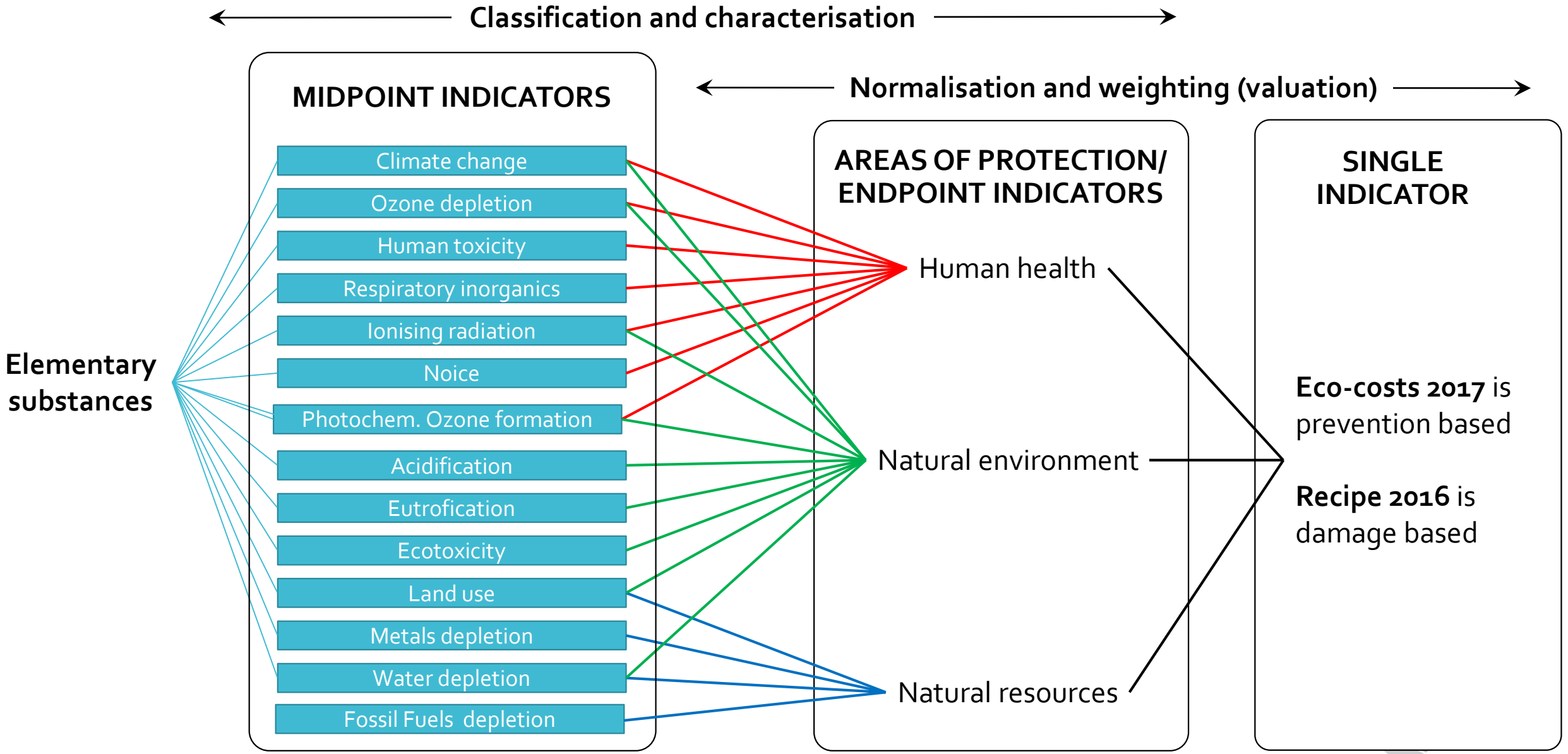

Classification and characterisation
Normalisation and weighting (valuation)
MIDPOINT INDICATORS
Climate change
Ozone depletion
Human toxicity
Respiratory inorganics
Ionising radiation
Noice
Photochem. Ozone formation
Acidification
Eutrofication
Ecotoxicity
Land use
Metals depletion
Water depletion
Fossil Fuels depletion
Elementary substances
AREAS OF PROTECTION/ ENDPOINT INDICATORS
Human health
Natural environment
Natural resources
SINGLE INDICATOR
Eco-costs 2017 is prevention based
Recipe 2016 is damage based

MIDPOINT vs ENDPOINT

	STRENGHT	WEAKNESS
MIDPOINT LEVEL	• More impact categories • Lower uncertainty	• Difficult interpretation
ENDPOINT LEVEL	• Easier interpretation	• Higher uncertainty

Midpoint characterisation factors (impact factors) of climate change: 1 kg of CH4 has 30.5 x the impact of CO2 (over a period of 100 years)

Greenhouse gas emission (1 kg)	Formula	GWP (CO_2 equiv.)
Carbon dioxide	CO_2	1
Methane	CH_4	30.5
Nitrous oxide	N_2O	298
Sulphur hexafluoride	SF_6	23.500
Hydrofluorocarbon-23	CHF_3	14.800
Hydrofluorocarbon-32	CH_2F_2	675
Perfluoromethane	CF_4	7.390
Perfluoroethane	C_2F_6	12.200
Perfluoropropane	C_3F_8	8.830
Perfluorobutane	C_4F_{10}	8.860
Perfluorocyclobutane	c-C_4F_8	10.300
Perfluoropentane	C_5F_{12}	13.300
Perfluorohexane	C_6F_{14}	9.300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ECO-COSTS (SINGLE INDICATOR)

The Eco-costs measure the amount of environmental impacts, agregating the impact categories of **acidification, eutrophication, ecotoxicity, human toxicity, summer smog, fine dust and global warming**.

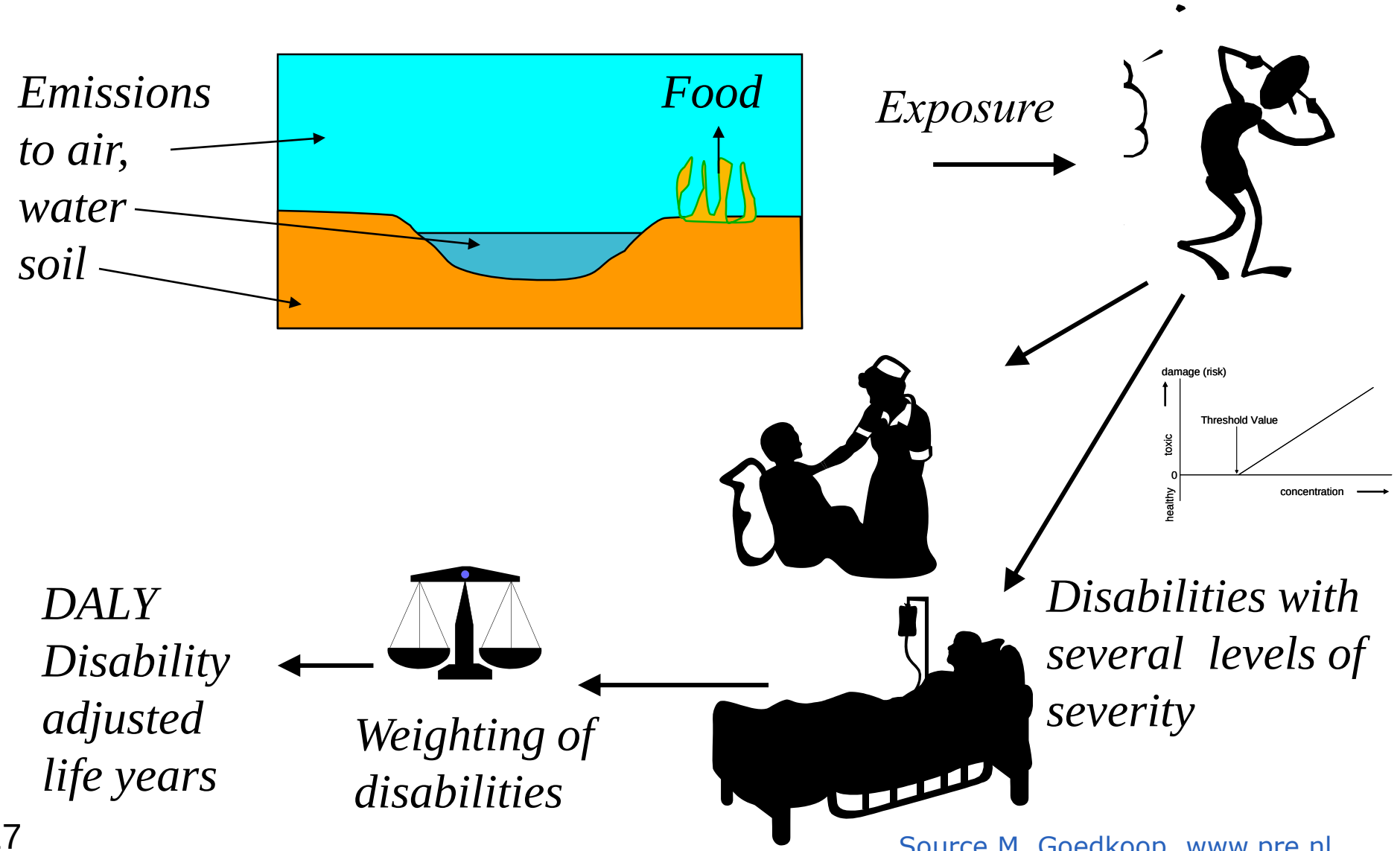
To agregate the impacts of these categories, the impacts in **equivalents are converted to Euros** using the **marginal prevention cost** (i.e., how much would cost to prevent that impact).

Examples:

Category	Multiplier (marginal prevention cost)	Midpoint table
eco-costs of acidification	8.75 €/kg SOx equivalent	ILCD 2011 Midpoint+ (incl. country factors)
eco-costs of eutrophication	4.17 €/kg phosphate equivalent	CML-IA baseline

The eco-costs indicator are often used in this course for calculations and exercises.

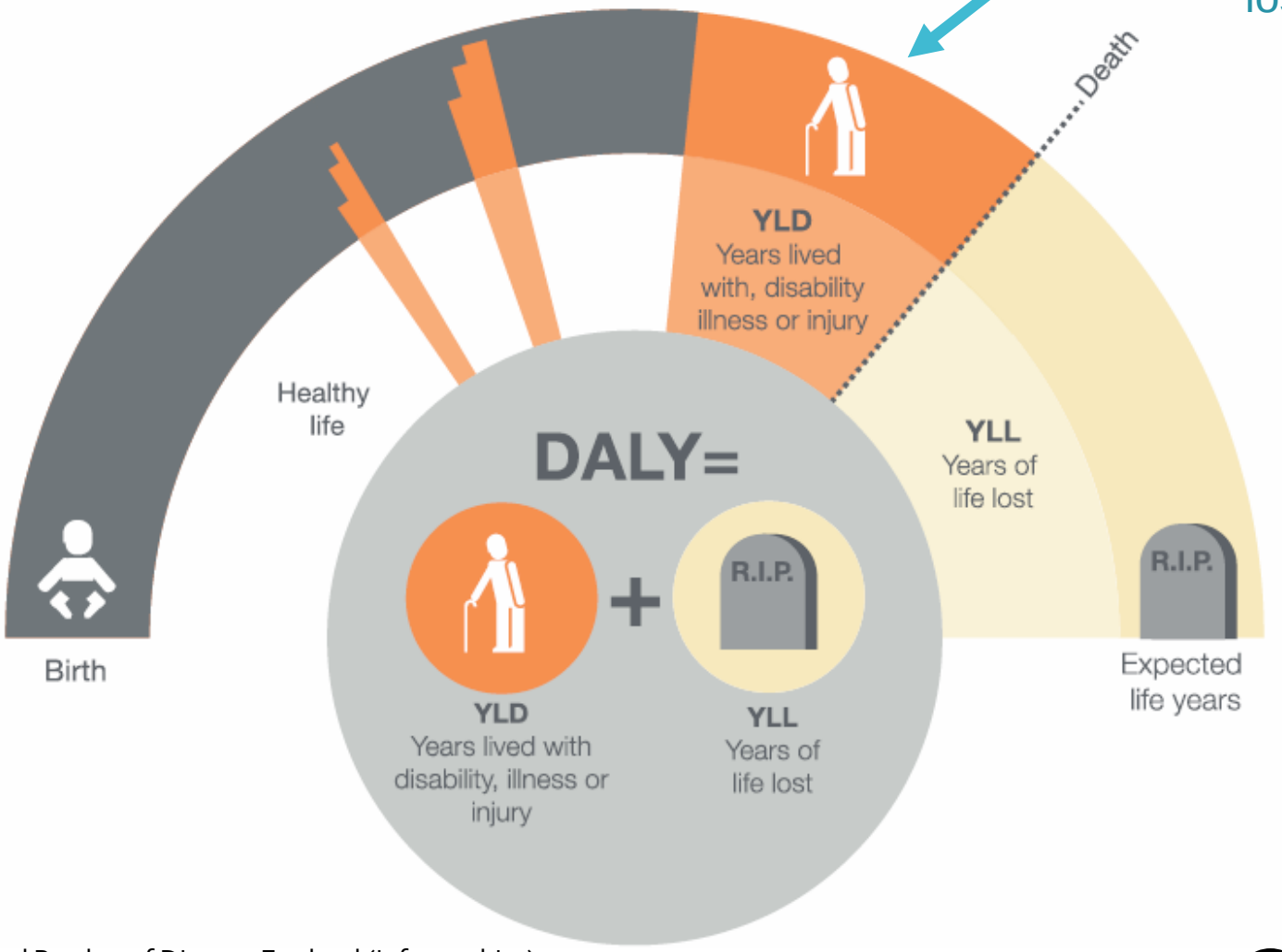
Calculation of the human health endpoint: the pathway from emission to effect



Source M. Goedkoop, www.pre.nl

IMPACTS ON HUMAN HEALTH: DALY

Every disease has its own factor for loss of quality of life



Source: Public Health England, The Global Burden of Disease England (infographics)
https://www.slideshare.net/PublicHealthEngland/global-burden-of-disease-england-infographic-slide-set

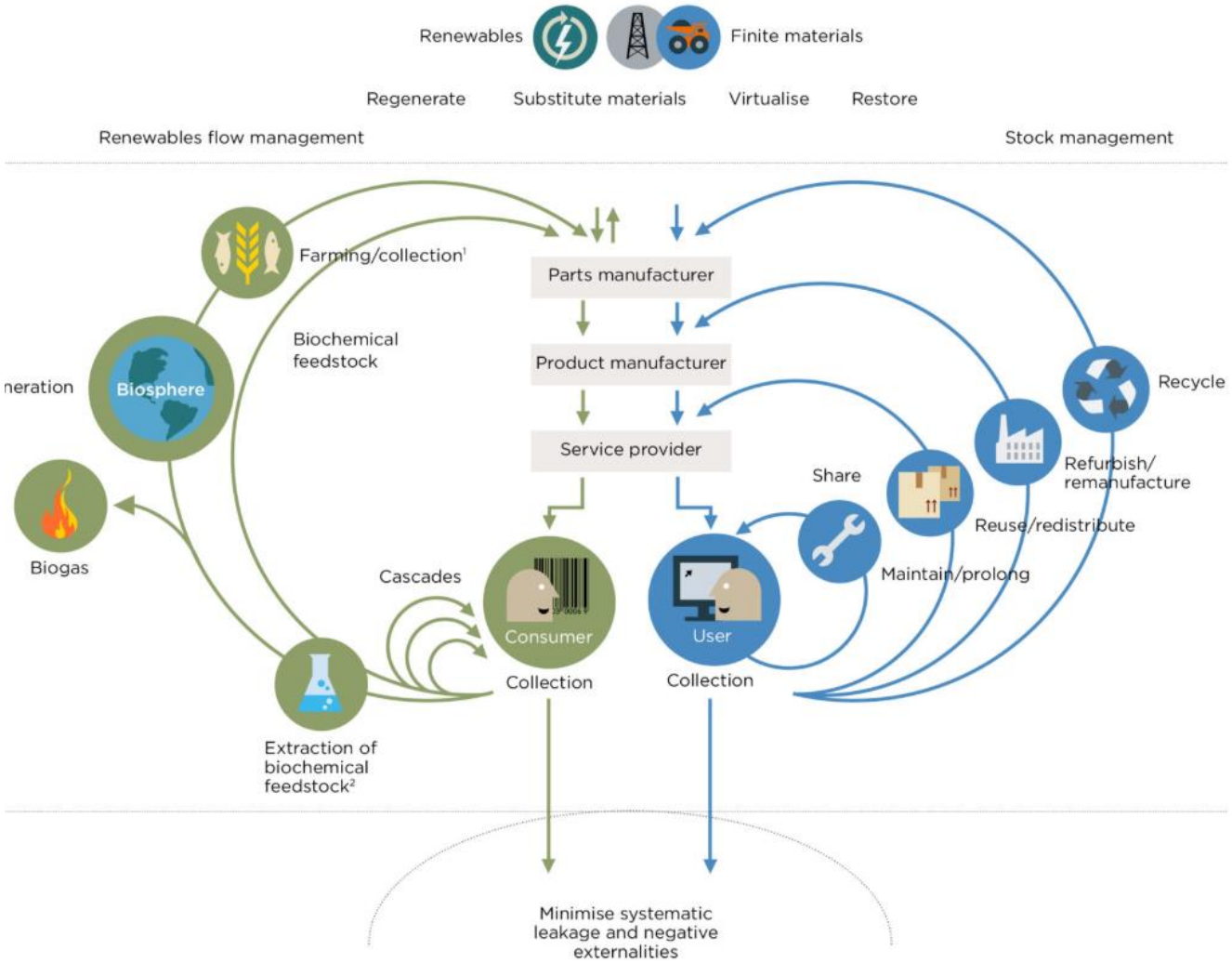
LCA Software

- SimaPro (PRé)
- GaBi (thinkstep)
- Open LCA (GreenDelta)
- Umberto
- **IdematLightLCA**
- Ecolizer design tool
- Bilan Produit

Idematapp excel file with 1200 data lines on eco-costs, carbon footprint, CED, and ReCiPe endpoimts:

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1				Process	Total eco-costs	eco-costs of human health	eco-costs of exo-tocicity	eco-costs of resource scarcity	eco-costs of carbon footprint	Carbon footprint	CED (Total)	ReCiPe human healt	ReCiPe ecotoxixity	ReCiPe resources	
2															
3			unit		euro	euro	euro	euro	euro	kg CO2 equiv.	MJ	DALY	H species.year	H USD2013	
4	A.100.03.104	1	kg	Idematapp2019 Steel beams, pipes, sheet (from market mix 44% recycled	0.40	0.01	0.05	0.07	0.27	2.32	29.41	6.72E-03	4.08E-05	0.086	
5															
6															

A holistic approach: THE BUTTERFLY DIAGRAM



Source: Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment; Drawing from Braungart & McDonough, Cradle to Cradle (C2C)

Ways to eliminate 'waste to landfill' in the butterfly:

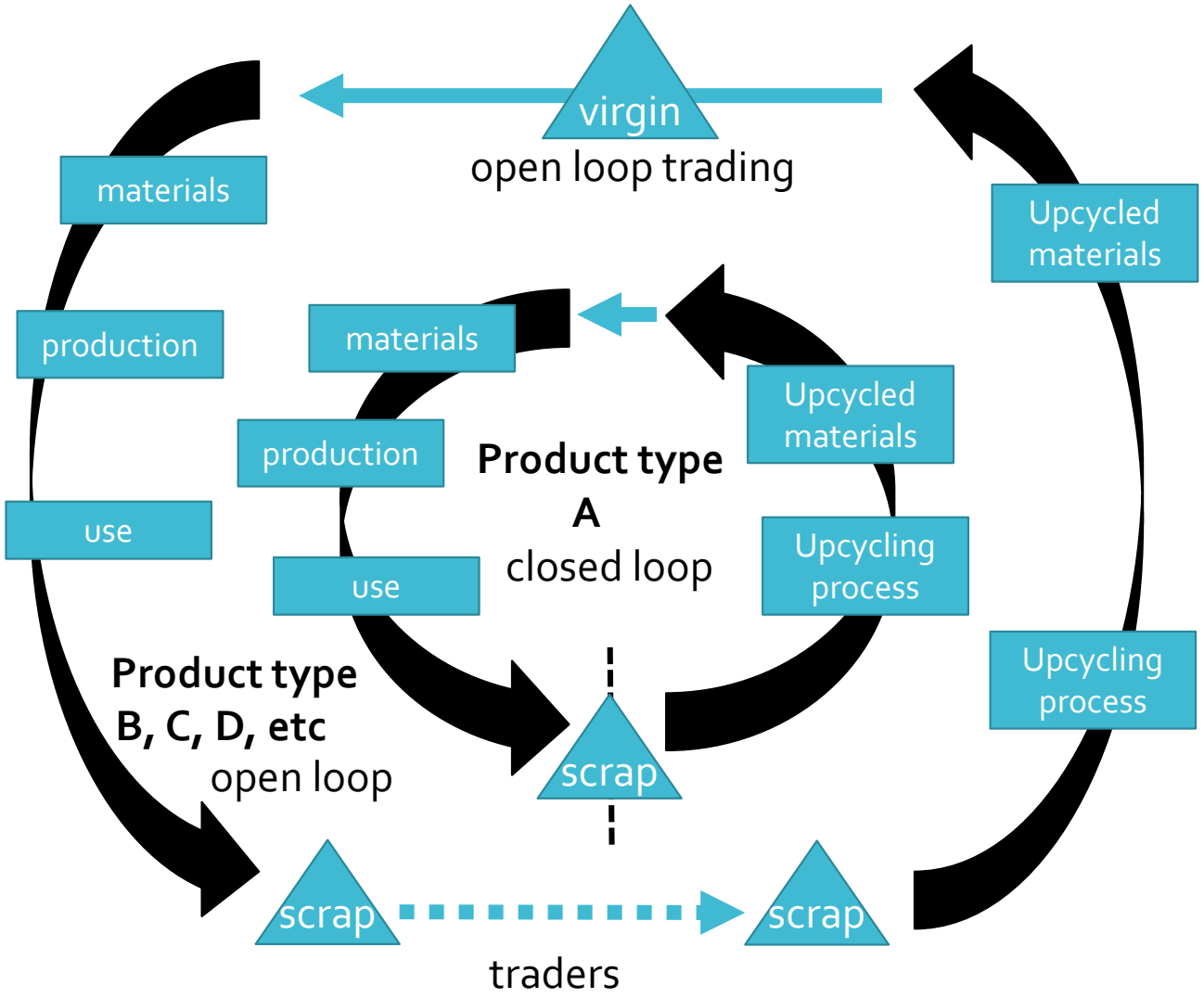
1. Reduce materials in the 'techno sphere':

- **Share**
- **Reuse**
- **Repair**
- **Refurbishing and Remanufacturing**
- **Recycle the materials**

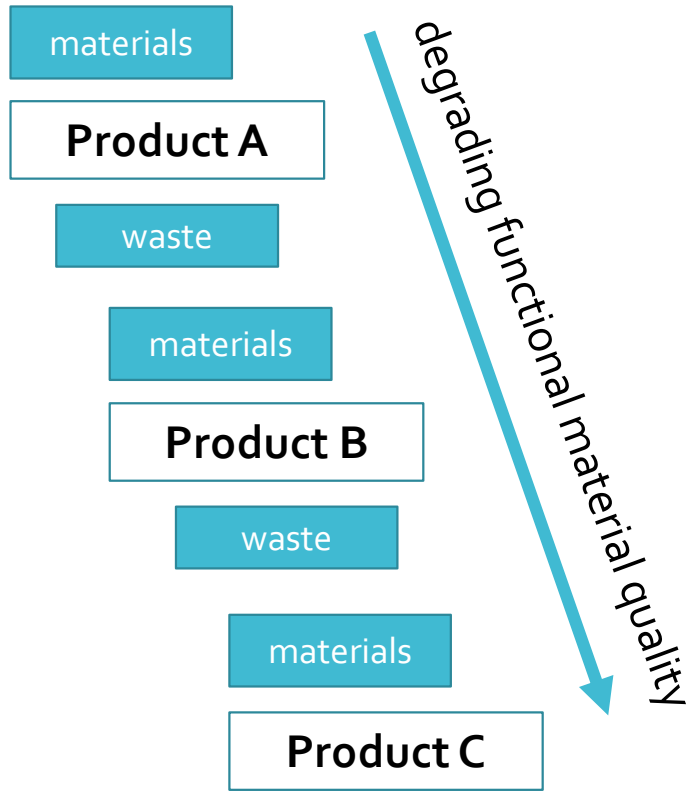
2. Shift to sustainable materials the 'bio sphere':

- **Recycle nutrients**
- **Make use of the recycling of biogenic CO_2 (the so-called 'short cycle' in nature): biogenic CO_2 is not counted in LCA (IPCC)**

Open and closed loop Upcycling

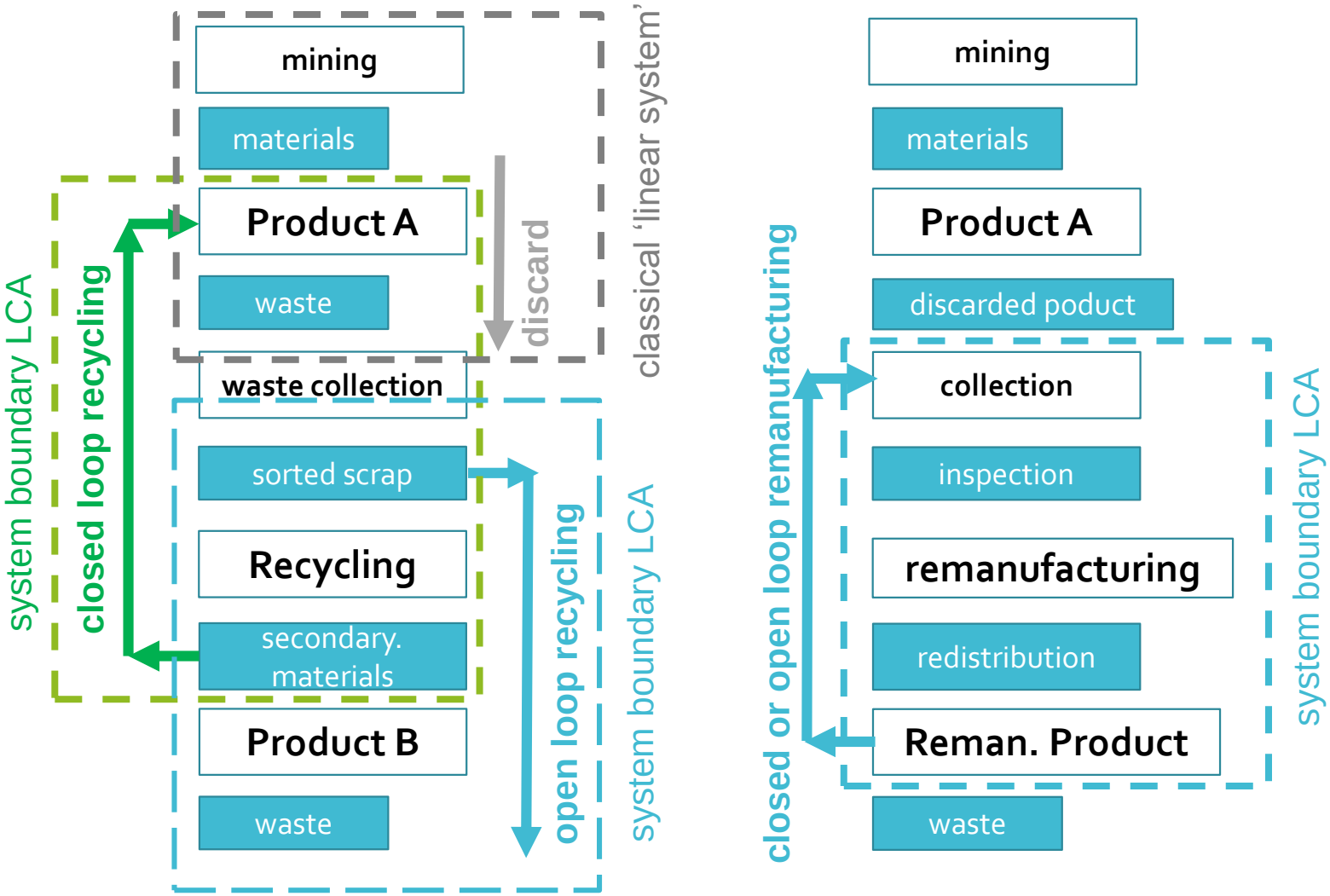


Open loop downcycling (cascading down)



final destination (e.g. under roads)

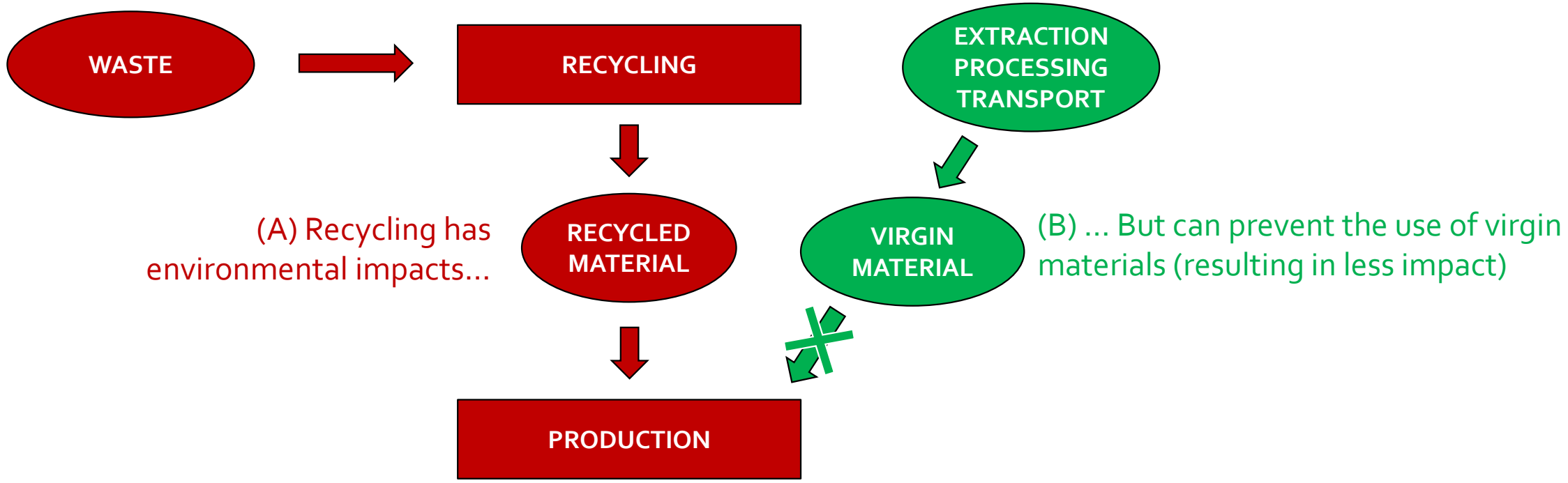
System boundaries and calculation rules in 'Product LCA' :



Calculation rules 'cut-off' and 'attribution' for "Product LCA":

- **Maintenance** is part of the main Life Cycle
- **Reuse** is part of the main Life Cycle: the eco-burden of production is allocated to the subsequent users according the economic value ("economic allocation")
- For **Refurbishing and Remanufacturing** a new Life Cycle is started; part of the ecoburden of the old product is carried over to the new product according economic allocation
- For **open loop upcycling** there is no carry over via the waste of the old product
- **Closed loop upcycling** is part of the main Lyfe Cycle
- **Downcycling** goes from waste to waste (no carry over)

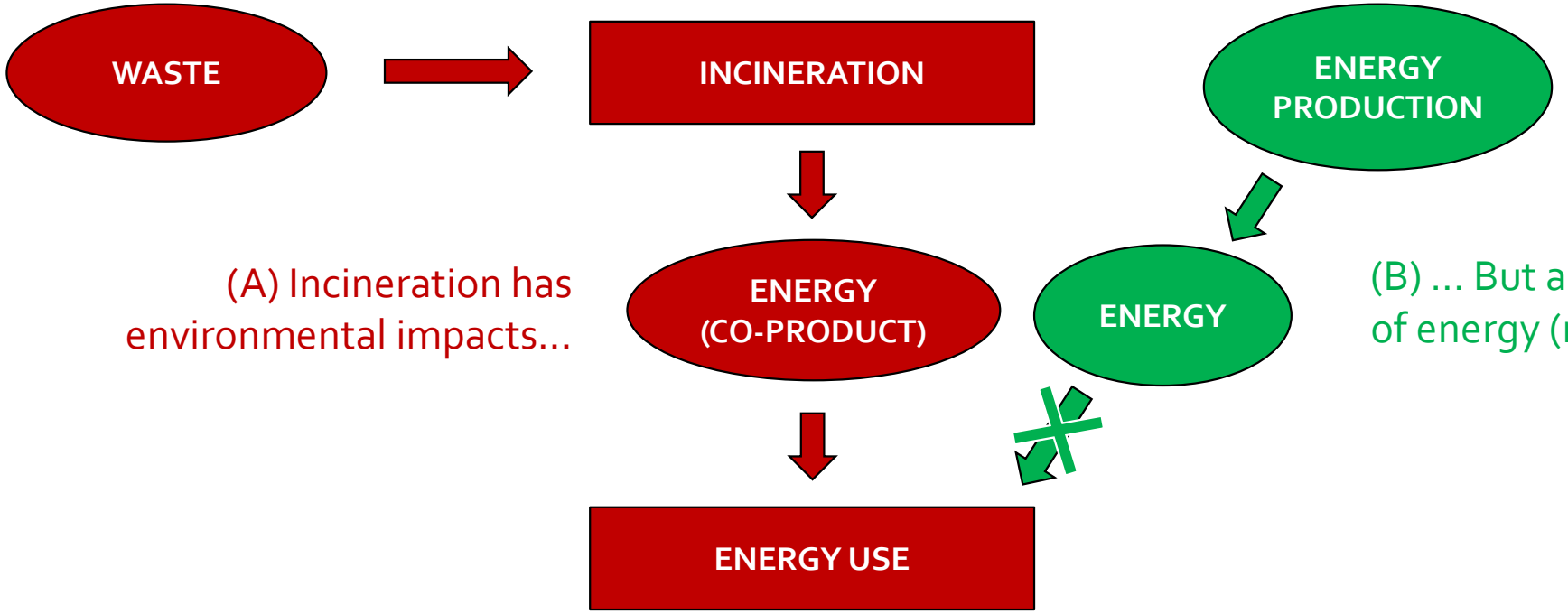
Upcycling in LCA: if the net impact is negative it is called a CREDIT



NET IMPACT = IMPACT (emissions) system A – AVOIDED IMPACT (emissions) system B

For metals the net impact is less (B is more than A), so recycling has a CREDIT

Incineration in LCA : if the net impact is negative it is called a CREDIT



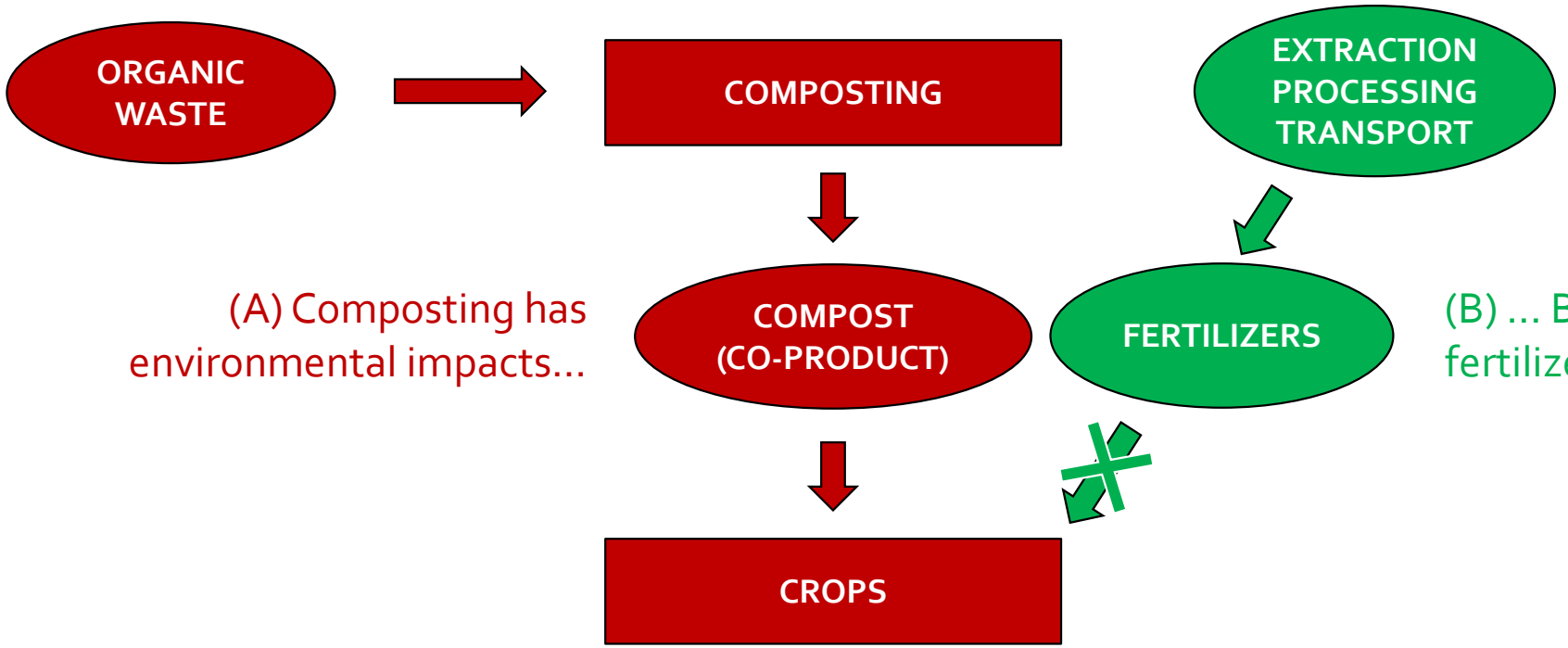
(A) Incineration has environmental impacts…

(B) … But also can prevent the use of energy (resulting in less impact)

NET IMPACT = IMPACT (emissions) system A – AVOIDED IMPACT (emissions) system B

For fossil based plastics the net impact is more, for biobased plastics and wood it is less

Composting of bio-waste in LCA : if the net impact is negative it is called a CREDIT



NET IMPACT = IMPACT (emissions) system A – AVOIDED IMPACT (emissions) system B

For natural products (i.e. agricultural waste) the net impact is less, for biodegradable plastics not

Significance of LCA results

- Identification of **hotspots** (i.e. main contributors to the impact)
- Identification of both **threats and opportunities** in the life cycle of the product or service
- Understanding **tradeoffs** between different life cycle stages
- **Benchmarking:** why design A is better than design B

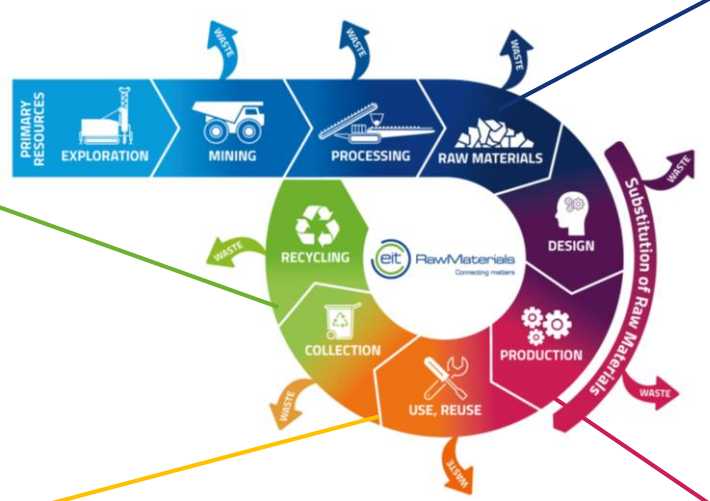
Examples of opportunities

DISPOSAL INTENSIVE

- Products including hazardous materials (difficult to dispose of safely)

USE INTENSIVE

- Electric and electronic equipment (electricity use)
- Products using consumables
- Products requiring intensive maintenance



RAW MATERIALS INTENSIVE

- Consumption of:
  - Virgin metals
  - Energy intensive materials
  - Natural extracts

PRODUCTION INTENSIVE

- Consumption of:
  - Energy
  - Concumer durables
  - Chemicals
  - Waste generation

Time to practice!

Compare a rechargeable battery vs a single use alkaline

You will need: exercise template (Excel file), Idematapp (Excel file), Instructions (PDF file)

Your own exercise: compare a rechargeable battery vs a single use alkaline,

FU: power to a bicycle lighting system (power: 960mWh) for one year (equivalent to 90 hours of lighting).

Tips to save time:

- In LCA benchmarking you can apply “streamlined LCA’, which means that all subsystems which are identical at both sides of the comparison can be neglected
- Be aware that the benefit of metals recycling goes to the next user (so the benefit for the manufacturer of the batteries have EoL = 0), since this case is open loop recycling
- You will experience that electricity for physical assembling can be neglected, as well as the transport in the system.
  Note: this is general, but not for wooden products
- When you cannot find an LCI, apply a ‘surrogate’ product or process, to find out how important it is what you are missing.

A.030.05		**materials, chemicals, inorganic**	eco-costs	carbon footpr	ReCiPe hum	ReCiPe eco	ReCiPe rec
A.030.05.101		kg	Idematapp2019 Boron	2.96	17.65	1.40E-01	8.50E-04	8.95E-01
A.030.05.102		kg	Idematapp2019 CoO2	28.75	5.02	1.50E-05	2.61E-08	1.49E+00
A.030.05.103		kg	Idematapp2019 Graphite for batteries	1.80	8.39	3.25E-02	1.98E-04	3.21E-01
A.030.05.104		kg	Idematapp2019 H2O2, 70% in H2O	0.07	0.53	6.30E-07	1.66E-09	0.073
A.030.05.105		kg	Idematapp2019 KOH	0.27	1.70	1.35E-02	8.19E-05	0.084
A.030.05.106	1	kg	Idematapp2019 Lime	0.12	0.59	5.98E-04	3.63E-06	0.073
A.030.05.107		kg	Idematapp2019 Manganese dioxide	0.48	0.94	-5.14E-03	-3.13E-05	0.144
A.030.05.108		kg	Idematapp2019 Silicon carbide	0.70	5.43	6.20E-06	1.65E-08	0.698
A.030.05.109		kg	Idematapp2019 Sodium silicate	0.04	0.31	3.51E-07	9.37E-10	0.039
A.030.05.110		kg	Idematapp2019 Sulphur	0.09	0.57	1.77E-06	6.73E-09	0.304
A.030.05.111		kg	Idematapp2019 Titanium dioxide	8.53	3.56	2.82E-02	1.71E-04	0.295
A.030.05.112		kg	Idematapp2019 Zinc Oxide	1.60	2.95	6.15E-03	3.74E-05	1.69E-01
A.050.04.119		m2	Idematapp2019 PCB = Printed Circuit Board (including ICs)	77.01	347.18	2.75E+00	1.67E-02	18.072
A.100.03		**materials, metals, ferro**						
A.100.03.101		kg	Idematapp2019 Steel USA	0.37	2.31	3.34E-06	8.36E-09	0.041
A.100.03.102		kg	Idematapp2019 Steel (21% sec = market mix average)	0.37	2.05	3.42E-06	1.14E-08	0.060
A.100.03.103		kg	Idematapp2019 Steel (secondary)	0.12	0.69	5.20E-03	3.16E-05	0.037
A.100.03.104	1	kg	Idematapp2019 Steel beams, pipes, sheet (from market mix 44% recycled)	0.40	2.32	6.72E-03	4.08E-05	0.086
A.100.14		**Materials, metals, non ferro**						
A.100.14.101		kg	Idematapp2019 Aluminium (primary)	2.67	10.08	6.79E-02	4.13E-04	0.571
A.100.14.102		kg	Idematapp2019 Aluminium (secondary)	0.25	1.87	9.57E-06	5.09E-08	0.241
A.100.14.103	1	kg	Idematapp2019 Aluminium trade mix (66% prim 33% sec)	1.84	7.27	4.48E-02	2.73E-04	0.457
A.100.14.104		kg	Idematapp2019 Antimony, CRM (virgin)	11.07	15.86	4.00E-05	7.24E-08	2.023
A.100.14.105		kg	Idematapp2019 Cadmium	17.92	3.30	1.58E-05	6.28E-08	0.220
A.100.14.106		kg	Idematapp2019 Chromium, CRM (virgin)	5.08	26.26	3.87E-05	9.08E-08	3.006
A.100.14.107		kg	Idematapp2019 Cobalt, CRM (virgin)	44.23	7.72	2.31E-05	4.02E-08	2.290
A.100.14.108		kg	Idematapp2019 Copper (primary)	7.61	3.60	7.24E-05	1.34E-07	0.510
A.100.14.109		kg	Idematapp2019 Copper (secondary)	0.30	2.24	9.99E-06	5.21E-08	0.288
A.100.14.110	1	kg	Idematapp2019 Copper wire, plate, pipe, trade mix (56% prim 44% sec)	4.39	3.00	4.50E-05	9.81E-08	0.412
A.100.14.126		kg	Idematapp2019 Nickel (primary)	23.65	79.18	7.43E-05	2.10E-07	6.857
A.100.14.127		kg	Idematapp2019 Nickel (secondary)	0.30	2.24	9.99E-06	5.21E-08	0.288
A.100.14.128		kg	Idematapp2019 Nickel trade mix (70% prim 30% sec)	16.64	56.10	5.50E-05	1.63E-07	4.886
A.100.14.150		kg	Idematapp2019 Zinc (primary)	2.35	3.30	1.58E-05	6.28E-08	0.182
A.100.14.151		kg	Idematapp2019 Zinc (secondary)	0.12	0.76	2.02E-05	1.20E-07	0.098
A.100.14.152	1	kg	Idematapp2019 Zinc trade mix (77% prim 23% sec)	1.84	2.71	1.68E-05	7.59E-08	0.162
A.100.16.113	1	kg	Idematapp2019 CuZn40Pb	3.32	2.86	3.30E-05	8.81E-08	0.308
A.120.01		**Materials, packaging, general**						
A.120.01.101		kg	Idematapp2019 Board and recycled paper (test liner and fluting)	0.073	0.50	1.09E-05	6.49E-08	0.007
A.120.01.102		kg	Idematapp2019 Brown paper (kraft liner), FSC	0.057	0.26	1.30E-05	7.78E-08	0.011
A.120.01.103		m2	Idematapp2019 Brown paper (kraft liner), FSC 70 gr/m2	0.004	0.02	9.10E-07	5.45E-09	0.001
A.120.01.104		kg	Idematapp2019 Brown paper (kraft liner), unsustainable	0.239	1.83	1.45E-05	8.22E-08	0.011
A.120.01.105		kg	Idematapp2019 Molded fiber products	0.052	0.36	7.31E-06	4.33E-08	0.005
A.120.01.106		kg	Idematapp2019 Paper, woodfree uncoated (virgin paper), FSC	0.175	1.21	1.87E-05	1.09E-07	0.156
A.120.01.107		m2	Idematapp2019 Paper, woodfree uncoated (virgin paper), FSC 80 gr/m2	0.014	0.10	1.50E-06	8.74E-09	0.012
A.120.01.108		kg	Idematapp2019 Paper, woodfree uncoated (virgin paper), unsustainable	0.358	2.78	2.02E-05	1.14E-07	0.156
A.120.01.109		m2	Idematapp2019 Printing, flexography with coating	0.065	0.19	7.26E-04	4.42E-06	0.025
A.120.01.110		kg	Idematapp2019 Semichemical fluting, virgin, FSC	0.088	0.50	1.33E-05	7.86E-08	0.011
A.120.01.111		kg	Idematapp2019 Semichemical fluting, virgin, unsustainable	0.270	2.07	1.48E-05	8.30E-08	0.011
A.130.04		**Materials, plastics, Thermoplasts**						
A.130.04.101		kg	Idematapp2019 ABS (Acrylonitrile butadiene styrene)	1.45	3.96	6.74E-06	2.07E-08	0.742
A.130.04.102		kg	Idematapp2019 ABS 30% glass fibre	1.04	2.92	1.39E-04	8.27E-07	0.530
A.130.04.103		kg	Idematapp2019 Ionomer, estimate	1.46	5.14	5.87E-06	1.57E-08	1.118
A.130.04.104		kg	Idematapp2019 PA 6 (Nylon 6, Polyamide 6)	2.02	9.18	1.45E-05	3.99E-08	0.879
A.130.04.105		kg	Idematapp2019 PA 6 GF30	1.44	6.57	1.44E-04	8.41E-07	0.625
A.130.04.106		kg	Idematapp2019 PA 66 (Nylon 66, Polyamide 6-6)	1.99	8.24	1.42E-05	4.23E-08	0.936
A.130.04.121		kg	Idematapp2019 PP (Polypropylene)	1.12	2.04	3.79E-06	1.29E-08	0.601
A.130.04.129		kg	Idematapp2019 PVC (Polyvinylchloride bulk polymerised)	0.71	2.33	4.34E-06	1.36E-08	0.254
A.130.04.130		kg	Idematapp2019 PVC (Polyvinylchloride emulsion polymerised)	0.80	2.57	4.87E-06	1.82E-08	0.471
A.130.04.131		kg	Idematapp2019 PVC (Polyvinylchloride suspension polymerised)	0.69	2.00	3.91E-06	1.50E-08	0.426

Your own exercise on LCA benchmarking: compare a rechargeable battery vs a single use alkaline.

to be discussied							
life time		eco-costs	carbon footprint	ReCiPe hum	ReCiPe ecotox	ReCiPe resources
1 year	54 single use batteries	1.18	3.71	6.30E-03	3.83E-05	2.04E-01
1 year	2 rechargebles+ charger	2.03	2.70	4.37E-05	2.25E-07	3.47E-01
2 year	2 rechargebles+ charger	1.43	1.87	3.87E-05	2.13E-07	2.17E-01
3 year	2 rechargebles+ charger	1.23	1.59	3.70E-05	2.09E-07	1.74E-01
4 years	2 rechargebles+ charger	1.13	1.45	3.62E-05	2.07E-07	1.53E-01

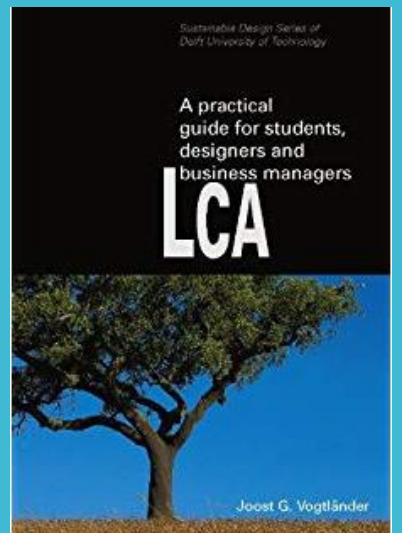
DISCUSSION

INNOMAT

LEARNING & TRAINING PACKAGES

LCA PRACTICAL GUIDE

You may read for additional information:



project:
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eit RawMaterials ACADEMY

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