INNOMAT

LEARNING & TRAINING PACKAGES

Module 1: Life Cycle Assessment

Block 1: Introduction

- Block 1:
  - Introduction to LCA
  - Goal and scope
- Block 2
  - Inventory analysis
  - Impact assessment
- Block 3
  - cradle-to-cradle
  - opportunities
- Examples

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eit RawMaterials ACADEMY

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We start with a personal question about your buying behaviour:

Suppose you need a new pair of trousers, blue jeans.
In the shop and you see two Diesel jeans. Both they have:

- ✓ the same cut, and the same colour
- ✓ the same the fabric, with the same feel and touch
- ✓ and suppose the quality is the same

One of the two has a green sticker with a green statement.

Question 1. Suppose that you believe Diesel, and suppose that both pair of jeans have the same price. Who of you will buy the jeans with the green sticker?

Question 2. 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 do honest)

Question 3. Suppose the green jeans costs 90 euro. Who of you will still buy the jeans with the green sticker?

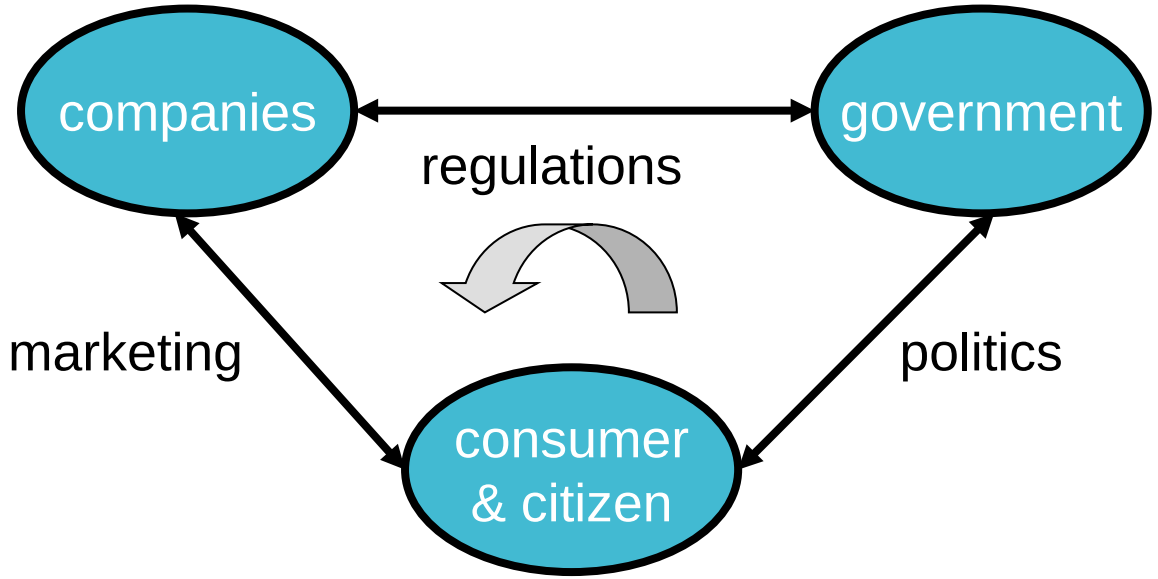
Content of this training package

- **Module 1: LCA**
  Introduction (Block 1)
  Calculation structure and tools (Block 2)
  LCA in circular business systems (Block 3)
- **Module 2: material scarcity in LCA**
- **Module 3: creating circular business models**
- **Module 4: eco-efficient value creation in product innovation**

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’

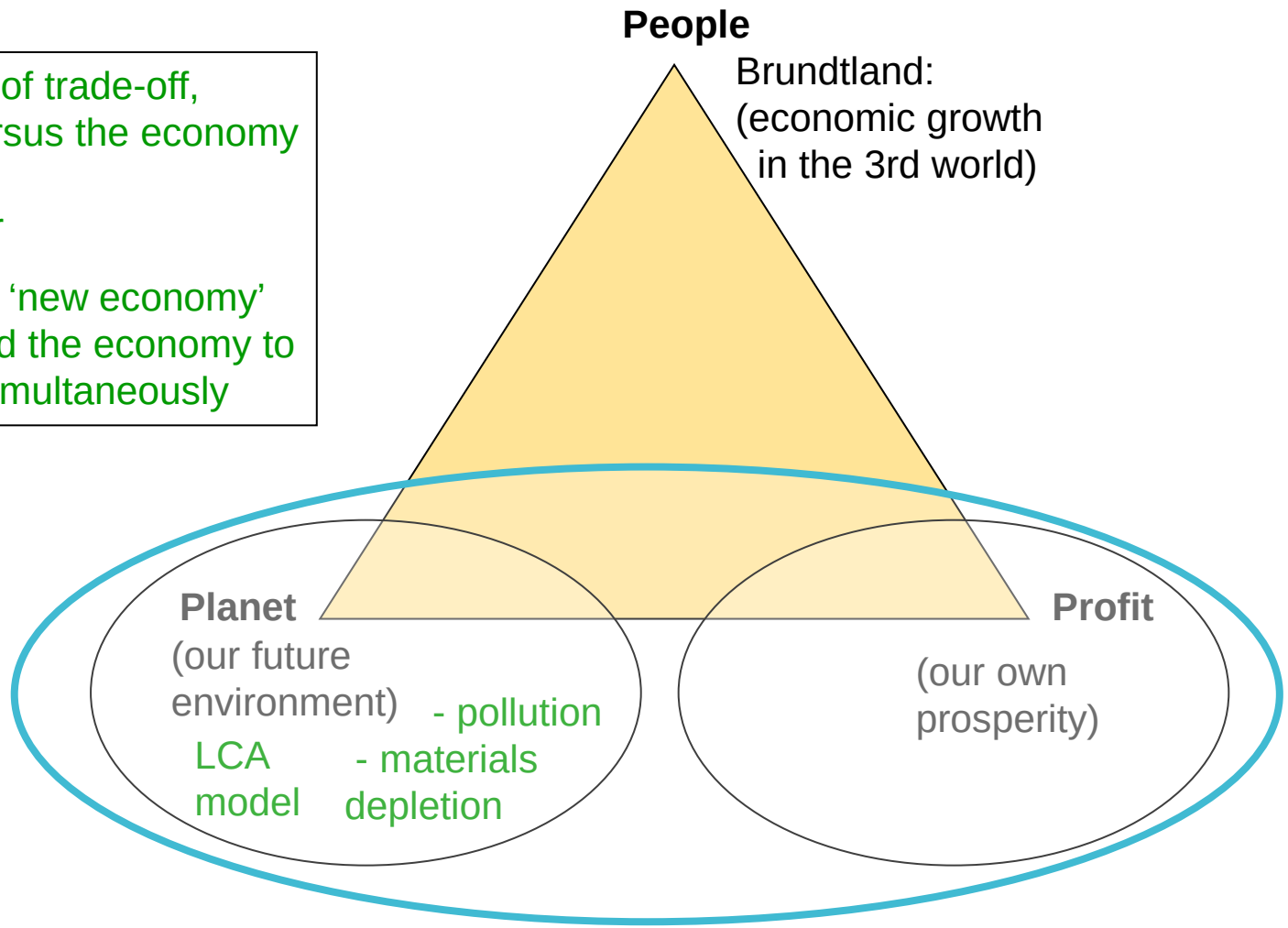
Source: Vogtlander J.G. et al. 2014. Eco-efficient Value Creation, Second edition, Delft Academic Press

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

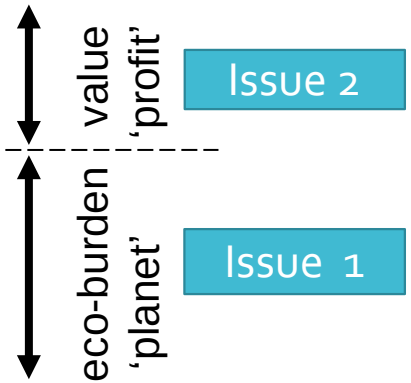
- Brundtland (1987) looked at the relationship between the poor environmental situation and poverty in 3rd world countries
- Elkington (1994) looked at business strategies, and proposed a more balanced trade-off in business:
  - saving our **planet,**
  - care for **people** :a better distribution of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

The business challenge of Sustainability

"What we need now is a new era of economic growth – growth that is forceful and at the same time socially and environmentally sustainable."
(Brundtland, 1987)

Issue 2

"The delivery of competitively priced goods and services that satisfy human needs and bring 'quality of life',
while progressively reducing ecological impacts and resource intensity, throughout the lifecycle, to a level at least in line with the earth's estimated carrying capacity" (WBCSD, 1995)



Issue 2

Issue 1

Our Innomat training course will deal with two issues:

- **Module 1 and 2:**
  what is the environmental impact of our products and services, i.e.
  Life Cycle Assessment, LCA
- **Module 3 and 4:**
  how do we create a business that combines profitability with reduced environmental impact, i.e.
  circular business models and eco-efficient value creation

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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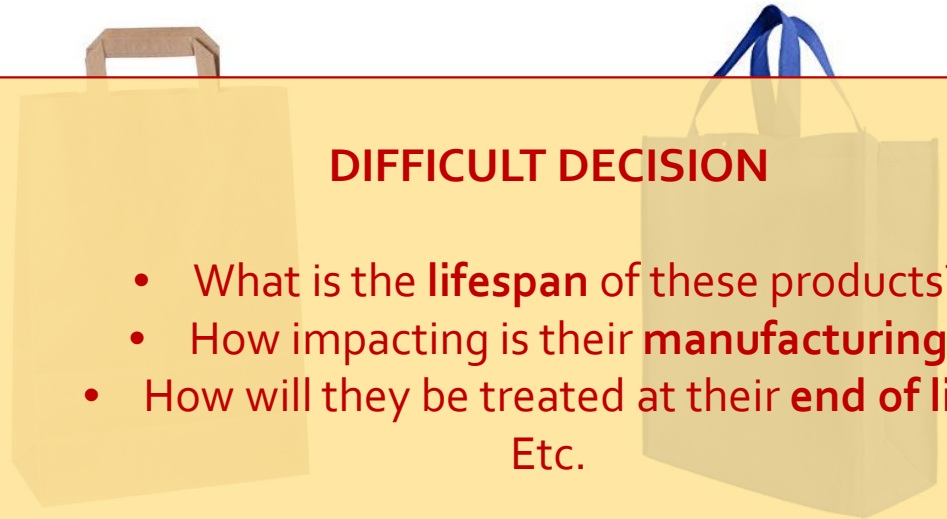


DIFFICULT DECISION

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

Etc.

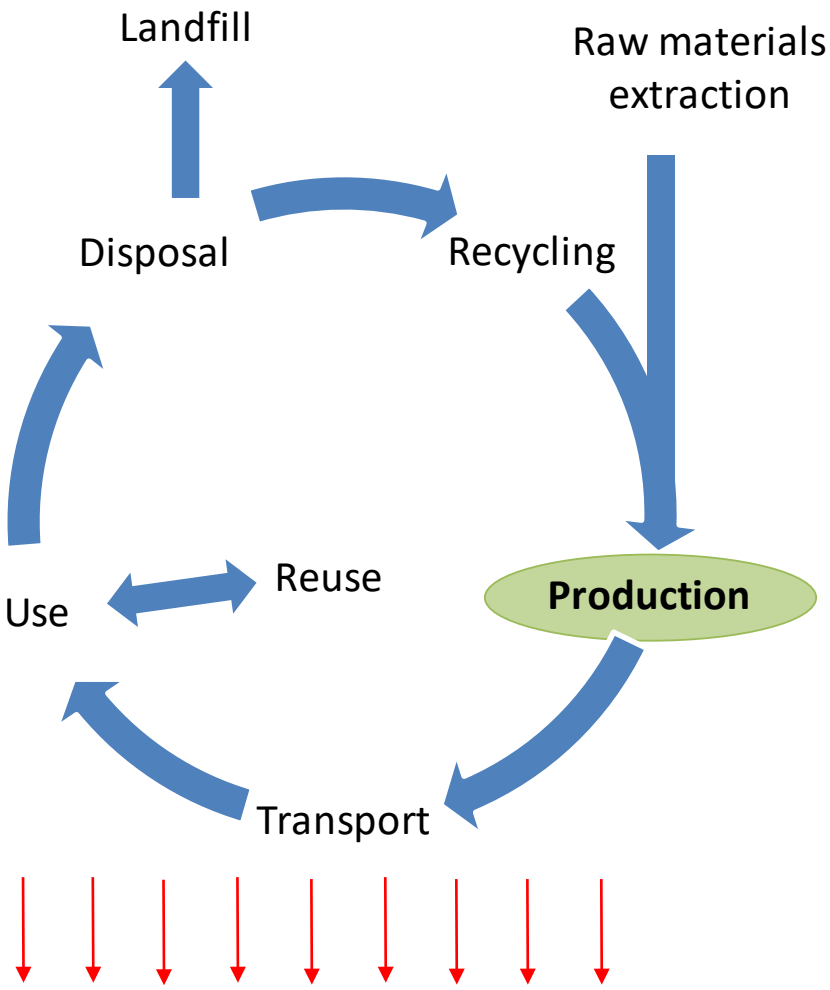
Paper bag

Reusable plastic bag

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

What is Life Cycle Assessment – LCA ?

"LCA is a technique that is used to quantify the environmental impact 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 required **resources** 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?

1a. Product comparison

Examples:

- Alkaline battery vs rechargeable battery?
- Fossil vs bio-based plastic?
- Concrete vs wood?
- Electricity from the grid versus electricity from PV cells

1b. Comparison of services

- Transport by train versus airplane
- Carsharing versus ownership versus bike
- Centralized wastewater treatment versus decentralized wastewater treatment

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: the blade and handle*
- *Use phase varies: maintenance (handwashing vs. dishwasher)*

Design strategy example

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

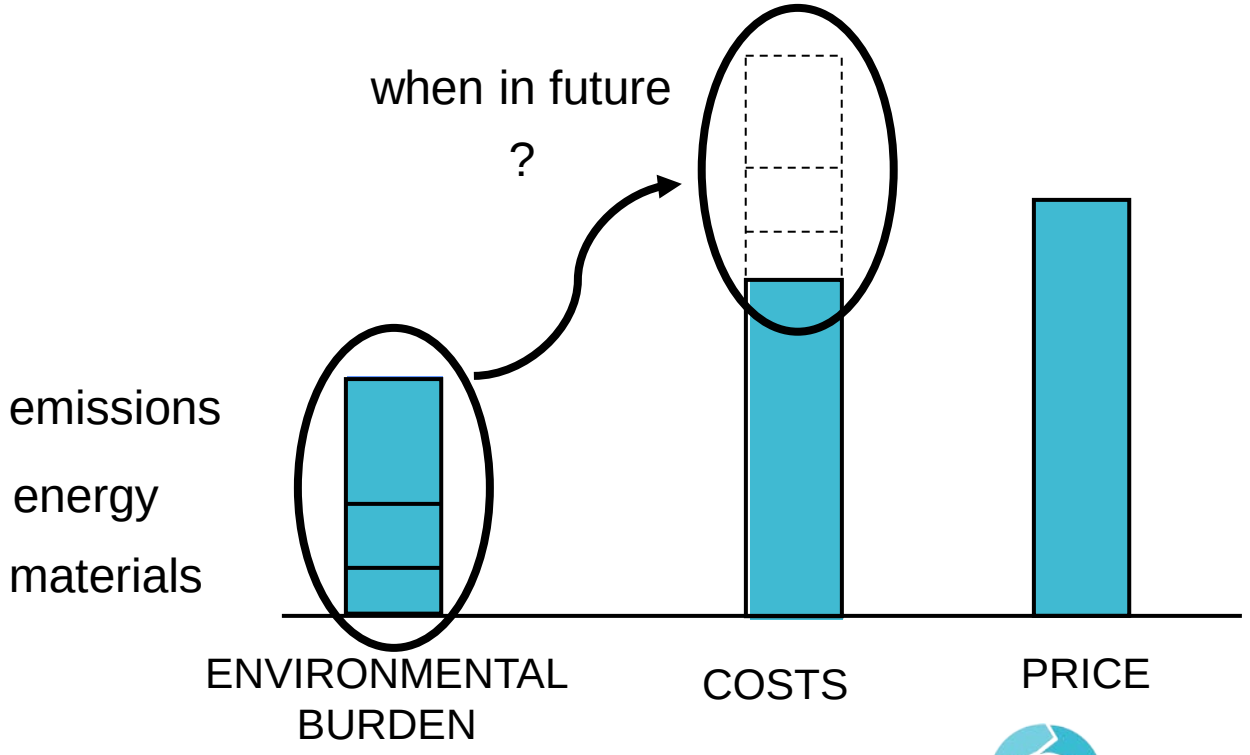
What is Life Cycle Assessment used for?

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 will happen is quite certain



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

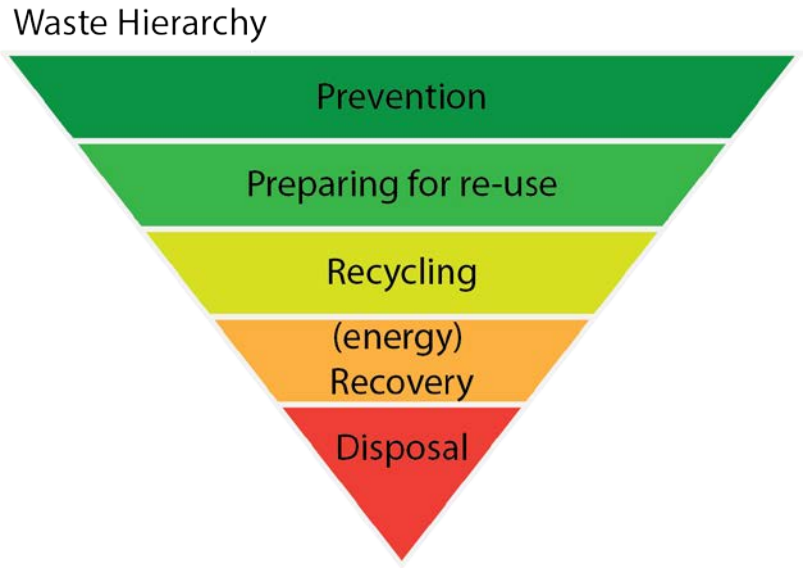
What is Life Cycle Assessment used for?

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?

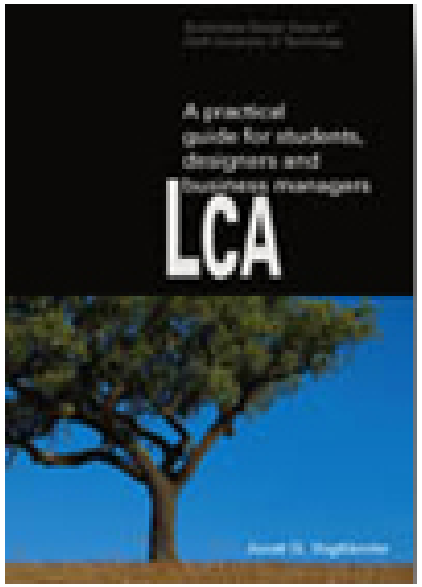
1. Product comparison
2. Product design and improvement
3. Ecolabelling
4. Strategic planning
5. Policy usage
6. **Comparison of alternative treatment processes of waste materials, wastewater etc.**

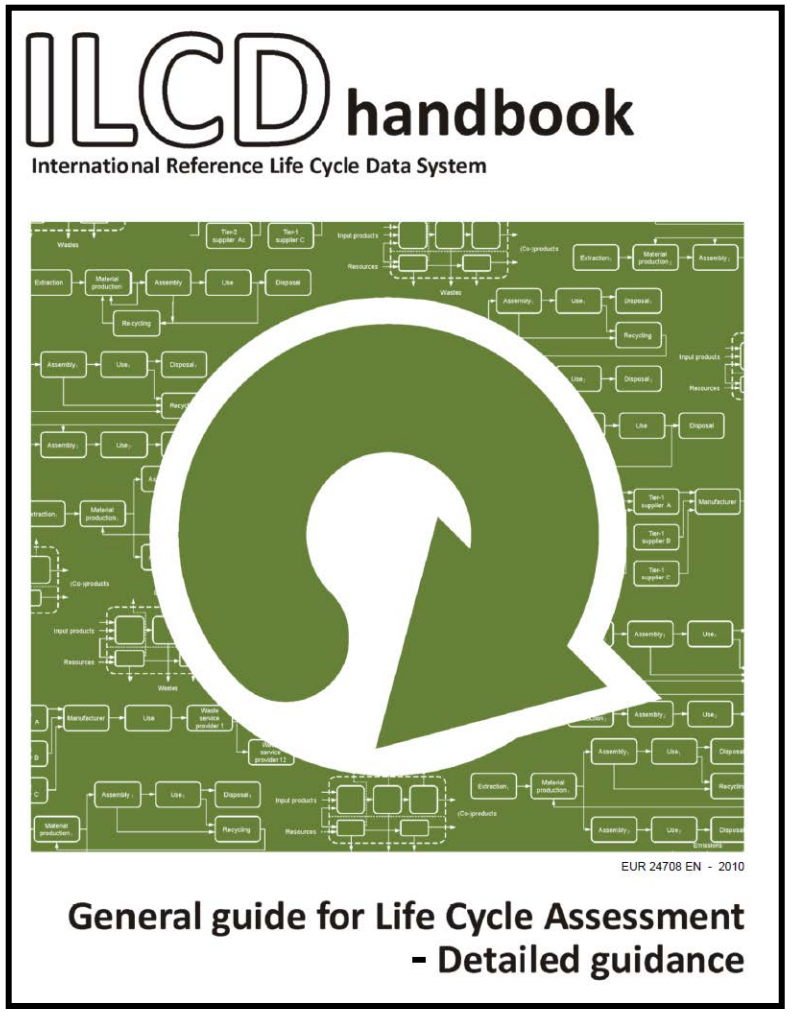


Life Cycle Assessment is well specified:

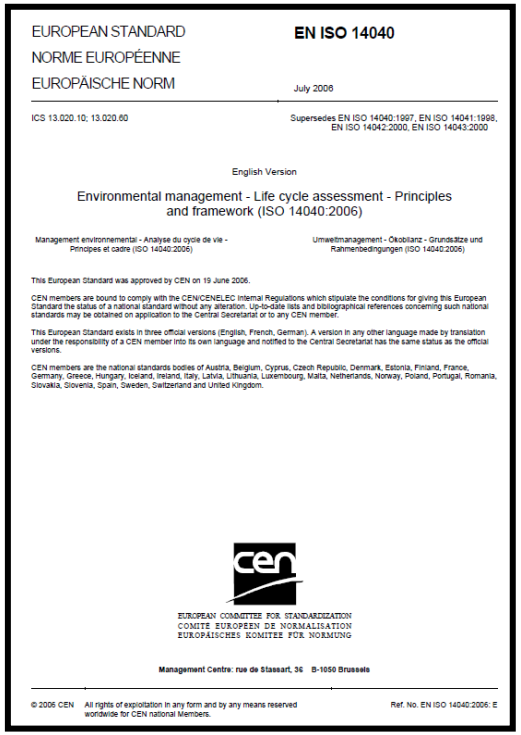
- Norms and definitions
- Scientific papers
- Handbooks
- Databases

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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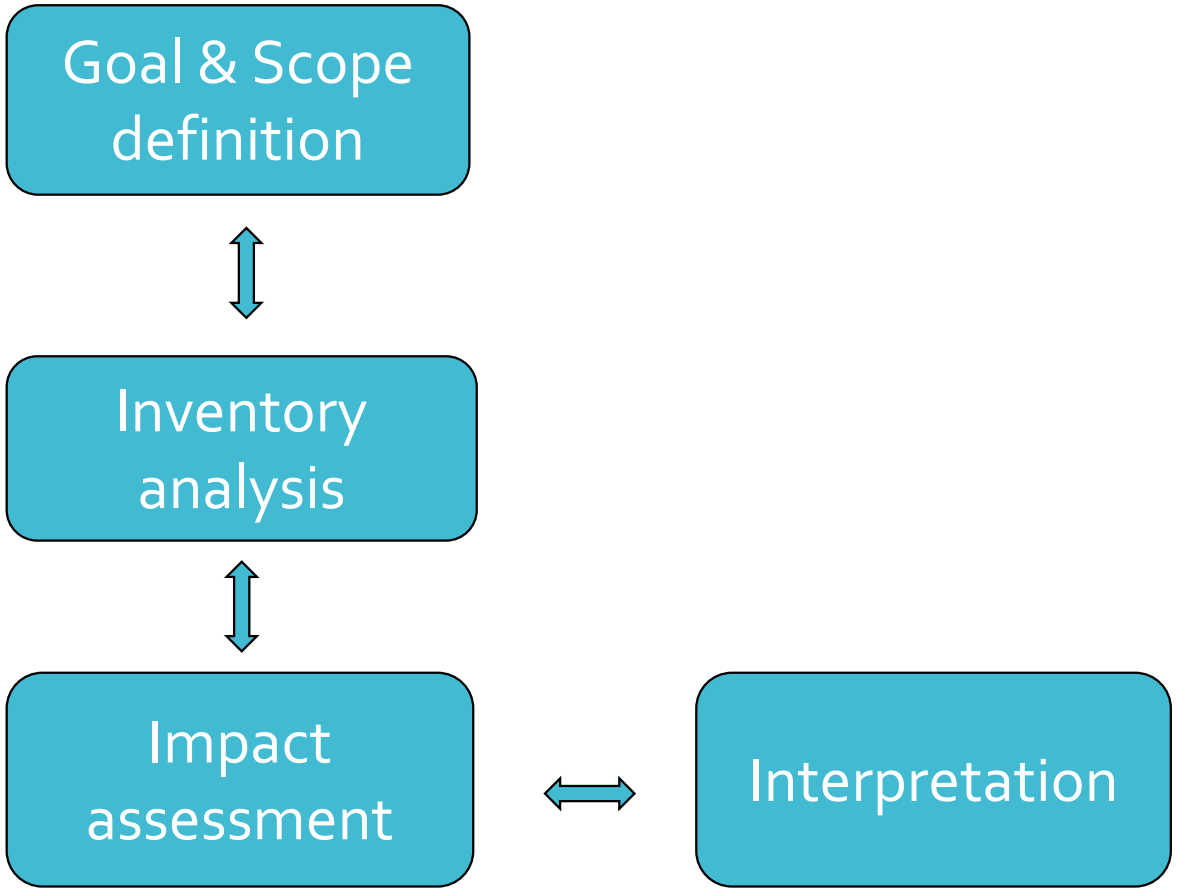
EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN ISO 14040:2006: E

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:

- *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)*
- *Supply of 100.000 lumen lighting for one year (= 90h)*
- *Transport from A to B*
- *Production of 1 kg steel (is called 'declared unit')*

System description and system boundaries of an LCA for a product or service

MATERIALS. ENERGY

PRODUCT or SERVICE

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 %)

The first assignment:
Discover the differences between the carbon footprint of materials like steel, plastics, bioplastics, and wood by using the IDEMAT app (in IOS or Android)

(stop the video, do the assignment, and after that, continue with the video)

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Module 1: Life Cycle Assessment

Block 2: calculation system and tools

- Block 1:
  - Introduction to LCA
  - Goal and scope
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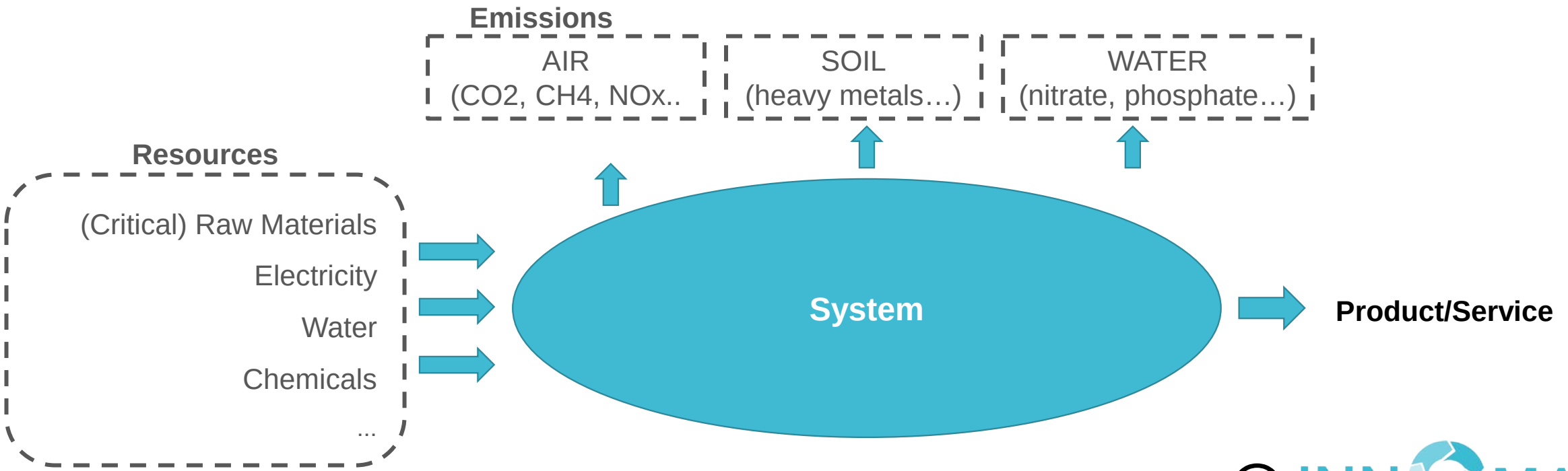
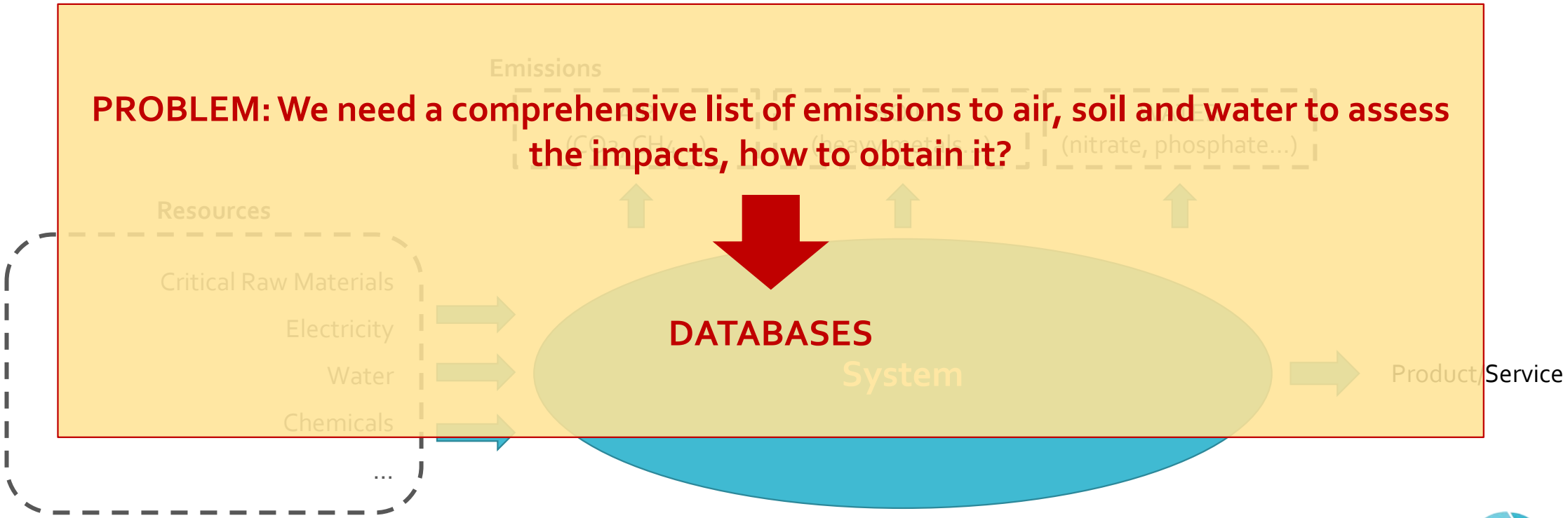
Creating the Life Cycle Inventory (LCI)

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



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

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

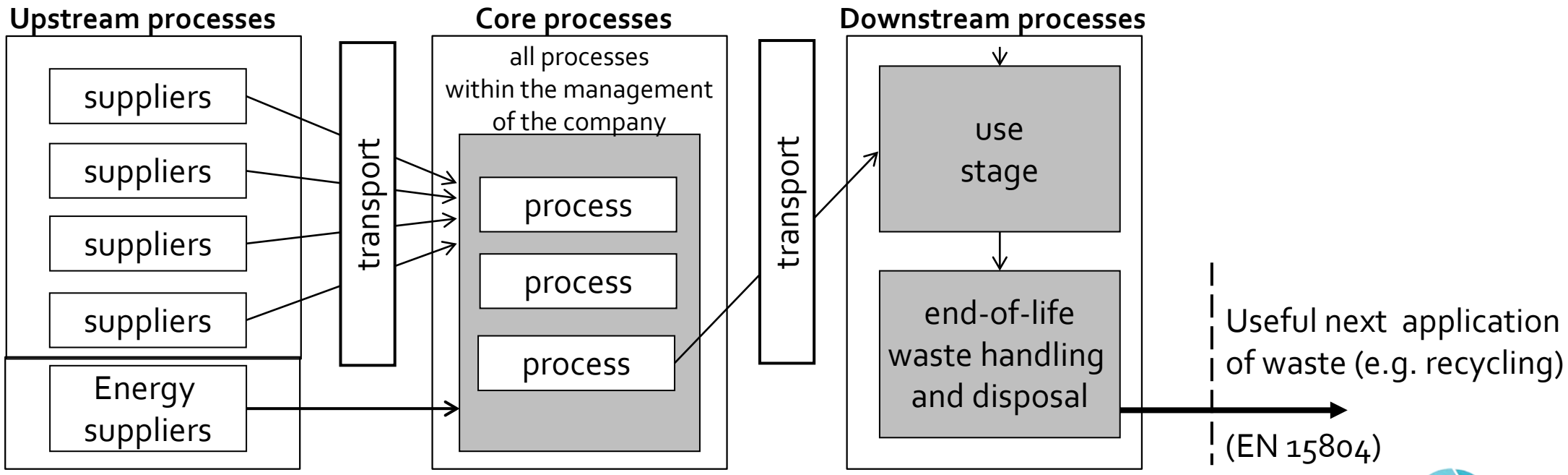


The foreground system and background systems, a practical consideration

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
- Materials mining
- Emissions of transportation
- Emissions of electricity generation

DATABASES WITH ENVIRONMENTAL INFORMATION

Ecoinvent database

Agri-footprint database

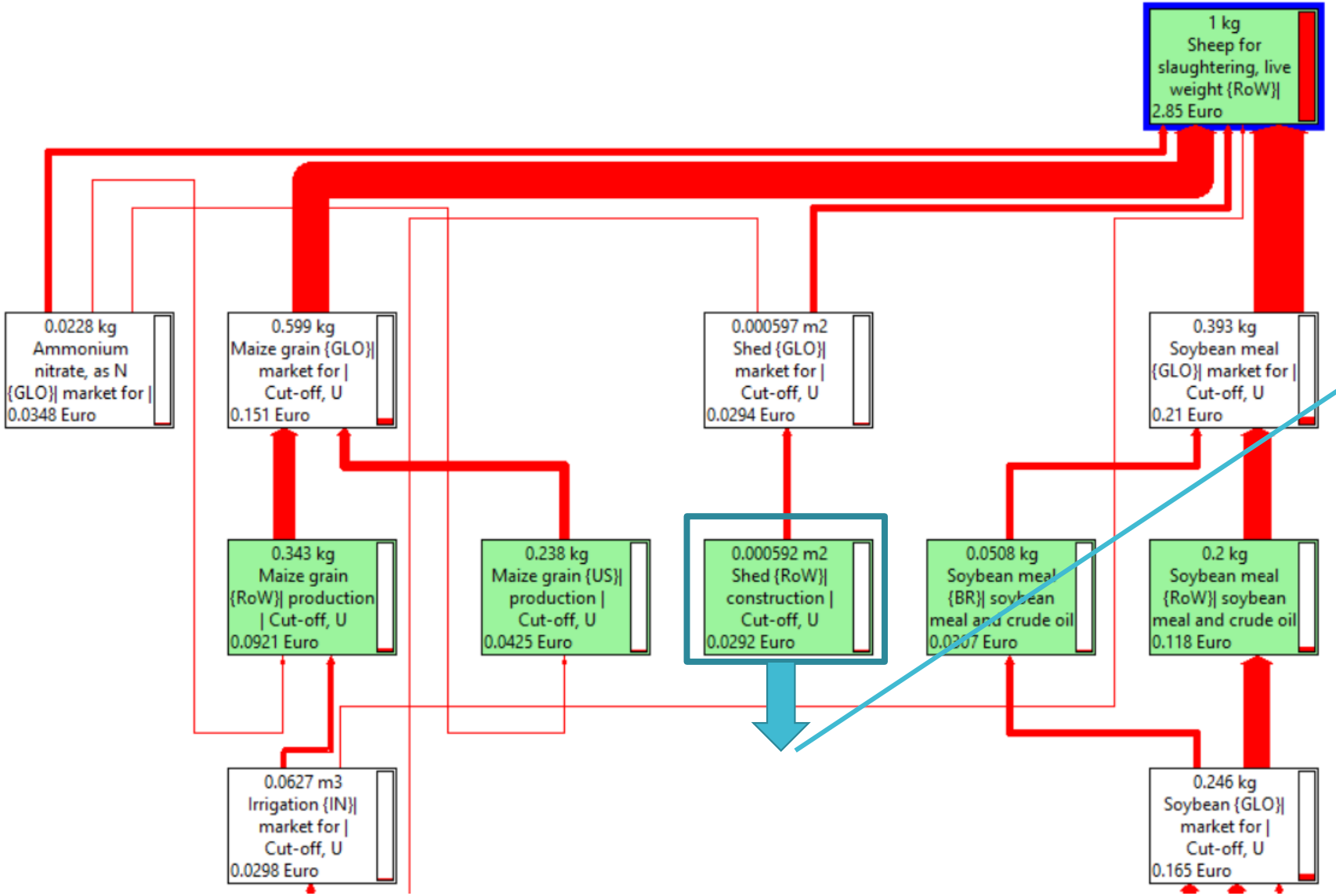
thinkstep GaBi

TU Delft Delft University of Technology

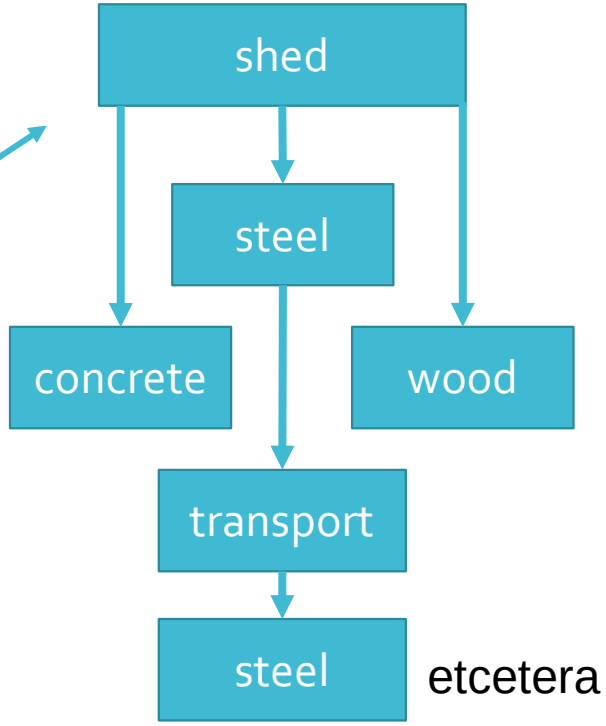
↓ data on effects of toxicity and scarcity

↓ 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	13.343
2	1-Butanol	Water	ng	142.58
3	1-Pentanol	Air	pg	169.57
4	1-Pentanol	Water	[illegible]	[illegible]
5	1-Pentene	Air	pg	128.14
6	1-Pentene	Water	pg	3.7933
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	75.46
719	Zirconium-95	Water	µBq	10.974

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)

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

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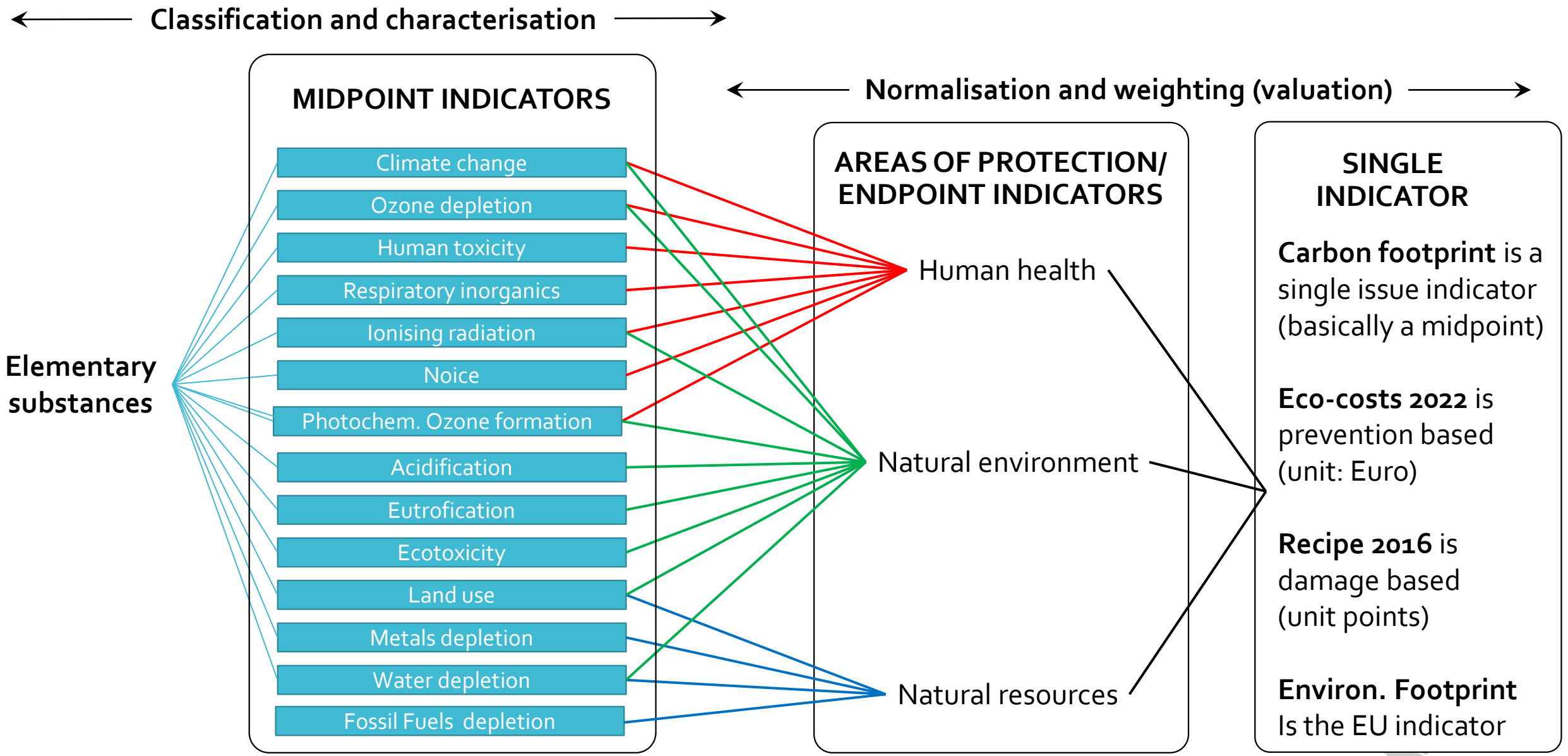
4	1-Pentanol	Water	pg	406.96
5	1-Pentene	Air	pg	128.14
6	1-Pentene	Water	pg	307.53
7	1-Propanol	Air	ng	11.545
8	1-Propanol	Water	pg	625.24
...				
714	Zinc-65	Air	nBq	384.12
715	Zinc-65	Water	nBq	947.68
716	Zirconium	Raw	µg	1.8466
717	Zirconium	Air	µg	14.051
718	Zirconium-95	Air	nBq	375.46
719	Zirconium-95	Water	µBq	10.974

SOLUTION = creating a "single indicator"

There are 3 types of single indicator systems:

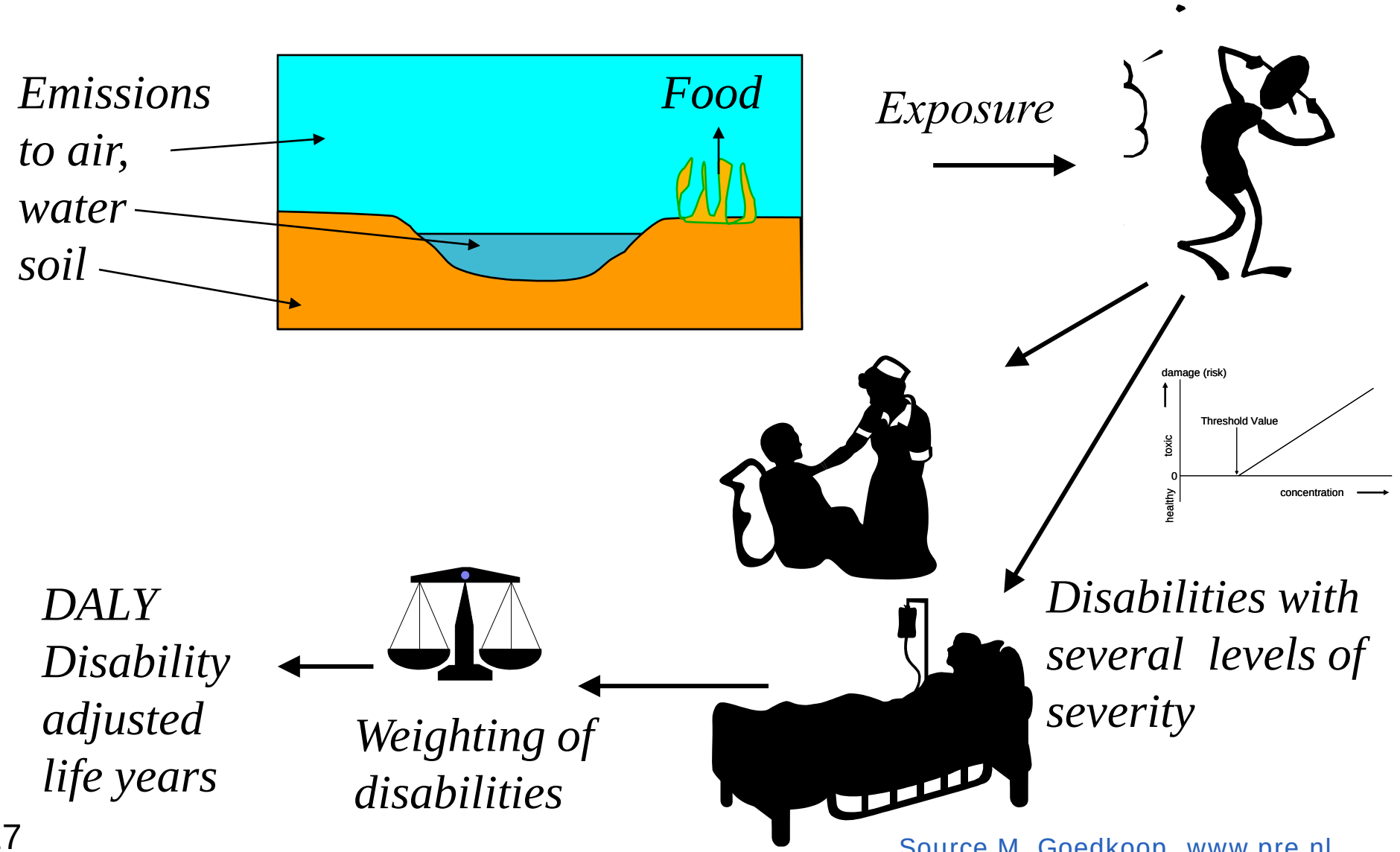
- based on 1 "single issue" the Carbon Footprint (CO_2)
- based on damage the Ecoindicator 99 / Recipe 2016
- based on prevention costs the Eco-costs 2017


Classification and characterisation
MIDPOINT INDICATORS
Normalisation and weighting (valuation)
AREAS OF PROTECTION/ ENDPOINT INDICATORS
SINGLE INDICATOR
Elementary substances
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
Human health
Natural environment
Natural resources
Carbon footprint is a single issue indicator (basically a midpoint)
Eco-costs 2022 is prevention based (unit: Euro)
Recipe 2016 is damage based (unit points)
Environ. Footprint Is the EU indicator

MIDPOINT vs ENDPOINT

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

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



Source M. Goedkoop, www.pre.nl

H245 | to ec-costs (€)

	A	B	C	D	E	F	G	H	I	J
111	111			**colour code:**		greenhouse			fine dust	
112	112					acidification			ecotoxicity	
113	113					eutrification			human toxicity, carcinoge	
114	114					summer smog				
115	115								**eco-costs (euro/kg)**	
118										
243	240	Air	(unspecified)	HFE-43-10pccc124 (H-Galden1040x)		2.82E+03	kg CO2 eq / kg	**multiplier**	327.120	
244	241	Air	(unspecified)	HG-02		2.73E+03	kg CO2 eq / kg	**from kg CO2e**	316.680	
245	242	Air	(unspecified)	HG-03		2.85E+03	kg CO2 eq / kg	**to ec-costs (€)**	330.600	
246	243	Air	(unspecified)	kg CO2 eq		1.00E+00	kg CO2 eq / kg	**0.116**	0.116	
247	**244**	**Air**	**(unspecified)**	**Methane**	**000074-82-8**	**3.05E+01**	**kg CO2 eq / kg**		**3.538**	
248	245	Air	(unspecified)	Methane, (difluoromethoxy)((difluoromethoxy)difluorom	249932-25-0	5.30E+03	kg CO2 eq / kg		614.800	
249	**246**	**Air**	**(unspecified)**	**Methane, biogenic**	**000074-82-8**	**2.78E+01**	**kg CO2 eq / kg**		**3.219**	
250	247	Air	(unspecified)	Methane, bromo-, Halon 1001	000074-83-9	2.00E+00	kg CO2 eq / kg		0.232	
251	248	Air	(unspecified)	Methane, bromochlorodifluoro-, Halon 1211	000353-59-3	1.75E+03	kg CO2 eq / kg		203.00	
252	249	Air	(unspecified)	Methane, bromodifluoro-, Halon 1201	001511-62-2	3.76E+02	kg CO2 eq / kg		43	
253	250	Air	(unspecified)	Methane, bromotrifluoro-, Halon 1301	000075-63-8	6.29E+03	kg CO2 eq / kg		72 640	
254	251	Air	(unspecified)	Methane, chlorodifluoro-, HCFC-22	000075-45-6	1.76E+03	kg CO2 eq / kg		04.160	
255	252	Air	(unspecified)	Methane, chlorotrifluoro-, CFC-13	000075-72-9	1.39E+04	kg CO2 eq / kg		612.400	
256	253	Air	(unspecified)	Methane, dibromo-	000074-95-3	1.00E+00	kg CO2 eq / kg		0.116	
257	254	Air	(unspecified)	Methane, dibromodifluoro-, Halon 1202	000075-61-6	2.31E+02	kg CO2 eq / kg		26.796	
258	255	Air	(unspecified)	Methane, dichloro-, HCC-30	000075-09-2	9.00E+00	kg CO2 eq / kg		1.044	
259	256	Air	(unspecified)	Methane, dichlorodifluoro-, CFC-12	000075-71-8	1.02E+04	kg CO2 eq / kg		1183.200	
260	257	Air	(unspecified)	Methane, dichlorofluoro-, HCFC-21	000075-43-4	1.48E+02	kg CO2 eq / kg		17.168	
261	258	Air	(unspecified)	Methane, difluoro-, HFC-32	000075-10-5	6.77E+02	kg CO2 eq / kg		78.532	
262	259	Air	(unspecified)	Methane, difluoro(fluoromethoxy)-	000461-63-2	6.17E+02	kg CO2 eq / kg		71.572	
263	260	Air	(unspecified)	Methane, difluoro(methoxy)-	000359-15-9	1.44E+02	kg CO2 eq / kg		16.704	
264	261	Air	(unspecified)	Methane, fluoro-, HFC-41	000593-53-3	1.16E+02	kg CO2 eq / kg		13.456	
265	262	Air	(unspecified)	Methane, fluoro(fluoromethoxy)-	000462-51-1	1.30E+02	kg CO2 eq / kg		15.080	
266	263	Air	(unspecified)	Methane, fluoro(methoxy)-	000460-22-0	1.30E+01	kg CO2 eq / kg		1.508	
267	**264**	**Air**	**(unspecified)**	**Methane, fossil**	**000074-82-8**	**3.05E+01**	**kg CO2 eq / kg**		**3.538**	
268	265	Air	(unspecified)	Methane, land transformation	000074-82-8	3.05E+01	kg CO2 eq / kg		3.538	
269	266	Air	(unspecified)	Methane, monochloro-, R-40	000074-87-3	1.20E+01	kg CO2 eq / kg		1.392	
270	267	Air	(unspecified)	Methane, tetrachloro-, CFC-10	000056-23-5	1.73E+03	kg CO2 eq / kg		200.680	
271	268	Air	(unspecified)	Methane, tetrafluoro-, CFC-14	000075-73-0	6.63E+03	kg CO2 eq / kg		769.080	

Introduction | materials depletion | materials list in Simap 2017 | **ecocosts emissions 2017** | acidification country list | water scarcity | land-use | fair wage d

Gereed

Tables in practice:

<u>Midpoint characterisation factors</u> of climate change: (over a period of 100 years)

1 kg of fossil CH4 has 30.5 x the impact of CO2, eco-costs = 3.54 (€/kg)

1 kg of biogenic CH4 has 27.8 x the impact of CO2 eco-costs = 3.22 (€/kg)

Note that 1 kg CO2e = 0.116 (€)

URL: www.ecocostsvalue.com tab data
Table: Idematapp2020

S3 | Sources of LCI:

			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	Environm. Footprint	
		unit		euro	euro	euro	euro	euro	kg CO2 equiv.	MJ	DALY	H species.year	H USD2013	Total Pt	Sources of LCI:
307	A.100.13.104	kg	Idematapp2020 67SiCr5	0.43	0.03	0.04	0.08	0.28	2.37	29.80	3.49E-06	1.04E-08	0.099	0.000269	Delft University of Technology, base ma
308															
309	A.100.14	Materials, metals, non ferro													
310	A.100.14.101	kg	Idematapp2020 Aluminium (primary)	2.61	0.15	0.46	1.17	0.84	7.27	142.9	2.60E-05	9.38E-08	0.465	0.001057	LCA update study from Intern Aluminiu
311	A.100.14.102	kg	Idematapp2020 Aluminium (secondary)	0.36	0.03	0.03	0.01	0.29	2.53	46.06	6.22E-06	2.80E-08	0.326	0.000511	energy from Univ of Bath
312	A.100.14.103	1 kg	Idematapp2020 Aluminium trade mix (66% prim 33% sec)	1.84	0.10	0.31	0.77	0.65	5.63	109.52	1.92E-05	7.11E-08	0.415	0.000866	Delft University of Technology, base ma
313	A.100.14.104	kg	Idematapp2020 Antimony, CRM (virgin)	11.36	0.40	1.19	7.93	1.84	15.86	205.37					
314	A.100.14.105	kg	Idematapp2020 Cadmium	17.79		0.22	17.03	0.38	3.30	41.78					
315	A.100.14.106	kg	Idematapp2020 Chromium, CRM (virgin)	5.71	0.39	0.74	1.53	3.05	26.26	502.32					
316	A.100.14.107	kg	Idematapp2020 Cobalt, CRM (virgin)	44.42	0.13		42.55	0.90	7.72	107.64					
317	A.100.14.108	kg	Idematapp2020 Copper (primary)	8.82	0.86	3.81	3.73	0.42	3.60	50.13					
318	A.100.14.109	kg	Idematapp2020 Copper (secondary)	0.32	0.02	0.03		0.26	2.24	40.71					
319	A.100.14.110	1 kg	Idematapp2020 Copper wire, plate, pipe, trade mix (56% prim 44% sec)	5.08	0.49	2.14	2.09	0.35	3.00	45.99					
320	A.100.14.111	kg	Idematapp2020 Gallium, CRM (virgin)	148.75	3.49	6.06	117.62		186.08	2,843.36					
321	A.100.14.112	kg	Idematapp2020 Gold (primary)	29,277.30	672.	2,619.80	23,908.08	2,076.76	17,903.08	274,800.34					
322	A.100.14.113	kg	Idematapp2020 Gold (secondary)	84.27	6.40	15.05	16.52	46.10		7,676.31					
323	A.100.14.114	kg	Idematapp2020 Gold trade mix (47% prim 53% sec)	13,804.99	319.54	1,23	11,245.55	1,000.51	8,625.0	133,224.61					
324	A.100.14.115	kg	Idematapp2020 Indium, CRM (virgin)	669.39	6.74	16.93	628.42	17.31	149.20						
325	A.100.14.116	kg	Idematapp2020 Lead (primary)	2.05	0.06	0.32		0.22	1.89	25.0					
326	A.100.14.117	kg	Idematapp2020 Lead (secondary)	0.09	0.01	0.01	0.01	0.07	0.60	10.88					
327	A.100.14.118	1 kg	Idematapp2020 Lead trade mix (25% prim 75% sec)	0.58	0.02	0.09	0.37		0.92	14.57					
328	A.100.14.119	kg	Idematapp2020 Lithium	7.83	0.17	0.57	4.96	2.13	18.34	2,078.39					
329	A.100.14.120	kg	Idematapp2020 Magnesium, CRM (primary)	9.22	0.06	0.23	0.45	8.48		150.48					
330	A.100.14.121	kg	Idematapp2020 Magnesium, CRM (secondary)	1.03	0.12	0.36	0.00	0.55	4.74	61.36					
331	A.100.14.122	kg	Idematapp2020 Magnesium, CRM, trade mix (57% prim 43% sec)	5.69	0.09	0.28	0.26	5.07	43.71						
332	A.100.14.123	kg	Idematapp2020 Manganese	1.02	0.04	0.15	0.54	0.29	2.53	49.55					
333	A.100.14.124	kg	Idematapp2020 Mercury (primary)	1,642.39	1,586.55	6.95	35.50	13.38	115.36	1,704.22					
334	A.100.14.125	kg	Idematapp2020 Molybdenum	49.08	0.50	2.16	45.43	1.00	8.63	154.41					
335	A.100.14.126	kg	Idematapp2020 Nickel (primary)	24.83	0.74	3.04	11.86	9.18	79.18	641.91					
336	A.100.14.127	kg	Idematapp2020 Nickel (secondary)	0.32	0.02	0.03	0.01	0.26	2.24	40.71					
337	A.100.14.128	kg	Idematapp2020 Nickel trade mix (70% prim 30% sec)	17.48	0.53	2.13	8.31	6.51	56.10	461.55					
338	A.100.14.129	kg	Idematapp2020 Palladium, CRM (primary)	93,419.84	9,323.37	74,882.59	8,130.95	1,082.93	9,335.64	114,965.91					
339	A.100.14.130	kg	Idematapp2020 Palladium, CRM (secondary)	36.64	2.78	6.54	7.18	20.05	172.82						
340	A.100.14.131	kg	Idematapp2020 Palladium, CRM, trade mix (97% prim 3% sec)	90,618.35	9,043.76	72,636.30	7,887.24	1,051.05	9,06	111,617.07					
341	A.100.14.132	kg	Idematapp2020 Platinum, CRM (primary)	135,359.43	13,873.57	111,426.92	8,447.51	1,611.43	13,691.60	223,206.87					
342	A.100.14.133	kg	Idematapp2020 Platinum, CRM (secondary)	129.40	9.83	23.11	25.36		610.27	11,786.85					
343	A.100.14.134	kg	Idematapp2020 Platinum, CRM, trade mix (95% prim 5% sec)	128,597.92	13,180.38	105,856.73	8,026.4	1,534.39	13,227.54	212,635.87					
344	A.100.14.135	kg	Idematapp2020 Rhodium, CRM (primary)	286,867.03	30,394.45	244,118.71	524.24	3,529.63	30,427.83	488,895.85					
345	A.100.14.136	kg	Idematapp2020 Rhodium, CRM (secondary)	365.35	27.75	6	71.60	199.88	1,723.10	33,280.53					
346	A.100.14.137	kg	Idematapp2020 Rhodium, CRM, trade mix (85% prim 15% sec)	243,891.78	25,839.45	207,510.69	7,511.35	3,030.17	26,122.12	420,553.55					
347	A.100.14.138	kg	Idematapp2020 Silicon	3.46	0.18	0.21	1.05	2.02	17.37	316.15					
348	A.100.14.139	kg	Idematapp2020 Silver (primary)	624.81	7.07	34.50	568.88	14.35	123.70	1,752.04					
349	A.100.14.140	kg	Idematapp2020 Silver (secondary)	1.61	0.11	0.27	0.30	0.83	7.13	137.68					

Tables in practice:

Simapro output background processes:

1 kg of market mix Aluminium is 1,84 euro eco-costs

1 kg of Copper wire is 5.08 euro eco-costs

1 kg of virgin Silver is 624.81 euro eco-costs

URL: www.ecocostsvalue.com tab data
Table: Idematapp2020

Introduction | Idematapp 2020 | Idematapp2020 midpoints | EF sytem (adapted) for PEF | processes+EoL (in CES) | agri-footprint | EVR gate to gate | EVR cradle to gate

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Example of a felt-tip pen (materials only), step1, hot spot analysis

copy/paste

				per kg	per 1000 felt-tip pens	
weight in kg per 1000 felt-tip pens			database	**eco-costs**	**eco-costs**	
			line number	euro	euro	
part	**weight**	**material**				
Cap	2	Polythene	A.130.04.111	1.14	2.28	
Support for felt	2	Polythene	A.130.04.111	1.14	2.28	
Felt	1	Polyamide	A.130.04.106	2.01	2.01	
Ink cartridge	4	Polyester	A.130.05.106	1.15	4.61	
Body	4	Aluminium	A.100.14.103	1.84	7.37	hotspot
Ink	15	ethanol **(bio)**	A.070.01.104	0.190	2.85	
weight total	28					
assembly	1 MJ/kg		B.040.01.102	0.028	0.78	
tra road	0.33		C.010.06.104	0.031	0.29	
tra rail	0.4		C.050.01.102	0.0053	0.06	
total					22.54	

Idematapp 2020 excel file

A.130.04	**Materials, plastics, Thermoplasts**			
A.130.04.104		kg	Idematapp2020 PA 6 (Nylon 6, Polyamic	2.15
A.130.04.105		kg	Idematapp2020 PA 6 GF30	1.54
A.130.04.106		kg	Idematapp2020 PA 66 (Nylon 66, Polya	2.01
A.130.04.107		kg	Idematapp2020 PA 66 GF30	1.44
A.130.04.108		kg	Idematapp2020 PB (Polybutadiene)	1.60
A.130.04.109		kg	Idematapp2020 PC (Polycarbonate)	2.08
A.130.04.110		kg	Idematapp2020 PC 30% glass fibre	1.49
A.130.04.111		kg	Idematapp2020 PE (HDPE, High density	1.14
A.130.04.112		kg	Idematapp2020 PE (LDPE, Low density	1.18
A.130.04.113		kg	Idematapp2020 PE (LLDPE, Linear low	1.12
A.130.05	**Materials, plastics, Thermosets**			
A.130.05.101		kg	Idematapp2020 CFRP 25% carbon	2.99
A.130.05.102	1	kg	Idematapp2020 Epoxy resin	1.32
A.130.05.103		kg	Idematapp2020 MF (resin)	0.75
A.130.05.104		kg	Idematapp2020 PF (resin)	0.80
A.130.05.105		kg	Idematapp2020 Phenolics (Bakelite)	1.01
A.130.05.106		kg	Idematapp2020 Polyester (unsaturated)	1.15
A.100.14	**Materials, metals, non ferro**			
A.100.14.101		kg	Idematapp2020 Aluminium (primary)	2.61
A.100.14.102		kg	Idematapp2020 Aluminium (secondary)	0.36
A.100.14.103	1	kg	Idematapp2020 Aluminium trade mix (6	1.84
B.040.01	**Energy, electricity country mix**			
B.040.01.101	1	MJ	Idematapp2020 Electricity General Indu	0.024
B.040.01.102	1	MJ	Idematapp2020 Electricity Industrial We	0.028
B.040.01.103	1	MJ	Idematapp2020 Electricity Industrial use	0.023
C.050.01	**Transport, rail**			
C.050.01.101		tkm	Idematapp2020 Train, freight diesel USA	0.0130
C.050.01.102		tkm	Idematapp2020 Train, freight, Europe (tl	0.0053
C.060.01	**Transport, road**			
C.060.01.102	1	m	Idematapp2020 Truck +trailer Euro 6 (m	0.00038
C.060.01.103	1	tkm	Idematapp2020 Truck+container, 28 tor	0.027
C.060.01.104	1	tkm	Idematapp2020 Truck+trailer 24 tons ne	0.031

LCA benchmarking of a pencil body, step 2, improvement: the base case, case 1 (other material) and case 2 (closed loop recycling)

copy/paste

				per kg	per 1000 felt-tip pens	
weight in kg per 1000 pencils			database line number	eco-costs euro	eco-costs euro	
base case	**part**	**Body**				
	weight	4				
	material	Aluminium	A.100.14.103	1.84	7.37	hotspot
	production	Extrusion	D.100.10.109	0.13	0.52	
	EoL	waste incin	no credit	0.00	0.00	
		total			**7.90**	
case1	**part**	**Body**				
	weight	15	note: normal PE instead of bio-PE is not a good idea			
	material	bio-PE	A.130.01.101	0.38	5.69	
	production	Extrusion	D.120.01.105	0.059	0.89	
	EoL	waste incin credit	F.090.01.102	-0.25	-3.78	
		total			**2.80**	
case2	**part**	**Body**				
	weight	4				
	material	Aluminium	A.100.14.103	1.84	7.37	
	production	Extrusion	D.100.10.109	0.13	0.52	
	EoL	closed loop rec.	F.110.01.101	-1.49	-5.95	however 100%?
		total			**1.95**	

Idematapp 2019 excel file

A.130.01	**Materials, plastics, biopolymers**			
A.130.01.101		kg	Idematapp2020 bio-PE (Polyethylene) not bi	0.38
A.130.04	**Materials, plastics, Thermoplasts**			
A.130.04.111		kg	Idematapp2020 PE (HDPE, High density Po	1.14
A.130.04.112		kg	Idematapp2020 PE (LDPE, Low density Poly	1.18
A.130.04.113		kg	Idematapp2020 PE (LLDPE, Linear low dens	1.12
A.100.14	**Materials, metals, non ferro**			
A.100.14.101		kg	Idematapp2020 Aluminium (primary)	2.61
A.100.14.102		kg	Idematapp2020 Aluminium (secondary)	0.36
A.100.14.103	1	kg	Idematapp2020 Aluminium trade mix (66% p	1.84
D.100.01	**Processing, non-ferro**			
D.100.10.109		kg	Idematapp2020 Extruding alum	0.13
D.100.10.110		kg	Idematapp2020 Forging aluminium	0.039
D.120.01	**Processing, plastics**			
D.120.01.103	1	kg	Idematapp2020 extrusion, machine only	0.022
D.120.01.104	1	kg	Idematapp2020 extrusion, production site	0.059
F.090.01	**waste treatment, municipal waste incineration with electricity, th**			
F.090.01.101		kg	Idematapp2020 ABS (Acrylonitrile butadiene	0.15
F.090.01.102		kg	Idematapp2020 bio-PE (Polyethylene) waste	-0.25
F.090.01.103		kg	Idematapp2020 bio-PET (Polyethylene terep	0.08
F.090.01.104		kg	Idematapp2020 CA (Cellulose polymers) was	-0.11
F.090.01.105		kg	Idematapp2020 Ionomer waste incineration	0.11
F.090.01.106		kg	Idematapp2020 PA-11 (Nylon-11) waste inci	-0.20
F.090.01.107		kg	Idematapp2020 PA (Nylons, Polyamides) wa	0.11
F.090.01.108		kg	Idematapp2020 PC (Polycarbonate) waste ir	0.15
F.090.01.109	1	kg	Idematapp2020 PE (Polyethylene) waste inci	0.11
F.060.01	**waste treatment, landfill of inert material, collection and sorting m**			
F.060.01.101	1	kg	Idematapp2020 landfill (inert waste, not bic	0.116
F.110.01	**waste treatment, recycling credit metals**			
F.110.01.101		kg	Idematapp2020 Aluminium, recycling credit	-1.49
F.110.01.102		kg	Idematapp2020 Copper, recycling credit clos	-4.76

Assignment 2: Make your own felt-tip pen calculation

(*stop the video, do the assignment, and after that, continue with the video)*

INNOMAT

LEARNING & TRAINING PACKAGES

Module 1: Life Cycle Assessment

Block 3: cradle-to-cradle

- Block 1:
  - Introduction to LCA
  - Goal and scope
- Block 2
  - Inventory analysis
  - Impact assessment
- Block 3
  - cradle-to-cradle
  - opportunities
- Examples

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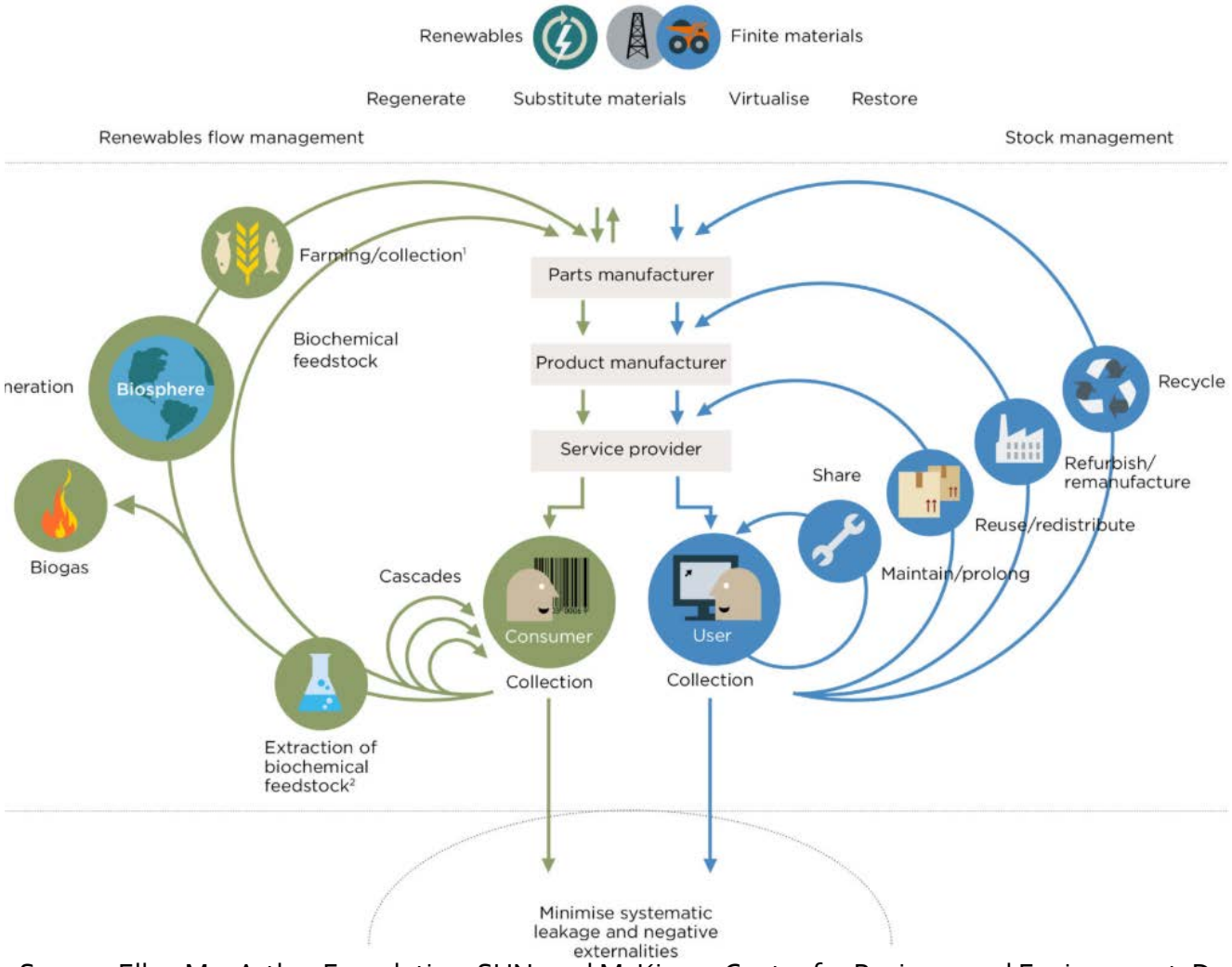
A holistic approach: THE BUTTERFLY DIAGRAM



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:

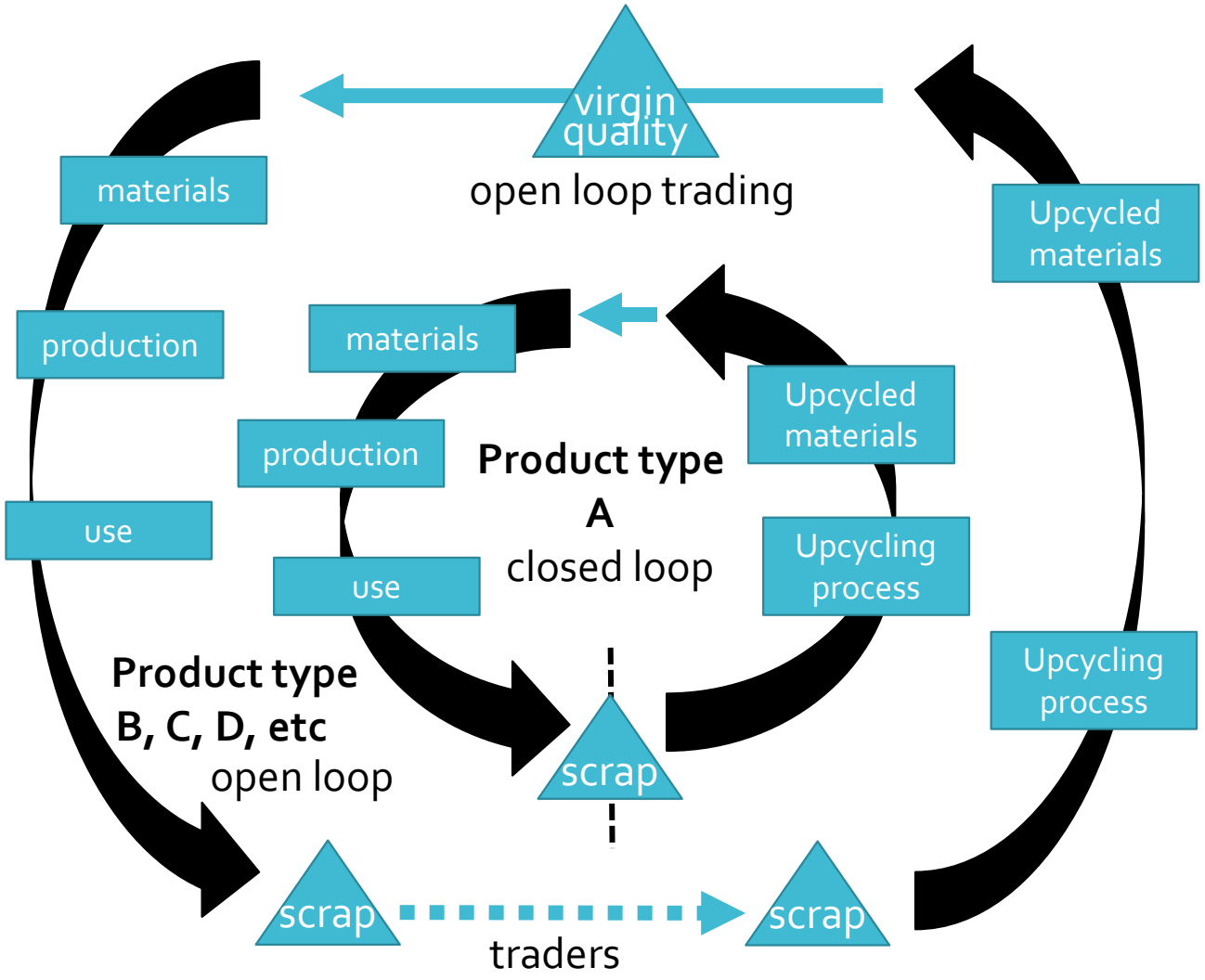
1. Reduce materials in the 'techno sphere':

- **Share/ maintain and prolong**
- **Reuse redistribute**
- **Refurbishing and Remanufacturing**
- **Recycle the materials**

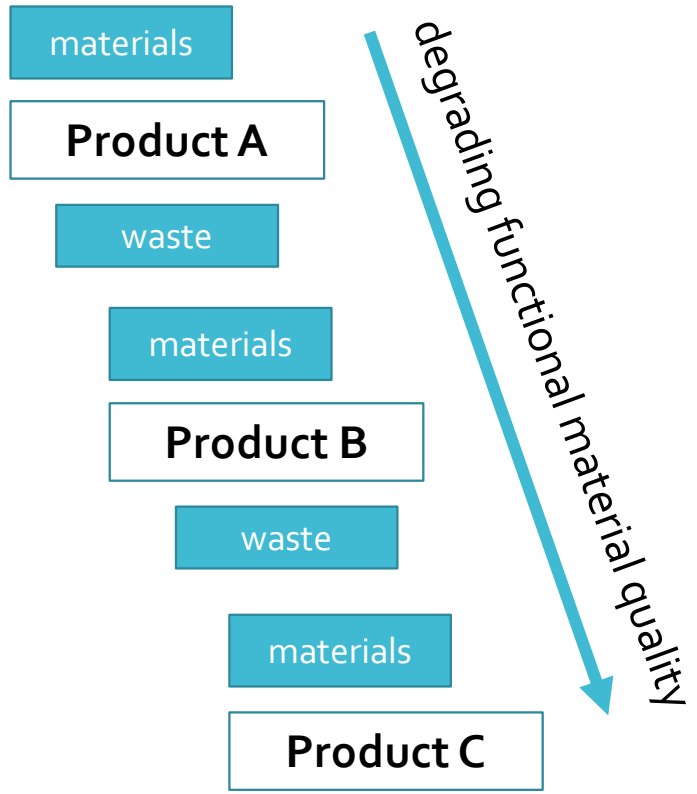
2. Shift to sustainable materials the 'bio sphere':

- **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

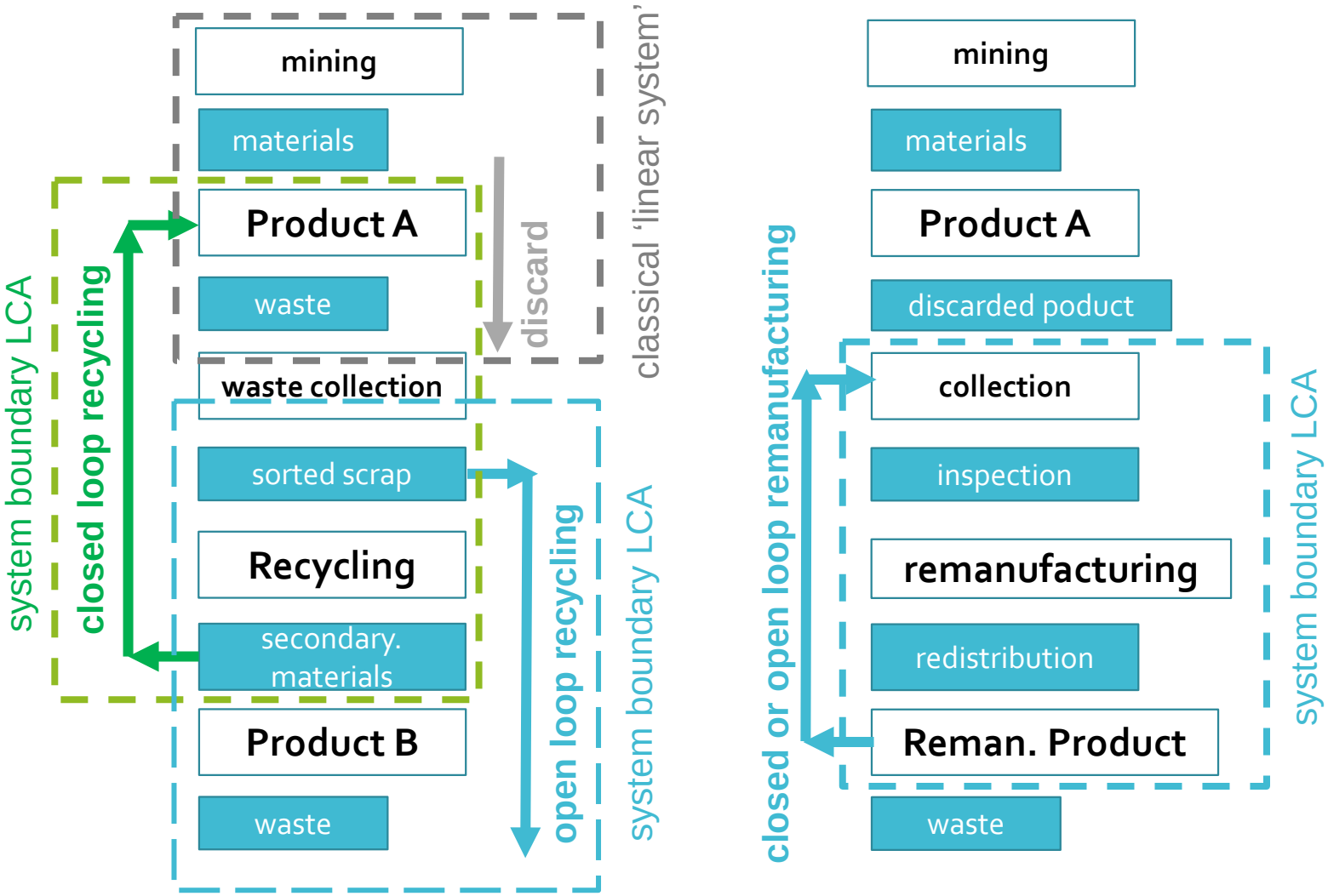


Open loop downcycling (cascading down)



final destination (e.g. under roads)

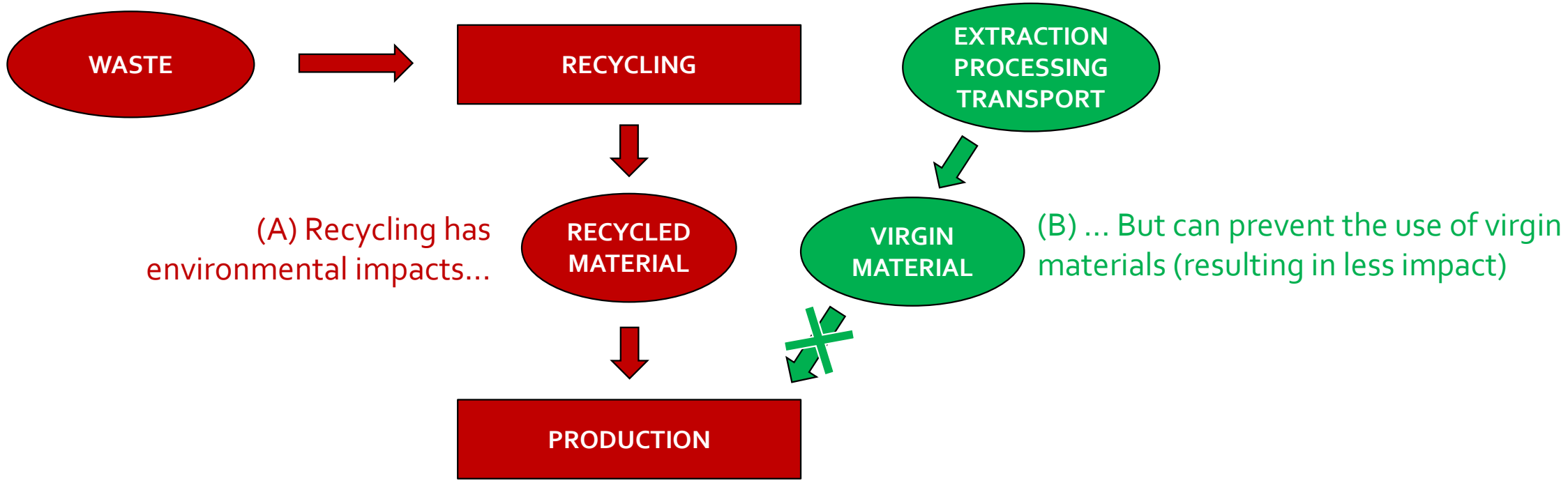
System boundaries and calculation rules in LCA :



Calculation rules for 'cut-off' and 'allocation' in 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, the original manufacturer gets neither any benefit of recycling,** nor there is any carry over from the old product to the new product via the waste
- **Downcycling** goes from waste to waste (no carry over)

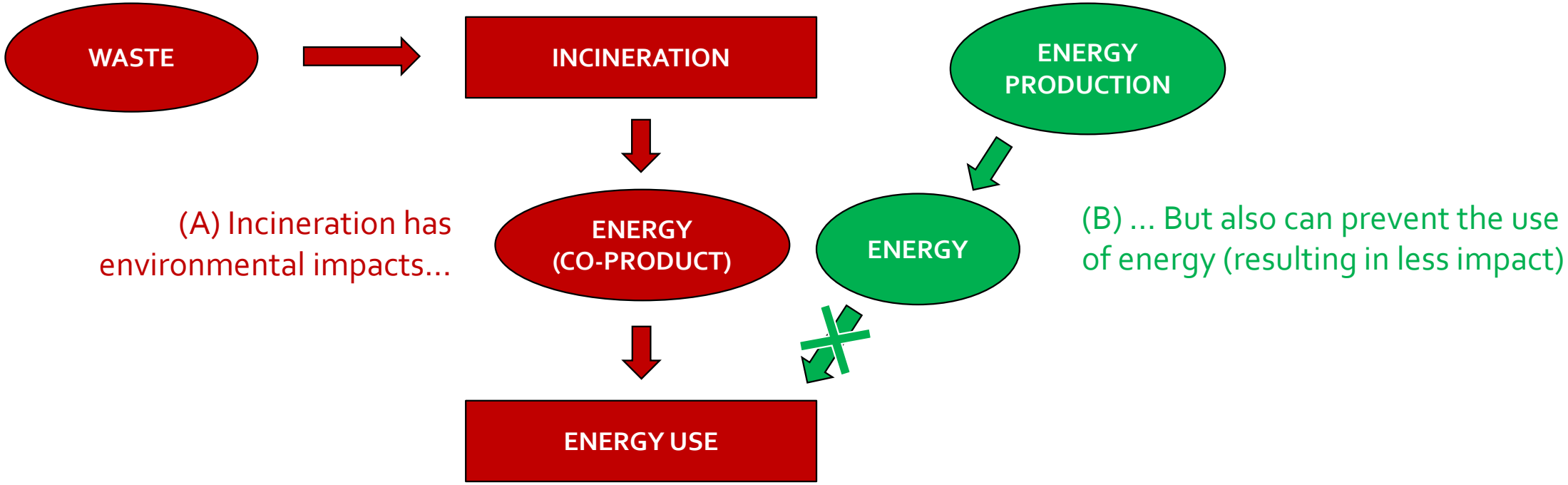
Closed loop Upcycling in LCA: if the net impact of recycling is negative it is called a CREDIT



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

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

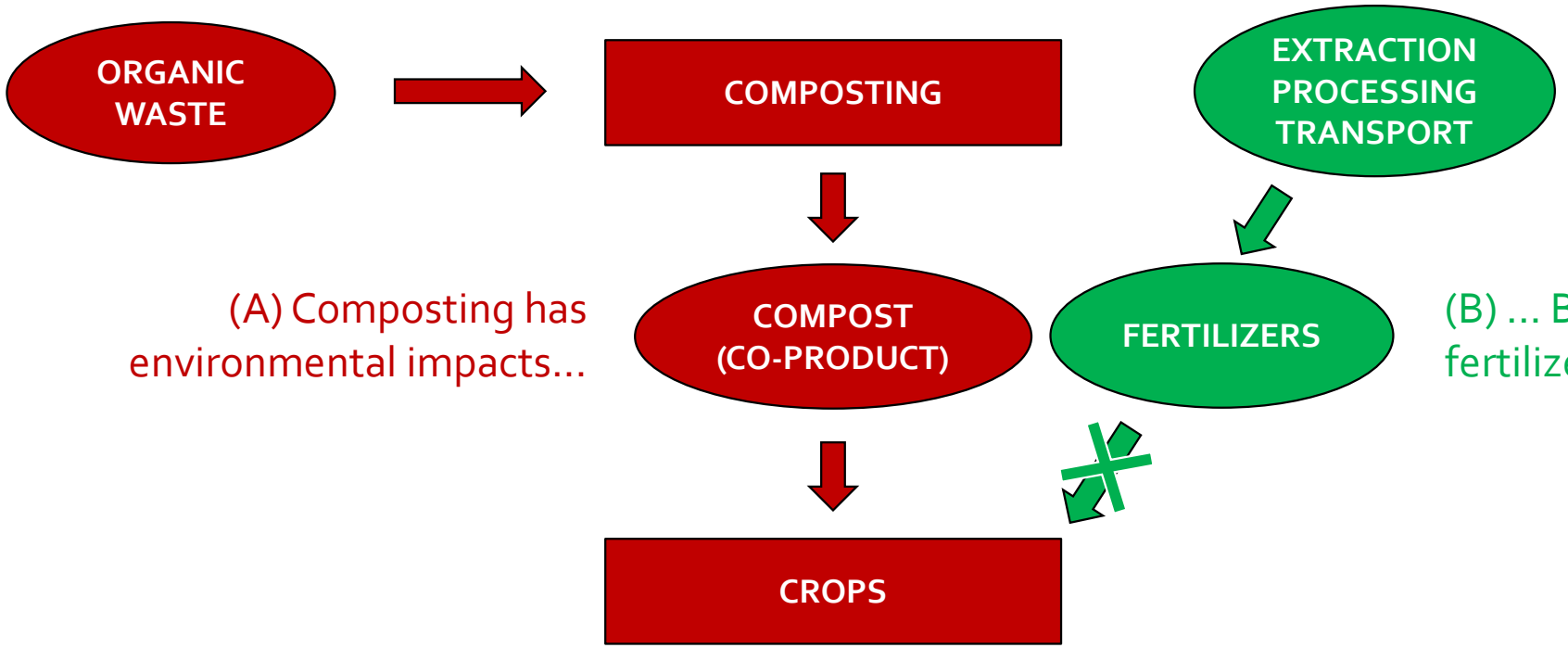
Incineration in LCA : if the net impact is negative it is called a CREDIT



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

For fossil based plastics the net impact of incineration is more eco-burden, for biobased plastics and wood it is less eco-burden (a credit)

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 eco-burden, for biodegradable plastics it is <u>not</u>, since it gives only H_2O and CO_2 (no compost)

S3 | Sources of LCI:

		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 healtl	ReCiPe ecotoxixity	ReCiPe resources	Environm. Footprint	
	unit		euro	euro	euro	euro	euro	kg CO2 equiv.	MJ	DALY	H species.year	H USD2013	Total Pt	Sources of LCI:
F.120.01	waste treatment, upcycling credit plastics													
F.120.01.101	kg	Idematapp2020 ABS, upcycling credit	-0.97	-0.05	-0.07	-0.81	-0.06	-0.48	-32.65	5.72E-06	4.15E-08	-0.293	0.000710	calculations based on virgin - s
F.120.01.102	kg	Idematapp2020 bio-PE (Polyethylene), upcycling credit	0.16	-0.02	-0.02	0.02	0.18	1.53	-6.70	8.52E-06	4.94E-08	-0.106	0.000854	calculations based on virgin - s
F.120.01.103	kg	Idematapp2020 bio-PET (Polyethylene terephthalate, upcycling credit	-0.70	-0.09	-0.09	-0.45	-0.07	-0.57	-25.70	5.11E-06	4.13E-08	-0.210	0.000712	calculations based on virgin - s
F.120.01.104	kg	Idematapp2020 CA (Cellulose polymers), upcycling credit	-0.32	-0.02	-0.03	0.02	-0.28	-2.45	-44.76	5.20E-06	4.12E-08	-0.314	0.000748	calculations based on virgin - s
F.120.01.105	kg	Idematapp2020 EVA (Ethylene vinyl acetate), upcycling credit	-0.47	0.01	0.01	-0.57	0.08	0.68	-21.53	8.77E-06	5.07E-08	-0.248	0.000883	calculations based on virgin - s
F.120.01.106	kg	Idematapp2020 Ionomer, upcycling credit	-1.02	-0.02	-0.02	-0.78	-0.20	-1.71						
F.120.01.107	kg	Idematapp2020 PA-11 (nylon-11), upcycling credit	-0.65	-0.05	-0.06	0.02	-0.56	-4.81						
F.120.01.108	kg	Idematapp2020 PA (nylons, polyamides), upcycling credit	-1.69	-0.16	-0.22	-0.61	-0.69	-5.97						
F.120.01.109	kg	Idematapp2020 PC (Polycarbonate), upcycling credit	-1.61	-0.15	-0.16	-0.73	-0.57	-4.90						
F.120.01.110	1 kg	Idematapp2020 PE (Polyethylene), upcycling credit	-0.61	-0.02	-0.01	-0.78	0.20	1.72						
F.120.01.111	kg	Idematapp2020 PEEK (Polyetheretherketone), upcycling credit	-2.36	-0.12	-0.14	-0.70	-1.40	-12.03						
F.120.01.112	kg	Idematapp2020 PET (Polyethylene terephthalate, upcycling credit	-0.82	-0.09	-0.09	-0.57	-0.07	-0.57						
F.120.01.113	kg	Idematapp2020 PHA, PHB (Polyhydroxyalkanoates), upcycling credit	-0.20	-0.03	-0.02	-0.19	-0.19	-1.62						
F.120.01.114	kg	Idematapp2020 PLA (Polylactide), upcycling credit	-0.26	0.01	-0.01	0.02	-0.14	-1.17						
F.120.01.115	kg	Idematapp2020 PMMA (Acrilylic Polymethyl Methacrylate), upcycling credit	-1.49	-0.15	-0.30	-0.54	-0.50	-4.27						
F.120.01.116	kg	Idematapp2020 POM, Acetal (Polyoxymethylene), upcycling credit	-0.58	-0.03	-0.09	-0.38	-0.28	-0.66						
F.120.01.117	1 kg	Idematapp2020 PP (Polypropylene), upcycling credit	-0.60	-0.01	-0.01	-0.78	0.20	1.72						
F.120.01.118	1 kg	Idematapp2020 PS (Polystyrene), upcycle credit	-0.98	-0.04	-0.05	-0.90	0.01	0.05						
F.120.01.119	kg	Idematapp2020 PTFE, Teflon (Polytetrafluoroethylene), upcycling credit	-1.30	-0.06	-0.07	-0.50	-0.67	-5.76						
F.120.01.120	kg	Idematapp2020 PTT (Polyltrimethylene terephthalate) , upcycling credit	-0.59	-0.01	-0.01	-0.42	-0.14	-1.21						
F.120.01.121	1 kg	Idematapp2020 PUR (Polyethane), upcycling credit	-1.37	-0.37	-0.19	-0.74	-0.06	-0.50						
F.120.01.122	1 kg	Idematapp2020 PVC (Polyvinylchloride), upcycling credit	-0.32	-0.01	-0.01	-0.08	-0.07	0.63						
F.120.01.123	kg	Idematapp2020 Starch-based thermoplastics (TPS), upcycling credit	0.24	0.02	0.02	0.02	0.18	1.59						
F.130.01	waste treatment, waste handling, collection & sorting													
F.130.01.101	1 kg	Idematapp2020 anaerobic digestion (fermentation) cow dung	-0.0075	-0.0006	-0.0007	0.0016	-0.0077	-0.0662						
F.130.01.102	kg	Idematapp2020 anaerobic digestion (fermentation) food waste	-0.0278	-0.0022	-0.0025	0.0015	-0.0247	-0.2121						
F.130.01.103	kg	Idematapp2020 anaerobic digestion (fermentation) garden waste	-0.0238	-0.0019	-0.0021	0.0013	-0.0213	-0.1837						
F.130.01.104	kg	Idematapp2020 composting biodegradable plastics	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000						
F.130.01.105	kg	Idematapp2020 composting organic waste (without transport)	-0.0027	-0.0002	-0.0005	-0.0002	-0.0018	-0.0155						
F.130.01.106	kg	Idematapp2020 landfill (inert waste, not biodegradable)	0.1160	0.0000	0.0000	0.1160	0.0000	0.0000						
F.130.01.107	kg	Idematapp2020 landfill organic waste without CH4 emission prevention	0.2749	0.0051	0.0001	0.0016	0.0000	2.3105						
F.130.01.108	kg	Idematapp2020 metal scrap stockpile	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000						
F.130.01.109	kg	Idematapp2020 plastic waste, collection&sorting	0.0323	0.0014	0.0017	0.0188	0.0101	0.0869						
F.130.01.110	kg	Idematapp2020 Scrap separation	0.0023	0.0002	0.0004	0.0005	0.0013	0.0111						
F.130.01.111	kg	Idematapp2020 Scrap, collection&sorting (alum.)	0.0161	0.0007	0.0009	0.0094	0.0050	0.0434						
F.130.01.112	kg	Idematapp2020 Scrap, collection&sorting (copper)	0.0161	0.0007	0.0009	0.0094	0.0050	0.0434						
F.130.01.113	kg	Idematapp2020 Scrap, collection&sorting (iron)	0.0108	0.0005	0.0006	0.0063	0.0034	0.0290						
F.130.01.114	kg	Idematapp2020 Scrap, collection&sorting (other non-ferro metals)	0.0323	0.0014	0.0017	0.0188	0.0101	0.0869						
F.130.01.115	kg	Idematapp2020 Scrap, collection&sorting (Pb)	0.0269	0.0012	0.0014	0.0157	0.0084	0.0724						
F.130.01.116	kg	Idematapp2020 Scrap, collection&sorting (Stainless st)	0.0323	0.0014	0.0017	0.0188	0.0101	0.0869						

Tables in practice:

Simapro output examples end-of-life processes:

upcycling credits of plastics

upclycling credits of bio-plastics

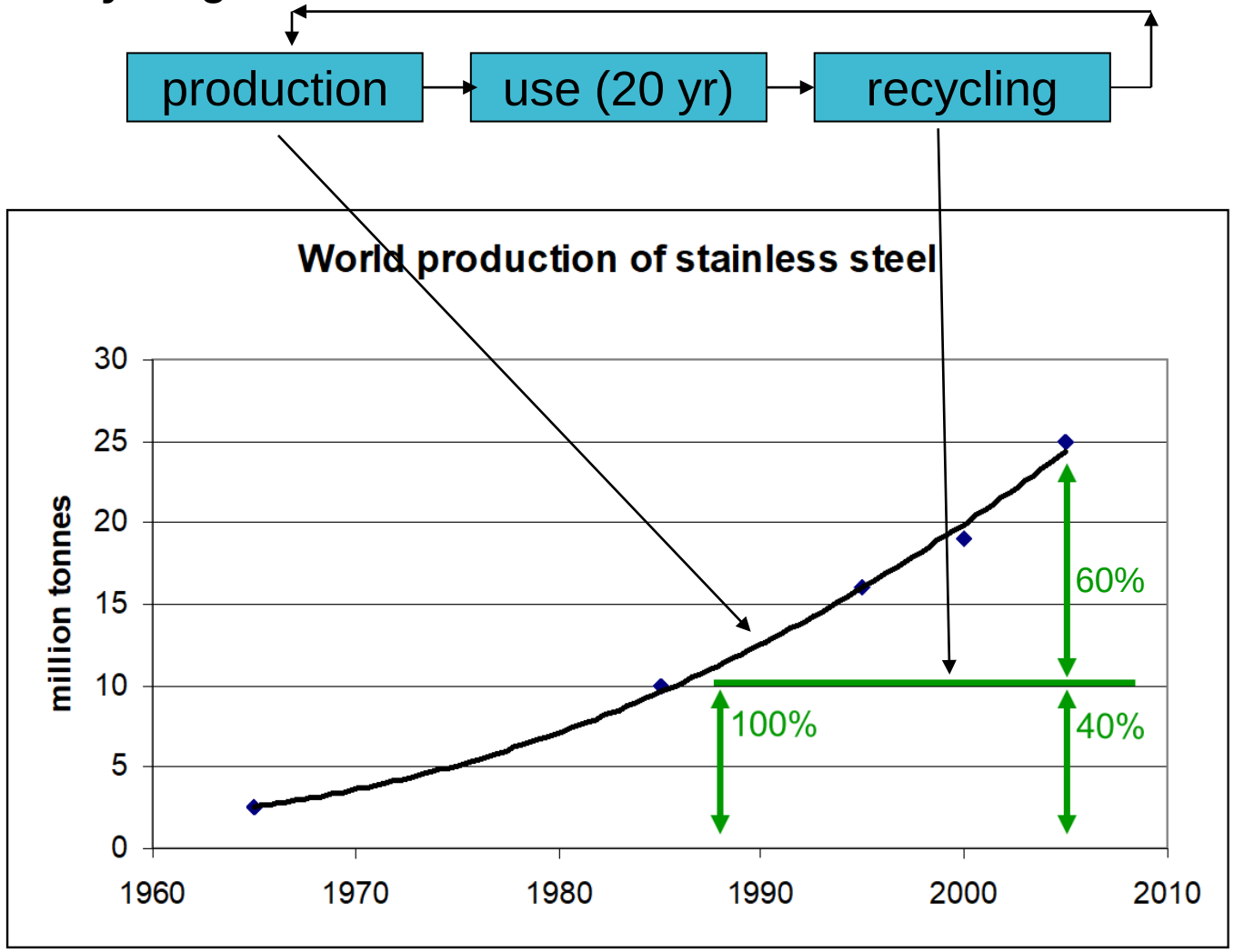
composting and fermentation

waste handling activities

URL: www.ecocostsvalue.com tab data Table Idematapp 2020

Introduction | Idematapp 2020 | Idematapp2020 midpoints | EF sytem (adapted) for PEF | processes+EoL (in CES) | agri-footprint | EVR gate to gate | EVR cradle to gate

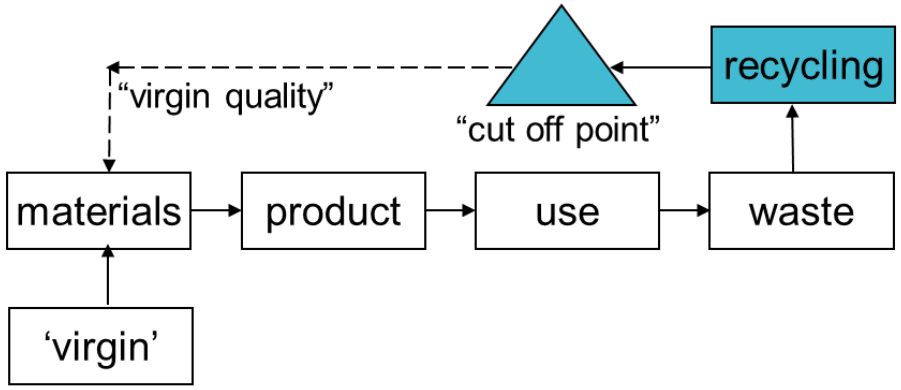
Metals recycling



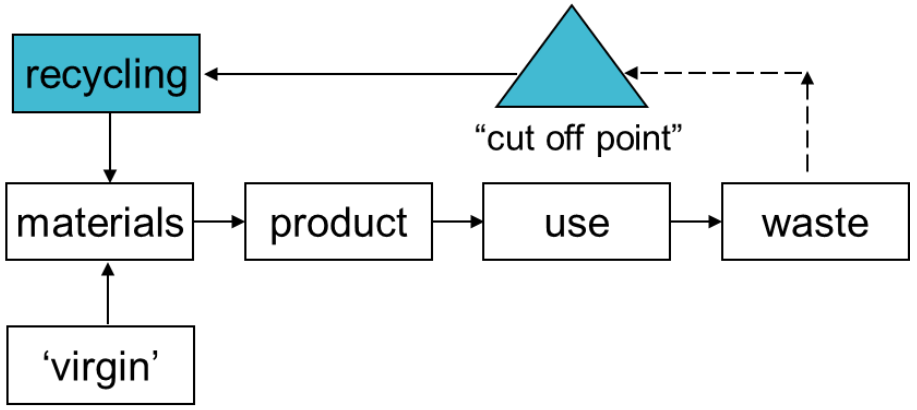
The recycling percentage of metals ("upcycling open loop")

- The average residence time of many metals like copper and stainless steel is about 20 years
- The consequences of such long resident times is that we recycle now what we produced 20 years ago
- We recycle nearly 100% of these metals
- However, since there is a rather big increase of the production of metals, we recycle only 40% of the current total production, the other 60% has to be virgin
- For **open loop upcycling** we take this 40% 60% ratio as "market mix" of
- Also for **closed loop upcycling** it is often not realistic to take 100% when the production volume is growing

“recycling credit” approach of closed loop recycling



“cut-off at recyclable waste”, also called “recycled content”, approach



318	1	A.100.14.109		kg	Idematapp2020 Copper (secondary)
319	1	A.100.14.110	1	kg	Idematapp2020 Copper wire, plate, pipe, trade mix (56% prim 44% sec)
320	1	A.100.14.111		kg	Idematapp2020 Gallium, CRM (virgin)
321	1	A.100.14.112		kg	Idematapp2020 Gold (primary)
322	1	A.100.14.113		kg	Idematapp2020 Gold (secondary)
323	1	A.100.14.114		kg	Idematapp2020 Gold trade mix (47% prim 53% sec)
324	1	A.100.14.115		kg	Idematapp2020 Indium, CRM (virgin)
325	1	A.100.14.116		kg	Idematapp2020 Lead (primary)
326	1	A.100.14.117		kg	Idematapp2020 Lead (secondary)
327	1	A.100.14.118	1	kg	Idematapp2020 Lead trade mix (25% prim 75% sec)
328	1	A.100.14.119		kg	Idematapp2020 Lithium
329	1	A.100.14.120		kg	Idematapp2020 Magnesium, CRM (primary)
330	1	A.100.14.121		kg	Idematapp2020 Magnesium, CRM (secondary)
331	1	A.100.14.122		kg	Idematapp2020 Magnesium, CRM, trade mix (57% prim 43% sec)
332	1	A.100.14.123		kg	Idematapp2020 Manganese
333	1	A.100.14.124		kg	Idematapp2020 Mercury (primary)
334					
503		**A.130.02**		**Materials, plastics, upcycled plastics**	
504	2	A.130.02.101		kg	Idematapp2020 ABS (Acrylonitrile butadiene styrene) upcycled (estimate)
505	2	A.130.02.102		kg	Idematapp2020 CA (Cellelose polymers) upcycled (estimate)
506	2	A.130.02.103		kg	Idematapp2020 EVA (Ethylene vinyl acetate) upcycled (estimate)
507	2	A.130.02.104		kg	Idematapp2020 Flexible Polymeer Foam (PE), upcycled (estimate)
508	2	A.130.02.105		kg	Idematapp2020 Ionomer, upcycled (estimate)
509	2	A.130.02.106		kg	Idematapp2020 Moulded Recycled mixed polymer
510	2	A.130.02.107		kg	Idematapp2020 PA-11 (Nylon-11), upcycled, estimate
511		A.130.02.108		kg	Idematapp2020 PA (Nylons) upcycled (estimate)
		A.130.02.109		kg	Idematapp2020 PC (Polycarbonate) upclycled (estimate)
		A.130.02.110		kg	Idematapp2020 PE/bio-PE (Polyethylene) upcycled (estimate)
		A.130.02.111		kg	Idematapp2020 PEEK (Polyetheretherketone) upcycled (estimate)
515	2	A.130.02.112		kg	Idematapp2020 PET/bio-PET upcycled (estimate)
516	2	A.130.02.113		kg	Idematapp2020 PHA and PHB (Polyhydroxyalkanoates, biodegradeble), upcycle
517	2	A.130.02.114		kg	Idematapp2020 PLA (Polylactide, starch based biodegradeble plastic), upcycled
518	2	A.130.02.115		kg	Idematapp2020 PMMA (Polymethyl methacrylate) upcycled (estimate)
519	2	A.130.02.116		kg	Idematapp2020 POM (Polyoxymethylene) upcycled (estimate)
520	2	A.130.02.117		kg	Idematapp2020 PP (Polypropylene) upcycled (estimate)
521	2	A.130.02.118		kg	Idematapp2020 PS (Polystyrene) upcycled (estimate)
522	2	A.130.02.119		kg	Idematapp2020 PTFE (Teflon), upcycled (estimate)
523		A.130.02.120		kg	Idematapp2020 PTT (Polyltrimethylene terephthalate), upcycled, estimate
524	2	A.130.02.121		kg	Idematapp2020 PUR (Polyurethane) upcycled (estimate)
525	2	A.130.02.122	1	kg	Idematapp2020 PVC (Polyvinylchloride) upcycled (estimate)
526	2	A.130.02.123		kg	Idematapp2020 TPS (Starch-based thermoplastics) upcycled (estimate)
527		A.130.02.124		kg	Idematapp2020. mechanical recycled plastic pellets (downcycled)
528		A.130.03		Materials, plastics, rubbers	

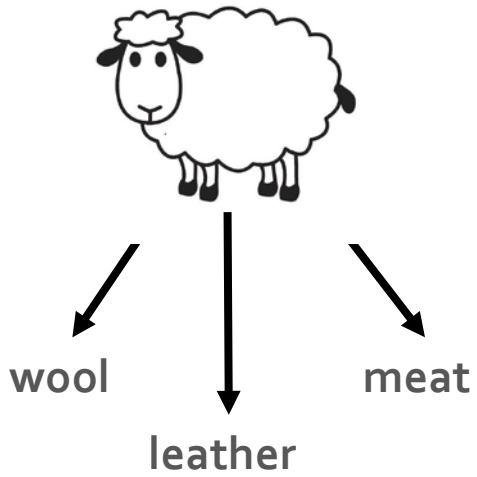
Introduction | Idematapp 2020 | Idematapp2020 midpoints | EF syte

Relevant for the bio-sphere: multi-product processes in agriculture

PROBLEM: How to distribute the inventory and impacts between the **main product and co-products**?

SOLUTION: Use a property of the system to allocate them (**allocation**)

ECONOMIC ALLOCATION



Example:

Wool	50% of the total revenue
Meat	45% of the total revenue
Skin for leather	5% of the total revenue

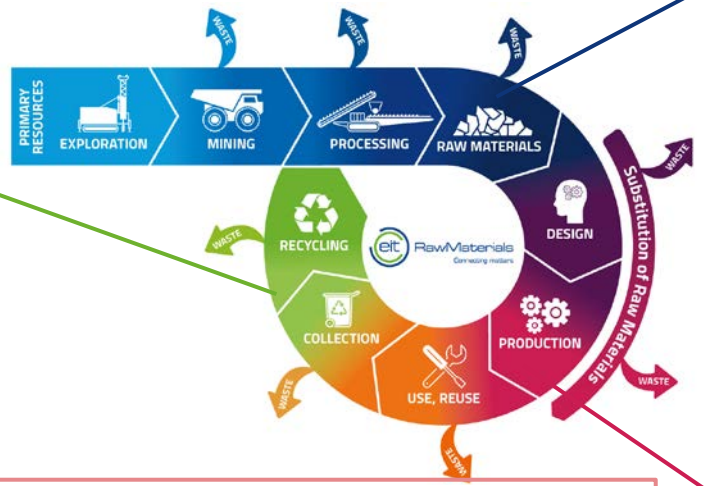
The total impact will be distributed:

Wool	50%
Meat	45%
Skin for leather	5%

Examples of opportunities

DISPOSAL
- Less hazardous materials
- Longer life spans
- More remanufacturing&recycling

TRANSPORTATION (between phases)
- Less Long distance
- Less weight, Less volume
- Less Fossil fuels
- Less Pollution of exhaust gasses



USE-PHASE (if energy intensive)
- Less Heat by better insulation
- Less Electricity by efficiency
- From fossil to renewable energy

RAW MATERIALS
- Better materials selection:
  - From Virgin to Recycled
  - Less Energy intensive
  - Bio-based

PRODUCTION
- Cleaner production:
  - Less Energy
  - Less Pollution
  - Less Chemicals
  - Less Waste

Assignments:

Assignment 3: Compare a few alternatives at the end-of-life of products

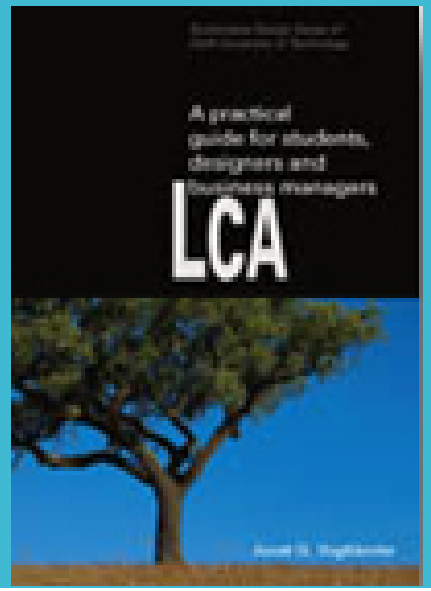
Assignment 4: Compare a rechargeable battery vs a single use alkaline

INNOMAT

LEARNING & TRAINING PACKAGES

The End of Module 1 (LCA)

You may read for additional information:



project:
EU EIT Raw Materials Lifelong Learning KAVA Education project (project number 17226)

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eit RawMaterials ACADEMY

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