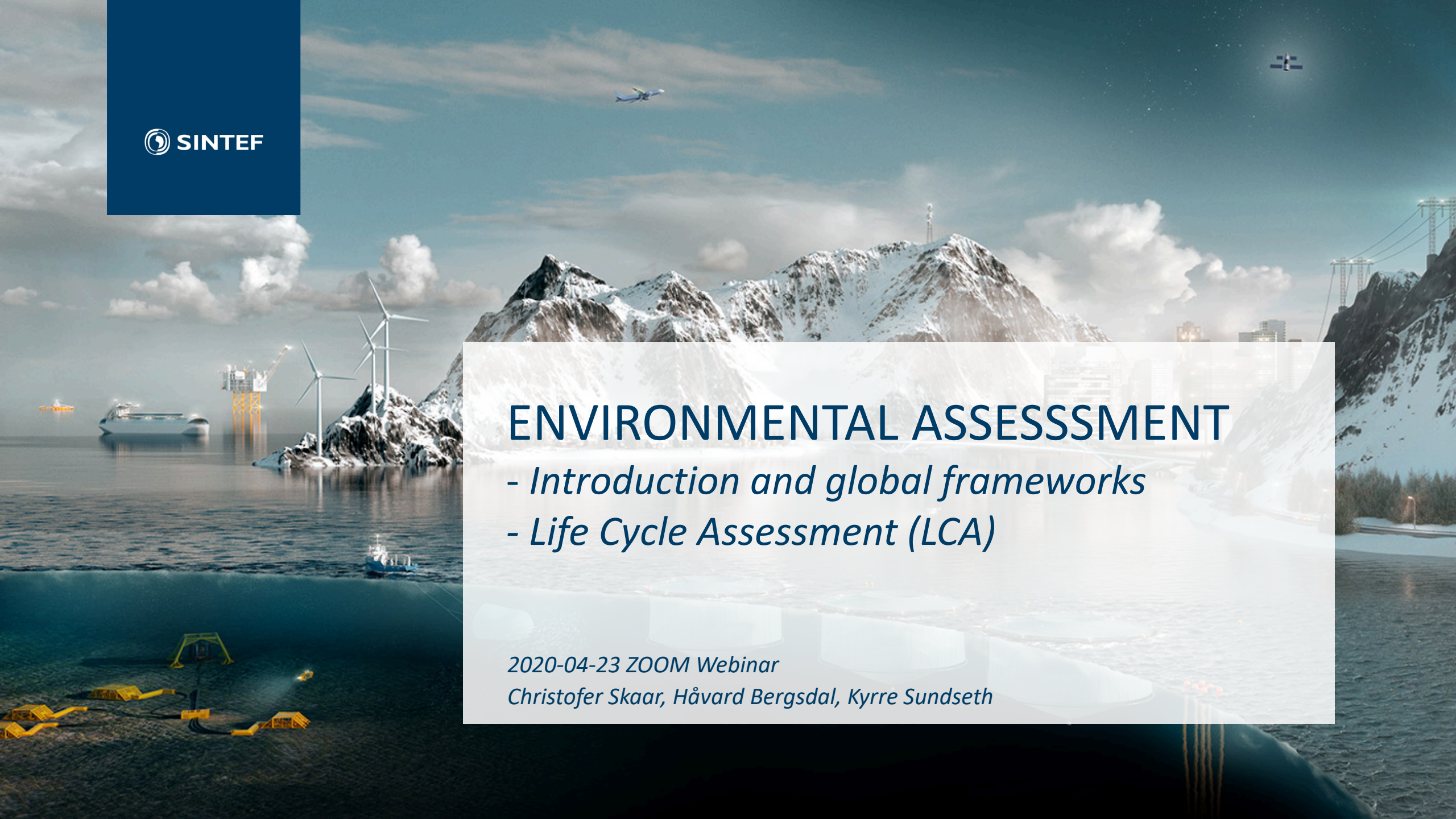

ENVIRONMENTAL ASSESSSMENT

- Introduction and global frameworks

- Life Cycle Assessment (LCA)

2020-04-23 ZOOM Webinar

Christofer Skaar, Håvard Bergsdal, Kyrre Sundseth

Introduction

ZOOM Webinar "Corona" Lecture Series

https://hydromet.no/seminarer/zoom-corona-webinars-spring-2020.html

Agenda

- Webinar format
- Brief presentation round & check-in
- Introduction and frameworks
  - The big picture
  - Environmental management principles
  - Environmental management toolbox
- Life Cycle Assessment: A brief introduction
  - Types of LCA
  - LCA methodology

Colour coding, transitions

Main theme

Sub-theme

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Webinar format

- We'll go through a powerpoint presentation – slides will be posted afterwards
- Questions are welcome – just write 'question' or 'comment' in the chat first
- Breakout rooms
  - We'll have two discussion rounds in breakout rooms
  - You'll be assigned to a room automatically and return to the main room automatically
- General
  - Mute your microphone when you're not talking
  - Turn on video when you're talking *(optional ☺)*

Presentation round

Senior research scientist, SINTEF Community
Adjunct assoicate professor, IØT NTNU

Themes: Environmental management, circular economy, life cycle assessment

Senior research scientist
SINTEF Community

Themes: Industrial ecology, life cycle assessment, dynamic stock & flow analysis

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Presentation round

Who are you? Name/affiliation

Check-in

What are the expectations from the webinar?

Introduction

What is sustainability?

What is sustainability?

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What is sustainability?

I = P x A x T

(Commoner, Ehrlich & Holdren, 1970s)

Impact = Population x Affluence x Technology

The aim is not zero impact, but to stay within ecological limits/thresholds

Keywords: state of the environment, decoupling, factor 4, factor 10, eco-efficiency

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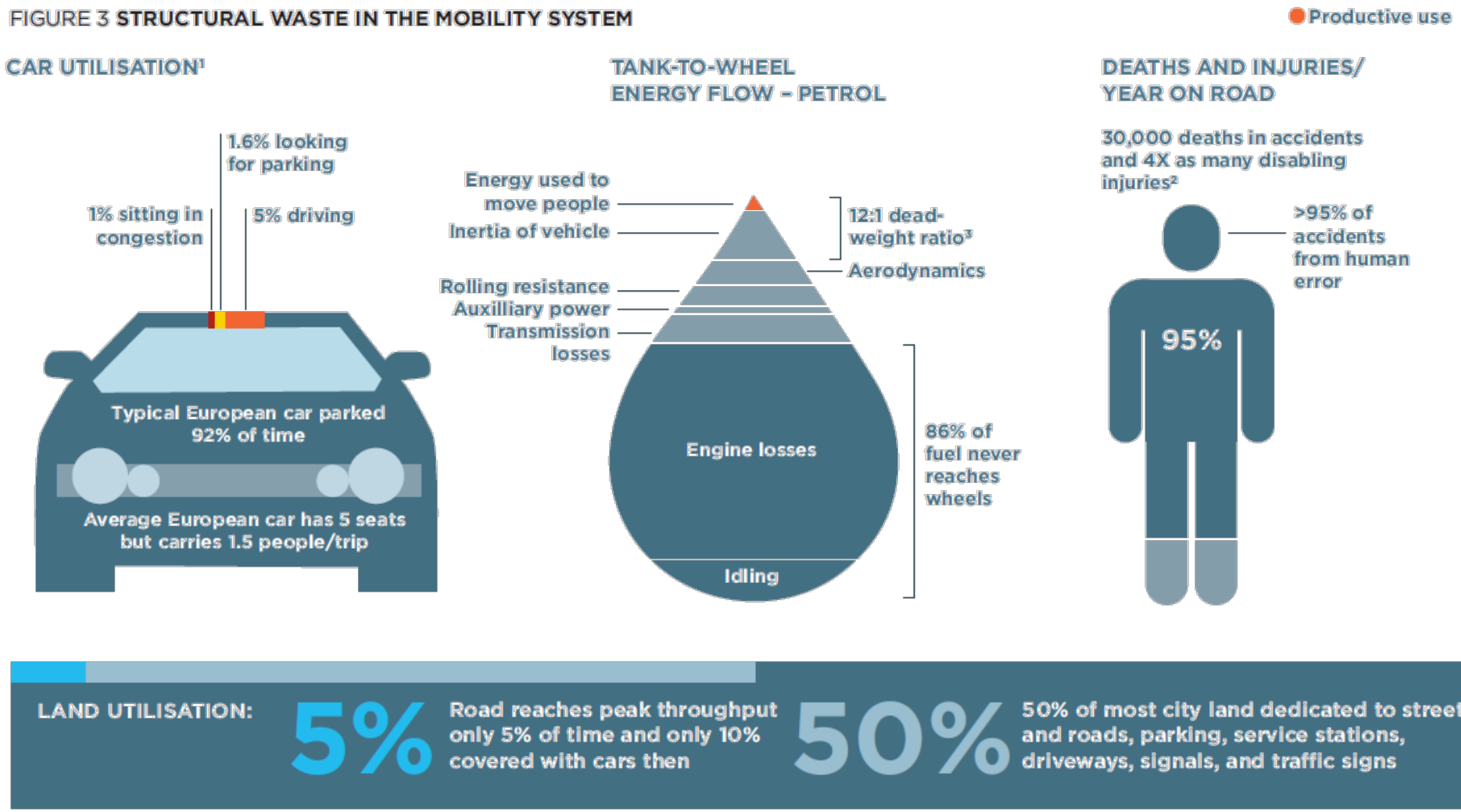
What is sustainability?



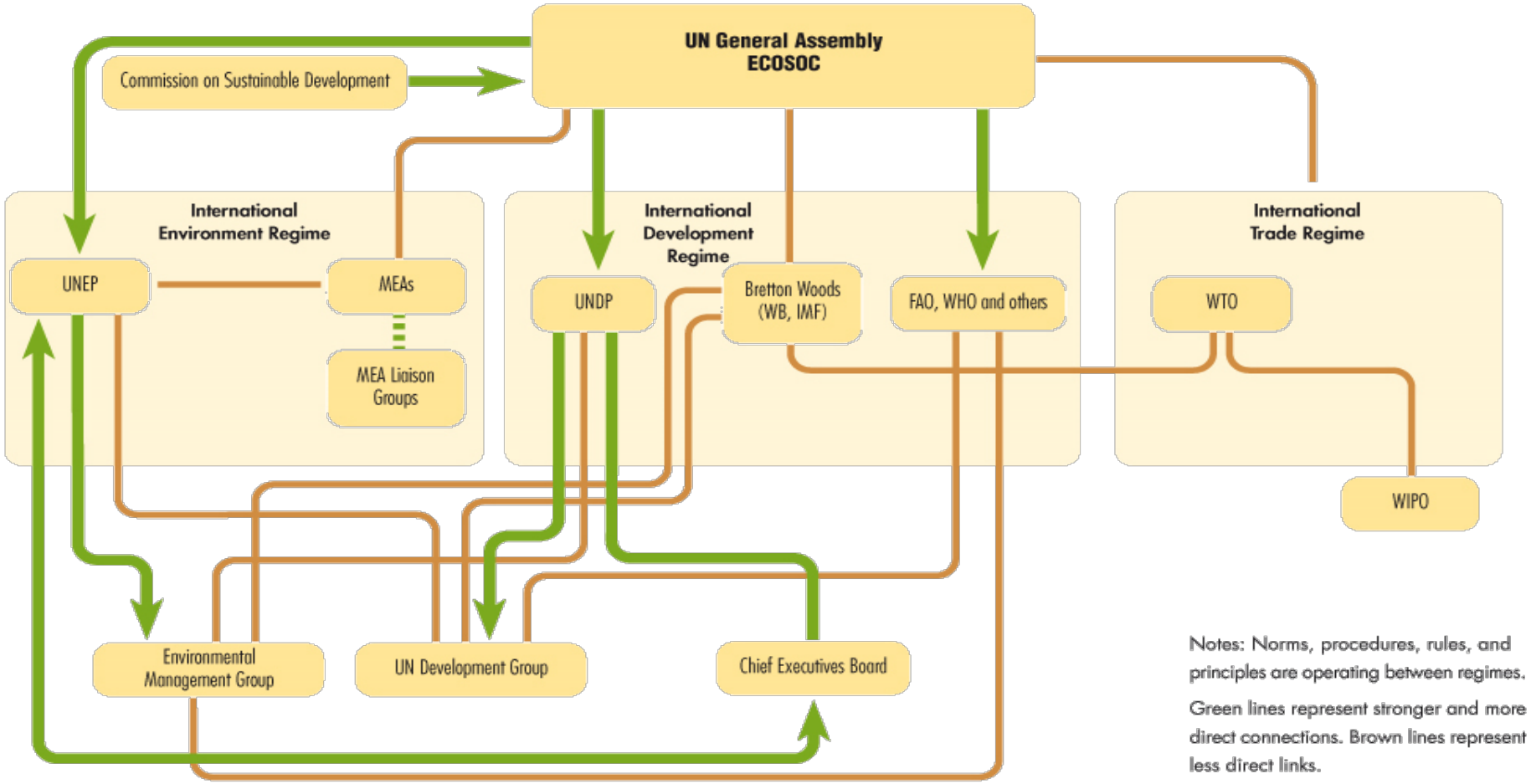
MacArthur Foundation / McKinsey (2015)

Global frameworks

- How do we attempt to govern the system?
- How do we attempt to understand the system?

Global frameworks: Governance

Figure 8.8 International governance-environment-development-trade interlinkages



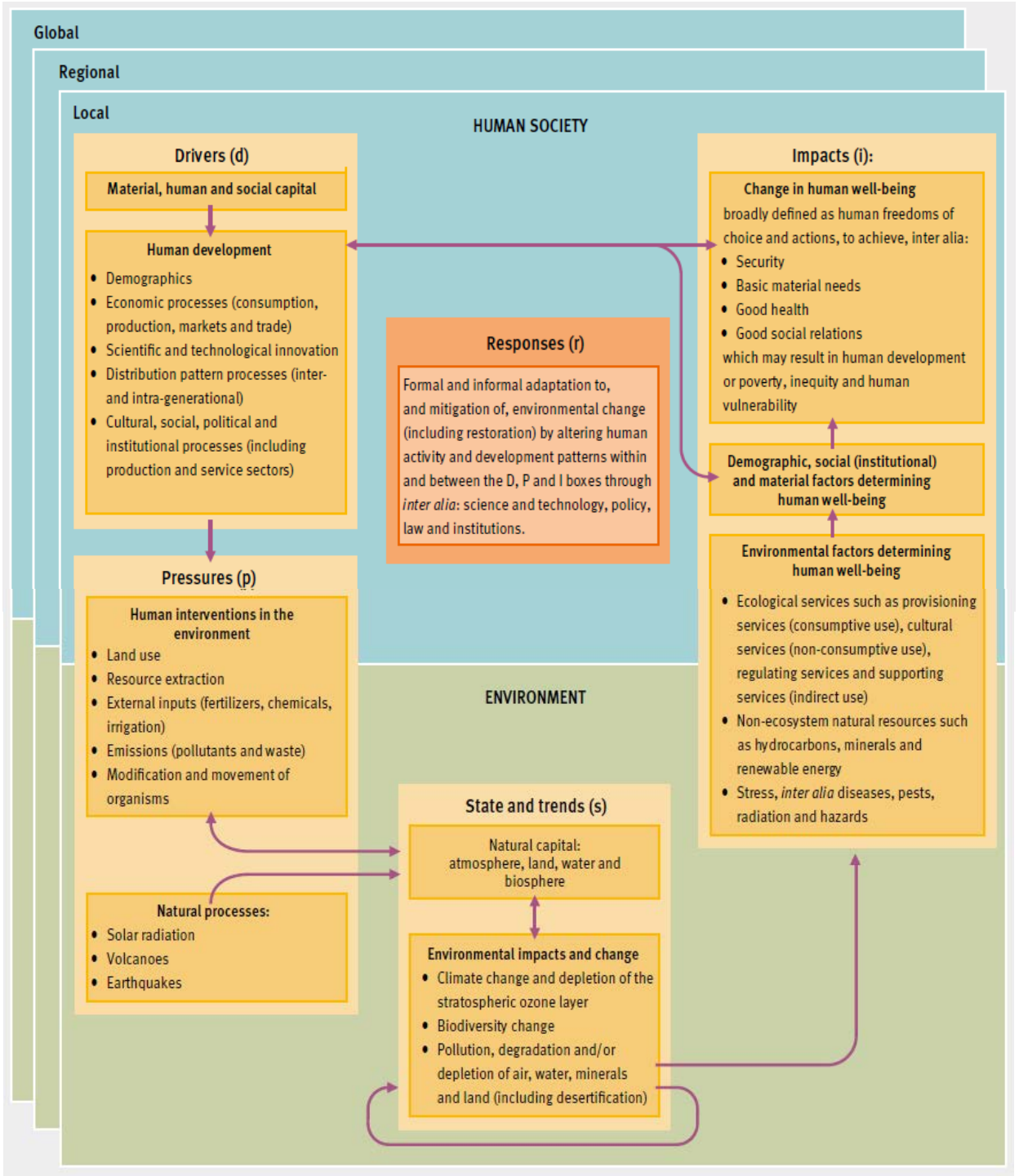
Notes: Norms, procedures, rules, and principles are operating between regimes.

Green lines represent stronger and more direct connections. Brown lines represent less direct links.

Global frameworks: Understanding

DPSIR framework

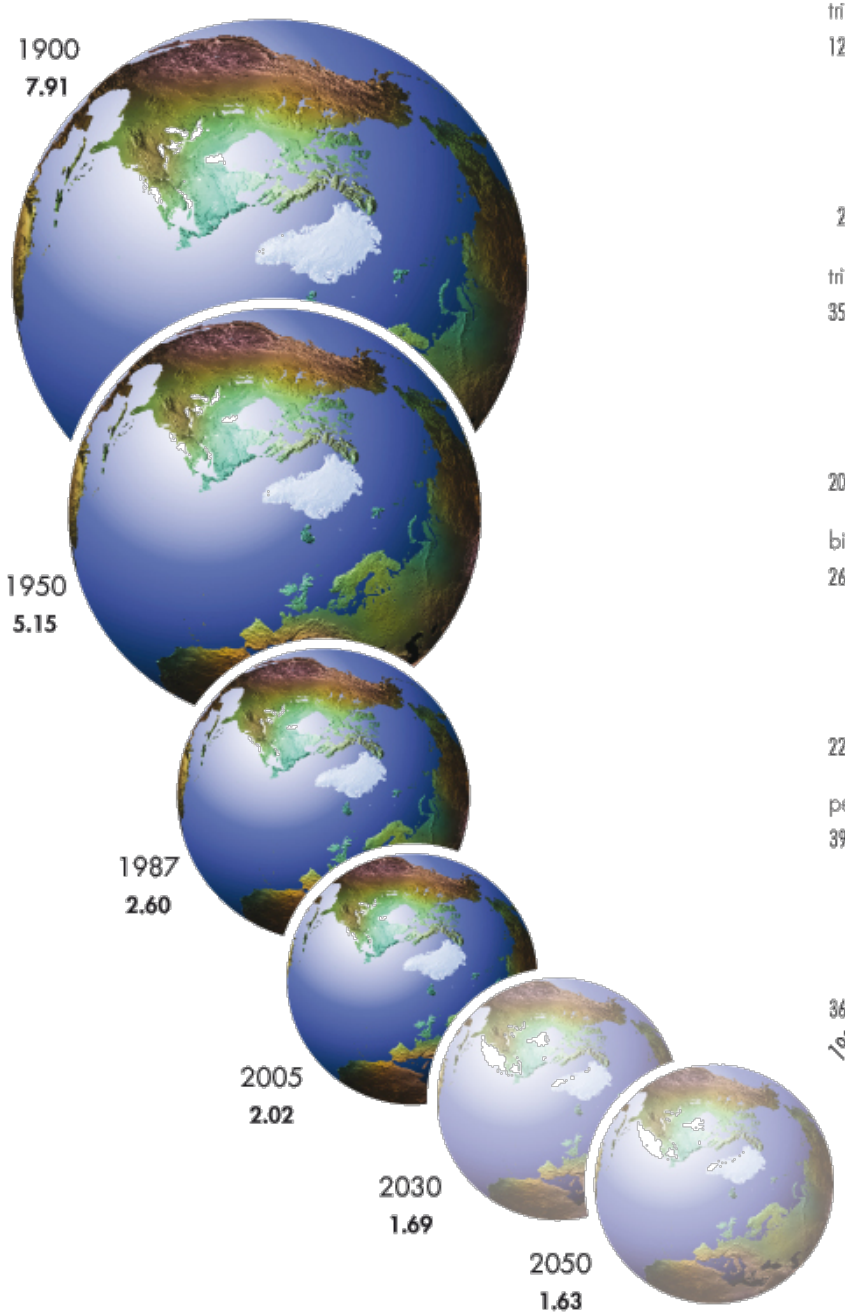
- Causal framework:
  - Driving forces
  - Pressures
  - States and trends
  - Impacts
  - Responses

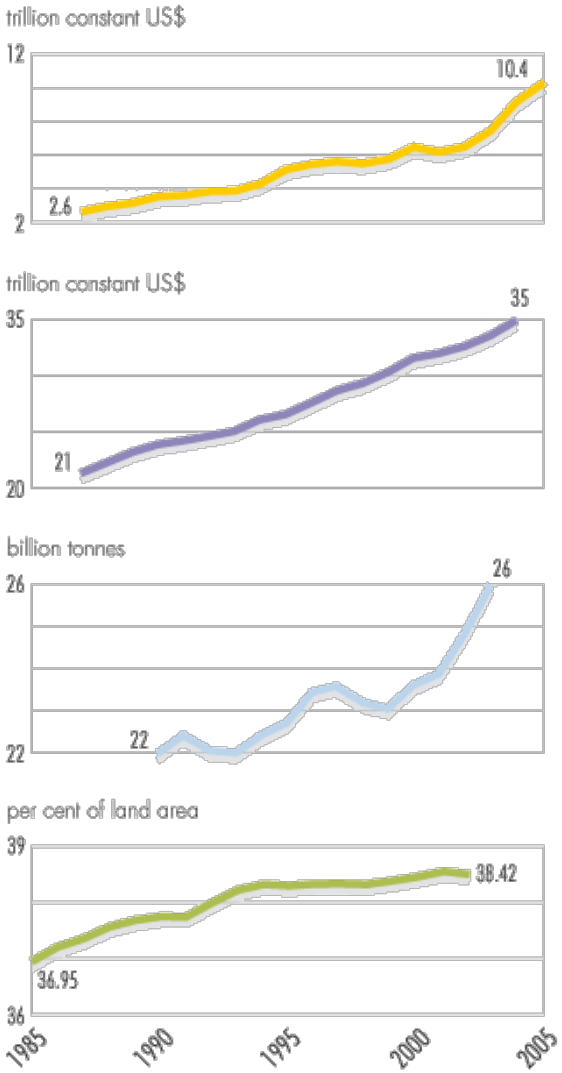


Source: UNEP GEO5

Footprint

Figure 8.1 Our "shrinking" Earth





Notes: Numbers next to images of Earth reflect hectares of land per capita.

Graphs show changes in trade volume (1987–2005), GDP (1987–2004), CO_2 emissions (1990–2003) and agricultural land area (1987–2002).

Sources: FAOSTAT 2006, Chapter 9 population projection, WTO 2007, GEO Data Portal compiled from UNPD 2007-low estimate, World Bank 2006a, UNFCCC-CDIAC 2006 and FAOSTAT 2004

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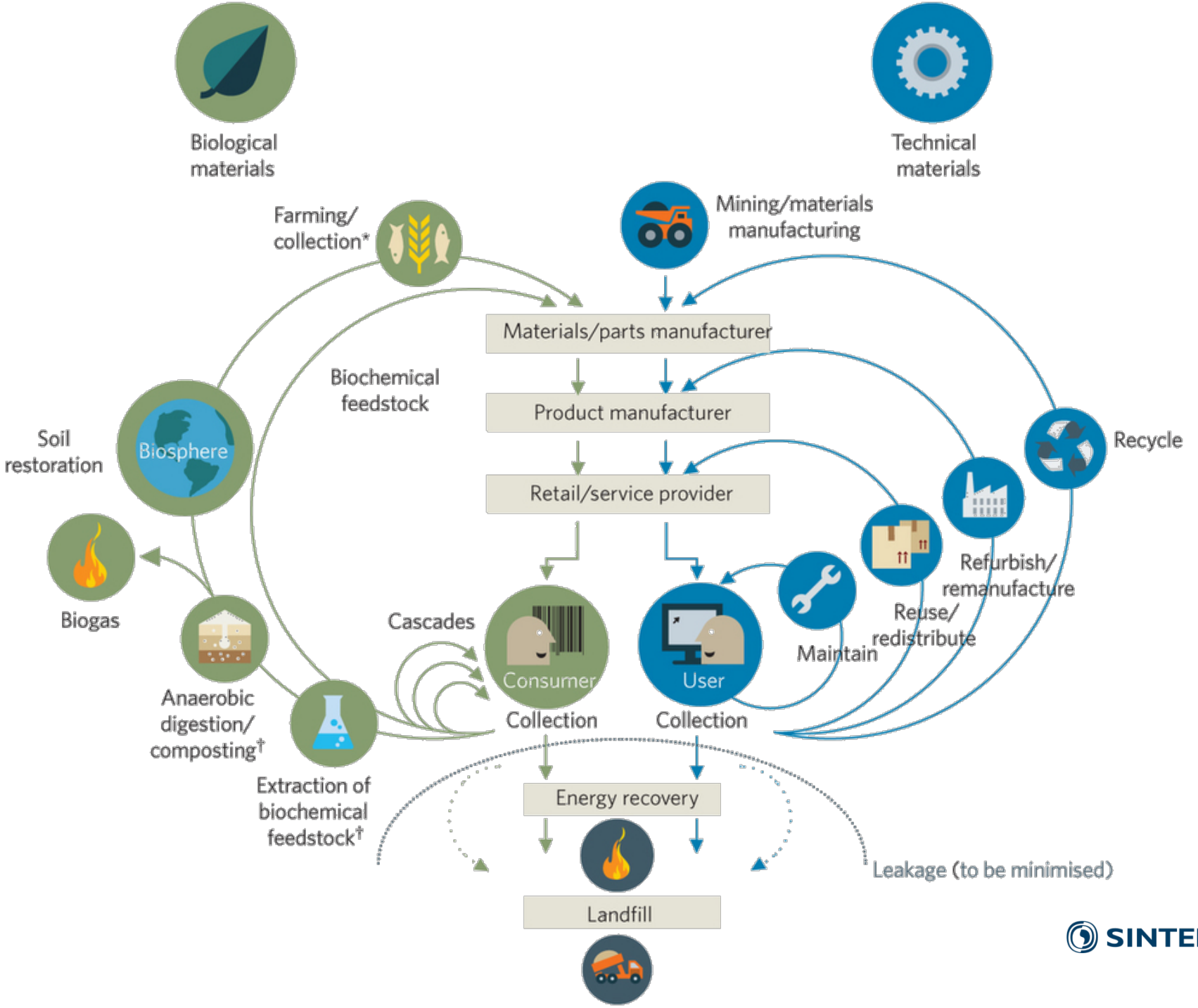
Circularity

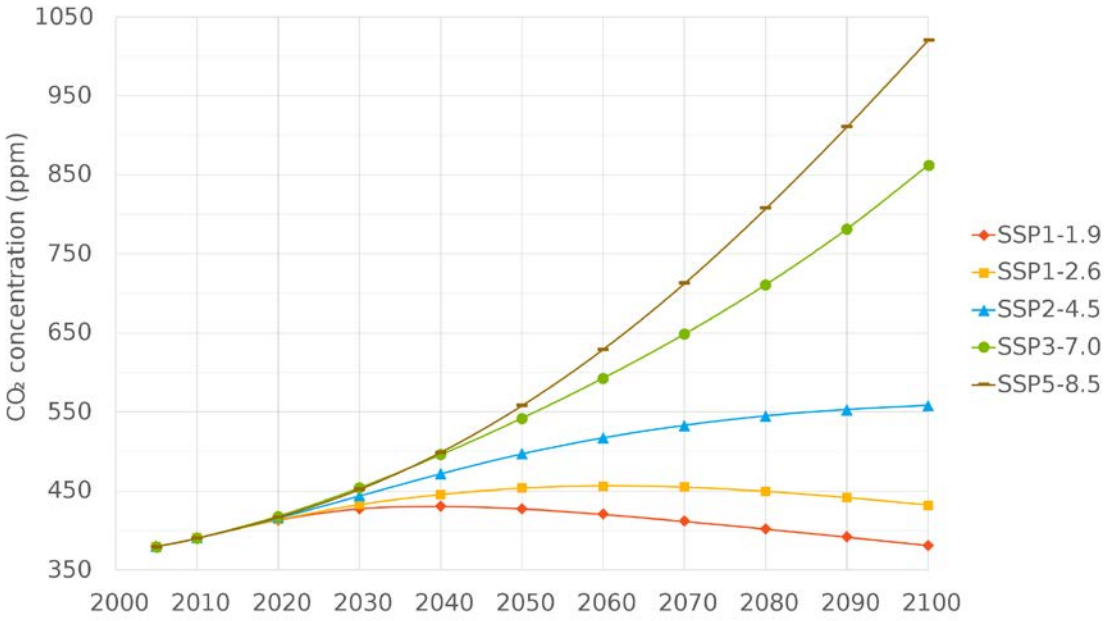


doi:10.1038/nclimate1842

Future pathways

Socio-Economic Pathways

Representative Concentration Pathways



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https://en.wikipedia.org/wiki/Shared_Socioeconomic_Pathways - more information on https://www.sciencedirect.com/science/article/abs/pii/S0959378015000060

Environmental management

- Organisational perspective
- Value chain perspective / life cycle perspective

Environmental management principles

Environmental management principles

- Systematic approach: Plan-Do-Check-Act (PDCA)
  (also known as the Deming circle or Shewhart circle)
- Continual improvement
  - Operational performance
  - Management performance
- Auditing
  - Internal (required in ISO 14001 and EMAS)
  - External (optional in ISO 14001 and required in EMAS)

- *Standards, examples:*
  - *ISO 14001*
  - *EMAS*
  - *Eco-lighthouse*

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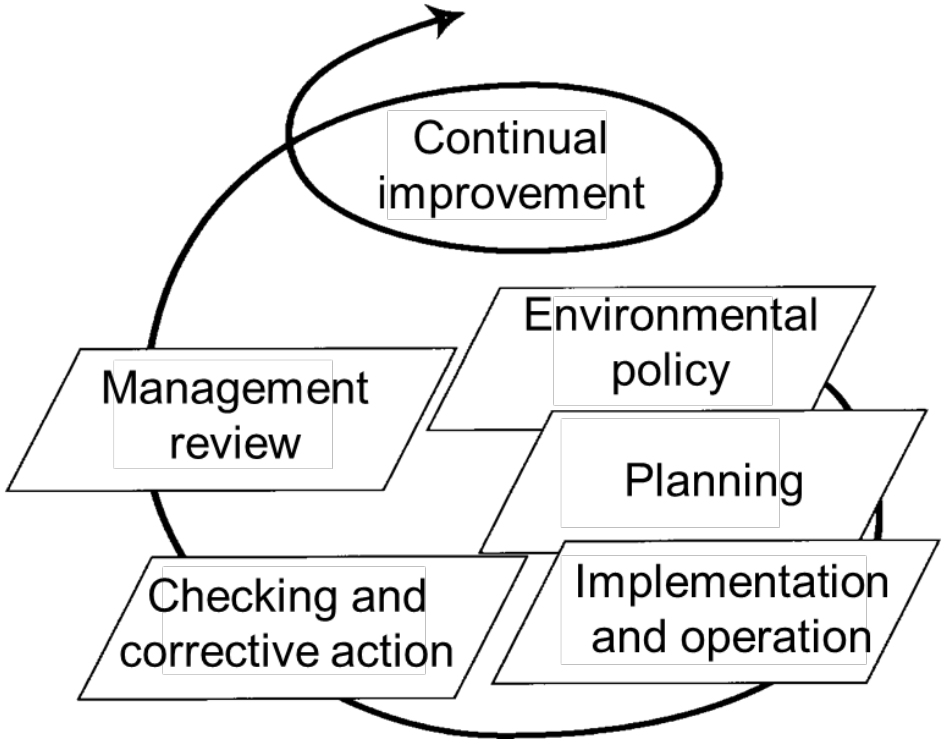

ISO14001:2004

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Environmental management principles

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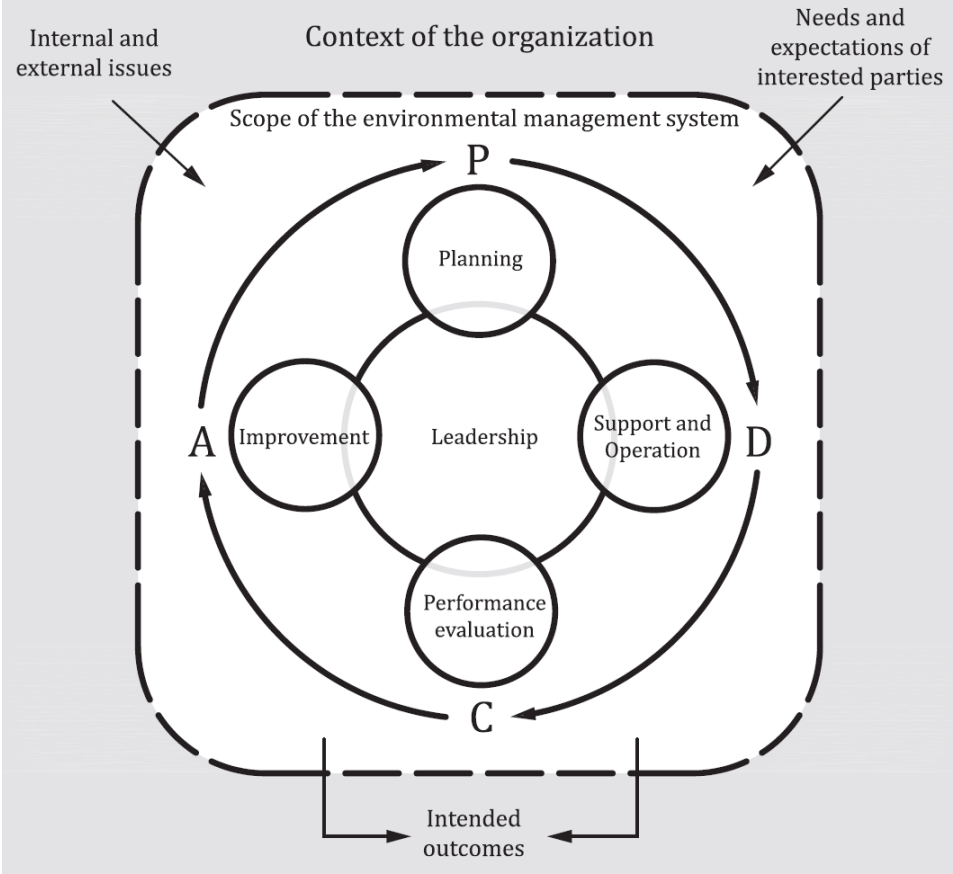

Current version: ISO14001:2015

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Environmental aspects

- What do we manage? Our significant environmental aspects

Environmental aspects

- What do we manage? Our significant **environmental aspects**

KEY CONCEPT

- An **environmental aspect** is an element of an **organization's** activities or products or services that can interact with the **environment** [ISO14001]

Environmental aspects

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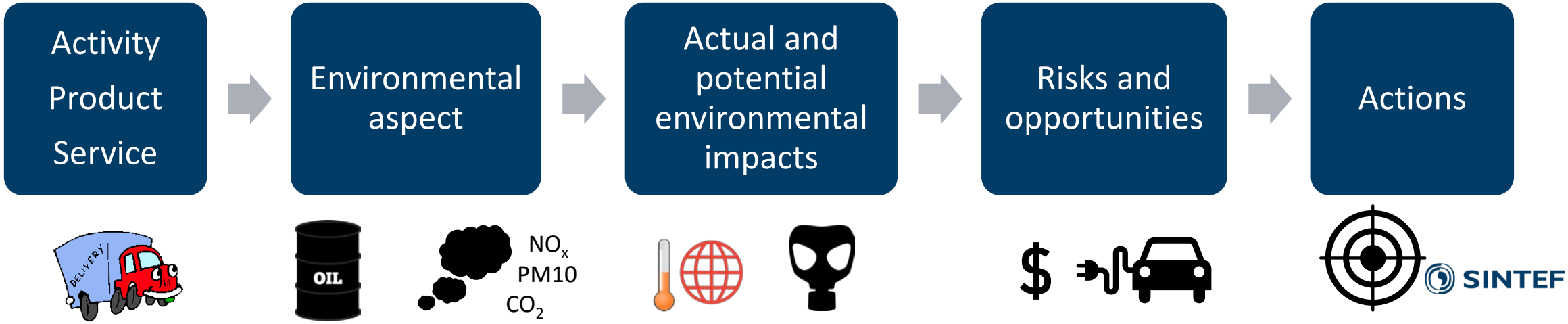


Environmental aspects

- What do we manage? Our significant **environmental aspects**

Environmental aspects

- What do we manage? Our **significant environmental aspects**

KEY CONCEPT

- Many methods to determine significance
- First ask yourself:
  - Does it have potential to harm the environment?
  - Is it controlled by legislation? *(now or in the near future)*
  - Is it of concern to your customers or the public?

Environmental aspects

<5 minutes breakout room>

Purpose: To get familiar with environmental aspects and to know the difference between *environmental aspects* and *signficant environmental aspects.*

Discussion task:

1) Select a person to present your discussion afterwards.

2) Pick a production process you know.

3) Identify two environmental aspects for this process.

4) Explain which one is the most significant of these two.

Environmental aspects

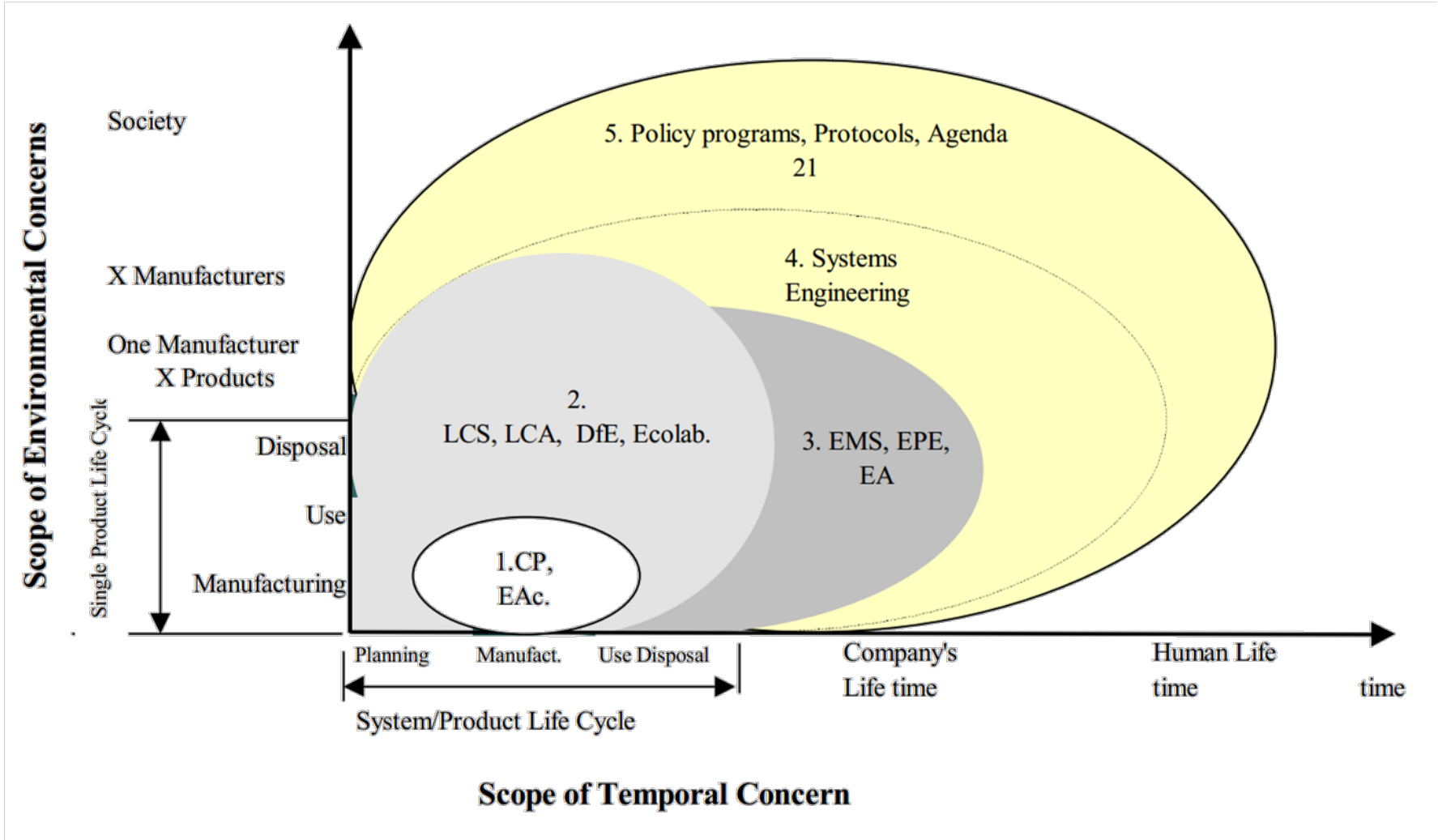
- Summing up

Environmental management toolbox

- What are our tools?
  - Depends on our purpose
  - Depends on our resources

- Next two slides: Toolbox examples

Environmental management toolbox



Fet (2000)

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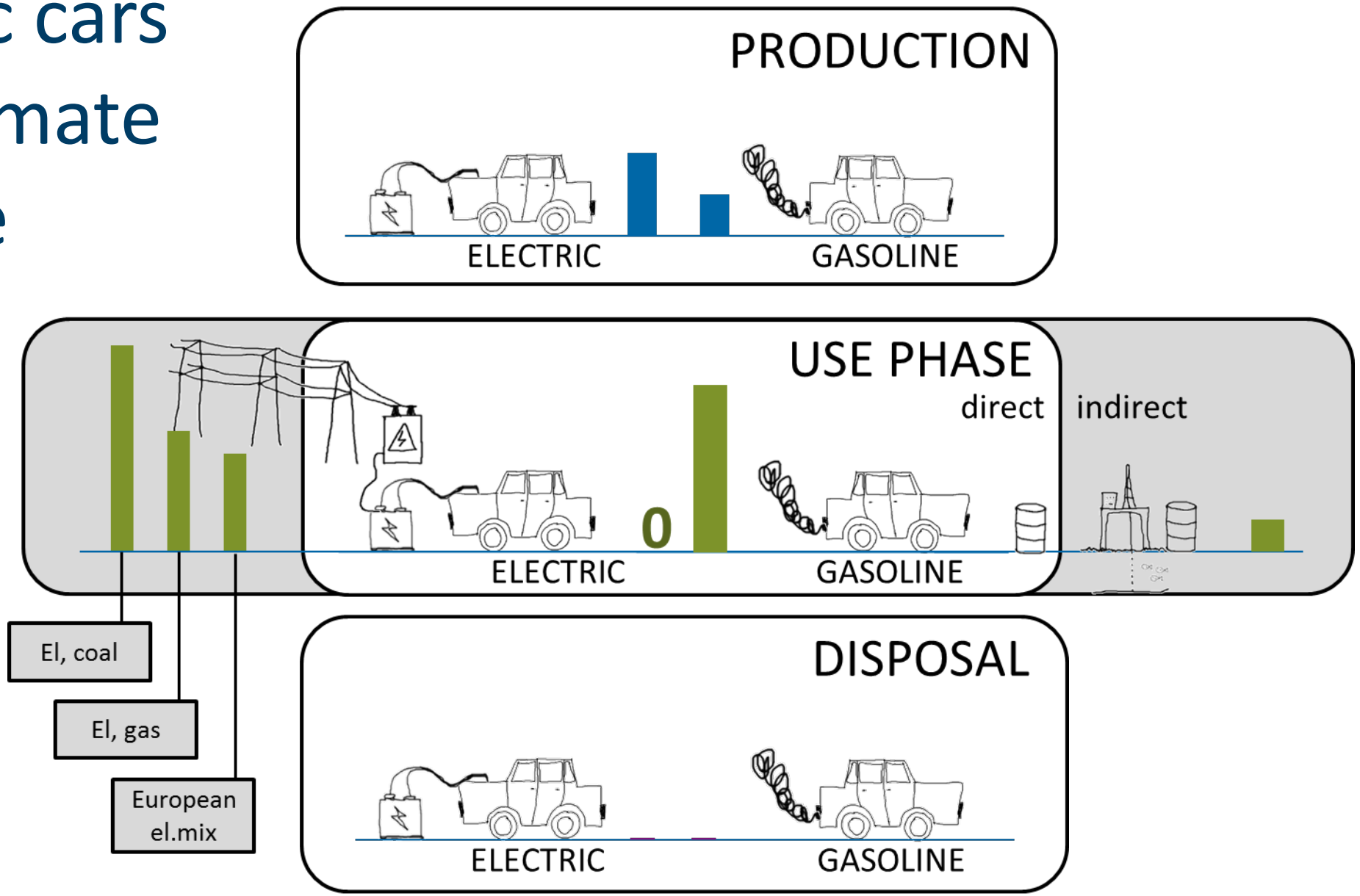
Environmental management toolbox

- Process related
  - Cleaner Production (CP)
  - Environmental accounting (EAc)
- Product related
  - Life Cycle Assessment (LCA)
  - Material, Energy and Toxicity analysis (MET)
  - Product labels/declarations
  - Design for X (DfX, x = environment, recyclability, re-use, etc.)
- Management related
  - Environmental management (EMS)
  - Environmental auditing (EA)
  - Environmental performance evaulation (EPE)

Life Cycle Assessment

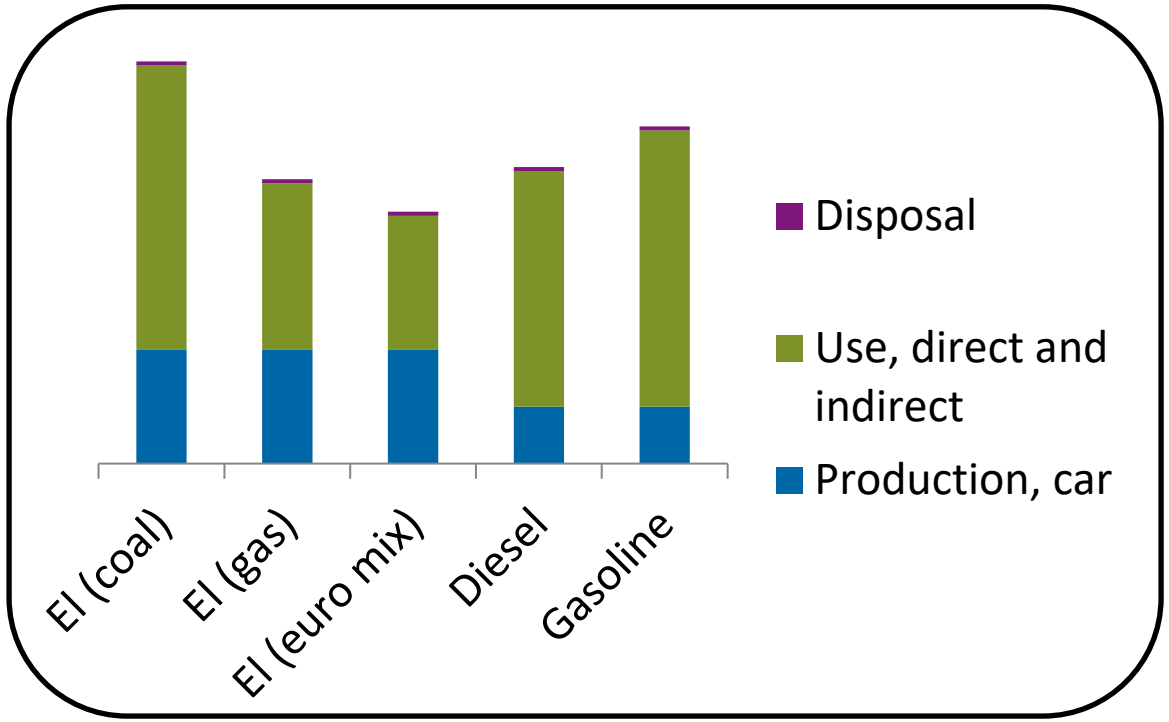
- *Key standards:*
  - *ISO 14040 Life cycle assessment — Principles and framework*
  - *ISO 14044 Life cycle assessment — Requirements and guidelines*

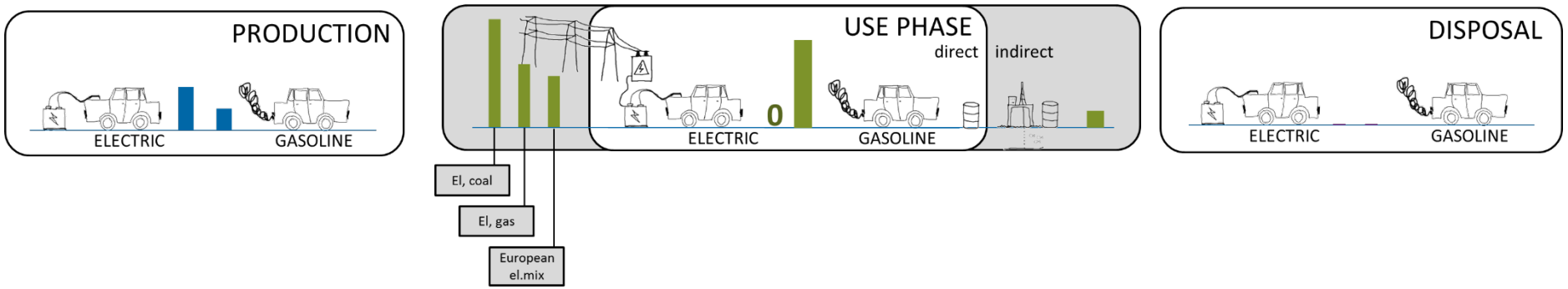
Electric cars and climate change



Hawkins et. al (2012), doi 10.1111/j.1530-9290.2012.00532.x

Electric cars and climate change





Hawkins et. al (2012), doi 10.1111/j.1530-9290.2012.00532.x

Life Cycle Assessment

- Environmental analysis: Choice of method depends on purpose
- Methodological variation in LCA, some examples:
  - **Attributional LCA**
  - Backcasting LCA
  - **Consequential LCA**
  - Decision LCA
  - Integrated LCA
  - Anticipatory LCA
  - Prospective LCA
  - Scenario-based LCA

Two key concepts in the LCA community

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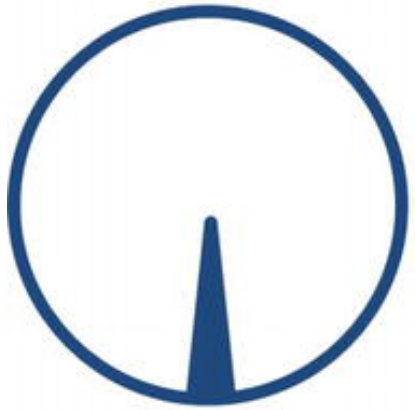
Guinée et al. 2018, https://doi.org/10.1007/s11367-018-1478-0

Background

Attributional LCA

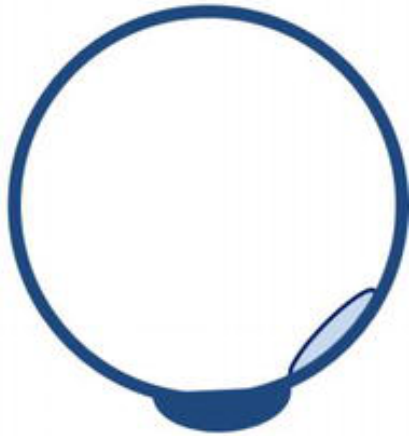


What part of the global environmental burdens should be assigned to the product?

XX kg CO2-equ.
etc.

Two types of LCA
To respond to different questions

Consequential LCA

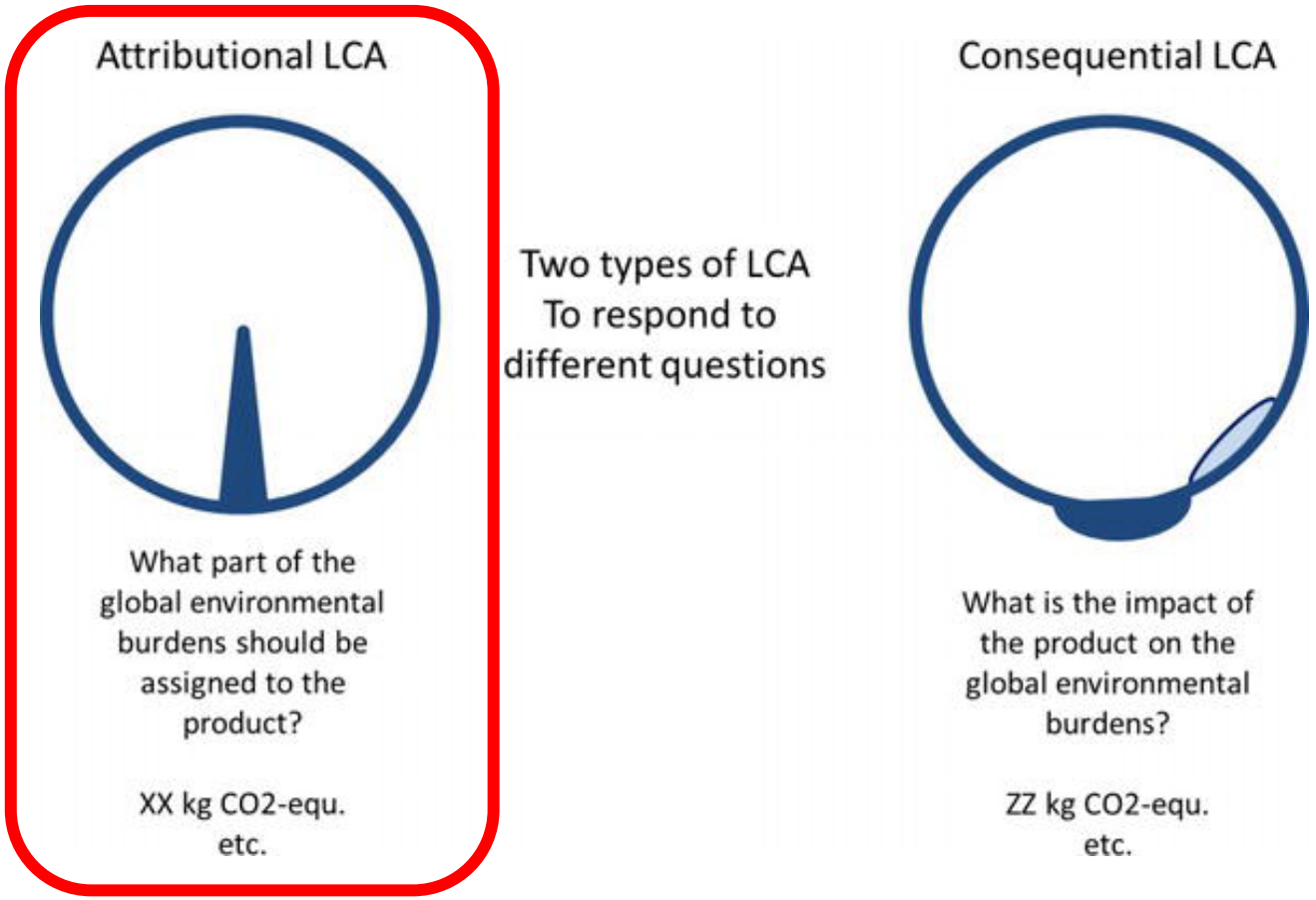


What is the impact of the product on the global environmental burdens?

ZZ kg CO2-equ.
etc.

https://www.intechopen.com/online-first/attributional-and-consequential-life-cycle-assessment

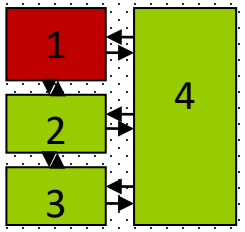
Background



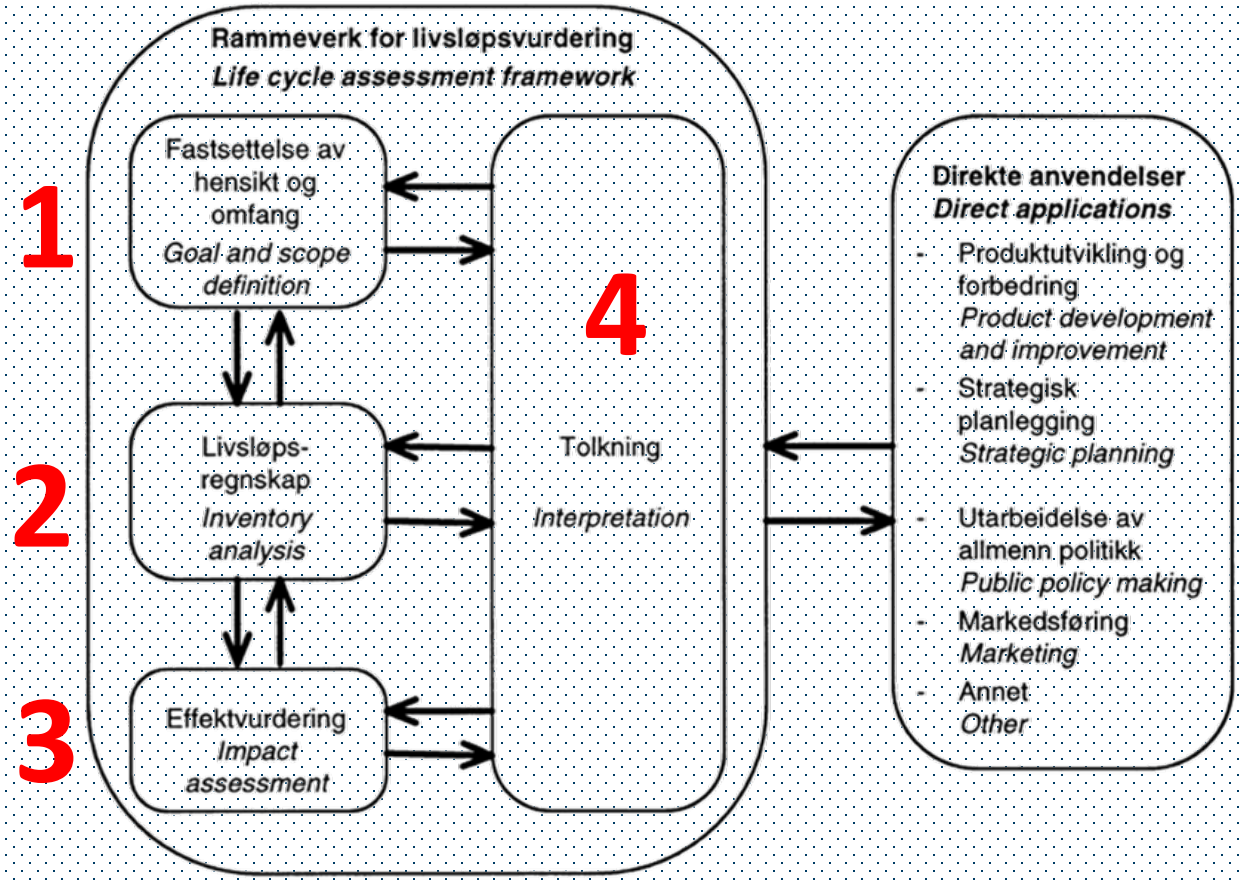
https://www.intechopen.com/online-first/attributional-and-consequential-life-cycle-assessment

Why use LCA?

- Understanding your products' environmental impact
- Product improvement *(eco-design?)*
- Comparison of products *(procurement?)*
- Advertisement / product information
- Strategic planning
- Public policy
- etc.



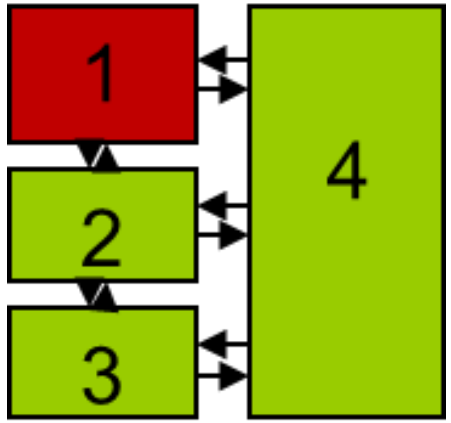
LCA methodology

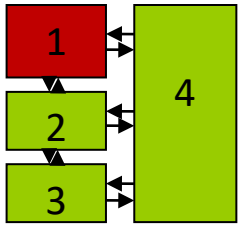


Figur 1 – Faser i en LCA
Figure 1 – Phases of an LCA

ISO 14040

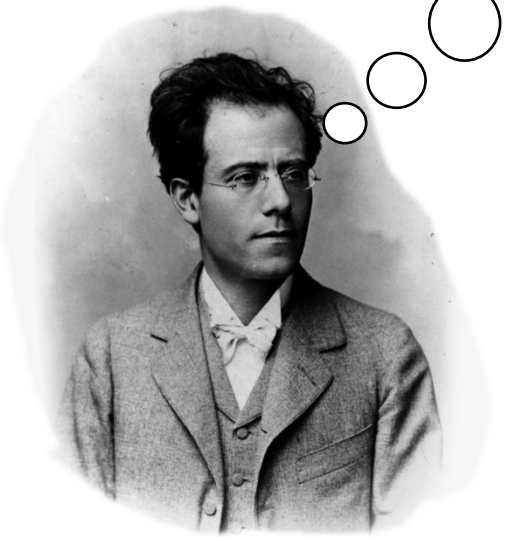
1. Goal and scope definition





FUNCTION?

Depends on context:
Who, what, how, where, when, how long, how good?



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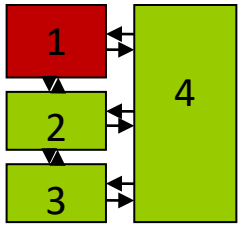

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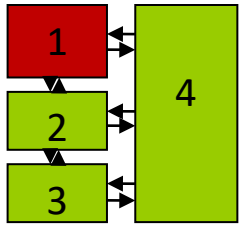
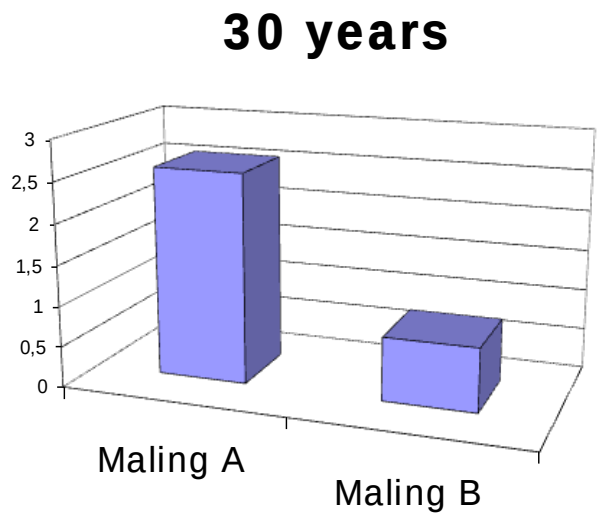


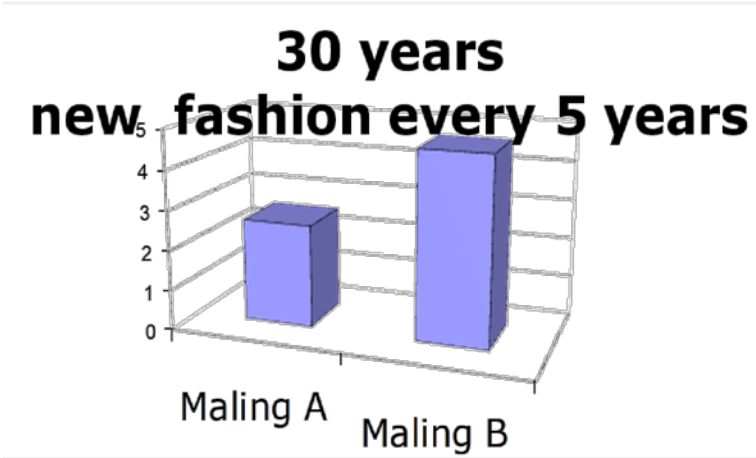
Example

Paint A
Lifetime: 5 years
Coverage: 6,5 sqm/liter
Env. load: 0,43 kg CO_2

Paint B
Lifetime: 30 years
Coverage: 6,5 sqm/liter
Env. load: 0,78 kg CO_2

Function:
Preserve wall for 30 years





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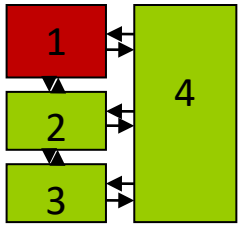
KEY CONCEPT



Funtional unit (FU)

Purpose?

- Example, paint: The function is preserving the wall. The functional unit is not ‘a can of paint’ or ‘1 liter of paint’, but rather ‘conserving 10 m^2 wall for 10 years’.
- Three dimensions
  - Quantity (‘how much?’)
  - Quality (‘how good?’)
  - Duration (‘how long?’)
- Defining a single function may be challenging, especially for complex products

https://www.metieroec.no/project/ntnu-sintef/

https://www.arkitektur-n.no/prosjekter/samfundshuset?cat=21

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Functional unit

<5 minutes breakout room>

Purpose: To get familiar with the idea of *functional units.*

Discussion task:

1) Select a person to present your discussion afterwards.

2) You are proposing a new Norwegian regulation to limit the carbon footprint of dwellings. Which functional unit would you use in the regulation?

What is the function/purpose of a house? How would we quantify it? *(functional unit)*

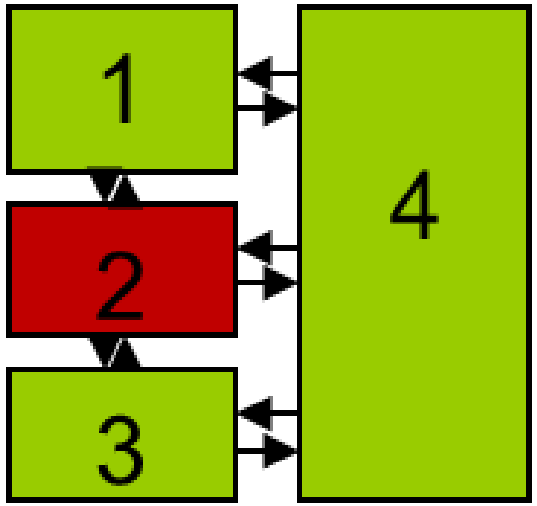
Examples of functional units in a lifetime perspective:

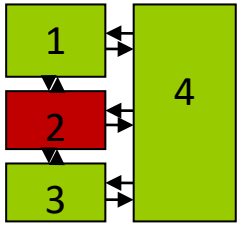
- Carbon footprint: Per house, per person, per bedroom, per m^2, per m^3, per NOK, etc.

Functional unit

- Summing up

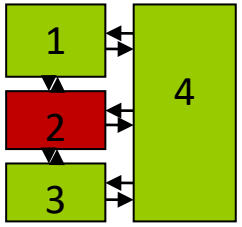
2. Life Cycle Inventory (LCI)





Life Cycle Inventory (LCI)

- Key points
  - Defining the system boundary: What is included in our system?
  - Process inventory and life cycle inventory: Which data do we need?
  - Allocation: How do we deal with joint production? (main products, co-products and bi-products)

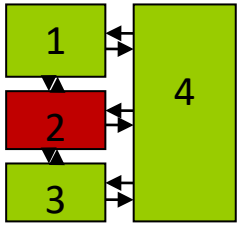


System boundaries

- What should we include and what should we exclude?

- Criteria for boundary selection = cut-off criteria
  - Preferably environment: ”all significant impacts included”
  - Sometimes mass
  - Or energy
  - Or cost
  - Often some idea (qualified guess? literature data? preliminary calculations?) about the significance of a process is used in the end to determine whether or not to include.
  - Many small left out contributions may add up to significant cut-offs. Eg. IO vs process LCA

System boundary selection:
How far back in the value chain should we look?



Life Cycle Emission Distributions 925

Upstream in the value chain

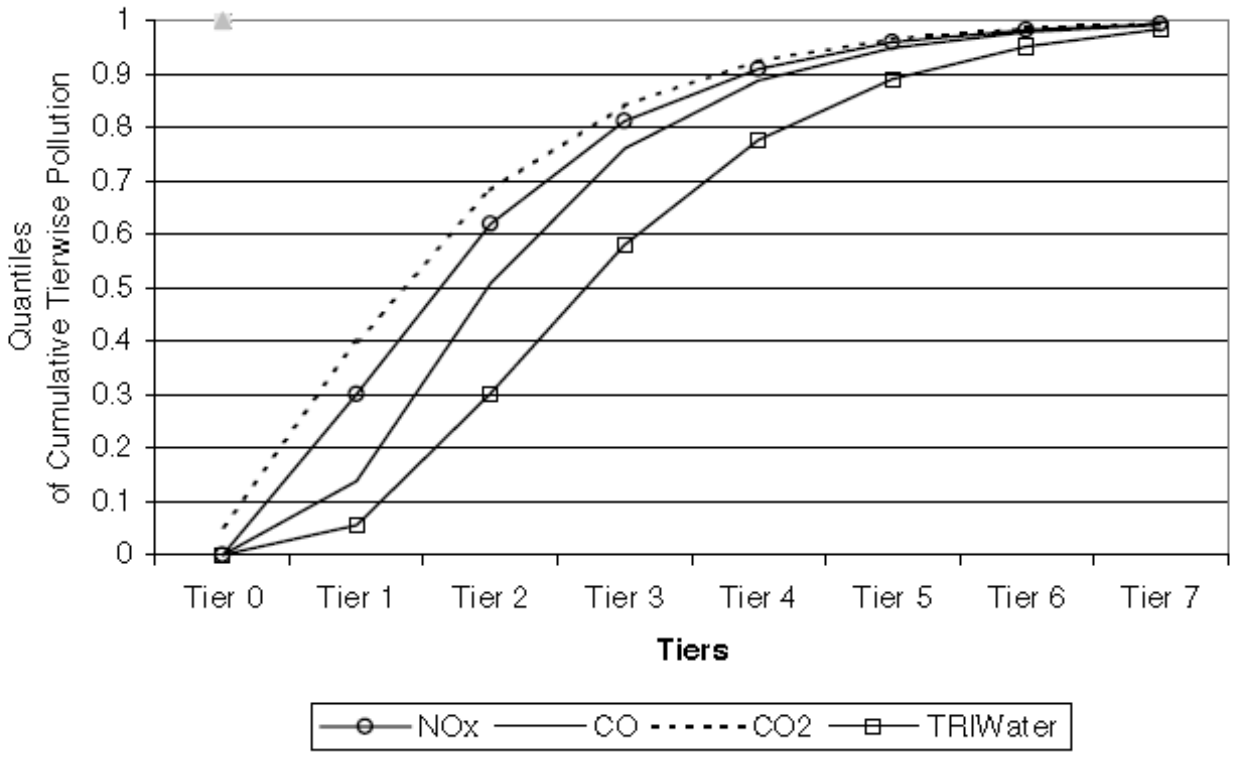


Fig. 4. 25th percentiles for upstream convergence, by pollutant type; convergence is slower than indicated for 25% of the commodities in the U.S. economy.

Norris 2002

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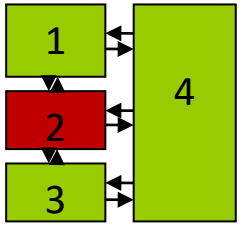
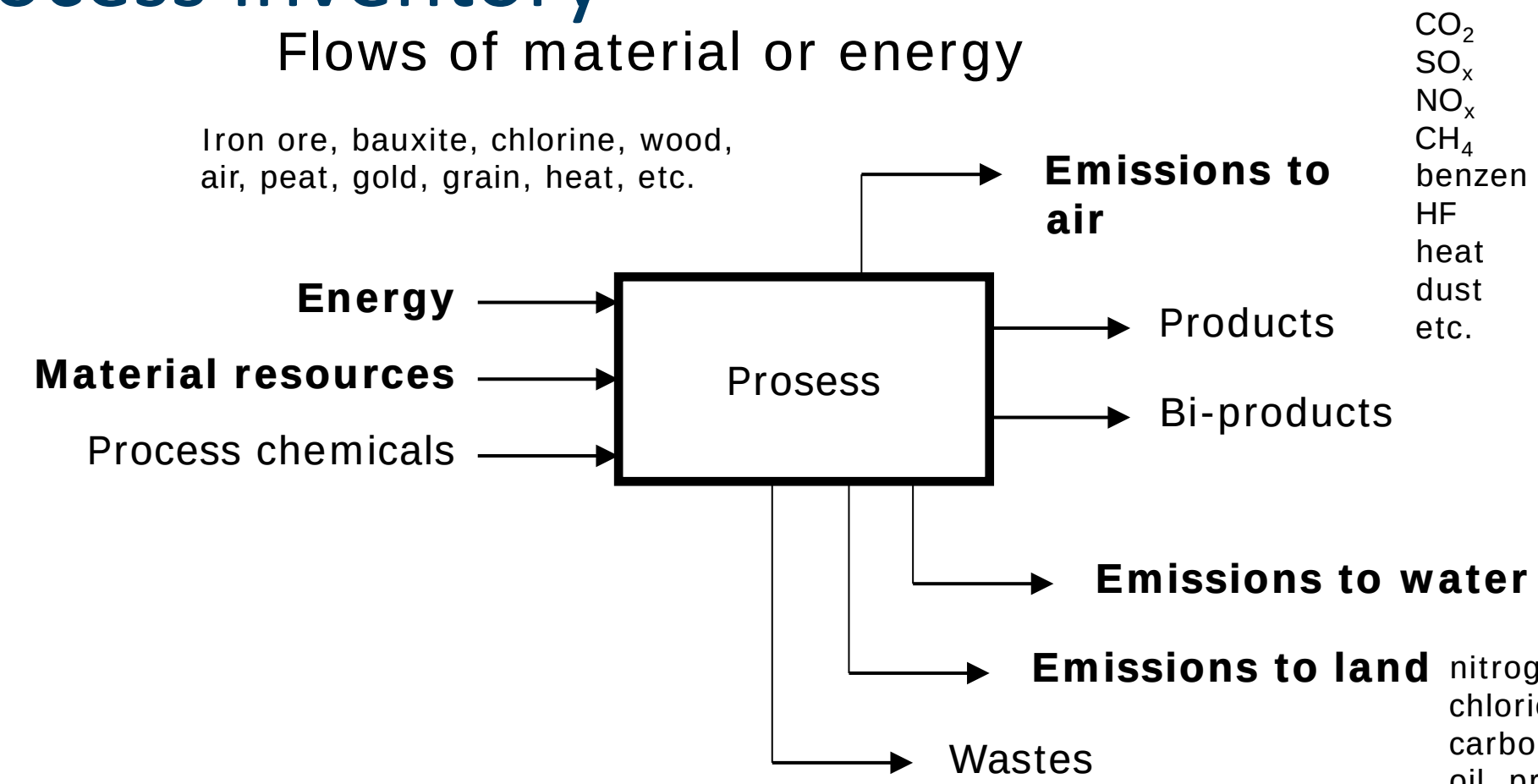


Process inventory

Flows of material or energy



Elementary flows: *from nature to our system / to nature from our system*

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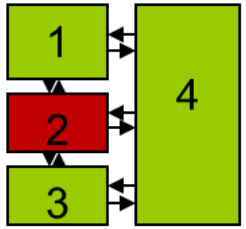
Life Cycle Inventory



SO_x
NO_x
CH_4
benzene
HF
dust
etc.

Iron ore, copper ore, sand, bauxite, silicon, chlorine, kaolin, wood, water, air, peat, corn, gold, stone, soil, etc.

Σ Energy

Material resources

Σ

Technosphere

Σ Emissions to air

Σ Emissions to water

Emissions to soil

Σ

nitrogen, arsenic, hydrogen chloride, pesticides, oil, process water, hydrogen chloride, etc.

Calculate the elementary inputs and outputs for all processes we have in our system.

Elementary flows: from nature to our system / to nature from our system

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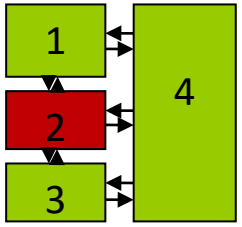
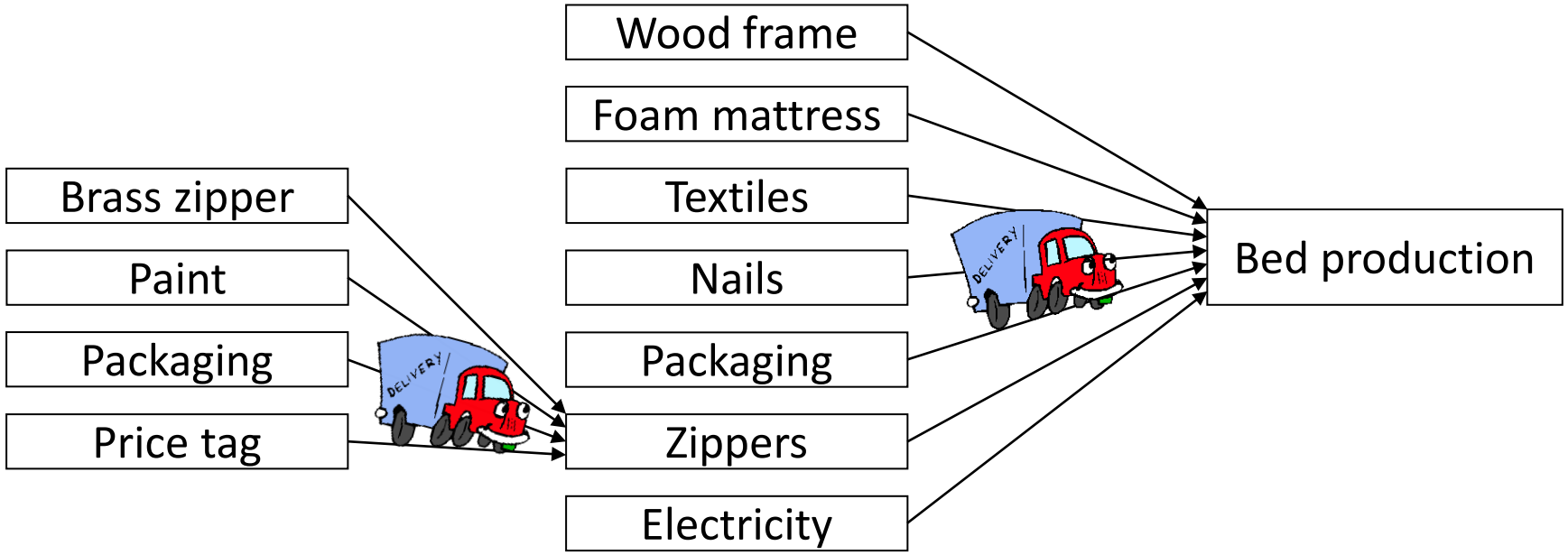


2. Inventory
Flow diagram

The criteria for system boundaries are defined in the goal and scope phase. A simple criterion can be:

- Include all significant processes



Which processes are significant for our study?

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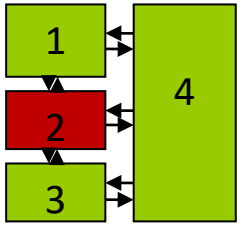
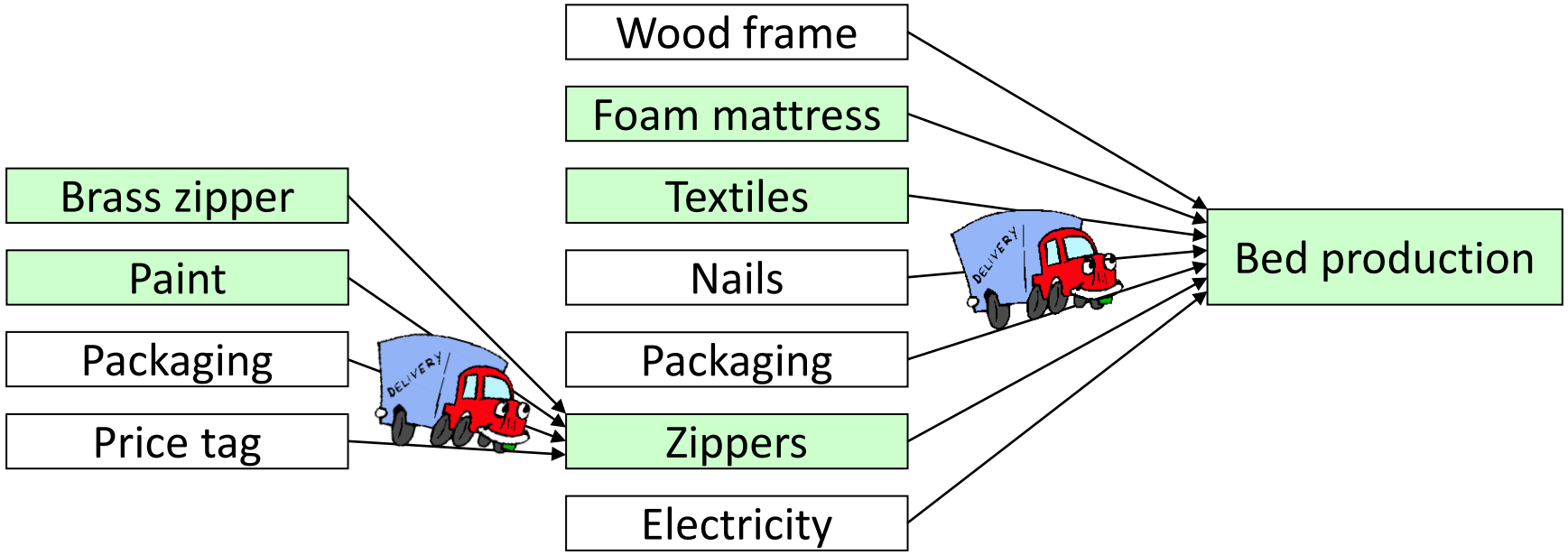


2. Inventory *(complexity)*
Foreground and background system

- Foreground: specific data gathered by you
- Background: generic data from databases



Example: here our goal is to improve the mattress in a bed,
we therefore decide to use generic/average data for the rest of the bed

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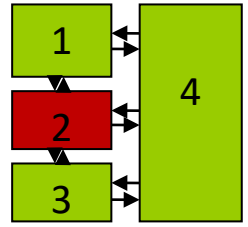
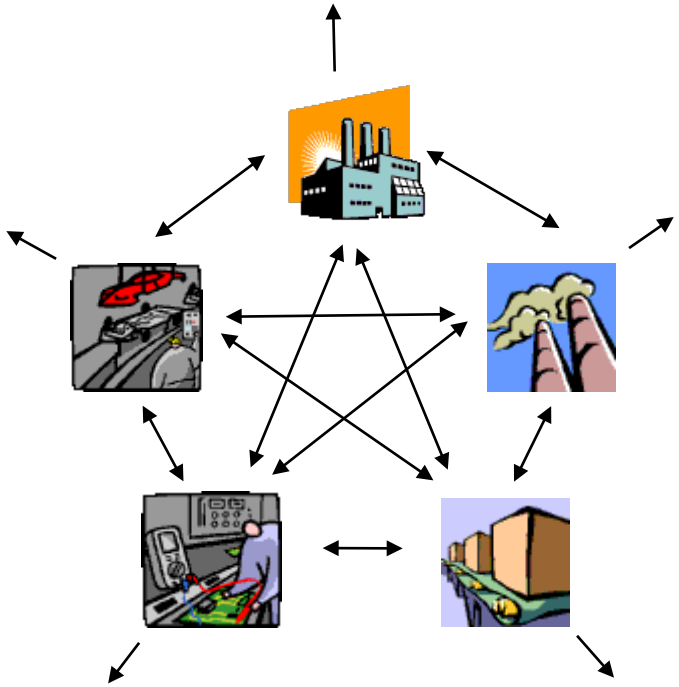
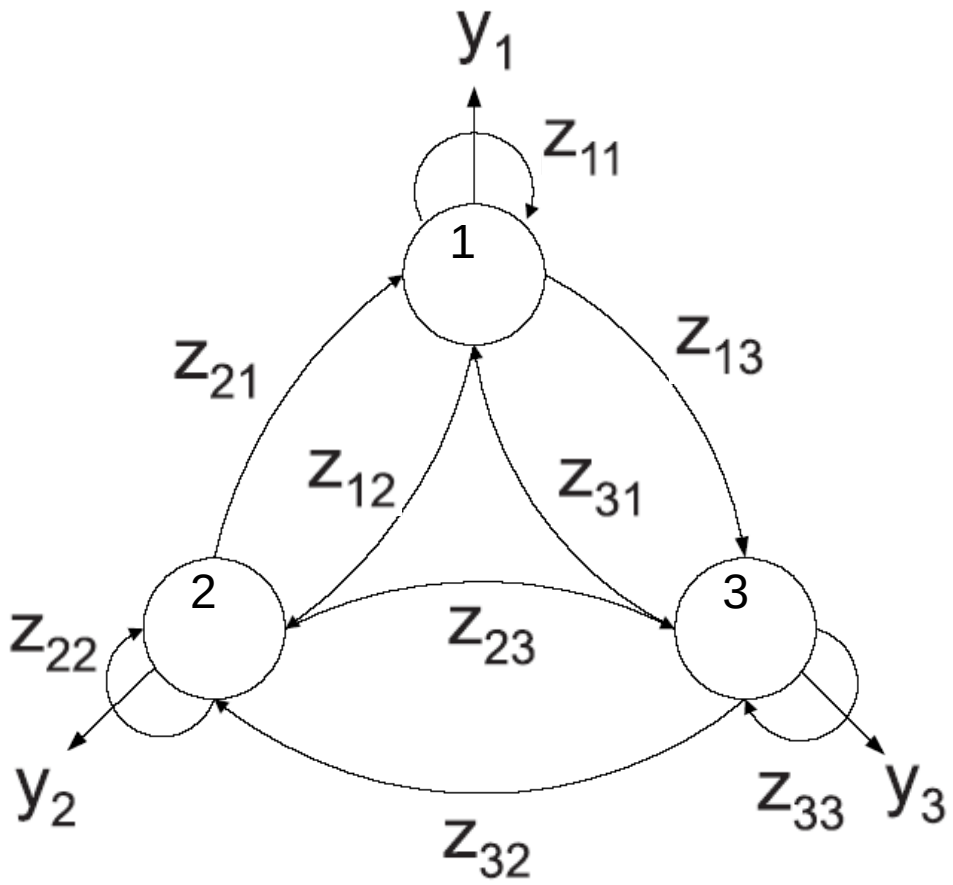


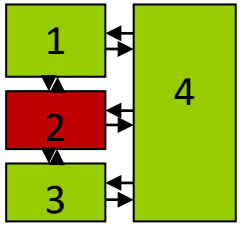
Calculating the flow (open Leontief model)



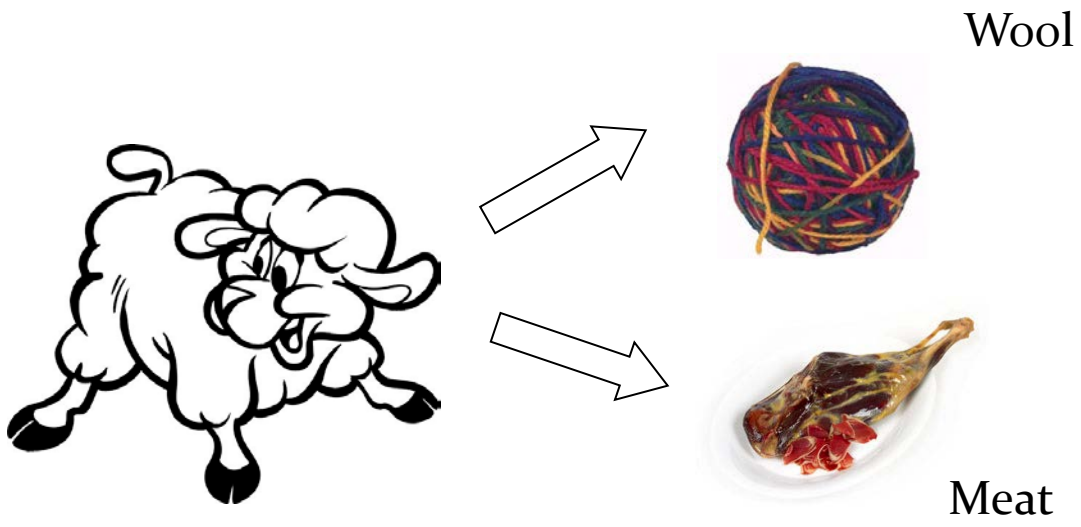


"...the system of economic interrelationships may be represented as a long path describing a wide circle and ending up again at its starting point. All along the way, it branches off into numerous smaller paths, some of which interweave in all manner of combinations..." Leontief (1928).

Source: Solli and Strømman (2005)



Allocation



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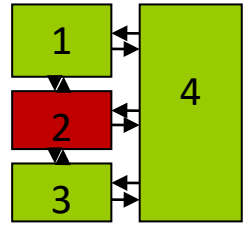
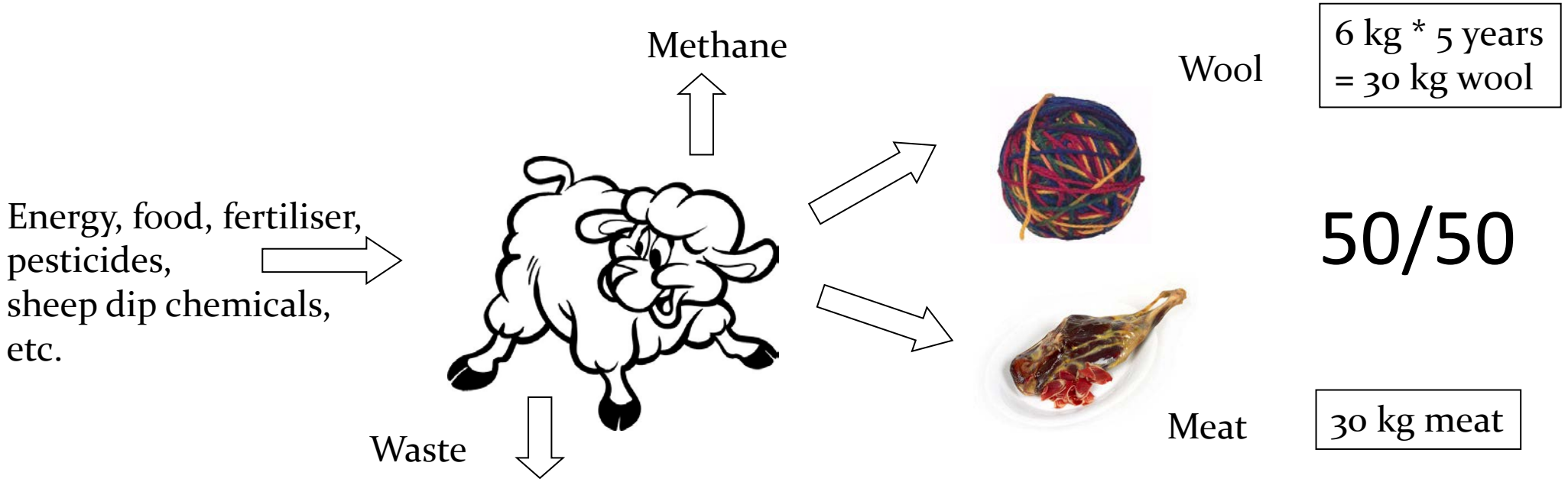


Allocation

Key question: How do we assign the environmental impacts to wool and meat?



Potential solutions:

- Avoid allocation
- Use physical properties
- Use economic values
- Use other methods

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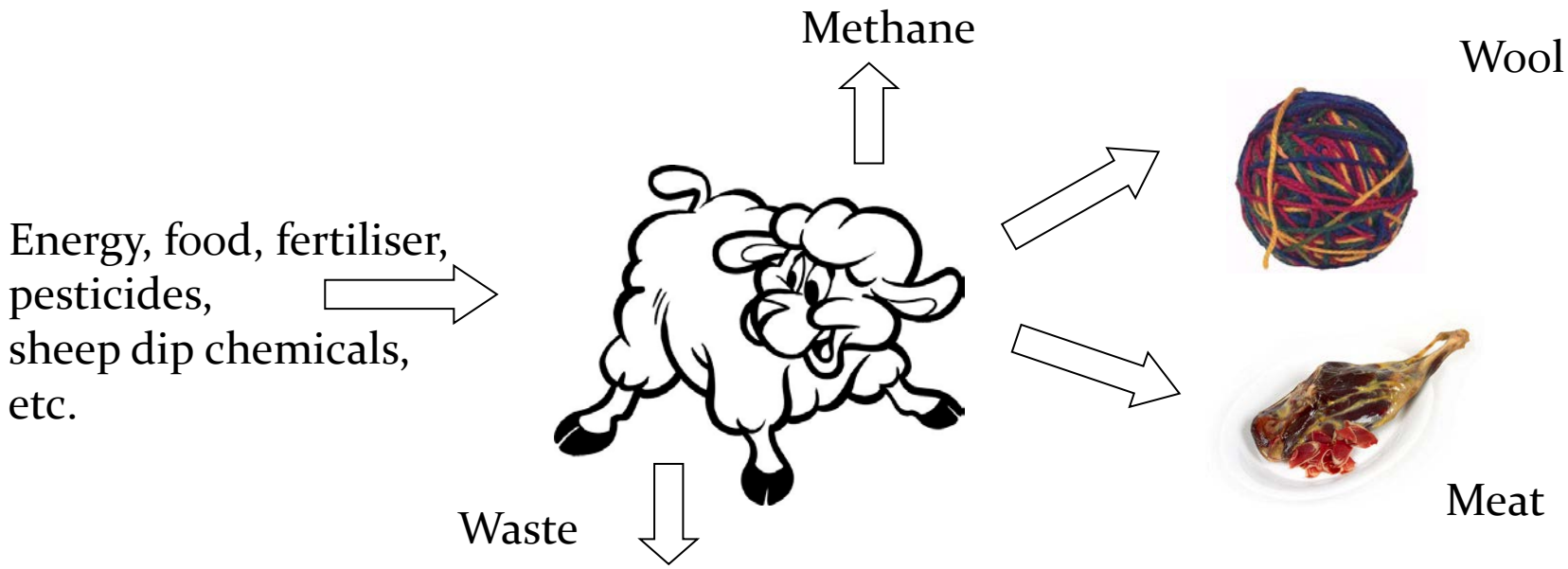
Allocation

Key question: How do we assign the environmental impacts to wool and meat?



6 kg * 5 years
= 30 kg wool
* 7 kroner / kg
= 210 kroner

20/80

30 kg meat
* 30 kroner / kg
= 900 kroner

Potential solutions:

- Avoid allocation
- Use physical properties
- Use economic values
- Use other methods

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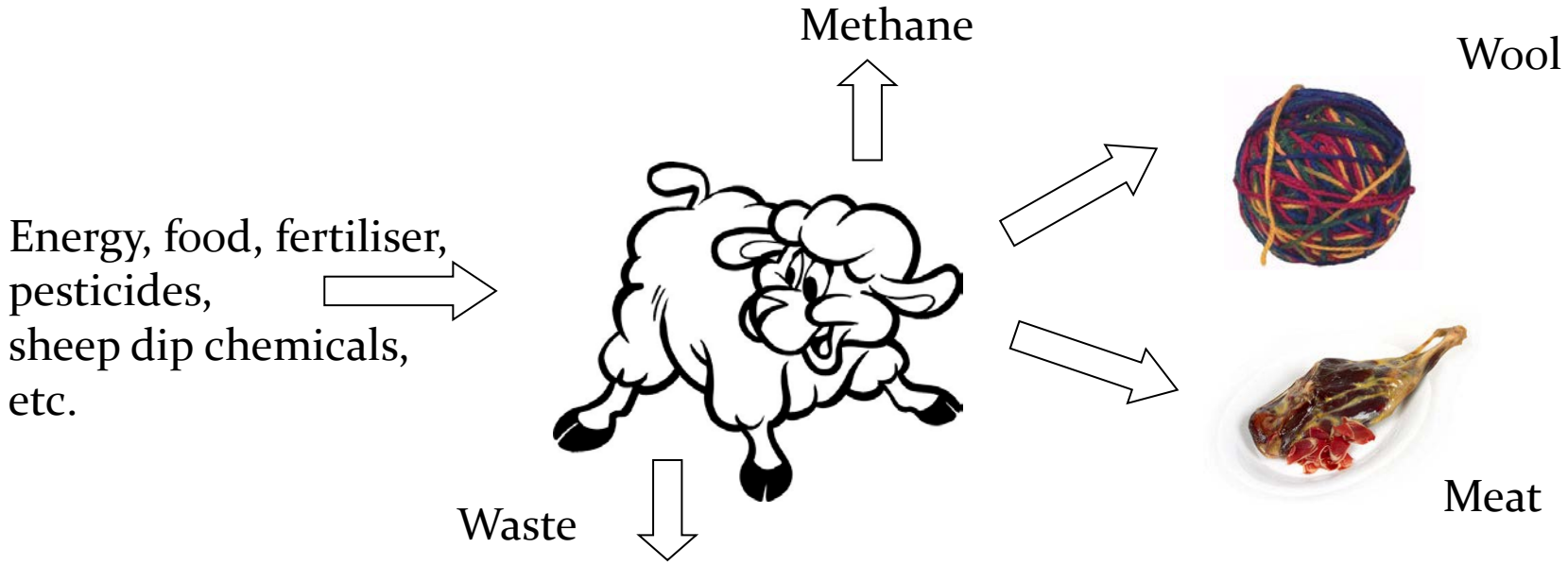
Allocation

KEY CONCEPT

Key question: How do we assign the environmental impacts to wool and meat?



Potential solutions:

- Avoid allocation
- Use physical properties
- Use economic values
- Use other methods

Recommendation: Consider what the main purpose of the process is.

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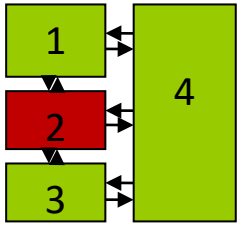

Allocation: Minerals

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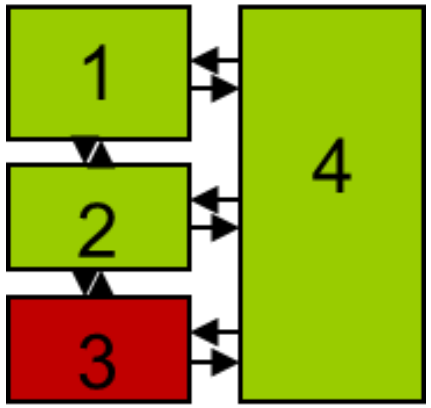
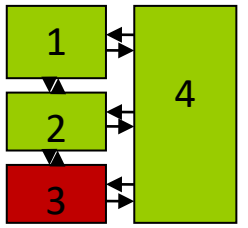
doi: 10.1371/journal.pone.0101298

3. Life Cycle Impact Assessment (LCIA)



Life Cycle Impact Assessment

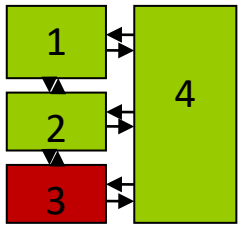
- Key points
  - General LCIA methodology in 5 steps: 3 mandatory + 2 optional
  - Key indicator challenge: Midpoint or endpoint?



Life Cycle Impact Assessment

- The life cycle inventory: all elementary flows, e.g.:
  - Inputs: Coal, iron ore, energy, biomass, etc.
  - Outputs: CO_2 and SO_2 to air, particles to water, tailings, etc.
- To understand the impact on the environment, we need to know the effect of every elementary stream
- Impact assessment
  a) Identify environmental impact categories
  b) Classification
  c) Characterisation
  d) Normalisation
  e) Weighting

NB: Normalisation and weighting are non-scientific (they are value based).



Life Cycle Impact Assessment

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- To understand the impact on the environment, we need to know the effect of every elementary stream
- Impact assessment
  - **a) Identify environmental impact categories**
  - **b) Classification** *Mandatory*
  - **c) Characterisation**
  - d) Normalisation
  - e) Weighting

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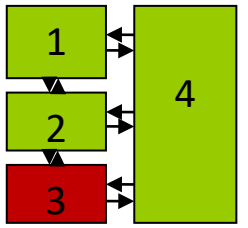

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Optional

NB: Normalisation and weighting are non-scientific (they are value based).

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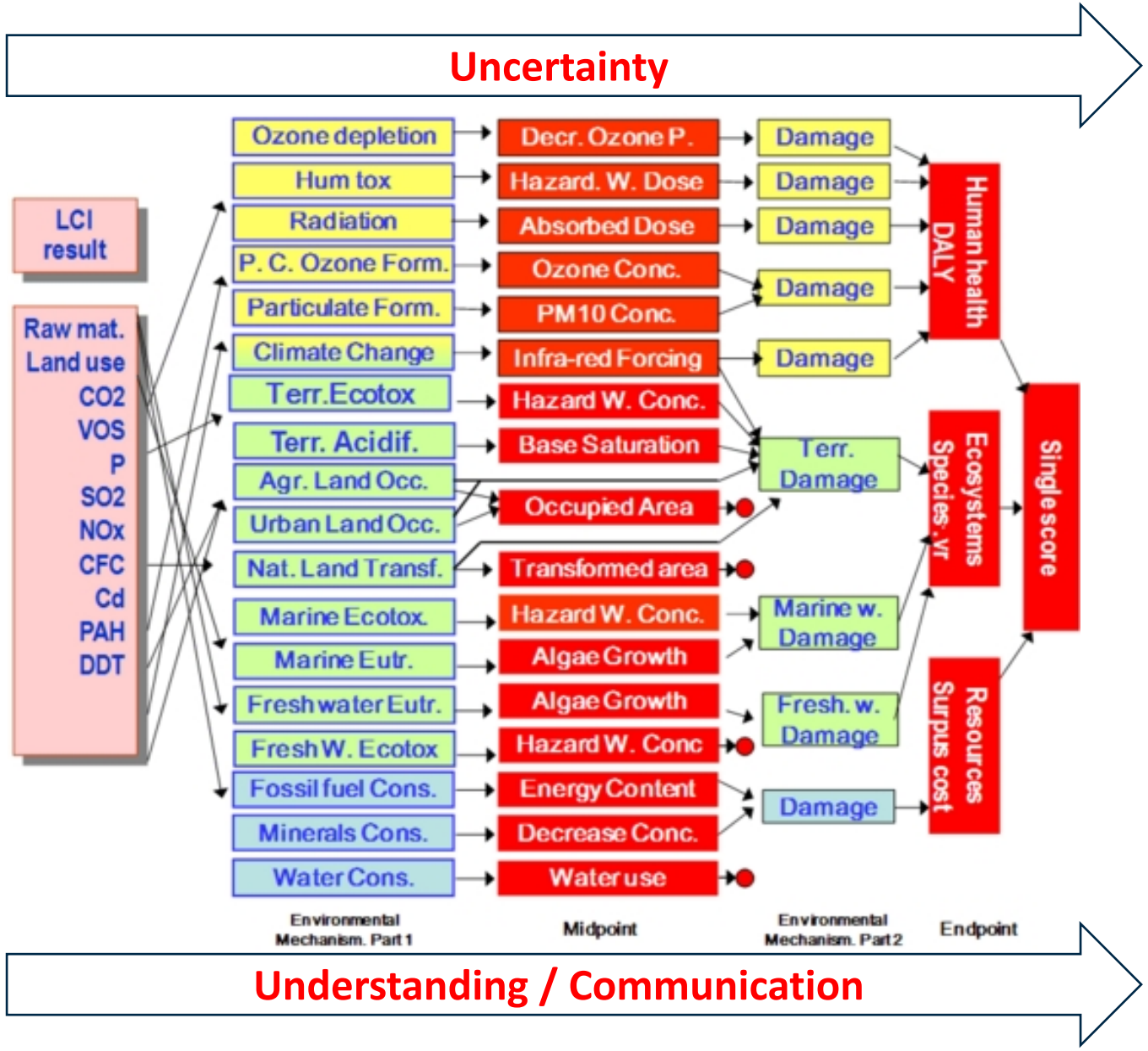
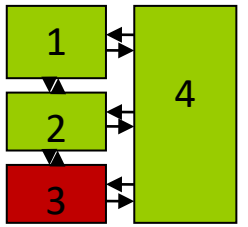
Midpoint or endpoint?





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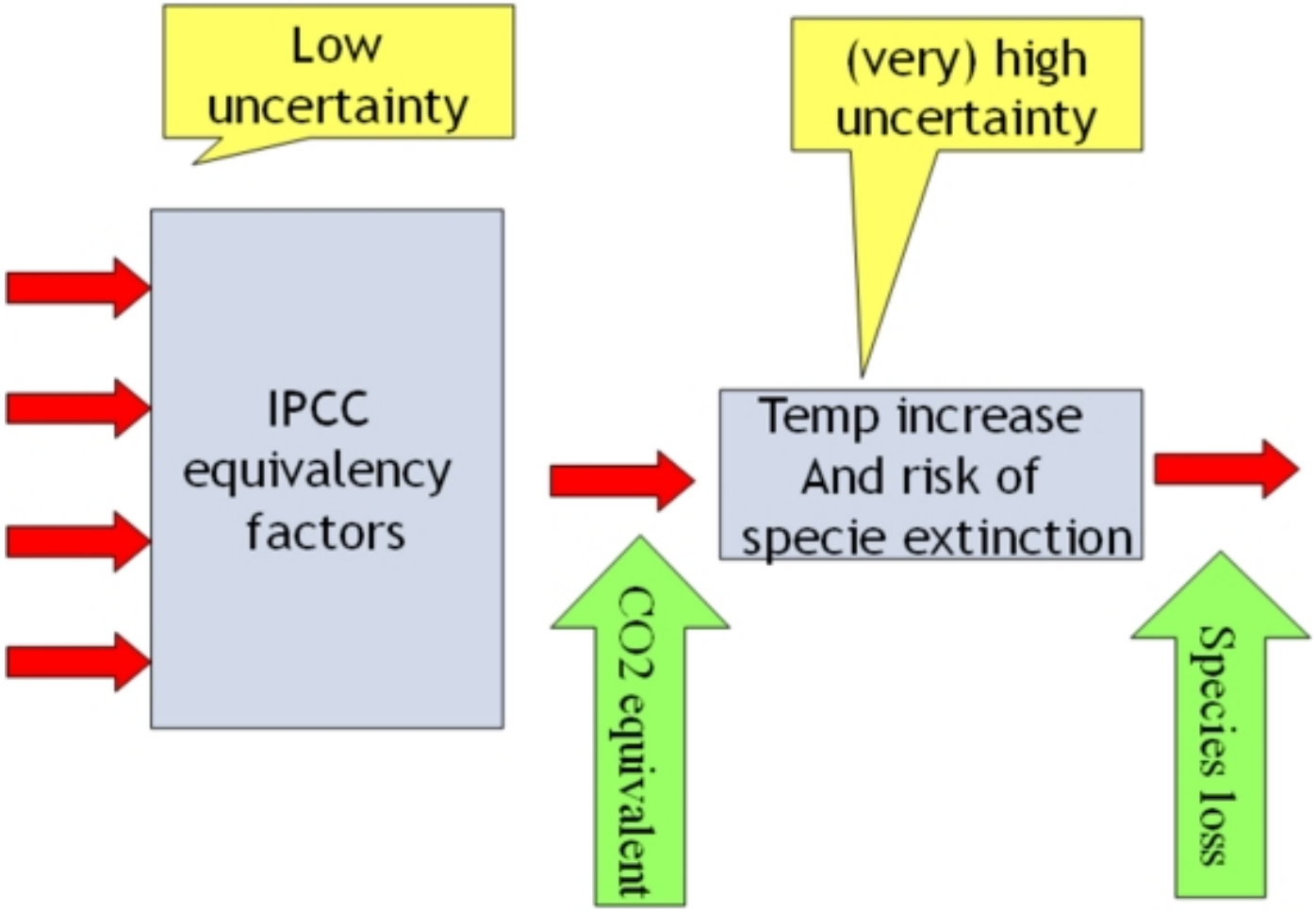
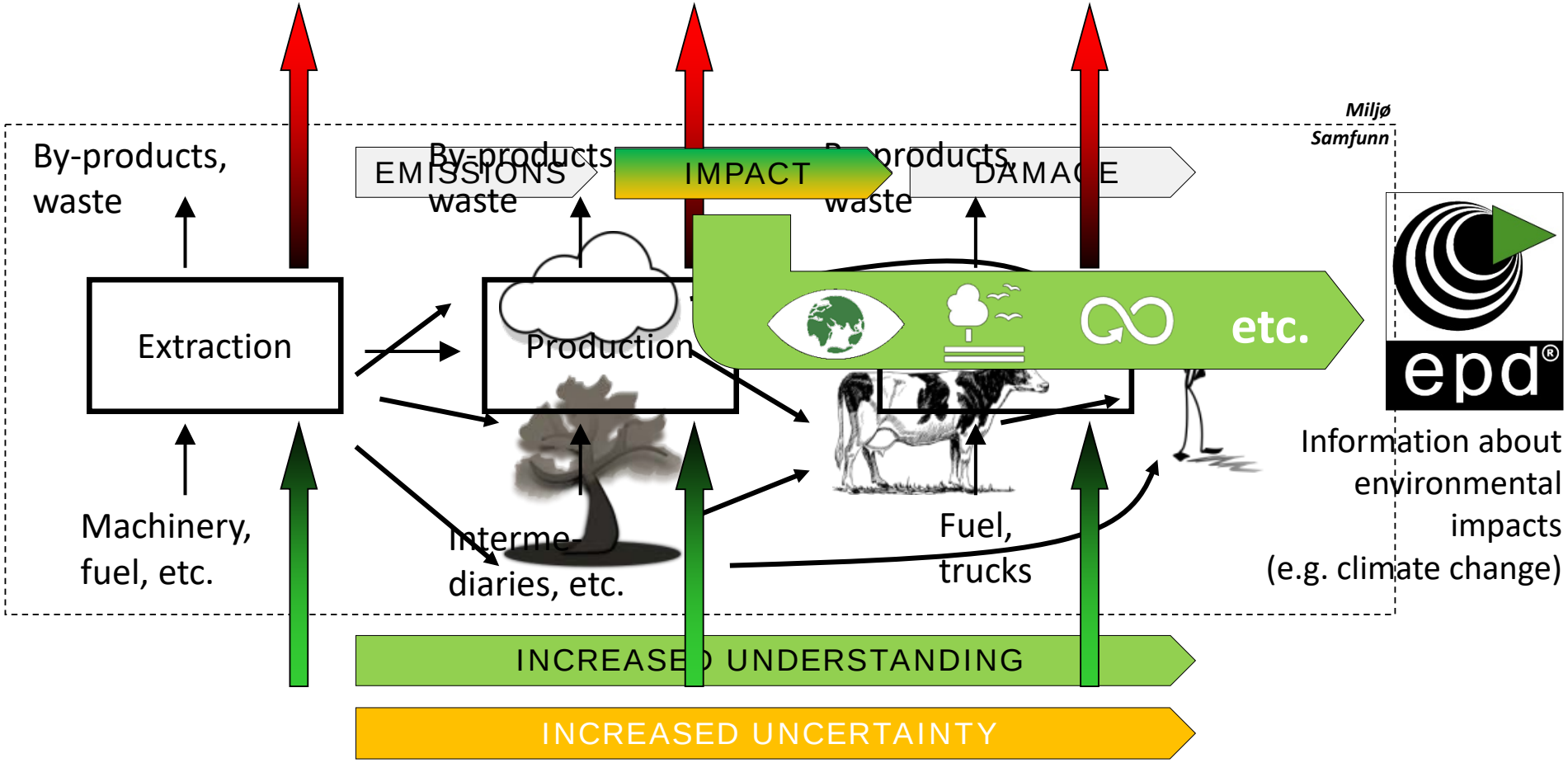
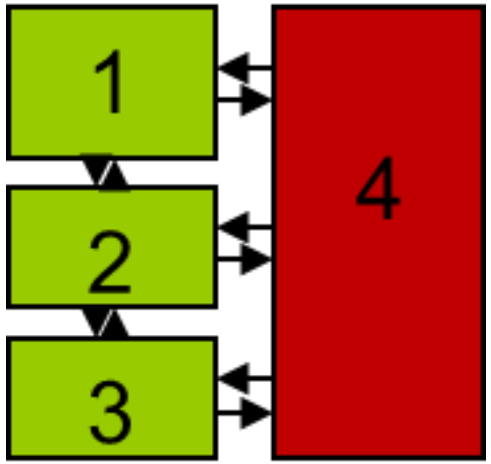
Midpoint or endpoint?
Global warming

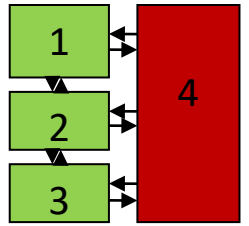


Example:
Environmental Product Declarations (EPD)



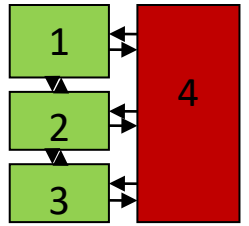
4. Interpretation





Interpretation

- Identify the significant issues
- Evaluate your results, e.g.
  - Completeness of data
  - Sensitivity to uncertainty and methodological choices
  - Consistency throughout the study
- Conclusions, limitations, recommendations



Interpretation *in practice*

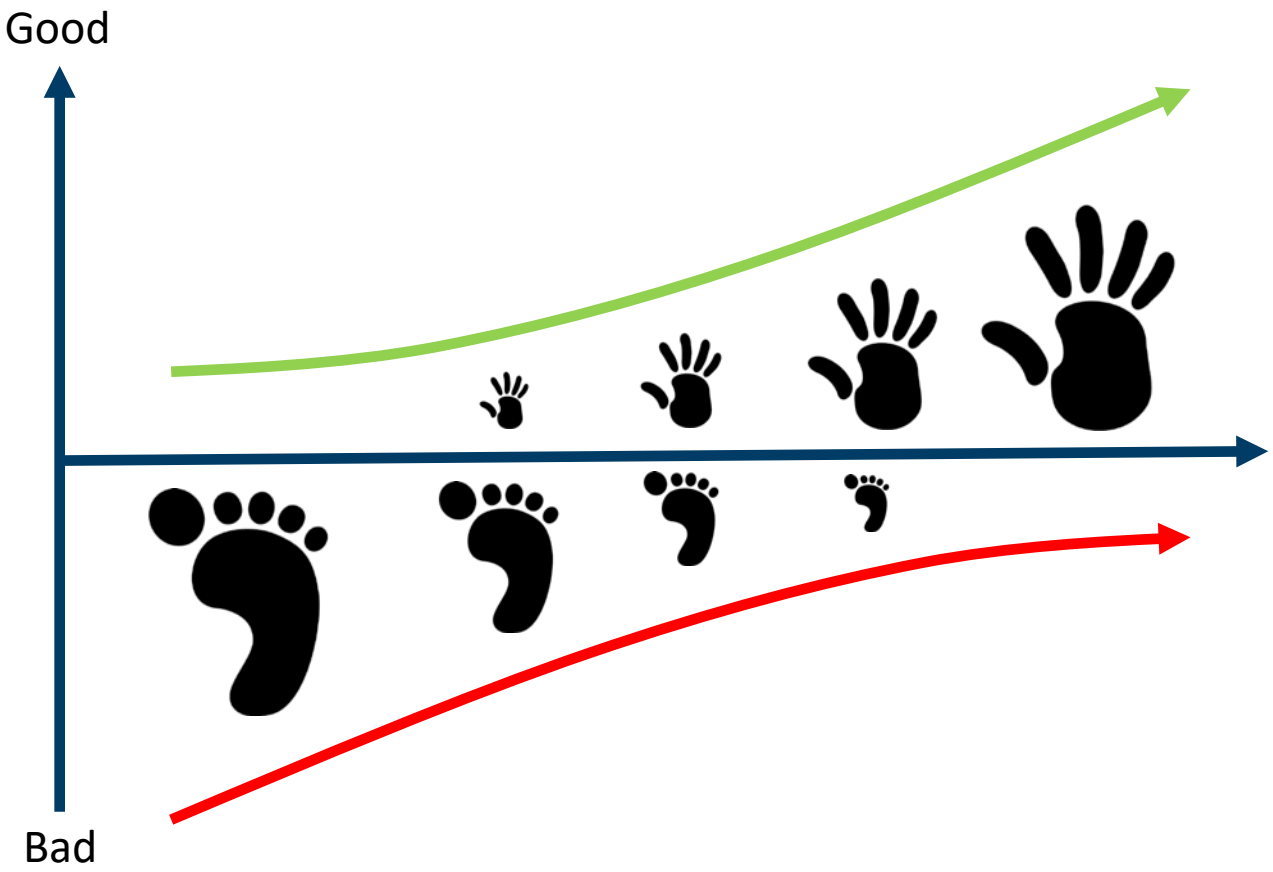
- Get to know the relevant production system(s) in your model!
- Leave time for multiple iterations on goal and scope + inventory
- New results can lead to new understanding
- Errors will occur, analyze often to identify errors.

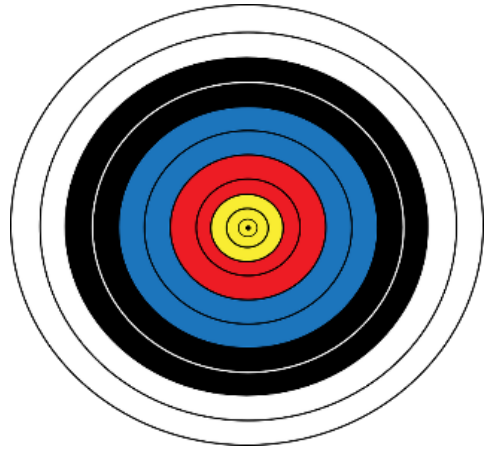
Summing up

Summing up (1/2)

- Keep the big picture in mind (sustainability)
- Be systematic and focus on continual improvement (environmental management)
- Use the right tools for the right questions (e.g. to know when LCA will be useful)
- Be aware of the limitations of your approach

Summing up (2/2)





LCA can help set targets and guide action

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Questions and check-out

- **Questions?**

- **Check-out: Were your initial expectations met?**
  (this will also guide development of the next lectures)

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