Welcome to

Life Cycle Assessment (AG2800)

Div. Environmental Strategies Research - fms
Dept. Sustainable development, Environmental science and Engineering (SEED)

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Göran Finnveden (Lectures)

Today (L1)

- Intro LCA (what, why, how, history)
- Examples - Food for thought for your projects
- Practical course info

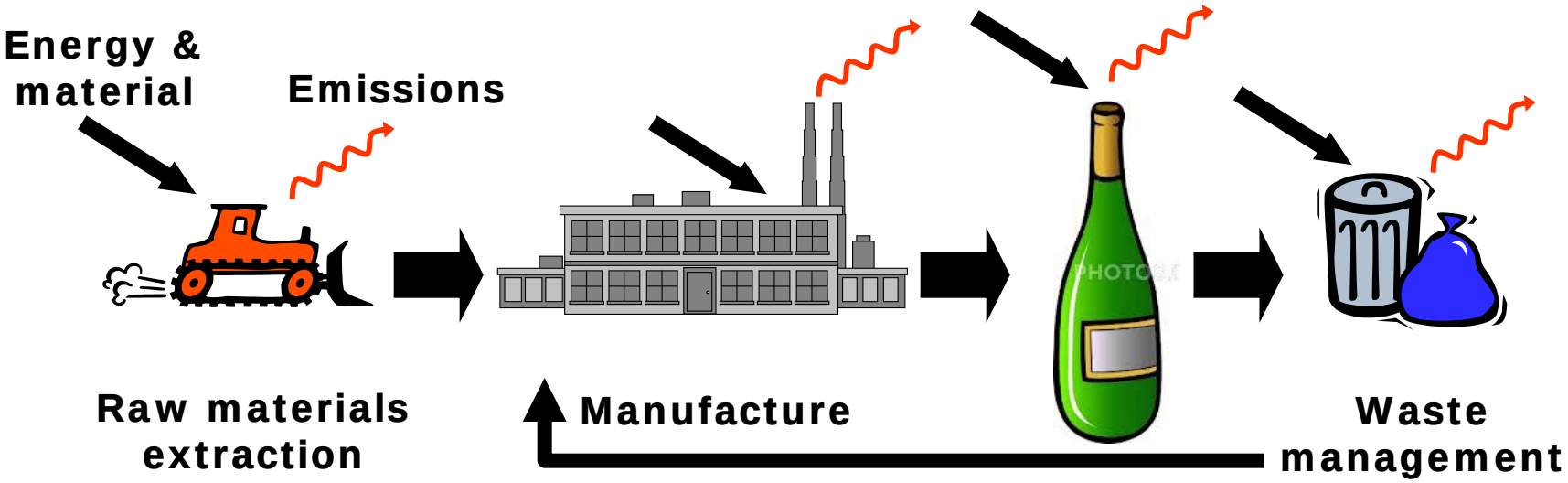
Next lecture

- Goal & scope definition in LCA
- Generate project ideas & form project groups

- What’s the environmental impact of a glass bottle?

- Which is better; aluminium cans, PET bottles, or glass bottles?

Life cycle assessment of a glass bottle

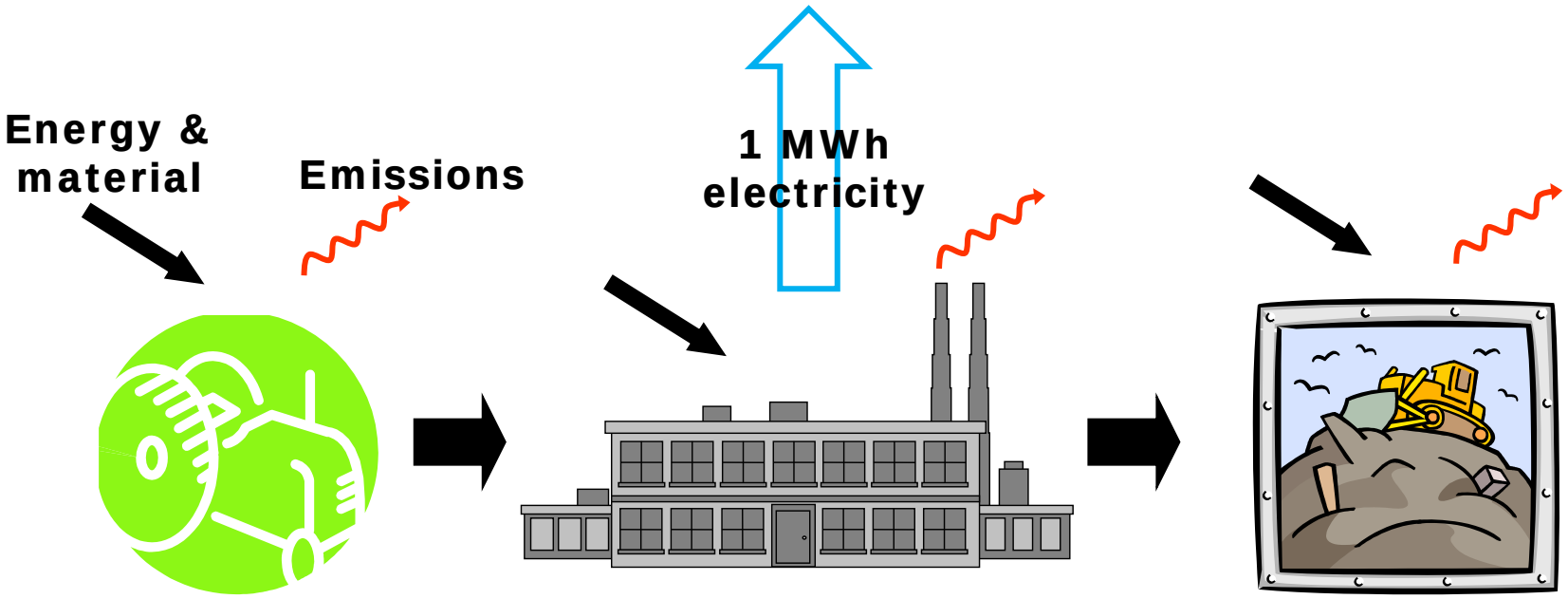


- Cradle-to-grave
- Resource use & emissions
- Direct & indirect

- Focus on *function*
- Stand-alone or comparative
- Accounting or change-oriented

- Typically not site-specific
- *Potential* impacts

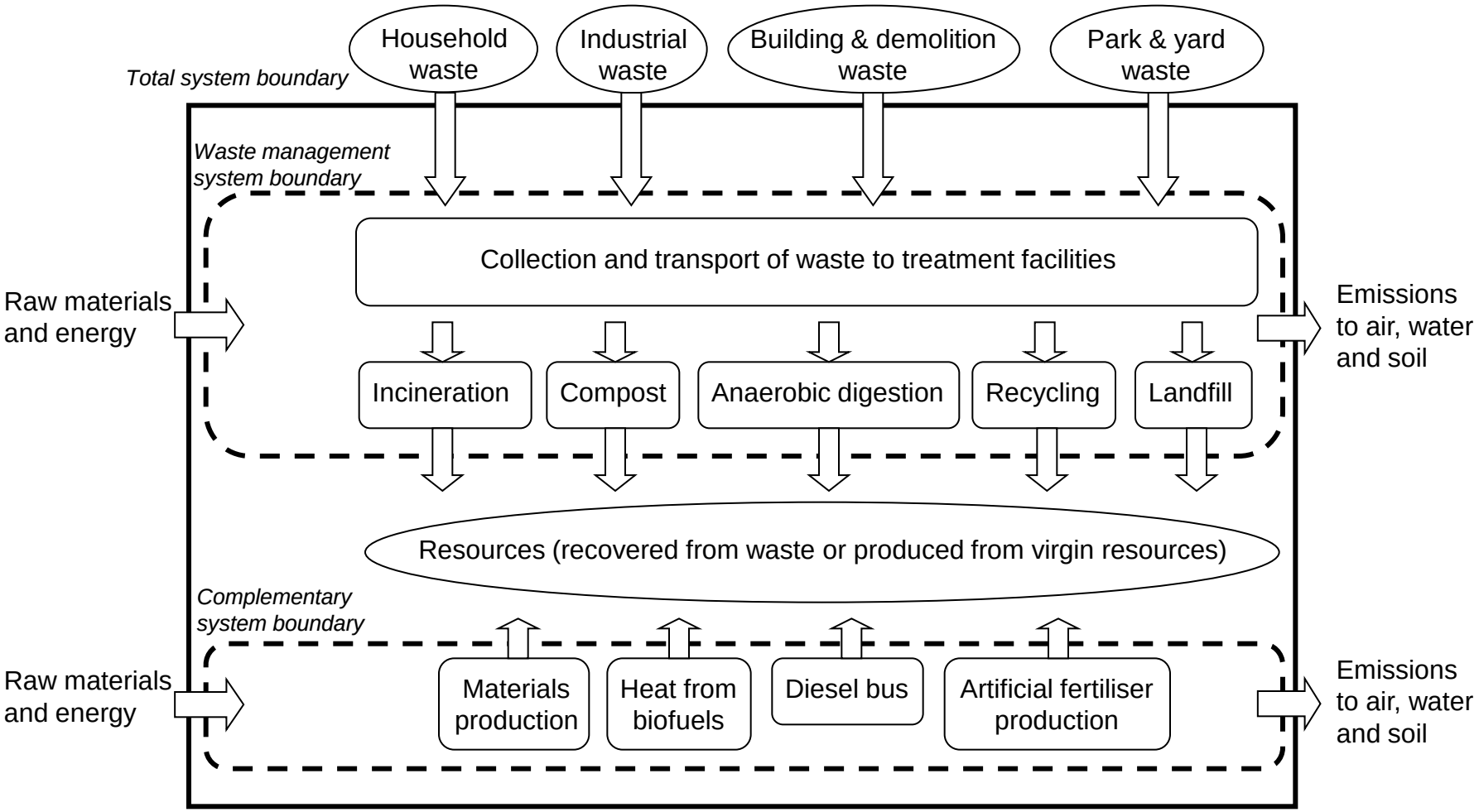
LCA of electricity from salix



- What's the environmental impact of 1 MWh electricity from biofuels?
- What processes in the production chain cause the major impacts?
- How would a certain process improvement affect the overall impact?
- Which alternative has higher overall impact – biofuels or hydro?

LCA of a waste management system

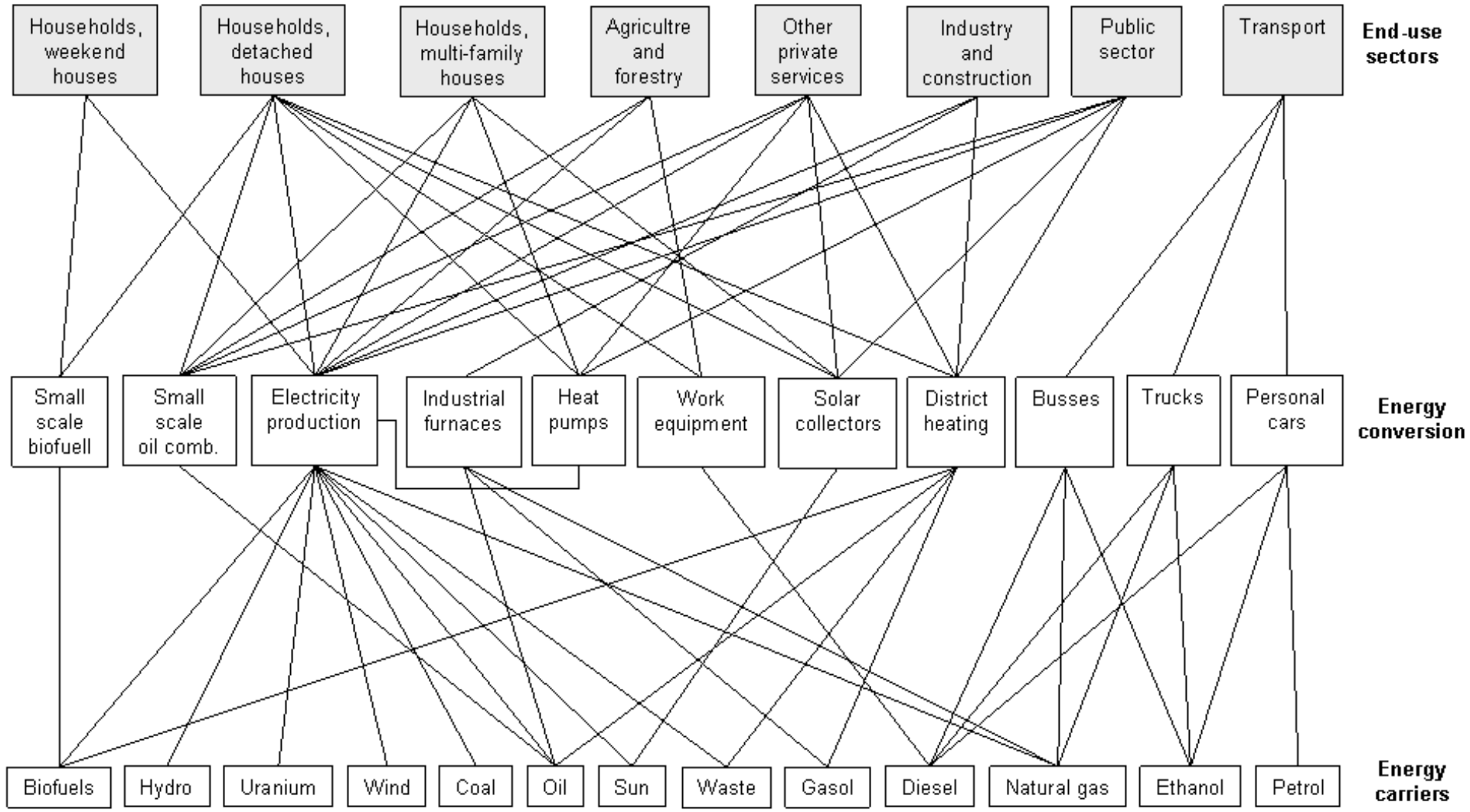
(e.g. for comparison of alternative treatment of waste)



Björklund and Finnveden
Waste management, 2003

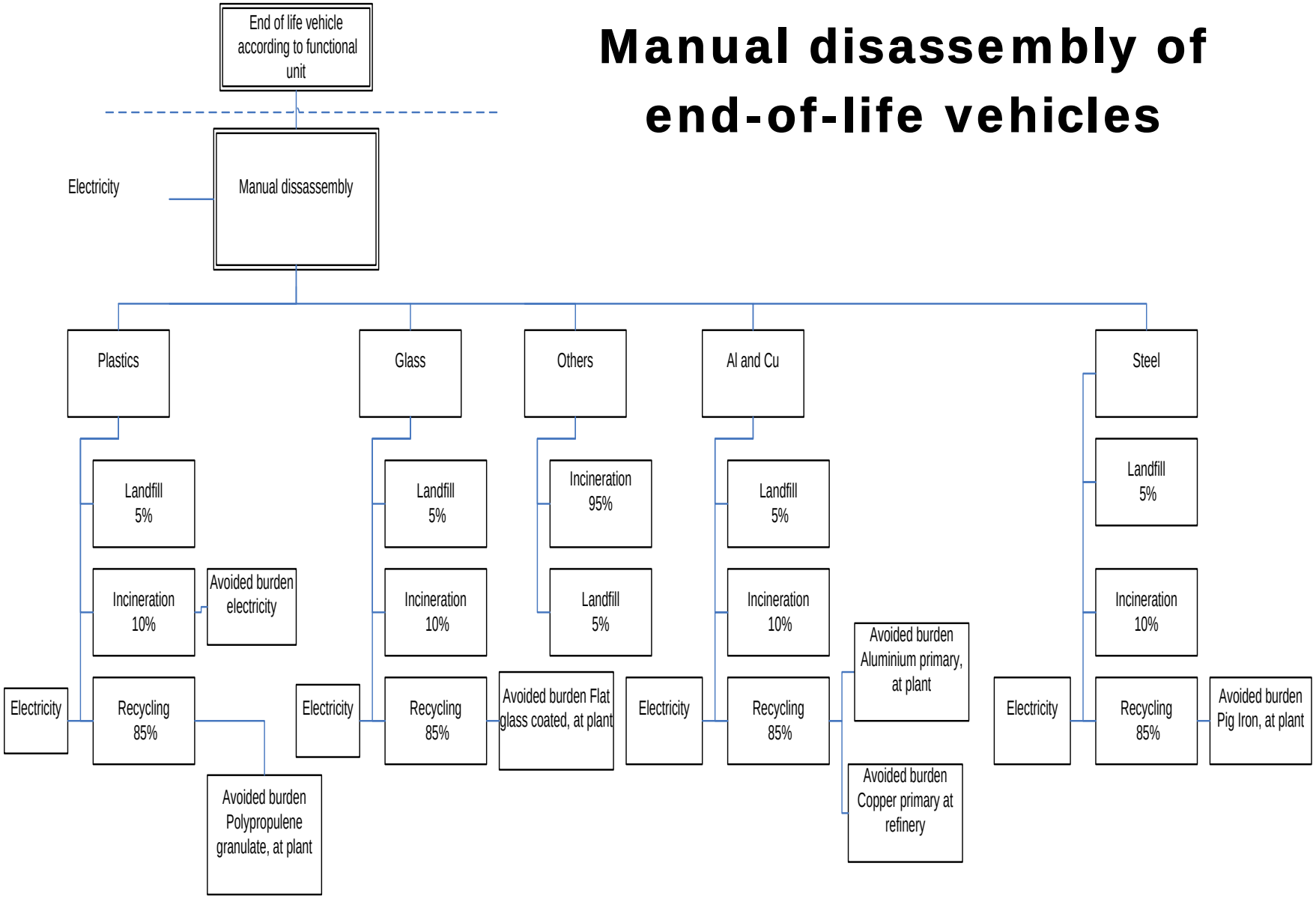
LCA of a municipal energy system

(e.g. for comparison of energy saving measures)

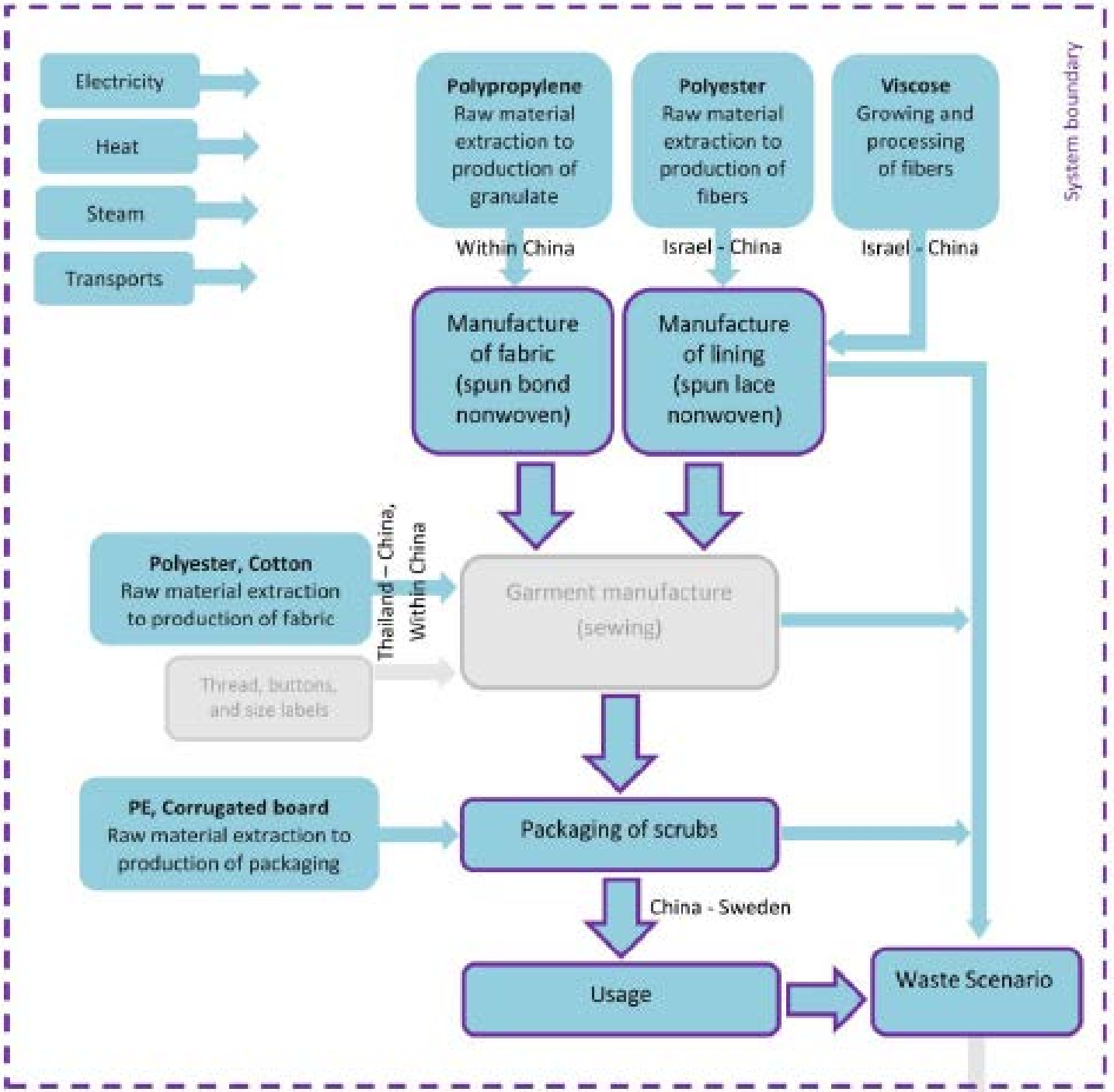


Björklund, 2011

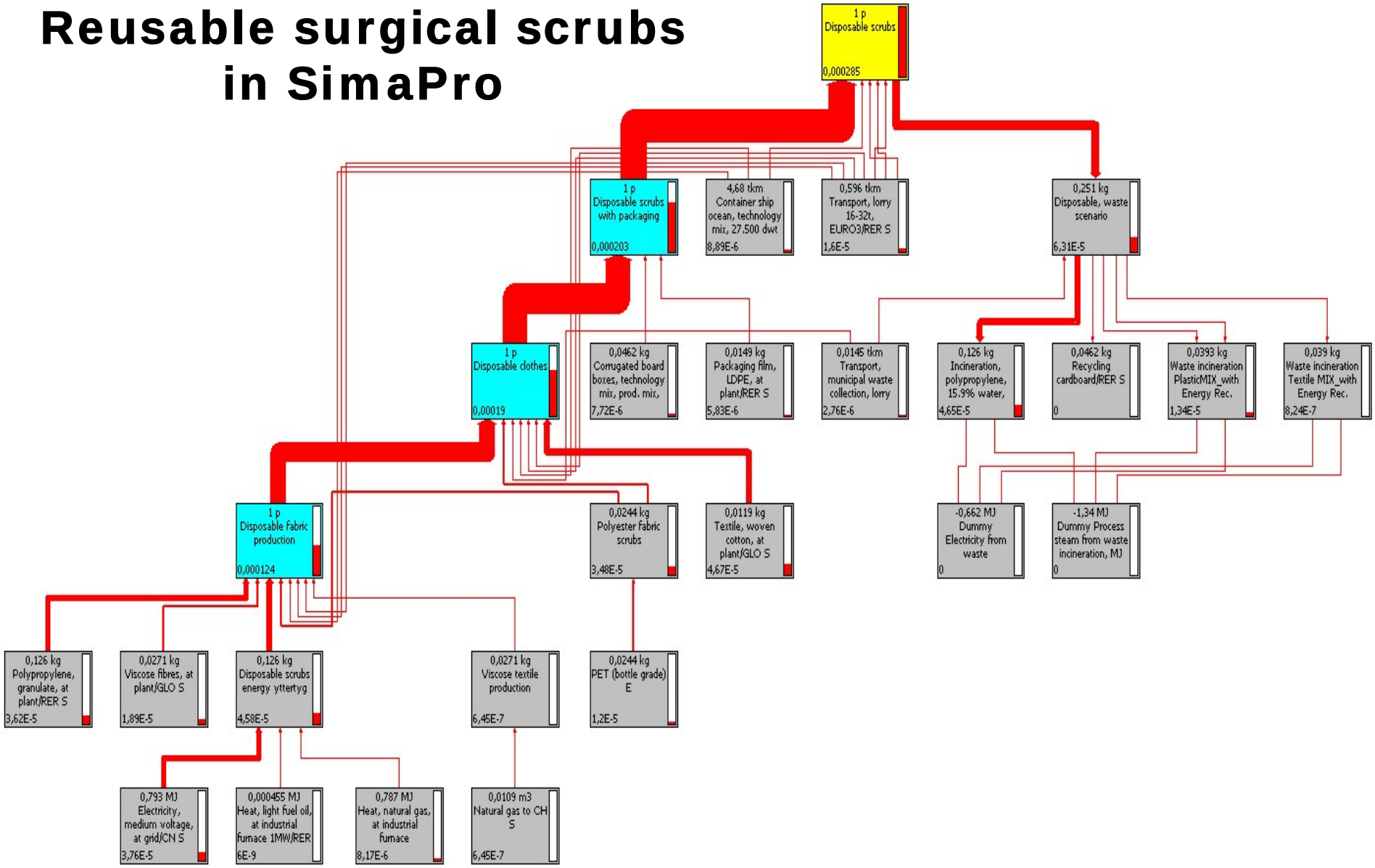
Manual disassembly of end-of-life vehicles



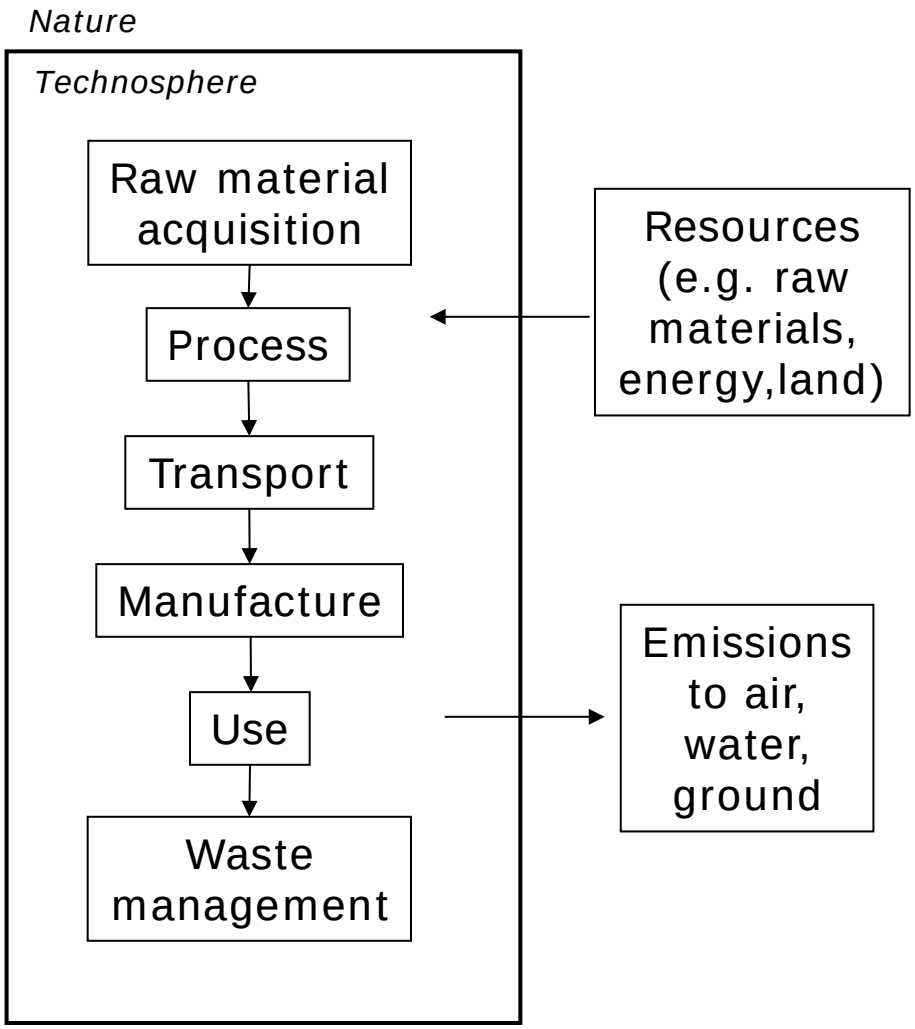
LCA of disposable vs. reusable surgical scrubs



LCA of disposable vs. Reusable surgical scrubs in SimaPro

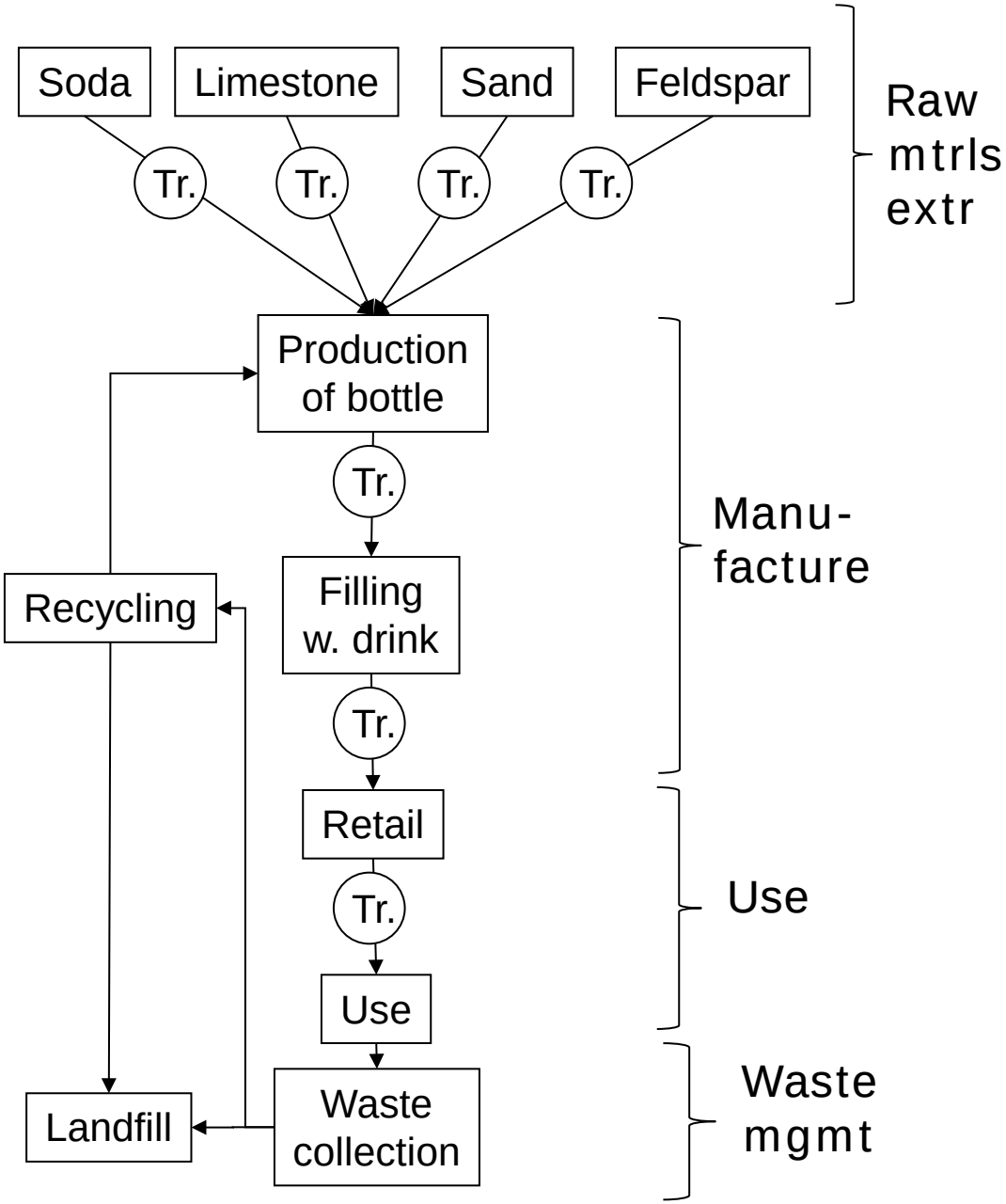


The life cycle model



Simplified flow chart

Life cycle of a glass bottle



Work in pairs (5 min)

TASK: Select any function (product or service). Draw a simplified flow chart of the life cycle of your product/service:

1. Indicate what processes (as boxes) are needed throughout the life cycle to provide the function, and
2. Indicate (with arrows)
   - Material, product, and waste flows
   - Emissions (some examples)
   - Resource inputs (which ones, in what life cycle phases?)

QUESTION: Where might there be a risk of suboptimization in your case if the full life cycle is not considered?

Overall aim of LCA course

- Basic analyst's competence in LCA.
- Experience of LCA software.
- Systems perspective on environmental issues, related to <u>your</u> own area of expertise.

During the break

Write brief comments about:

- Your background/area of expertise?
- Why did you choose this course?
- Prior knowledge of LCA?
- Your expectations on this course?

Start thinking about project topics !!! Groups will be formed during next lecture.

Brief LCA history

1960-1970: ”Silent spring”, ”Limits to growth”, waste debate, oil crisis.

1969: ”Resource and Environmental Profile Analysis” of beverage packaging, by Coca Cola. (Similar studies in UK, Germany, Sweden).

1980’s: Growing use of LCA. Mainly applied to packaging. Mostly known to researchers.

1991: Agreement on the term ”Life Cycle Assessment”.

1996: First scientific LCA journal.

1997: First ISO standard on LCA.

Today: LCA used in public policy, design, decision making, product labelling, education.

ISO 14040 series

(Environmental management – Life cycle assessment)

ISO 14040: Principles and framework

ISO 14044: Requirements and guidelines

ISO 14047: Impact assessment - Examples

ISO 14048: Data documentation format

ISO 14049: Goal and scope & inventory analysis - Examples

Single issue standards

- ISO 14046: GHG accounting
- ISO 14046: Water footprint

Other LCA standards

- International Reference Life Cycle Data System (ILCD) (EU initiative)

Life cycle based labelling

- ISO 14025: Environmental labels and declarations
- Product Environmental Footprint (PEF) (EU initiative)

Definition of LCA (ISO 14040)

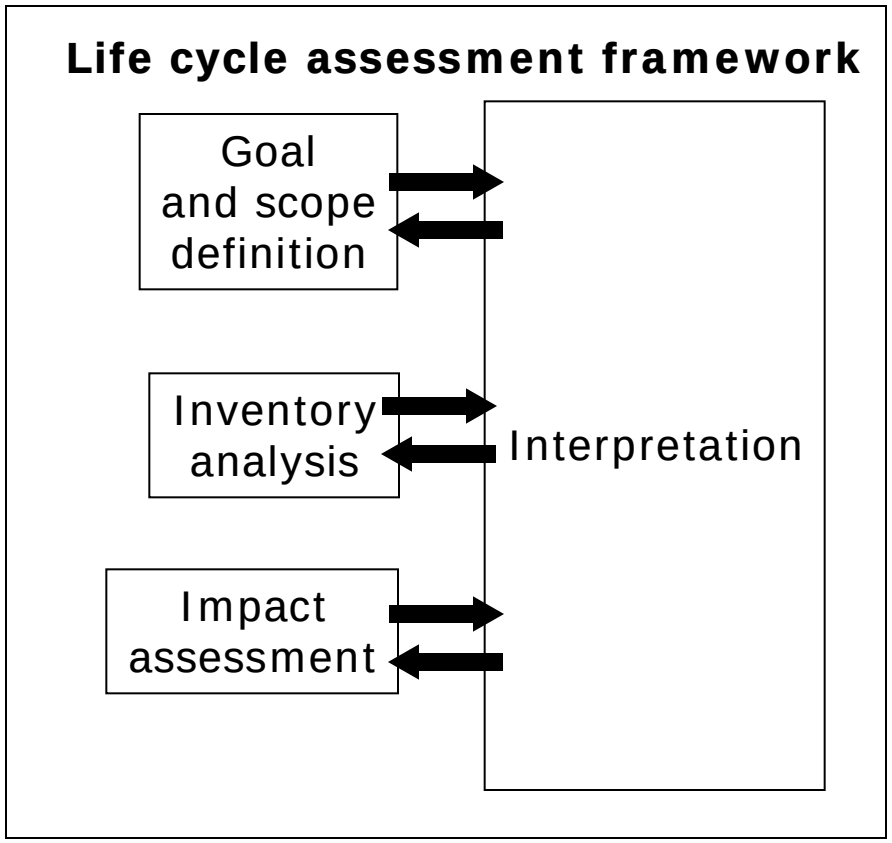
Technique for assessing environmental aspects and potential impacts of a *product* or *service* by:

-compiling an *inventory* of relevant *inputs and outputs* of a *product system*;

-evaluating *potential environmental impacts* associated with those inputs and outputs;

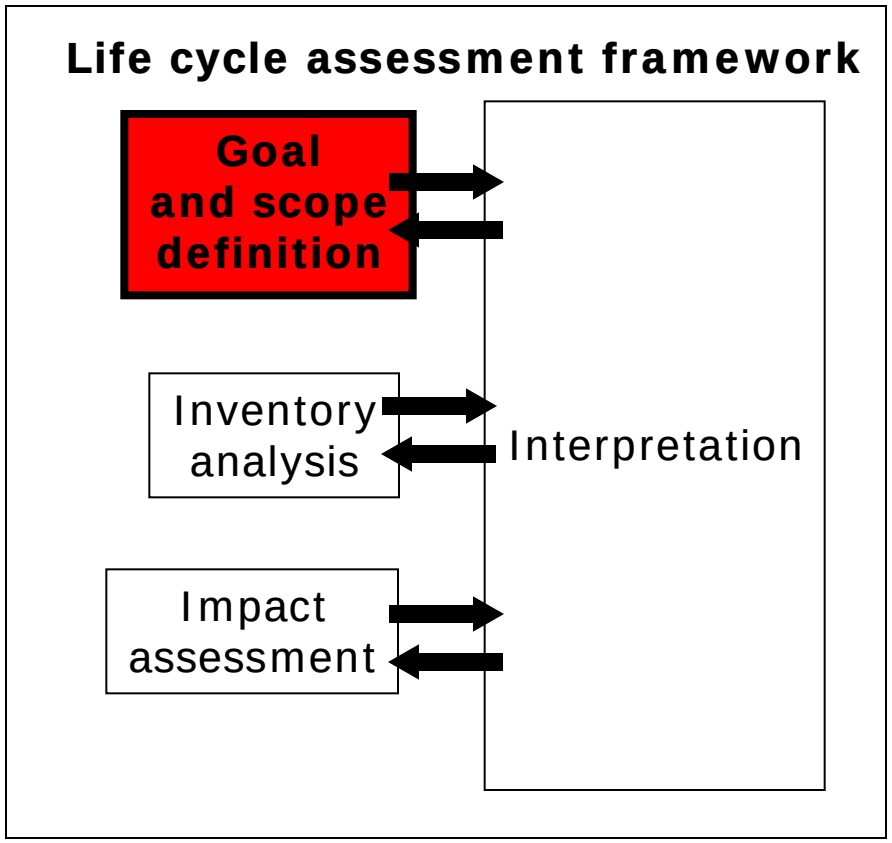
-interpreting the results.

LCA framework



Source: ISO 14040

LCA framework



Source: ISO 14040

Goal and scope definition

- **Goal:**
  - Purpose
  - Intended application
  - Intended audience

Applications of LCA

- **Product development & improvement**
  - Eco-design, e.g. choice of materials
- **Processes**
  - Process development & improvement
- **Corporate strategic planning**
  - Choice of product
  - Choice of supplier
- **National strategic policy & planning**
  - Tools for transport, energy, and waste planning
- **Procurement**
  - Criteria for environmental procurement
- **Marketing and labelling**
  - Eco-labelling (Type III environmental declarations)
  - Carbon footprints
  - Water footprints

Goal and scope definition

- **Goal:**
  - Purpose
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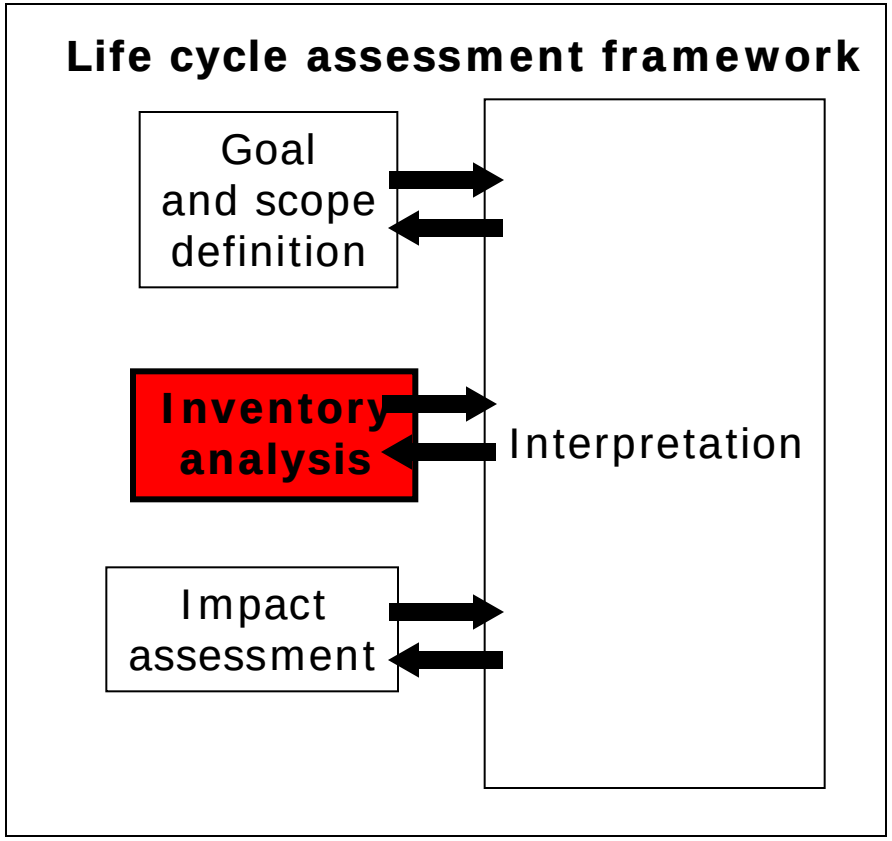
  - Intended audience

- **Scope:**
  - Studied product (or service)
  - System boundaries (what, where, and when?)
  - Impacts (global warming, acidification, etc.)
  - Data requirements (eg. age and technical representativity)
  - Functional unit (quantified measure of studied product)

LCA framework



Source: ISO 14040

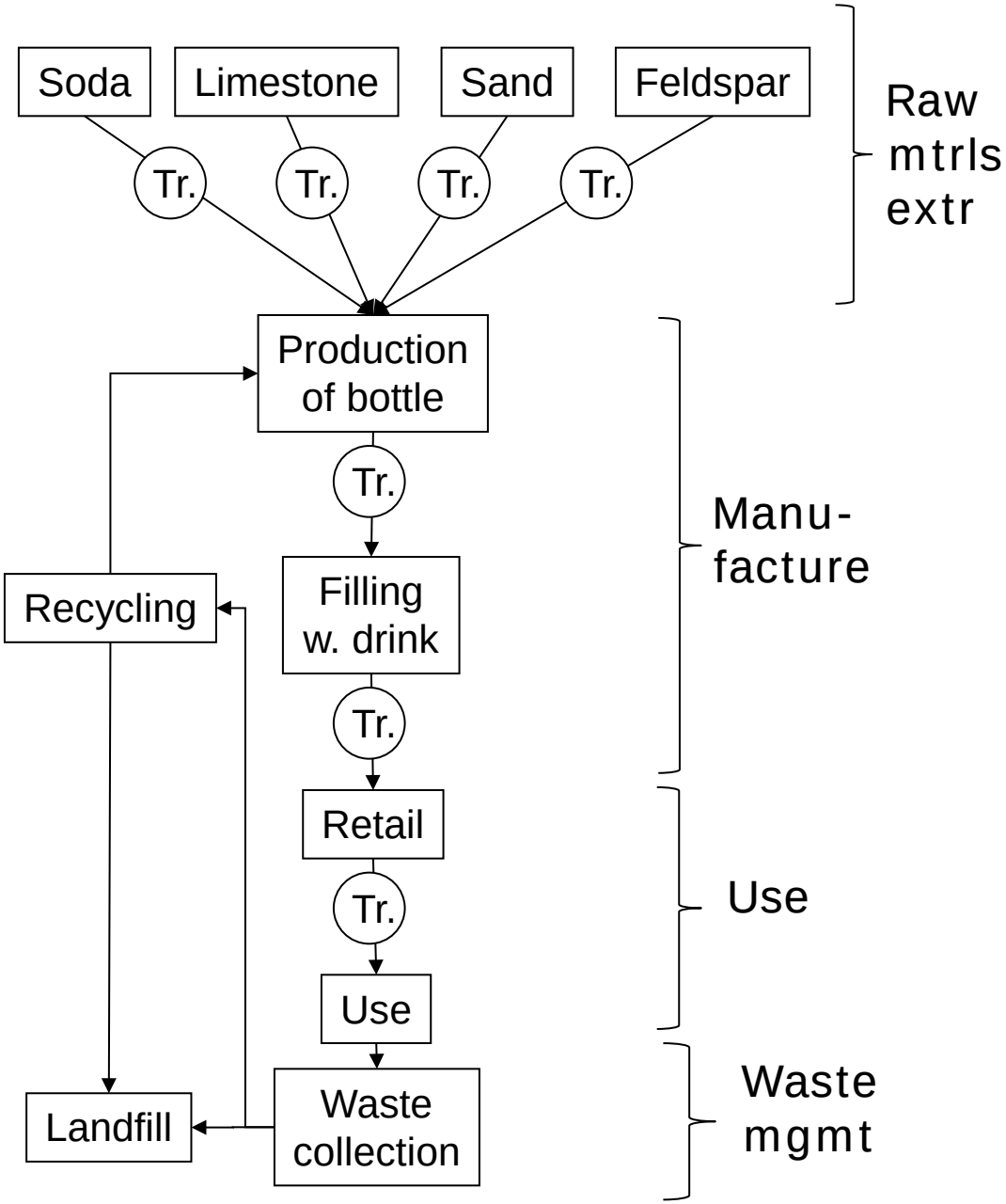
Life cycle inventory (LCI) & modelling

“Compilation and quantification of inputs and outputs for a product throughout its life cycle“

1. Draw flow chart (simplified and detailed)

Simplified flow chart

Life cycle of a glass bottle



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2. Collect data (resource use, emissions)
   - LCA databases, reports, scientific papers, on-site investigation, expert knowledge, qualified guesses (!)

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3. Build model of product system
   - computerised in generic LCA software tool, Excel, or other

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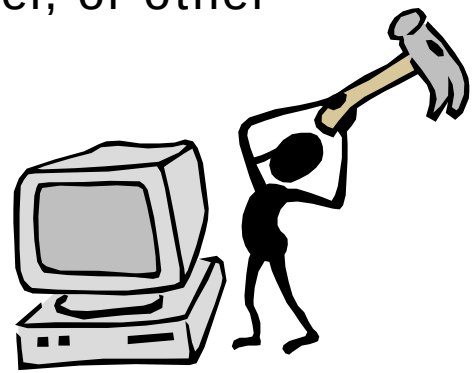
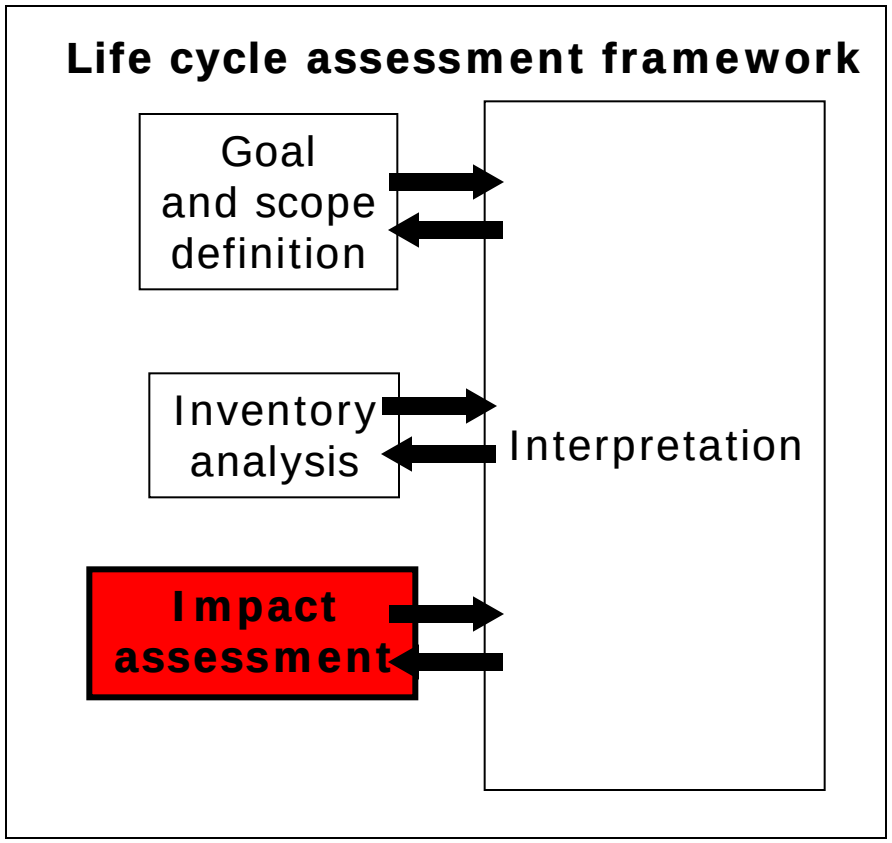
4. Calculate resource use and emissions

Iterative procedure!



LCA framework



Source: ISO 14040

Life cycle impact assessment (LCIA)

Understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product

Life cycle impact assessment (LCIA)

1. **Selection of environmental impact categories:** for instance GWP, CED

2. **Classification:** Sort inventory parameters (resource use & emissions) in environmental impact categories.

3. **Characterisation:** Calculate the contribution of emissions and resource use to environmental impact categories.

Global warming potential, GWP, (CO_2 equivalents)

1 kg CH_4 = 25 kg CO_2 equivalents
1 kg N_2O = 320 kg CO_2 equivalents
1 kg CO = 2 kg CO_2 equivalents
1 kg kg CO_2 = 1 kg CO_2 equivalents

Cumulative energy demand, CED (MJ equivalents)

1 kg Coal, grown, in ground = 10.3 MJ eq
1 m3 Gas, natural, in ground = 36 MJ eq
1 MJ Energy from uranium = 1 MJ eq

Exercise

Task

1. Draw process flow chart of product A.
2. Calculate the total fuel energy (MJ) of product A.
3. Identify life cycle stage with the highest contribution to global warming potential.
4. Caculate normalised GWP of product A, using CO_2/capita in Sweden as normalisation reference.

Scope

- Functional unit = one item of product A.
- Include raw materials extraction, production, use, and disposal.

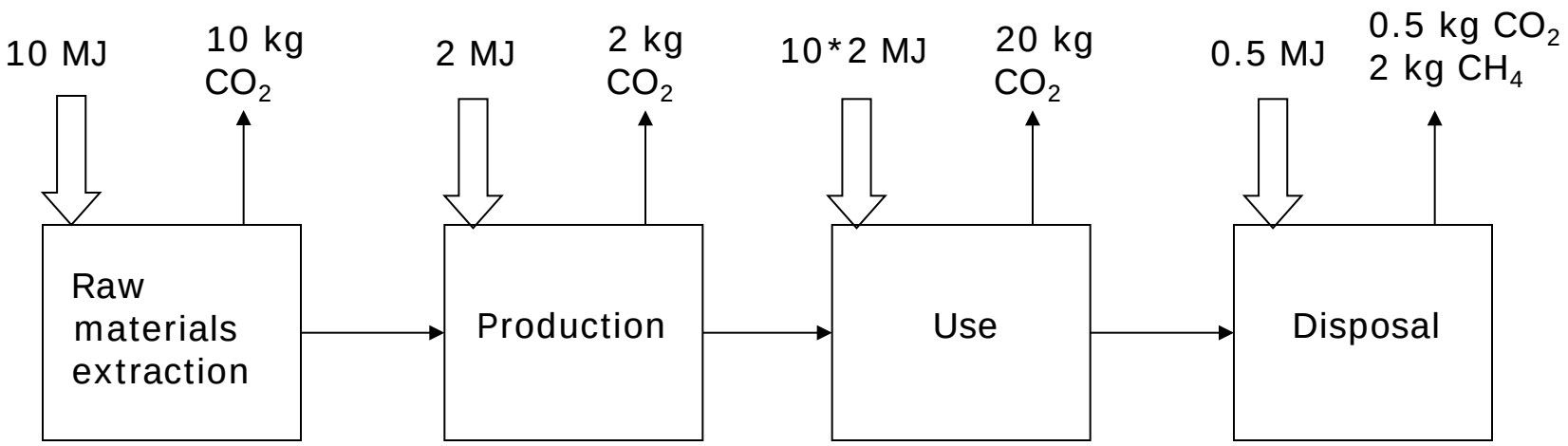
Life cycle data for product A

Extraction of raw material: 10 MJ fuel/product A
Production: 2 MJ fuel/product A
Use: 2 MJ fuel/year/product A;
Use: life time of product A is 10 years
Disposal: 0,5 MJ/product A; 2 kg CH_4 emitted/product A
Emission factor of fuel: 1 kg CO_2/MJ fuel
Sweden CO_2/capita: 4.8 tons/year

Characterisation factors, global warming potential (GWP)

GWP(CO_2)= 1 [kg CO_2-equivalents/kg]
GWP(CH_4)= 21 [kg CO_2-equivalents/kg]

Answer to exercise



- 1 kg CO_2 emitted/MJ fuel
- life time of A is 10 years
- GWP(CH4)= 21 [kg CO2-equivalents/kg]

Total energy demand [MJ] = 10 + 2 + 10*2 + 0.5 = 32.5 MJ
Disposal GWP [kg CO_2-eq] = 0.5 + 21*2 = 42.5 kg CO_2-eq
Normalised total GWP = (10+2+20+42.5)/4.8e6 = 1.5e-5

Life cycle impact assessment (LCIA)
(Optional steps)

Normalisation

- Calculation of relative importance of category indicator
- Indicator results divided by a reference value
- Ex: [GWP of system A/total GWP (per capita)]
- Unitless
- Based on measurable data (more or less objective)

Weighting

- Category indicator results aggregated in one single number
- Unit: eg. eco-points, cost
- Based on subjective values.

Interpretation

- Summarise and explain results from inventory and impact assessment
- Ensure results meet goal of the study
- Determine level of confidence/evaluate sensitivity

- Draw conclusions
- Make recommendations

Course info

Course content (7.5 hp = 5 weeks)

Theory (1.5 weeks)

- 9 lectures (2h)
- Reading + excercises
- Home exam

Projects (3.5 weeks)

- Learn software
- Supervision meetings
- Own project work
- Supervised work in computer labs
- Two project seminars
- Final report

Canvas

https://kth.instructure.com/

- Course documents
- Submit assignments
- Project group sites
- Discussion forum

KTH Social

https://www.kth.se/social/

- Schedule

Course memo

- Course goals
- Lecture overview
- Literature
- Computer labs
- Mid-term home exam
- Projects and supervision **(+ separate instructions)**
- Report **(+ separate instructions)**
- Seminars (pre- and final)
- Course requirements
- Grading

About plagiarism

***Using someone else's work as your own, without appropriate use of references*.**

- If you are not sure when and how to use references in your report, please discuss this with your teacher.
- Intentional plagiarism is a serious form cheating!!!
- KTH rules concerning cheating: http://www.kth.se/student/studentliv/studentratt

L2: Select project

– You define your own projects

– Get inspired
  - ”Suggested topics for projects”
  - Examples of previous projects

– Groups with 4 students

Computer lab (C1)

– Instructions in Canvas
– Work in pairs from your project group