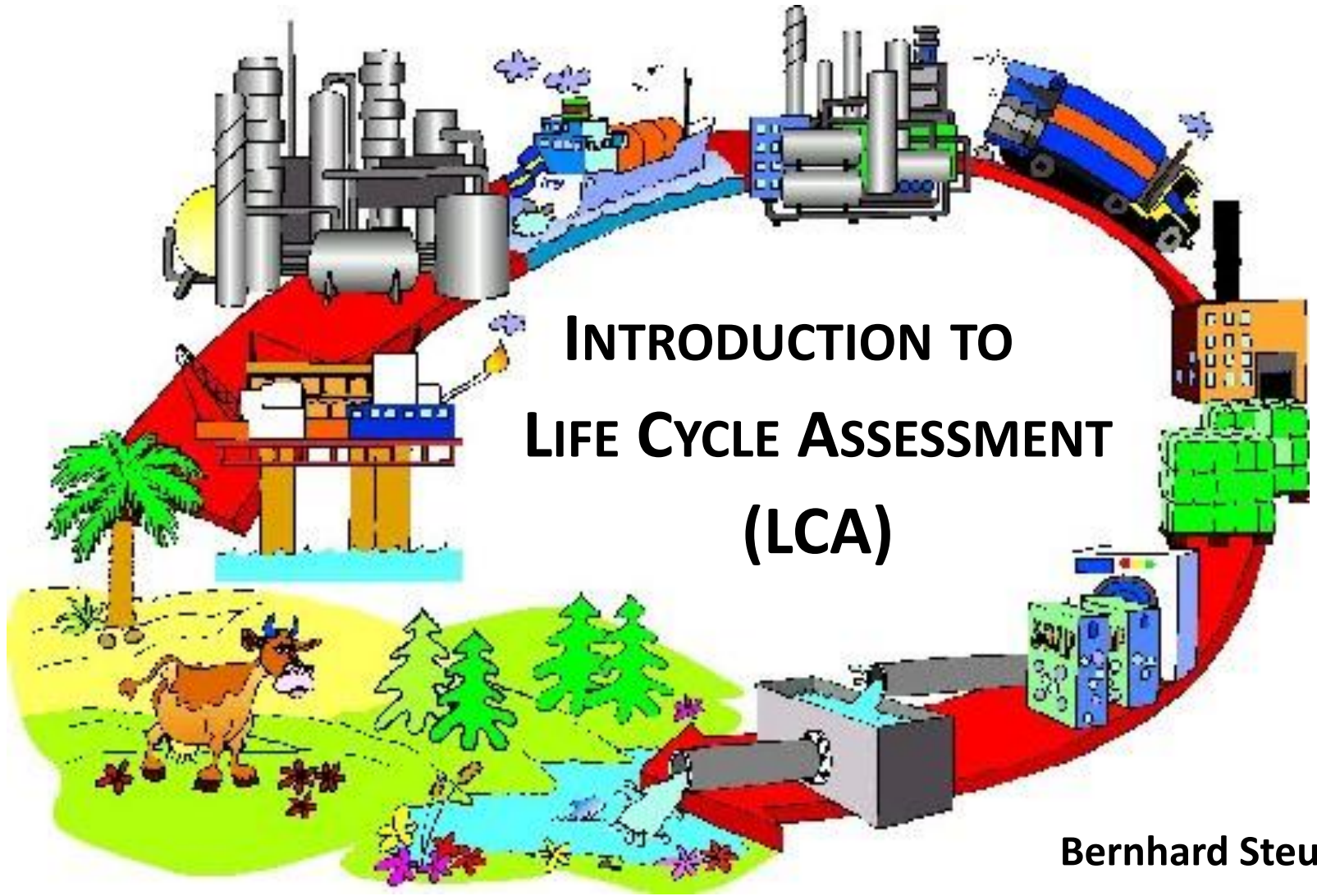


LCA workshop

Bernhard Steubing, Institute for Environmental Engineering, ETH Zurich
Chris Mutel, Technology Assessment Group, PSI)

Objectives:

- Basic understanding of LCA
- Position yourself on a relevance/complexity chart
 - Specific and appropriate tools and data sources



INTRODUCTION TO LIFE CYCLE ASSESSMENT (LCA)

Bernhard Steubing

What is the environmental impact of...?



1'000 pkm Transport

Source:
Rolf Frischknecht

Often comparisons: what is better for the environment?

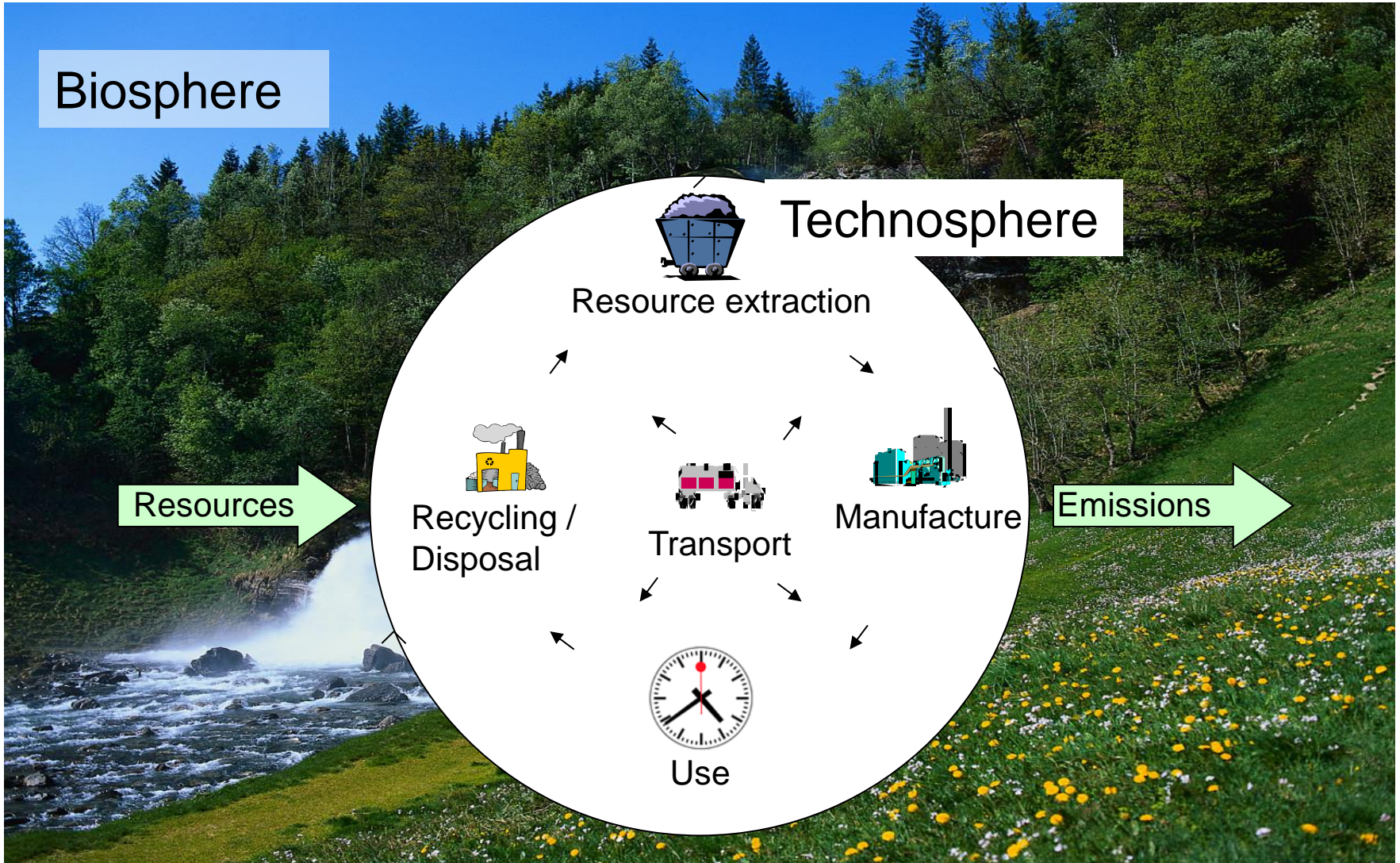
Services



Products



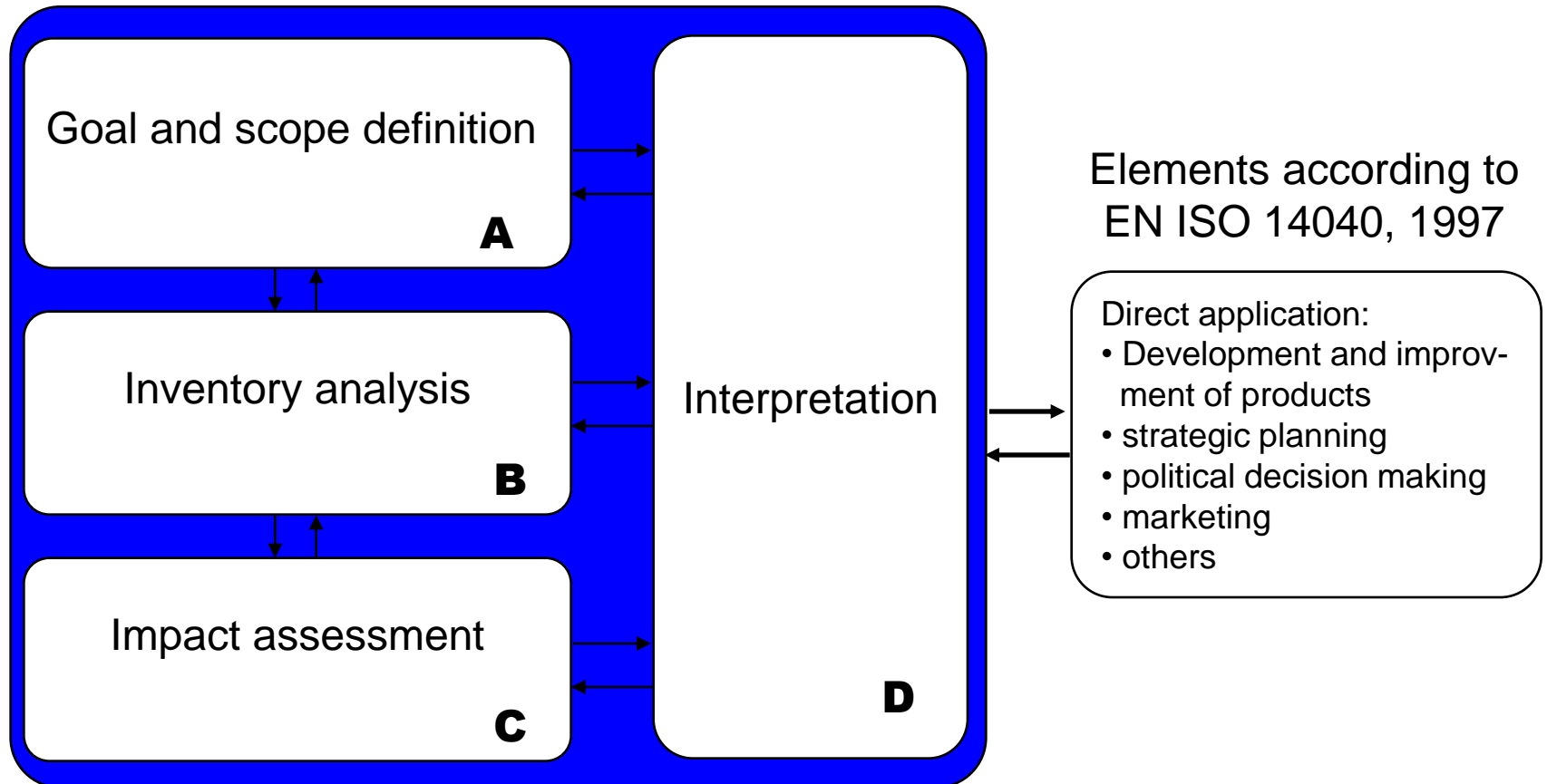
Life cycle assessment (LCA) is the compilation and evaluation of the inputs and outputs and the potential environmental impacts of a product system throughout its life cycle



LCA: Systematic procedure

Proceeding to establish an LCA:

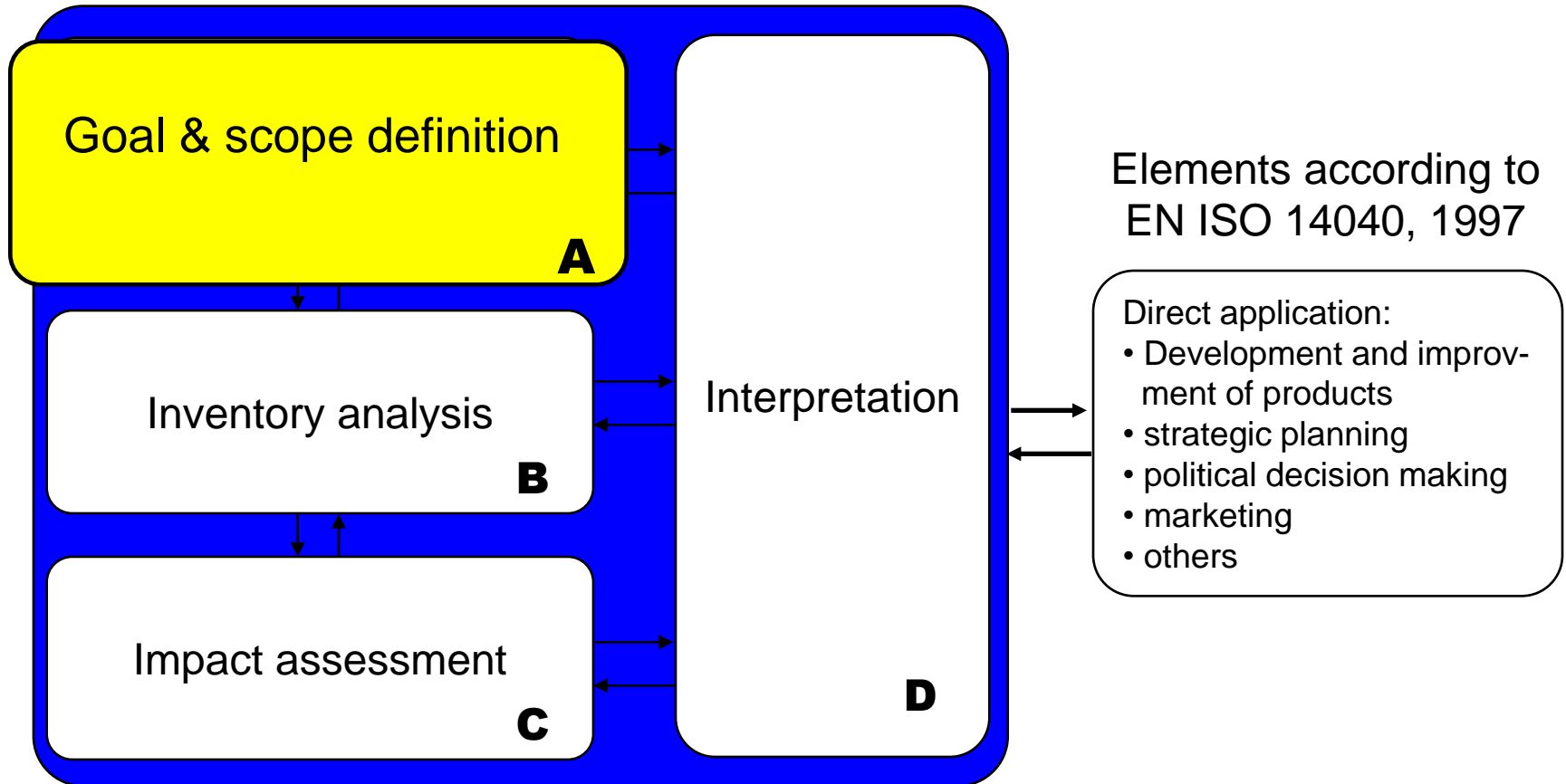
ISO 14'040 and 14'044



LCA: Systematic procedure

Proceeding to establish an LCA:

ISO 14'040 and 14'044

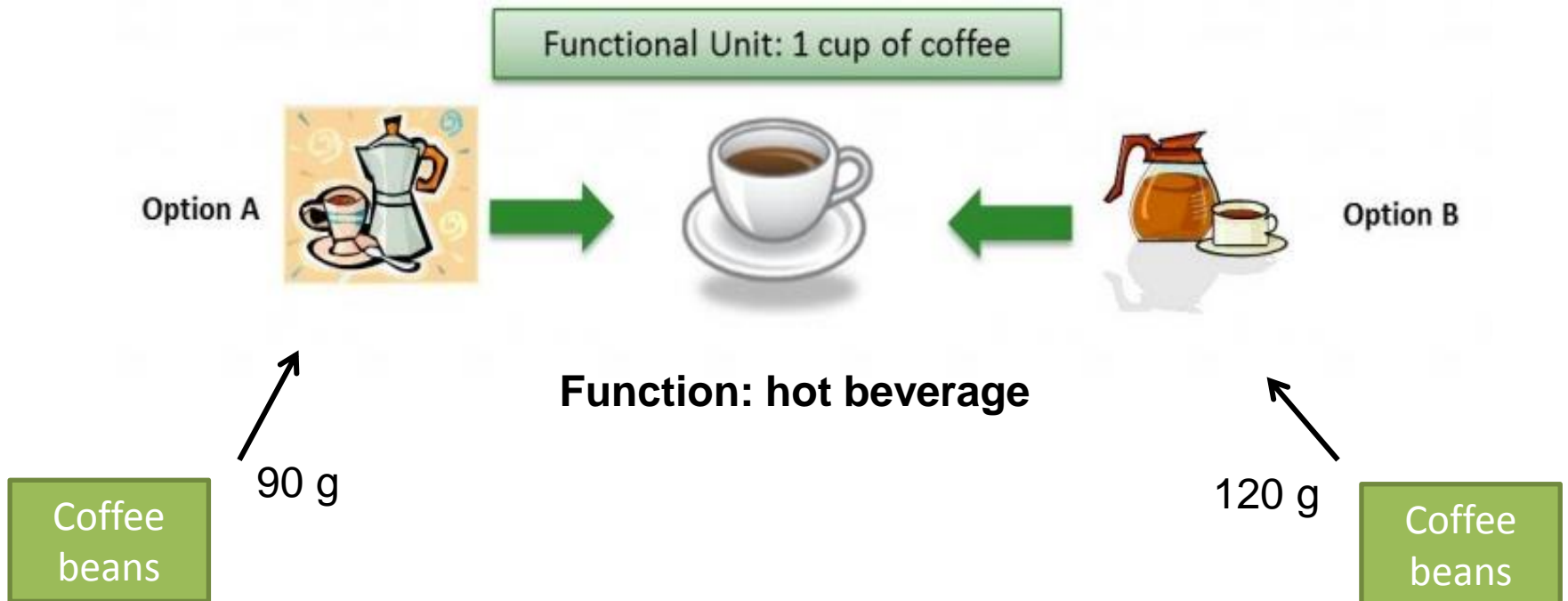


Goal and scope: typical questions

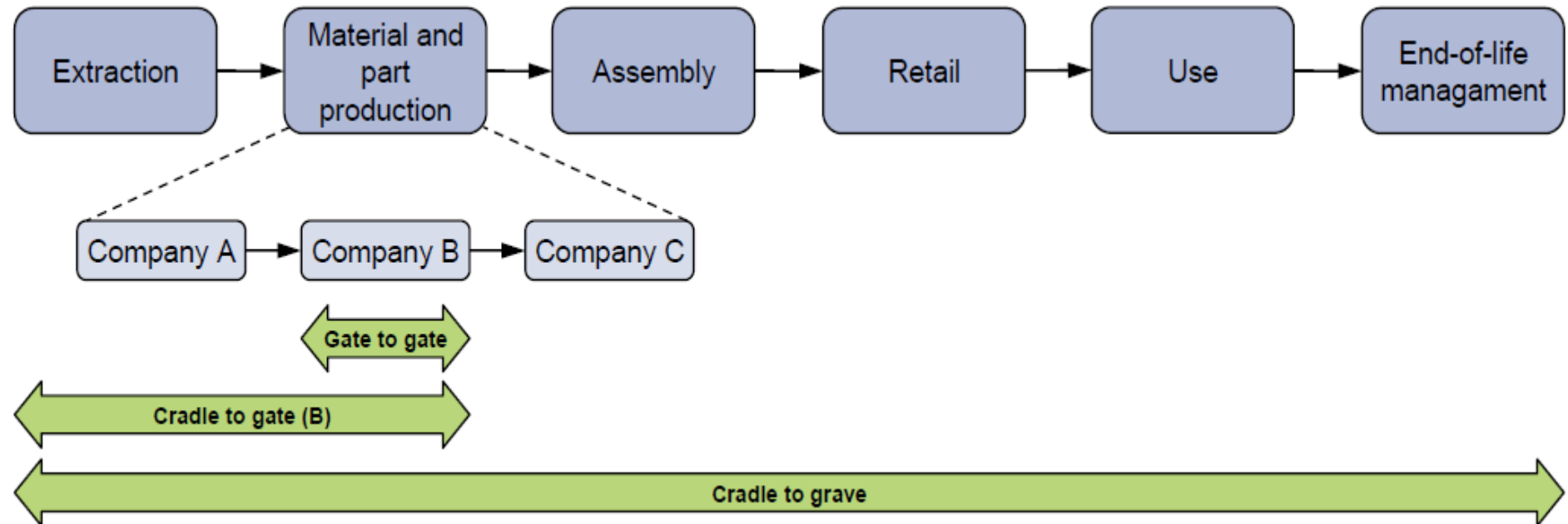
- Aim of the study? (e.g. product comparison?)
- Functions of the system?
- System boundaries (geographical, temporal, technological, etc.)?
- Allocation approaches?
- Assumptions?
- Environmental indicators?
- Target audience? (internal vs. external)

Function, functional unit and reference flow

- **Function:** what the system is supposed to deliver
- **Functional unit:** unit and amount that the function is measured by



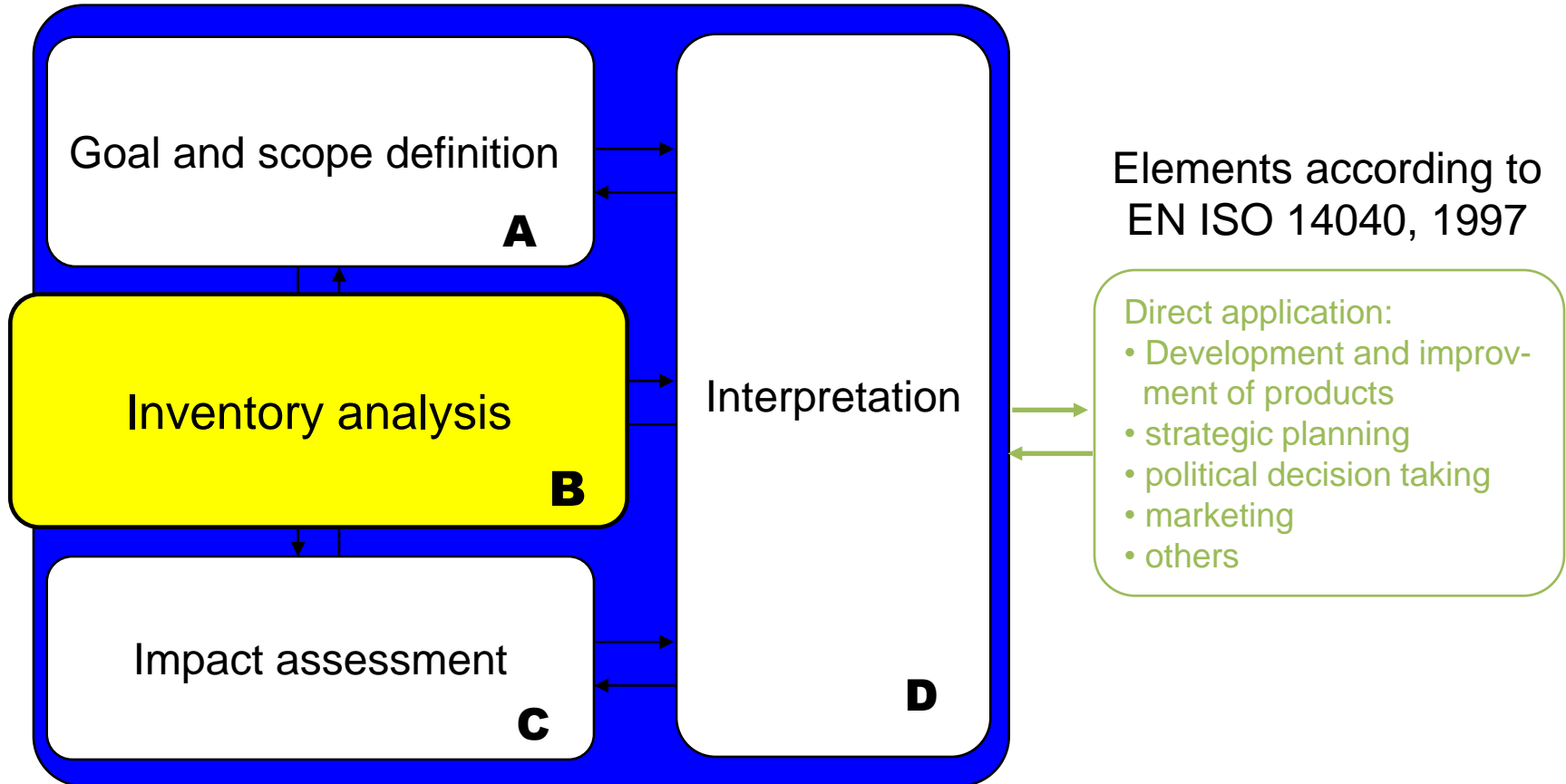
System boundaries: “Cradle to gate”, “cradle to grave” and “gate to gate”



LCA Systematic procedure

Proceeding to establish an LCA:

ISO 14'040 and 14'044



Up- and downstream processes

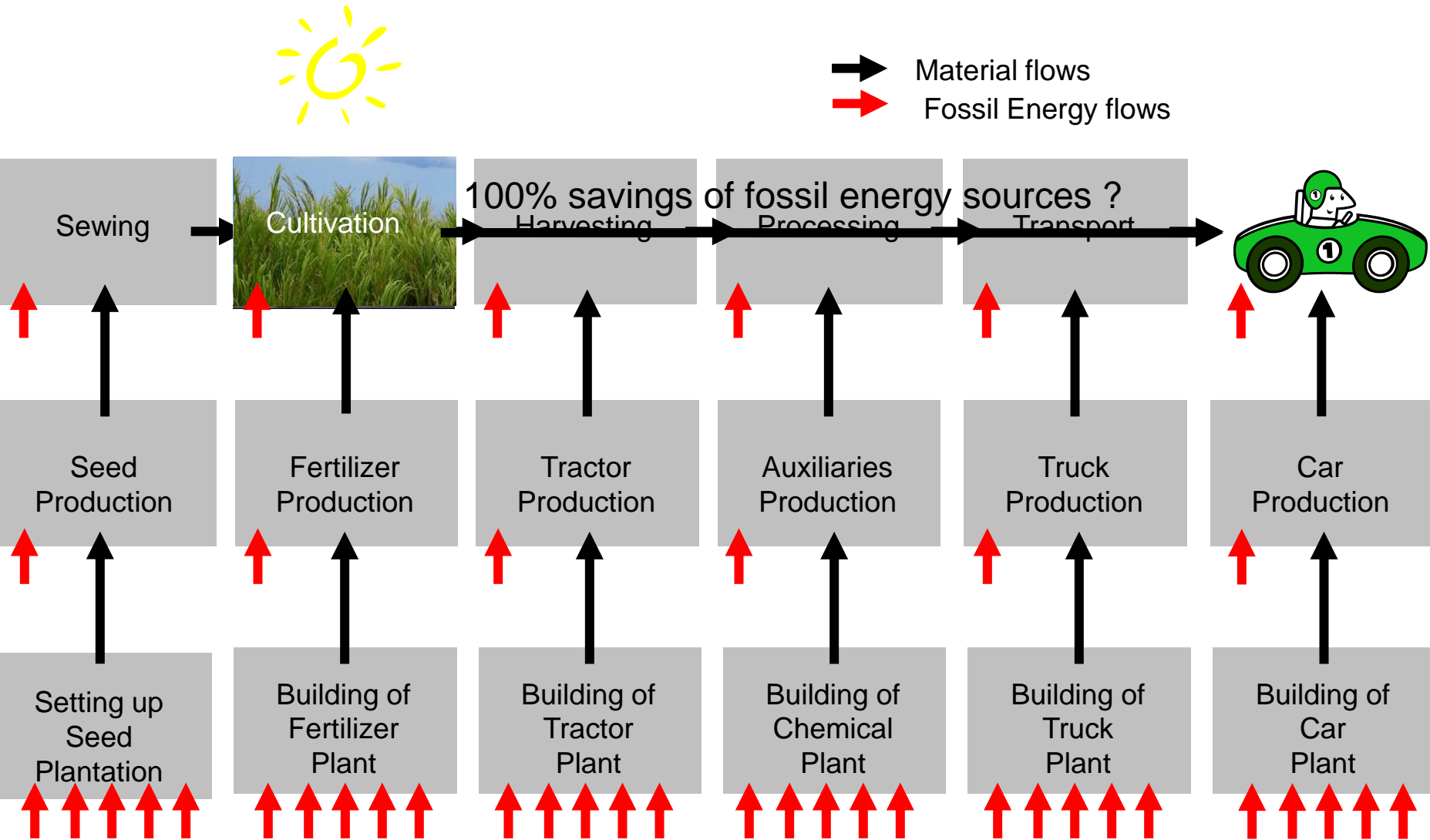
Example “flying”



1'000 pkm Transport

Source:
Rolf Frischknecht

Example: Fossil Energy Demand of Biofuels

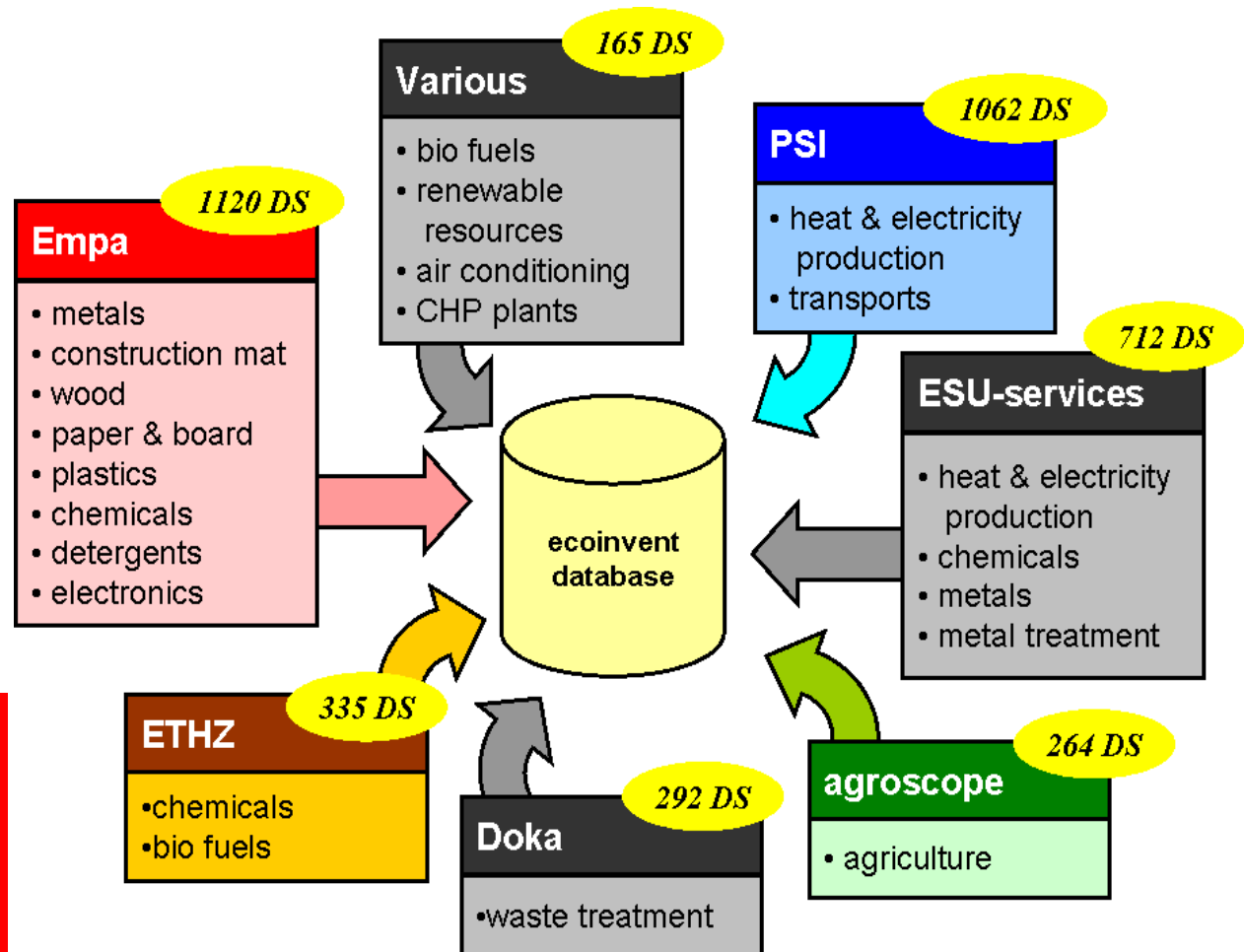


Source: Empa

Background data: ecoinvent database

v2.2: ~4000 inventories

V3: ~11000 inventories



www.ecoinvent.org

Multi-Output Processes

Production of several products within the same process

Example: Chlor-Alkali-Electrolysis



„Fair“ distribution of emissions and resource inputs to different products?

Allocation approaches

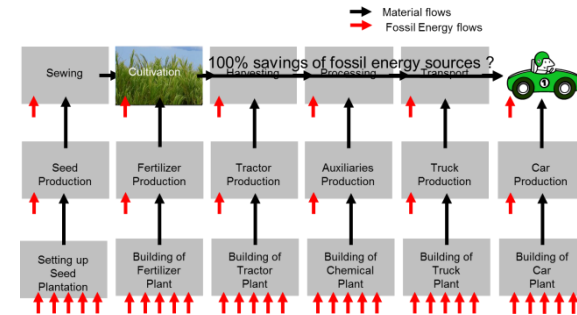
Distribution of emissions and resource inputs to different products

Procedure according to ISO 14044::

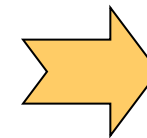
1. **A) Subdivisioning of processes**
B) System expansion: Expansion of a system with additional functions in a way that all compared systems fulfill the same functions.
2. Allocation according to **physical or chemical relationships**
3. Allocation on the basis of other relationships: e.g. **economic value**

Result of the inventory analysis

**Sum of all biosphere flows
(environmental interventions)
throughout the product system**



Name	Category	Unit	methanol, at plant	methanol, at regional storage
Oil, crude, in ground	resource	kg	0.0057	0.0191
Gas, natural, in ground	resource	Nm3	0.93	0.932
Carbon dioxide, fossil	air	kg	0.517	0.524
Nitrogen oxides	air	kg	0.0008	0.0011
Methanol	air	kg	0.00053	0.00103
...



Direct interpretation

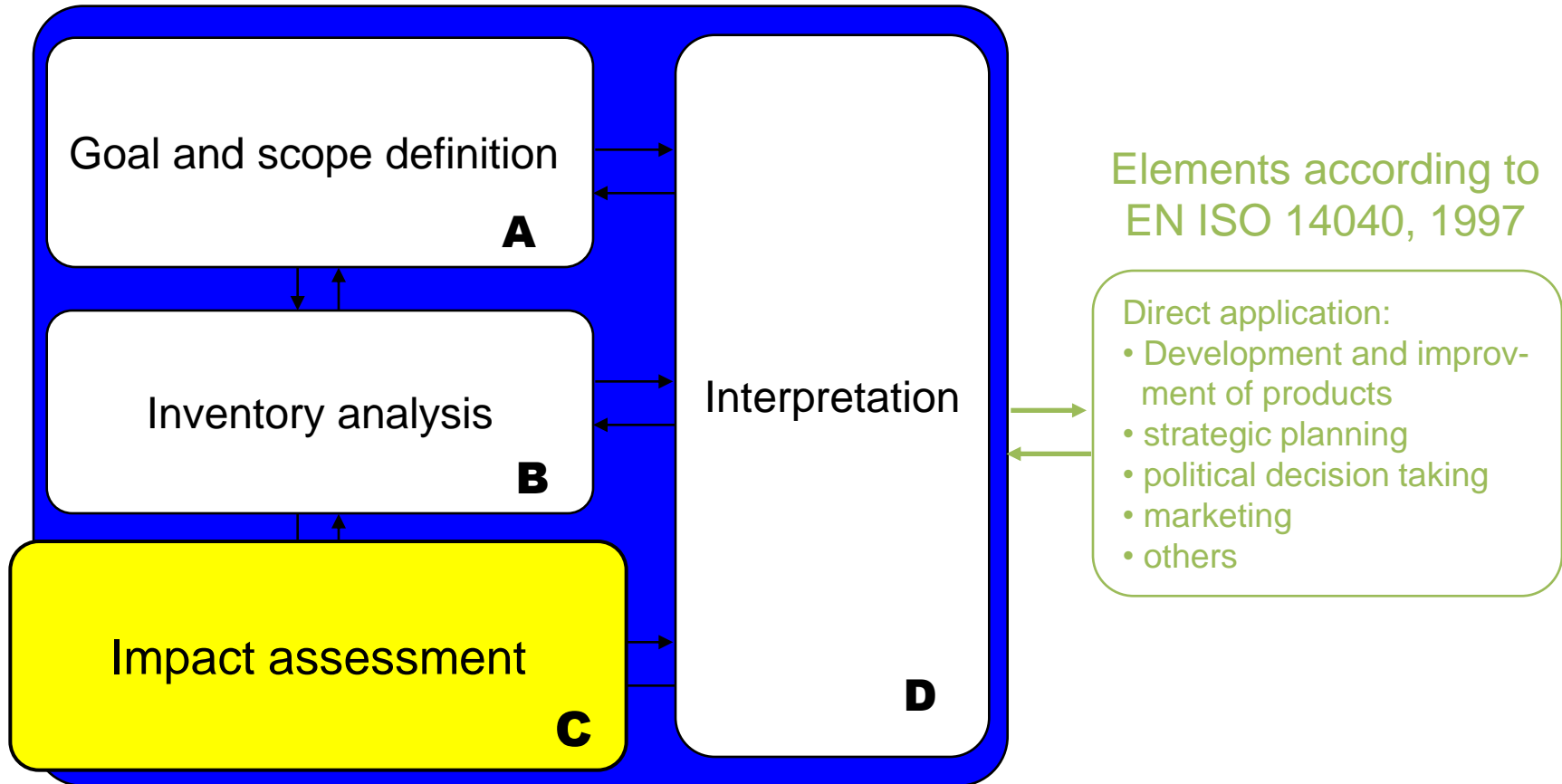


Impact assessment

LCA: Systematic procedure

Proceeding to establish an LCA:

ISO 14'040 and 14'044



Biosphäre

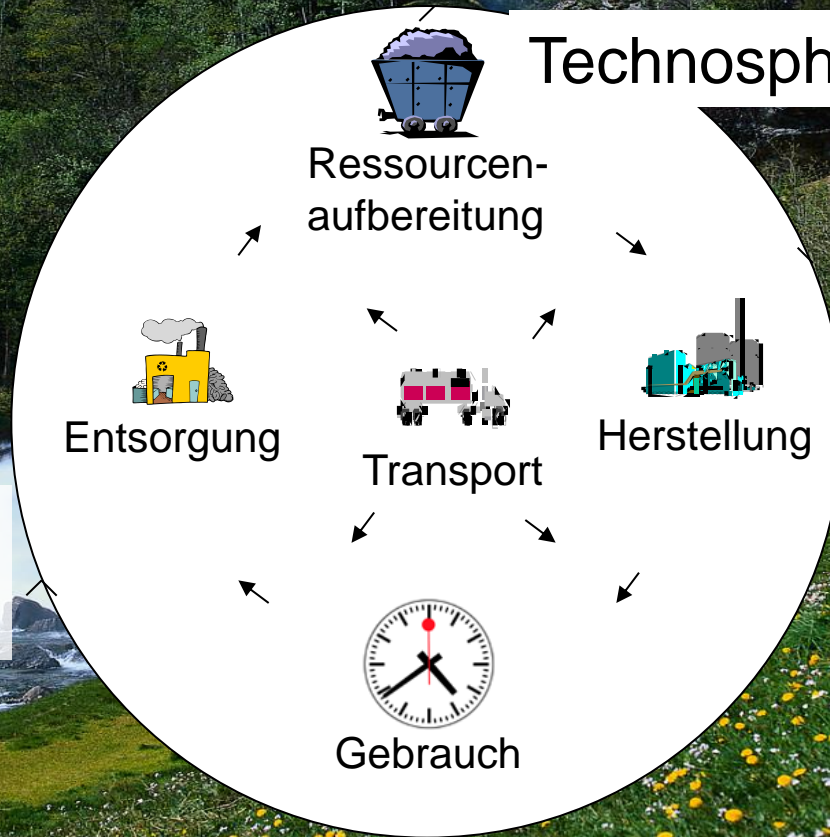
Technosphäre

Ressourcen

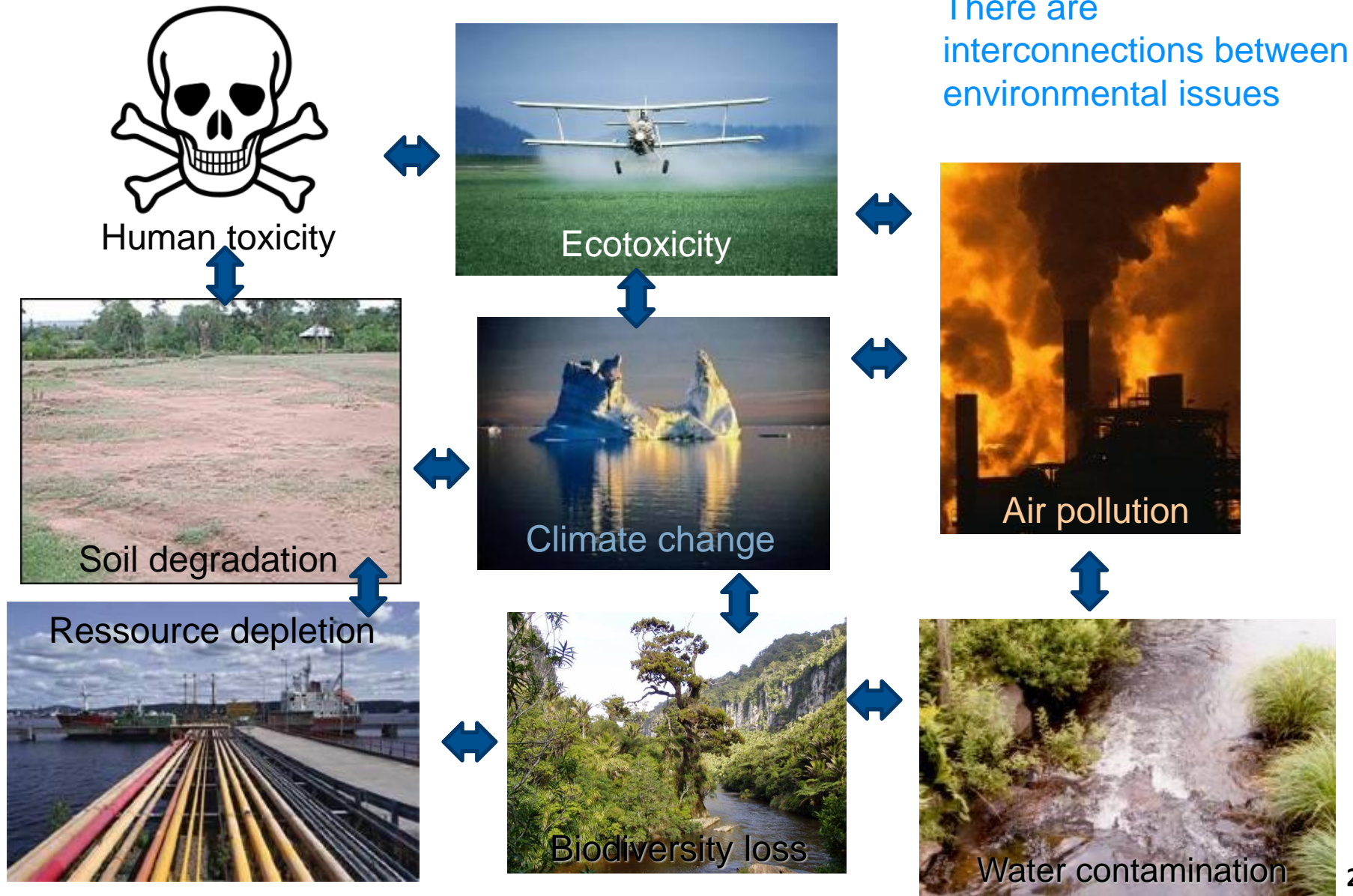
Emissionen

How bad is this?

How bad is this?



Range of environmental problems



Impact assessment

Inventory

Emission	unit	compartment	amount per FU
CO ₂	kg	air	0.5
CH ₄	kg	air	1.0
N ₂ O	kg	air	0.01
NO _x	kg	air	0.5
PO ₄	kg	water	0.5
Cd ²⁺	kg	water	0.0001
Fe	kg	soil	0.5
Cu	kg	resource	3
...			

Impact assessment

Global Warming

<i>Emission</i>	<i>CF</i>	CO₂-eq.
CO ₂	1	0.5
CH ₄	23	23.0
N ₂ O	296	2.96
Summe		26.46

Eutrophication

		PO₄-eq.
NO _x	0.1	0.05
PO ₄	1	0.5
Sum		0.55

Human toxicity

		1,4 Dichlorbenzol
NO _x	1.4	0.07
Cd ²⁺	23	0.0023
Sum		0.0723

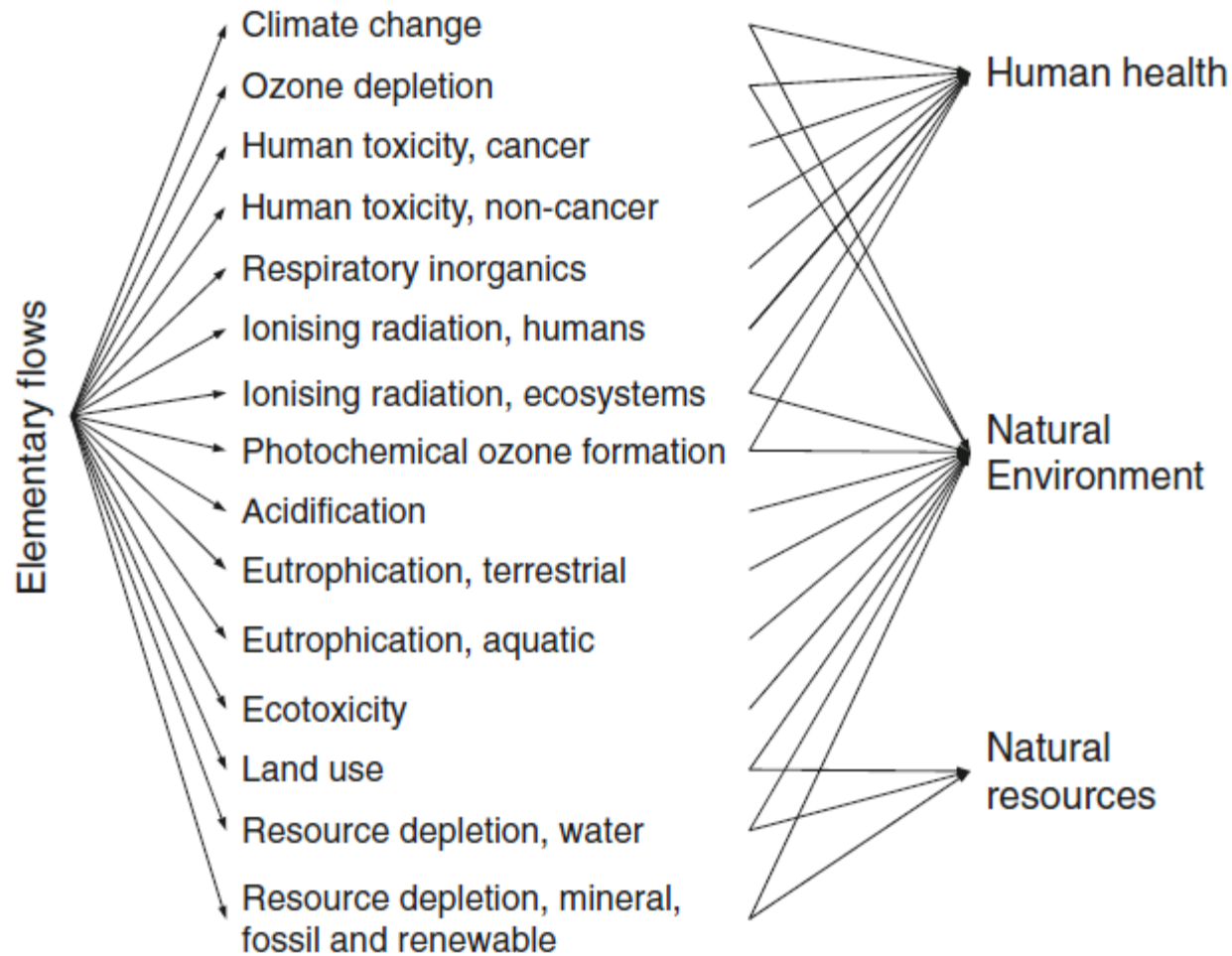
Source: Stefanie Hellweg

Inventory results

Midpoint

Endpoint

Area of protection

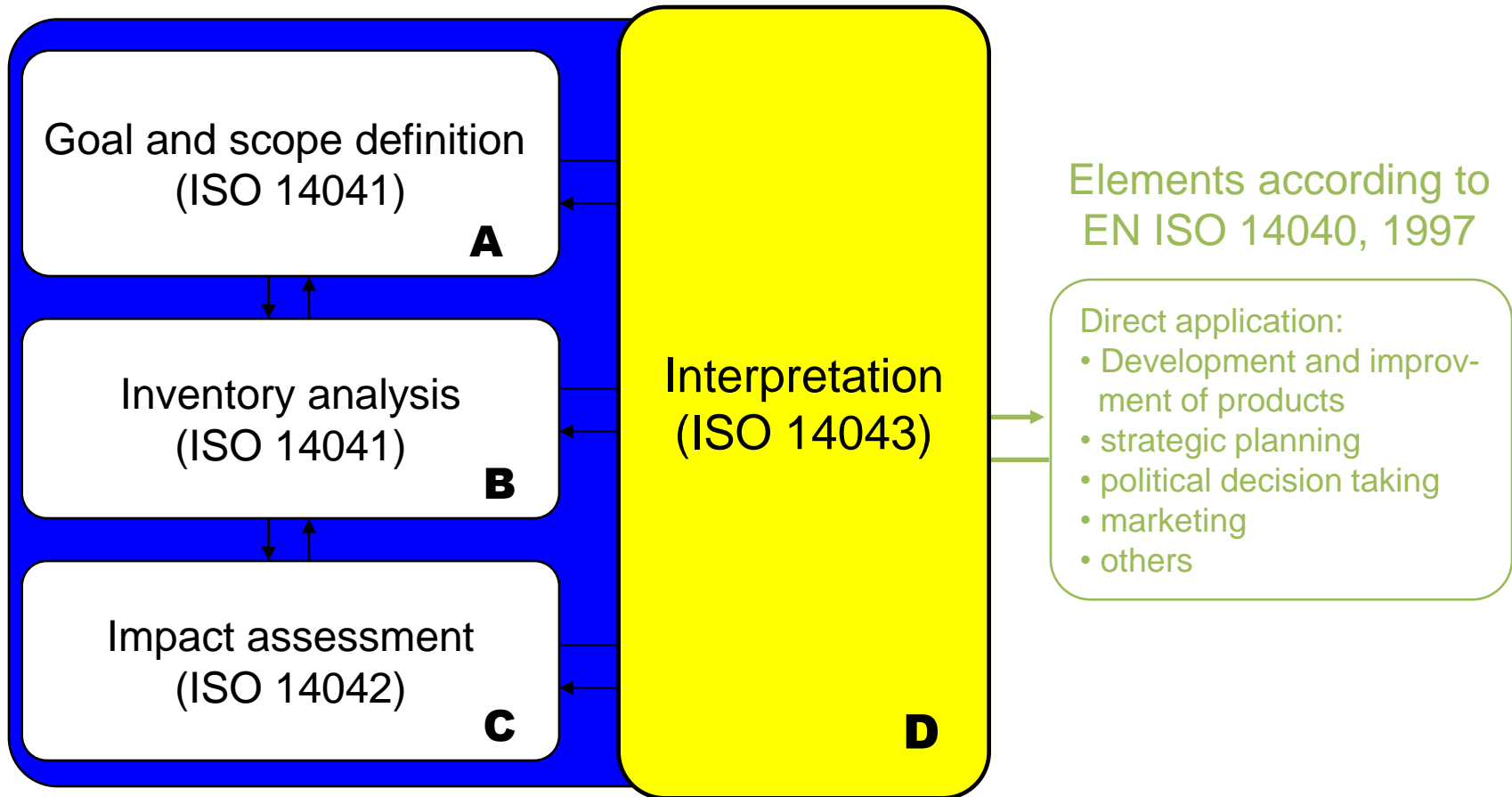


relevance for the society

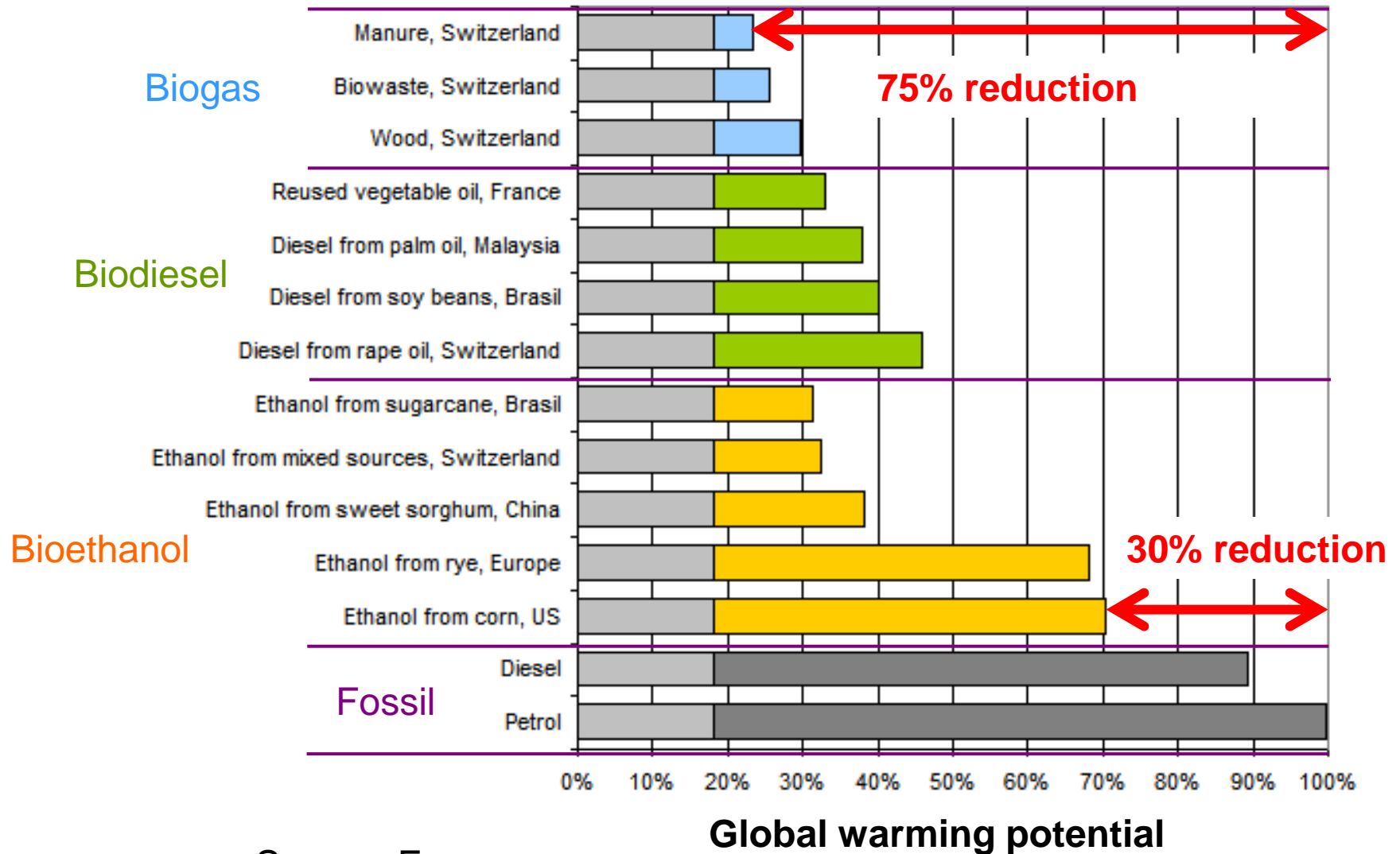
scientific accuracy

Systematic procedure

Proceeding to establish an LCA according to ISO 14'040

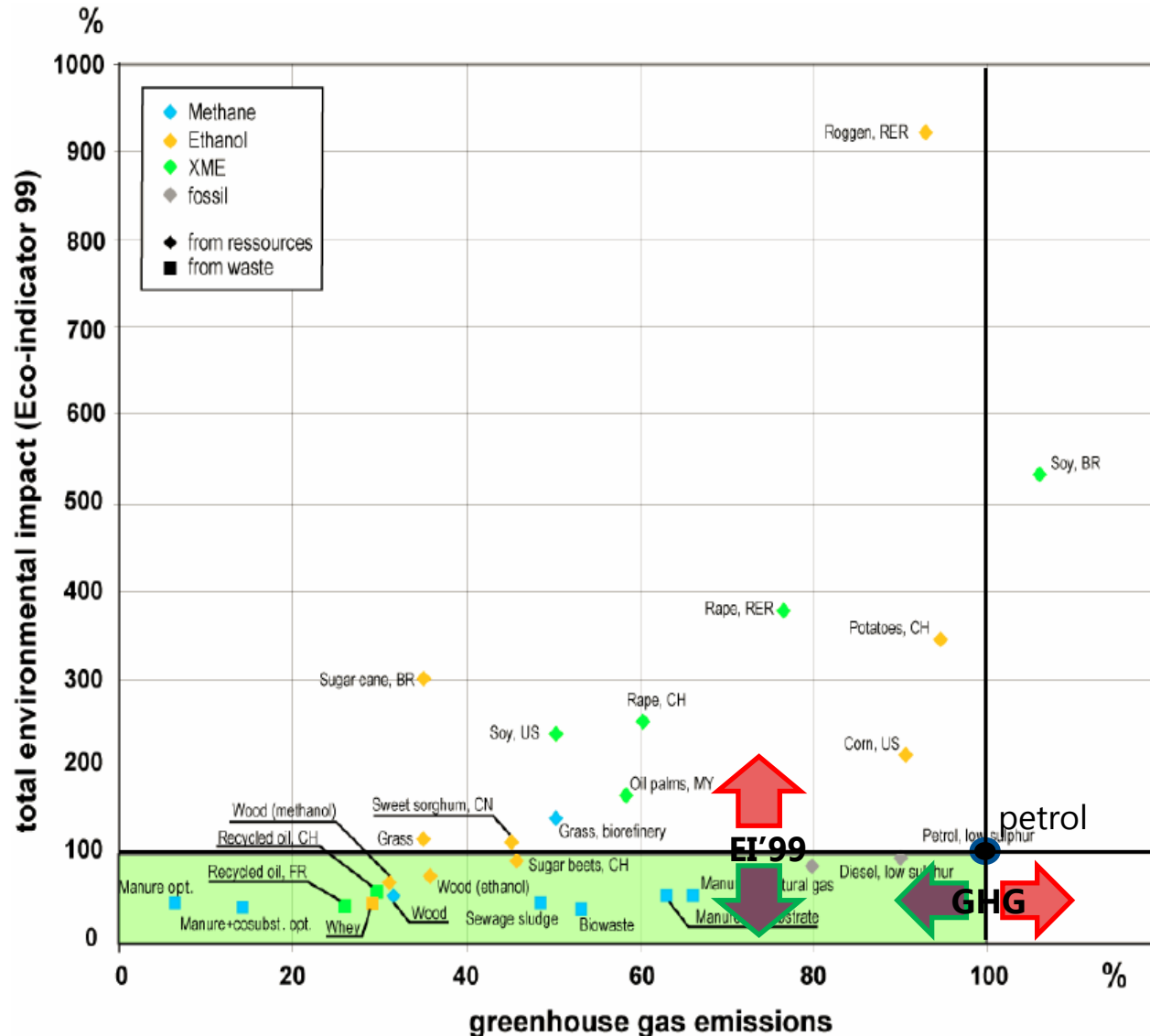


Example: Fossil energy consumption of biofuels:



Source: Empa

Trade offs between environmental concerns



Most biofuels show GHG benefits

But: many show higher impacts in other categories

→ often **trade-offs**

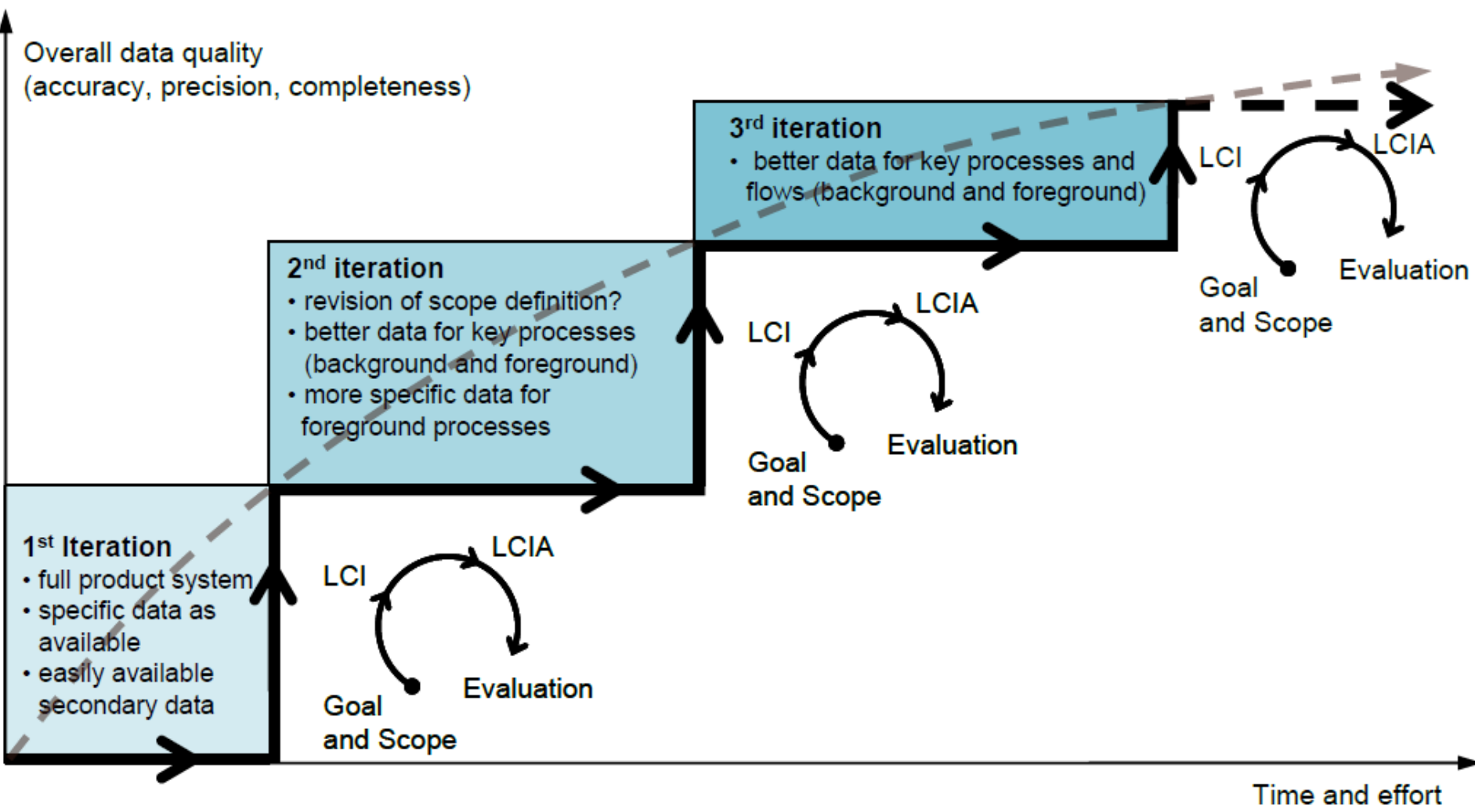
Source: Zah et al. 2007

Main questions

What are...

- the results?
- the uncertainties of the results?
- the results most sensitive to?
- the limitations of the study (e.g. what was not considered?)?
- the conclusions and recommendations?

LCA can be an iterative process



Software

The screenshot displays the Simapro software interface, which is used for Life Cycle Assessment (LCA). The main window is titled "LCA Explorer" and shows a hierarchical tree structure of products and processes. The "Inventory" tab is selected, showing a list of processes such as "Electricity, hard coal, at power plant/CN U" and "Electricity, hard coal, at power plant/NORDEL U".

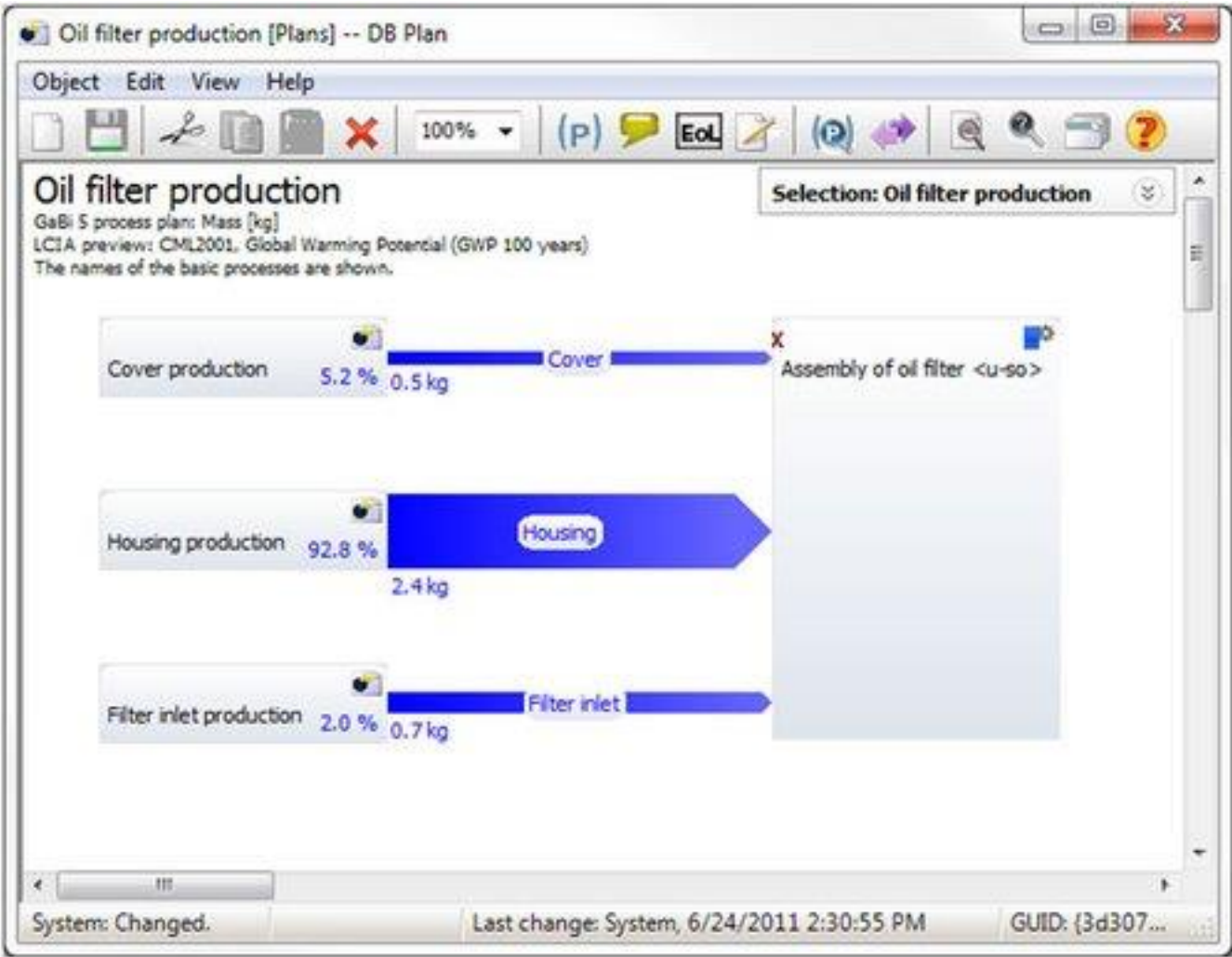
Overlaid on the main window are two other windows:

- Compare Electricity, ... CN U, Electricity, ... NORDEL U and Electricity, ... US U**: This window shows a bar chart comparing the environmental impacts of electricity production from hard coal in three regions: CN (China), NORDEL (North America), and US (United States). The chart displays 11 impact categories on the x-axis, including Global warming (GWP100), Acidification, Eutrophication, and others. The y-axis represents the impact magnitude, ranging from 15 to 120. The legend indicates that red bars represent CN, green bars represent NORDEL, and yellow bars represent US.
- Analyze Electricity, hard coal, at power plant/CN U**: This window shows a network diagram of the process, illustrating the flow of materials and energy between different components of the power plant. The diagram includes a "Navigation" pane and a "20 nodes visible of 1958" indicator.

The bottom of the screenshot shows the Windows taskbar with various open applications, including Microsoft Office and Simapro 7.

Simapro: <http://www.pre-sustainability.com/>

Software



GaBi: <http://www.thinkstep.com/>

Software

The screenshot shows the openLCA framework 1.2 interface. The left pane displays a navigation tree under 'MySQL at localhost:3306' with 'elcd' expanded to show 'Actors' and 'Organisations'. The right pane shows a process window titled 'Process: Articulated lorry transport, Euro 0, 1, 2, 3, 4 mix, 40 t total weight, 27 t max payload (elcd)'. Below the title is a 'Parameters' table with columns for 'Name' and 'Formula'.

Name	Formula
E0Sp_CO2_AB	$(715.6907349 + (1103.905396 - 715.6907349) \cdot \text{Auslast}) / (\text{Nutzlast} \cdot 1000 \cdot \text{Auslast})$
E0Sp_CO2_AO	$(684.4699707 + (1184.046387 - 684.4699707) \cdot \text{Auslast}) / (\text{Nutzlast} \cdot 1000 \cdot \text{Auslast})$
E0Sp_CO2_ges	$((\text{Anteil_AB} \cdot \text{E0Sp_CO2_AB}) + (\text{Anteil_AO} \cdot \text{E0Sp_CO2_AO}) + (\text{Anteil_IO} \cdot \text{E0Sp_CO2_IO})) \cdot \text{Distanz}$
E0Sp_CO2_IO	$(1110.033691 + (1918.750122 - 1110.033691) \cdot \text{Auslast}) / (\text{Nutzlast} \cdot 1000 \cdot \text{Auslast})$
E0Sp_CO_AB	$(1.627172947 + (1.838482857 - 1.627172947) \cdot \text{Auslast}) / (\text{Nutzlast} \cdot 1000 \cdot \text{Auslast})$
E0Sp_CO_AO	$(1.58979249 + (2.022540808 - 1.58979249) \cdot \text{Auslast}) / (\text{Nutzlast} \cdot 1000 \cdot \text{Auslast})$
E0Sp_CO_ges	$((\text{Anteil_AB} \cdot \text{E0Sp_CO_AB}) + (\text{Anteil_AO} \cdot \text{E0Sp_CO_AO}) + (\text{Anteil_IO} \cdot \text{E0Sp_CO_IO})) \cdot \text{Distanz}$
E0Sp_CO_IO	$(3.268083811 + (4.885313988 - 3.268083811) \cdot \text{Auslast}) / (\text{Nutzlast} \cdot 1000 \cdot \text{Auslast})$
E0Sp_Diesel_AB	$(0.2254144 + (0.34768674 - 0.2254144) \cdot \text{Auslast}) / (\text{Nutzlast} \cdot 1000 \cdot \text{Auslast})$
E0Sp_Diesel_AO	$(0.21558109 + (0.37292798 - 0.21558109) \cdot \text{Auslast}) / (\text{Nutzlast} \cdot 1000 \cdot \text{Auslast})$
E0Sp_Diesel_ges	$((\text{Anteil_AB} \cdot \text{E0Sp_Diesel_AB}) + (\text{Anteil_AO} \cdot \text{E0Sp_Diesel_AO}) + (\text{Anteil_IO} \cdot \text{E0Sp_Diesel_IO})) \cdot \text{Dist}$
E0Sp_Diesel_IO	$(0.34961694 + (0.60433075 - 0.34961694) \cdot \text{Auslast}) / (\text{Nutzlast} \cdot 1000 \cdot \text{Auslast})$
E0Sp_N2O_AB	$9.4 / (\text{Tonnage} \cdot 1000)$
E0Sp_N2O_AO	$13.6 / (\text{Tonnage} \cdot 1000)$
E0Sp_N2O_ges	$((\text{Anteil_AB} \cdot \text{E0Sp_N2O_AB}) + (\text{Anteil_AO} \cdot \text{E0Sp_N2O_AO}) + (\text{Anteil_IO} \cdot \text{E0Sp_N2O_IO})) \cdot \text{Distanz}$
E0Sp_N2O_IO	$16.2 / (\text{Tonnage} \cdot 1000)$

OpenLCA: <http://www.openlca.org/>

Software

Calculation Setups: Example

Products and amounts:

	Activity name	Amount	Unit
1	steel, converter, chromium steel 18/8, at plant	1.0	kilogram
2	steel, electric, chromium steel 18/8, at plant	1.0	kilogram
3	powder coating, steel	1.0	square meter
4	welding, arc, steel	1.0	meter
5	welding, gas, steel	1.0	meter
6	sheet rolling, steel	1.0	kilogram
7	steel, converter, unalloyed, at plant	1.0	kilogram
8	wire drawing, steel	1.0	kilogram
9	drawing of pipes, steel	1.0	kilogram

LCIA Methods:

	Name
1	ReCiPe Endpoint (E,A), total, total
2	ReCiPe Endpoint (E,A), resources, total
3	ReCiPe Endpoint (E,A), human health, total
4	ReCiPe Endpoint (E,A), ecosystem quality, total

Databases:

	Name	Depends	Last modified
1	biosphere3		a month ago
2	ecoinvent 2.2	biosphere3	2 days ago

Activities:

	Name	Reference Product	Location	Unit
1	steel, converter, chromium steel 18/8, at plant		RER	kilogram
2	steel, electric, chromium steel 18/8, at plant		RER	kilogram
3	powder coating, steel		RER	square meter
4	welding, arc, steel		RER	meter
5	welding, gas, steel		RER	meter
6	sheet rolling, steel		RER	kilogram
7	steel, converter, unalloyed, at plant		RER	kilogram
8	wire drawing, steel		RER	kilogram
9	drawing of pipes, steel		RER	kilogram

This database has no biosphere flows

Welcome Project: default Database: ecoinvent 2.2

Brightway2 Activity Browser: <http://brightwaylca.org/>

THANK YOU FOR YOUR ATTENTION