Material Flow Analysis and Life Cycle Assessment

TECHNISCHE UNIVERSITÄT DARMSTADT

7. Unit: LCA – The Life Cycle inventory III

SoSe 2011/12

Prof. Dr. Liselotte Schebek
Fachgebiet Industrielle Stoffkreisläufe
Institut IWAR

IWAR

TECHNISCHE UNIVERSITÄT DARMSTADT

7. Unit: Life Cycle Inventory Analysis(II)

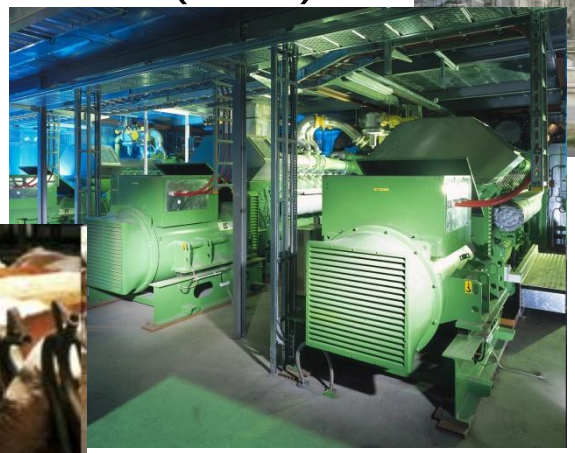
IWAR

Multi-product processes

TECHNISCHE UNIVERSITÄT DARMSTADT

Example for multi-product processes:

- Refinery
- Chemical process
- Combined heat and power unit (CHP)
- Livestock husbandry



IWAR

Problems of multi-product processes

TECHNISCHE UNIVERSITÄT DARMSTADT

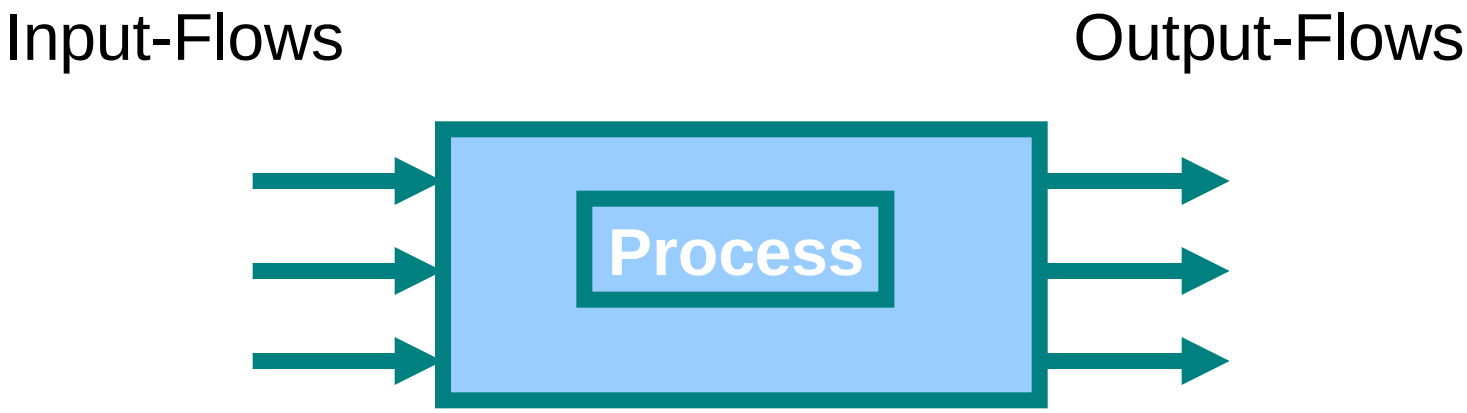
Multi-product processes have

- ....several „benefits“
- ... Several functional units
- ... Several reference flows („functional flows“)

➔How to allocate the environmental impact of the process to the different "benefits"?

➔How is the calculation of product systems carried out, when processes have several reference flows?

Product flows in multi-product processes



Which are the „functional flows“?

Example: Livestock farming

TECHNISCHE UNIVERSITÄT DARMSTADT

Functional Unit:

Production of wool, milk, meat

Functional flows:

x kg/a Wool

y l/a Milk

z kg/a Meat

IWAR

Example: waste incineration

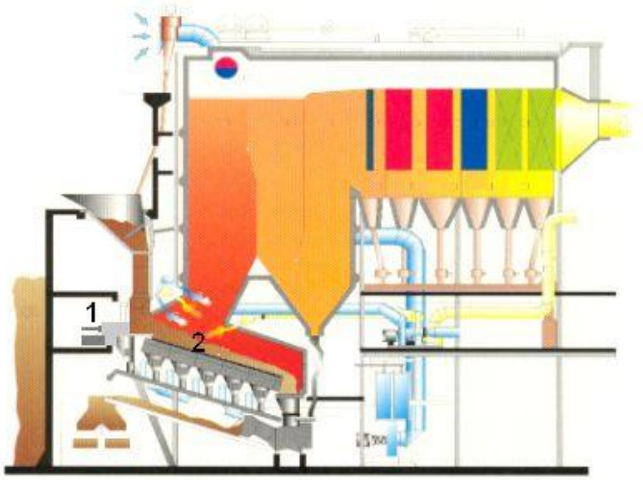
Functional Unit:

Treatment

of 1 t waste

Functional flow:

1 t waste



Identification of functional flows

TECHNISCHE UNIVERSITÄT DARMSTADT

Example:

A plastic producer produces plastic parts, accumulating a small amount of cuttings. The cuttings are – since it is pollution-free material - disposed in the municipal waste incinerator.

Is the material flow “cuttings of plastic parts" a functional flow?

Generally:

- The identification of functional flows results from the perspective of the process.
- A functional flow is such that has for each process an **economic value**.

General definition for multi-product processes

TECHNISCHE UNIVERSITÄT DARMSTADT

Functional flow:

Each flow that contributes to the economic benefits of a process:

- Product of a product process
- Waste of a waste treatment process

Multi-product process:

A process that has more than one functional flow:

- Co-production (multi-output process)
- Combined waste treatment (multi-input-process)
- Waste treatment with recycling? (Input-Output-Process/multi-Input-Output-Process)

Types of multi-product processes: Co-Production (multi-Output-Process)

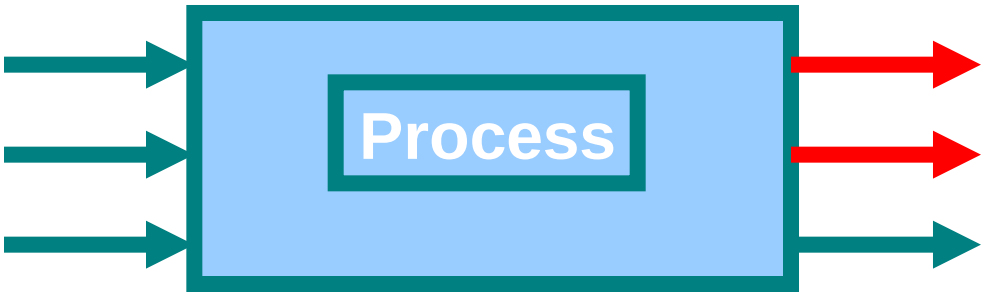
TECHNISCHE UNIVERSITÄT DARMSTADT

Example: chlor-alkali electrolysis

Output: hydrochloric acid, sodium hydroxide

Input-Flows

Output-Flows

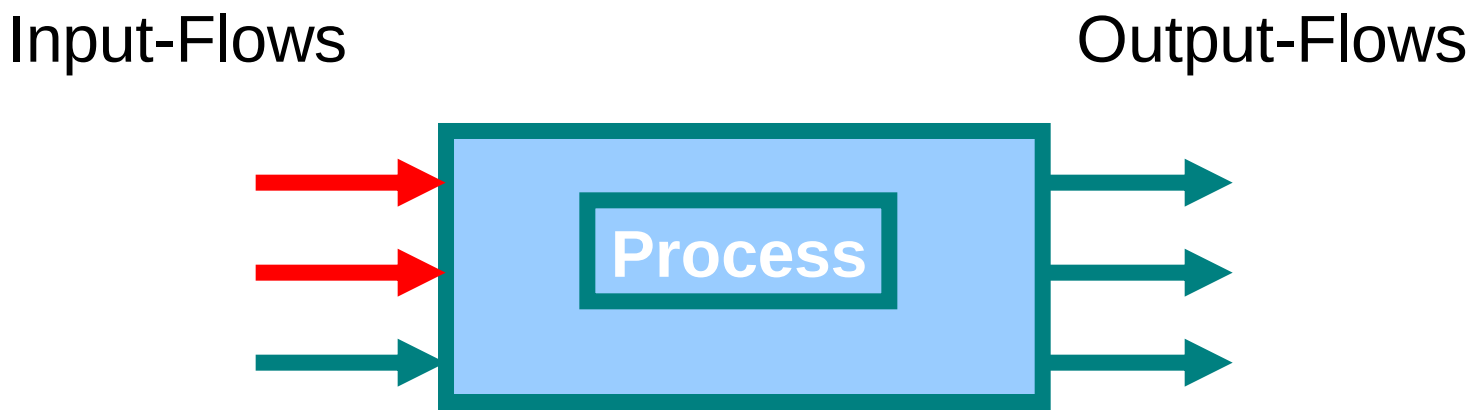


Types of multi-product processes: Combined waste treatment (multi-input process)

TECHNISCHE UNIVERSITÄT DARMSTADT

Example: **underground disposal of hazardous waste**

Input: n categories of hazardous waste



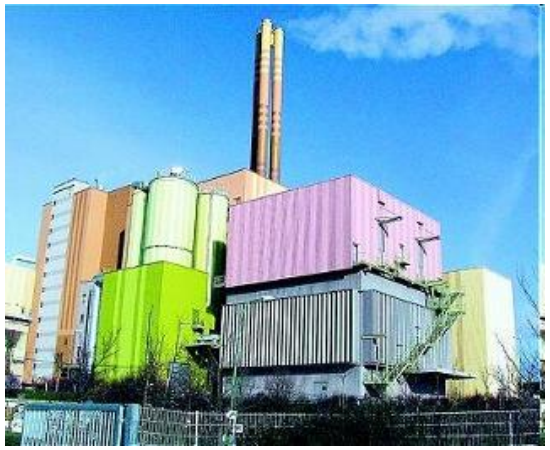
Types of multi-product processes: Waste treatment with recycling (input-output process)

TECHNISCHE UNIVERSITÄT DARMSTADT

Example: **waste incineration plant**

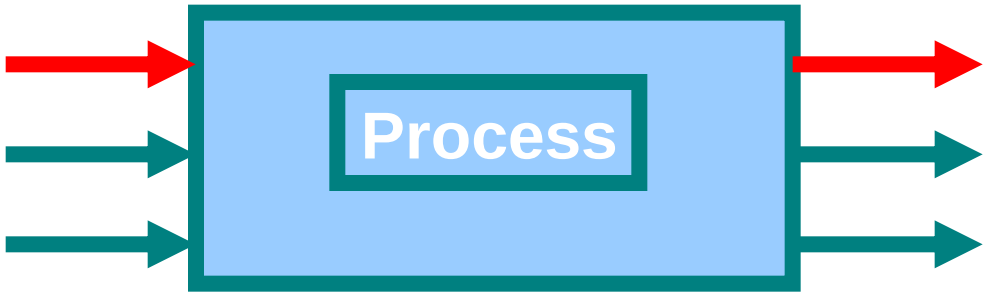
Input: municipal waste

Output: heat



Input-Flows

Output-Flows



IWAR

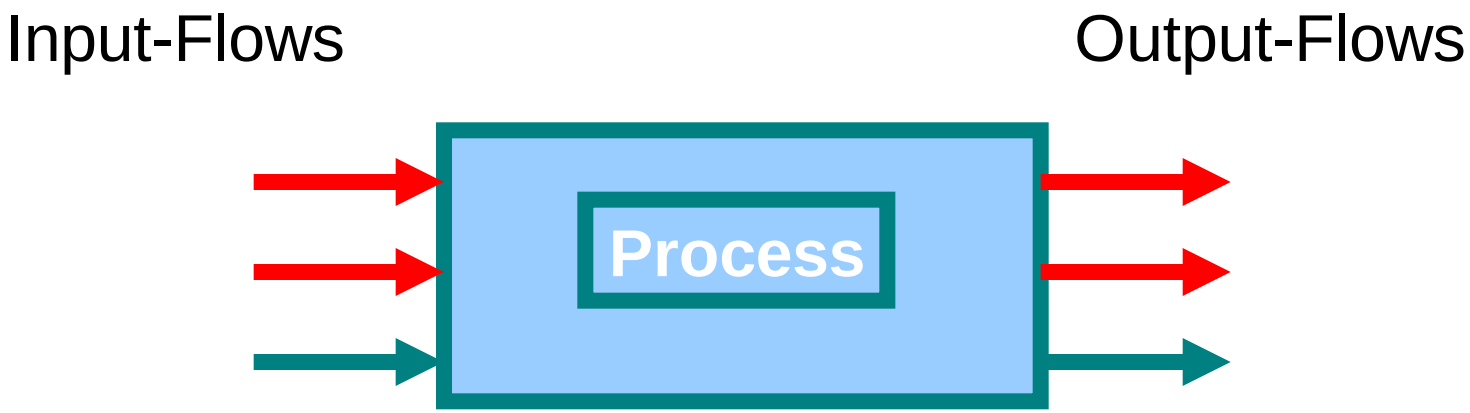
Types of multi-product processes: Waste treatment with recycling (multi-input-output process)

TECHNISCHE UNIVERSITÄT DARMSTADT

Example: **waste incineration plant**

Input: municipal waste; industrial waste

Output: heat; electricity



Treatment of multi-product processes(I)

TECHNISCHE UNIVERSITÄT DARMSTADT

Allocation procedure

Within the scope of this study, the processes which are used together with other product systems have to be indentified and then be treated gradually according to the procedure 3) shown below:

A) Step 1: Wherever possible, an allocation can be avoided by

1) Division of the affected process modules into two or more sub-processes and collection of input and output data related to these sub-processes or
2) Expansion of the product system by including additional features that relate to co-products, at which the requirements have to be considered according to 4.2.3.3.

EN ISO 14044:2006 (D/E)

Behandlung von Mehrprodukt-Prozessen (II)

TECHNISCHE UNIVERSITÄT DARMSTADT

B) Step 2: When an allocation can not be avoided, the inputs and outputs of the system between its different products or functions should be assigned that way, so that the underlying physical relationships are reflected between them, i.e. they should reflect the way in which inputs and outputs change by quantitative changes in the products or services provided by the system.

C) Step 3: When physical relationships alone can not set up or can not be used as a basis for allocation, the inputs between the products and functions should be assigned that way, so that it reflects other relationships between them.

For example, data can be assigned to the co-products on the input and output side in proportion to the economic value of the products.

EN ISO 14044:2006 (D/E)

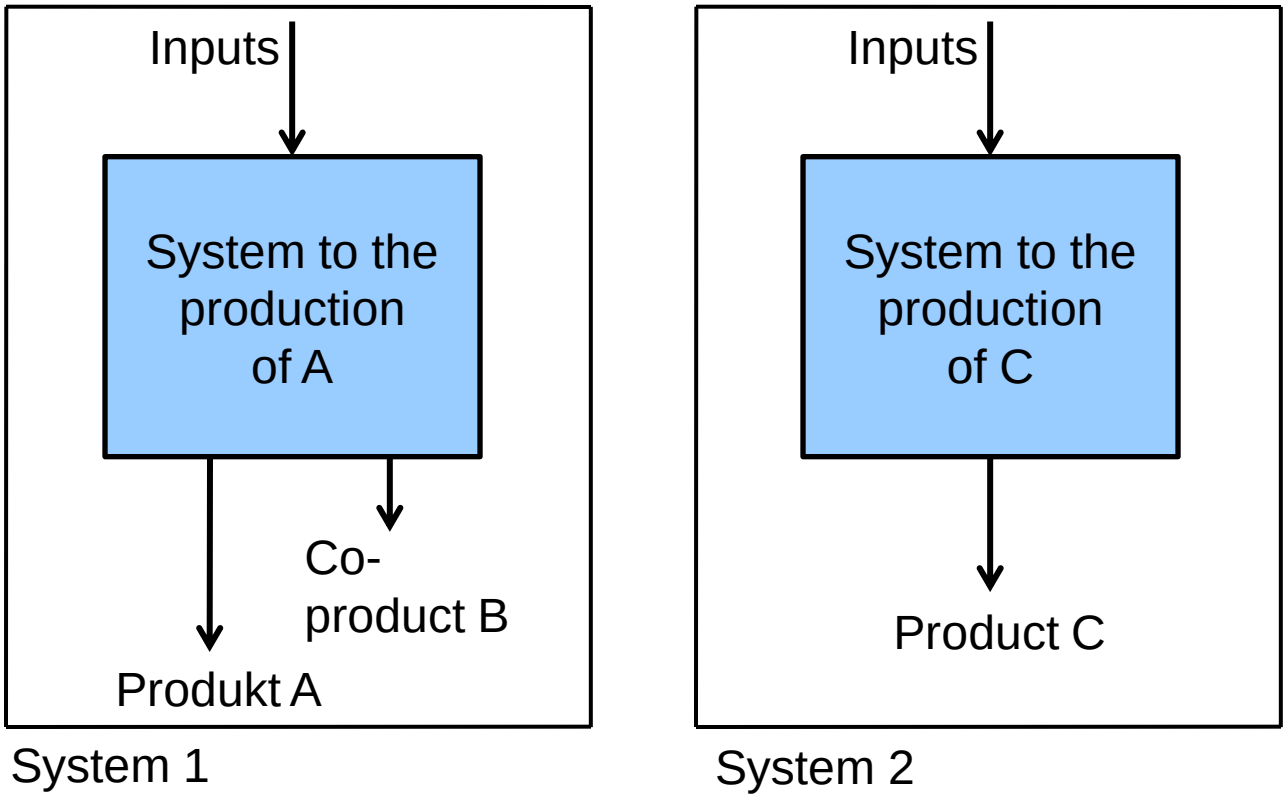
TECHNISCHE UNIVERSITÄT DARMSTADT

7. Unit: Life Cycle Inventory Analysis (II)

IWAR

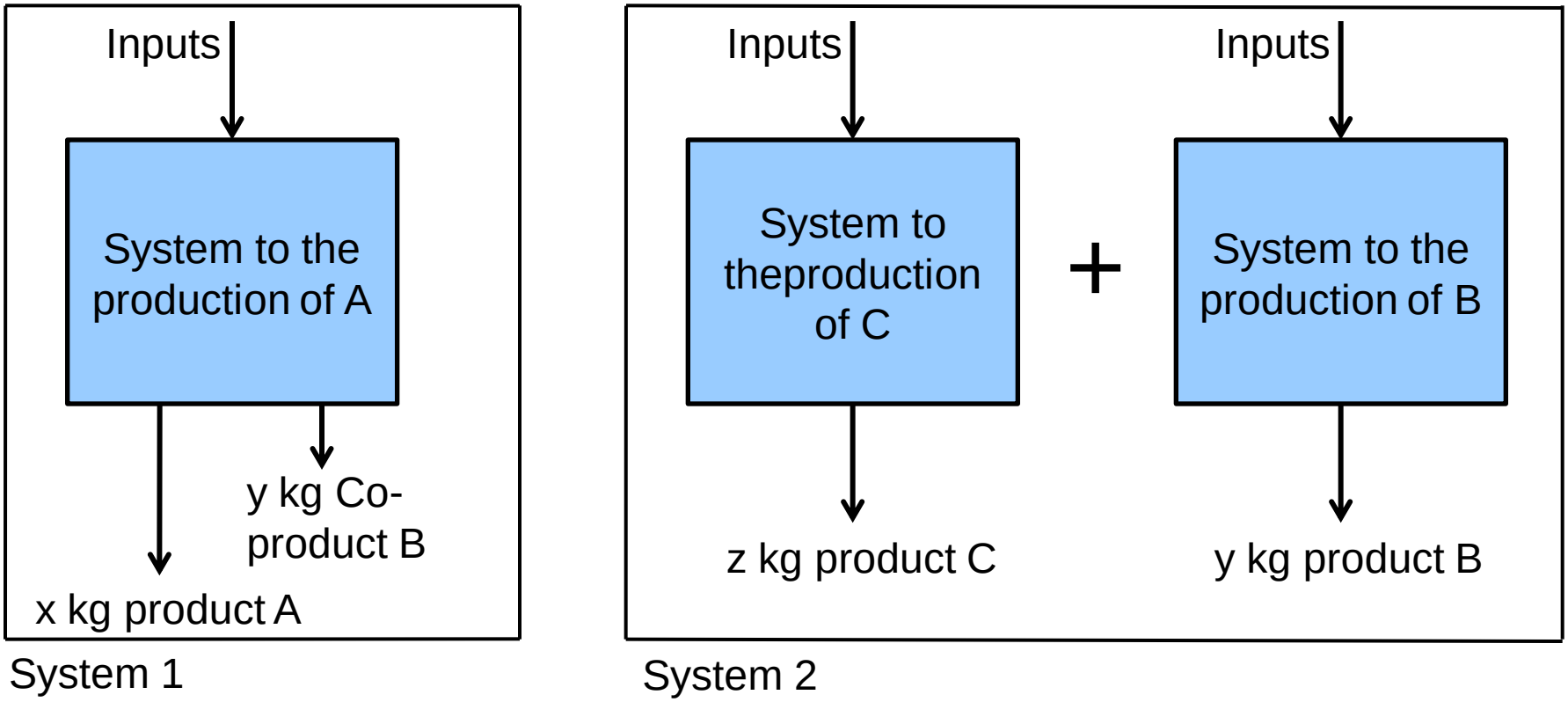
Product comparison with system expansion

Example: Comparison of the **products of equal utility A and C**
(only production; Use and disposal is not illustrated);
at th production of A accumulates the **co-product B**:



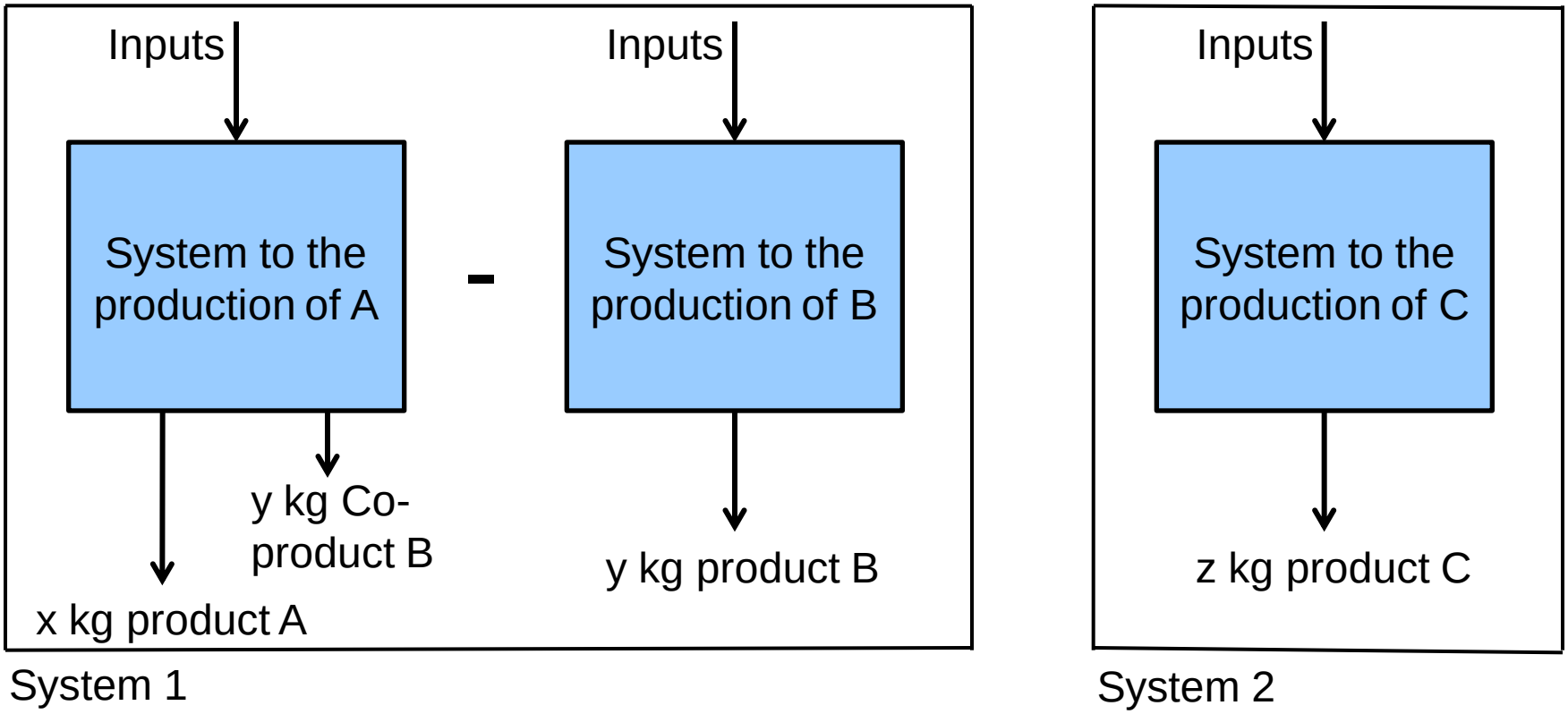
Product comparison with system expansion: Variant “shopping cart concept"

… to compare the systems, the separate manufacture of B is added to the production of C



Product comparison with system expansion: Variant "avoided burden approach"

Idea: subtract the environmental contamination associated with the manufacture of B from A



Product comparison with system expansion: methodological problems

TECHNISCHE UNIVERSITÄT DARMSTADT

- if several manufacturing methods exist for B, the most common is selected -> arbitrariness of the selection process?
- if B can **only** be produced as a co-product of A -> need of the availability of B is not detected
- if more co-products result from other production processes of B -> higher data requirements, may estimation

Product comparison with system expansion- retrospective and prospective LCA

TECHNISCHE UNIVERSITÄT DARMSTADT

retrospectively (classic):

- detects the status quo, no alternative production chains

prospectively:

- based on market oriented future scenarios
- However, additional assumptions required, resulting in increased data complexity and additional uncertainty

System expansion: Example sludge disposal

TECHNISCHE UNIVERSITÄT DARMSTADT

Anteil der Entsorgungswege in NRW in %						
Jahr	Landwirt-schaft	Landschafts-bau / Kom-postierung	Deponierung	Verbrennung	Zwischenlager /sonstige Entsorgung	Summe
1995	31,0	14,6	17,9	32,3	4,2	100,0
1996	29,2	14,0	13,2	37,0	6,5	100,0
1997	28,3	21,8	11,3	33,3	5,4	100,0
1998	27,6	17,4	9,3	40,5	5,3	100,0
1999	28,5	13,4	8,2	41,2	8,7	100,0
2000	30,7	17,6	6,5	37,2	7,9	100,0
2001	22,9	14,5	9,6	39,7	13,1	100,0
2003	22,1	9,5	5,1	53,4	9,8	100,0

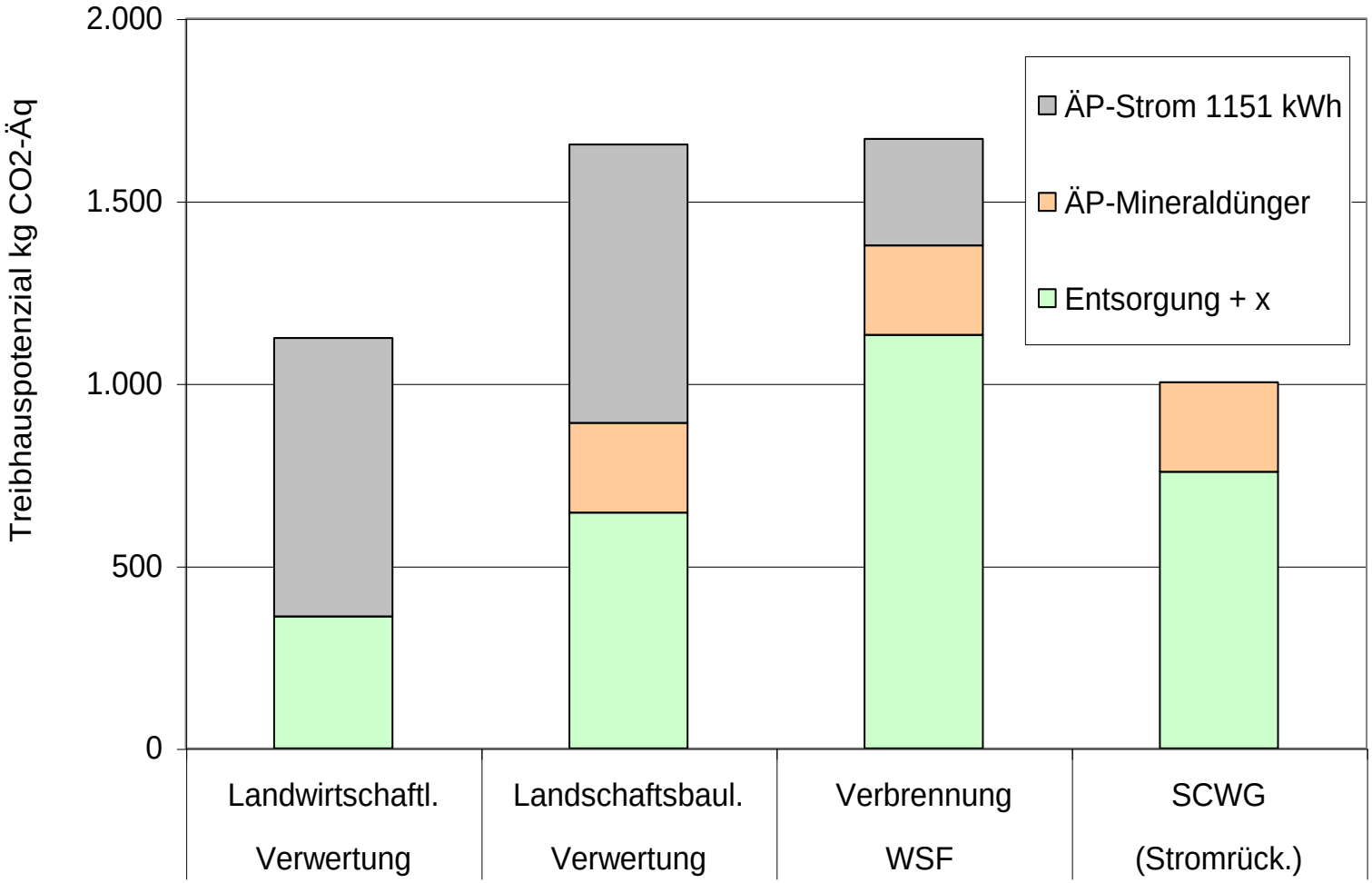
fertilizer **disposal** **energy**

IWAR

equivalent processes

Prozess / Funktion	Land-wirtschaftliche Verwertung	Land-schaftsbau	Ver brennung	SCWG
Entsorgung	erfüllt	erfüllt	erfüllt	erfüllt
Dünger	erfüllt	ÄP Dünger	ÄP Dünger	ÄP Dünger
Strom-herstellung	ÄP Strom	ÄP Strom	Zusätzlich ÄP Strom	erfüllt

Presentation of results with equivalent processes



TECHNISCHE UNIVERSITÄT DARMSTADT

7. Unit: Life Cycle Inventory Analysis (II)

IWAR

Allocation

TECHNISCHE UNIVERSITÄT DARMSTADT

Allocation in a narrower sense

(cp. 4.3.4.2 allocation procedures DIN EN ISO 14044)**:**

Division of non-functional flows into several functional flows of a process according to:

- Physical relations
- Other realtions

Allocation:
Example Mining

TECHNISCHE UNIVERSITÄT DARMSTADT

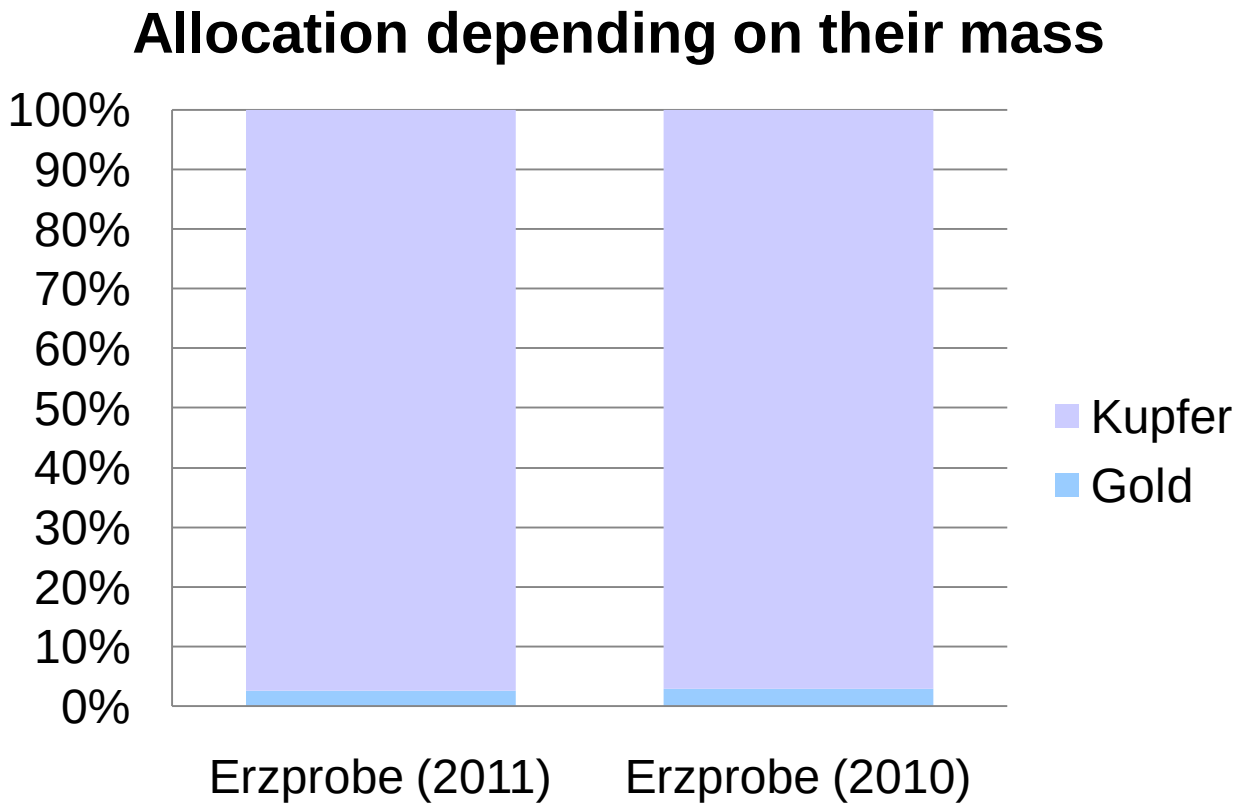
Ore mining

Burra Burra Mine in Australia

	Erzprobe (2011)	Erzprobe (2010)
Gold	0,04%	0,035%
Kupfer	1,55%	1,20%

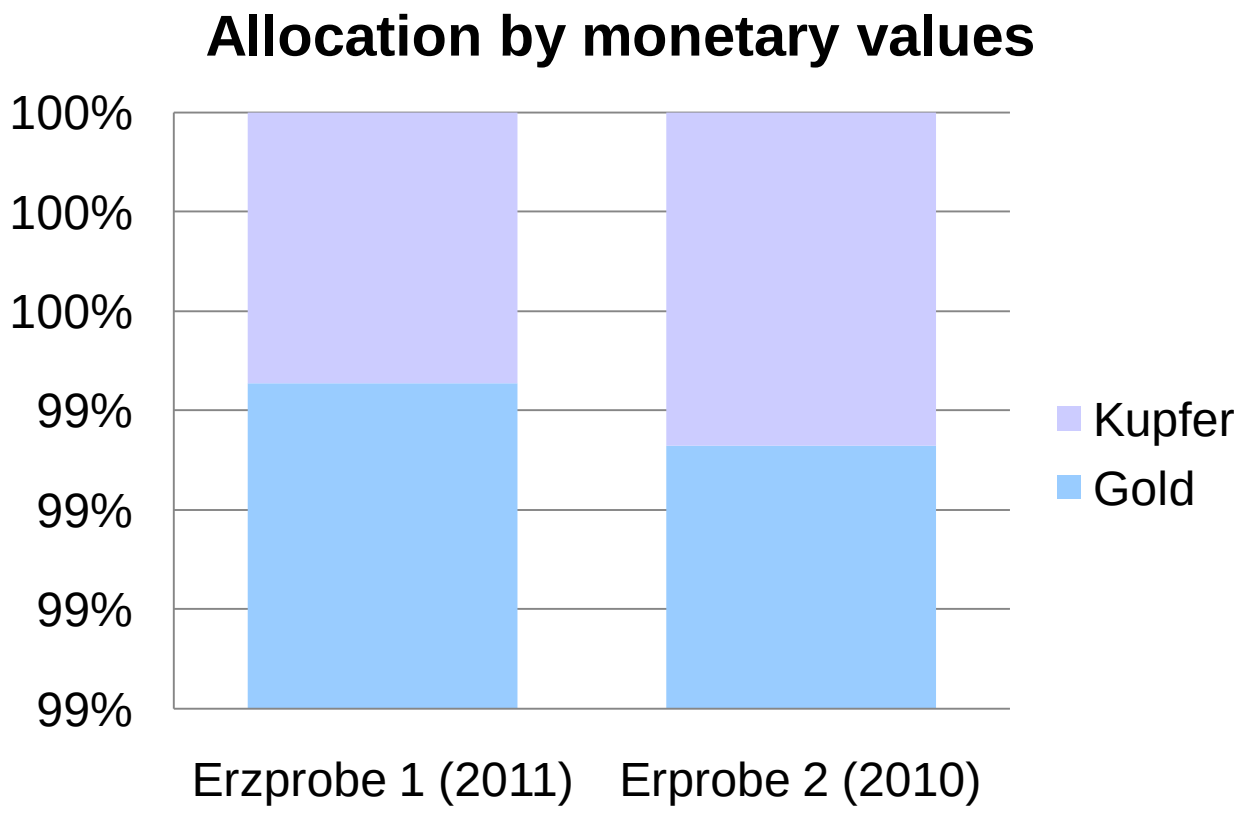
Allocation – by mass

Example extraction of ore



Allocation by monetary values

Example extraction of ore



Copper price:

7.870,00 US $/t (02.11.2011)
8.925,00 US $/t (11.11.2010)

Gold price:

1.730,03 US $/Feinunze (02.11.2011)
1.408,80 US $/Feinunze (11.11.2010)

Pros and cons of different approaches of the allocation

TECHNISCHE UNIVERSITÄT DARMSTADT

By physical factors:

Pro:

- Physical conditions represent invariable allocations of the products.

Cons:

- The allocation to the physical conditions does not reflect the economic motivation for the implementation of a process.

By economic conditions:

Pro:

- The economy represents the "driving force" for the implementation of a process
- In business administration also other "burdens" according to the ratio of the monetary value of products are assigned.

Cons:

- mostly no costs for the allocation are available, but prices. These are influenced by market conditions and can fluctuate greatly in short periods of time, which makes the result of the allocation very uncertain.