



Life Cycle Assessment
A product-oriented method
for sustainability analysis

UNEP LCA Training Kit

Module g – Multifunctionality, allocation & system boundaries



UNEP

Life Cycle



Initiative



Contents

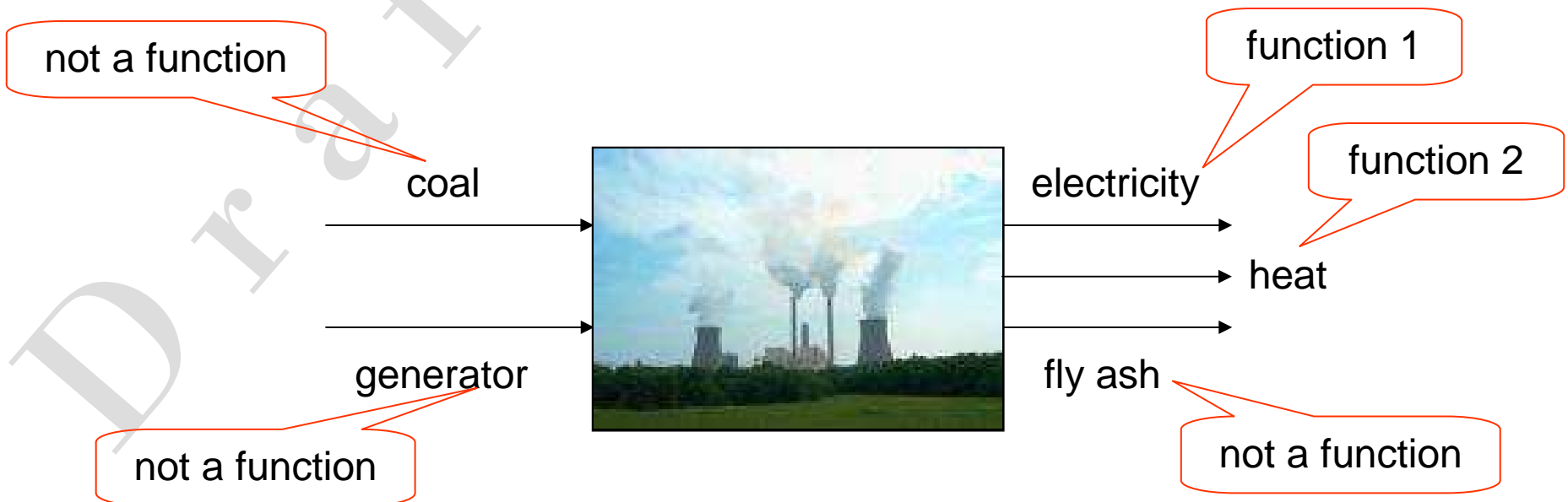
This module be used to expand on the presentation of LCI in module d.

- **The problem**
- **Definitions and typologies**
- **Solving the multifunctionality problem**
- **Allocation according to ISO**
- **System boundary and allocation**
- **Economic allocation**

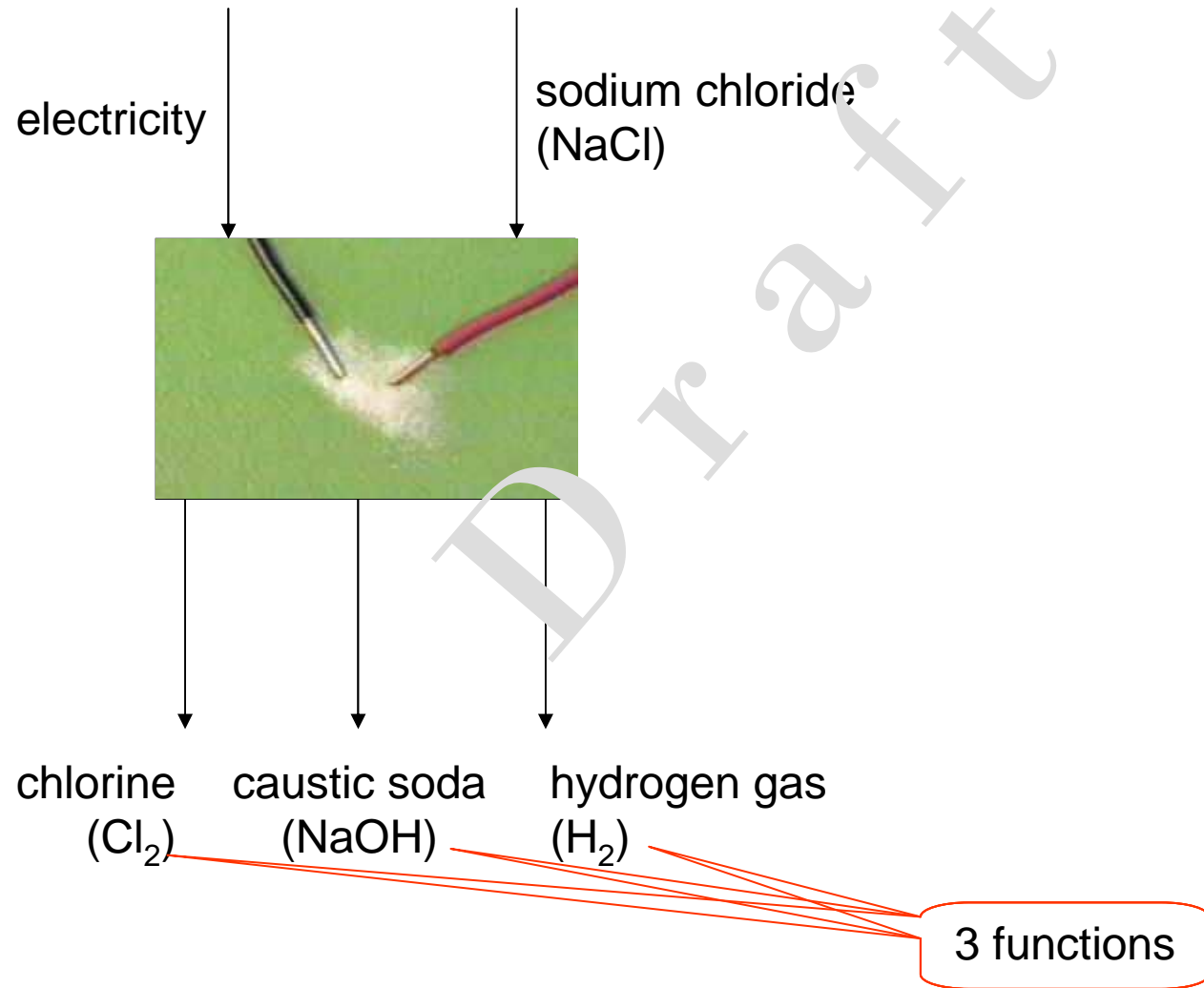
The problem

Some processes have more than one function.

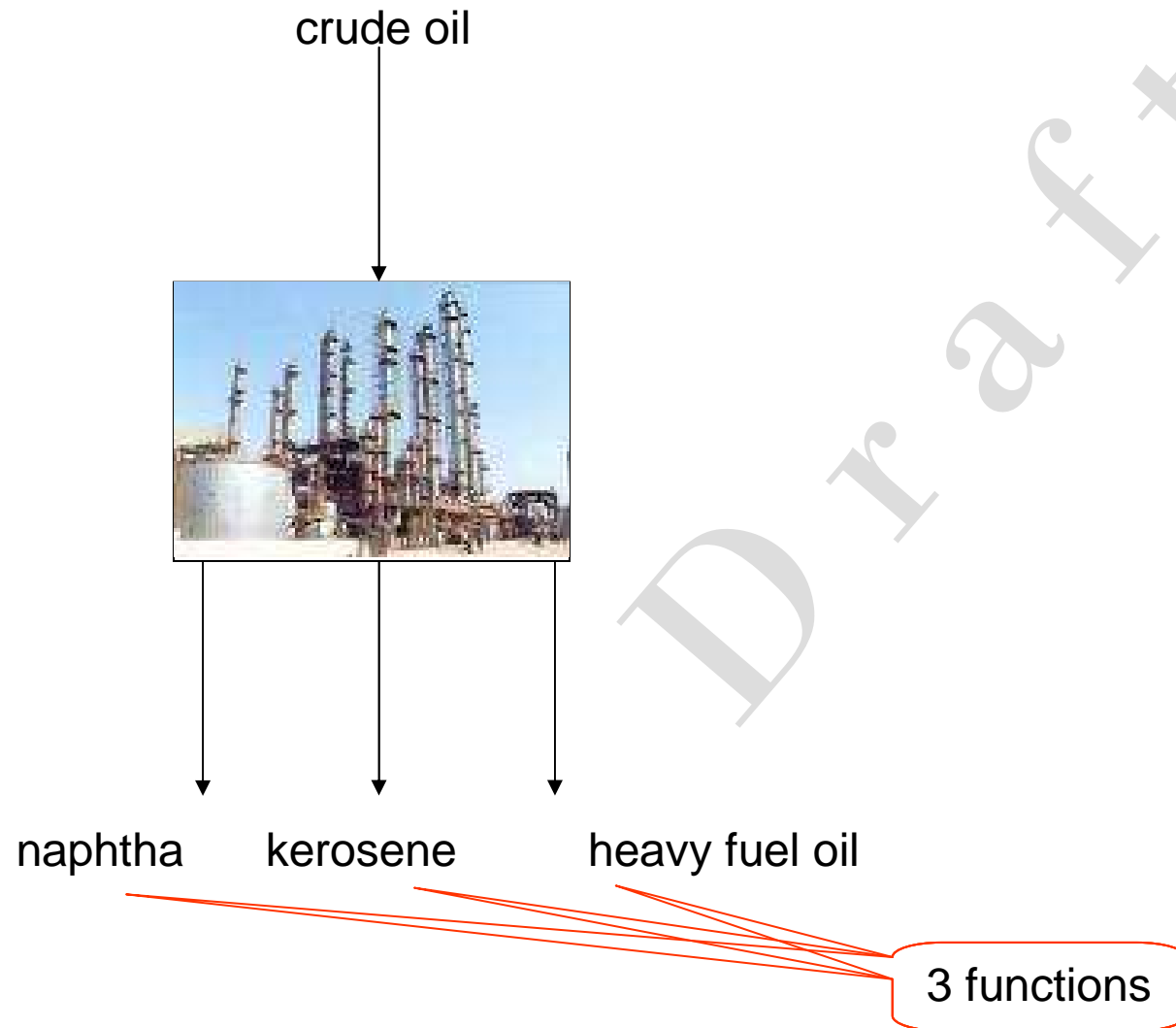
– “multifunctional processes”



The problem



The problem



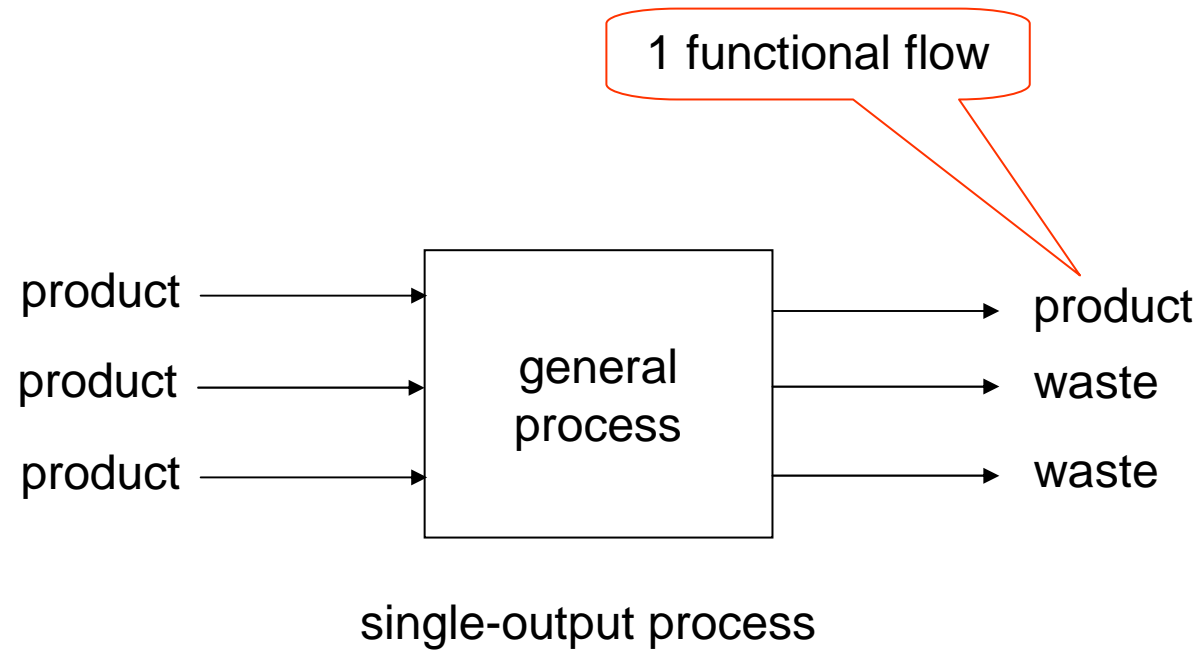
The problem

- **Two problems:**
 - How should the environmental impacts of these processes be allocated to the different product systems involved?
 - Which processes belong to the product system studied and which do not?

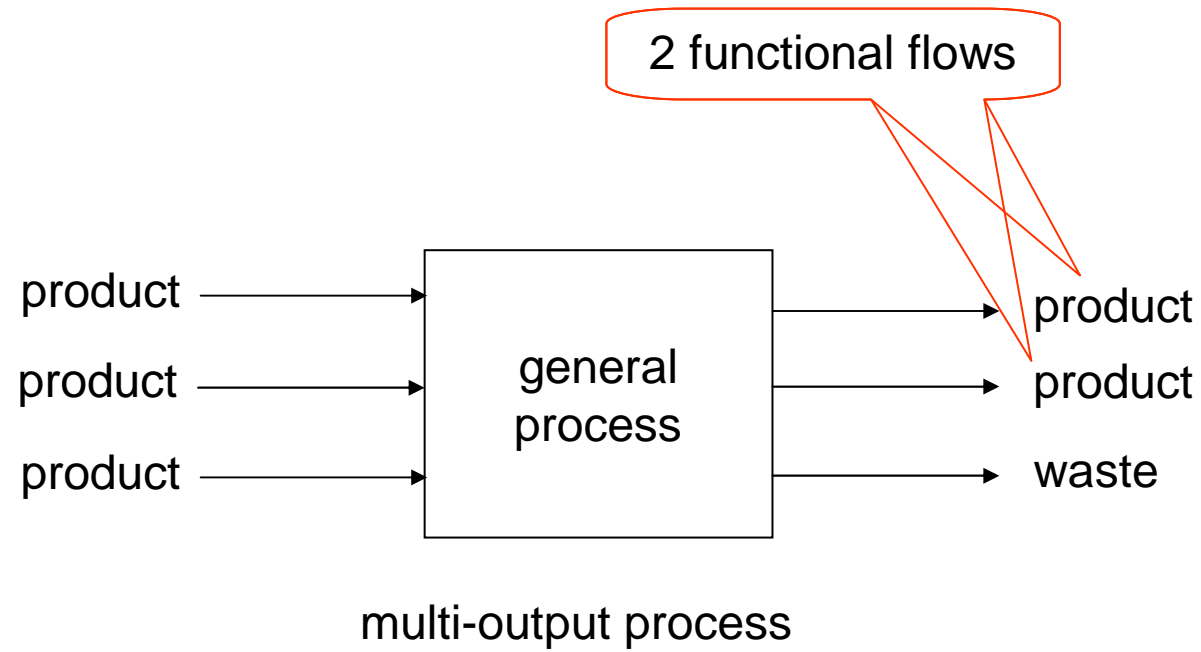
Definitions and typologies

- **Functional flow**
 - any of the flows of a unit process that constitute its goal
 - product outflows of a production process
 - waste inflows of a waste treatment process
- **Multifunctional process**
 - a unit process yielding more than one functional flow
 - co-production (multi-output)
 - combined waste processing (multi-input)
 - recycling (input-output)

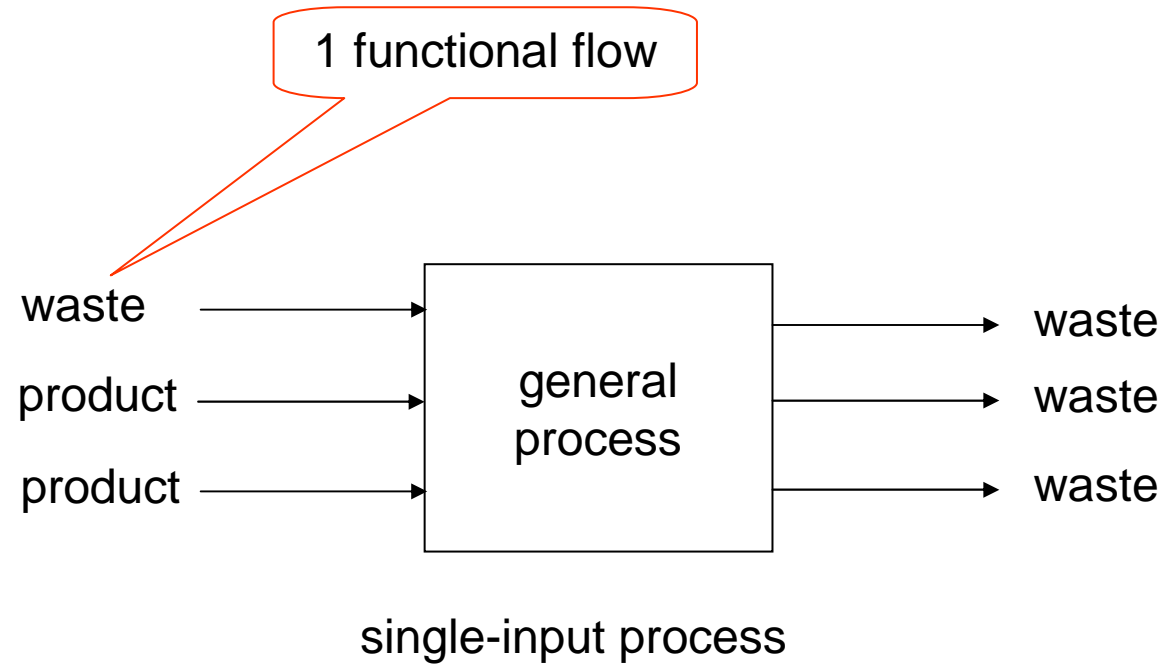
Definitions and typologies



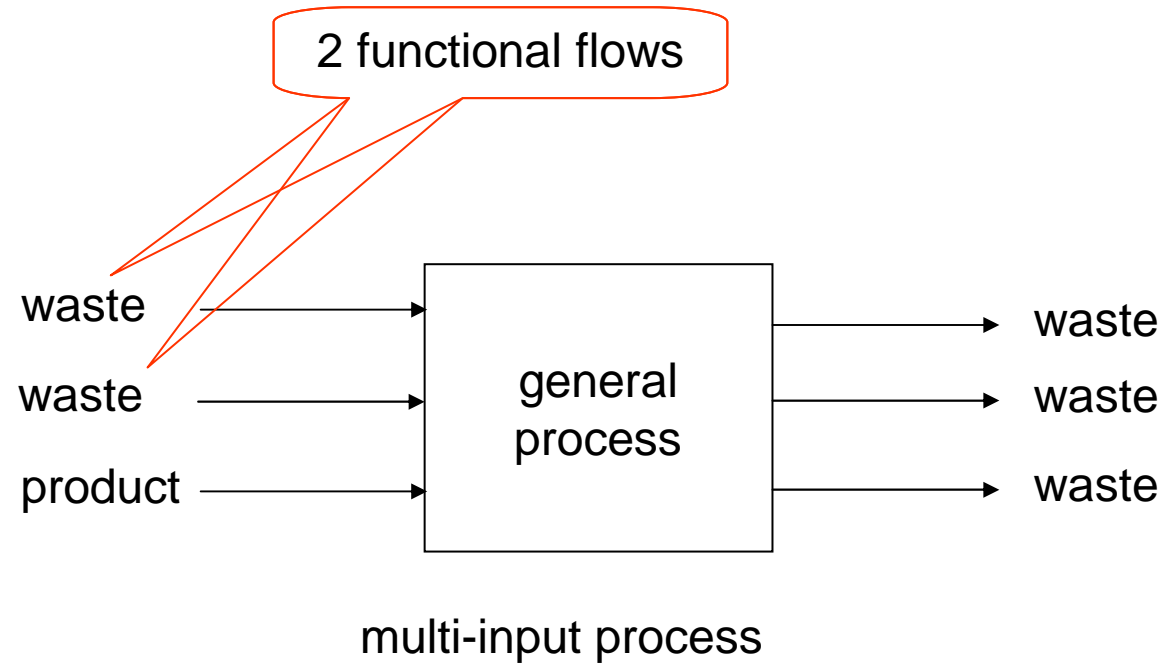
Definitions and typologies



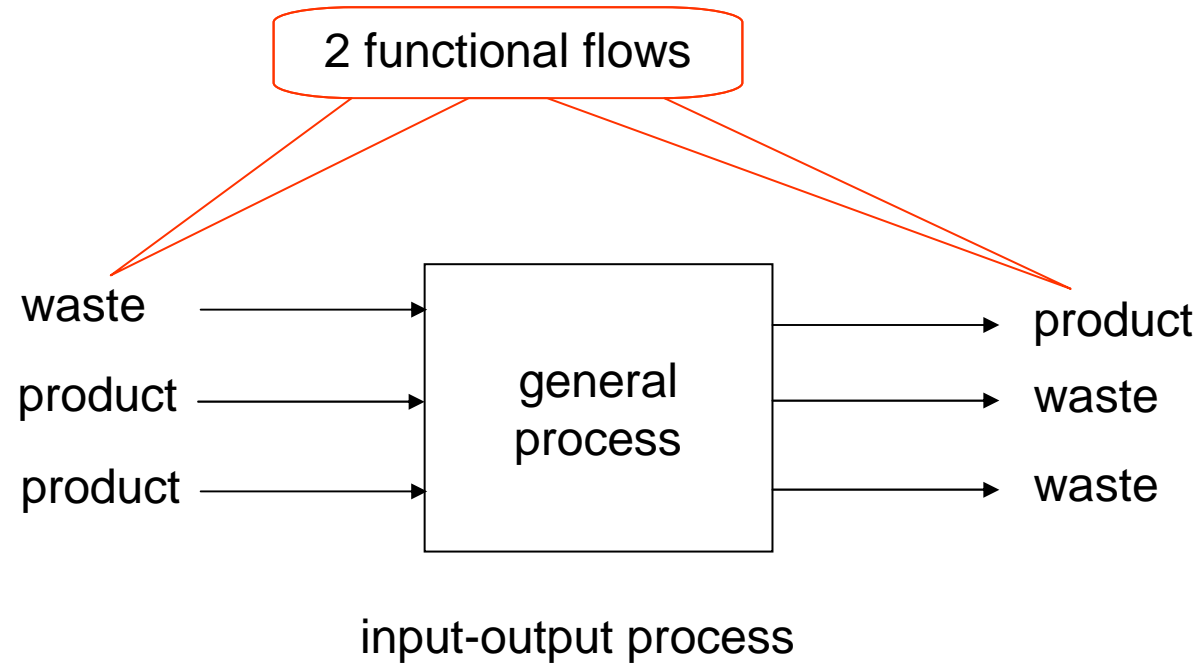
Definitions and typologies



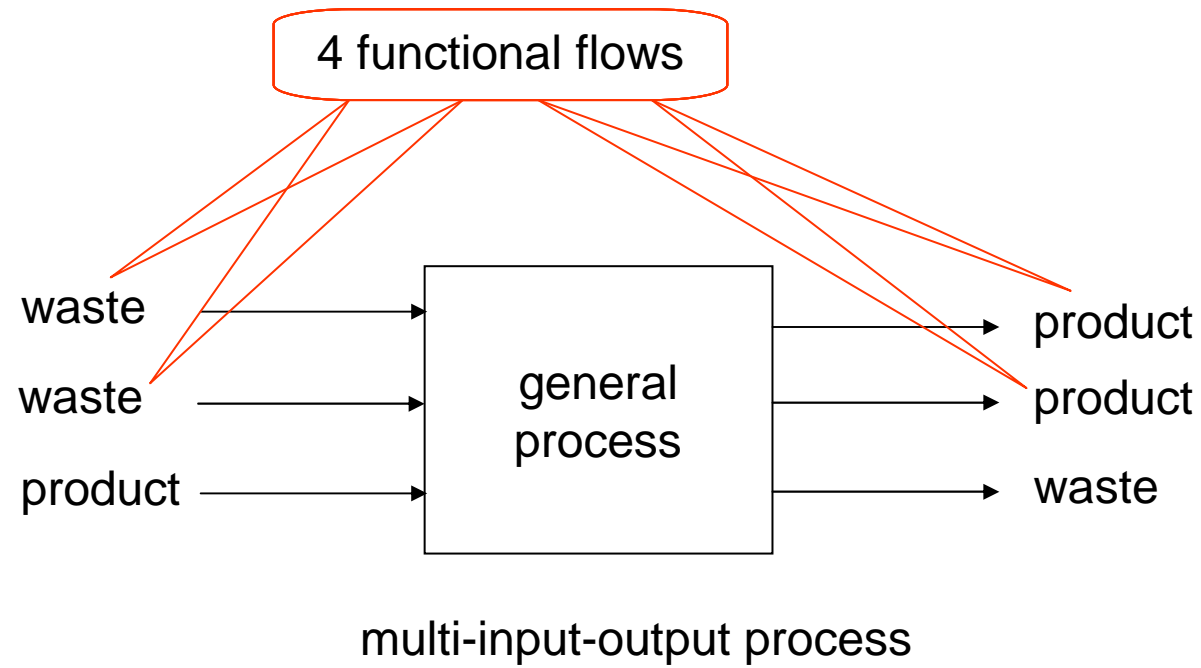
Definitions and typologies



Definitions and typologies



Definitions and typologies



Definitions and typologies

- **Allocation problem**
 - Partitioning (the inputs and outputs of) unit processes among product systems can be a challenge.
- **Multifunctionality problem**
 - Across LCA inventory modelling
 - what are the functional flows of every process?
 - which processes are multi-functional processes?
 - how to resolve the problems related to that?

Definitions and typologies

- **Problem**
 - When a product system needs product 1, it also produces product 2.
- **Possible solutions**
 - more refined data collection
 - system expansion
 - substitution
 - partitioning (=allocation)
 - surplus

Definitions and typologies

- **More refined data collection**
 - ... not allocation, but re-iteration of data collection
- **System expansion**
 - add extra function(s) to the functional unit
 - ... but are you still doing the LCA of a product?

Definitions and typologies

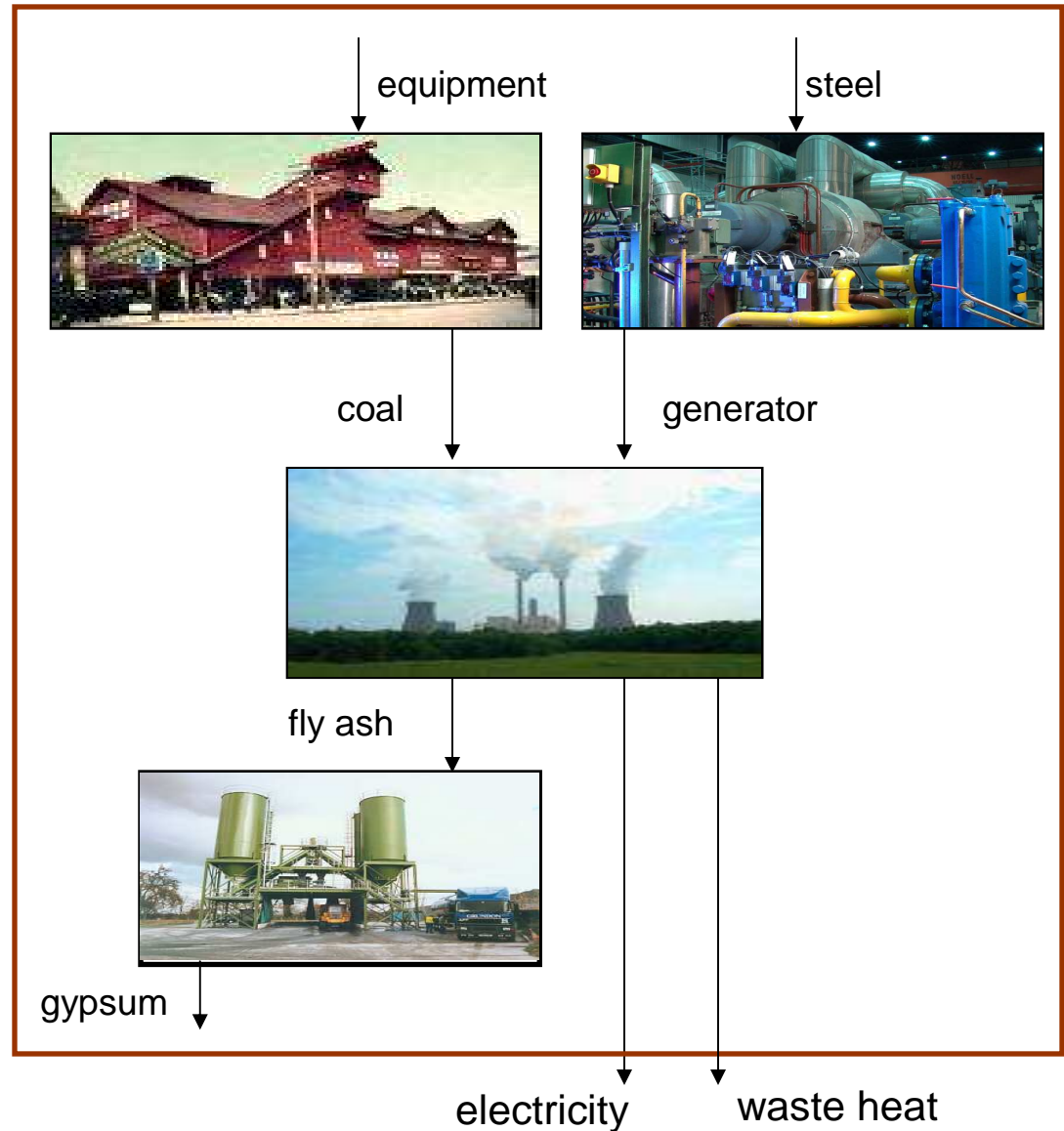
- **Substitution method**
 - defining an “avoided” process with subsequent “avoided” interventions/impacts
 - ... but which process is avoided?
- **Partitioning method**
 - splitting the multifunctional process into several monofunctional processes
 - ... but what basis for splitting?
- **Surplus method**
 - ignoring co-products

Solving the multifunctionality problem

- **The allocation problem is an artefact of isolating one function.**
- **Artefacts can only be cured in an artificial way; there is no “correct” way – not even in theory.**
- **A solution should be consistent in itself, and with main modelling principles.**

Solving the multifunctionality problem

- What to do with the extra heat?

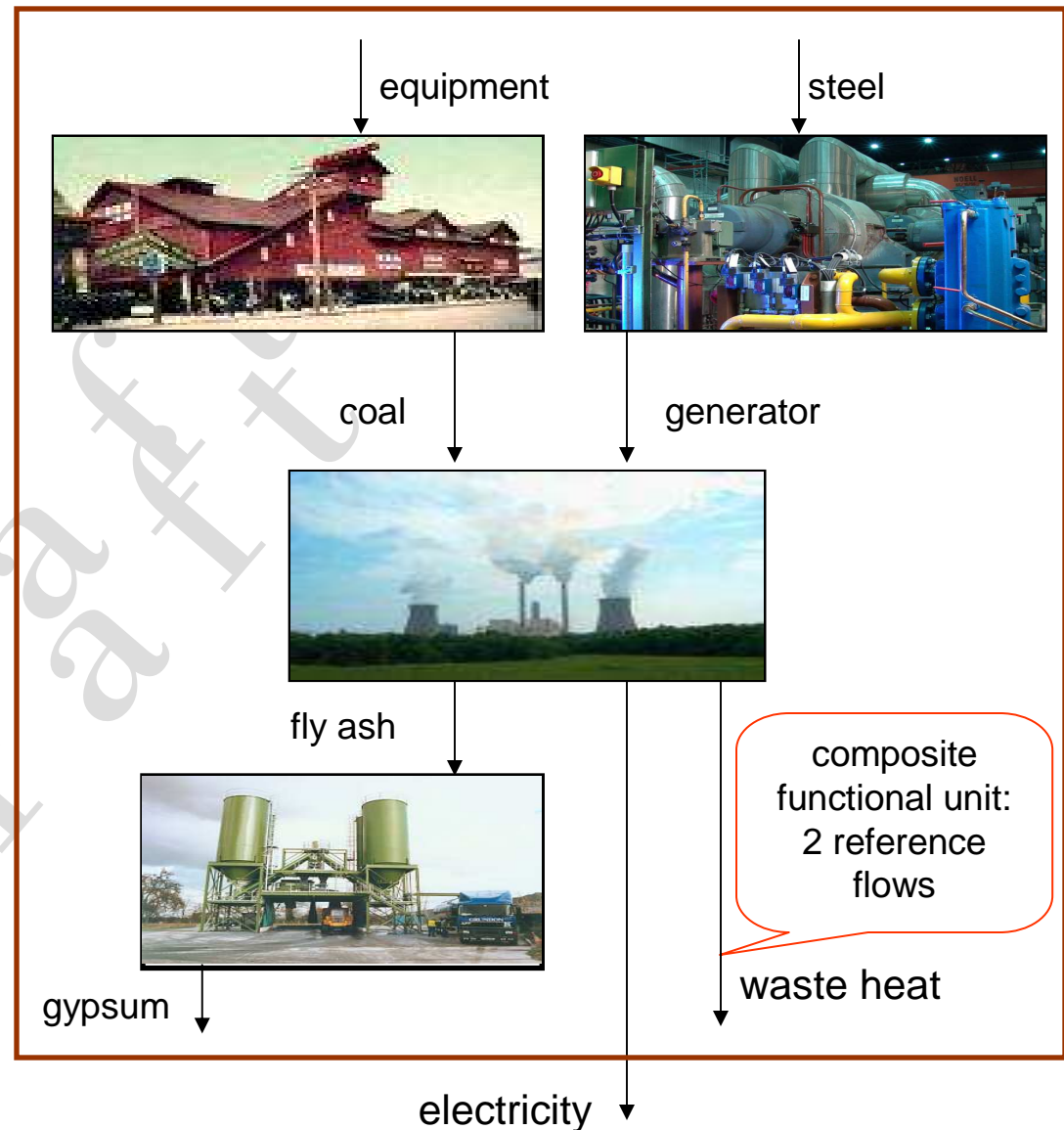


Solving the multifunctionality problem

- **There are two main strategies for dealing with multifunctionality:**
 - 1 Accept extra functions as a composite reference flow**
("system expansion")
 - 2 Eliminate extra functions by an extra modeling step**
("allocation")
 - subtracting "avoided" burdens ("substitution")
 - allocating only part of burden to function needed ("partitioning")

Solving the multifunctionality problem

- **System expansion**
 - change system boundary
 - include extra function(s) in functional unit
 - must also do this for the other alternative

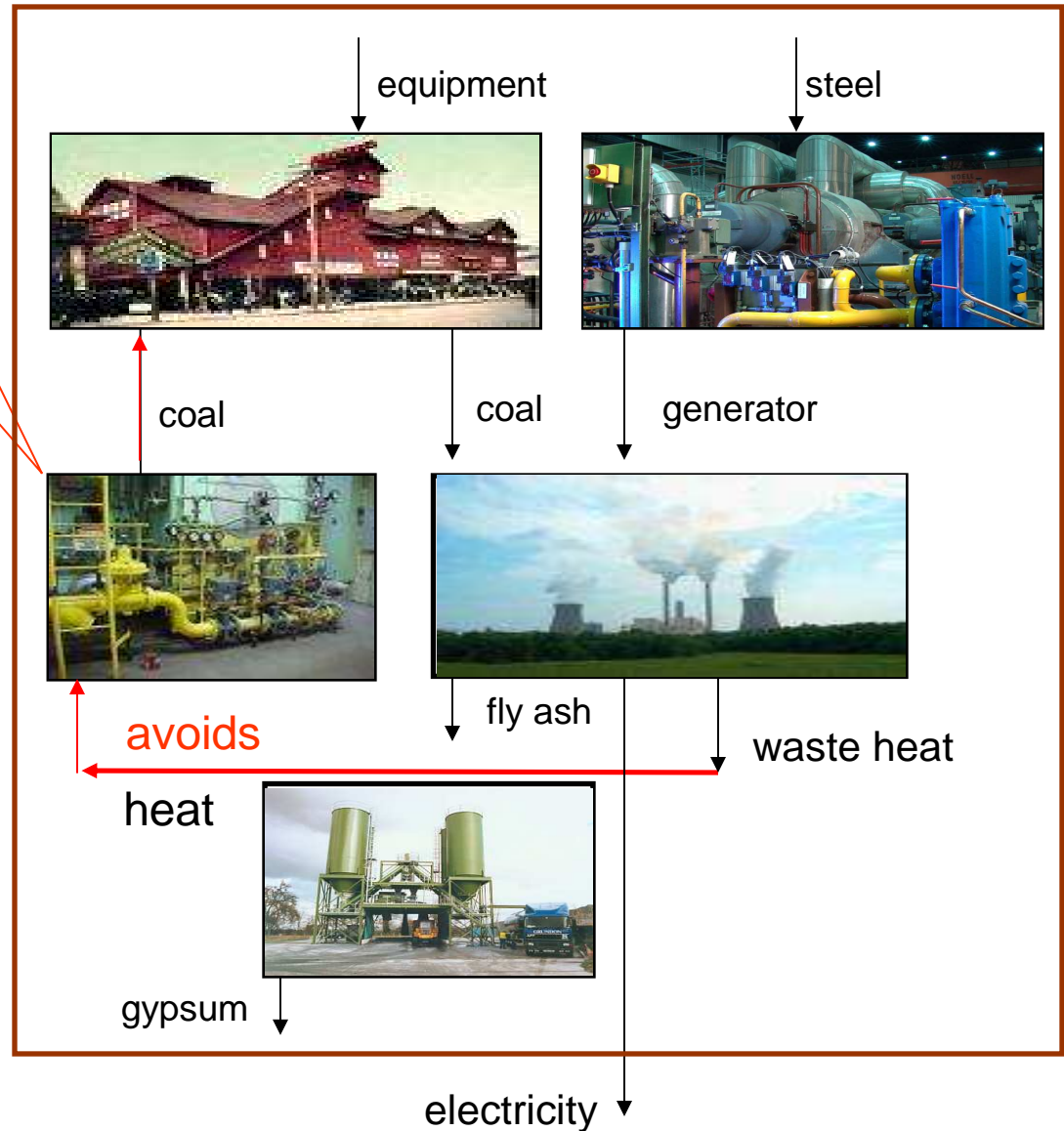


Solving the multifunctionality problem

- **Allocation-Substitution**

- change system boundary
- add extra process
- subtract “avoided” process
- with consequences upstream and downstream

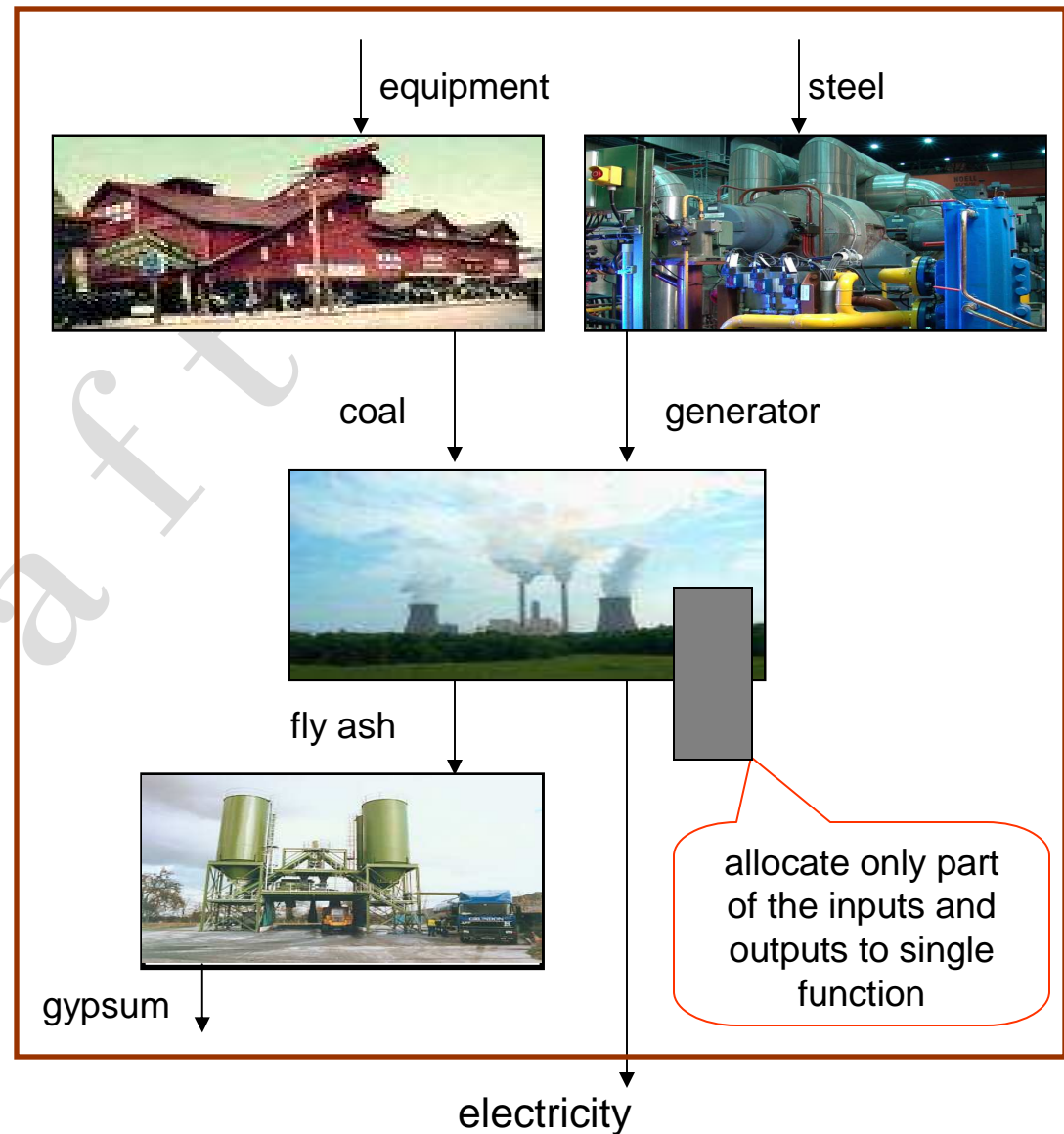
avoided process



Solving the multifunctionality problem

- **Allocation-Partitioning**

- allocate only a part of the process to the function considered
- with consequences upstream and downstream



Solving the multifunctionality problem

- Comparison of solutions on three aspects:

	functional unit	flow diagram	process data
system expansion	revised (for all alternatives)	enlarged (for other alternatives)	same
substitution	same	enlarged (with avoided processes)	same
partitioning	same	same	changed (by multiplying with allocation factors)

Solving the multifunctionality problem

- Problems with the three solutions:

problem

**system
expansion**

you don't answer the question you started with

substitution

which processes are avoided?

partitioning

what are the allocation factors?

Allocation according to ISO

6.5.3 Allocation procedure

On the basis of the principles mentioned above, the following stepwise procedure²⁾ shall be applied.

- a) **Step 1:** Wherever possible, allocation should be avoided by:
 - 1) dividing the unit process to be allocated into two or more subprocesses and collecting the input and output data related to these subprocesses;
 - 2) expanding the product system to include the additional functions related to the coproducts, taking into account the requirements of 5.3.2.
- b) **Step 2:** Where allocation cannot be avoided, the inputs and outputs of the system should be partitioned between its different products or functions in a way which reflects the underlying physical relationships between them; i.e. they shall reflect the way in which the inputs and outputs are changed by quantitative changes in the products or functions delivered by the system. The resulting allocation will not necessarily be in proportion to any simple measurement such as the mass or molar flows of coproducts.
- c) **Step 3:** Where physical relationship alone cannot be established or used as the basis for allocation, the inputs should be allocated between the products and functions in a way which reflects other relationships between them. For example, input and output data might be allocated between coproducts in proportion to the economic value of the products.

D r a f t

Allocation according to ISO

- **Step 1:**

Wherever possible, allocation should be avoided by:

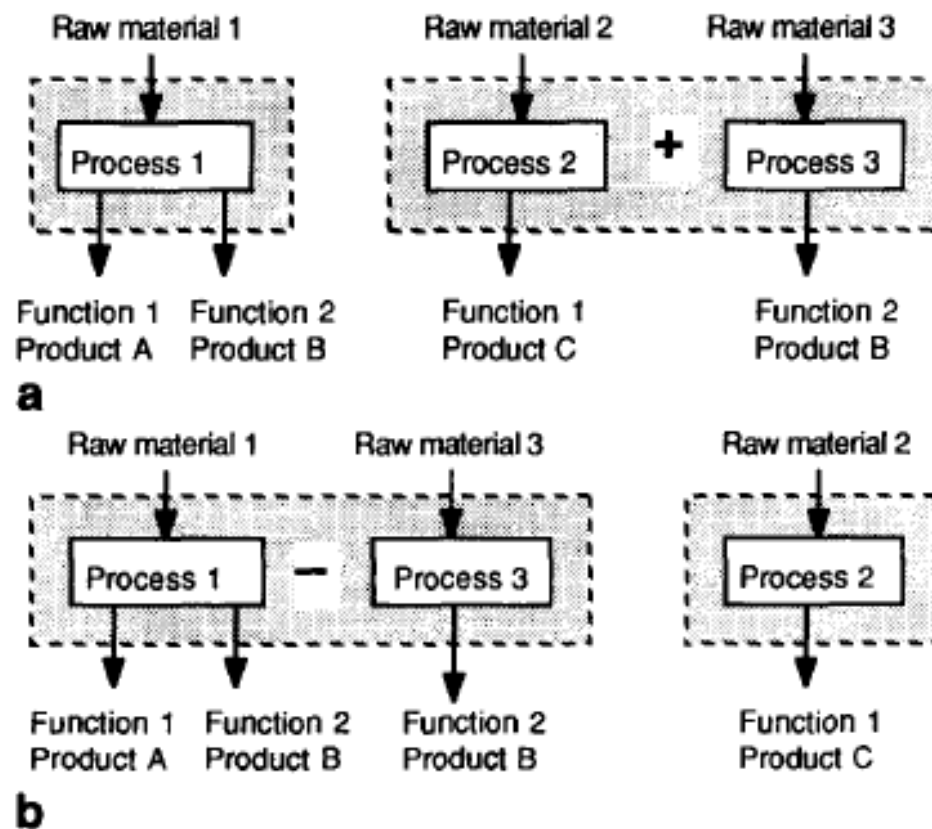
- dividing the unit process to be allocated into two or more sub-processes and collecting the input and output data related to these sub-processes
- expanding the product system to include the additional functions related to the co-products

Allocation according to ISO

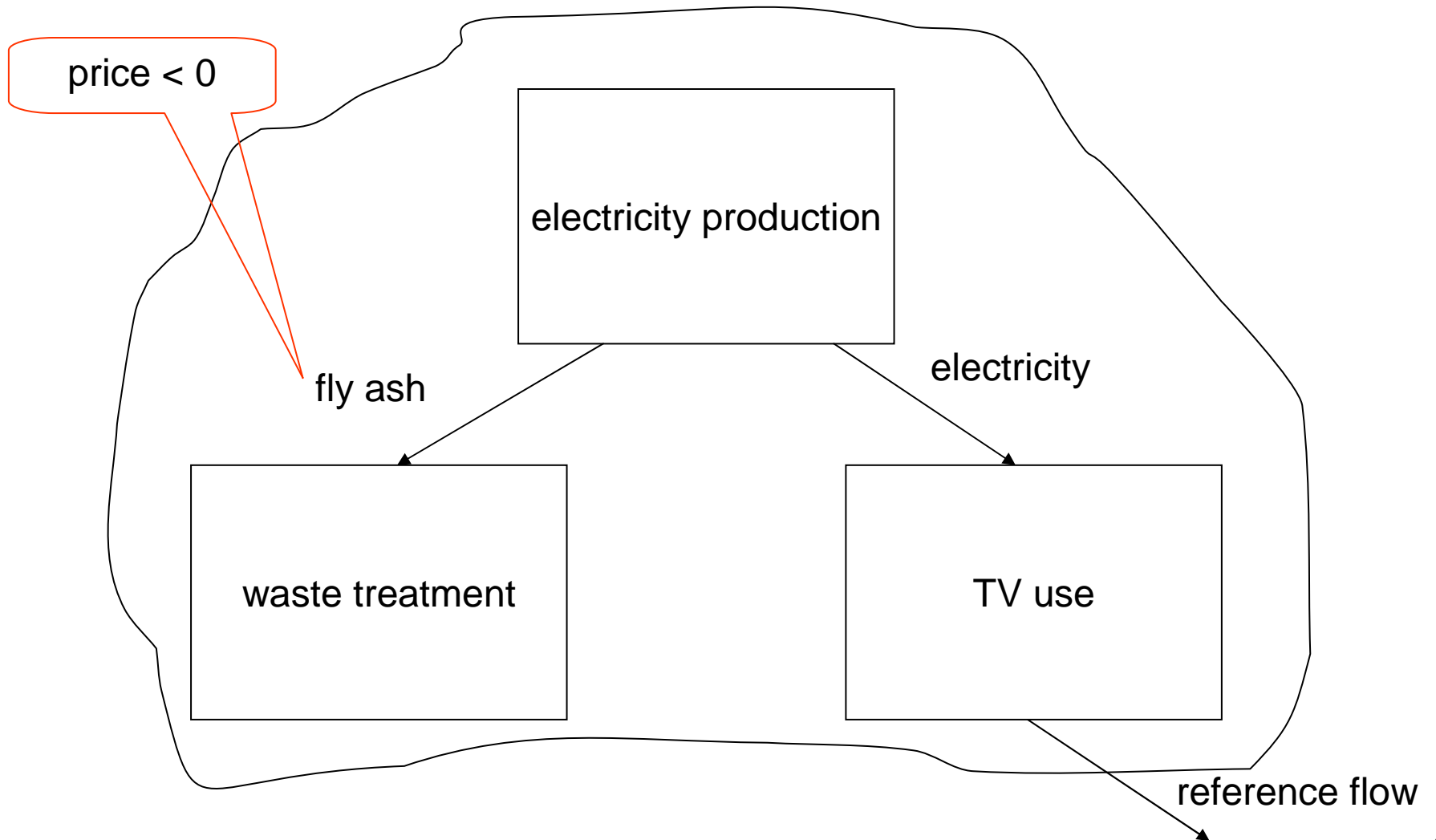
- **Step 2:**
Partition inputs and outputs in a way which reflects the underlying physical relationships between them.
 - This is not necessarily mass or molar flows.
- **Step 3:**
Partition inputs and outputs in a way which reflects other relationships between them.
 - For instance, they can be partitioned in proportion to the economic value of the products.

Allocation according to ISO

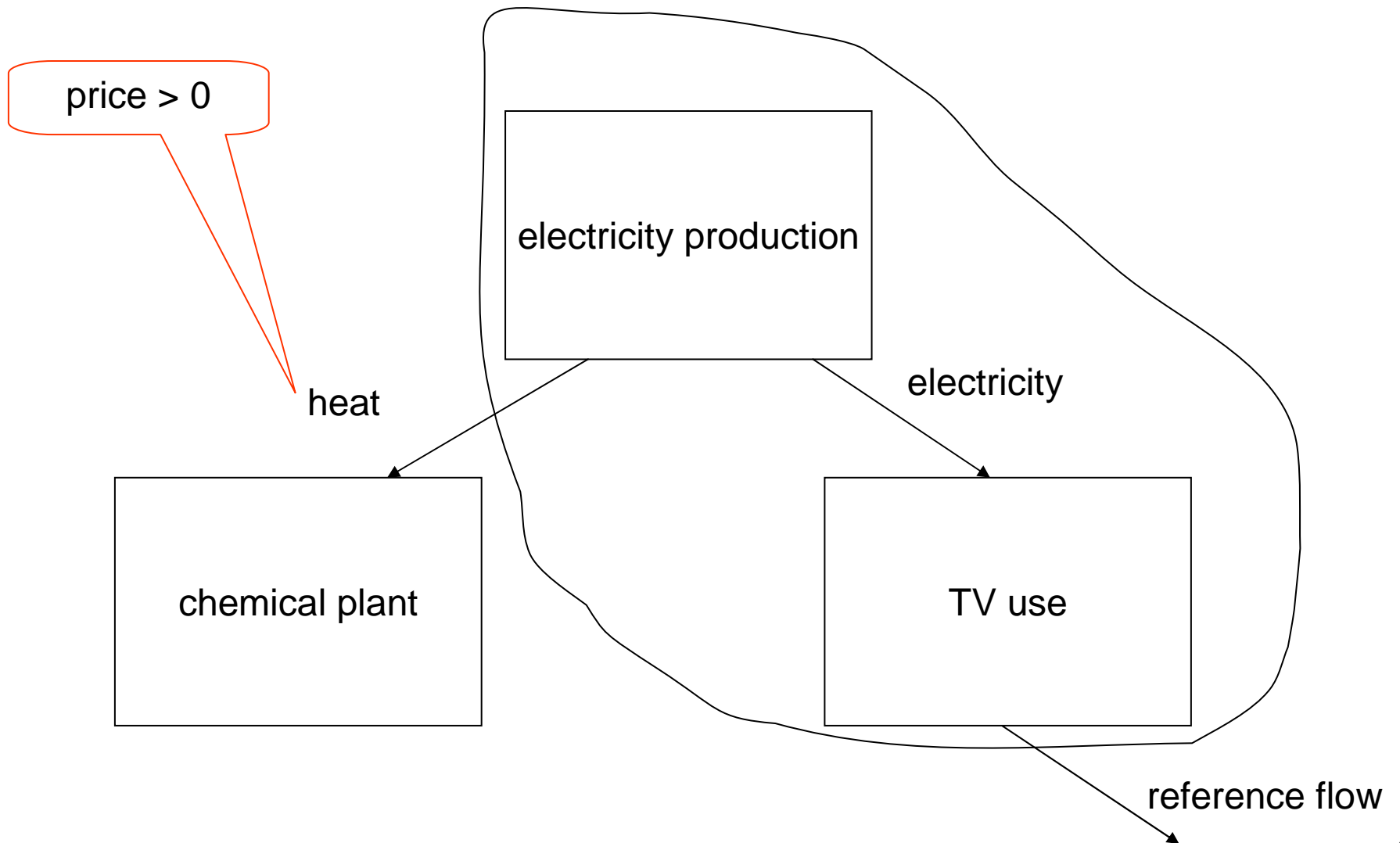
- System expansion versus substitution



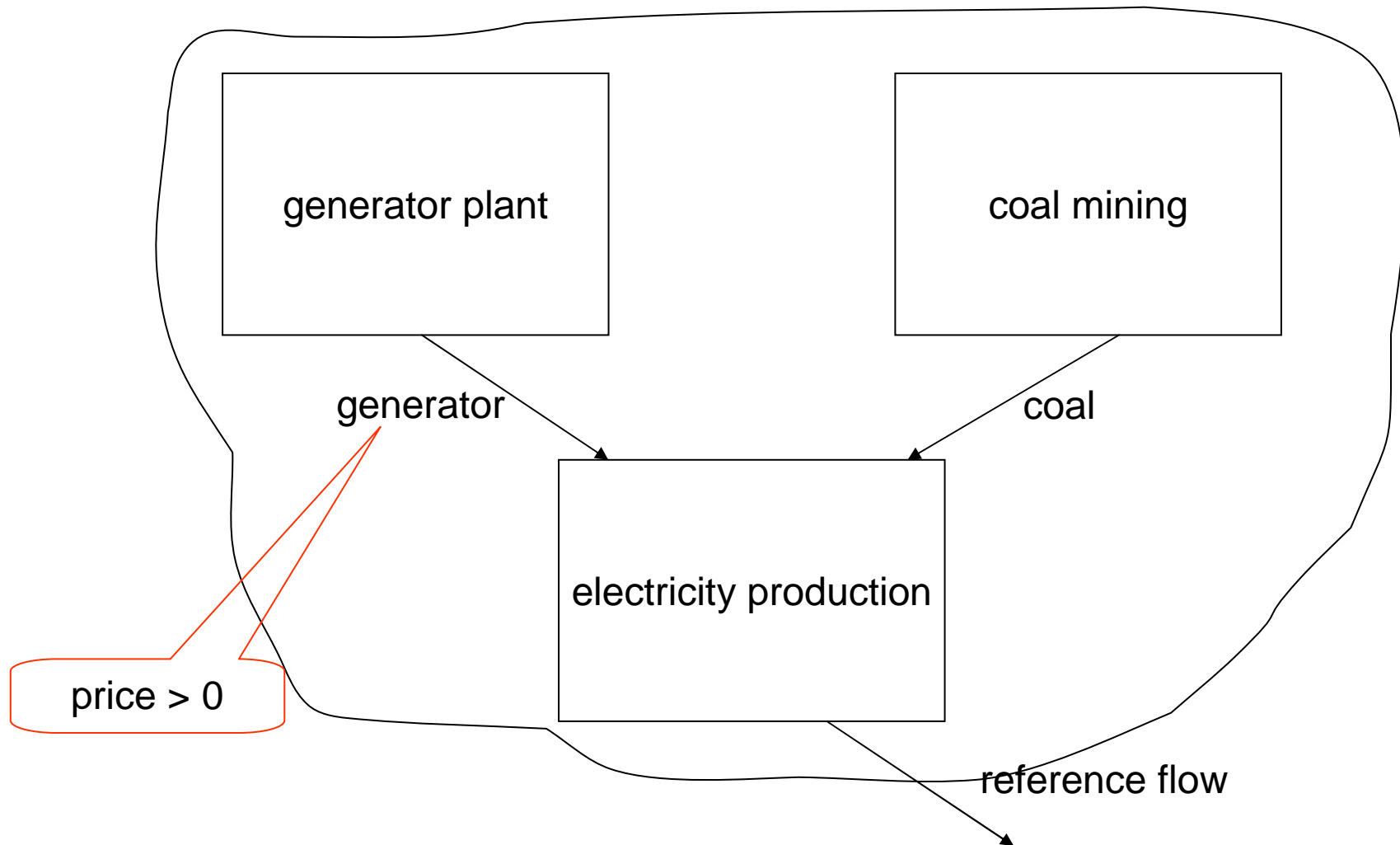
System boundary and allocation



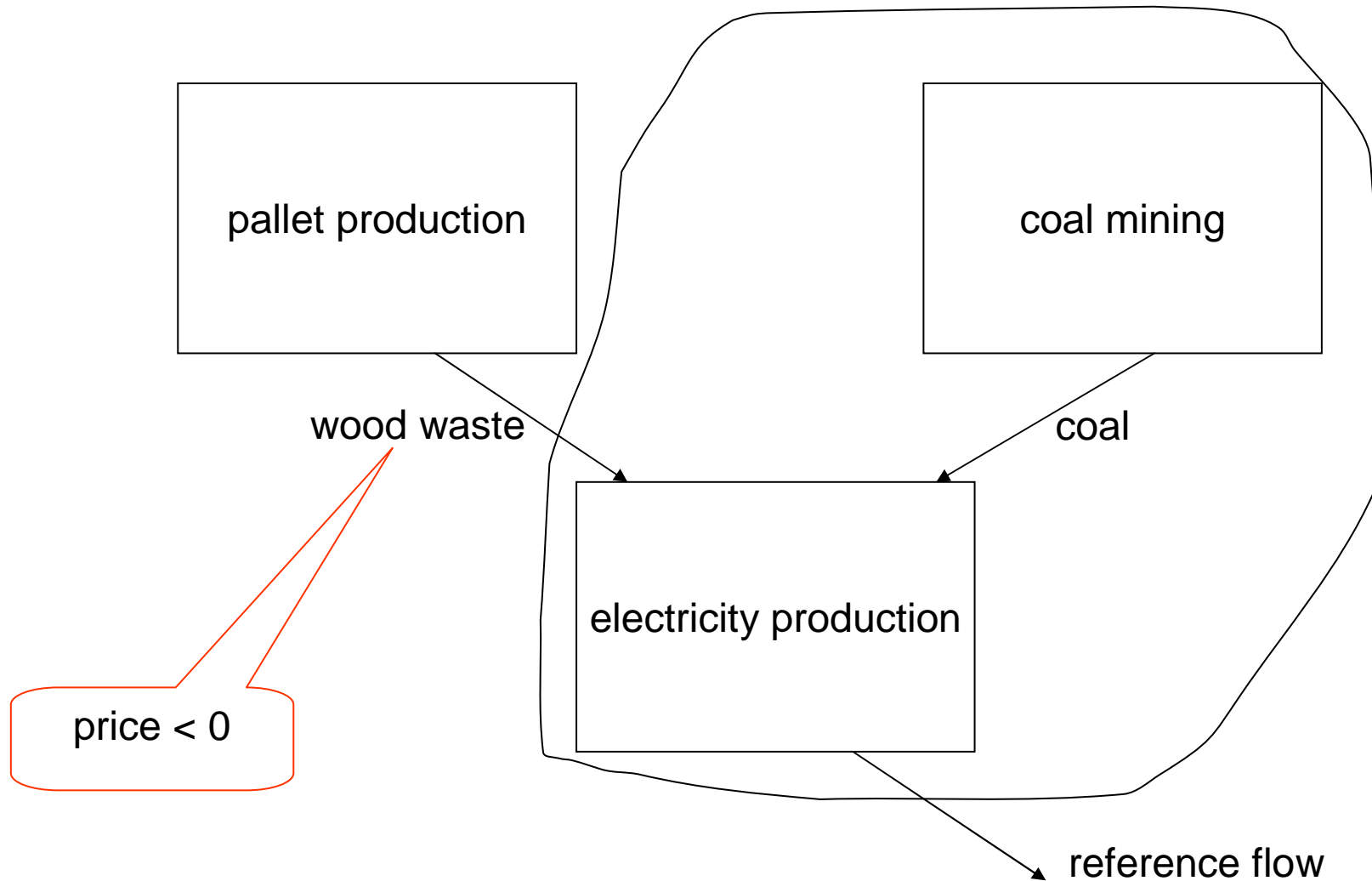
System boundary and allocation



System boundary and allocation



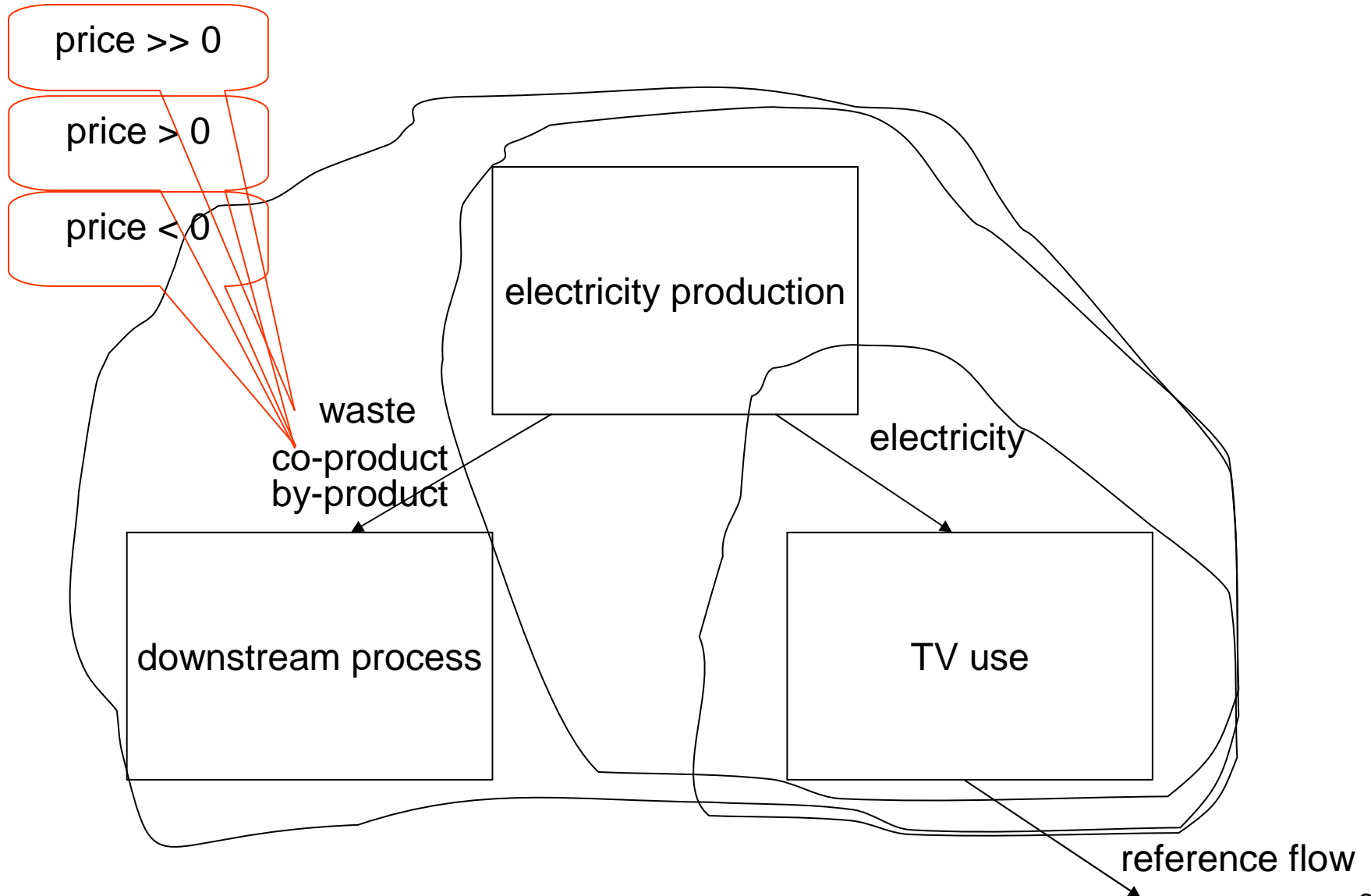
System boundary and allocation



System boundary and allocation

- **The price determines:**
 - if a process is to be included
 - if allocation is needed for a process
 - extent to which a process is included
- **Economic allocation determines for the price:**
 - price < 0: exclude
 - price > 0: include a bit
 - price >> 0: include a lot

System boundary and allocation



Economic allocation

- **Allocation factors are based on shares of outcomes.**

total amount produced \times economic value/unit

- Absolute values are not needed.
- Any monetary unit can be used, if it is the same.
- Any base year can be used, if the same.

Economic allocation

- **Problems**
 - market prices not known
 - fluctuating prices
 - inflation
 - trends in real prices
 - market distortions
 - markets not yet existing
- **Some solutions are suggested in Leiden University Environmental Science Centre (CML) LCA Handbook.**

Conclusions

- **Transparency is crucial in drawing system boundaries and in solving the multifunctionality problem.**
 - what are the flow diagrams of the systems?
 - which flows are goods, which are wastes?
 - where are the multifunctional processes?
 - how is the multifunctionality problem solved in each of these?
 - system expansion: what is the function added? (also in the other alternatives)
 - substitution: what is the avoided process?
 - partitioning: what are the allocation factors?



You may wish to review some segments of this module on allocation.

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The remaining modules
explore these topics:

Module	contents
h	LCA mathematics
i	LCIA mathematics
j	Life cycle costing
k	Uncertainty in LCA
l	Carbon footprint