



Life Cycle Assessment
A product-oriented method
for sustainability analysis

UNEP LCA Training Kit
Module d – Inventory analysis



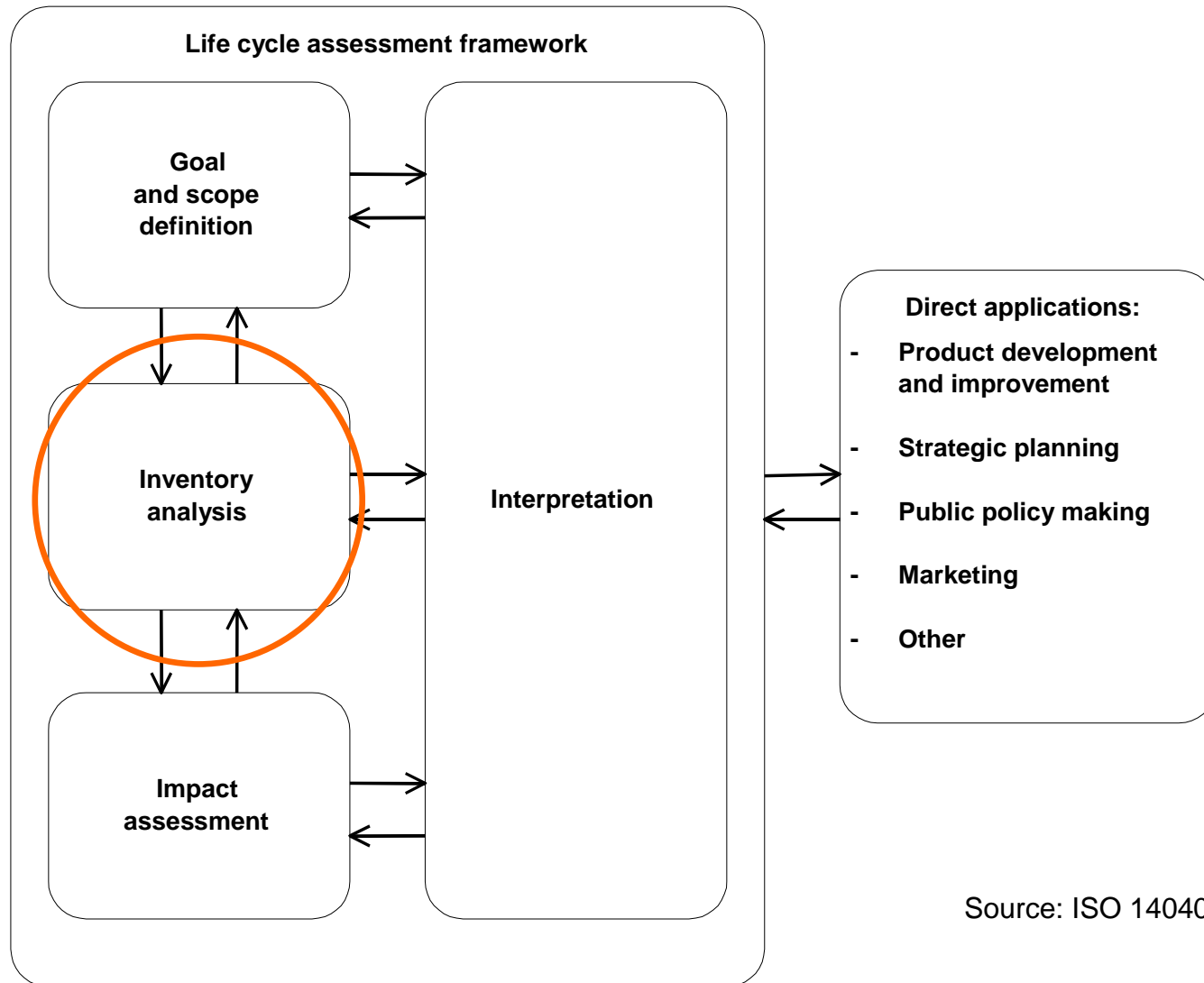
UNEP

Life Cycle



Initiative

ISO 14040 framework



Life cycle inventory analysis

- **ISO: Inventory Analysis** is the LCA phase involving the compilation and quantification of inputs and outputs, for a given product system throughout its life cycle.
 - International Standard ISO 14041
 - Technical Report ISO/TR 14049
- **The second phase of an LCA**
 - LCI



Contents

- Economy-environment system boundary
- Flow diagram
- Format and data categories
- Data quality
- Data collection and relating data to unit processes
- Data validation
- Cut-off and data estimation
- Multifunctionality and allocation
- Calculation

Economy-environment system

- **This boundary separates what is included in the product system from what is excluded.**
- **Each product/material/service should be followed until it has been translated into elementary flows.**
(emissions, natural resource extractions, land use, ...)

Economy-environment system

- **Example: a television**
 - **upstream:**
 - TV → transformer → copper wire → copper → copper ore
 - **upstream:**
 - TV → electricity → high-voltage electricity → coal
 - **downstream:**
 - TV → electronic equipment waste → removal of precious and recyclable materials → landfill site

Economy-environment system



wide system boundary

Flow diagram

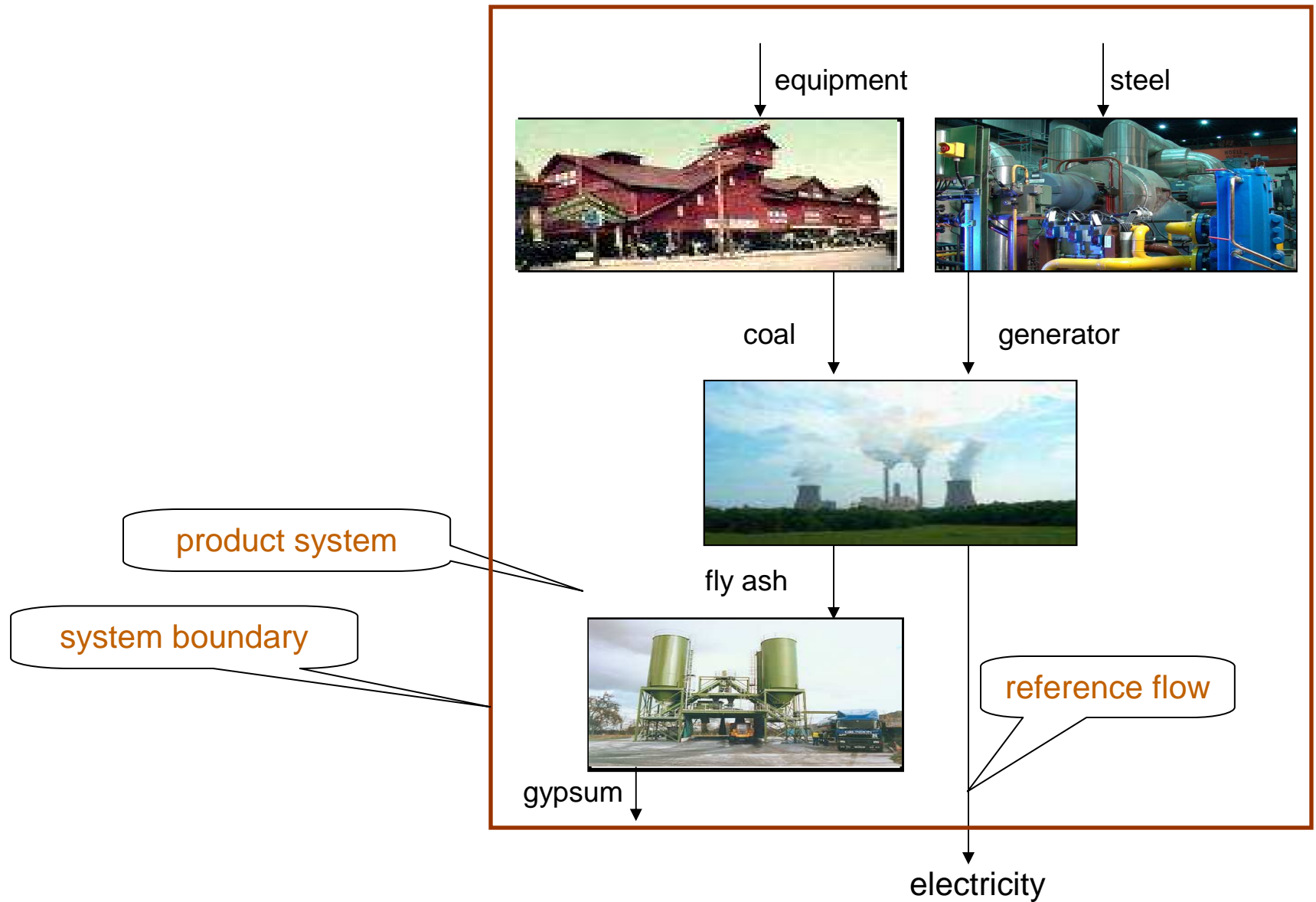
- **Graphical representation of structure product system**
- **Showing the interdependence of economic processes**
- **Can be organized as hierarchical (multi-level) flow diagrams**

Flow diagram

- **Simple rules, consistently applied:**
 - process = box
 - economic flow = arrow
 - no environmental flows
 - no numbers



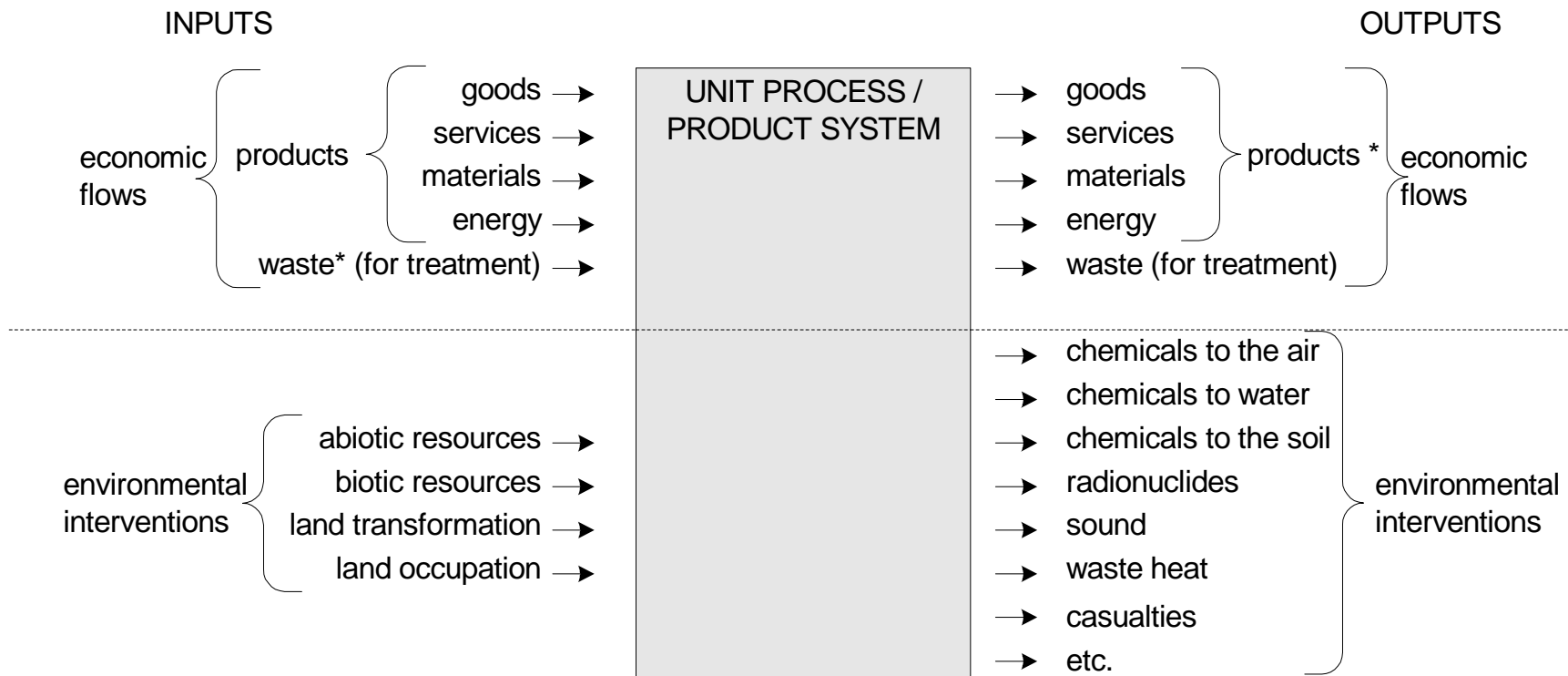
Flow diagram



Format and data categories

- **General considerations:**
 - processes have inputs and outputs
 - processes have economic flows and environmental/ elementary flows
 - several types of each (materials, energy, atmospheric emissions)
 - symmetry in economic flows

Format and data categories



* the functional flows of the process

Format and data categories

- **Several standards for data exchange:**
 - ISO 14048
 - Spold/EcoSpold
 - Spine
 - UNEP/SETAC
 - ELCD (European Commission)

Format and data categories

- **More detailed standardisation:**
 - representing numbers (1.2E-3, 0,0012)
 - choice of units (kg, mg, μg , lbs, tonne)
 - language/character set (English, German, Chinese)
 - choice of names (carbon dioxide, CO₂)
 - codes (SIC, NACE, CAS, EINECS)
 - other info (uncertainties, missing values)

Data quality

- **Crucial to address data quality**
 - precision
 - completeness
 - representativeness (temporal, geographical, technology)
 - consistency
 - reproducibility
- **Data quality requirements according to ISO 14044**
 - time coverage
 - geographical coverage
- **There is no available standardised method for overall assessment of data quality.**

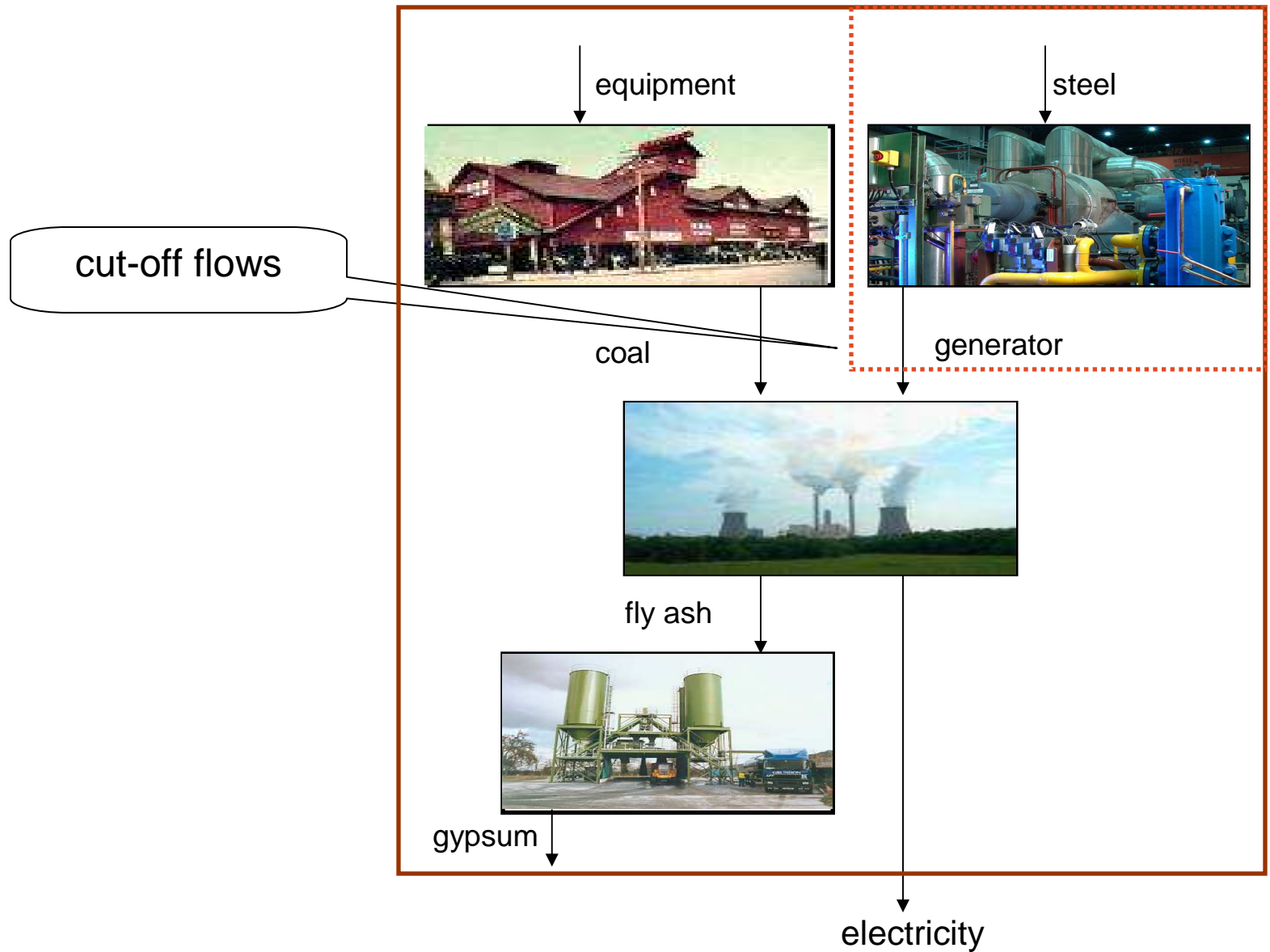
Primary and Secondary data collection

- **Different ways to obtain data**
 - **Primary data collected on-site**
 - measurements
 - interviews
 - annual reports
 - **Secondary data from generic sources**
 - LCA databases
 - previous LCA-studies
 - IOA data

Primary and Secondary data collection

- **Errors are easily introduced ...**
 - errors in measurements
 - errors in data entry
 - errors with units (liter versus gallon)
 - errors with prefixes (mg versus mcg)
 - errors with nomenclature (N₂O versus NO₂)
- **... and can sometimes easily be detected**
 - mass and energy balances
 - comparative analysis of different data sources

Cut-off and data estimation



Cut-off and data estimation



Cut-off and data estimation

- **Problem**
 - many data needed
 - limited time and budget
- **Possible solutions**
 - cut-off certain flows
 - provide a rough estimation
 - difference analysis

Multifunctionality and allocation

- **Many processes produce more than one function:**

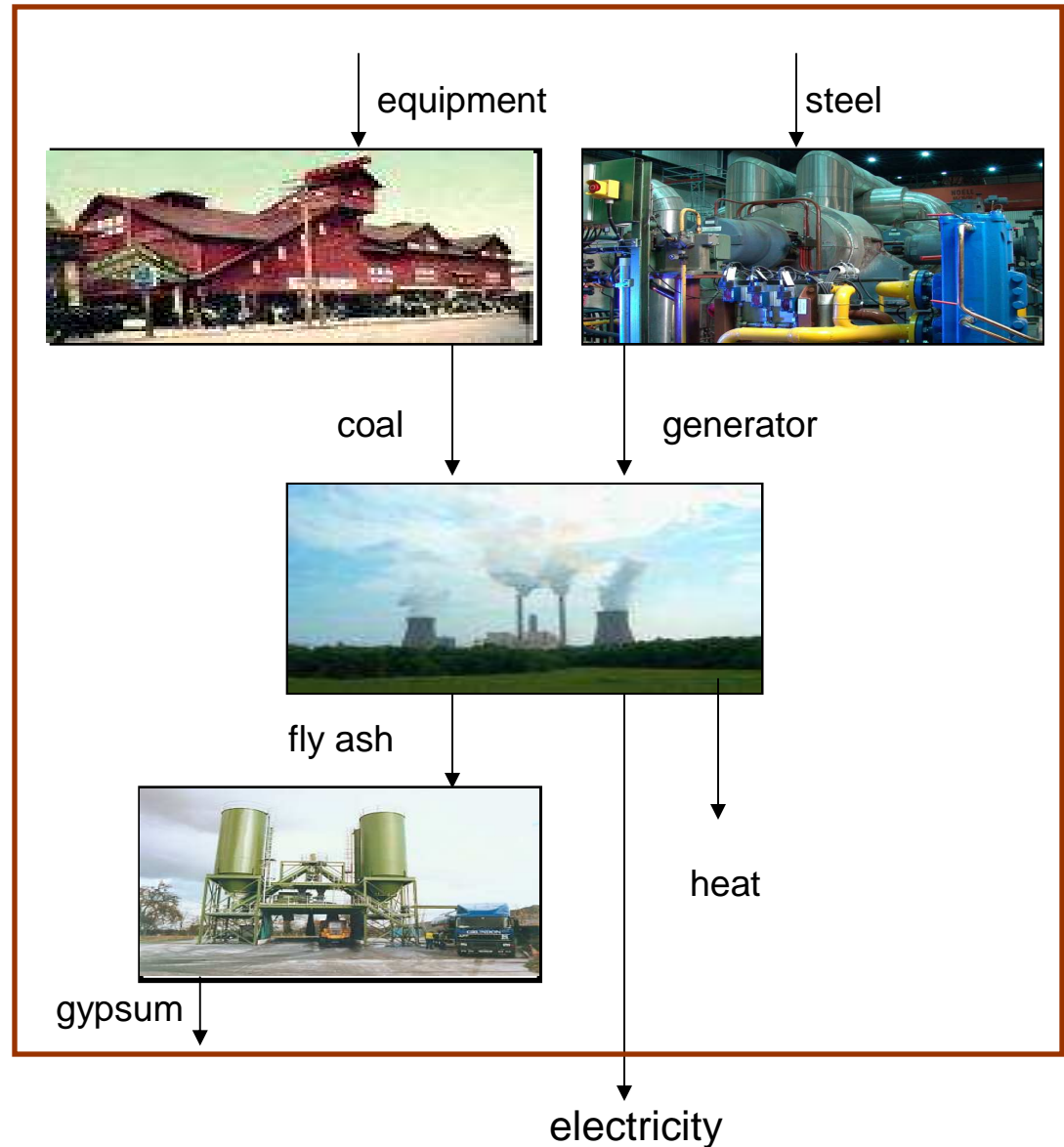


Multifunctionality and allocation

- **Typology I:**
 - co-production
 - combined waste treatment
 - recycling
- **Typology II:**
 - joint production
 - combined production

Multifunctionality and allocation

- **What to do with the extra heat?**
 - accept it as an extra reference flow
 - eliminate it by an extra modeling step



Multifunctionality and allocation

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

Multifunctionality and allocation

- **More refined data collection**
 - ... not really allocation, but more 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?

Multifunctionality and allocation

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

Multifunctionality and allocation

- **Allocation according to ISO:**
- **Whenever 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
- **Partition inputs and outputs** of the system between its different products or functions in a way which reflects the underlying physical relationships between them
- **Partition input and output data** between co-products in proportion to the economic value of the products.

Calculation


- **Relating unit processes to reference flows**
 - Based on linear scaling of processes
 - Take account for (feedback) loops
 - Matrix procedure available
- **But calculation sometimes fails ...**
 - missing processes
 - multifunctional processes

Calculation



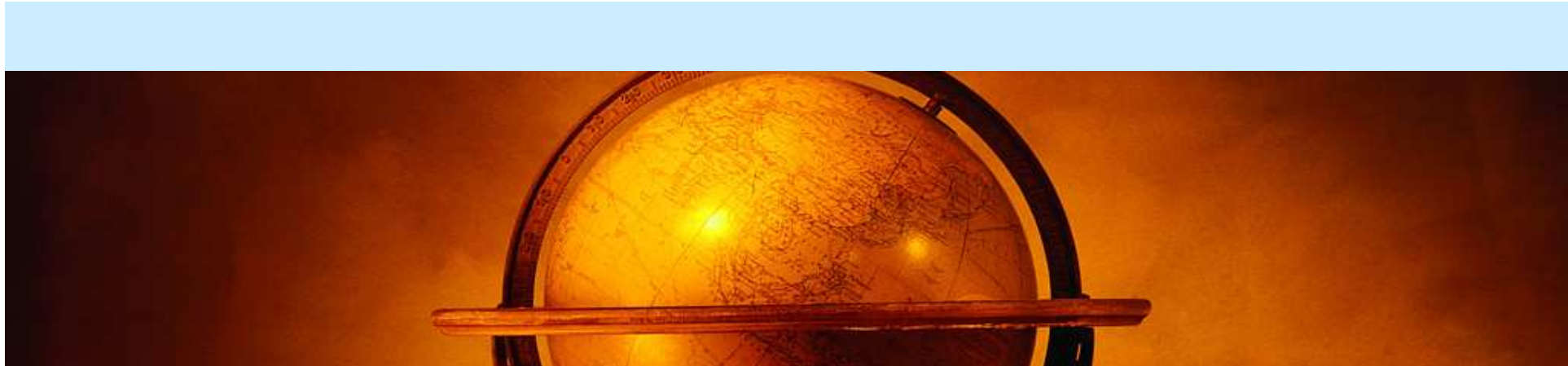
- **Example of an inventory table**

Elementary flow	Incandescent lamp	Fluorescent lamp
CO2 to air	800000 kg	50000 kg
SO2 to air	1000 kg	80 kg
Copper to water	3 g	20 g
Crude oil from earth	37000 kg	22000 kg
Etc.



Are there segments of this module that you want to review?

- Economy-environment system boundary
- Flow diagram
- Format and data categories
- Data quality
- Data collection and relating data to unit processes
- Data validation
- Cut-off and data estimation
- Multifunctionality and allocation
- Calculation



This is an overview of all of the remaining modules in the toolkit.

Module	contents
e	Impact assessment
f	LCA interpretation
g	Allocation in LCA
h	LCA mathematics
i	LCIA mathematics
j	Life cycle costing
k	Uncertainty in LCA
l	Carbon footprint