Life Cycle Assessment

A product-oriented method for sustainability analysis

UNEP LCA Training Kit

Module b – ***Overview of LCA***

SETAC

UNEP

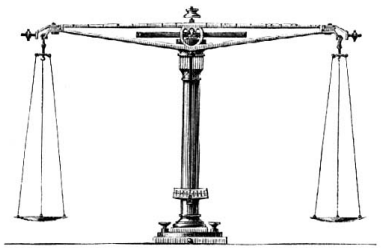
Life Cycle Initiative

Contents

- **What is LCA?**
- **Why LCA?**
- **The ISO 14040 framework**
  - **Goal and scope definition**
  - **Inventory analysis**
  - **Impact assessment**
  - **Interpretation**

What is LCA?

- Officially: **Life Cycle Assessment**
- Here, LCA is confined to:
  quantitative environmental Life Cycle Assessment of products
  - Quantitative
  - Environmental
  - Life Cycle
  - Assessment
  - Product system



What is LCA?

- LCA has at least three different meanings:
  - **LCA as a field of study**
  - **LCA as a technique**
  - **LCA as a specific study**

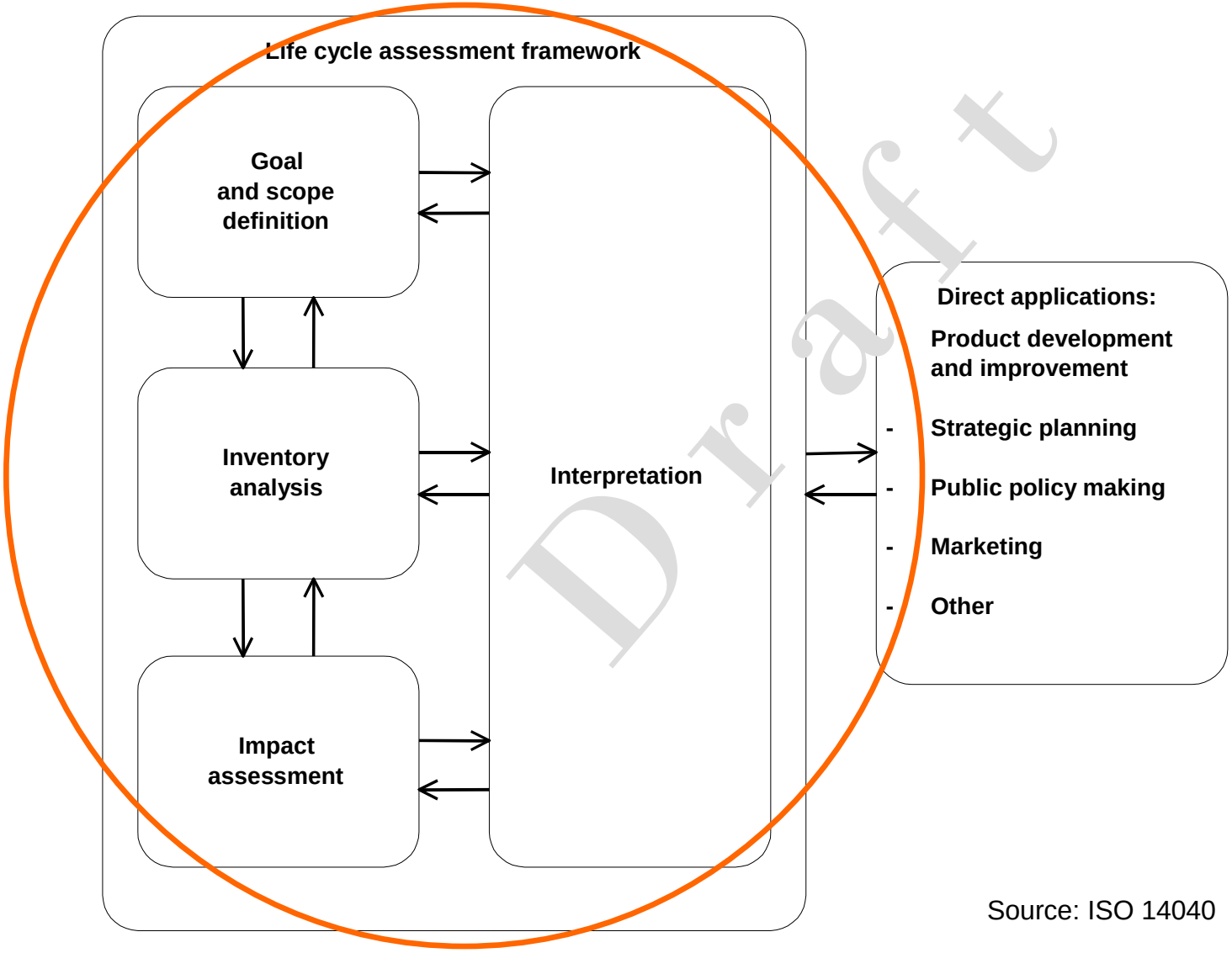
What is LCA?

- **Tool for decision-support**
  - **computational aspects**
    - which data?
    - which models?
    - which formulas?
  - **procedural aspects**
    - who to involve?
    - how to report?
    - how to use?

What is LCA?

- **ISO 14040 - standardised LCA procedure**
  (ISO 14040, created in 1997-2000; revised in 2006)
  - Structured framework: four phases
  - Rules, requirements and considerations specified
  - Specific data and calculation steps not specified
  - Much attention for transparency in reporting

ISO 14040 framework



Draft

Source: ISO 14040

ISO 14040 framework

- **ISO:** Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle
  - International Standard ISO 14040
  - complementary International Standards ISO 14041, 14042, 14043
  - no Technical Report to 14040, but Technical Reports to 14041 and 14042
  - 14044 merges the revised 14040-14043 (2006)
  - 14020, 14021, 14024 and 14025 address public assertions of environmental performance on products

Why LCA?

- **Why an integrated information tool?**
  - **Prevent problem shifting**
    - to other life cycle stages
    - to other substances
    - to other environmental problems
    - to other countries
    - to the future

Why LCA?

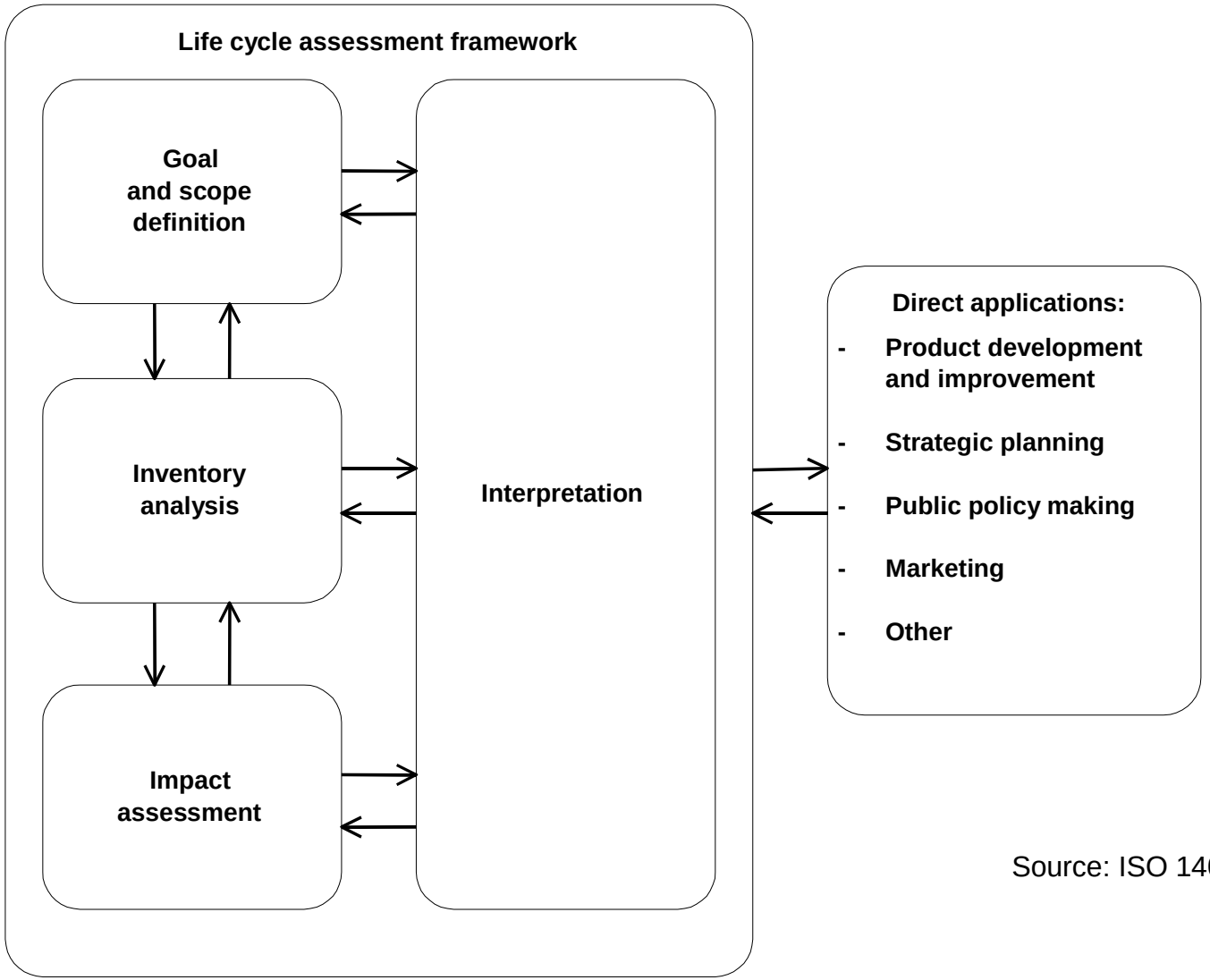
- **Why a method?**
  - To structure the large amount of complex data
  - To facilitate comparisons across product alternatives
  - To enable benchmarking

Why LCA?

Raw product data can be difficult to understand

Product property	Incandescent lamp	Fluorescent lamp
power consumption	60 W	18 W
life span	1000 hr	5000 hr
mass	30 g	540 g
mercury content	0 mg	2 mg
etc	…	…

ISO 14040 framework



Source: ISO 14040

Phase 1: Goal and scope definition

- **Goal and scope definition** is the LCA phase in which the aim of the study is established. The breadth and depth of the study are also established in relation to that.
  - goal definition
  - scope definition

Phase 1: Goal and scope definition

- **Goal definition:**
  - **intended application**
    - product development and improvement
    - strategic planning
    - public decision making
    - marketing
    - other
  - **reasons for carrying out the study**
  - **intended audience**

Phase 1: Goal and scope definition

- **Scope definition:**
  - **function, functional unit and reference flow**
  - **initial choices**
    - system boundaries
    - data quality
  - **critical review and other procedural aspects**

Phase 1: Goal and scope definition

- **Functional unit:**
  - comparison on the basis of an equivalent function
  - example: 1000 liters of milk packed in glass bottles or packed in carton, instead of 1 glass bottle versus 1 carton

Phase 1: Goal and scope definition

- **Critical review and other procedural aspects**
  - critical review to ensure the consistency, scientific validity, transparency of the report, etc.
  - internal review, external review, review by interested parties
  - procedural embedding of LCA: LCA as a (participatory) process

Phase 2: Inventory analysis

- **Inventory analysis** is the LCA phase involving the compilation and quantification of inputs and outputs for a given product system throughout its life cycle.

- **Steps:**
  - preparing for data collection
  - data collection
    (both described in ISO 14041)
  - calculation procedures
  - allocation and recycling
    (both described in ISO 14042)

Phase 2: Inventory analysis

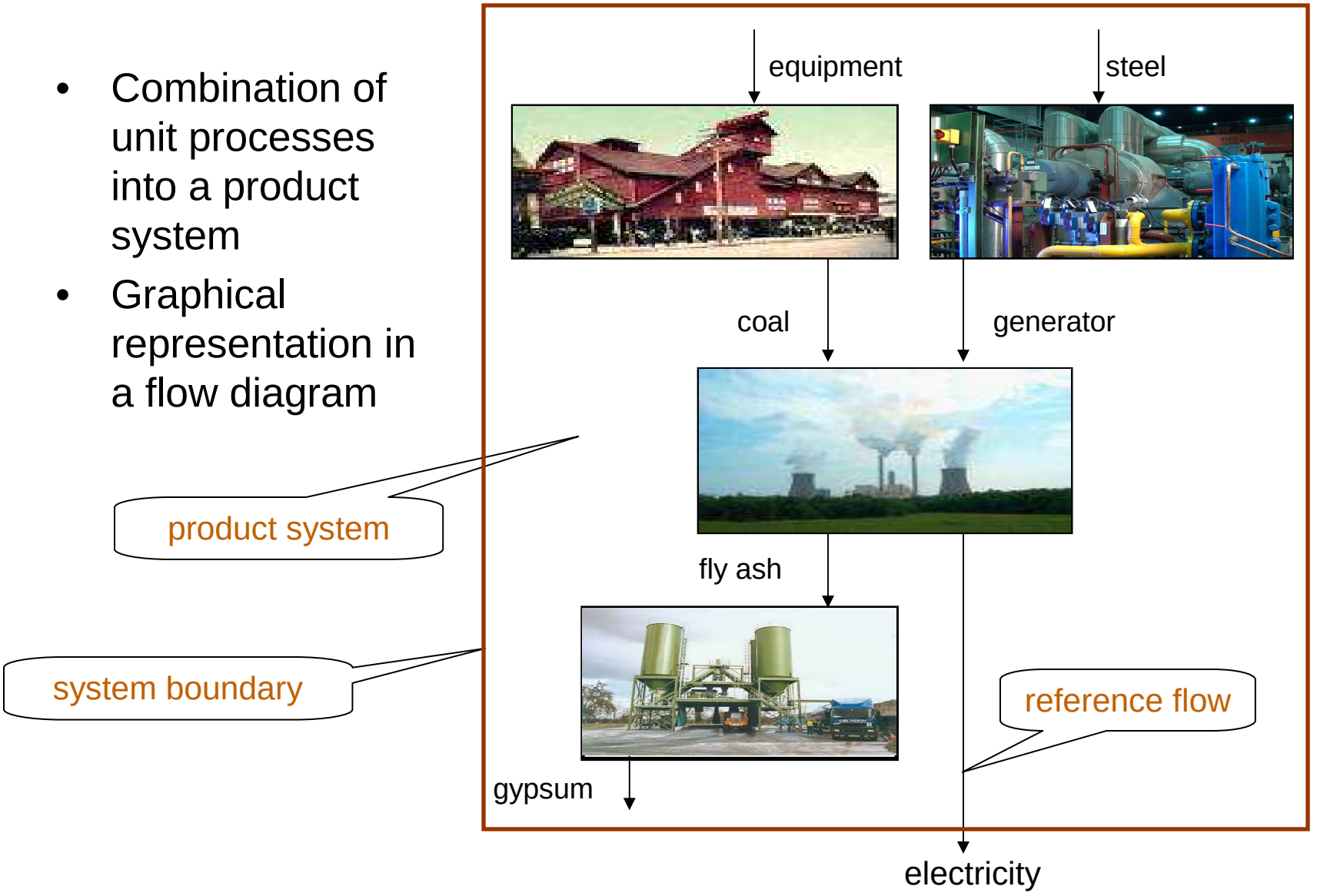
- **Central position for unit process**
  - smallest portion of a product system for which data are collected
- **Typical examples:**
  - electricity production by coal combustion
  - PVC production
  - use of a passenger car
  - recycling of aluminum scrap

Phase 2: Inventory analysis

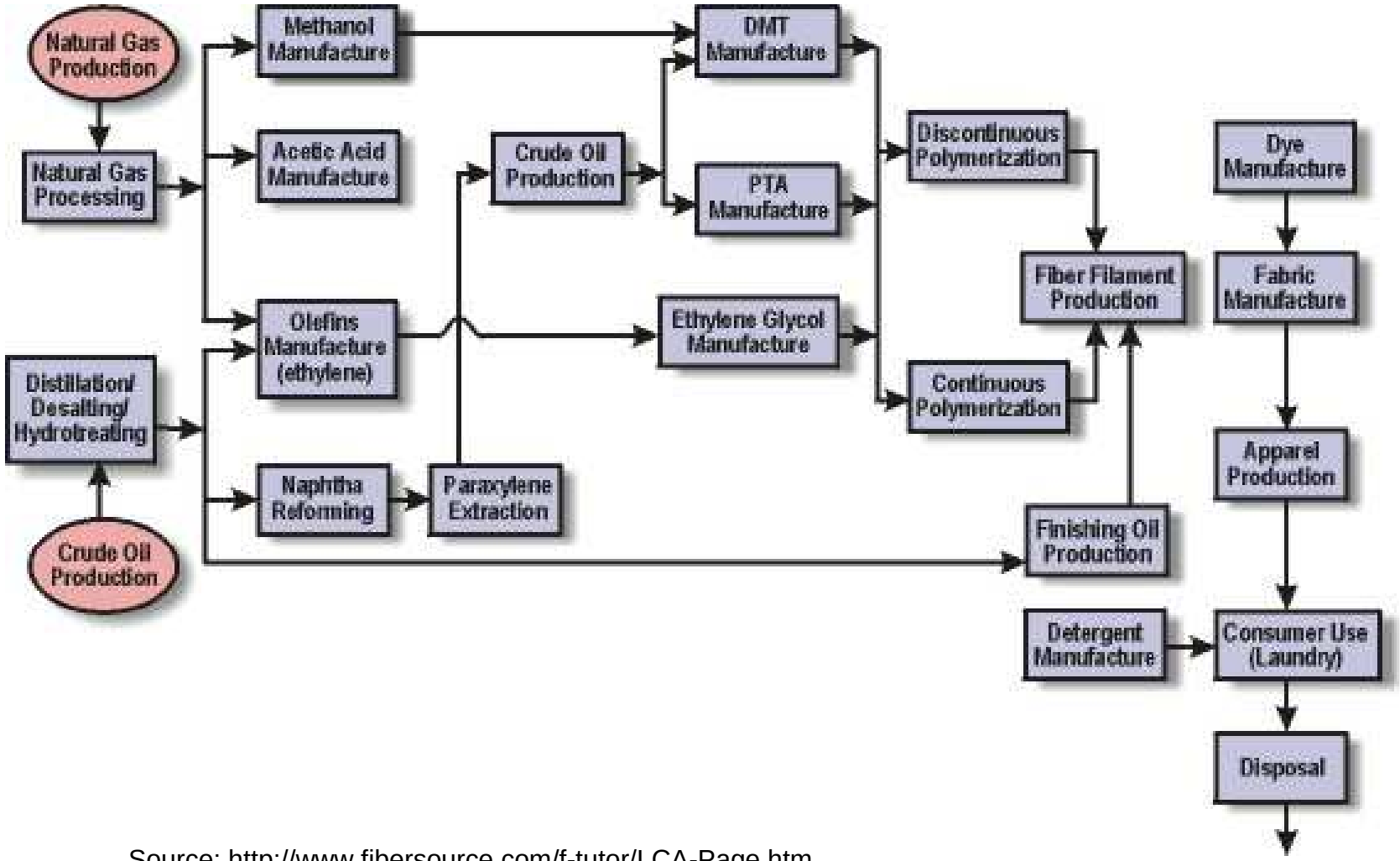
- **Data collection for unit processes:**
  - flows of intermediate products or waste for treatment
  - elementary flows from or to the environment

Phase 2: Inventory analysis

- Combination of unit processes into a product system
- Graphical representation in a flow diagram



Phase 2: Inventory analysis



Source: http://www.fibersource.com/f-tutor/LCA-Page.htm

Phase 2: Inventory analysis

- **Calculation procedures**
  - relate process data to the functional unit (matrix algebra)
  - allocation of multiple processes (multiple outputs, multiple inputs, re-use and recycling)

  - aggregation over all unit processes in the inventory table

Phase 2: Inventory analysis

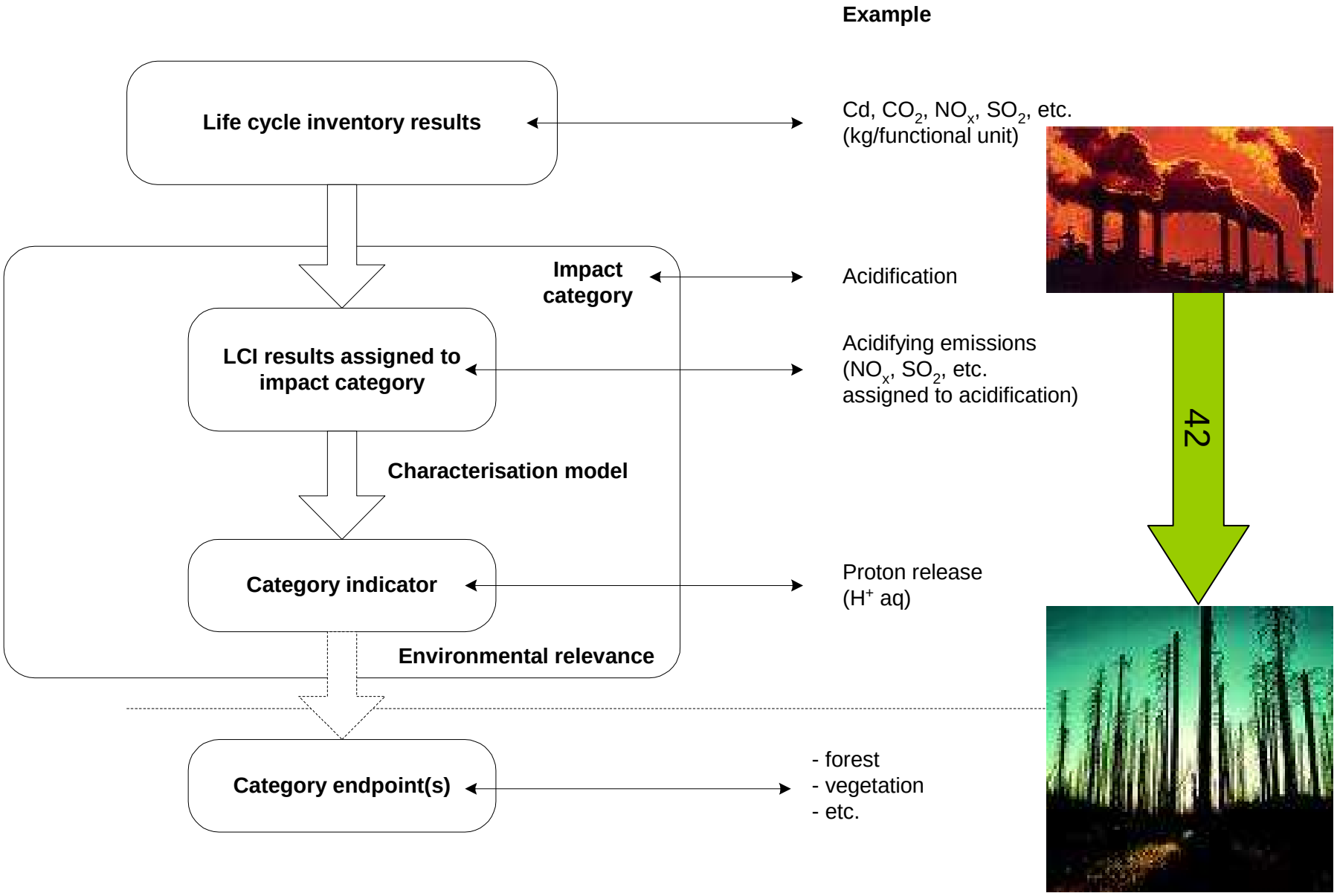
- **Inventory table**

Elementary flow	Incandescent lamp	Fluorescent lamp
CO_2 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	…	…

Phase 3: Impact assessment

- **Impact Assessment is the LCA phase that evaluates the importance of the potential environmental effects with the aid of the results of the inventory analysis.**
- **Steps:**
  - selection and definition of impact categories, indicators and models
  - classification
  - characterisation
  - normalisation
  - aggregation and/or weighing

Phase 3: Impact assessment



Phase 3: Impact assessment

- **Example of a category indicator**

Global Warming: Global Warming Potential (GWP): measure for Global Warming in terms of radiative forcing of a mass-unit

Example calculation:

5 kg CO_2 (GWP = 1)

+

3 kg CH_4 (GWP = 21)

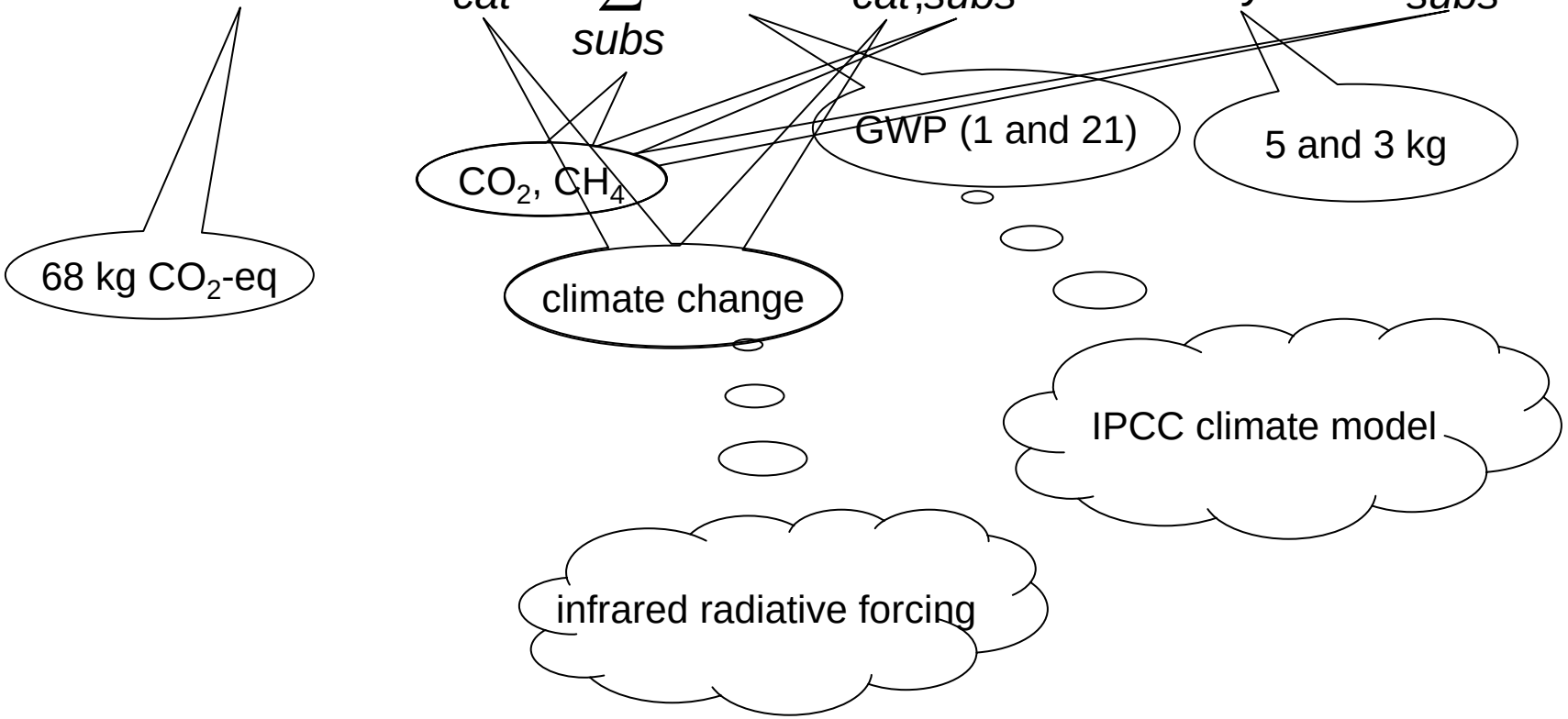
=

1 x 5 + 21 x 3 kg CO_2 equivalents = 68 kg CO_2 equivalents

Phase 3: Impact assessment

- **Characterisation:**
- **Simple conversion and aggregation of GHGs:**

$$\text{IndicatorResult}_{cat} = \sum_{subs} \text{CharFact}_{cat,subs} \times \text{InventoryResult}_{subs}$$



Phase 3: Impact assessment

Example impact categories, characterisation models, factors & units

Impact category	Indicator	Characterisation model	Characterisation factor	Equivalency unit
Abiotic depletion	Ultimate reserve/ annual use	Guinee & Heijungs 95	Abiotic depletion potential	kg Sb eq.
Climate change	Infrared radiative forcing	International Panel on Climate Change	Global warming potential	kg CO_2 eq.
Stratospheric ozone depletion	Stratospheric ozone breakdown	World Meteorological Organization model	Stratospheric ozone layer depletion potential	kg CFC-11eq.
Human toxicity	Predicted daily intake, Accepted daily intake	EUSES, California Toxicology Model	Human toxicity potential	kg 1,4-DCB eq.
Ecological toxicity	PEC, PNEC	EUSES, California Toxicology Model	AETP, TETP, etc.	kg 1,4-DCB eq.
Photo-oxidant smog formation	Tropospheric ozone production	UN-ECE trajectory model	Photo-oxidant chemical potential	kg C_2H_6 eq.
Acidification	Deposition/ critical load	Regional Acidification Information & Simulation	Acidification potential	kg SO_2 eq.
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Phase 3: Impact assessment

Impact category	Incandescent lamp	Fluorescent lamp
Climate change	120000 kg CO2-eq.	40000 kg CO2-eq.
Ecotoxicity	320 kg DCB-eq.	440 kg DCB-eq.
Acidification	45 kg SO2-eq.	21 kg SO2-eq.
Depletion of resources	0.8 kg antimony-eq.	0.3 kg antimony-eq.
etc	…	…

Phase 3: Impact assessment

- **Impact category results still difficult to understand:**
  - difference in units
  - difference in scale
- **Normalisation relates the results to a reference value**
  - for example, total world impacts in 2002
  - result is often referred to as the normalised environmental profile

Phase 3: Impact assessment

Impact category	Incandescent lamp	Fluorescent lamp
Climate change	1.2×10^{-11} yr	4×10^{-12} yr
Ecotoxicity	1.6×10^{-10} yr	2.2×10^{-10} yr
Acidification	9×10^{-11} yr	4.2×10^{-11} yr
Depletion of resources	24×10^{-12} yr	9×10^{-13} yr
etc	…	…

Phase 3: Impact assessment

Even after normalisation, there is no clear answer.

- aggregation of (normalized) impact category results into a single index
- subjective weighting factors increase the priority given to impact categories we think are important, and decrease the priority given to those we think are unimportant

Phase 3: Impact assessment

Example of a weighted environmental index

Weighed index	Incandescent lamp	Fluorescent lamp
Weighted index	8.5×10^{-10} yr	1.4×10^{-10} yr

Phase 4: Interpretation

Conclusions, recommendations, analysis:
all relate to the goal and scope of the research.

- Interpretation should be based on an evaluation of data quality and sensitivity analysis.
- Review by independent experts is important.

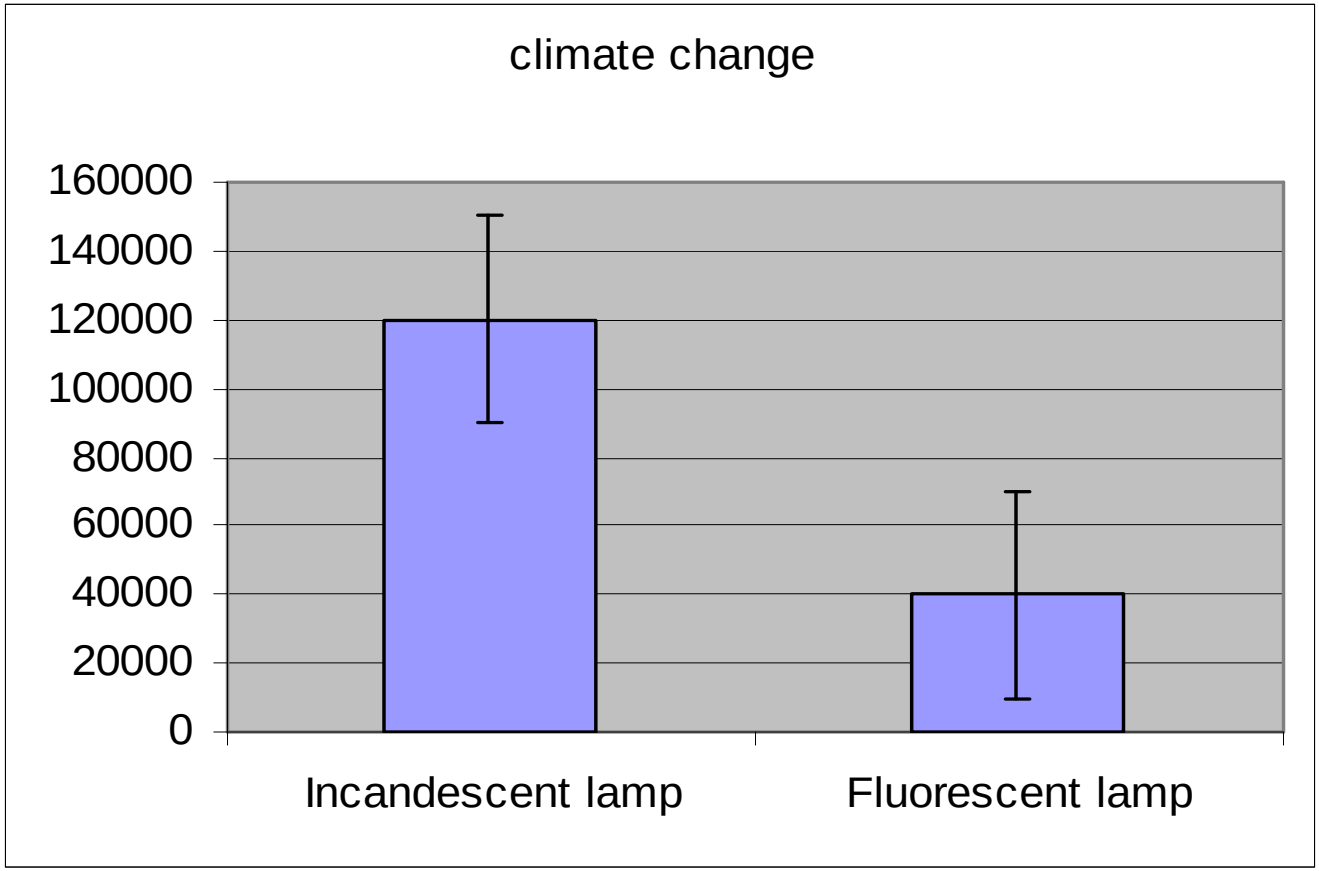
Phase 4: Interpretation

Example of a contribution analysis

Process	Incandescent lamp	Fluorescent lamp
Electricity production	88%	60%
Copper production	5%	15%
Waste disposal	2%	10%
Other	5%	15%
Total climate change	120000 kg CO2-eq	40000 kg CO2-eq

Phase 4: Interpretation

Example of an uncertainty analysis



You may want to review some segments of this module that describes the structure of LCA.

- **What is LCA?**
- **Why LCA?**
- **The ISO 14040 framework**
  - **Goal and scope definition**
  - **Inventory analysis**
  - **Impact assessment**
  - **Interpretation**

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

Module	contents
c	**Goal and scope definition**
d	**Inventory analysis**
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