Material Flow Analysis and Life Cycle Assessment

TECHNISCHE UNIVERSITÄT DARMSTADT

9. Unit: LCA – Impact Assessment II, Evaluation and Critical Review

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9. Unit: Impact Assessment (II)

9.1 Optional components of the impact assessment

9.2 Specific assessment methods

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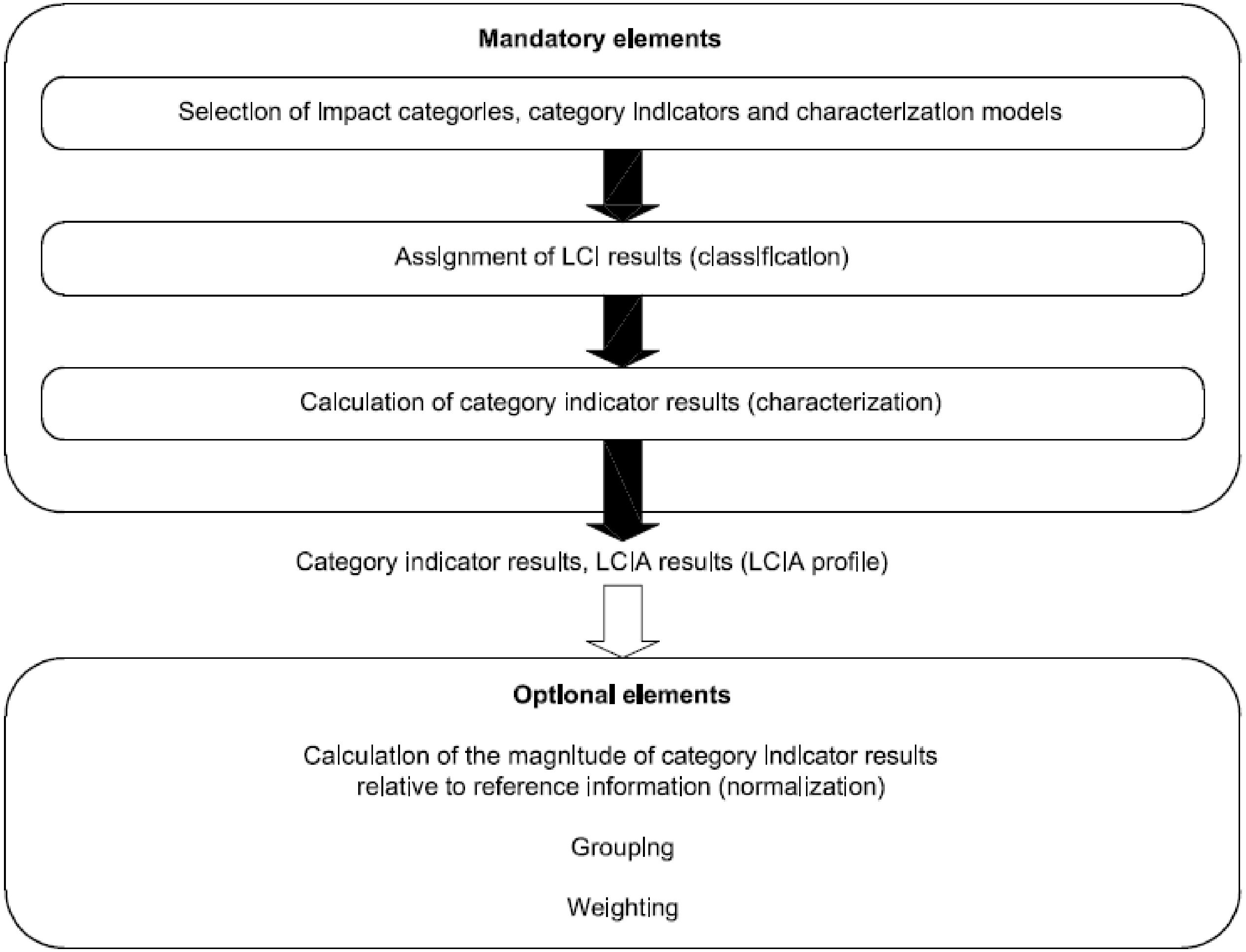
LIFE CYCLE IMPACT ASSESSMENT



ISO 14040

Optional components of the impact assessment

The optional components standardization, order and weighting are regarded as the evaluation step within the impact assessment.

- standardization
- order
- weighting
- data quality analysis

Evaluation steps

Standardization

The result of the impact indicator is set in relation to a spatial reference or reference value, so that a better understanding of the relative ratio of each indicator result is obtained. In the synopsis useful statements on the ecological importance of each indicator result are obtained in the overall result of the investigated product system.

Possibilities of reference values:

- Total emissions or resource use for a given spatial region, which can be local, regional, national or global
- Total emissions or resource use for a given spatial area per person of the population
- A given alternative product system as a reference scenario

Data basis for the standardization

http://www.pre.nl/normal.html

download training events partners contact search

Normalization figures for Dutch territory, Dutch consumption and West European territory

Three reference levels for normalization in LCA

By H. Blonk and M. Lafleur (IVAM); R. Spriensma, M.J. Goedkoop and S. Stevens (PRé Consultants), A. Agterberg, B. van Engelenburg and K. Blok (State University Of Utrecht). Commisioned by RIZA and VROM.

CML class	Unit	Dutch Territory around 1993/ 1994	Uncertainty Dutch territory	Dutch consumption around 1993/1994	West European territory 1990-1994
enhancement greenhouse effect	kg CO2-eq/an	2,1E+11	S	1,4E+11	4,2E+12
depletion ozone layer	kg CFC11eq/an	4,4E+06	M	2,6E+06	5,6E+07
photochemical smog formation	kg ethane-eq/an	1,9E+08	M	1,3E+08	6,3E+09
acidification	kg SO2eq/an	9,2E+08	S	5,4E+08	3,4E+10

Order in the impact assessment

The order divides the selected impact categories into one or more classes, it may include a classification and / or rank formation.

Possible methods for ordering :

- The classification of the impact categories on a nominal scale for example based on characteristics such as emissions and resources or global, regional and local spatial scales
- The rank formation of impact indicators on an ordinal scale for example in a given order or hierarchy like high, medium or low priority. The ranking is based on value systems..

Assessment procedure of the Federal Environmental Agency

Guideline: An impact category is judged to be more environmentally damaging,

- the more serious the potential danger to ecological subjects of protection (effect endpoints) is to be regarded in the relevant impact category (From the viewpoint of 1999)
- the more the current state of the environment is removed in this impact category of a state of ecological sustainability or any other desired environmental condition,
- The larger is the impact indicator result in relation to unified reference values, for example the share in the respective total annual emissions in Germany

→ Derivation of assessment criteria

Quelle: UBA-Texte 92/99 Bewertung in Ökobilanzen, Berlin 1999

Assessment procedure of the Umweltbundesamt

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➔ Derivation of assessment criteria

1. **Ecological hazard (rank formation of impact categories)**
2. **Distance-to target (distance to the desired state of the environment)**
3. **Specific contribution of a standardized impact indicator result of a concrete LCA**

Quelle: UBA-Texte 92/99 Bewertung in Ökobilanzen, Berlin 1999

Assessment criteria Ecological Hazard

To assess an impact category the following aspects were considered:

- The potential impact of a damage to natural resources (level of damage and extent of potential impacts)

  Pervasive impacts such as the influence in higher levels of the hierarchy are more serious

- The extent of reversibility of the harmful effect

  Irreversible effects are more severe

- The spatial extent of the damage

  Ubiquitously occurring effects are more severe

- Uncertainties in predicting the impacts, i.e. inadequate knowledge with regard to cause-and-effect relationships as well as the delay of a potential damage occurrence

  Greater uncertainty is more severe (precautionary principle)

Quelle: UBA-Texte 92/99 Bewertung in Ökobilanzen, Berlin 1999

Assessment criteria Distance-to-Target

To assess an impact category the following aspects were considered:

- Distance of the environmental condition of any quantifiable environmental quality objective (e.g. Immission concentrations),for the comparability of the difference between different impact categories the quotient of current and aspired environmental condition should be used .

  A larger distance or a greater ratio between the actual condition and quality target is more serious.

- Current or expected trend of the environmental conditions, e.g. due to measurements made

  Increasing loads (e.g. emissions) are more severe.

- Enforceability (organizational) and effectiveness (technical feasibility) of a measure required for the achievement of objectives.

  Less enforceability and effectiveness are more severe.

Quelle: UBA-Texte 92/99 Bewertung in Ökobilanzen, Berlin 1999

Weighting in the LCIA

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The weighting is a method for conversion of the indicator results by using numerical factors, known as weighting factors for the different impact categories, based on values and not on scientific findings.

Possible methods of weighting :

- Conversion of the impact indicator results or standardized results with selected weighting factors
- Possible summary of this converted impact indicator results or standardized results over the impact categories

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Analysis of data quality

What analysis and techniques are required for the data quality depends crucially on the determined goal definition and scope.

•Sensitivity analysis: measures the extent to what changes, for instance characterization models influence the impact indicator results.

•Focus analysis: This is a statistical method, which detects those data (input- and output-related LCI results) which provides the greatest contribution of an indicator result.

•Error estimation: describes the statistical variability of the data set to determine whether the impact indicator results of an associated impact category are distinguish.

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Special assessment methodsSpezielle Bewertungsverfahren

Proxy-Indicators

- MIPS
- CED

Single-Score-Methods

- Ecopoints
- Ecoindicator 95/ Ecoindicator 99

Material intensity per service unit (MIPS)

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The concept of the material intensity per service unit (MIPS) uses the amount of moving materials in mass units as a proxy (Schmidt-Bleek 1992).

All inputs of materials / raw materials. That were taken from the environment or rather actively moved there, to produce a product or service (in kg or t) are taken into account and added that were taken from the environment and actively moved there (ores, sand, gravel, etc.).

Material inputs are shown separately in five categories:

- Abiotic raw materials (mineral resources, fossil fuels, burden, excavation),
- Biotic raw materials (biomass),
- Soil movements (mechanical tillage and erosion),
- Water (surface water, groundwater and deep groundwater) and
- Air(-components) (for combustion and chemical transformation)

Cumulative energy demand - (CED)

- Since the 70s cumulative energy demand is used worldwide as a benchmark for energy systems.
- In the early 90s, experts of the Association of German Engineers (VDI) designed with the participation of the Federal Environmental Agency a rule for determining the CED, the VDI directive 4600.
- The VDI 4600 gives definitions, calculation methods and examples of CED applications. It is the cornerstone of all modern CED works and clarifies what is meant by the cumulative energy demand.

VDI directive 4600

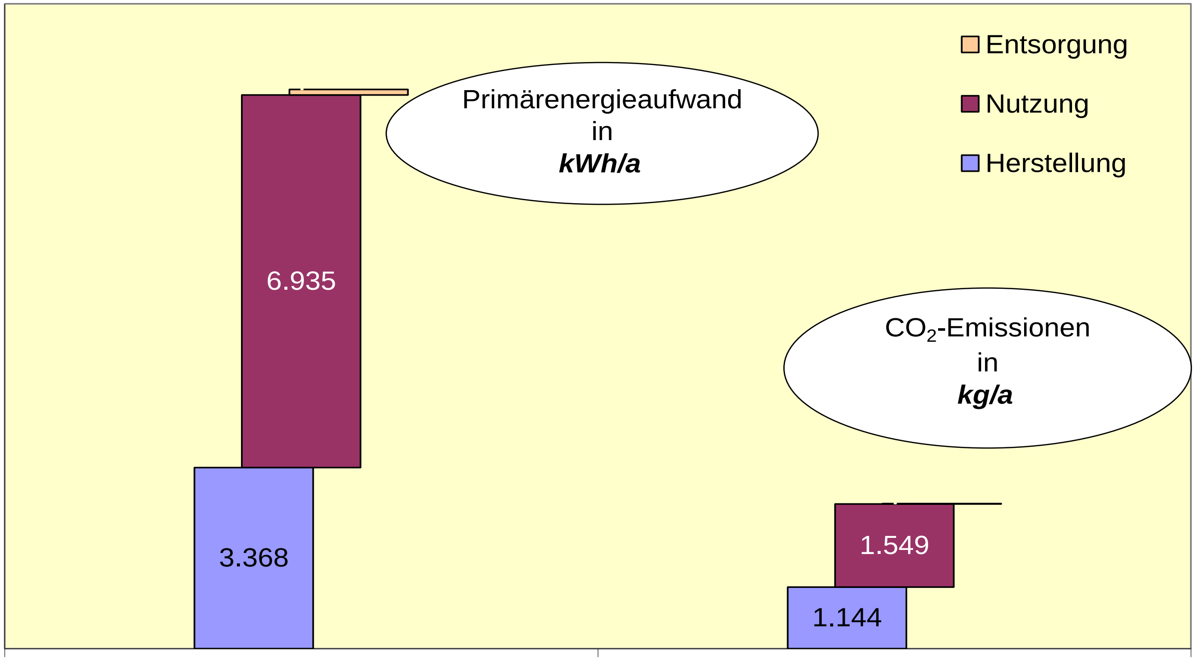
The „**c**umulative **e**nergy **d**emand (CED)„ is the sum of all energy demands and includes therefore

- both the process-specific consumption (CEC)
- And those expenses that are not consumed in individual processes, but remain stored recyclable in the product (e.g. calorific value of wood in furniture, or oil, which is bound in plastic).

CED – example of application

Primary energy consumption and CO2 emissions throughout the life cycle of a building (50a)

Beispiel: 3-Liter-Haus mit Erdreich-Wasser-Wärmepumpe



Quelle: Wagner, Universität Bochum

Method of ecological scarcity

…allows the weighting of the data, collected in an LCI data base. The basics were published for the first time in 1978 (Müller-Wenk 1978), the latest version in 1998 (BUWAL 1998a).

- The method is based on the principle of "distance-to-target".
- Here, the total current flow per substance (e.g. nitrogen oxides) of a country and the corresponding scope of the environmental objectives as the maximum allowed considered (critical) environmental impacts of these rivers are used.
- Critical and current flows are defined in the original version corresponding to swiss conditions.

Eco-Indicator 99

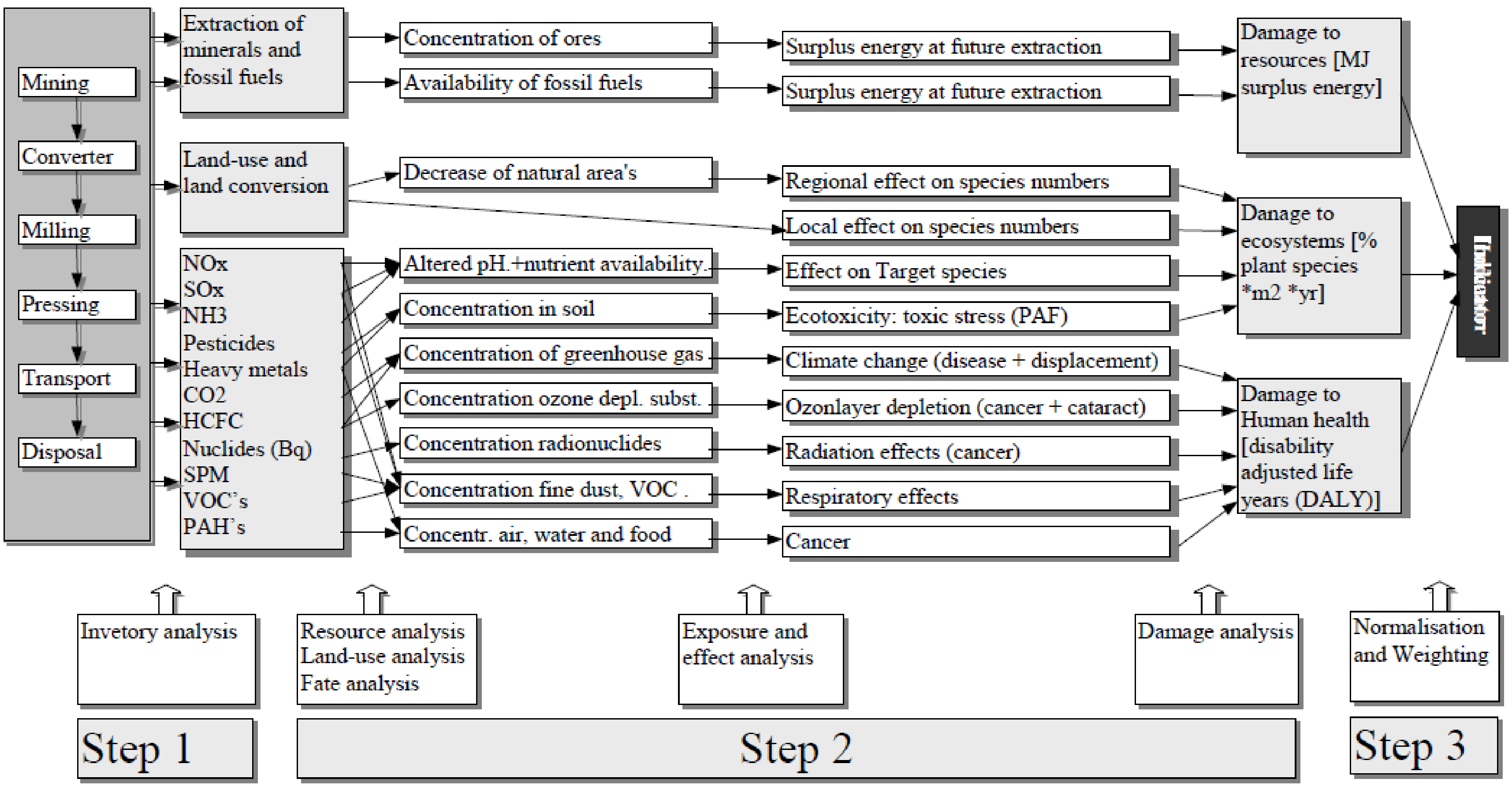


Figure 7: Detailed representation of the damage model (step 2)

Quelle: Goefkoop et al 2000

Eco-Indicator 99

- **Advantages:**
  - Modeling of the actual damage to the nature
  - Easier interpretation of the LCA
  - Clear overview of the completeness of the LCA

- **Disadvantages:**
  - Increased unvertainty
  - More value-laden assumptions (social value setting)
  - Significant gaps in knowledge (e.g. what happens at a temperature increase of 1 ° C)

The three perspectives – Example EU LCA

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- **Hierarchist:** Human Health and Ecosystem Quality is 40% each. Respiratory effects and greenhouse effects dominate Human Health damages. Land use dominates Ecosystem Quality; Resources is dominated by fossil fuels.
- **Egalitarian:** Ecosystem Health contributes 50% to the overall result. The relative contributions within the damage categories are about the same as in the Hierarchist perspective, except for carcinogenic substances. A Hierarchist would consider a substance as carcinogenic if sufficient scientific proof of a probable or possible carcinogenic effect is available (IARC class 3 and up).
- **Individualist:** Human Health is by far the most important category. Carcinogenic substances however play virtually no role. The individualist would only include those substances for which the carcinogenic effect is fully proven (IARC class 1). The Individualists would also not accept (based on experience) that there is a danger fossil fuels can be depleted. This category is left out. For this reason Minerals become quite important.