Material flow analysis and Life Cycle Assessment

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10. Unit: Evaluation and Critical Review

Prof. Dr. Liselotte Schebek
Fachgebiet Industrielle Stoffkreisläufe
Institut IWAR

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10. Unit: Life Cycle Assessment - Evaluation

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Quality of data

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The wise use of information and data is only possible if it can be demonstrated that they are a sufficiently accurate figures of the real conditions.

(cp. Unit 2: Validation of models)

Approaches to describe the data quality in Life Cycle Assessment:

- Description of data quality using selected data quality criteria
- Quantification of uncertainty in data and results
- Use of so-called semi-quantitative approaches

According to: Jens Warsen: Validierung von Stoffflussdaten in der Ökobilanz durch Daten aus dem öffentlichen Berichtswesen Dissertation, TU Darmstadt 2009, WAR-Bericht XXX

Data quality criteria according to ISO 14044

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ISO 14044 4.2.3.6ff:
Requirements on data quality for comparative studies

- time-related scope
- geographical scope
- technological scope
- precision
- completeness
- representativeness
- consistency
- reproducibility
- data sources
- uncertainty of information

Specific data – generic data

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Specific data:

- specific to a concrete plant / process / company / ...;
- in the sense of directly measured data, also known as primary data

Generic data:

- Form such processes, on which the creator of an LCA itself has no control and which have no direct relevance for the aim and framework of the study

Quantification of Uncertainty

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Error: deviation of a measurement from the "true" value / expected value

Expected value: derived average value from the infinite number of measurements

Systematic error

- Definition: deviation of the "true value" from the expected value
- Determination: by calibration standards, reference methods, round robin tests…

Random errors

- Definition: deviation of the measured value of a single measurement from the expected value
- Determination: by statistical methods

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Interpretation and Presentation of results

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Presentation: (graphical) Presentation of results of the Life Cycle Inventory analysis (LCI) and Life Cycle Impact Assessment (LCIA)

Interpretation (in the LCA terminology):
Analyse data to draw conclusions

Interpretation also includes the control of the conclusions:

- Sensivity analysis
- Uncertainty analysis
- Asessment of data quality

Interpretation and Presentation of results

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ISO 14040 (2006):

Evaluation – part of the LCA, in which the results of the inventory analysis and impact assessment, or both, with respect to the defined goal and scope are assessed to derive conclusions and to give recommendations

Unexpected results outlying of the scope up to now can suggest to adapt the framework and the goal to take into account and record the additional findings in the analysis.

Presentation possibilities for the results

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1) Guidelines by the character of each conducted LCA
- Only LCI
- Impact assessment up to characterization
- Weighting and optionally aggregation of results

2) Guidelines that are chosen by the purpose of the investigation or the person in charge
- Dominance analysis
- Kontributionsanalyse
- Coverage point analysis
- Decision analysis

3) Presentation of the uncertainties, result control
- Error estimation
- Sensitivity analysis
- Scenario analysis

LCI results

Here, a selection of the actual measured values for the analysis is used , but which measured values are used has to decide and justify the analyst.

To describe the environmental impact, for example, is a mixture of the usual, the most important and the most problematic environmental pollution indicators chosen.

These results mostly are compared on the basis of standardized bar charts. Indicators can then be combined in different charts, each containing its own message.

Impact assessment

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From the Life Cycle Inventory analysis to the impact assessment is the amount of parameters highly aggregated, so that mostly all parameters can be presented in a single diagram.

Indicators are now, taking into account their effects, summarized.

The impact assessment can be further aggregated by weighting the obtained parameters individually and represent this overall result. Problematical is then, however, often to set the weightings and to justify these.

Target group ←→ results

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- Life cycle inventories are mostly presented to a target group with expert knowledge, as they have sufficient background knowledge to understand these data.

- The producers in contrast use aggregated, impact-related data, because the products mostly get too complex and they have neither the required expert knowledge nor the time to understand the results of the Life Cycle Inventory analysis.

- For a general target group, the data are further aggregated to get a fast overview of the product and to simplify the comparison.

Qualitative LCA studies

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- Qualitative studies lose in contrast to quantitative studies of accuracy and Detail richness, but they are easy and quick to prepare. Quantitative studies are therefore not necessarily non-intuitive or less revealing.

- In case of incomplete data sets, it is sometimes useful to add qualitative entries due to the lack of quantitative entries, so that they are not forgotten and if necessary they can be supplemented.

- Qualitative means, that these entries are either approximated / estimated, or otherwise marked (asterisk).

Presentation possibilities of the results

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Presentation on the basis of analytical methods

- Dominance analysis
- Kontributionsanalyse
- Coverage point analysis
- Decision analysis

Dominance analysis

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For a more detailed analysis of a Life Cycle it must be „looked into“ the cycle, that means pick out out single processes and look for „hot spots“.

The dominance analysis is now used to find out the part of the Life Cycle which contibutes the greatest, most dominant part to the environmental impact. This can be achieved, for instance, through picking out the process with the greatest emissions.

The dominance analysis is therefore very useful to detect the problematic and unproblematic processes.

Dominance analysis

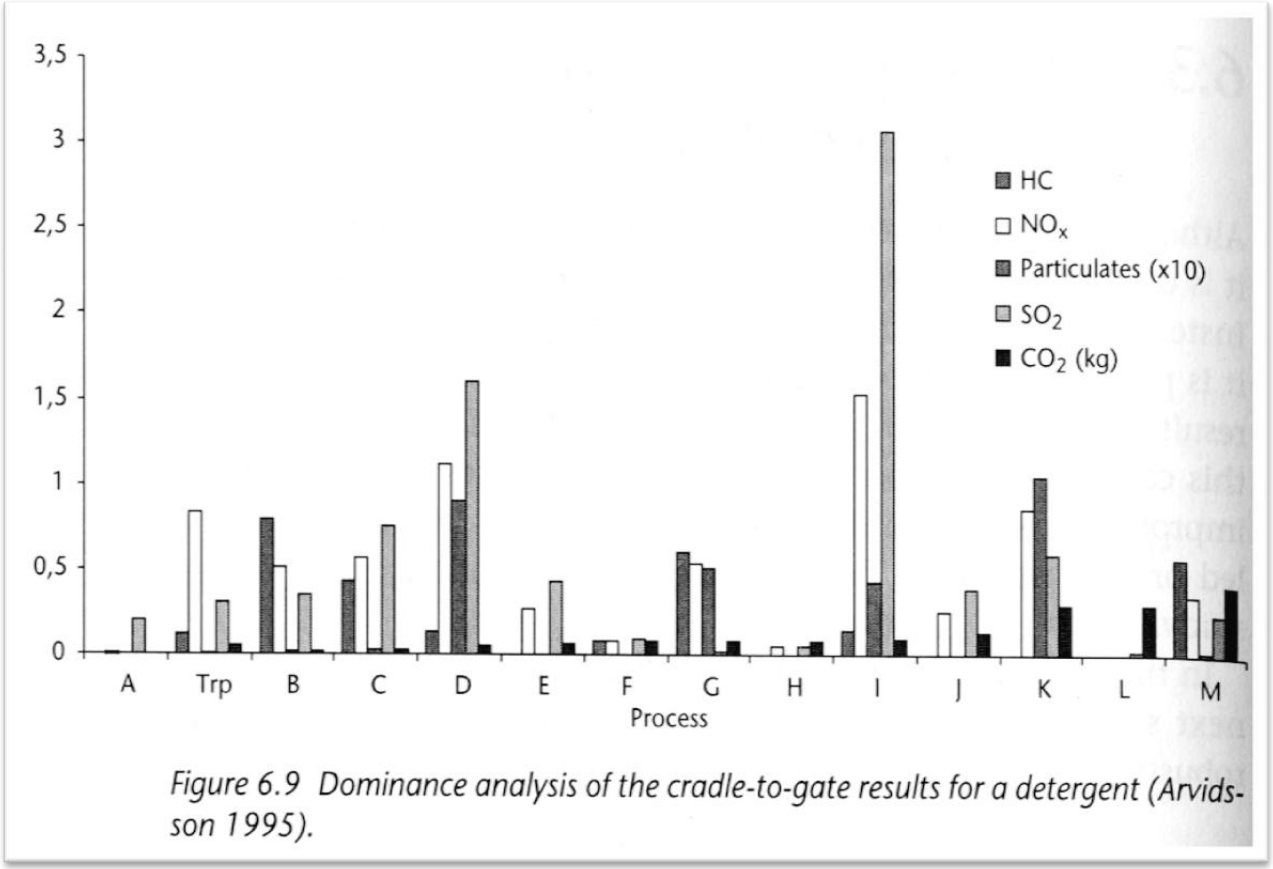


Figure 6.9 Dominance analysis of the cradle-to-gate results for a detergent (Arvidsson 1995).

Source: H. Baumann, A.-M. Tillman; The Hitch Hicker's Guide to LCA

Kontributionsanalyse

In contrast to the dominance analysis, where the processes are in the focus, are here the entries of single environmental impacts investigated.

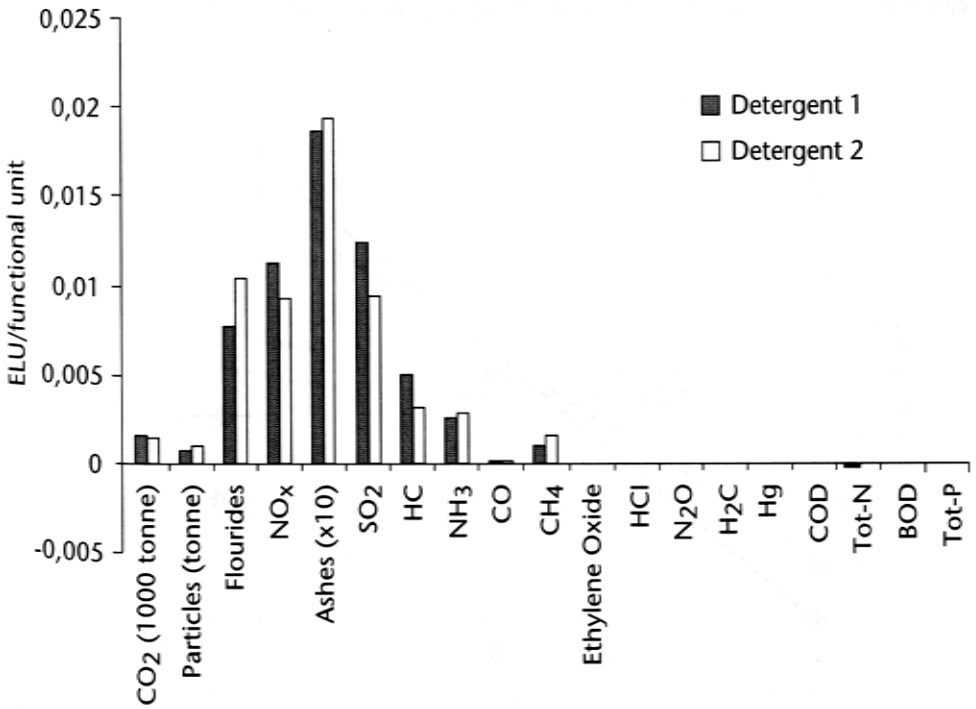


Figure 6.11 Contribution analysis of the cradle-to-gate result for two detergents (Arvidsson 1995).

Quelle: H. Baumann, A.-M. Tillman; The Hitch Hicker‘s Guide to LCA

Coverage point analysis

This method compares products with different economic life-time. Trying for instance to find out the point where a multi-cycle system is more profitable than a one-way system.

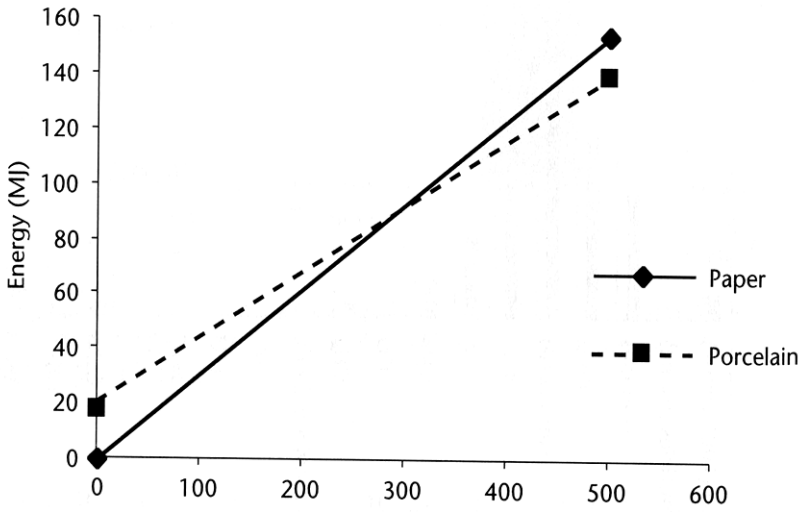
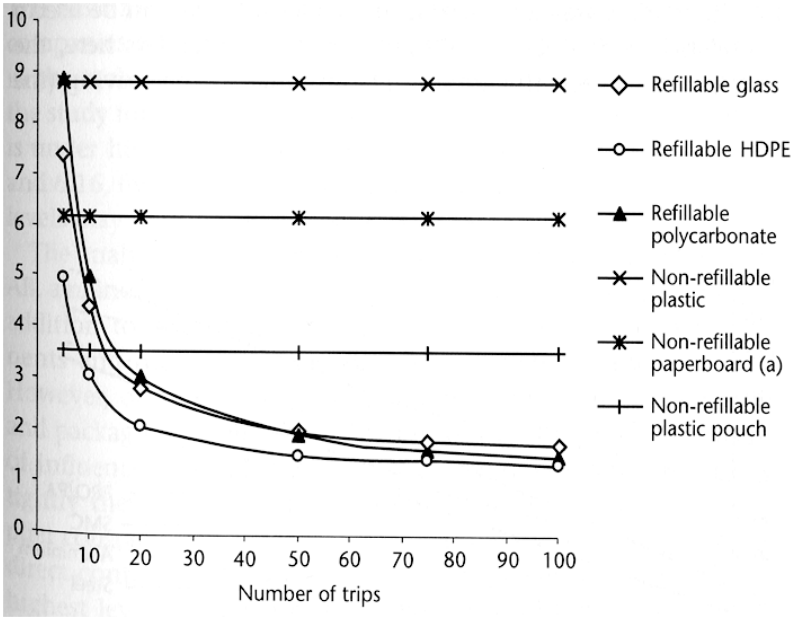
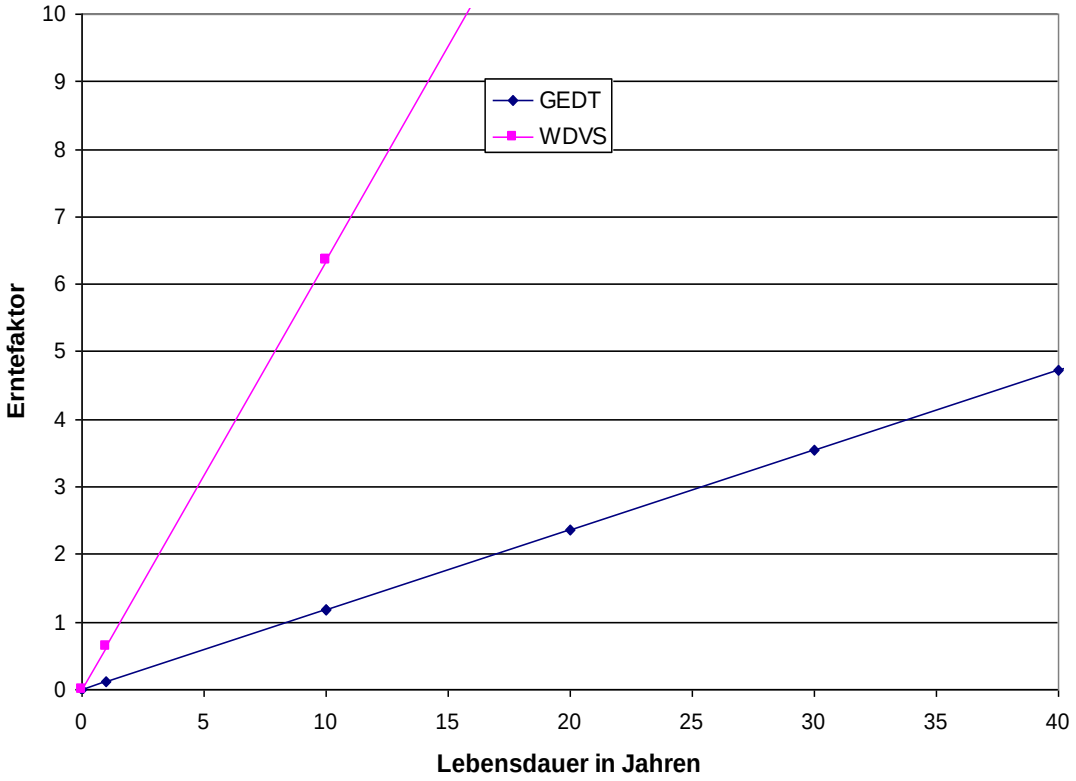


Figure 6.12 Break even analysis in a comparison of porcelain coffee mugs with single-use paper cups (van Eijk et al. 1991). The energy use is accumulated over the number of servings with paper cups/servings in porcelain cups.



Quelle: H. Baumann, A.-M. Tillman; The Hitch Hicker's Guide to LCA

Example:
Investigation of the energetic efficiency of Vacuum insulation panels



Erntefaktoren eines GEDT-Elements mit Vakuumdämmung und eines EPS-Wärmedämmverbundsystems (WDVS) in Abhängigkeit von der Lebensdauer
(Bewertungsbasis: Kumulierter Energieaufwand)

Decision-maker-analysis

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Fundamental in this analysis is the identification of the individual businesses that perform the various processes within a system.

The aim of such analysis is to assess how the environmental impact of the system can be affected by the decision maker of the study.

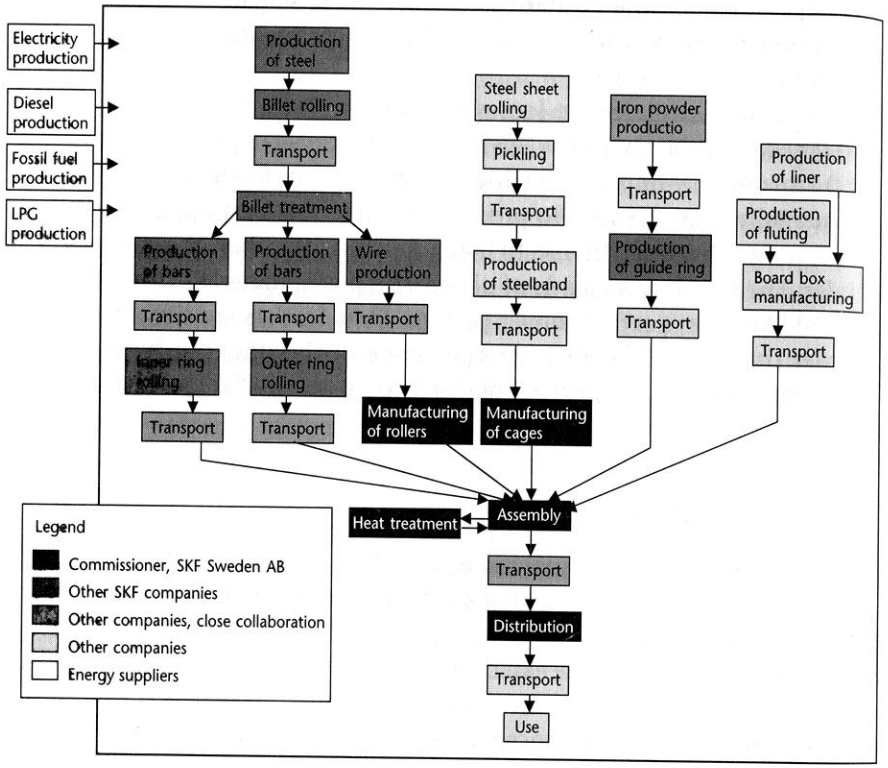


Figure 6.15 Decision maker analysis. Relationship between LCA commissioner and other companies involved in the production of spherical roller bearing.

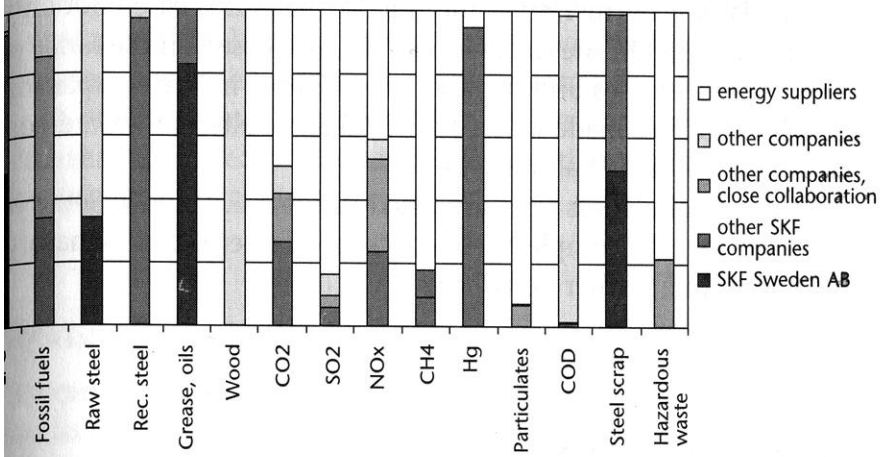
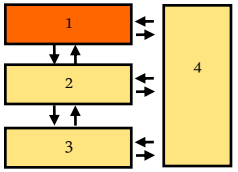


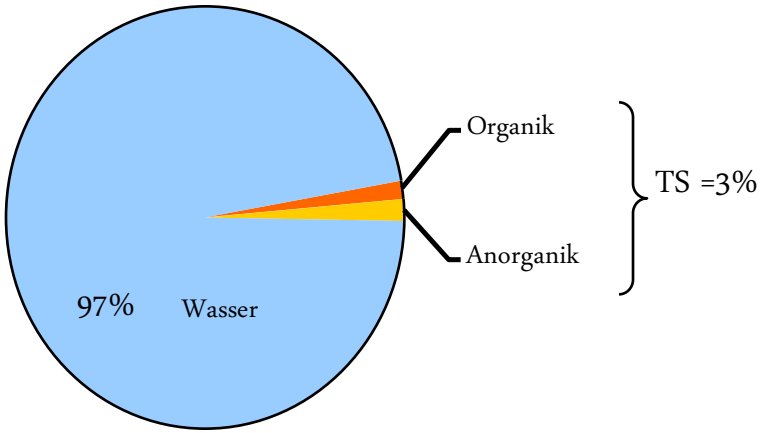
Figure 6.16 Decision maker analysis of selected inventory results for a spherical roller bearing (based on Ekdahl 2001). The diagram shows among other things that SKF Sweden AB stands for the majority of the electricity consumption, use of greases and oils and generation of steel scrap. To reduce emissions to air (CO_2, SO_2, NO_x and CH_4) the decision maker needs to influence the choice of energy suppliers. The commissioner at SKF Sweden AB must target other companies in the SKF group in order to reduce emissions of mercury (Hg).

Quelle: H. Baumann, A.-M. Tillman; The Hitch Hicker‘s Guide to LCA

Functional Unit

- 1 t of dry matter digested sludge of a municipal wastewater treatment plant
- DM content of 3%. :
  (= 33333 kg wet sludge)
- Dry matter consists of 50% organic matter (ODM) and 50% inorganic matter





Calculation of errors and sesitivity analysis

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- To understand the implications of inaccurate data a error analysis is made.
- If the result is too inaccurate, so that we can't make any reliable conclusions, we first perform a sensitivity analysis to determine which inaccuracies contribute the most to the error of the result.
- The sensitivity analysis identifies the processes in which only small changes are amplified observable in the result.
- The data for these processes must therefore again have a high degree of accuracy, as it is reflected correspondingly high in the results.

Sensitivity analysis

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Only one variable is investigated!

Strengths

- Indentify the revelance of individual variables
- Find information deficits

Debilities

- Interdependencies are hidden
- They are estimated values

Example: packaging systems for beer

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- Project: Life Cycle Assessment for beverage packaging
- Participants:
  1) Frauenhofer-Institute for Food Technology and Packaging, Munich
  2) Institute for Energy and Environmental Research, Heidelberg
  3) Society for Packaging Market Research, Wiesbaden
- Parameter of the scenario:
  - Distribution Distance: 100km
  - Circulation frequency of beer glass bottle: 50
  - Use ratio of tin cans: : 45%
- Varied parameters:
  - Distribution Distance : 100 – 600 – 1000km

Source: Hummer, Stoffstromanalyse,Prozessoptimierung und Bilanzierung/LCA , Vorlesung Montanuniversität Leoben

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Need of the Critical Review

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ISO 14040 (2006) - 7.2 Need of the Critical Review

- A Critical Review can help to better understand and enhance the credibility of an LCA, e.g. by including stakeholders.
- The application of the results of the LCA for comparative statements raises special issues and requires a Critical Review, because the application likely relates interested parties who are not involved in the production of the LCA.
- The fact that a critical examination was carried out, should by no means imply that a comparative statement is approved which is based on a life cycle assessment study.

Need of the Critical Review

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A few points:

- Are the used methods consistent with the standards?
- Are the methods relevant relating to the target definition?
- Are the scientific and technical practices generally accepted?
- Is the data adequate and appropriate?
- Are the calculations right?
- Are the conclusions supported by the results?
- Is the report transparent and consistent throughout?
- Does the report meet the requirements of the standard?

ISO 14040 (2006) - Critical Review Procedure

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- The review should ensure that the components of the classification, characterization, normalization, order and weighting suffice and is documented in a way that makes it possible to carry out the evaluation phase of the LCA.
- Where necessary, confidentiality agreements should be made about the content of the LCA.

Critical Review by an internal or external expert

The internal or external expert should be familiar with the requirements of the LCA and should have the relevant scientific and technical knowledge.

Critical Review – Example

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Goal: Comparison of laundry washed with cold water with laundry washed with warm water and their relative environmental impacts.

Scope:

Germany, washing machine, degree of hardness, standard laundry detergent, ...

Functional Unit: 100 full washing machines per year

It's clear that cold washed laundry is more environmentally friendly because no energy is required for heating the water

Conclusion: Waash your laundry with cold water!

Review: What about the level of cleanliness of the washed laundry? Conclusion is not universal!

→ New functional unit, Rectification leads to another conclusion!