The influence of normalization and weighting on results by different possibilities given in the ISO Standard

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Normalization and weighting: The forgotten theme in LCA
Monday, 9 September 2019, ETH Zürich
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Normalization and weighting: The forgotten theme in LCA
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Who are we?

Over 20 years of experience in life cycle assessment

Founded 1998 as an ETHZ spin-off

Clients from industry, NGOs, administration, universities

Own LCA database with more than 6,000 datasets

Dr Niels Jungbluth

Christoph Meili
LCA for improvement options in dairy processing

GOAL AND SCOPE
Goal of the example LCA

- Analyze a baseline model of an European dairy plant
- Analyze and evaluate improvement scenarios for technologies delivering heat, electricity and chilling in the dairy
- LCA study for the European research project SUSMILK (2012-16)
Key questions to be answered with the LCA

The following key questions are answered in this LCA study:

• What influence on the environmental impacts can be expected by replacing conventional energy technologies by other state-of-the-art or new technologies?

• How relevant are the energy and water uses in different process stages in the dairy from an environmental point of view?

• Provide guidance for improvement in European dairy industries
Focus of this presentation

- Simplifying LCIA results by normalization and weighting according to ISO standards
- Lessons learned from applying different options
Calculation of LCIA indicator results

- ILCD & Exergy
  - Midpoint, no weighting of environmental impacts
  - 15 categories of ILCD recommendation e.g. climate change, water use etc.
  - Cumulative exergy demand

- Detailed discussion in public report

- Too complicated for a presentation and decision making by plant operators
Normalization options

- Internal reference without raw milk input
- Internal reference with raw milk input
- European annual emissions
- Global annual emissions
Weighting options

• Equal weighting (EU proposal at time of study)
• Expert weighting with a structured interpretation (ESU-services)
• Stakeholder weighting (SUSMILK project partners)
LCIA APPROACH FOR NORMALIZATION AND WEIGHTING
PEF-points

- Equal weighting
- European normalization
- Recommended at the time of project by ILCD
SUSMILK-points (Panel weighting)

• Initial discussion of category indicator results

• 12 answers by project members on: “Please add your weighting figure to the 16 environmental impact categories. The value must be between the minimum (1%) and maximum (85%) weight. The total must add up to 100%. Choose the weight according to the way you would consider the categories for decision making.”

• «SUSMILK-points»: value choices of project partners
  – Normalization ("Reference"): Total European emissions
  – Weighting: average of chosen percentages by people

➢ Framing of questions already an important part of the final result
Weighting, SUSMILK

Climate change 40%

Particulate matter 6%

Human toxicity, cancer effects 4%

Human toxicity, non-cancer effects 4%

Ozone depletion 4%

Terrestrial eutrophication 3%

Marine eutrophication 3%

Freshwater eutrophication 3%

Freshwater ecotoxicity 3%

Acidification 3%

Abiotic resource depletion 2%

Land use 5%

Cumulative exergy demand 6%

Water depletion 6%
ESU-points (Interpretive weighting)

• «ESU-points»: value choices of LCA experts
  - Normalization, three approaches:
    • Global emissions / resource uses per person and day
    • Impact of LCA dairy operation, including milk
    • Impact of LCA dairy operation, excluding milk

• Weighting interpreting the reliability of data (back-& foreground), reliability of method, overlap and the focus of the project
ESU-points: Criteria of structured weighting

<table>
<thead>
<tr>
<th>Weighting</th>
<th>Robustness European normalization</th>
<th>Reliability, LCI, background</th>
<th>Reliability, LCI, foreground</th>
<th>Reliability, LCIA</th>
<th>Overall score (multiplication, w/o robustness)</th>
<th>Weighting, ESU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change</td>
<td>kg CO2 eq</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Ozone depletion</td>
<td>kg CFC-11 eq</td>
<td>60%</td>
<td>20%</td>
<td>80%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Human toxicity, non-cancer effects</td>
<td>CTUh</td>
<td>20%</td>
<td>50%</td>
<td>80%</td>
<td>60%</td>
<td>100%</td>
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<td>Human toxicity, cancer effects</td>
<td>CTUh</td>
<td>20%</td>
<td>50%</td>
<td>80%</td>
<td>60%</td>
<td>100%</td>
</tr>
<tr>
<td>Particulate matter</td>
<td>kg PM2.5 eq</td>
<td>100%</td>
<td>90%</td>
<td>80%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Ionizing radiation HH</td>
<td>kBq U235 eq</td>
<td>60%</td>
<td>90%</td>
<td>100%</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>Photochemical ozone formation</td>
<td>kg NMVOC eq</td>
<td>60%</td>
<td>100%</td>
<td>100%</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>Acidification</td>
<td>molc H+ eq</td>
<td>80%</td>
<td>100%</td>
<td>100%</td>
<td>80%</td>
<td>33%</td>
</tr>
<tr>
<td>Terrestrial eutrophication</td>
<td>molc N eq</td>
<td>60%</td>
<td>100%</td>
<td>100%</td>
<td>80%</td>
<td>33%</td>
</tr>
<tr>
<td>Freshwater eutrophication</td>
<td>kg P eq</td>
<td>40%</td>
<td>100%</td>
<td>100%</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>Marine eutrophication</td>
<td>kg N eq</td>
<td>40%</td>
<td>100%</td>
<td>100%</td>
<td>80%</td>
<td>33%</td>
</tr>
<tr>
<td>Freshwater ecotoxicity</td>
<td>CTUe</td>
<td>20%</td>
<td>100%</td>
<td>100%</td>
<td>60%</td>
<td>100%</td>
</tr>
<tr>
<td>Land use</td>
<td>kg C deficit</td>
<td>60%</td>
<td>90%</td>
<td>100%</td>
<td>40%</td>
<td>100%</td>
</tr>
<tr>
<td>Water resource depletion</td>
<td>m3 water eq</td>
<td>40%</td>
<td>80%</td>
<td>100%</td>
<td>40%</td>
<td>100%</td>
</tr>
<tr>
<td>Mineral, fossil &amp; ren resource depletion</td>
<td>kg Sb eq</td>
<td>20%</td>
<td>30%</td>
<td>80%</td>
<td>80%</td>
<td>50%</td>
</tr>
<tr>
<td>Cumulative exergy demand</td>
<td>MJ-eq</td>
<td>100%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
<td>50%</td>
</tr>
</tbody>
</table>

➢ 5 themes for interpretation considered
➢ Different mathematical options to summarize
➢ Here multiplication of 5 issues and then recalculate for 100%
Weighting, ESU

- Cumulative exergy demand: 6%
- Climate change: 23%
- Ozone depletion: 2%
- Human toxicity, non-cancer effects: 3%
- Human toxicity, cancer effects: 3%
- Particulate matter: 3%
- Ionizing radiation: 8%
- Photochemical ozone formation: 9%
- Acidification: 3%
- Terrestrial eutrophication: 9%
- Freshwater eutrophication: 3%
- Marine eutrophication: 3%
- Land use: 4%
- Freshwater ecotoxicity: 7%
- Water depletion: 7%
- Abiotic resource depletion: 1%
LCIA RESULTS
Provision of heat: Considered options

- Natural gas
  - Boiler (reference, ecoinvent)
  - Cogeneration with motor and turbine (ecoinvent)
  - Gas-engine driven heat pump (Simaka; heat: waste & cogen. natural gas)
- Light fuel oil boiler (ecoinvent), diesel boiler (Queizuar)
- Wood
  - Cogeneration (ecoinvent)
  - Pellet boiler (Queizuar/Solarfocus)
- Solar collectors
  - Small system on roof (Queizuar/Solarfocus)
  - Large system on field & on roof (Solarfocus) + location specific sensitivity analysis
Provision of heat: SUSMILK and ESU-points

Referenced to natural gas (100%)

- Outcome of comparison changes with weighting/normalisation applied
- Decisive for interpretation of wood energy
➢ Also normalization can change comparative results (wood)
➢ Internal normalization critical for new types of impacts
Provision of heat: Single Score

Larger variation for new or distinctly different technologies (solar, wood)
Conclusion Normalization

• Higher variation of results if impacts of new options form only a small part of present normalization

• Internal reference can change results significantly depending on the scope and can favour the present status

• Unsolved issues like exclusion of capital goods and long term-emissions in annual references

➢ Normalization can also include value choices
Conclusions Weighting

- Equal weighting or zero weighting does not avoid the problems and leads to strange results.
- Stakeholder weighting might be biased by expectations, frame of questions, choice of participants and the averaging of answers (mean/median, by person/stakeholder).
- Structured expert weighting is possible and should take into account the issues of interpretation as described in ISO norm. But, also here the mathematical sum-up can be an important point.
Recommendations from this study

- Use global normalization (or even better global targets)
- Using different sets of weighting/normalisation with recommended category indicators instead of applying different LCIA methods
- Use a structured expert weighting as a form of interpretation for comparative assertions
- Provide better guidance in the ISO norm on interpretation, normalization and weighting approaches including approaches how to frame questions, summarize answers in a panel or criteria in multi-criteria analysis

Question: Would a structured expert weighting approach be a compromise to be acceptable for comparative assertions in published LCA?
Thank you very much for your attention!

Detailed discussion in public Del. 7.3
www.esu-services.ch/projects/lcafood/susmilk/

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