ライフサイクルアセスメント

生命週期評估

전 과정 평가

வாழ்க்கை வட்டப் பகுப்பாய்வு

ارزیابی چرخه عمر

Evaluarea Ciclului de Viață

Posuzování Životního Cyklu

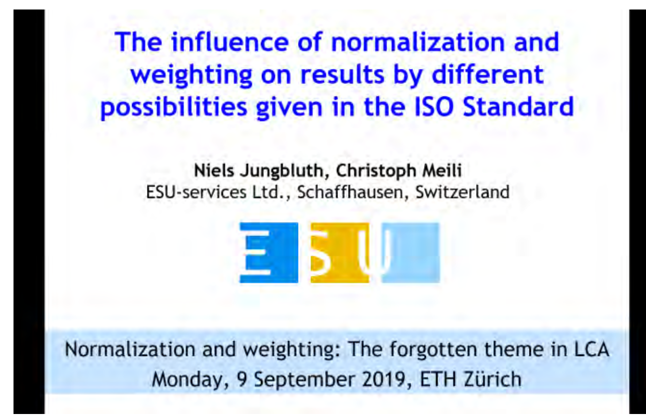
Bizi zikloaren analisi

Olelusringi hindamine

Lífsferilsgreining

Levenscyclusanalyse

Livscyklusvurdering



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

<u>Niels Jungbluth</u>, Christoph Meili
ESU-services Ltd., Schaffhausen, Switzerland

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

Who are we?

Dr Niels Jungbluth

Over 20 years of experience in life cycle assessment

Founded 1998 as an ETHZ spin-off

Christoph Meili

Clients from industry, NGOs, administration, universities

Own LCA database with more than 6‘000 datasets

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

LIFE CYCLE IMPACT ASSESSMENT

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

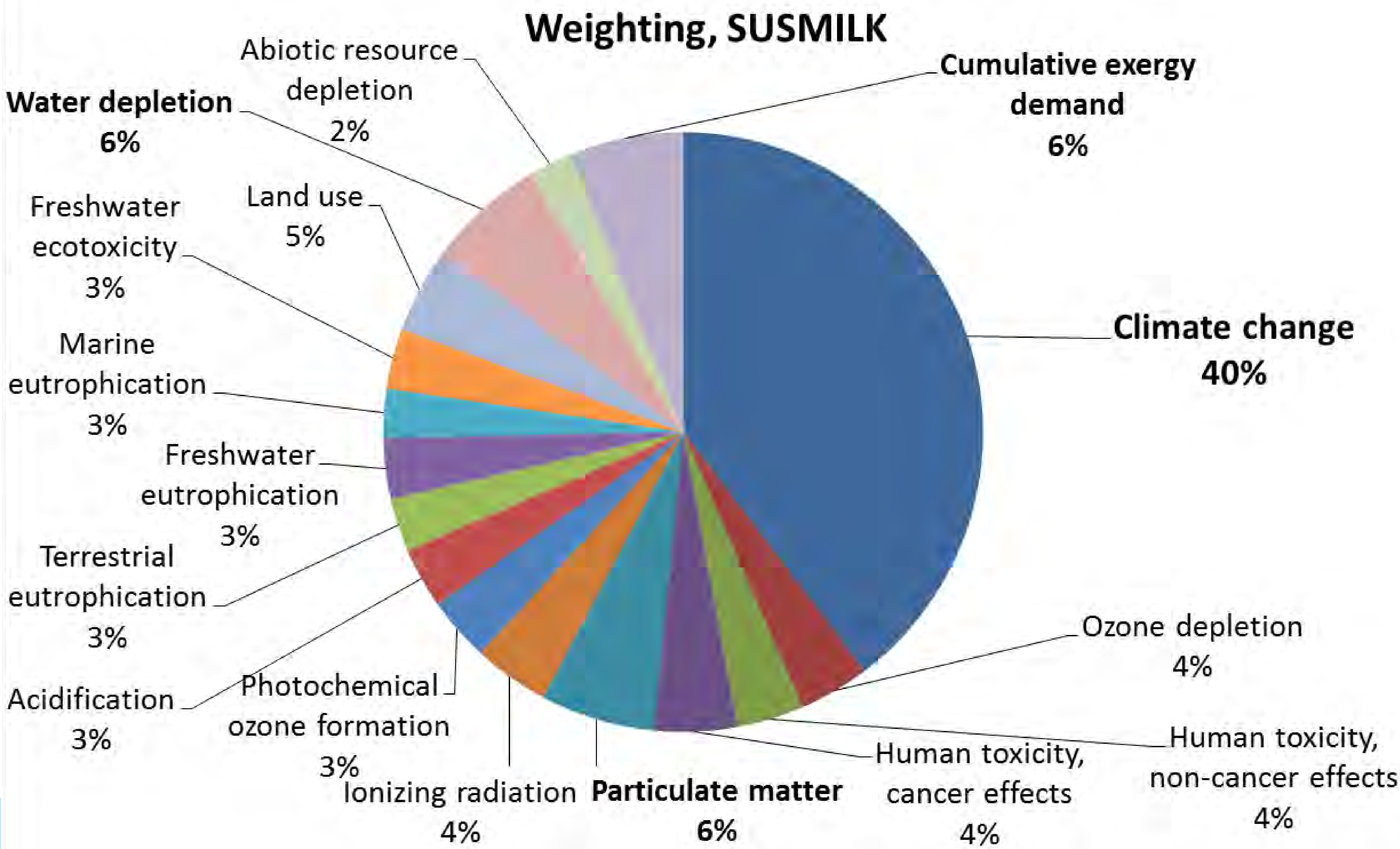
PEF-points

- 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
Abiotic resource depletion 2%
Cumulative exergy demand 6%
Water depletion 6%
Land use 5%
Freshwater ecotoxicity 3%
Climate change 40%
Marine eutrophication 3%
Freshwater eutrophication 3%
Terrestrial eutrophication 3%
Ozone depletion 4%
Acidification 3%
Photochemical ozone formation 3%
Human toxicity, non-cancer effects 4%
Human toxicity, cancer effects 4%
Ionizing radiation 4%
Particulate matter 6%

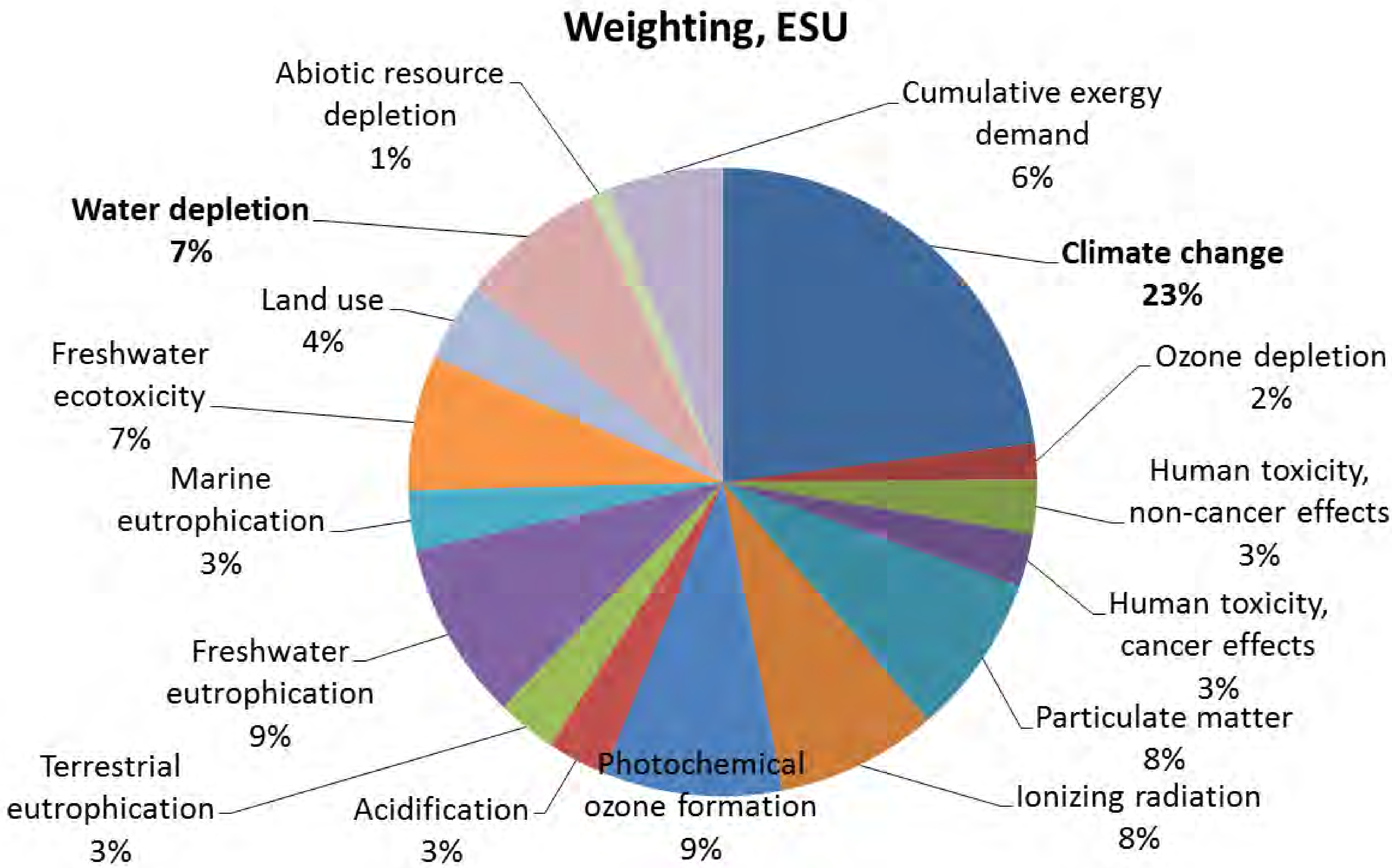
ESU-points (Interpretive weighting)

- «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

Weighting		*Robustness European normalization*	Reliability, LCI, background	Reliability, LCI, foreground	Reliability, LCIA	Overlap, LCI	Focus SUSMILK	Overall score (multiplication, w/o robustness)	**Weighting, ESU**
Climate change	kg CO2 eq	*100%*	100%	100%	100%	100%	100%	100.0%	**23.0%**
Ozone depletion	kg CFC-11 eq	*60%*	20%	80%	100%	100%	50%	8.0%	**1.8%**
Human toxicity, non-cancer effects	CTUh	*20%*	50%	80%	60%	100%	50%	12.0%	**2.8%**
Human toxicity, cancer effects	CTUh	*20%*	50%	80%	60%	100%	50%	12.0%	**2.8%**
Particulate matter	kg PM2.5 eq	*100%*	90%	80%	100%	100%	50%	36.0%	**8.3%**
Ionizing radiation HH	kBq U235 eq	*60%*	90%	100%	80%	100%	50%	36.0%	**8.3%**
Photochemical ozone formation	kg NMVOC eq	*60%*	100%	100%	80%	100%	50%	40.0%	**9.2%**
Acidification	molc H+ eq	*80%*	100%	100%	80%	33%	50%	13.3%	**3.1%**
Terrestrial eutrophication	molc N eq	*60%*	100%	100%	80%	33%	50%	13.3%	**3.1%**
Freshwater eutrophication	kg P eq	*40%*	100%	100%	80%	100%	50%	40.0%	**9.2%**
Marine eutrophication	kg N eq	*40%*	100%	100%	80%	33%	50%	13.3%	**3.1%**
Freshwater ecotoxicity	CTUe	*20%*	100%	100%	60%	100%	50%	30.0%	**6.9%**
Land use	kg C deficit	*60%*	90%	100%	40%	100%	50%	18.0%	**4.1%**
Water resource depletion	m3 water eq	*40%*	80%	100%	40%	100%	100%	32.0%	**7.4%**
Mineral, fossil & ren resource depletion	kg Sb eq	*20%*	30%	80%	80%	50%	50%	4.8%	**1.1%**
Cumulative exergy demand	MJ-eq	*100%*	80%	80%	80%	50%	100%	25.6%	**5.9%**
			20%	20%	20%	20%	20%	434%	100.0%

- 5 themes for interpretation considered
- Different mathematical options to summarize
- Here multiplication of 5 issues and than recalculate for 100%

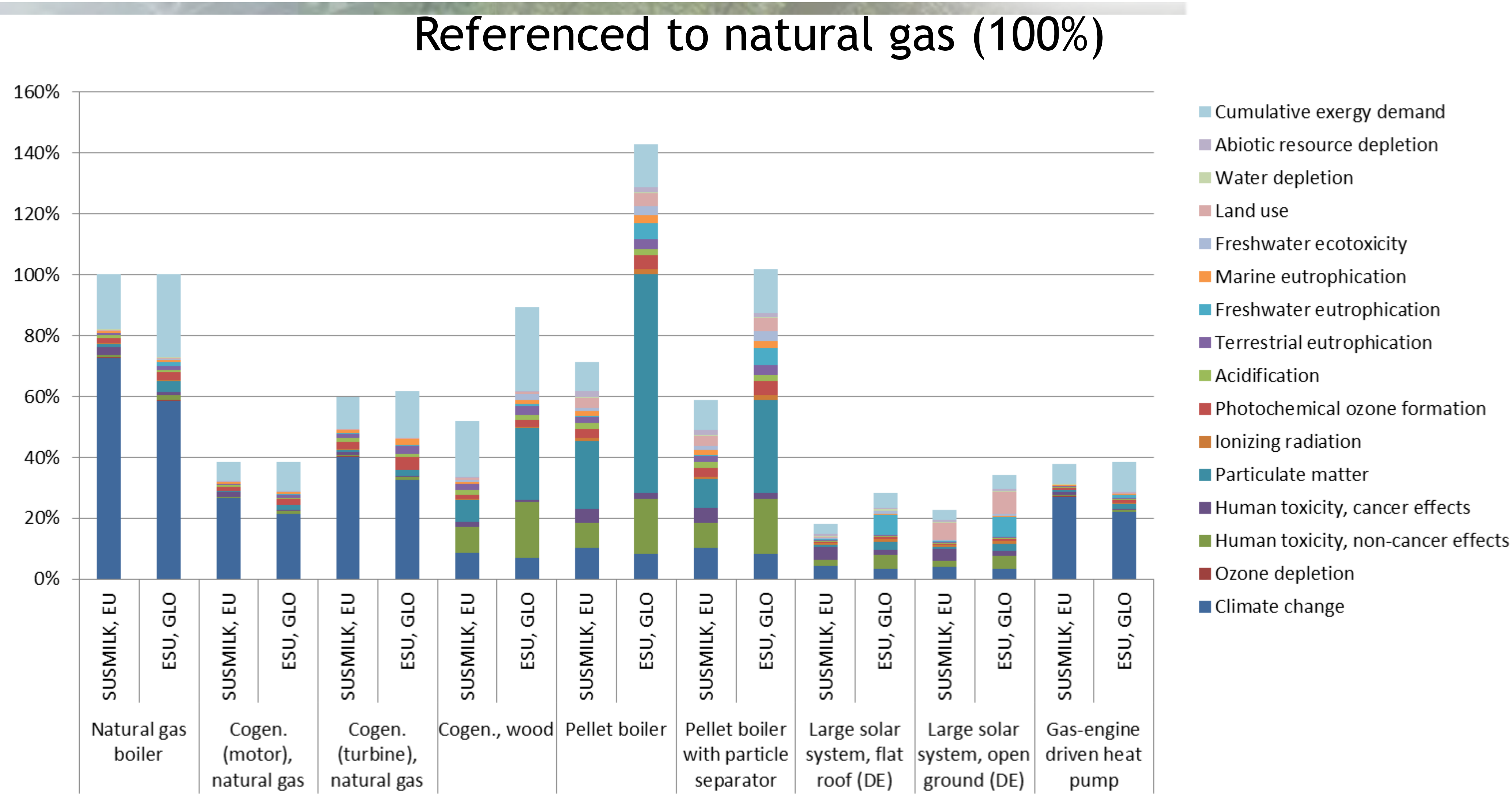

Weighting, ESU
Abiotic resource depletion 1%
Cumulative exergy demand 6%
Water depletion 7%
Climate change 23%
Land use 4%
Freshwater ecotoxicity 7%
Ozone depletion 2%
Marine eutrophication 3%
Human toxicity, non-cancer effects 3%
Human toxicity, cancer effects 3%
Freshwater eutrophication 9%
Particulate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

LCIA RESULTS

Provision of heat: Considered options

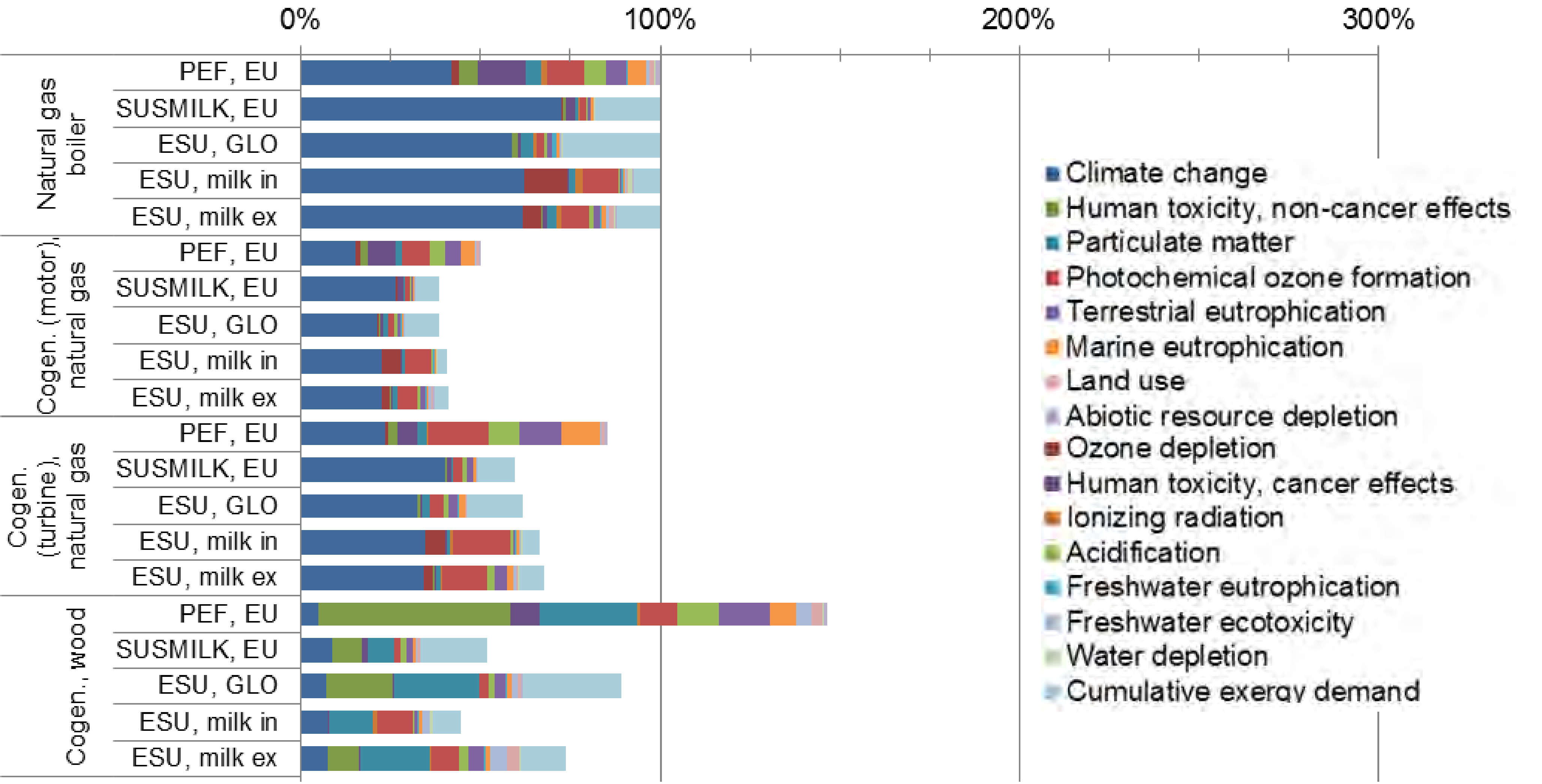
- Natural gas
  - Boiler (reference, ecoinvent)
  - Cogeneration with motor and turbine (ecoinvent)
  - Gas-engine driven heat pump (Simaka; heat: waste & cogen. natural gas)
- Light fuel oil boiler (ecoinvent), diesel boiler (Queizuar)
- Wood
  - Cogeneration (ecoinvent)
  - Pellet boiler (Queizuar/Solarfocus)
- 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



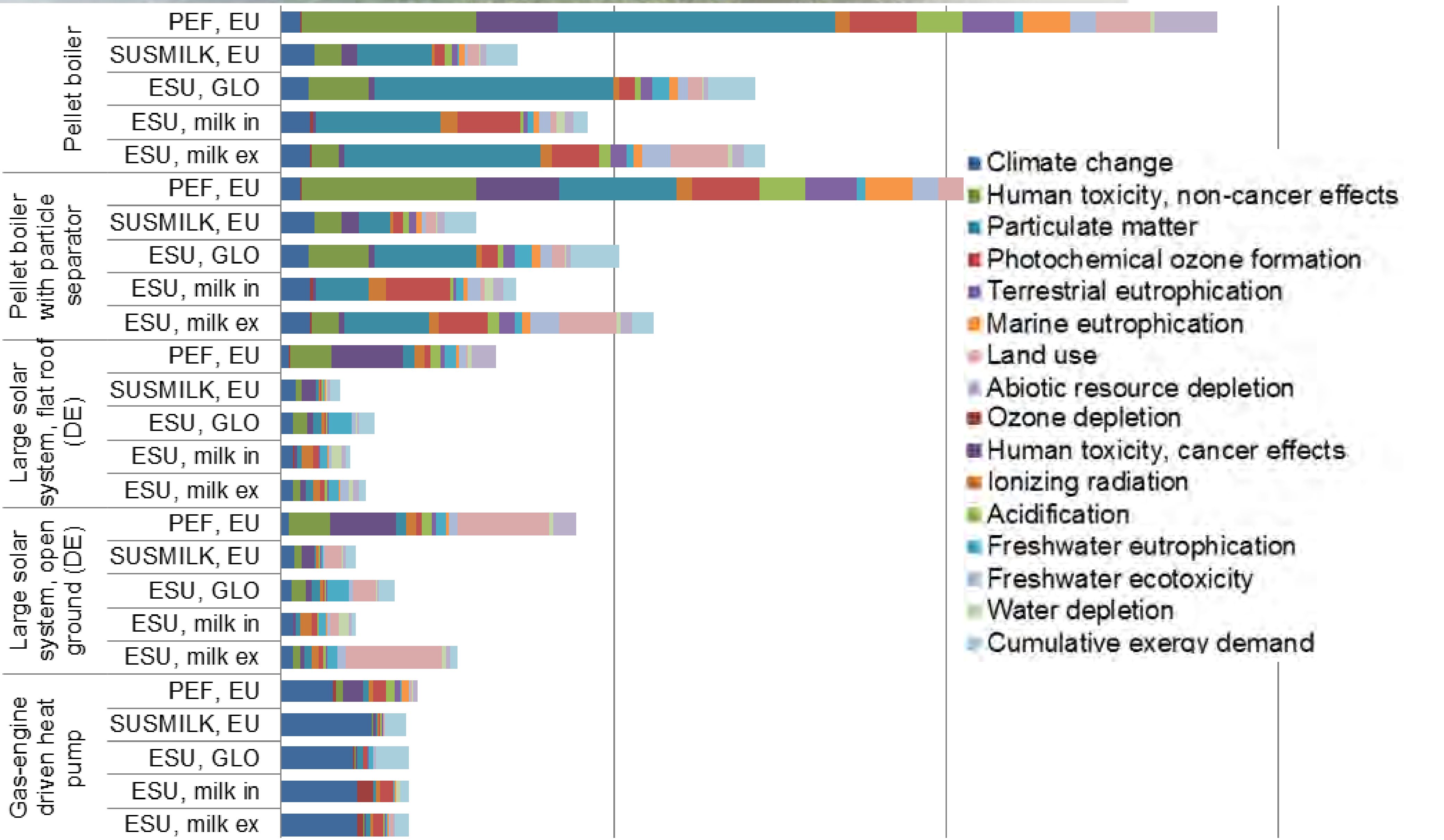
- Outcome of comparison changes with weighting/normalisation applied
- Decisive for interpretation of wood energy

Provision of heat: Single Score



- 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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