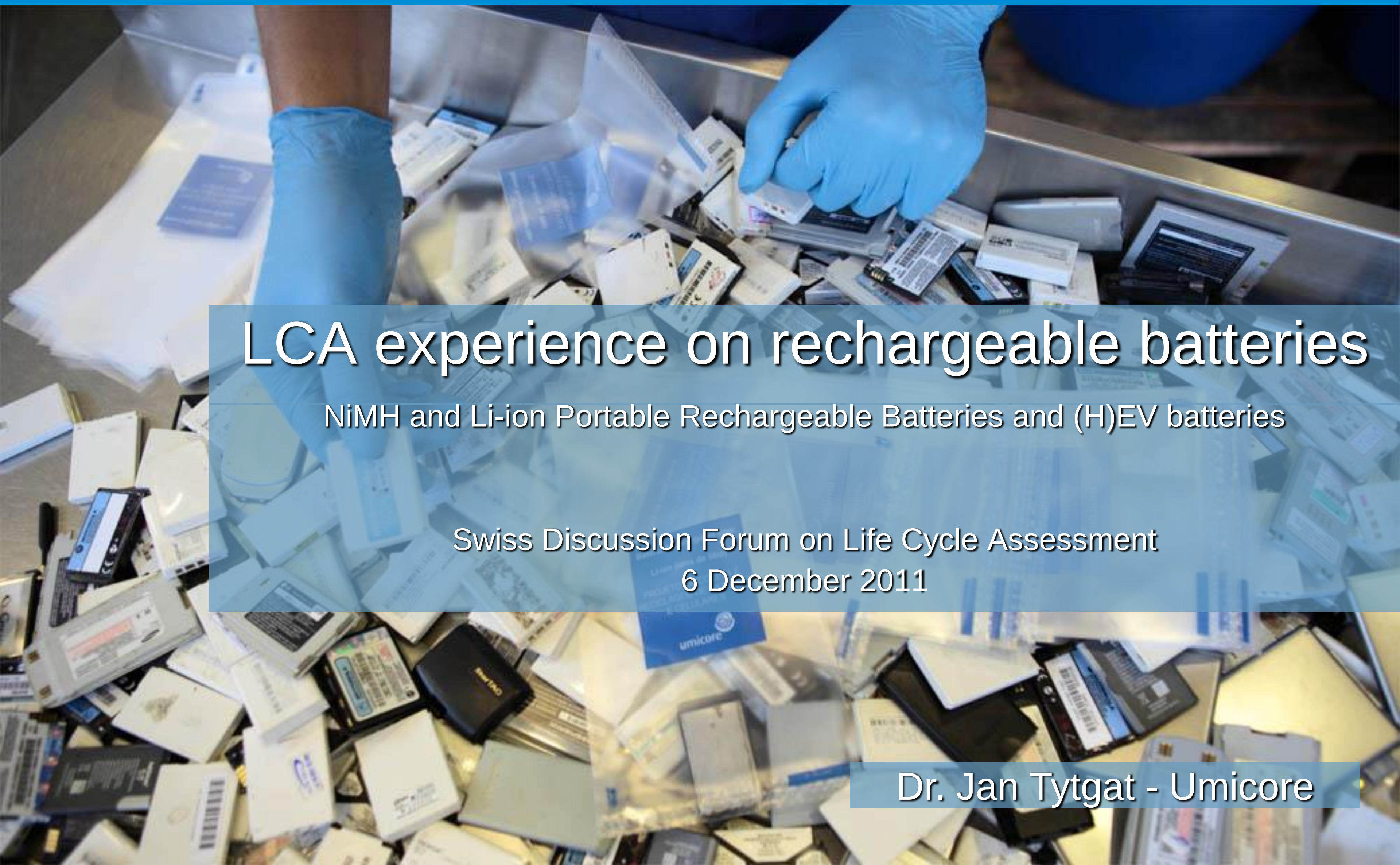


LCA experience on rechargeable batteries

NiMH and Li-ion Portable Rechargeable Batteries and (H)EV batteries

Swiss Discussion Forum on Life Cycle Assessment
6 December 2011

Dr. Jan Tytgat - Umicore

Introduction

Umicore Battery Recycling is a business unit of Umicore.

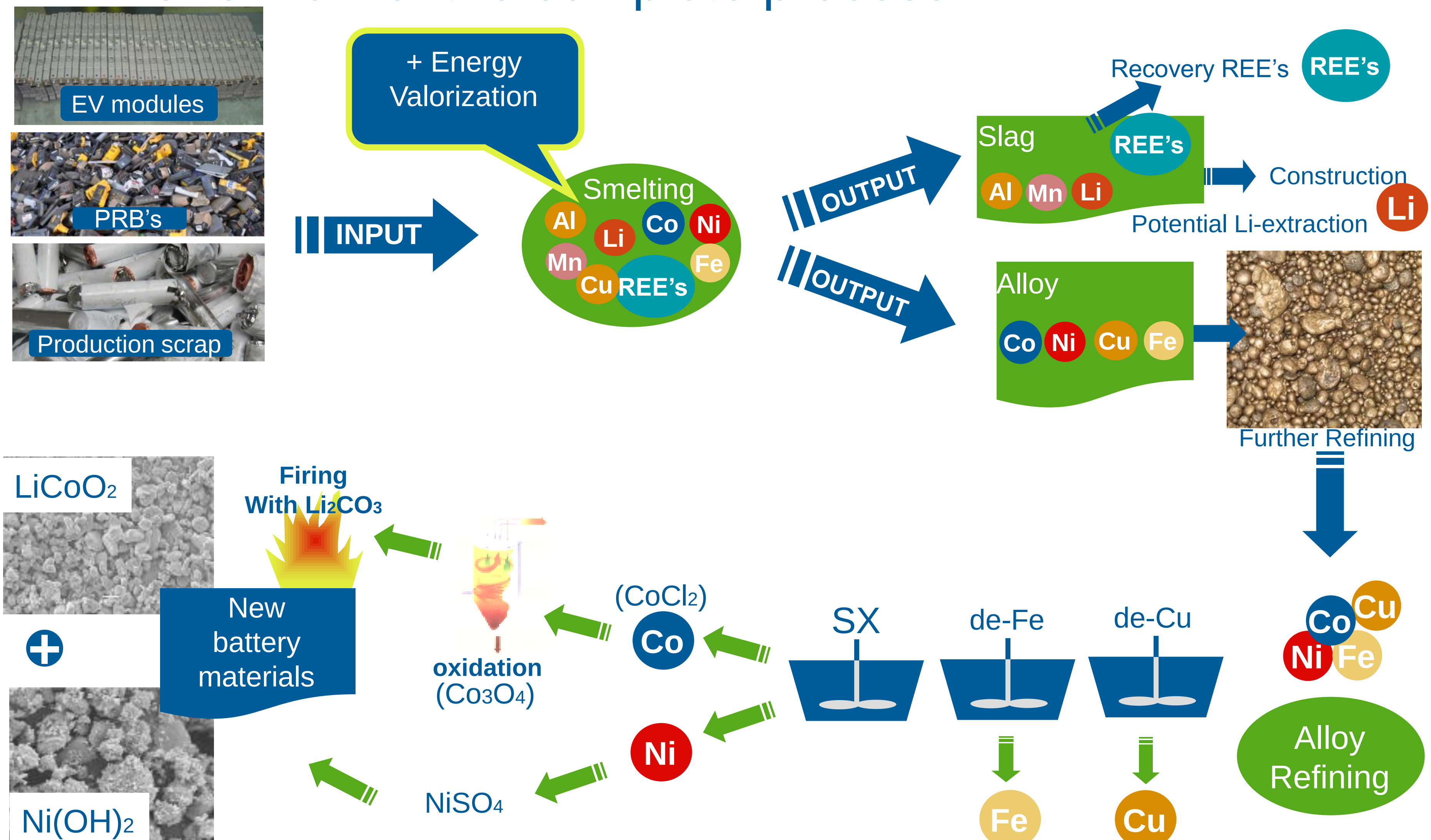
On request of several customers, we have commissioned, or participated to several LCA's studies.
Within Umicore Group R&D, Umicore is developing LCA competence.
UBR was the first business unit to commission an LCA from Group R&D

UBR is not an 'LCA specialist', but an active contributor. From this perspective, we want to report some **experiences** with LCA.
LCA **results** can be provided if interested in.

Content

- process description
- LCA overview
- Lessons learned
- conclusions

Overview of the complete process



Simplified LCA by SAFT

Goal & scope and selected impact categories:

to compare impact of recycling on CO_2 production and energy consumption for the production of a Saft MP 176065 Integrat*ion*® cell

- **Production of LiCoO2 material :**
  - **Option 1 : from Ni, Co ores extracted from mines**
  - **Option 2 : from Ni, Co recycled from Li-ion batteries**

Functional unit: production of 1 of these cells

Data collection:

- **Option 1: Based on published data: www.informine.com; www.oee.nrcan.gc.ca and www.nickelinstitute.org**
- **Option 2: based on Umicore information**

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Battery Recycling

LCA on Prius NiMH battery by Oeko institute

Goal & scope: The general objectives of the LCA study are:

- To investigate the impact of nickel in rechargeable batteries,
- To identify the key environmental parameters influenced by the production, the use and the end of life;
- To identify areas for possible improvements
- To compare the net impact of driving a Prius vs. a conventional car.

Selected impact categories:

- Global Warming Potential
- Acidification Potential (air, water, soil)
- Eutrophication Potential
- Photochemical Ozone Creation Potential
- Use of non-renewable energy carriers
- Ozone depletion potential
- Depletion of mineral resources

Functional unit: production of 1 Prius pack + 150000 km use phase

Review: EMPA, Switzerland

LCA on mixed oxide Li-ion battery (Ghent University)

Goal & scope:

What resources can be saved through recycling Li-ion batteries?

- Scenario A: cathode production from recycled Co, Ni (Mn into slag)
- Scenario B: cathode production from primary (ores) Co, Ni

Impact category:

natural resource consumption

Data acquisition:

- Umicore for cathode production and recycling
- Eramet, Xstrata
- Eco-invent

Functional unit: production of 1 kg of active cathode material (MNC-type)

Calculation method

In order to aggregate use of energy and materials in one figure, a unique quantifier is used: exergy; it is expressed in Joule

Review: EMPA, Switzerland

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Battery Recycling

LCA Ford battery pack

Goal & scope: The general objective of the LCA study is:

- to assess the environmental impact of recycling a full Li-ion battery pack, to include the results in an overall environmental impact study of FORD EV’s

Functional unit: recycling of a full Li-ion battery pack with UBR-UHT technology

Selected impact categories:

- Global Warming Potential
- Acidification Potential (air, water, soil)
- Eutrophication Potential
- Photochemical Ozone Creation Potential
- Primary Energy Demand (non)-renewable
- Abiotic Depletion potential

Review: Oeko, Germany

Lessons learned (1)

- Scope definition and allocation of burden en credits

Theory: define scope in such a way that allocation is not necessary

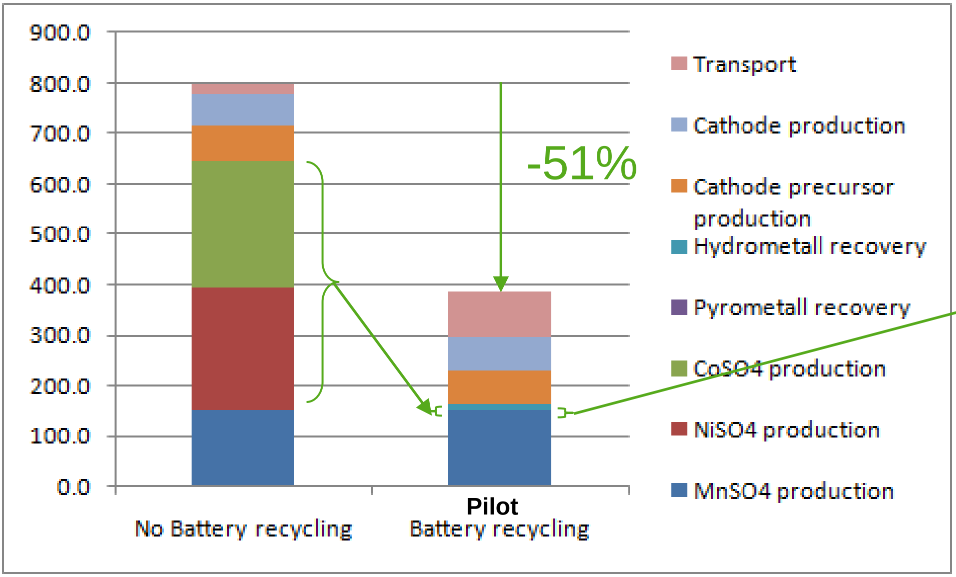
Practice: system boundaries are always a discussion item

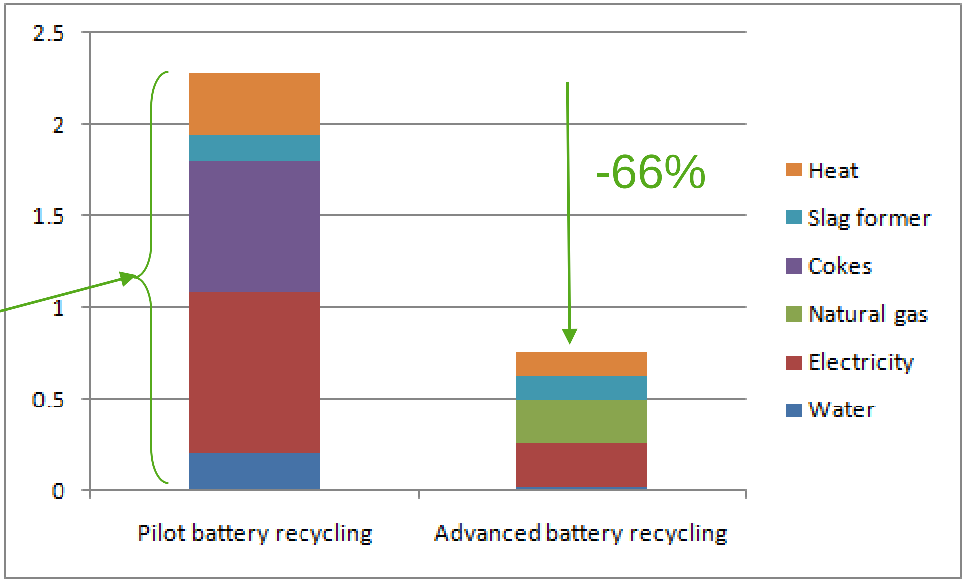
Example NMC versus FORD case

- NMC case: use of slag was not in scope ➔ no process ‘burden’ to slag, no credits for Al, Li, Mn in slag ⟵➔ FORD case: use of slag is in scope: not important whether some burden is allocated to slag or not.
- broader scope ➔ more LCI ➔ less focus on target ‘(see next slide)

Lessons learned (2)

- Scope definition and dilution effect
  - Recycling has a huge impact on NMC production
  - Process improvement from ‘pilot’ to advanced is significant on recycling level, but negligible on NMC production level





Lessons learned (3)

- Collection of data

1) Availability of data
   - $LiNO_3$: no dataset available, Li_2CO_3 used as proxy
   - Cu residue: no dataset available, ‘copper concentrate at beneficiation’ used as proxy and Cu concentration taken into account

2) Reliability of datasets
   - Co: calculation of the credits for the recovered Co
     - Option 1: Ecoinvent dataset “GLO: cobalt, at plant”
     - Option 2: PE International “GLO: cobalt mix”

⇒Large discrepancies in GWP (especially)

⇒Comparison with Ni GWP: GWP(Co)>> or<< GWP (Ni): none of the option “satisfying”

⇒We will inform the Cobalt Development Institute about the issue

Lessons learned (4)

3) Collection of industrial data:

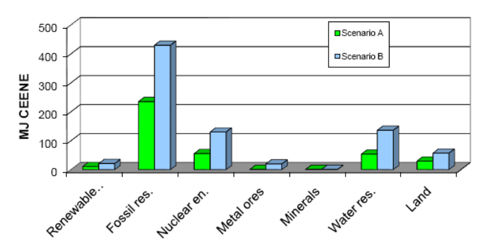
- Confidentiality of data:
  - e.g. technical yields are hard to obtain because of commercial reasons.
- Interpretation of questions:
  - e.g. ‘installed power’ versus ‘real energy consumption’
- Not always a considered as a top priority!
  - Many people involved; LCA-project leader needs the authority to motivate colleagues and external partners to deliver their contribution in a tight timeline

Lessons learned (5)

- Presentation of the results to non experts:
  - Impact categories: characterization factors and category indicator not always “intuitive”
    - E.g.

      Global Warming Potential: OK

      Human Toxicity Potential: difficult
  - Exergetic LCA: concept ‘exergy’ difficult to explain
  - Non aggregated results: difficult to select best alternative based on LCA

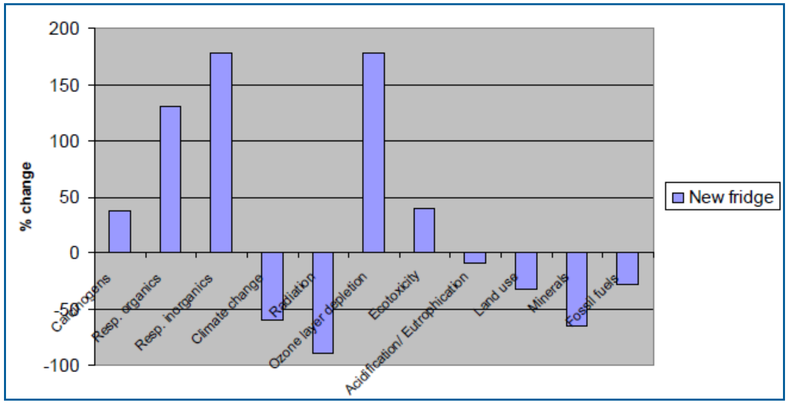


Relative numbers: largest savings: Metal ores: 95%

Absolute numbers: largest savings due to reduction of energy requirements:

Fossils: 195 MJ (45% reduction)

Nuclear : 74 MJ (57% reduction)



Source: LCA training package (Cascade)

Lessons learned (6)

- Selection of impact categories

1) GWP is ‘fashion’ ➔ focus for some organizations

Suppose:

- Process A: shredding batteries ➔ fraction separation ➔ plastic fraction is land filled
- Process B: shredding batteries ➔ fraction separation ➔ plastic fraction is burnt with energy recovery

➔ GWP B > A; conclusion: A is better!

2) Biodiversity: not yet included in our LCA’s, but seems to be interesting for a metals recycling company!

Conclusions

Umicore UBR wants to use LCA for process assessment next to traditional evaluation of technological performance

- Advantages:
  - Motivation to do better
  - Service to customers
- Difficulties
  - System boundaries and selection of impact categories are crucial but not value-free
  - Slow and expensive tool (especially in HR)
  - Hard to compare, especially with third parties

➔ **A useful tool, with limitations: intellectual effort of reader required!**

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