Introduction to Life Cycle Assessment

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About myself:

Professor of organic chemistry

Research on biomass conversion to biofuels and biobased chemicals, and petroleum chemistry

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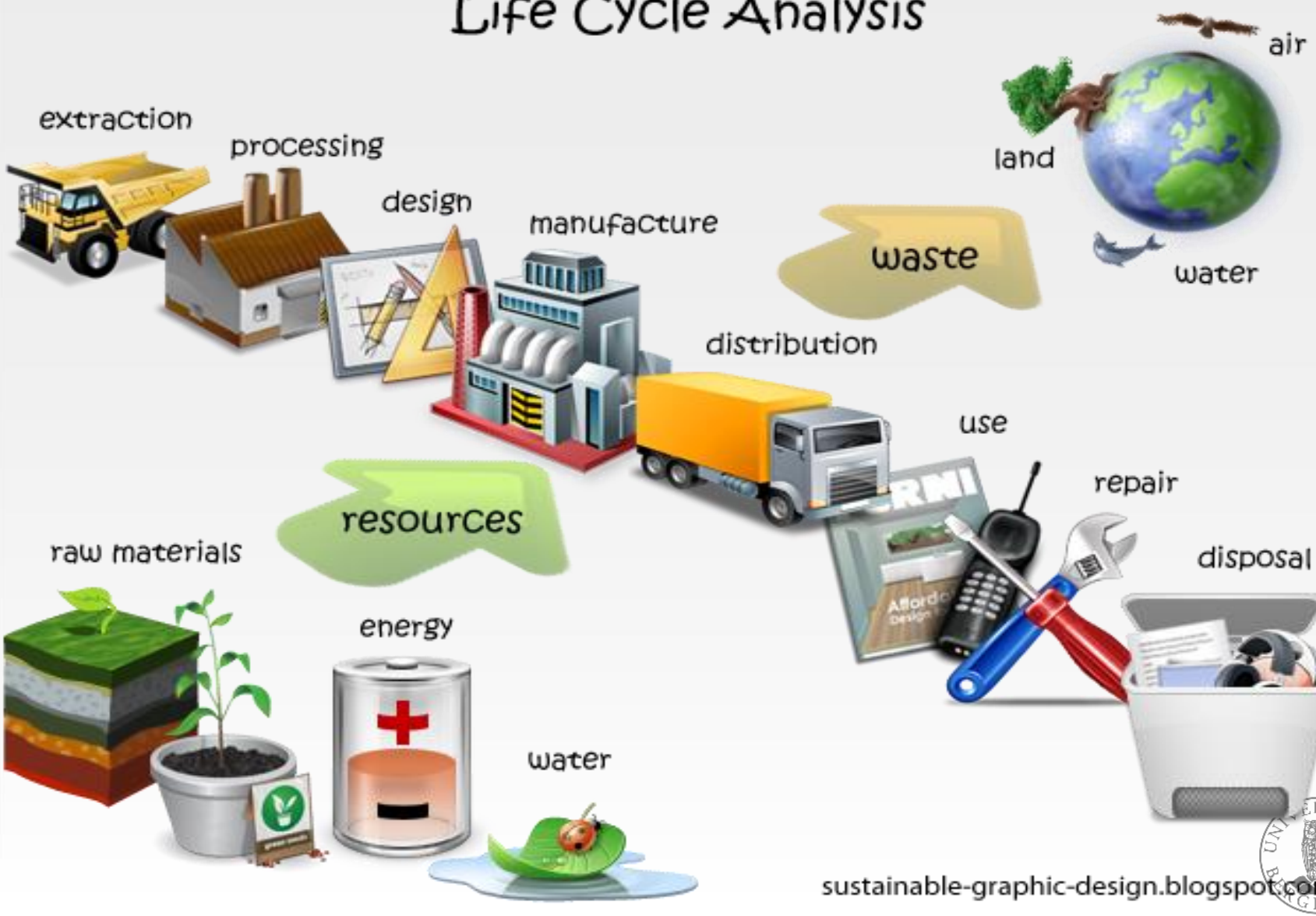
We use input from LCA to evaluate feedstocks and products in our research

LCA is complicated, and the results depend on how you do it !

Life Cycle Analysis



sustainable-graphic-design.blogspot.com

LCA can assist in
— identifying opportunities to improve the environmental performance of products at various points in their life cycle,
— informing decision-makers in industry, government or non-government organizations (e.g. for the purpose of strategic planning, priority setting, product or process design or redesign),
— the selection of relevant indicators of environmental performance, including measurement techniques, and
— marketing (e.g. implementing an ecolabelling scheme, making an environmental claim, or producing an environmental product declaration).

T**here are four phases in an LCA study:**
a) the goal and scope definition phase,
b) the inventory analysis phase,
c) the impact assessment phase, and
d) the interpretation phase

https://www.iso.org/obp/ui/#iso:std:iso:14040:ed-2:v1:en

4 steps in LCA

Goal and scope

- Goal
- System boundaries
- Functional unit

Inventory (LCI phase)

Impact assessment

Interpretation

Courtesy of Femke Brouwer
Avans university, NL
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Goal and scope

- Goal → defines next choices
- Boundaries
  - Which processes do you take into account
  - How much in depth
- Functional unit → impacts per what?
- Assumptions and methods
  - Uncertainties?

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Phases of LCA

Goal and scope

- Goal
- System boundaries
- Functional unit

Inventory (LCI phase)

- Data gathering (in- and outputs)
- Description of unit processes
- Allocation

Impact assessment

Interpretation

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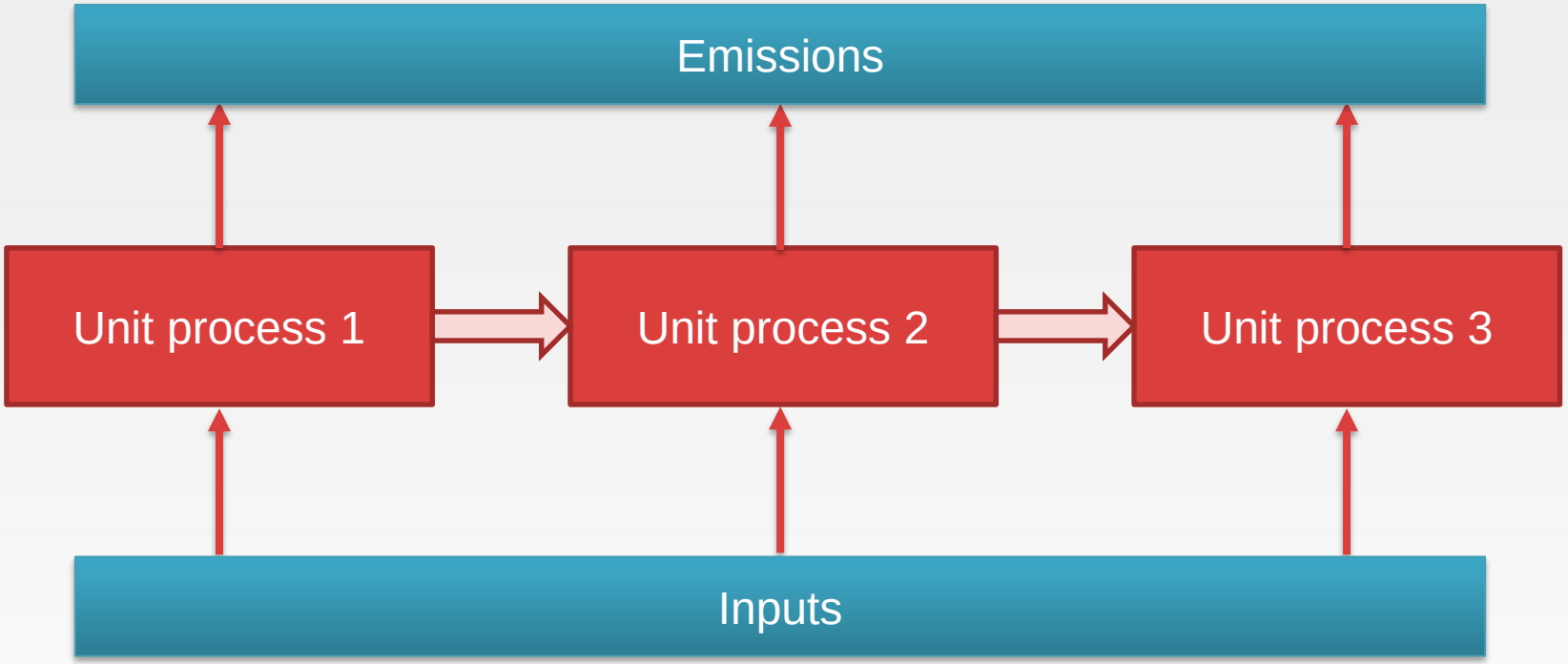
Inventory phase: Data gathering and evaluation



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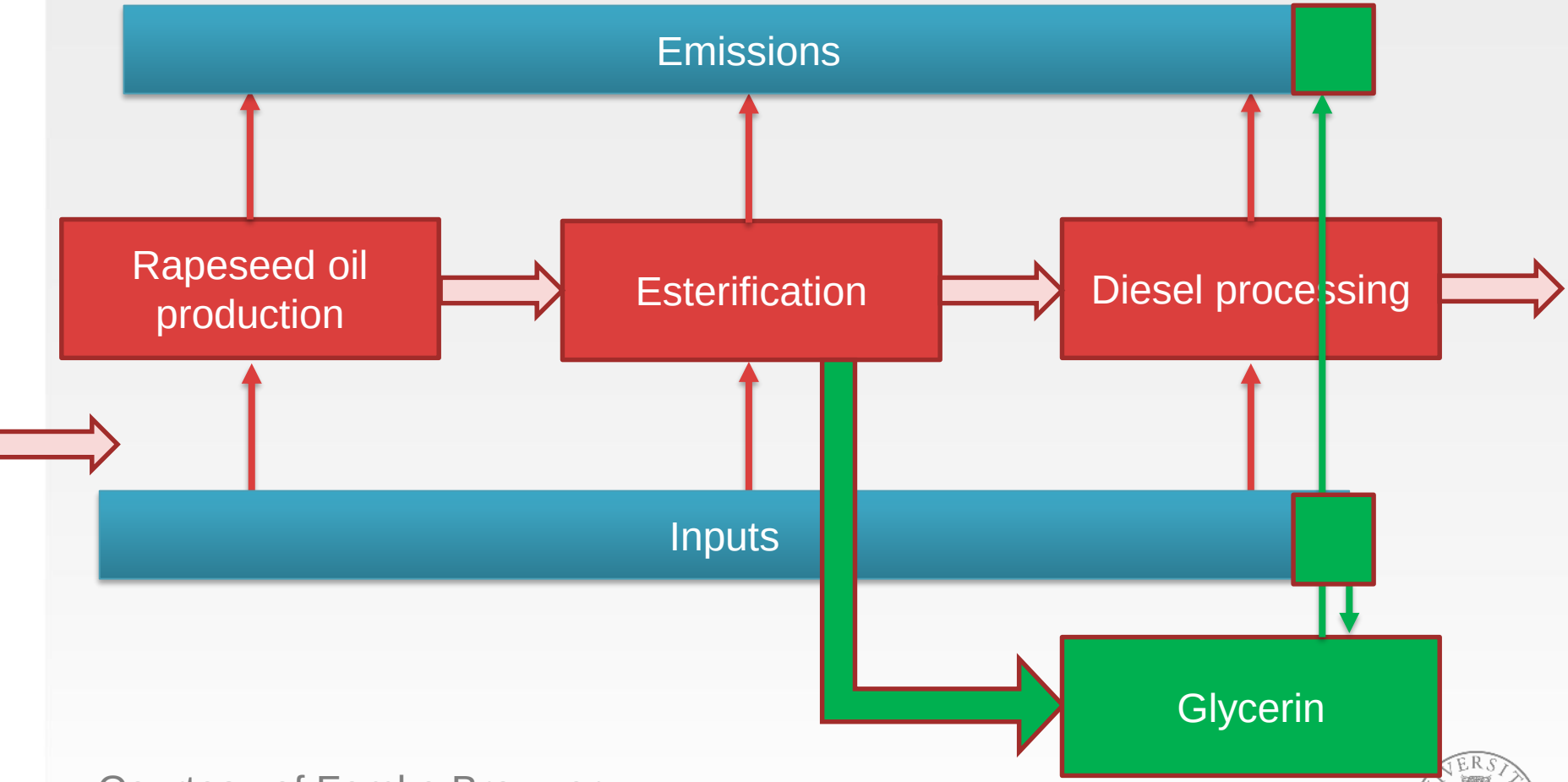
Inventory phase: Allocation



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Phases of LCA

Goal and scope

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Impact assessment

- Classification
- Characterization
- (Normalization)
- (Weighting)

Interpretation

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Impact assessment

- **Translation of emissions to impacts**
  - Classification: Connecting inputs to environmental impacts
    - For example CFC's → Global warming, Ozone depletion
  - Characterization: Quantification of impact using characterization models
    - Translation of kg CH_4 to kg CO_2-eq using the GWP100 indicators
- **Normalization**
  - Making all values relative to a reference value
    - Reference scenario
    - Regional value
  - Values from different environmental impacts become comparable
- **Weighting**
  - Define which impacts are important and which are less relevant

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Phases of LCA

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Impact assessment

- Classification
- Characterization
- (Normalization)
- (Weighting)

Interpretation

- Identification of significant issues
- Evaluation of results (related to data and methods)

Interpretation

- Critical evaluation of significant issues
  - Methods
  - Data
  - Assumptions

- Putting conclusions and advice in context

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Example:

European Energy agency report on electric cars:

EEA report confirms: electric cars are better for climate and air quality

https://www.eea.europa.eu/highlights/eea-report-confirms-electric-cars

The full report:

Electric vehicles from life cycle and circular economy perspectives

TERM 2018: Transport and Environment Reporting Mechanism (TERM) report

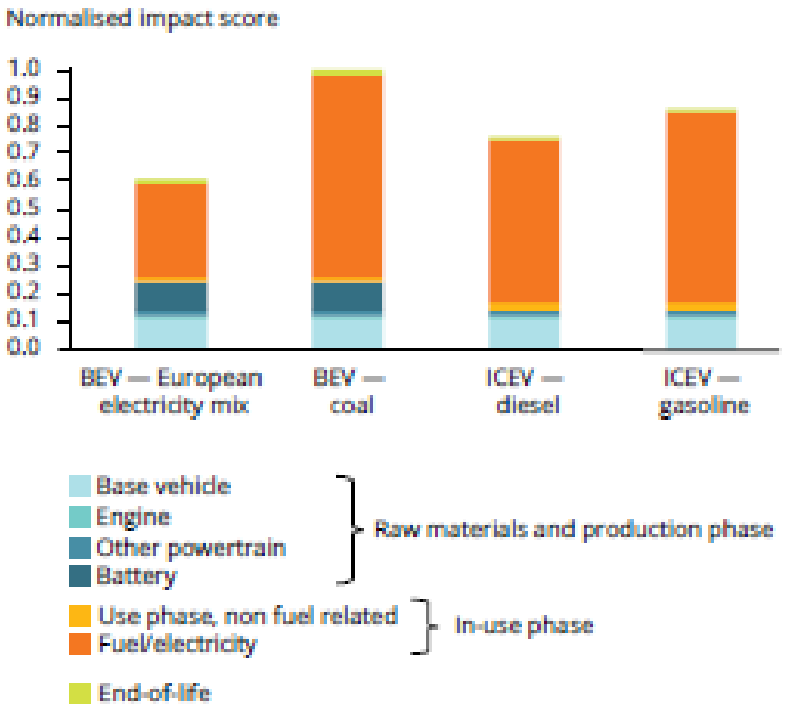
https://www.eea.europa.eu//publications/the-first-and-last-mile

EEA report confirms: electric cars are better for climate and air quality
https://www.eea.europa.eu/highlights/eea-report-confirms-electric-cars

The report confirms that the **greenhouse gas emissions of electric vehicles,** with the current EU energy mix and over the entire vehicle life cycle, are about **17-30 % lower than the emissions of petrol and diesel cars**. However, as the carbon intensity of the EU energy mix is projected to decrease, the life-cycle emissions of a typical electric vehicle could be cut by at least 73 % by 2050.
For **local air quality**, electric vehicles also offer clear benefits, mainly due to zero exhaust emissions at street level. However, even **electric vehicles emit particulate matter** from road, tyre and break wear, the report reminds. Shifting to electric vehicles could also reduce **noise pollution**, especially in cities where speeds are generally low and traffic often stands still.
The result of the comparison is **less favourable for electric cars** when looking at the current impacts of their production on **ecosystems** and the **toxicity** of the materials involved. These impacts are mostly due to the **extraction and processing of copper, nickel and critical raw materials**.
The report suggests that these impacts could be minimised through a circular economy approach that facilitates **reuse and recycling** — especially of batteries.

From the EEA report summary: On average there is a CO_2 emission benefit (BEV- Battery Electric Vehicle, ICEV: Internal Combustion Engine Vehicles)

Figure 6.1 Climate change impacts: example comparison of BEVs with ICEVs



Note: See footnote 8 for a description of the study system.

Source: Hawkins et al., 2013.

- But some other environmental aspects are more negative than for IC motors….

Figure 6.2 Human toxicity impacts: example comparison of BEVs with ICEVs

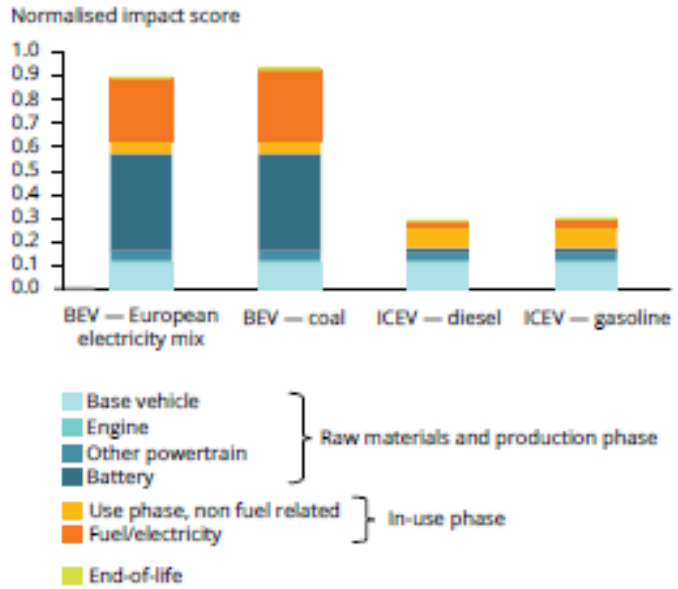
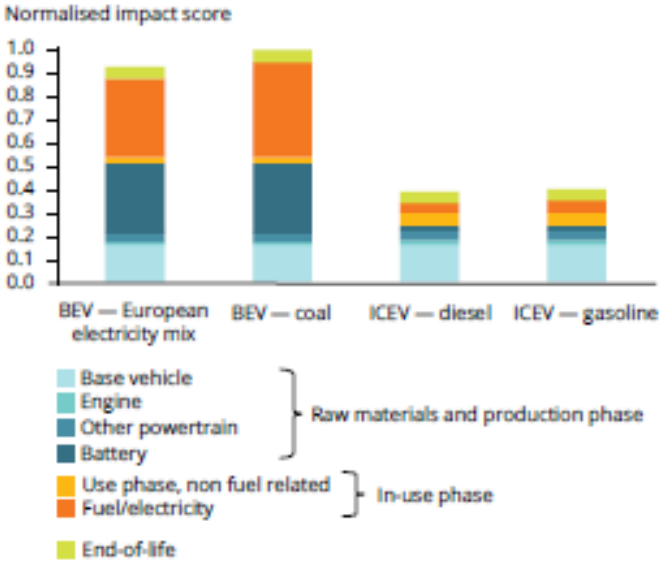


Figure 6.3 Freshwater ecotoxicity impacts: example comparison of BEVs with ICEVs



LCA is very useful for trying to understand sustainability in a wide perspective, but requires a rational and balanced scientific approach to definitions and evaluations!

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