Session 4: GLOBAL WARMING, ENERGY AND THE CIRCULAR ECONOMY
Industrial Ecology:
Science, the Environment and the Circular Economy, April, 25th, 2016

Prof. Dr.-Ing. Christoph Herrmann
Institute of Machine Tools and Production Technology
Chair of Sustainable Manufacturing and Life Cycle Engineering

Agenda

1. As-Is Situation - Using Automotive Industry as Case Study
2. Existing Trade-offs and Methods/Tools to support Decision Making
3. Transition towards Electric Vehicle
4. Future Trade-offs and Methods/Tools to support Decision Making
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As-Is Situation - Using Automotive Industry as Case | Focus: Reduction of GHG during the use phase

I = Environmental Impact (e.g. kg CO₂-eq)

Production

Use phase

End-of-Life (EoL)

0 km x = distance [km]

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Existing Trade-offs and Methods/Tools supporting Decision Making

Mitigation options to reduce GHG during use phase:
- Lightweight Design
- Improve efficiency of ICE
- Alternative powertrains
- ...

I = Environmental Impact
I_{ice} = \text{Environmental Impact of ICE}

\begin{align*}
   & 0 \text{ km} \quad x = \text{distance [km]} \\
\end{align*}

Production \quad Use phase \quad End-of-Life (EoL)
Existing Trade-offs and Methods/Tools supporting Decision Making

Mitigation options to reduce GHG during use phase:
- Lightweight Design
- Improve efficiency of ICE
- Alternative powertrains
- ...

Higher GHG emissions in raw material extraction and production phase

Use phase

Production

End-of-Life (EoL)

Compiled from [Das 2000], [Das 2011], [Duflou 2012], [enW 2012], [Ehrenberger 2013], and [Volkswagen 2015]

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Existing Trade-offs and Methods/Tools supporting Decision Making

Lower GHG emissions in use phase

Trade-off 1

Higher GHG emissions in raw material extraction and production phase

Production

Use phase

End-of-Life (EoL)

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Existing Trade-offs and Methods/Tools supporting Decision Making

- Vehicle design
- Lightweight Materials
- Environmental Impact
- Carbon emissions
  - Use Phase
- Delay
- Waste
- Recycling Efficiency

**Trade-off 1**
- Higher recycling efforts
- Lower recycling rates
- Downcycling

**Trade-off 2**

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Source: [Soo et al. 2015]

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Existing Trade-offs and Methods/Tools supporting Decision Making

Input Parameters
- e.g. RRR Directive
- e.g. ELV Directive
- Product Strategy
- New Technologies

Information flow – Methods & Tools
- Planning
  - Life Cycle Assessment (LCA)
- Conceptualization
  - Design for Environment (DfE)
- Draft
  - Design for Disassembly (DfD)
- Prototype
  - Design for Recycling (DfR)

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Future Trade-offs and Methods/Tools to support Decision Making

Use phase

0 km

x = distance [km]

Trade-off 1

Electric Car Manufacturing

Battery Production

Battery Cell Production

Trade-off 2

Trade-off 1

Impact from use phase strongly depends on local electricity mix

Use of Low carbon electricity mix

- Impact from use phase

End-of-Life (EoL)

Production

Use phase

End-of-Life (EoL)

Use phase

Trade-off 2

- New disassembly and Recycling processes are required

- Downcycling?

New Complex Components (e.g. Battery System)

Carbon emissions

Use Phase

Recycling Efficiency

Waste

Electric Vehicle design

Environmental Impact

Delay
Future Trade-offs and Methods/Tools to support Decision Making | Closing the loop

battery management system

re-use stationary

condition valuation

disassembly of cell

material processing

disassembly of battery system

condition valuation

recycling products

cell

battery system

usage mobile

components

material processing

Source: www.lithorec.de, www.lithorec2.de, see also: [Buchert et al. 2015]

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Future Trade-offs and Methods/Tools to support Decision Making

Input Parameters

- e.g. RRR Directive
- e.g. ELV Directive
- Product Strategy
- New Technologies

Information flow – Methods & Tools

- Planning
- Conceptualization
- Draft
- Prototype

- Procurement
- Production
- Use & Service
- End-of-Life

e.g. Example of methods

e.g. Example of tools

Source: www.lithorec.de, www.lithorec2.de, see also: [Buchert et al. 2015]
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