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A procedure for Prospective LCA in Materials Development - The Case of Carbon Fibre Composites

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Decreasing the impact of carbon fibre composites

- Carbon fibre reinforced polymers (CFRPs) consist of carbon fibres in a polymer matrix
- The material is light and strong, and can decrease e.g., fuel consumption in vehicles
- Carbon fibres are very energy intensive to produce
- How can we decrease the environmental impact of CFRPs?
 - The LIBRE project (2016-2021) aimed primarily to produce carbon fibres from lignin

How can LCA practitioners handle the lack of data in early stages of material development?

We will describe how we handled this in the LIBRE project

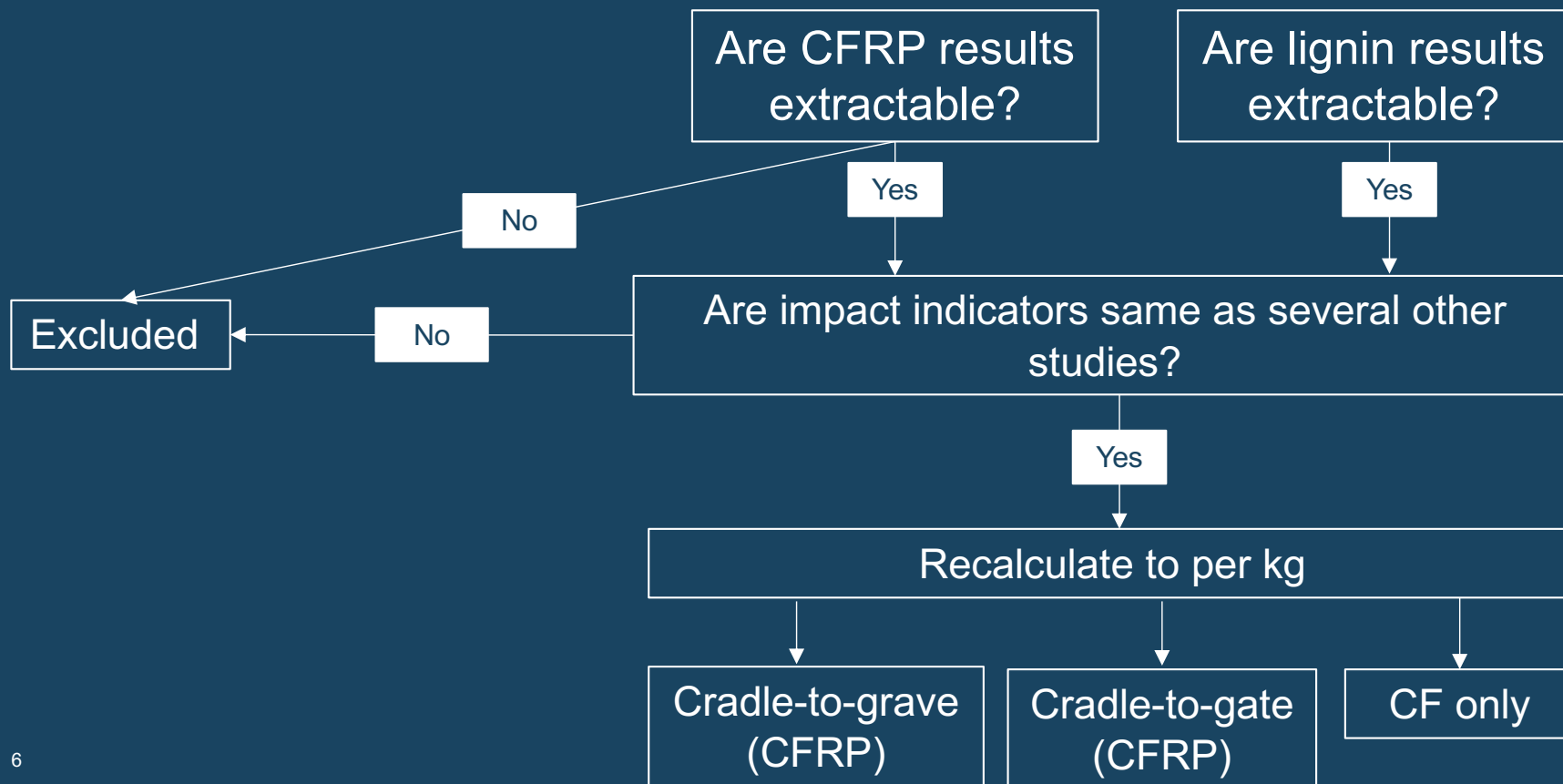
Meta-analysis of LCA studies



Meta-analysis of LCA studies

- Published in Hermansson et al. (2019)
- We wanted to :
 1. Identify hotspots in the CFRP life cycle
 2. Know the influence of transitioning to lignin as a raw material
 3. Identify other routes for decreasing the environmental impacts of CFRP
 4. Identify key methodological challenges

Meta-analysis of LCA studies



Meta-analysis of LCA studies: Results

- The use of CFRP does not automatically decrease the environmental impact of the application
- A shift to **lignin** could decrease the environmental impact of CFRP
- The **recycling** of the CFRP and recovery of carbon fibres is an important route
- Choice of allocation approach is important

Meta-analysis of LCA studies

Identify hotspots in
system

Identification of technology
development routes

Identify important allocation issues

Development and
assessment of influence
from allocation approaches
for multi-output processes



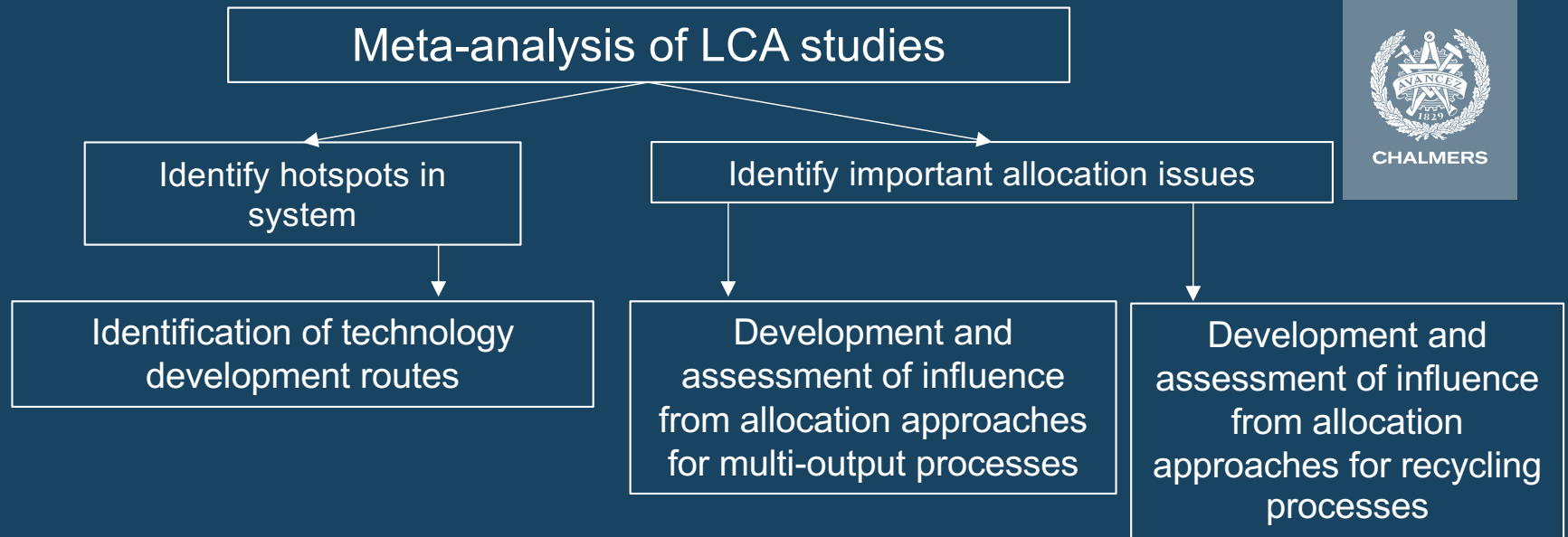
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Important allocation issues – Lignin production

- Published in Hermansson et al. (2020)
- Allocation approaches were applied to a case study of a Kraft pulp mill
- Approaches were assessed based on changes in temporal settings

Important allocation issues – Lignin production: Results

- Many allocation approaches are very sensitive to the temporal settings of the study, e.g.:
 - Economics
 - Main reason for lignin extraction

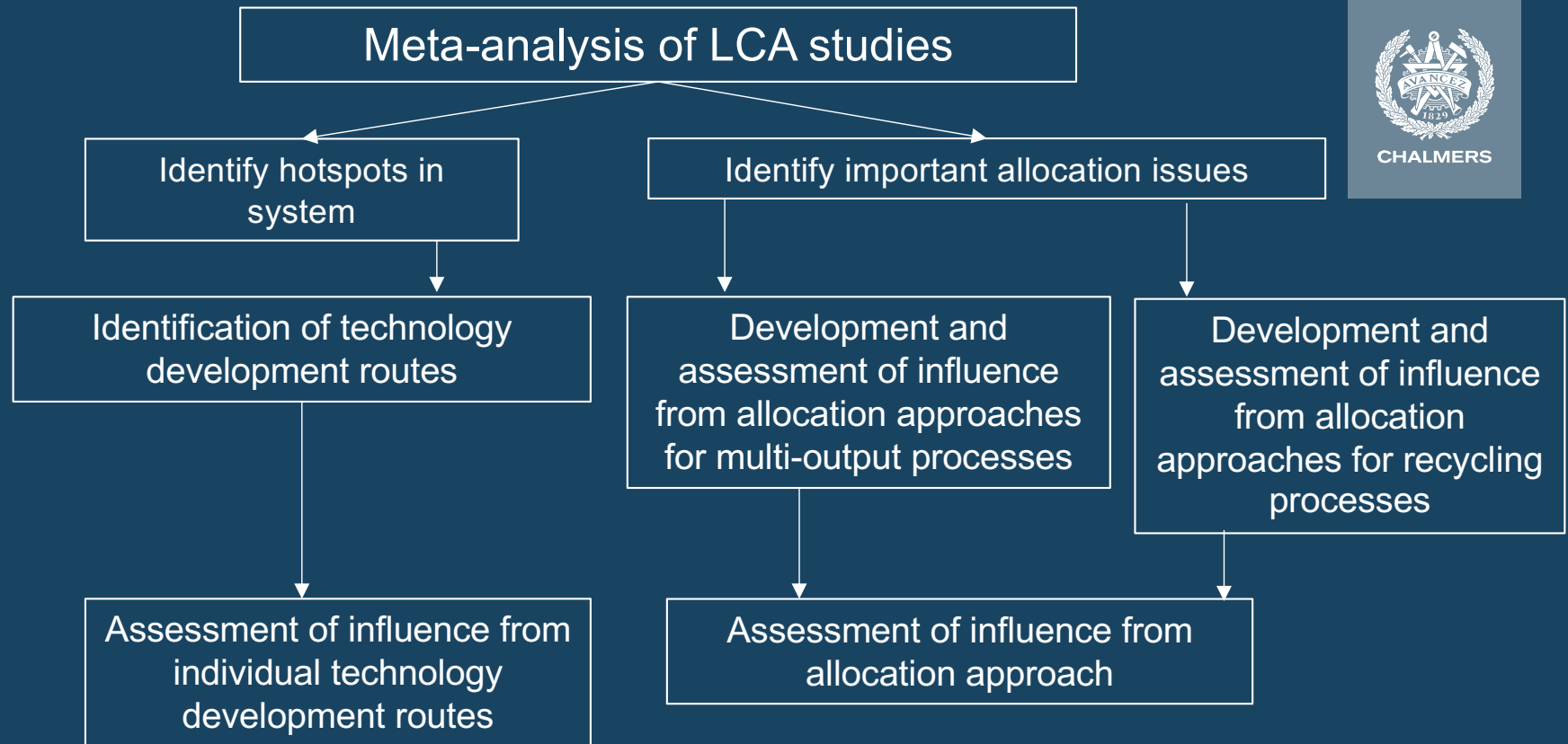


Important allocation issues - Recycling processes

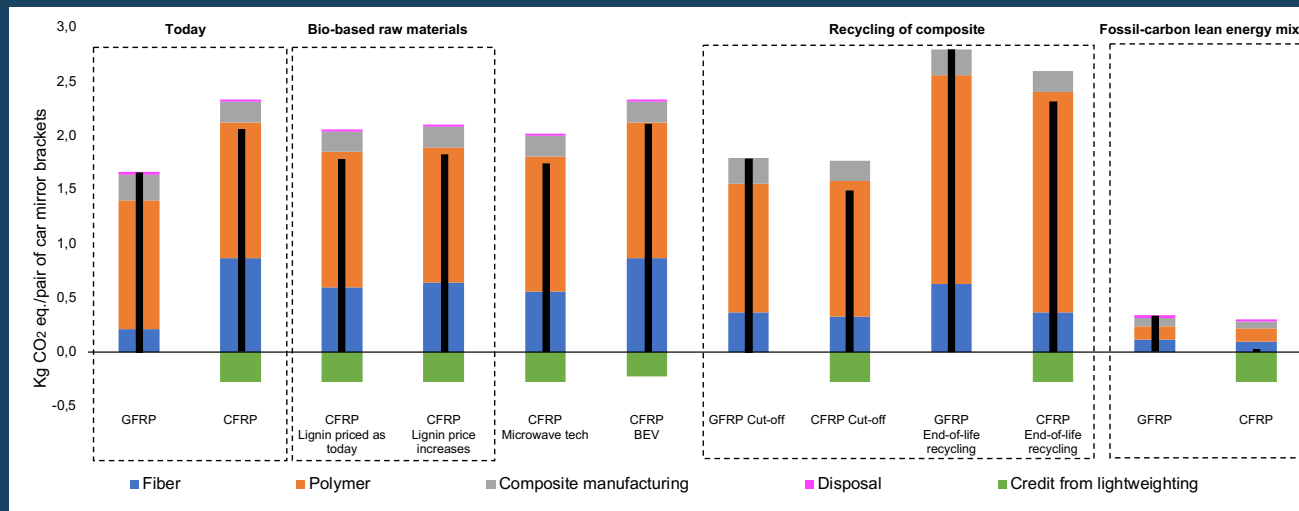
- Published in Hermansson et al. (2022 a)
- The influence of allocation approach in recycling was assessed in a case study
 - Cut-off approach
 - End-of-life recycling approach
 - Circular footprint formula (CFF)
- Allocation approaches redefined to capture different fates for polymers and fibres in composites

Important allocation issues - Recycling processes

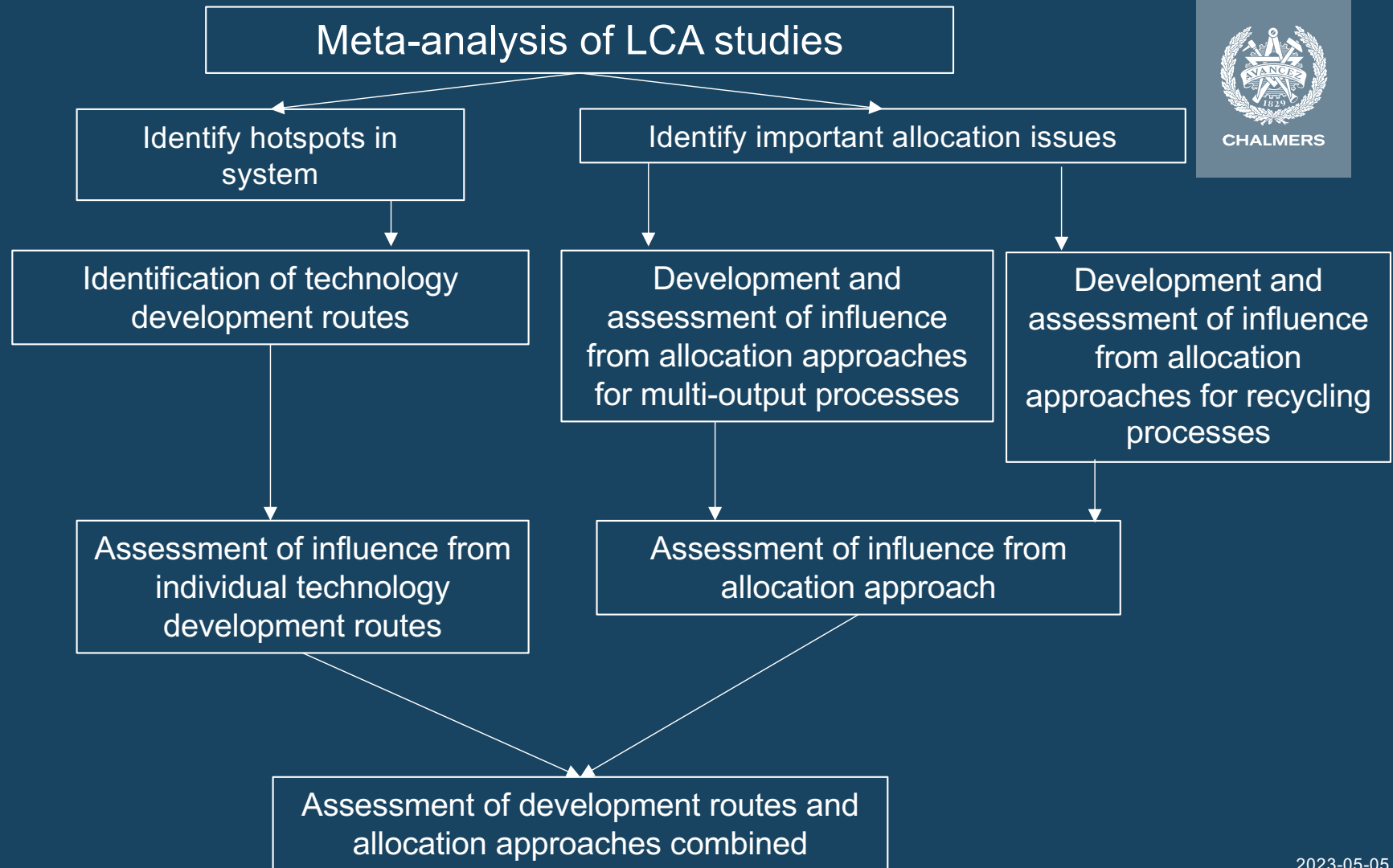
- Outcome highly dependent on the inherent incentives for recycling
 - Cut-off approach – Use recycled materials
 - End-of-life recycling approach – Provide recycled materials
 - CFF – Use and provide recycled materials, based on market supply and demand
- The CFF can be seen as a compromise between cut-off and end-of-life recycling approach



Assessment of influence from technology routes and allocation approaches



Adapted from Hermansson et al. (2022 b)

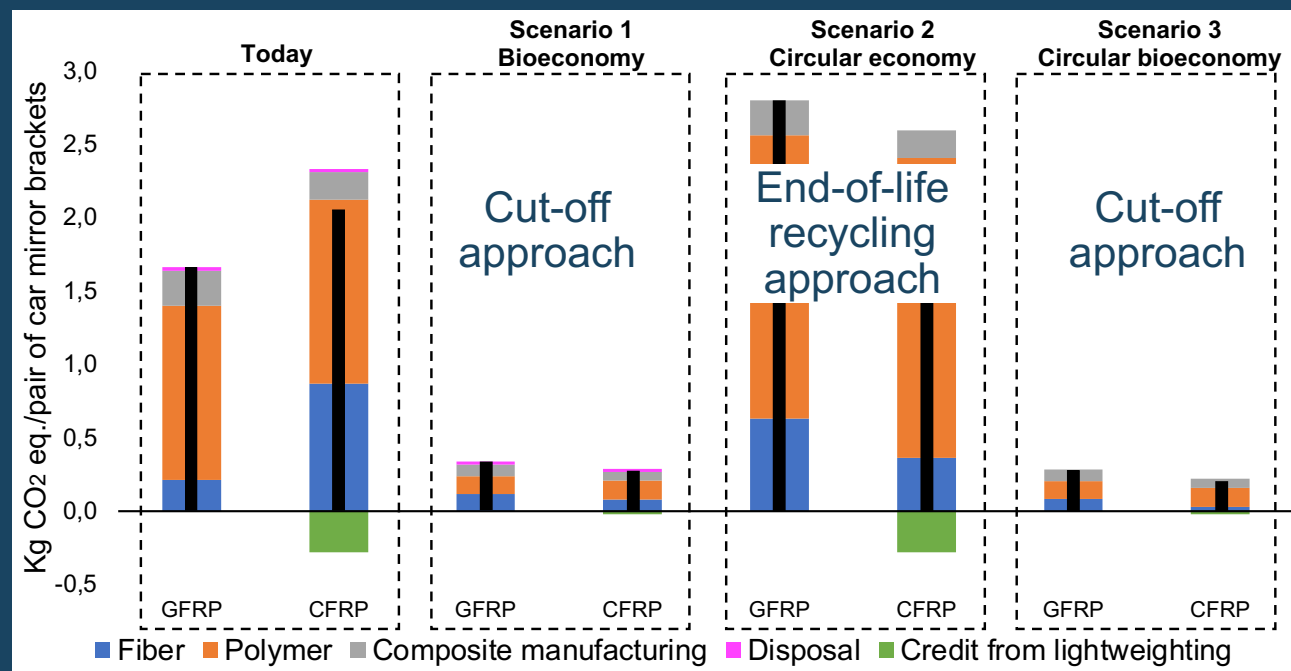


Assessment of development routes and allocation approaches combined



- It is likely that some development routes happen simultaneously
 - Technology development routes and allocation approaches were grouped into three coherent scenarios
 - Can provide guidance to technology- and policy developers

Assessment of development routes and allocation approaches combined



Adapted from Hermansson et al. (2022 b)

Meta-analysis of LCA studies

Identify hotspots in system

Identify important allocation issues

Identification of technology development routes

Development and assessment of influence from allocation approaches for multi-output processes

Development and assessment of influence from allocation approaches for recycling processes

Assessment of influence from individual technology development routes

Assessment of influence from allocation approach

Parameters with the largest influence can be identified

Assessment of development routes and allocation approaches combined

Indication of future impact of emerging technology

Identification of key parameters

Application in case study

Conclusions

- Meta-analysis proved useful to identify the most important parameters
- Allocation in multi-output processes should be handled carefully in pLCAs
- Both the cut-off approach and the end-of-life recycling approach should be used in prospective studies
 - Avoid using CFF in prospective studies

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