Lessons learned when assessing emerging composite materials using life cycle assessment

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Lessons learned when assessing emerging composite materials using life cycle assessment

- Carbon fibre composites (CFRPs) are lightweight and can reduce the energy consumption in the use-phase of vehicles
  - Energy intensive to produce
- Can we decrease the environmental impact of CFRP?
  - The LIBRE project (2016-2021) aimed to produce carbon fibres from lignin
  - We will present the work progress for assessing the environmental impact throughout the project

Project work progress

- Early project assessment
- The climate impact of lignin-based carbon fibres
- The climate impact of recycling of CFRP and recovery of fibres
- The future climate impact of CFRP

Project work progress

- **Early project assessment**
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Early project-phase assessment

- Meta-analysis of old LCA studies
  - The use of CFRP instead of conventional materials does not automatically reduce the environmental impact
  - The carbon fibre production is the main contributor to the environmental impact of CFRP
    - The environmental impact can be decreased by:
      - Using a bio-based raw material such as lignin
      - Recycling and recovery of the fibres

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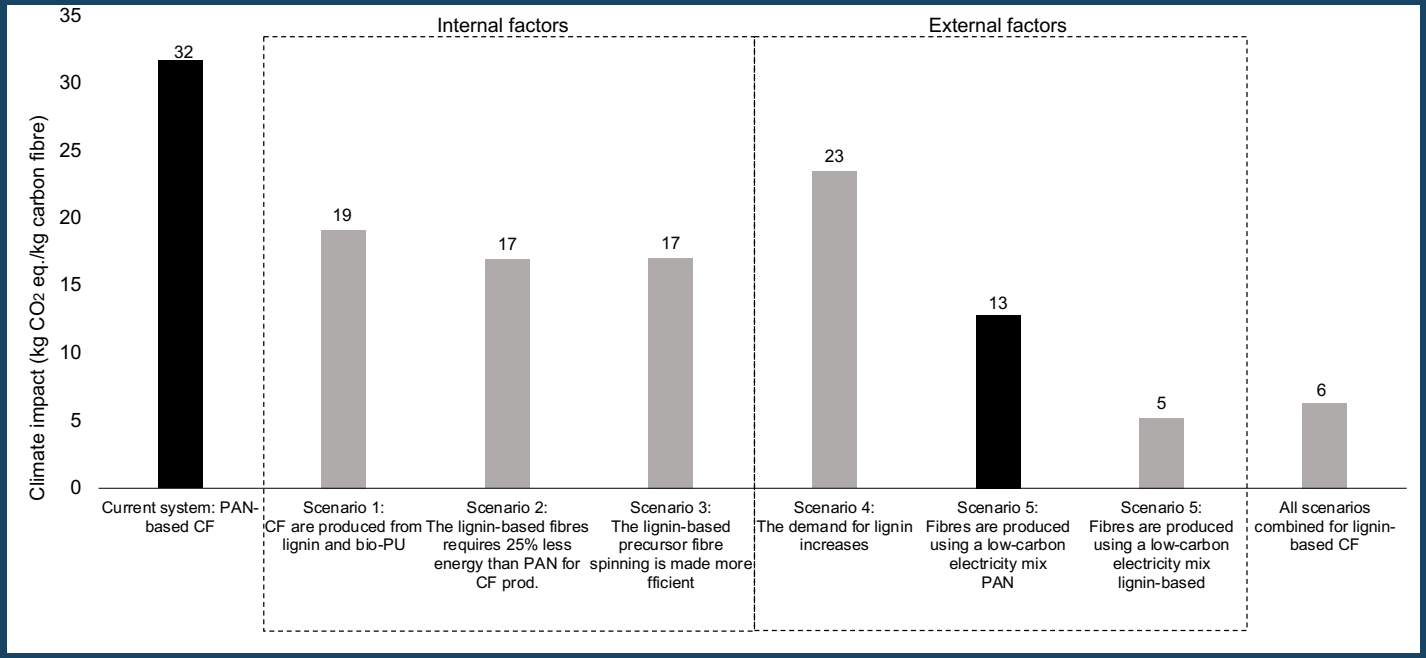
The climate impact of lignin-based carbon fibres

- Functional unit: 1 kg of carbon fibres
  - 50% Kraft-lignin and 50% bio-PU OR 100% PAN
- Production is taking place in Germany
- Economic allocation used in the kraft pulp mill
- Different development routes were assessed:
  - The lignin based carbon fibres require less energy
  - More efficient spinning of fibres
  - Price of lignin increases
  - Decarbonized energy system

The climate impact of lignin-based carbon fibres



Hermansson (2020)

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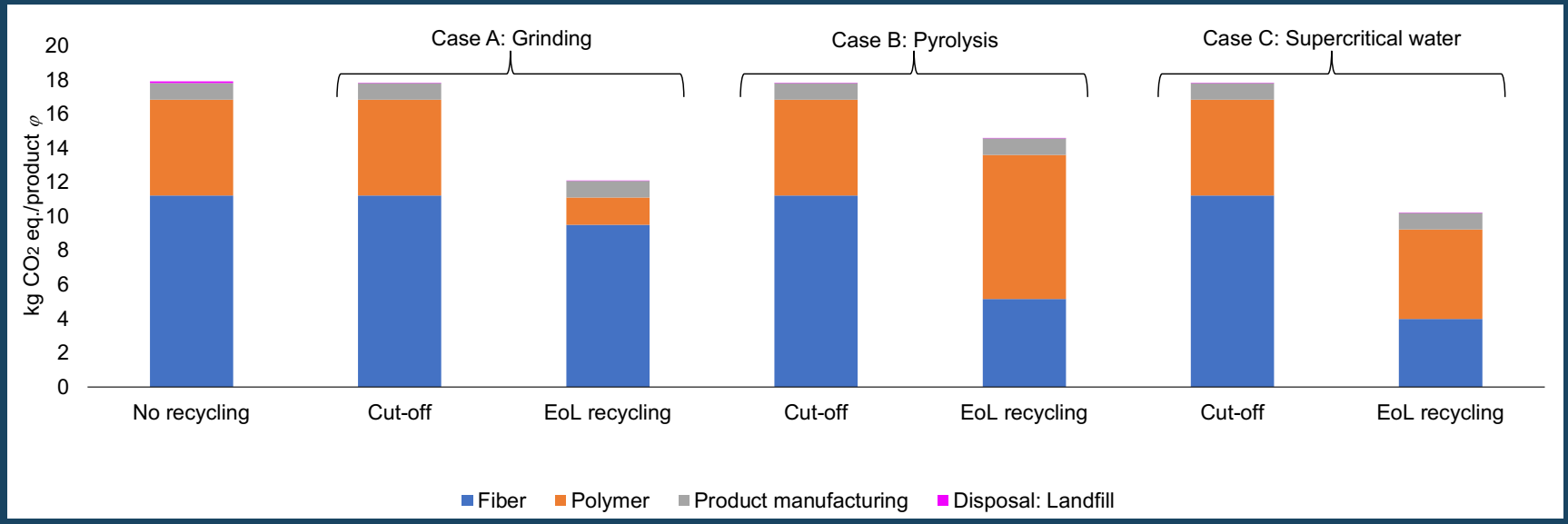
- **The** climate **impact of recycling of CFRP and recovery of fibres**
- The future climate impact of CFRP

The climate impact of recycling of CFRP and recovery of fibres

- Recycling of CFRP was assessed in three fictious recycling systems
  - Grinding
  - Pyrolysis
  - Supercritical water
- Three different allocation approaches were used
  - Cut-off apporach
  - End-of-life recycling approach
- Allocation approaches were redefined to allocate the recycling impacts between the polymer and the fibre

The climate impact of recycling of CFRP and recovery of fibres



Adapted from Hermansson et al. (2022)

Project work progress

- Early project assessment
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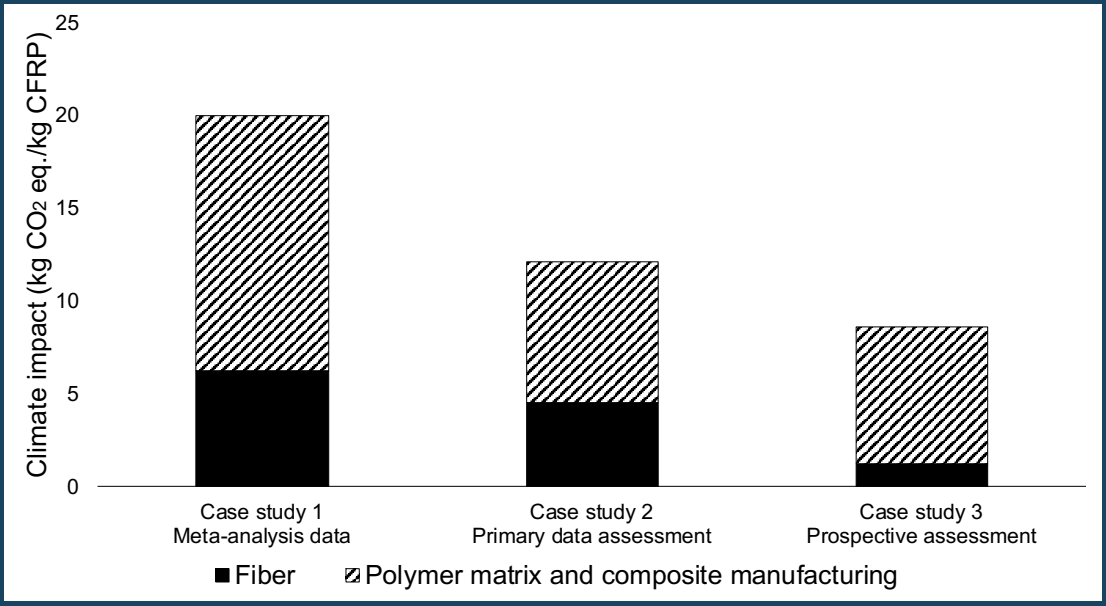
- **The future** climate **impact of CFRP**

The climate impact of CFRP

- Findings were applied in a cradle-to-gate LCA
  - Functional unit: 1 kg CFRP, 20 wt% fibres, 80 wt% polymer
- **Case study 1**
  - Results from meta analysis recalculated
- **Case study 2**
  - Primary data as much as possible
- **Case study 3**
  - Changes in foreground system:
    - Using lignin as raw material
    - Using microwave tech. In carbon fibre production phase
    - Using recycled carbon fibres

The future climate impact of CFRP



Some final comments

- The carbon fibre production is the hotspot
  - Decrease energy consumption
- All suggested routes proved fruitful for decreasing the climate impact of CFRP
  - Recycling of composites has the highest technology readiness level
    - Might be the route most likely to soon be implemented

References

- Hermansson, F. (2020). *Assessing the future environmental impact of lignin-based and recycled carbon fibres in composites using life cycle assessment.* Chalmers Tekniska Hogskola (Sweden)
- Hermansson, F., Ekvall, T., Janssen, M., & Svanström, M. (2022). Allocation in recycling of composites - the case of life cycle assessment of products from carbon fiber composites. *Int. J. Life. Cycle. Assess., 27*(3), 419-432. doi:https://doi.org/10.1007/s11367-022-02039-8

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