

Assessing efforts to reduce the environmental impacts of carbon fibre composites in vehicles

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Background/introduction

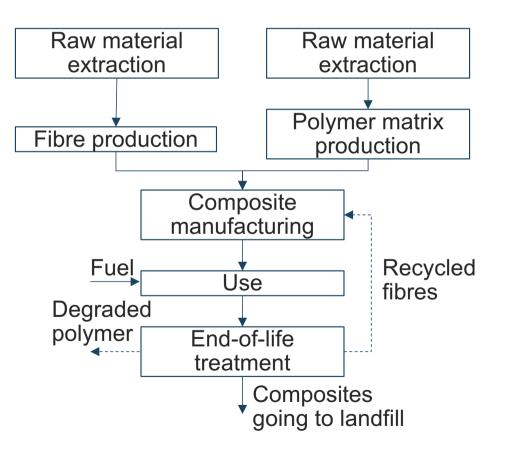
- Work was carried out within the LIBRE project-Lignin based carbon fibres for composites
- Carbon fibre composites are often used in vehicles for their lightweighting properties
 - Compared to using fibreglass, this does not automatically decrease the life cycle environmental impact [1]
 - The carbon fibre production is often the hotspot for carbon fibre composites [1]
- Three routes that could reduce the environmental impacts of carbon fibre composites are:
 - The use of bio-based raw materials

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- The use of microwave technology in carbonization
- The recycling of composites and recovery of fibres
- This study assesses the environmental impact of these three routes and if they can make carbon fibre composites (aka CFRP) in vehicles environmentally competitive to fibreglass (aka GFRP)



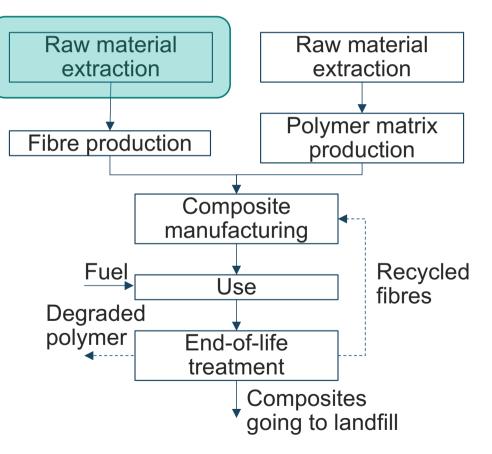
Basic outline of the composite life cycle when used in a vehicle





Route 1: The use of bio-based raw materials

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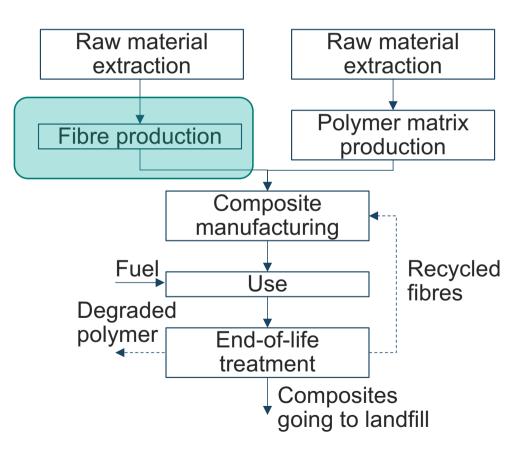


Route 1: The use of bio-based raw materials

- Carbon fibres can be produced from lignin instead of fossil based polyacrylonitrile (PAN)
 - Lignin is a macromolecule found in wood
 - A by-product from the pulping industry and biorefineries
- Not applicable to glass fibre production



Route 2: The use of microwave technology in carbonization





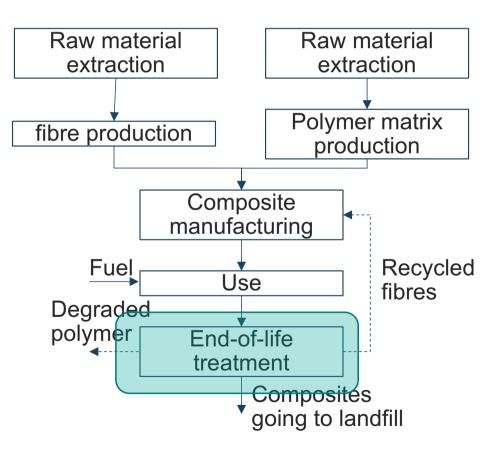
Route 2: The use of microwave technology in carbonization

- Microwave technology instead of conventional furnaces can be used to decrease the energy use in carbon fibre production
- Can decrease energy consumption with more than 90% as suggested by Lam et al. [2]
 - · This is connected to a fast heating rate and a short process time
- Not applicable to glass fibre production

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Route 3: The recycling of composites and recovery of fibres





Route 3: The recycling of composites and recovery of fibres

- Composites can be recycled by means of, for example, pyrolysis, grinding, or super critical water dissolution
 - Liberates the fibres with some tenisle strength reduction
 - Polymer can be recovered to various extent depending on method
- Applicable to **both** carbon fibre composites and fibreglass



LCA goal and scope

- Functional unit: 1 pair of car mirror brackets used for 100 000 km
 - Produced from either fibreglass (0.24 kg) or carbon fibre composites (0.19 kg)
 - Fibreglass: 40% fibre and 60% polyamide
 - Carbon fibre composite: 20% fibre and 80% polyamide
- Cradle-to-grave study
 - Composites are assumed to be sent to landfill after use if not recycled
- The vehicles with carbon fibre composite mirror brackets are given a credit for avoided fuel use due to lightweighting
- All composites are assumed to be produced from primary materials
- Impact categories: Climate impact and cumulative energy demand



LCA goal and scope

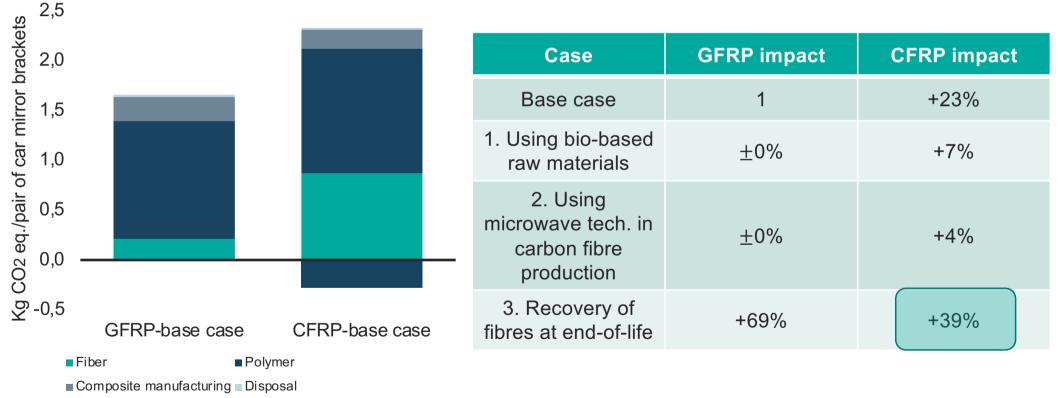
• Three technology development routes were assessed

- 1. Lignin-based carbon fibre in composites
 - Fibres assumed to be made from 50% lignin and 50% bio-polyurethane
 - · Economic allocation for distributing impacts of biorefinery in lignin production
 - We assumed 50% material yield in stabilization and carbonization
- 2. PAN-based carbon fibres produced by means of microwave technology in composites
 - We used a proxy value of an energy reduction of 93.5% based on data by Lam et al. [2]
 - We assumed 50% material yield in stabilization and carbonization
- 3. The recycling of the composites by means of pyrolysis after use
 - Using the end-of-life recycling approach as suggested by Hermansson et al. [3]
 - Considers the tensile strength reduction for quality degradation
 - 100% recycling rate

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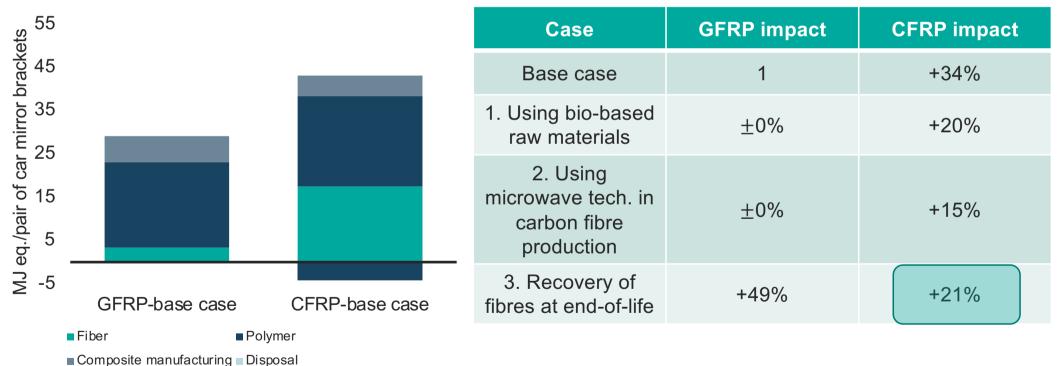
Results - Climate impact



Credit from lightweighting



Results- Cumulative energy demand



■ Credit from lightweighting



Conclusions

- Microwave technology and the use of bio-based raw materials routes show potential for decreasing the relative environmental impacts of carbon fibre composite
 - However the env. impact of carbon fibre composites is still higher than for fibreglass
- Only one route results in lower env. impact than fibreglass: Recycling of composites and recovery of fibres
 - This is very dependent on the allocation approach used
 - Recovery of high quality products is important!
- Fibre production is a hotspot!
 - Would a combination of recycling of bio-based carbon fibres produced by means of microwave technology be possible?
 - What would the quality of recycled bio-based carbon fibres be?



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