The environmental benefits and challenges of a composite car with structural battery materials

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Reducing the fuel consumption for electric vehicles

- One way to reduce the environmental impact of battery electric vehicles (BEVs) is to reduce fuel consumption
  - This can be done by reducing the vehicles mass
  - Two possible materials are: carbon fibre reinforced polymers (CFRPs) or structural battery materials (SBs)
    - The SBs provide both structural integrity but also stores energy
- This study assesses the change in life cycle environmental impacts related to transitioning from a conventional BEV to a vehicle with components made from either CFRPs or SBs.

Designing the conceptual composite car

- Which parts of an BEV could we replace with:
  1. CFRPs?
  2. SBs?
  - What would the **influence on the mass** of the vehicle be?
  - What would the total **life cycle environmental impacts** be?

Designing the conceptual composite car

- Discussions with technology experts on which parts that could be replaced with either CFRP or SBs
  - 10 components
    - Some more structural like the roof
    - Some less structural like inner door panels
- By calculating CFRP's and SBs' effective modulus and energy density we could assess how much composite materials that would be needed to maintain the components structural integrity
  - We could calculate the changes in vehicles mass due to changing of components
  - We could calculate how much smaller battery the SB vehicle could have

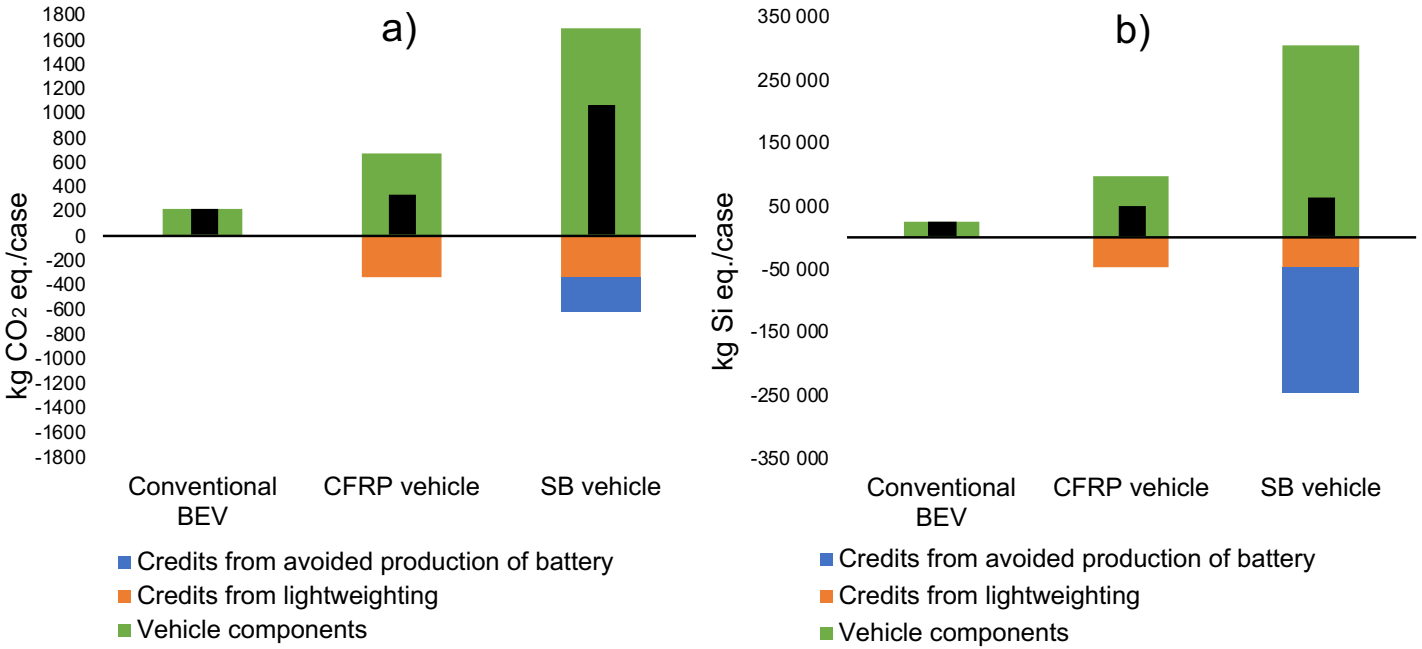
LCA goal and scope

- Assessed three different BEVs used for 200 000 km
  - Conventional BEV
  - BEV with components from CFRP
  - BEV with components from SB
- Functional unit: The selected components and the battery
- Cradle-to-grave study with system expansion by substitution
  - Materials are assumed to be recycled at end-of-life
- A lighter vehicle is given a credit for avoided fuel use
- Assessed impact categories: Climate impact and crustal scarcity indicator

Mass and fuel savings for the three cases

	Δm (kg) Material substitution	Δm (kg) Battery size	Δm(kg) Total	Fuel saved (kWh)
Conventional BEV	n/a	n/a	n/a	n/a
CFRP vehicle	-37.6	0	-37.6	-519
SB vehicle	+3.68	-42.0	-38.4	-529

LCA results


a)
1800
1600
1400
1200
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
-1400
-1600
-1800
kg CO2 eq./case
Conventional BEV
CFRP vehicle
SB vehicle
b)
350 000
250 000
150 000
50 000
-50 000
-150 000
-250 000
-350 000
kg Si eq./case
Conventional BEV
CFRP vehicle
SB vehicle
Credits from avoided production of battery
Credits from lightweighting
Vehicle components

Conculsions

- The use of CFRP and SB's in vehicles shows great potential to reduce vehicles mass and thus the fuel consumption
- From a life cycle perspective, the use of CFRPs and SBs increase environmental impacts today
  - Environmental hotspots are: energy consumption in the carbon fibre production and structural batteries manufacturing/assembly process
- Future research could include:
  - Manufacturing fibres, composites and SBs by means of microwave technology
  - The use of bio-based raw materials (lignin) for carbon fibre production
  - Recycling and recovery of high quality fibres at the end-of-life

References

- Berg, I. & Sandberg, K. (2021). The environmental opportunities and challenges of a structural battery car (Unpublished master's thesis)

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