Supplementary material

Allocation in recycling of composites
-the case of life cycle assessment of products from carbon fiber composites

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1. Life cycle inventory

1.1 Production processes

Table S1: Composite manufacturing inventory.

Flow	Amount	Provider	Data source
Inputs			
Carbon fiber	0.3 kg	n/a	A modified version of Fazio and Pennington (2005) for precursor fiber production and Romaniw (2013)[1] for carbon fiber production
Polymer: Polyamide	0.7 kg	nylon 6-6 production | nylon 6-6 | APOS, U - RER	Ecoinvent 3.3 (Wernet et al., 2016)
Injection moulding	1 kg	injection moulding | injection moulding | APOS, U - RER	Ecoinvent 3.3 (Wernet et al., 2016)
Outputs			
Composite	1 kg	n/a	n/a

1.1.1 Modifying the PAN fiber dataset

As the PAN fiber production dataset is from another database than Ecoinvent, some modifications needed to be made to be able to use Ecoinvent impact assessment methods. In most cases, the modification was simply just to change the flows' name to match the name of the flow used in the Ecoinvent impact assessment methods. However, for some flows, some assumptions and recalculations needed to be made:

- We assumed that the methane, carbon monoxide, and carbon dioxide emissions from the PAN production are 100% fossil. While some of the emissions are likely to be biogenic in reality, we also account for the carbon dioxide resource use on the input side by subtracting this from the carbon dioxide emissions on the output side.
- Some original flows were expressed in amounts of energy, while the Ecoinvent impact assessment method required them to be in mass or volume to be accounted for. To recalculate the flows to the right flow property, we assumed that the energy content of crude oil was 42.3 MJ/kg, hard coal was 26.3 MJ/kg, brown coal was 11.9 MJ/kg, and peat 8.4 MJ/kg (as stated in the original inventory flow's names). We also assume that the natural gas had an energy density of 0.04034 MJ/liter[2] (Engineering Toolbox, 2008) and that the energy content of uranium was 500 000 MJ/kg (World Nuclear Association, 2012).
- We assumed that the inputs of biomass and wood were correspondent to eachother.

Note that this conversion leads to slightly different results compared to using the original flows and OpenLCA cumulative energy demand impact assessment method (approximately 10% lower per kg PAN fibers). For climate impact, the difference is minor. The discrepancy in impacts is not likely to influence the overall results of the study in a significant way.

[1] See Romaniw (2013) p. 324 for inventory. We used the Ecoinvent 3.3 (Wernet et al., 2016) providers "market for electricity, low voltage | electricity, low voltage | APOS, U – DE" for electricity production and "market for nitrogen, liquid | nitrogen, liquid | APOS, U – RER" for nitrogen production. We also assumed that the output flows of methane, carbon dioxide, and carbon monoxide were fossil.

[2] This is the gross heating value, which was used due to data availability.

1.2 Recycling processes

Table S2: Grinding inventory. Inputs are based on data found in Dong et al. (2018). Note that the inventory is for 100% recycling rate and will vary between case studies and recycling rates.

Flow	Amount	Provider	Data source
Inputs			
Composite	1 kg	n/a	See Table S1
Electricity	0.27 MJ	market for electricity, low voltage | electricity, low voltage | APOS, U - DE	Ecoinvent 3.3 (Wernet et al., 2016)
Outputs			
Grinded composite	1 kg	n/a	n/a

Table S3: Pyrolysis inventory. Inputs are based on data found in Dong et al. (2018). Note that the inventory is for 100% recycling rate and will vary between case studies and recycling rates.

Flow	Amount	Provider	Data source
Inputs			
Composite	1 kg	n/a	See Table S1
Electricity	30 MJ	market for electricity, low voltage | electricity, low voltage | APOS, U - DE	Ecoinvent 3.3 (Wernet et al., 2016)
Outputs			
Carbon fiber*	0.3 kg	n/a	See Table S1
Pyrolysis oil	0.7 kg	petroleum production, onshore | petroleum | APOS, U RoW	Ecoinvent 3.3 (Wernet et al., 2016)

*Degraded

Table S4: Supercritical water treatment inventory. Inputs are based on data found in Dong et al. (2018). Note that the inventory is for 100% recycling rate and will vary between case studies and recycling rates.

Flow	Amount	Provider	Data source
Inputs			
Composite	1 kg	n/a	See Table S1
Electricity	9.4 MJ	market for electricity, low voltage | electricity, low voltage | APOS, U - DE	Ecoinvent 3.3 (Wernet et al., 2016)
Heat	66.2 MJ	heat production, natural gas, at industrial furnace >100kW | heat, district or industrial, natural gas | APOS, U - Europe without Switzerland	Ecoinvent 3.3 (Wernet et al., 2016)
Water	3.5 kg	market for tap water | tap water | APOS, U - Europe without Switzerland	Ecoinvent 3.3 (Wernet et al., 2016)
Cooling water	72.02 t	n/a (considered a resource, assumed to be re-circulated)	n/a
Outputs			
Carbon fiber*	0.3 kg	n/a	See Table S1
Polymer*	0.7 kg	nylon 6-6 production | nylon 6-6 | APOS, U - RER	Ecoinvent 3.3 (Wernet et al., 2016)

*Degraded

1.3 Disposal processes

The disposal of the material to landfill is modelled using the process “treatment of waste plastic, mixture, sanitary landfill | waste plastic, mixture | APOS, U-Europe without Switzerland” provided by Ecoinvent 3.3 (Wernet et al., 2016).

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