#ArchitectingAviation

Environmental assessment of the CFRP shells of a Type V liquid hydrogen tank for the aviation sector

Showing the importance of primary data in Life Cycle Assessment (LCA) models

The Reason Why

Less weight means less emissions. This statement is well known in the aviation industry. That's why, in addition to alternative fuels, lightweight systems are playing an increasingly important role on the road to sustainable aviation.
The combination leads to a Type V liquid hydrogen (LH2) tank, which includes composite shells. Literature reports about projects where Type V pressure vessels with the Automated Fiber Placement (AFP) manufacturing process have achieved a **weight reduction of 25 %** compared to aluminium-lithium tanks [1].
This positive effect in weight reduction will influence the environmental impact of the use-phase.

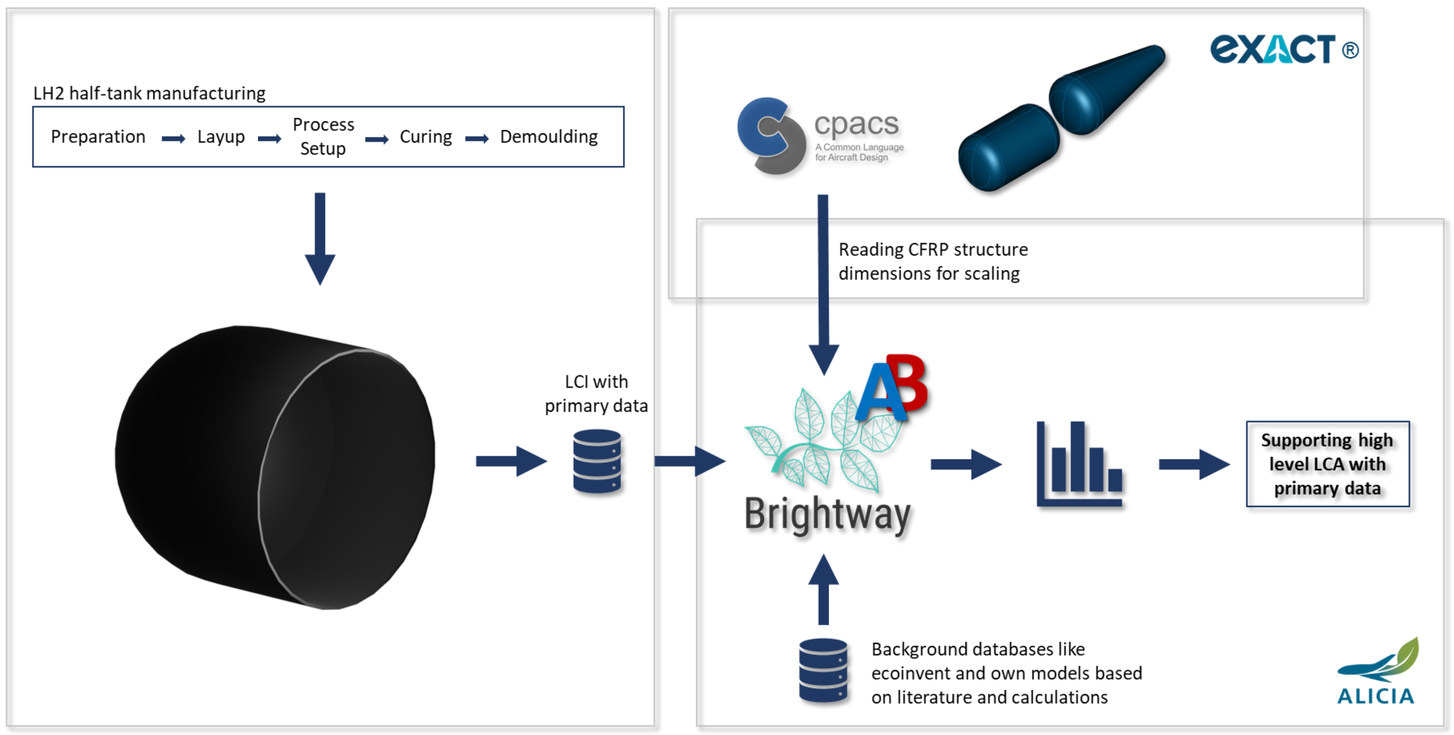

Fig. 1: Schematic description of the methodical approach and the synergies of projects which were used to calculate the environmental impacts for a specific aircraft concept with a cradle-to-gate LCA

Environmental Assessment

This work takes a step back from the use-phase and looks at the manufacturing phase of Type V tank shells made out of Carbon Fiber Reinforced Polymers (CFRP). Specifically, the environmental impacts of manufacturing are quantified using Life Cycle Assessment (LCA) methodology, which **supports the high level LCA** approach with results based on primary data. The importance of representative LCI data will be shown in this work.

Goal and Scope

- Goal: Calculation of the environmental impacts of the production of LH2 tanks scaled to the respective application.
- Functional unit: CFRP shells of all tanks in CPACS of the aircraft concept D250-TFLH-MHEP-240
- System boundary: Cradle-to-gate, cutoff: 0.01
- LCIA methodology: Environmental Footprint (EF 3.1)
- Background database: ecoinvent 3.9.1.-cutoff
- Software: open-source software brightway2/Activity-Browser

While EF 3.1 includes several categories and therefore multiple indicators, this work will focus on the Global Warming Potential (GWP100) as it is one of the main indicators that will be shown in the **ALICIA Dashboard**.

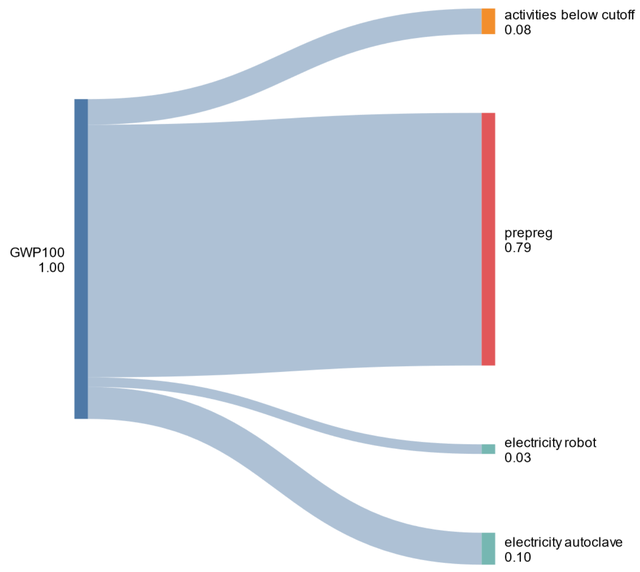

Fig. 2: Sankey diagram showing the relative contribution of the activities to the GWP100 with the cutoff criteria of 0.01

As Fig. 2 shows the **main contributors** are the **prepreg** (carbon fiber + epoxy resin) material and the **energy** consumed during processing. Infrastructure, transport within the facility and equipment are not included in the systems boundary in this study.

Primary Data vs Existing Datasets

Fig. 3 shows the **significant differences** in using the few existing datasets for CFRP compared to using primary data with the same functional unit.
Also changing the database version can lead to different results like it is for the dataset in the ecoinvent database from version 3.9.1 to 3.11.

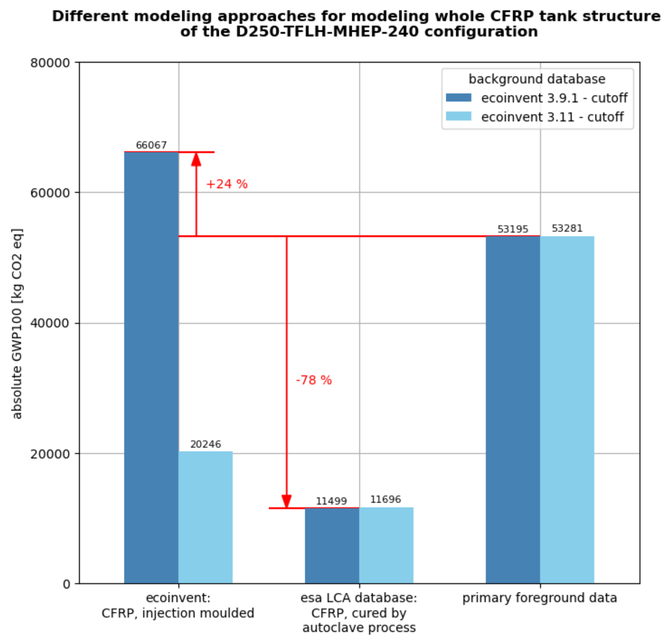

Fig. 3 : Comparison of the environmental impacts of the model using primary data and datasets from background databases and also different versions for the CFRP tank structure of the D250-TFLH-MHEP-240

Next steps

- Quantification of uncertainties and conducting sensitivity analyses
- Addition of infrastructure, equipment and tools
- Including tank systems in the model
- Expand model to represent other manufacturing processes
- Connecting LCA with information on critical materials and supply chains

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Reference
[1] Air, et al. (2022). A review of Type V composite pressure vessels and automated fibre placement based manufacturing. Composites Part B. doi.org/10.1016/j.compositesb.2023.110573