SUSTAINABILITY IN TRAIN STRUCTURES: AN APPROACH FOR LCA OF NEW MATERIAL COMBINATIONS

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Background

The DLR Rolling Stock (RoSto) project is developing innovative technologies for the design of next-generation railway vehicles. In addition to the requirements of passengers, manufacturers and operators, the use of resource-efficient and sustainable materials is of great importance. For this reason, the design process of new structural elements is supported by life cycle assessment (LCA) as an established method for estimating possible environmental impacts. In the following, an approach for analysing a roof structure is developed (Figure 1).

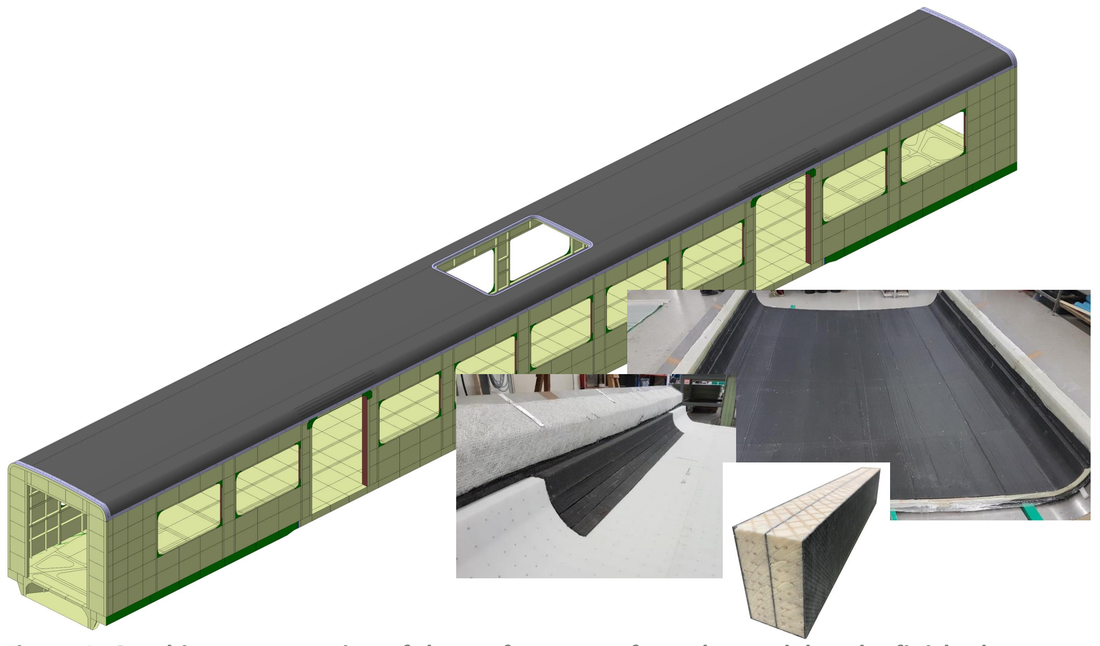

Figure 1: Graphic representation of the roof structure from the model to the finished structure

Creating the life cycle inventory

In order to be able to make meaningful material recommendations in the future, it is essential to compile a comprehensive life cycle inventory (LCI). However, this can be a major challenge, especially when researching new materials and manufacturing processes which are often not found in conventional LCA databases. For this reason, existing data sets can either be modified or created on the basis of laboratory and literature data. Therefore, a mass balance of the selected materials is necessary.

Table 1: Mass balance of the materials used in the demonstrator

Materials	M [%]
Resin	37
Carbon fiber	24
Steel, unalloyed	15
Aluminum alloy	2
Adhesive	1
PET-Core	21
	100

As shown in Table 1, the material component with the largest mass fraction is the resin used. Due to the multitude of resin systems, it can be difficult to create a suitable data basis for carrying out an LCA study. Therefore, two strategies are pursued:

1. **Investigation and use of proxy data sets**
2. **Creation of a specific epoxy resin data set**

Effects of using different resin systems

To analyse future material recommend-dations, proxy datasets are used in a life cycle inventory along-side the Environmental Footprint impact indicators. The LCA software OpenLCA V2.4.0 was used for this purpose in order to be able to draw a comparison by directly exchanging the resin systems as part of a parameter study. The result is represented by Figure 2.

INFLUENCE OF DIFFERENT RESIN SYSTEMS

- **Limited Number** of proxy data sets available
- Comparison of different resin systems using **Ecoinvent (EI) and cm.chemicals (CM)** for proxy data sets (Figure 2).
- Modeling of an representative epoxy resin using **literature data** and **safety data sheets** (Figure 3).
- The self-modelled resin contributes approximately **30% less** CO_2-equivalents in the category Climate Change (Figure 4).
- For the entire roof structure, a **reduction of about 1.7%** in kg CO_2 -equivalents is observed (Figure 5).

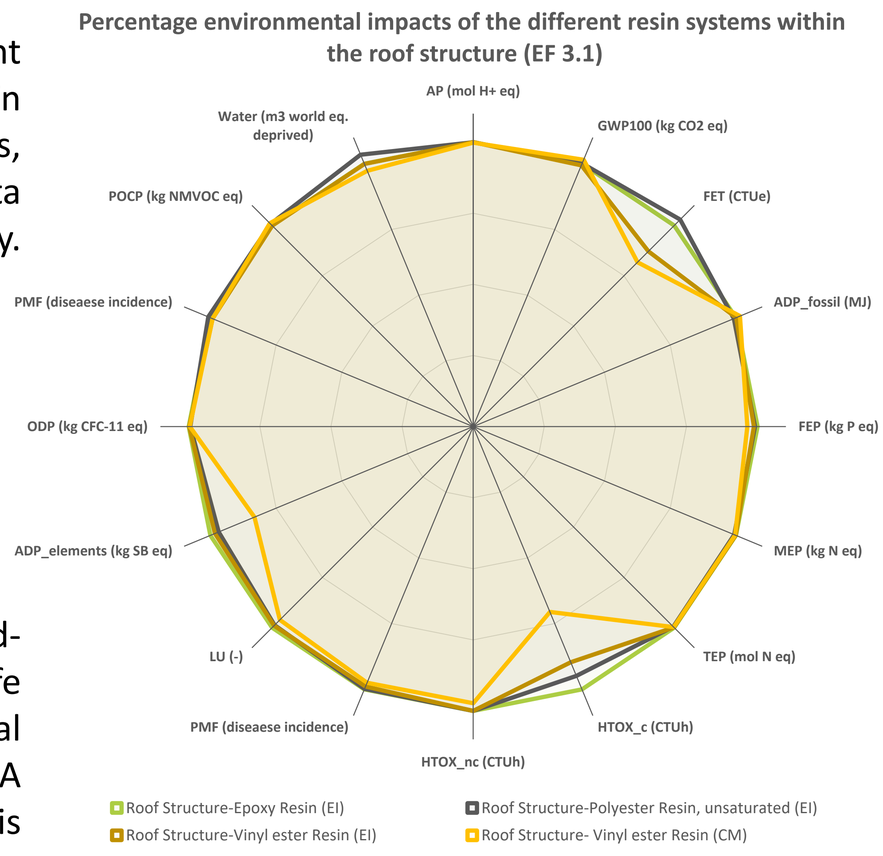

Figure 2: Relative environmental impacts of resin systems with epoxy resin, liquid as reference

Creation of the specific epoxy resin data set

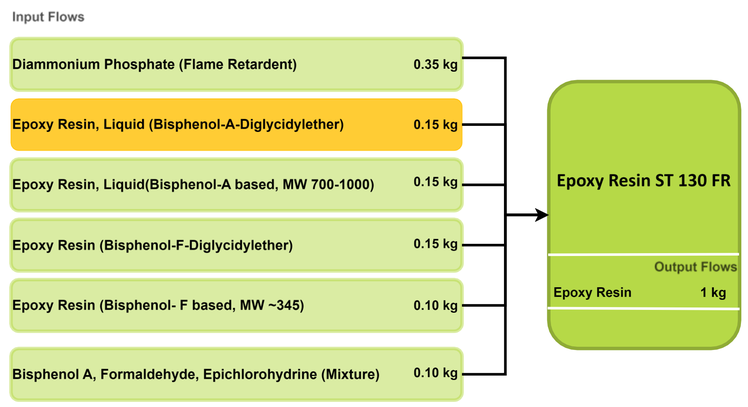

Figure 3: Modified model graph for the representative epoxy resin dataset

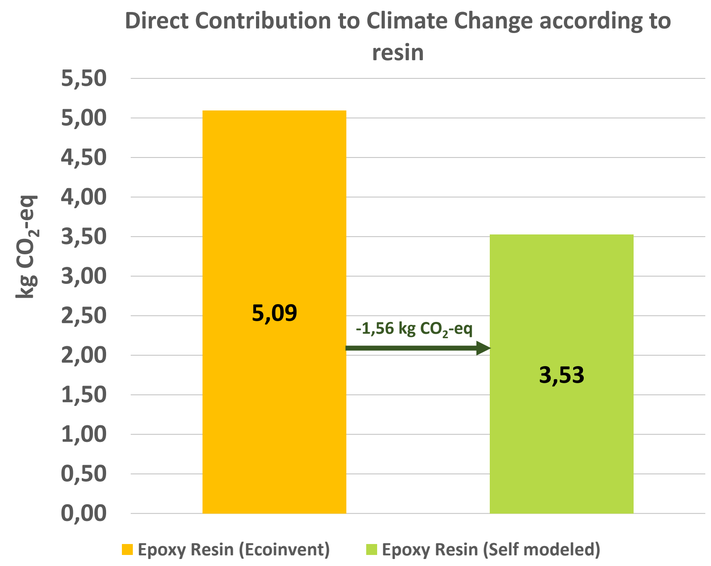

Figure 4: Graphical representation of the direct contribution to climate change per kilogram of resin (EF 3.1)

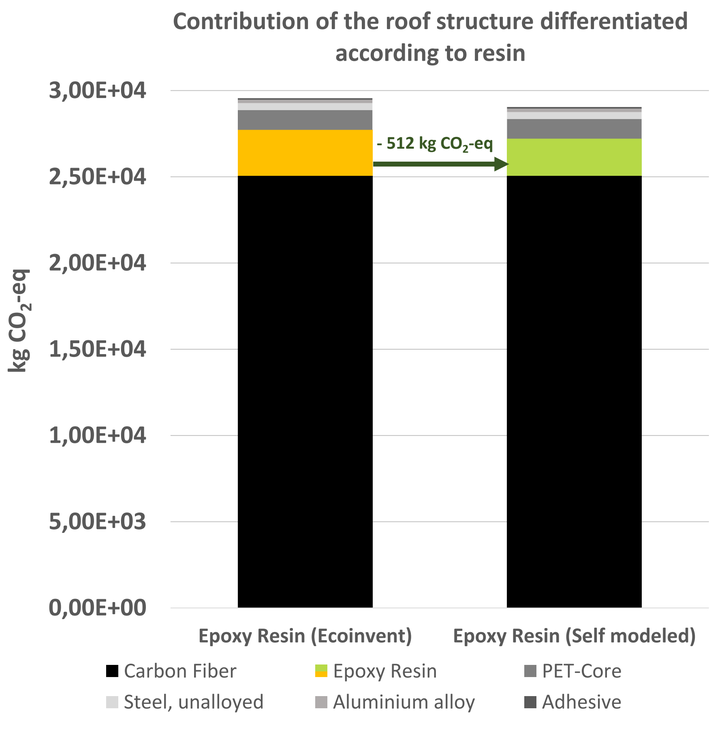

Figure 5: Graphical representation of the direct contribution to climate change (EF 3.1)

GWP100 = Climate Change Global Warmin Potential 100 years, ODP = Ozone Layer Depletion, HTOX_c = Human Toxicty Carcinogenic effects, HTOX_nc = Human Toxicty Non-carcinogenic effects, PMF = Particulate Matter Respiratory Effects, inorganics, IRP = Human Health Ionizing Radiation POCP = Photochemical Ozone Creation, AP = Acidification Freshwater and Terrestrial Acidification, TEP = Eutrophication Terrestrial, FEP = Eutrophication Freshwater, MEP = Eutrophication Marine, FET = Ecotoxicity Freshwater, LU = Land Use Soil Quality Index, ADP = Abiotic Resource Depletion