

VESO Concept: life cycle assessment of the MANIFICA project

VESO Concept, a company committed to sustainable development, has begun a new era in its continuing growth. In addition to designing and developing bio-based composites for the mobility sector, they are now working on carbon fibre recycling in the aeronautics industry. VESO Concept partnered with major companies in the sector to develop the MANIFICA(*) project, which is part of the European Horizon 2020/Clean Sky JU project (Call: H2020-CS20-CFP10-2019-01).

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The goal of the MANIFICA project is to set up a recycling chain for carbon fibre composites, from aeronautic waste to innovative composite parts. The concept is that high-quality recycled carbon fibre will help the recycling industry maximize the value of this source of recycle. To this end, the carbon fibre recycling sector was looked at from a systemic point of view, taking into consideration all its aspects, from logistics, recycling, and production of ready-to-use semi-products to new recycled carbon fibre (rCF) based industrial demonstrators.

Partners involved in the consortium

To reach the project's objectives, the MANIFICA consortium brings together several partners: the University of Bordeaux (I2M), two industry leaders in carbon fibres and waste treatment: TORAY CFE, and PAPREC Group, and the VESO Concept innovative composite SME, thus combining the necessary scientific, technical and industrial skills.

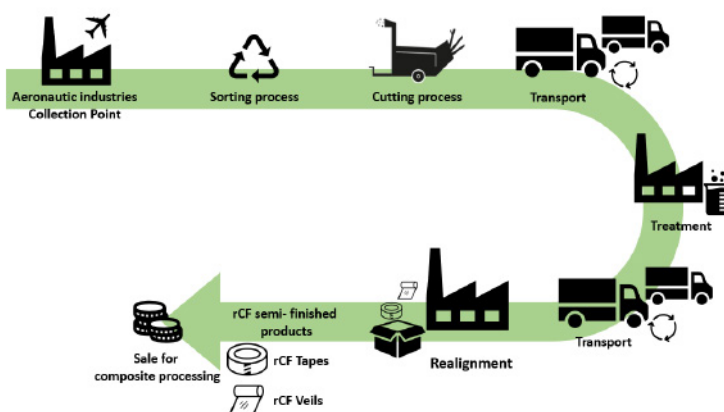


Fig. 1: The MANIFICA process' life cycle

Life cycle analysis approach

This article focuses on the life cycle analysis approach required to understand the circular economy model. The MANIFICA process' life cycle includes the collection and sorting of carbon fibre-reinforced composite (CFRP) waste recovered from the aeronautic industry. This waste is transported by truck to the sorting and re-sizing facility, where 70% of the total waste is retained while 30% is rejected due to the presence of metal inserts, plastic bags, etc., and transferred to an incineration facility.

The CFRP waste retained is resized by an industrial machine to facilitate its treatment, using industrial shears capable of processing 4 tons per hour, with an installed power of 300 kW. At that point, the fibres are separated from the matrix. Then, the rCFs are realigned into a unidirectional or bidirectional fabric, which is later used by VESO to manufacture semi-structural aircraft parts.

On average, the production of 1 kg of rCF (high-performance aeronautic material) with the MANIFICA system consumes around 3 kg of composite waste, 5 kWh of energy and smaller amounts of other materials. The project also considers creating value from the remaining waste in future stages. Eventually, the process should reach an industrial scale and be able to recycle 200 tons of CFRP waste per year.

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IV. Recycling & Recovery

The carbon fibre waste issue

Carbon fibre revolutionized the materials world by making many of our everyday life products lighter, stronger, and more durable. Its versatility has led to increasing demand in recent years. However, these products come with many challenges, including their constantly growing production volumes that result in large amounts of waste to be treated to reduce their environmental impact. Incineration with energy recovery is one of the technologies traditionally used to treat this type waste. However, the resulting emission savings are not high enough to offset the waste combustion emissions and incineration can release harmful chemicals. At the same time, landfill presents some challenges due to the nature of carbon fibre composite matrices, which include organic substances and cannot be fully considered as non-hazardous waste. MANIFICA offers an innovative solution to close the carbon fibre production loop in the aeronautics industry because rCF not only reduces waste, but also constitutes a valuable investment in a growing market that is currently estimated at up to 20 million euros.

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Assessing the environmental footprint of the MANIFICA approach

The life cycle of MANIFICA's recycled carbon fibre offers both structural and environmental advantages. VESO Concept assessed the environmental footprint of the project through a life cycle analysis to estimate and evaluate the impacts of the MANIFICA recycling process. Two solutions were proposed to close the loop by recycling carbon fibres. The life cycle assessment focused on the recycling chain for carbon fibre composites, from aeronautic waste to recycled carbon fibre semi-products. The objectives were to assess the environmental impacts of each step in the recycling chain, from collection to semi-finished products, to measure the environmental impact and carbon footprint reductions for this new sector (carbon recycling), and to identify the individual processes with the strongest environmental impacts. The results (Figure 2) show that CFRP waste treatment (green) is the main hotspot of the whole process, accounting for more than 75% of the environmental impact in all the impact categories. In other categories such as ionizing radiation, CFRP waste collection and rCF realignment show higher contributions (more than 10%) due to power consumption.

Figure 3 presents the life cycle assessment of CFRP waste treatment (hotspot), showing that the production of the chemical used in the process is the main contributor to the environmental impact. The land use indicator is the most strongly affected (around 90%),

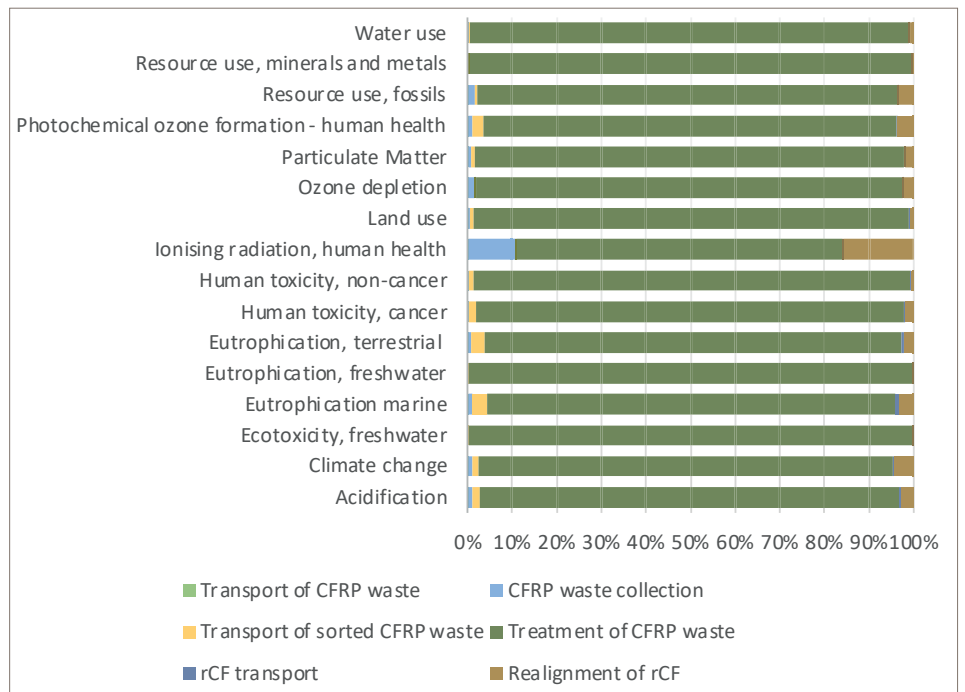


Fig. 2: Environmental impact of each process in the product's life cycle

IV. Recycling & Recovery

maybe due to the displacement of natural ecosystems to expand industrial areas. Resource use, mineral and metal, human toxicity, cancer and non-cancer, eutrophication, and ecotoxicity, freshwater are also highly impacted by the production of this chemical. The graph also shows that natural gas has a major influence on resource use, fossils, photochemical ozone formation, human health, and climate change.

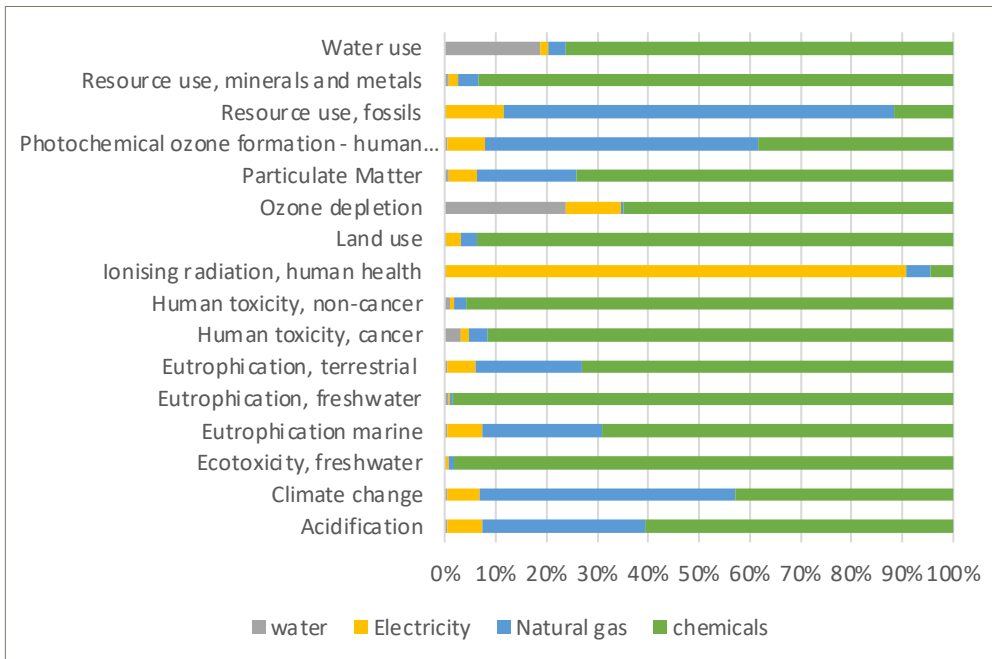


Fig. 3: LCA of CFRP waste treatment

As mentioned before, the treatment used to separate the fibres from the matrix contributes the most to the overall impact compared to other processes such as transportation, waste collection, sorting, and realignment. The fibre treatment process alone releases around 5 kg of CO₂ eq. to the atmosphere, while using more resources than the other processes, around 275 MJ. In general, the material's transportation does not have a high impact on the MANIFICA cycle as the trucks' diesel consumption and emissions are insignificant.

Summary of the life cycle analysis results

The results show that the production of 1 kg of rCF releases 5.4 kg of CO₂ eq. in the atmosphere, in contrast with the production of virgin fibre, which releases 41.1 kg of CO₂¹ eq. per kg. In this scenario, the main environmental impact contributor in the whole MANIFICA process is the fibre treatment step, contributing 93% of CO₂ emissions. On the other hand, the second scenario proposes to recover carbon fibres by means of a dry

process (avoiding the CFRP waste treatment), reducing emissions to only 0.3 kg of CO₂ eq. Overall, the minimum and maximum impacts of MANIFICA range between 0.3 and 5.4 kg of CO₂ eq. It is important to highlight that, when the project reaches its industrial scale, all carbon fibre waste could be recovered and converted into new semi-products, using even less energy and resources than virgin fibre.

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¹ « Base Impacts® - Consulter les Procédés ».

IV. Recycling & Recovery

MANIFICA recycling outperforms more traditional options such as incineration and landfill. The recycling process can achieve a net reduction of -10.4 kg of CO₂ per kg of CRFP waste treated (regarding the more conservative scenario), due to the benefits resulting from the switch from virgin to recycled carbon fibre, avoiding an energy-intensive process and preserving raw materials. For recycling to be environmentally appropriate, the sum of recycling impacts has to be lower than the combined impacts from the alternative waste treatment and virgin material production processes. Despite the low CO₂ emissions of incineration and landfill, both have a high global warming impact since they fail to use the recycling potential of carbon fibre in CFRP waste.

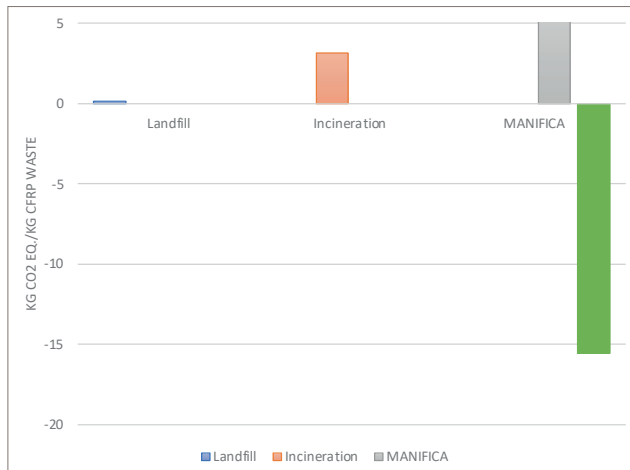


Fig. 4: MAGNIFICA recycling outperforms more traditional options such as incineration and landfill

Company profile

Founded in 2008 and headquartered in Fontenilles, France, VESO Concept is a research unit that specializes in R&D and engineering applied to the design and development of innovative biosourced and/or recycled composite solutions for the mobility sector (aeronautics, automotive, shipbuilding, etc.) as well as sports and leisure activities.

Additionally, the MANIFICA process results in high-quality rCF semi-products (UD, 2D, tape, NCF fabrics), ensuring good processability for the manufacture of composite parts. rCF offers good properties, including a tensile strength at break of up to 850 MPa. Another advantage is that it combines the processability of current processes with fibre contents of over 60%. Any player in the composite industry will be able to take advantage of this, whatever their field of activity.

As part of this circular economy approach, aircraft part demonstrators currently developed by VESO will be presented in 2023 and will be the subject of a new publication.



Fig. 5: CFRP waste

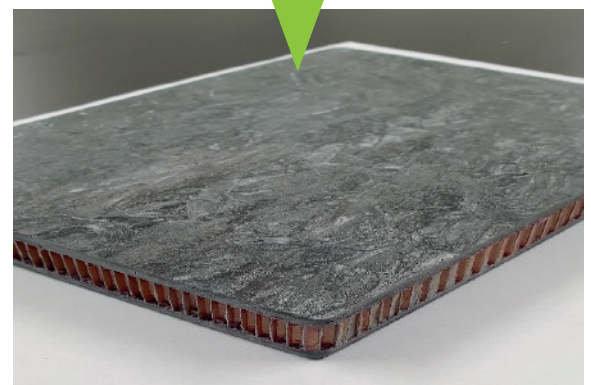


Fig. 6: Honeycomb/rCF sandwich panel

MANIFICA project is led in partnership with :



More information: www.veso-concept.com

*<https://manifica.eu/>