Re-inventing the future

CIRCE
Circular Economy Model
for Carbon Fibre Prepregs

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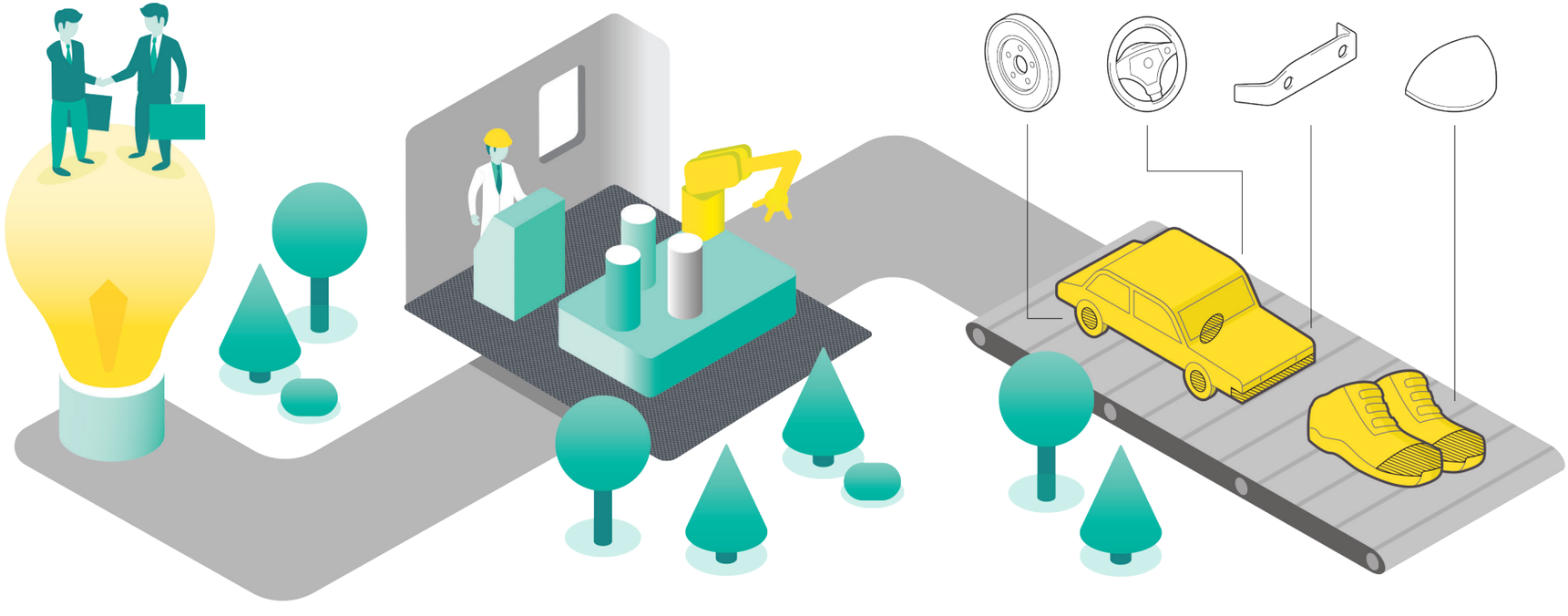
LIFE 18 ENV/IT/000155

Index



Introduction

CIRCE is a project born within the **LIFE programme**, the European funding instrument for supporting new initiatives aiming to protect the environment. Its strength was based on the partnership of five Italian companies operating in the research and industrial sector, oriented to product and industrial processes innovation. Companies with different core businesses, yet firmly bound by a common objective: encouraging the **reuse of composite materials** through the circular economy paradigm. Which, basically, means giving **new life to the future of the planet**.

The **CIRCE** project (**LIFE 18 ENV/IT/000155**) aimed to achieve ambitious goals over almost four years: from **1 September 2019** to **30 April 2023**. These goals range from the reduction of the environmental impacts of industrial wastes, to the optimization of the use of natural resources; from the development of a leaner and less polluting mobility to the birth of a recycling virtuous paradigm dedicated to the carbon fibre sector.

Total project budget: 2.278.694 €
EU co-funding: 1.180.681 €

Partnership

HP composites

HP Composites is world leader in the production of carbon fiber components for the motorsport and automotive sectors.

hpcomposites.it

Alci

Alci Group is a manufacturing company in metal and mechanical field, born in 1990. Alci develops customized machineries and production lines for rubber, pharmaceutical, food and chemical industries.

alcigroup.it

Cetma

Cetma is a Research and Technology Organization (RTO) which carries out for more than 25 years applied research, experimental development and technology. It is a non-profit organization reinvesting all profits in research, training and technology transfer.

cetma.it

Petroceramics

Petroceramics S.p.A. is an Italian SME with decennial experience and expertise in the design, fabrication, processing and testing of various types of innovative ceramics and composites. It develops new advanced ceramic materials such as: automotive and aerospace engineering, defense engineering, equipments, energy and environment, architectural design.

petroceramics.com

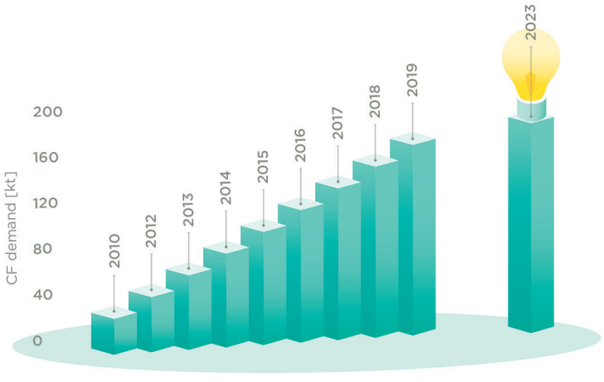
Base protection

Base protection starts from the comfort to create work footwear which combine technologies and functionality, responding to the needs of workers.

baseprotection.com

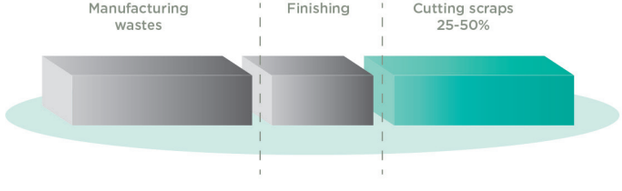
Background

Composite materials market is constantly expanding as a result of the increasing demand for lightweight products characterized by high engineering properties.



The growing demand of Carbon Fiber Reinforced Polymers (CFRPs) raises some issues related to the relevant environmental impacts of their manufacturing. In particular, the environmental footprint is mainly determined by the high energy consumption required to produce raw materials that accounts for about 90 % of the total impacts.

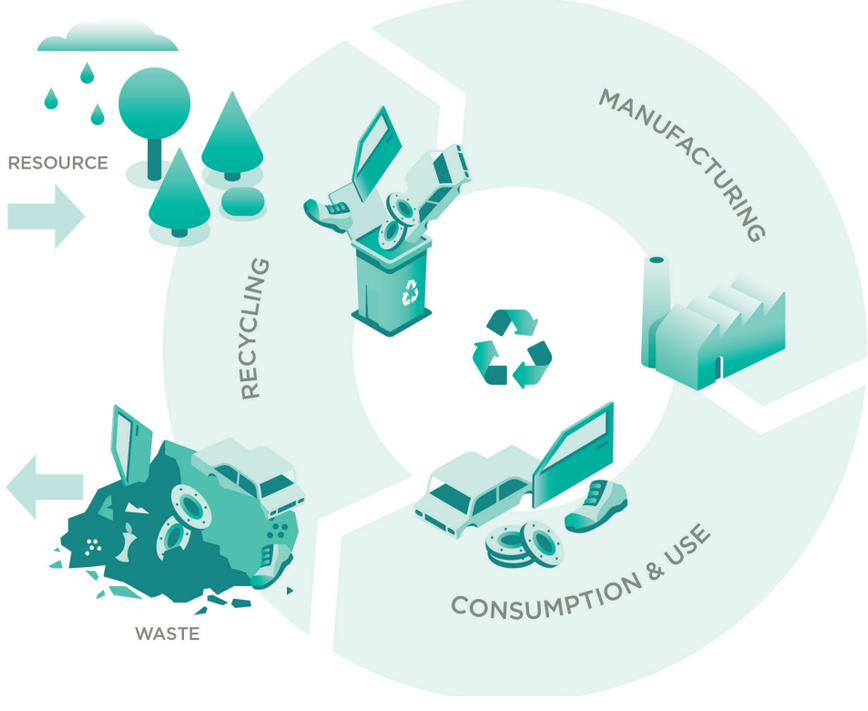
In next years, the CFRP waste production is expected to increase, reaching up 20 ktons per year by 2025. Approximately the 40% of the wastes is generated during the components manufacturing phase, and the 60% of these are side-streams coming from the woven trimmings and ply cut operations. Indeed, the buy to fly ratio of a composite produced with CFRP prepreg can range from 1.2: 1 to 3.5: 1.



The «buy to fly» of a CFRP component can vary from 1.2:1 up to 3.5:1

In this context, it is thus crucial to reduce the reliance on landfills by implementing recycling techniques and innovative ways to reuse the residues generated during the production process giving new value to the scrap materials.

How can we put the carbon fiber prepreg scraps back into the value chain?



CIRCE project
Uncured material reprocessed

Projects

1

CFRP production

The carbon fiber reinforced polymers are innovative and ultralight materials, increasingly appreciated and applied in the automotive, motorsport, shipbuilding, aerospace, industrial and design sectors.

2

Where the scraps end up

During the production of carbon fibre composites, waste and scraps of industrial material are generated. Wastes that - in the best scenario - end up in landfills or inside incinerators, with important repercussions in terms of pollution. Today, due to the technical complexity required by the recovery process, no effective system for recycling such industrial waste exists.

3

The ideas behind the Circe project

From the imperative need of safeguarding the environment and optimizing the use of natural resources, an ambitious idea is born: CIRCE. Five Italian companies for a project intending to redesign the industrial recycling chain through innovation.

4

The means to reach the goal

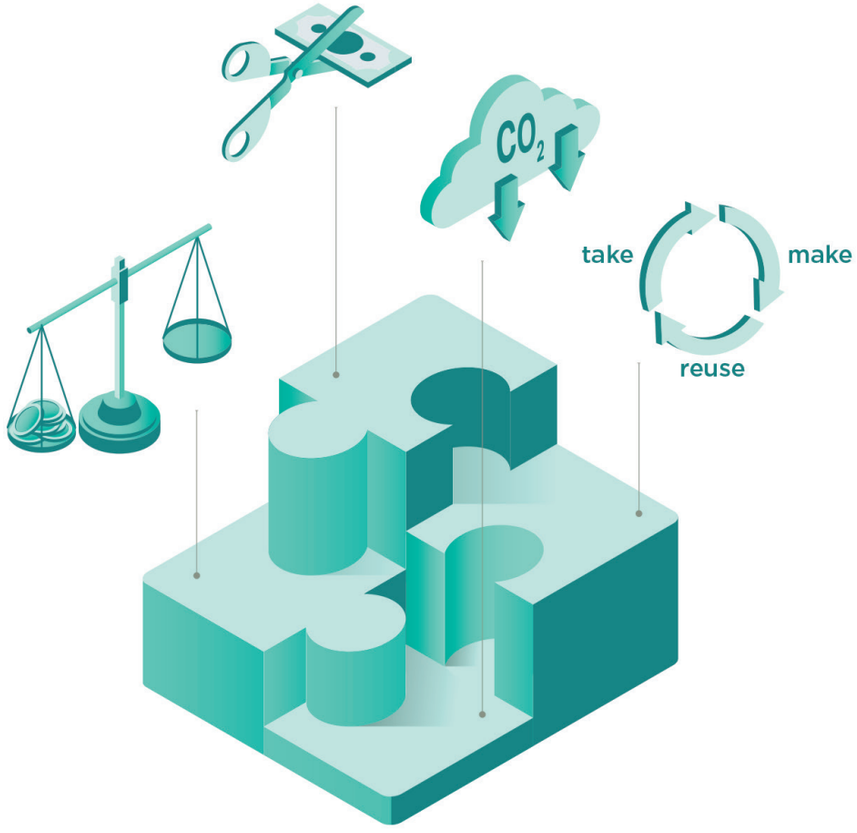
The CIRCE team developed two innovative machines that allow to select, resize and process carbon fiber scraps for their re-use.

5

Reuse to create new products

The re-processed carbon fibre prepreg scraps have been used to produce automotive components, brake discs, toecaps for safety work shoes and other types of applications.

Goal



Sustainable lightweighting

1. Weight reduction
2. Cost efficient
3. CO2 savings
4. Increasing circularity in composite

Results

CIRCE project set-up a circular economy model for uncured CFRP prepreg scraps. The achieved goal was 100 % valorization of this waste, to transform it into a useful secondary raw material to be used for producing new products.

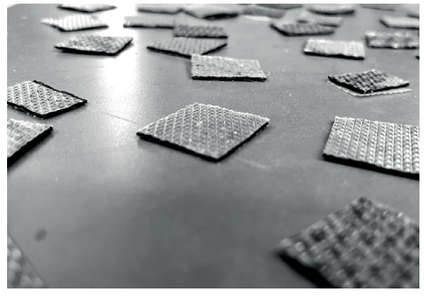
To reach this goal, **CIRCE**:

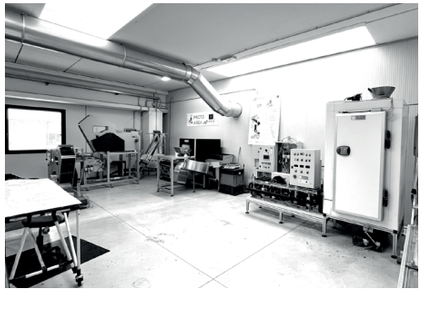
1) developed and industrialized a new industrial reprocessing treatment of prepreg scraps in order to prepare them for reuse;
2) overcame the absence of useful and economically affordable applications where to reuse the CFRP prepreg scraps.

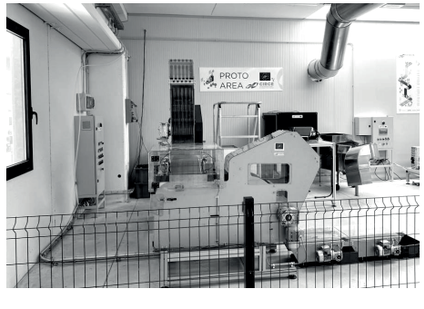
Specific objectives:

- Design, construction and validation of two innovative industrial pilot machines enabling CFRP prepregs sizing, treatment and packaging, by making the uncured CFRP scraps reusable;
- Demonstrate the production of new products (carbo-ceramic brakes, toe caps, automotive components) using recycled CFRP and prove their technical features and economic suitability;
- Elaborate and establish a circular economy model for those materials through industrial symbiosis;
- Perform quantitative assessment of the environmental impact indicators by LCA and LCC aiming to prove cost/environmental effectiveness of the proposed new solutions.

Recycling plant







1

Scraps preparation

The process starts with the arrival of prepreg waste at the recycling line. A pre-cutting operation is needed to prepare the scraps for being processed.

2

Shredding

The pre-cutted scraps are poured onto a conveyor belt. The belt advances and feeds a cutting station to resize the scraps according to specific dimensions. The output material is made by chips with regular shape (mainly rectangular) and dimensions, according to the machine set-up, ranging from 10 mm to 50 mm.

3

Peeling-off

A batch of re-sized chips are discharged into the hopper of the peeling station. The hopper opens and the peeling process starts. The protective films are removed by the prepreg and send to recycling through an aspiration duct. The peeled chips fall down into an outlet hooper. At the exit of the peeling station, we collect a batch of peeled prepreg chips ready to be used for new products manufacturing.

4

Quality control

For assuring that the material has been properly reprocessed, an optical control system is used. The new secondary raw material, by means of a conveyor belt, pass beneath a vision system to detect any anomalies. Only adequately reprocessed chips are packed at the end of the quality control station. Abnormal chips are discarded.

5

Storage unit

A freezing unit is used to storage both the inlet material and the new secondary raw material.

Second life applications

Toecaps

Using an experimental and numerical approach, CETMA and BASE PROTECTION worked strongly together to develop a new ecofriendly toecap, using carbon fiber prepreg scraps as raw material. The right thickness and layering of the composite material for the toecap for footwear was defined, with the purpose to reach high impact and compression resistances, as required in the Standard UNI EN ISO 20345. Structural optimization was conducted to improve the toecap design and performance and, also, to reach the best fit between the toecap and the commercial footwear line. The BASE PROTECTION KAPTIV line has been used for the testing validation. The results of laboratory tests have confirmed the good resistance of the toecaps made by 100% recycling material.

Carboceramics Brakes

Petroceramics was engaged in the recycling of waste from prepreg production to fabricate brake discs for high-performance applications in automotive. Carbo-ceramics prototype-discs were realized adding prepreg scraps as a partial substitution of carbon fibre chops. Good results of physical, thermal and mechanical properties were obtained up to 10% of prepreg content. The material properties are comparable to reference state-of-the-art material without prepreg.

Automotive components

HP Composites proved that the reclaimed materials could be successful used to manufacture vehicle components. Two different components have been developed and produced by using recycled prepreg: an accelerator pedal frame and a bonnet. These two components prove the flexibility of the new raw material in manufacturing different kind of components (structural and aesthetical). A dedicated manufacturing process has been developed for an efficient and effective production. Outstanding results both in terms of performance and aesthetical quality products have been reached, saving 50 % of environmental impacts respect to state-of-the-art technologies.

Environmental, economicand social benefits

The CIRCE project focusing on collecting and repurposing scraps of carbon fiber prepregs, resulted in significant environmental, economic, and social benefits. By diverting scraps from traditional waste streams and utilizing them in applications such as carbon ceramic brakes, toe caps, and car components, the project not only reduces the environmental impacts but also offers economic advantages and contributes to a more sustainable and socially responsible industry.

1

Environmental Benefits

The CIRCE project plays a crucial role in mitigating the environmental impact associated with carbon fiber prepreg waste. By collecting and reusing these scraps, it effectively reduces the amount of waste that would end up in landfills or incinerators. This approach helps conserve landfill space, reduces greenhouse gas emissions, and minimizes the depletion of natural resources needed for virgin carbon fiber production.

Overall, the CIRCE project's contributions to LIFE Environment & Resource Efficiency and LIFE Climate Action objectives are substantial. Through reductions in emissions, energy consumption, and resource usage, the project actively supports environmental sustainability. Additionally, by promoting the circular economy model and showcasing the benefits of recycled carbon fiber, the project influenced related policies and fostered a more climate-resilient industry. The CIRCE project exemplified the positive impact that targeted initiatives can have on environmental and climate goals.

2

Economic Benefits

One of the significant advantages of the CIRCE project lies in its economic benefits. By repurposing carbon fiber prepreg scraps, the project reduces the need for virgin carbon fiber production, which is an energy-intensive and costly process. This leads to substantial cost savings for industries utilizing these recycled materials.

The project stimulates the growth of a new market for recycled carbon fiber, fostering innovation and creating new business opportunities. The economic viability of the CIRCE project not only benefits companies involved but also contributes to overall industry sustainability and competitiveness.
By aligning economic success with environmental responsibility, the CIRCE project exemplified the potential of sustainable initiatives to drive both financial prosperity and long-term environmental sustainability.

3

Social Benefits

The CIRCE project extends its benefits beyond the environmental and economic aspects by positively impacting society. Firstly, it promotes sustainability awareness and responsible consumption, encouraging individuals and businesses to actively participate in waste reduction and recycling initiatives. Secondly, the project contributes to job creation and supports the growth of a skilled workforce specializing in carbon fiber recycling and related industries. This, in turn, enhances local economies and provides employment opportunities in communities where the project operates. Lastly, by minimizing the environmental footprint of carbon fiber production, the project helps safeguard the well-being and quality of life for present and future generations.

By addressing socio-economic challenges and promoting inclusive and sustainable practices, the project contributes to the overall well-being and social progress of individuals and communities. These social benefits reinforce the project's positive impact and its significance in driving holistic sustainability and responsible development.

TEAM

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