Bio-based and recyclable composite materials for transport application

Luigia Longo, CETMA & FURHY

Open Innovation Workshop

Processes and methods for recycling, reuse, and recovery of advanced composite materials in the transport sector

REPOXYBLE - Depolymerizable bio-based multifunctional closed loop recyclable epoxy systems for energy efficient structures
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repoxyble
BIO-BASED MULTIFUNCTIONAL RECYCLABLE COMPOSITES

Bio-based and recyclable composite materials for transport applications

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Materials and Structures Technology Department

Co-funded by the European Union

CETMA - Research and Technology Organization

- **Research and Technology Organization (RTO);**
- Applied research, experimental development and technology transfer in the field of **advanced materials**, **ICT** and **product development;**
- **65+ Employees: r**esearchers, engineers, designer & manager;
- **Offices and laboratories** extended for over 3.500 m^2.

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European Project

FURHY

PROJECT	
Project number	101091828
Project name	FULLY RECYCLABLE HYBRID BIO-COMPOSITE FOR TRANSPORT APPLICATIONS
Project acronym	FURHY
Call	HORIZON-CL4-2022-RESILIENCE-01
Topic	HORIZON-CL4-2022-RESILIENCE-01-11
Project starting date	1 July 2023
Project duration	42 months

- FURHY: **42-month EU project**, funded by Horizon Europe program, started on 1st of July 2023.
- Project Coordinator: **CETMA**
- Consortium: consists of **9 Partners across 5 countries**.

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Project Summary

The project aims at the development of a **new, bio-based, smart and completely recyclable composite material**, obtained by fast and low energy consumption out-of-autoclave process.

- **Matrix: new bio-based epoxy resin formulation filled by expanded graphite (EG);**
- **Hybrid composite: hemp and recycled carbon fibers (rCFs) as reinforcement;**
- **Manufacturing process: low energy version of the prepreg compression moulding (PCM);**
- **Main sectors of interest: aeronautics and automotive.**

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Consortium

- **8 partners** come from 4 different European countries;
- **1 associated partner** from UK.

N.	Role	Legal name	Short name	Type	Country
1	COO	CETMA - CENTRO DI RICERCHE EUROPEO DI TECNOLOGIE DESIGN E MATERIALI	CETMA	RTO	Italy
2	BEN	ONYRIQ LABS, SL	ONY	SME	Spain
3	BEN	LEONARDO - SOCIETA PER AZIONI	LND	LE	Italy
4	BEN	RINA CONSULTING SPA	RINA-C	LE	Italy
5	BEN	OLGUN CELIK SANAYI VE TICARET ANONIM SIRKETI	OLGUN	LE	Turkey
6	BEN	UNIVERSITA' DEGLI STUDI DI SALERNO	UNISA	HE	Italy
7	BEN	NANO-TECH SPA	NANO	SME	Italy
8	BEN	CENTRE SCIENTIFIQUE & TECHNIQUE DEL'INDUSTRIE TEXTILE BELGE ASBL	CTB	RTO	Belgium
9	AP	GEN 2 CARBON LIMITED	GEN2C	SME	UK

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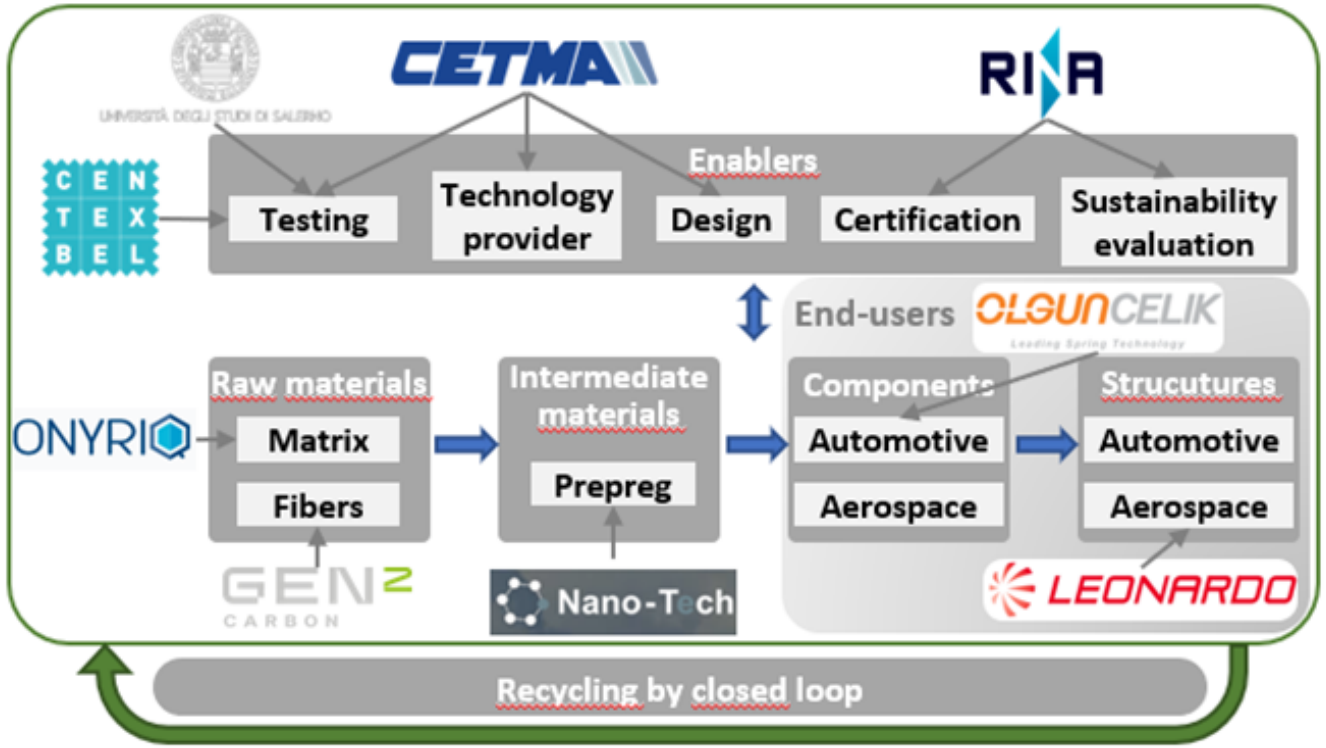
Consortium



- All the **expertise** necessary to finalize the project activities in the best way;
- A strong **complementary** in the know-how and equipment of the partners involved.

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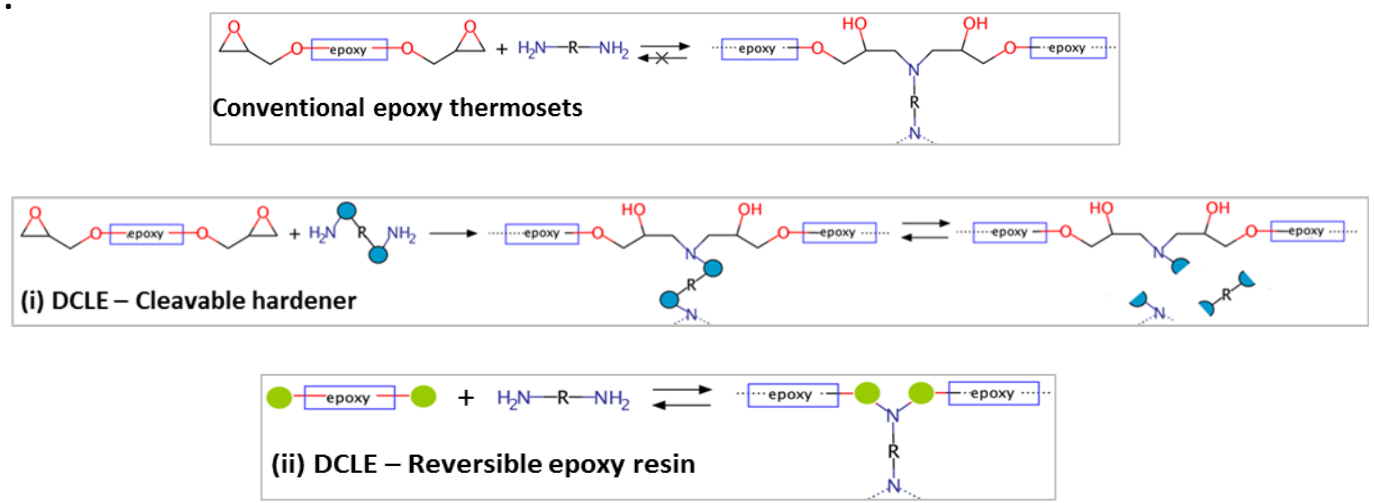
Project objectives

OB1. To develop an optimized **bio-based, fast curing, recyclable epoxy resin**, filled with **expanded graphite (EG)** that will promote electro-curing and will provide multifunctional and self-monitoring capability and a list of enhanced properties to the final composite material.

KPIs:

- Percentage of components coming from renewable resources in the epoxy resin: up to 80% with respect to the total components of the resin formulation.
- Glass transition temperature (Tg) of the final resin: 200°C - the target Tg of unfilled epoxy resin will be 150°C, increased of more than 30% thanks to EG.



Scheme of the two approaches of the Depolymerizable Closed Loop Epoxy (DCLE) system, compared with conventional epoxy thermosets

FURHY
Project objectives

OB2. To develop hybrid reinforcing fibers textiles by combinations of **bio-based virgin fibers and recycled carbon fibres**, including **appropriate fibre coatings** to maximize the fiber properties.

KPIs:

- Composite mechanical properties increase, given by the application of the coating to the fibers, of at least the 20% (both static and dynamic properties).
- Commingled hemp/rCF non-woven: fibre areal weight variation lower than +/-8% to ensure properties repeatability and correct closed mould processing.

Fiber architectures at ply level - (a) innovative hybrid commingled hemp/ rCF non-woven, (b) commercial rCF non-woven, (c) hemp fabric

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Project objectives

OB3. To develop a new effective and **reduced energy consumption out-of-autoclave process** for the new bio-based composite component manufacturing, consisting in prepreg compression moulding (PCM).

KPIs:

- PCM cycle time: <2 min for 3 mm thick laminates.
- Void % in the final composite material: <2%.

Hot-melt prepreg line for prepreg manufacturing at Nano Tech

Pilot-scale (CETMA) press for PCM process development

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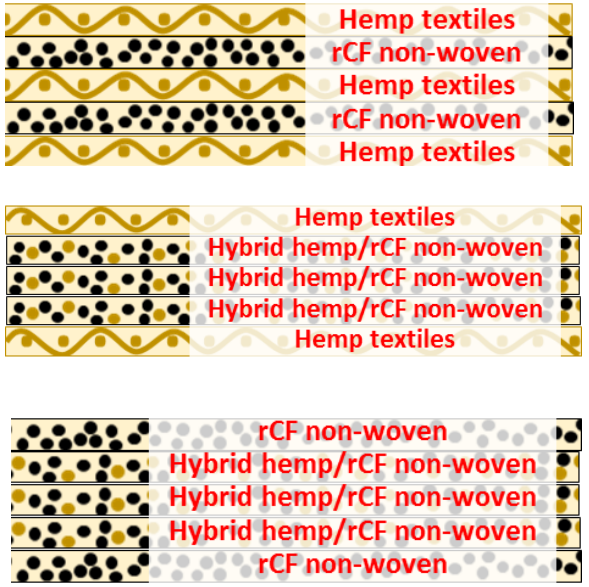
Project objectives

OB4. To design and develop a set of new composites, with **different lay-up**, thus providing the possibility to tailor functionality for a range of possible applications.

KPIs: New bio-based hybrid laminates with tensile modulus up to 30÷40 GPa and tensile strength up to 300÷400 MPa, with improved dumping properties.



Examples of interply hybrid laminates

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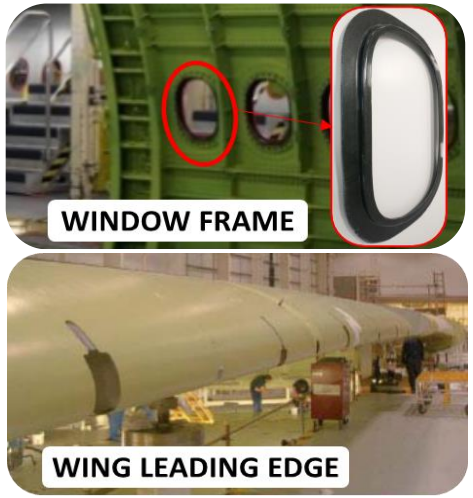
Project objectives

OB5. To demonstrate the potential of the innovative composite material by the design of 2 **aeronautic** and 2 **surface transport (automotive) application**.

KPIs: Design of N° 4 demo products.



Components candidate to be selected for the aerospace (left) and the automotive (right) applications

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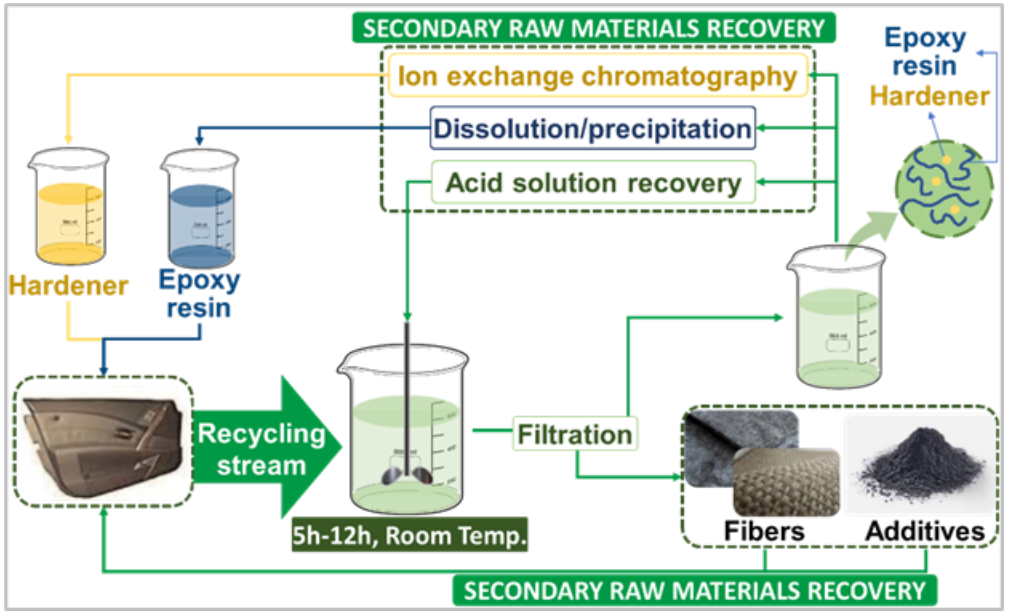
Project objectives

OB6. To develop a **new recycling technology** suitable for the **recovery of all the constituents of the composite structure**, providing secondary raw materials having properties similar to the virgin original materials.

KPIs:

- 85% of starting monomers recovered, 90% of EG recovered, 100% of reinforcing fibers recovered.
- 75% of mechanical performances (strength and modulus) retained for hemp fibers, 95% for rCF.



Closed loop (synthesis + chemical recycling) for DCLE-based composite

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Methodology

furhy
fully recyclable hybrid
bio-composite
for transport application

Innovative solutions in each stage of the product chain.

Real step **change** in the composite material sector.

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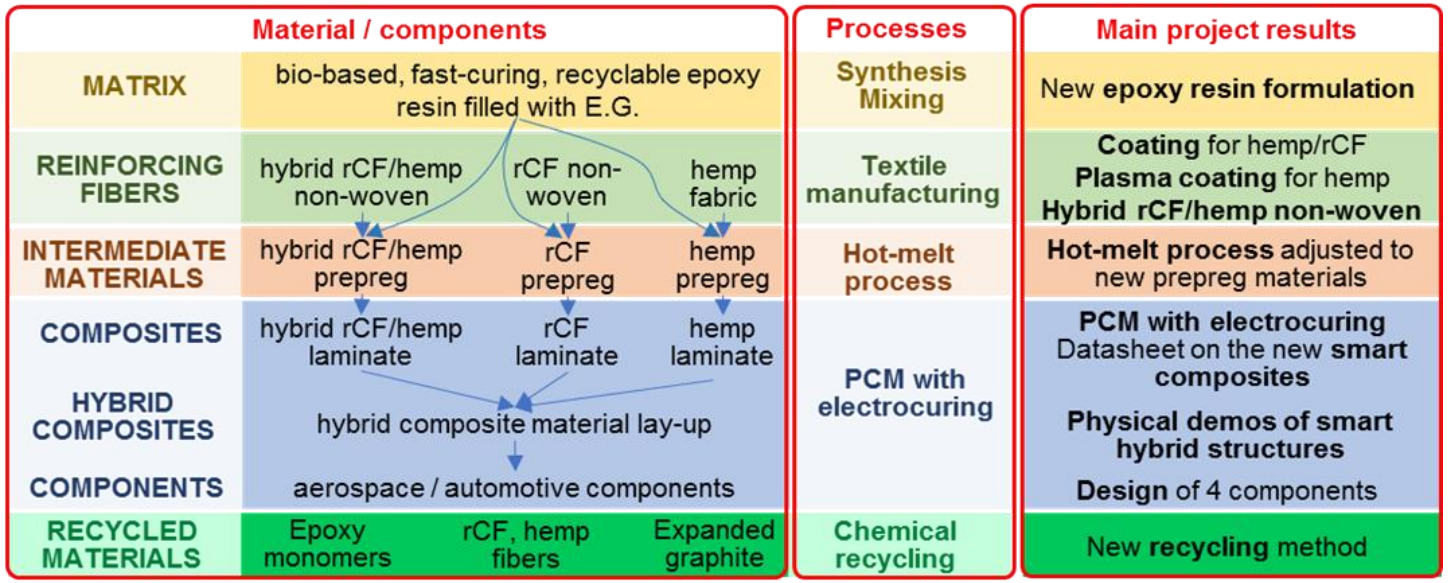
Methodology



- **Innovative materials and components;**
- **Innovative manufacturing processes.**

Very numerous variables involved in the new materials/processes development.

Collection of the necessary data **in all the stages of project development.**

Use of **material modelling** and **virtual testing**.

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Ambition

- High-performance bio-based epoxy resins;
- Fast-curing epoxy system;
- Fully recyclable epoxy systems;
- Hybrid hemp/rCF reinforced composites;
- Self-monitoring;
- Electro-curing (material improvement);
- Prepreg compression moulding by electro-curing (process improvement).

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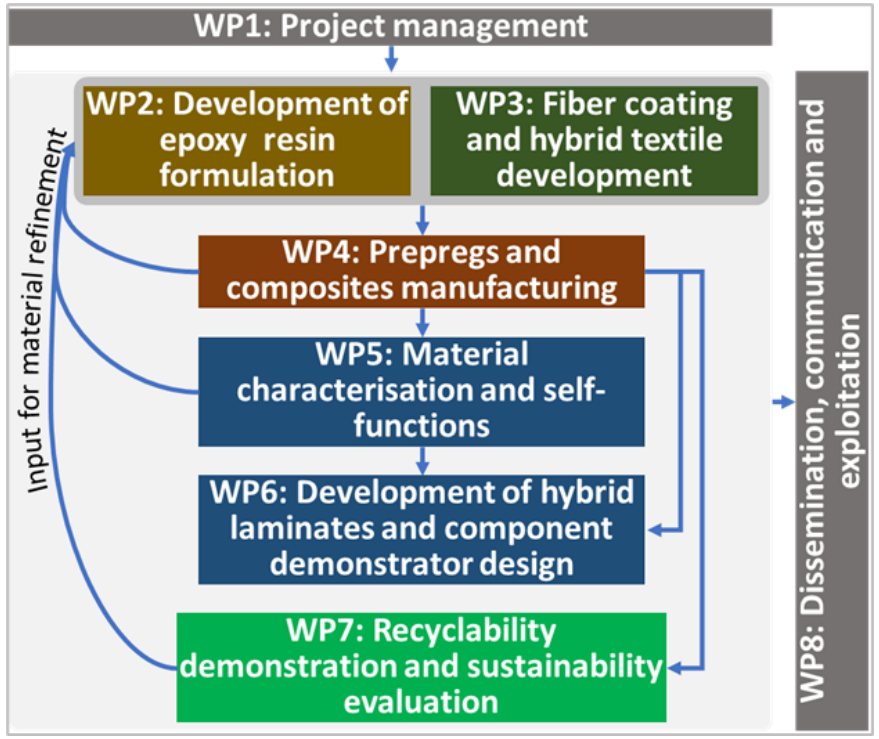
WPs and Work plan

Work Package n.	Work Package name	Lead Beneficiary	Start month	End month
WP1	Project Management	CETMA	1	42
WP2	Development of epoxy resin formulation	ONY	1	39
WP3	Fiber coating and hybrid textile development	GEN2C	1	39
WP4	Prepregs and composites manufacturing processes development	CETMA	7	39
WP5	Material characterization and self-functions analysis	UNISA	22	28
WP6	Development of hybrid laminates and component demonstrator design	OLGUN	29	42
WP7	Recyclability demonstration and sustainability evaluation	UNISA	19	42
WP8	Dissemination, communication and exploitation	RINA-C	1	42



Thank you!

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