Challenges and pathway towards sustainable recycling, reuse or repair of large composite structures; the EURECOMP approach

1st EURECOMP Webinar

13.03.2024/TEAMS

Dr. Kate Trompeta, Prof. Costas Charitidis

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

R-NANO

Content Overview

- ❑ Motivation
- ❑ EuReComp in a nutshell
- ❑ Consortium
- ❑ Mission
- ❑ Objectives
- ❑ Concept
- ❑ Work Plan
- ❑ Meet Our Team

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

Motivation

When wind turbine blades get old what's next?

1 day ago

The old wind turbines at Hagshaw Hill wind farm in Scotland have been dismantled

- Traditional solutions include using pieces of decommissioned blades in cement kilns to manufacture cement, though this can be an energy intensive process.
- Blades are also commonly disposed of in landfill sites which will be banned
- Innovative solutions such as repurposing blades into playgrounds or bike sheds have been shown to be effective only at a local level
- Scientists and start-ups are working on the problem, with many focusing on tackling the challenge of breaking down the materials used in the blades.

"**At the end of life, if we're going to get any value out of the materials, we need to be able to separate the fibres from the resin in some way or another**," Dr Claire Barlow, sustainability and materials engineer, from University of Cambridge

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

EuReComp Mission

The **cumulating composite wastes** are more prominent than the needed new composites. The **aircraft** and **wind energy** sectors contribute to a major share.

Across all industries about 60% of waste **fibre reinforced** composites is **landfilled**, causing severe **societal and environmental issues**.

EU's **Circular Economy plan** seeks to reduce the landfill down to 10% by increasing the rate of **recycling.**

Stakeholders seek **advanced technologies** and **end-of-life options**, which promote the **recycling** of carbon fibres.

EuReComp project has a strong focus on **circularity**, setting out to provide **sustainable methods towards recycling and reuse of composite materials**, coming from components used in various industries, such as aeronautics and wind energy.

EuReComp pathways towards circularity:

- Repairing, repurposing and redesigning parts from end-of-life large scale products and
- Recycling and reclamation of the materials used in such parts

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

EuReComp in a nutshell

DURATION
48 months

9 EU countries

COORDINATOR
Prof C. Charitidis

STARTING DATE
01/04/2022

20 partners

BUDGET
~9 M euros

PROJECT ACRONYM/TITLE
EuReComp
European recycling & circularity in large composite components

GA NUMBER
101058089
CALL: A digitized, resource-efficient and resilient industry 2021

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

EuReComp Consortium

20 Industrial and academic partners with complementary and multidisciplinary expertise!

- ✓ 2 IND
- ✓ 11 RTO
- ✓ 7 SME

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

EuReComp Consortium

KOM Meeting, April 2022, NTUA, Athens

12M Meeting, April 2023, TUD, Dresden

6M Meeting, September 2022, Barcelona

18M Meeting, September 2023, INEGI, Porto

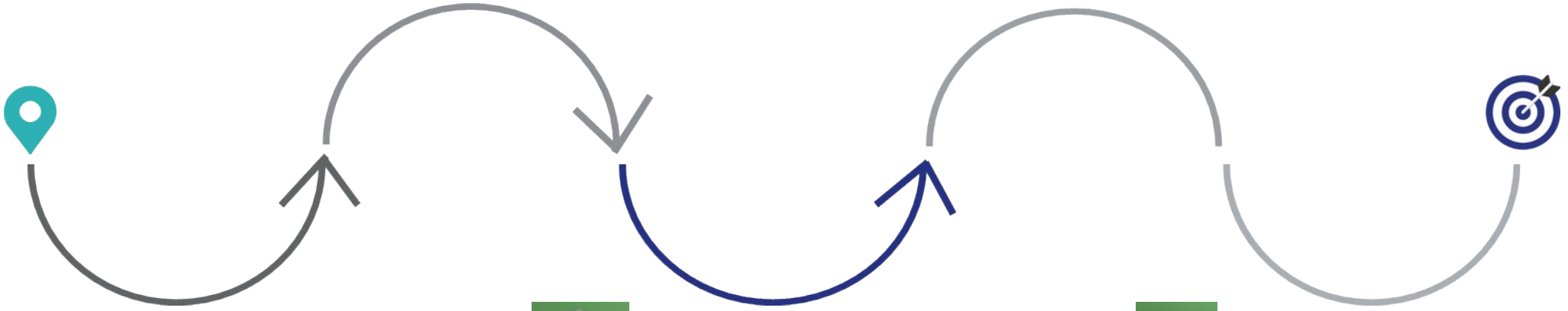
Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

EuReComp Objectives

To develop and integrate novel solutions for a **higher reuse** of whole products and components

To develop tools to demonstrate the **circularity** and the **environmental benefits** of the solutions tested



To propose innovative **dismantling** and **sorting** systems enabling reuse and recycling of complex composite materials

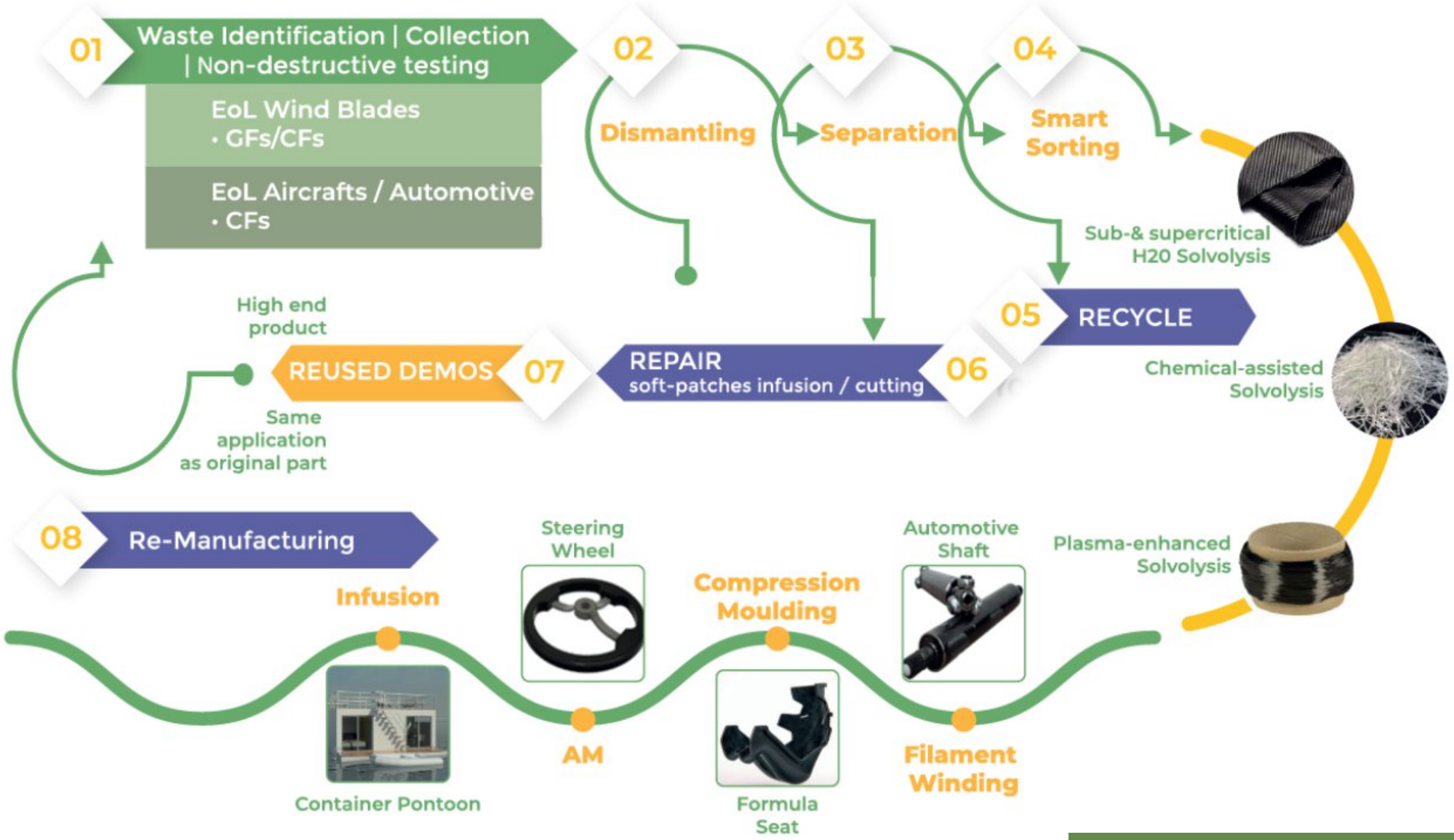
Pilot demonstration of reuse/recycling approaches of composites & secondary raw materials

To consider the **co-design of learning resources** together with local and regional educational organizations for current and future generations of employees

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

EuReComp Concept



Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

Work Plan

WP6 – IRES

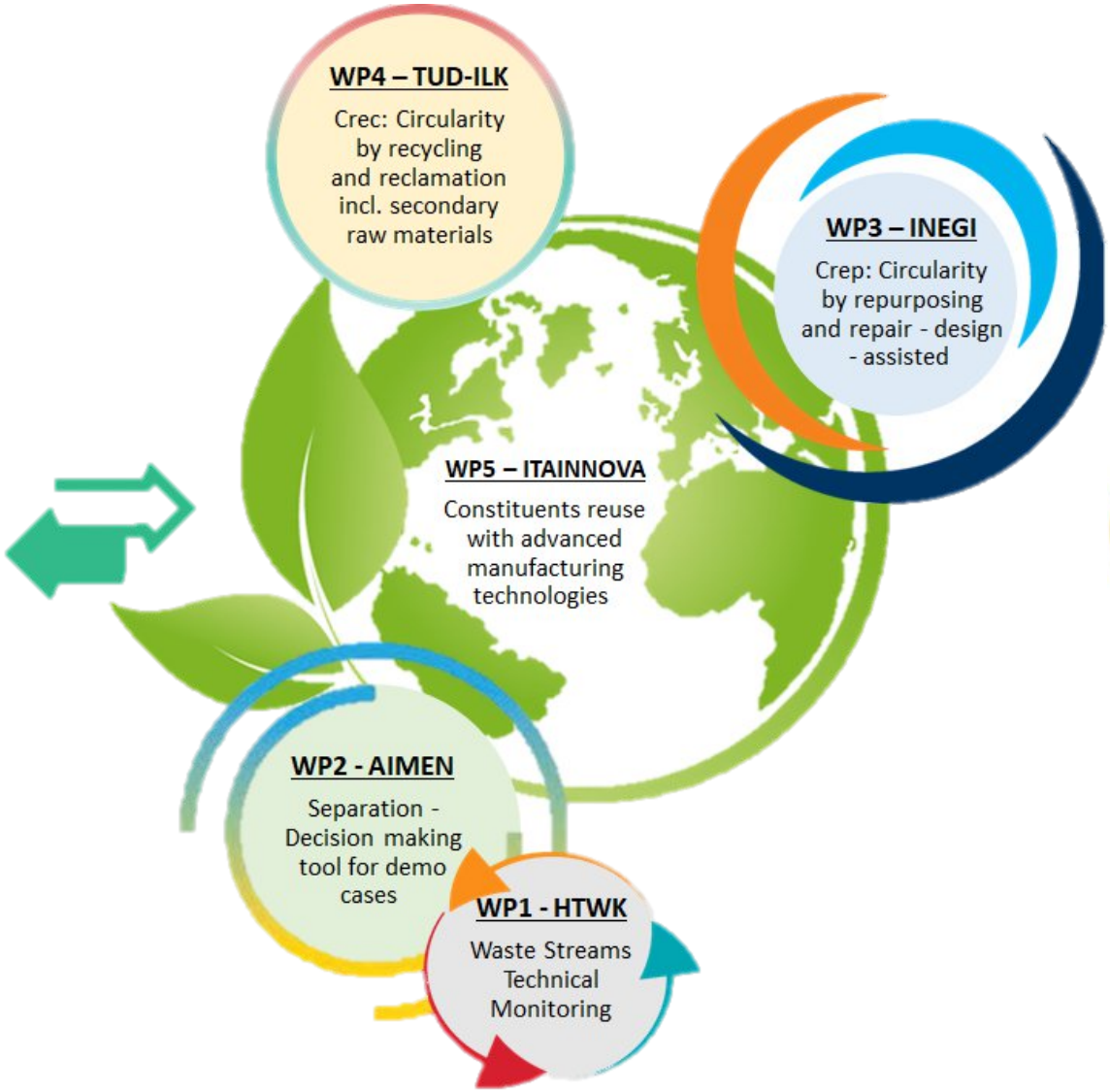
SEP labelling: Safety-Environment-Performance

WP7/8 – KUZ/EASN

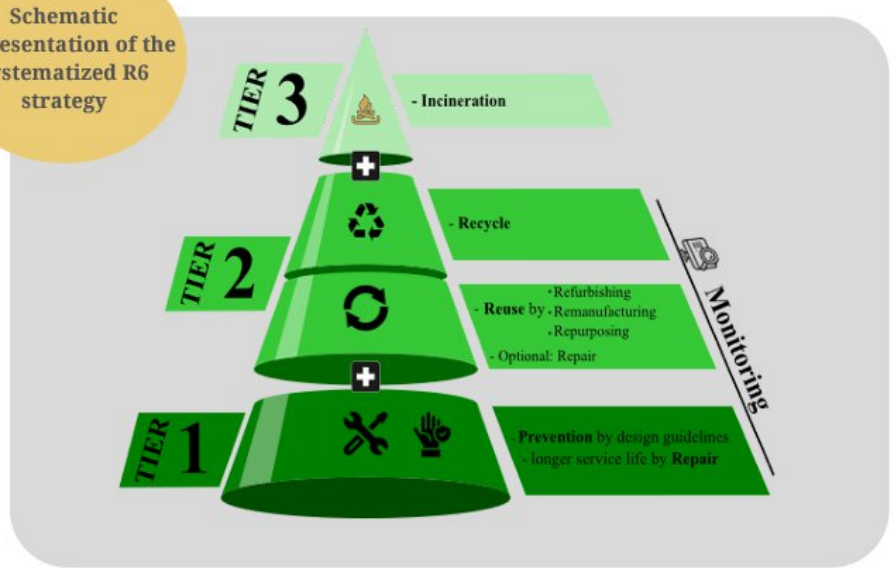
Commercial attractiveness – standardization, policies and exploitation

WP9 – NTUA

Project Management



Schematic representation of the systematized R6 strategy



Funded by the European Union

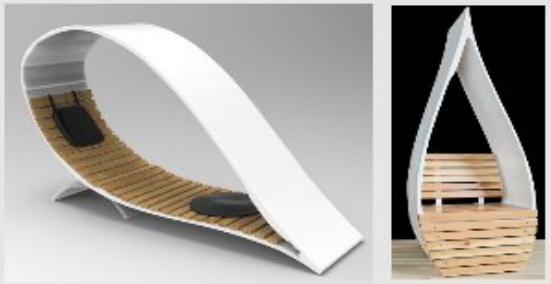
Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

WP1: R6 Strategy for waste streams management

WP1: R6 Strategy for waste streams management

Objectives:

1) Circular design strategies with increased product durability
2) Stakeholder identification for new commercial possibilities and business opportunities
3) Networking with other clusters, networks, projects and regional initiatives
4) Establishment of waste management system and logistical framework for EuReComp

Structural applications	Non-structural applications
 Bridge; [13],[22],[28]	 Sound barriers along freeways; [28]
 Bike shed; [3]	 Playground; [3],[9],[29],[13],[23]
 Cell-phone-tower; [28]	 Bench; [30]

Funded by the European Union

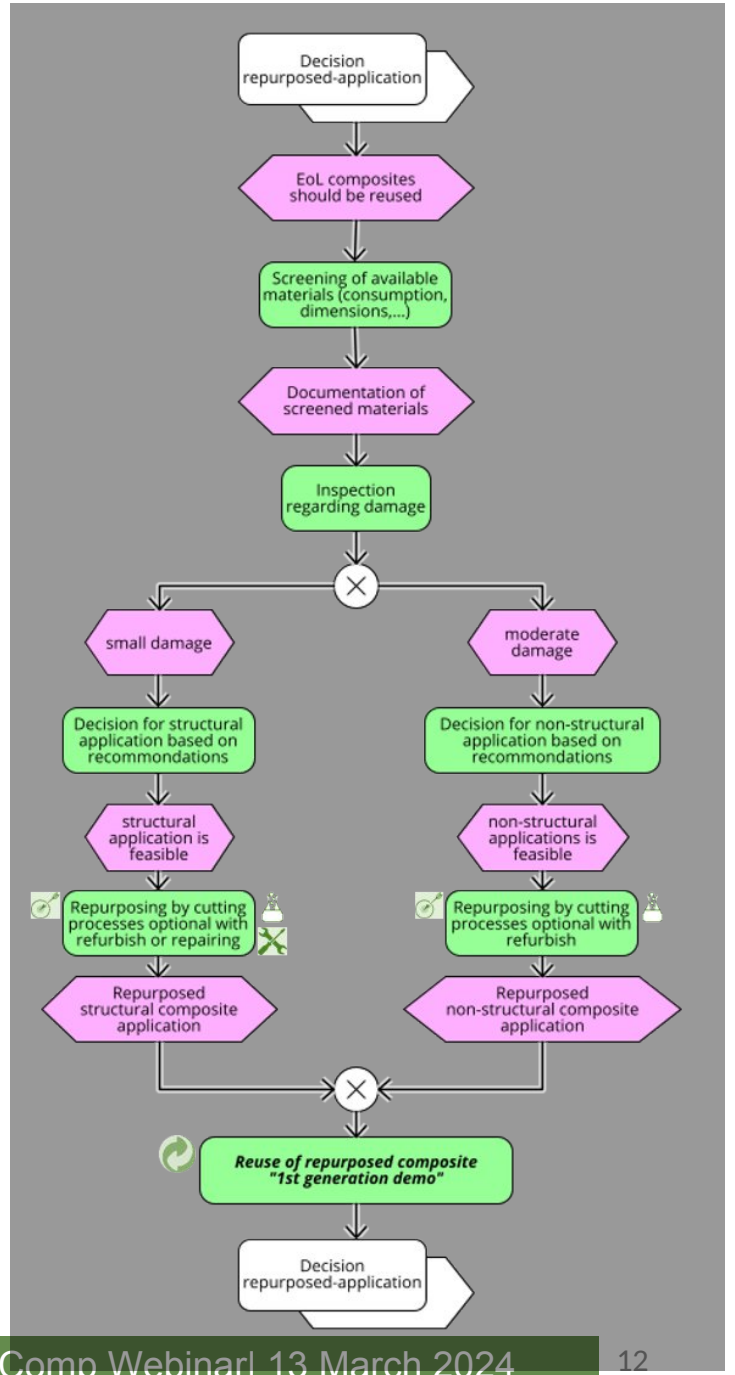
Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

WP1: R6 Strategy for waste streams management

MS1 – Business cases defined based on R6 strategy

Design strategies specifically tailored for large-scale composites:

- **Material selection:** Choice of composite materials known for their durability and environmental resistance.
- **Recycled materials:** Investigate the use of recycled composites from discarded structures or products as feedstock for the production of new composites.
- **Eco-friendly manufacturing:** Implement eco-friendly manufacturing practices, such as reducing waste and energy consumption in the production of large composite parts.
- **Modular construction:** Design of large composite structures in modular sections that can be easily replaced or upgraded individually, reducing the need for complete replacement.
- **Design of durability/Adaptive design:** Principles that allow large composites to adapt to changing conditions, reducing the need for replacement.
- **Repairability:** Design composite structures with easily accessible components that allow for easy and cost-effective repair.
- **Material traceability:** Implement traceability systems to track the source and life history of composite to ensure they can be properly recycled or repurposed at EoL.
- **Certifications and standards:** Ensure that composite products meet relevant sustainability certifications and standards.



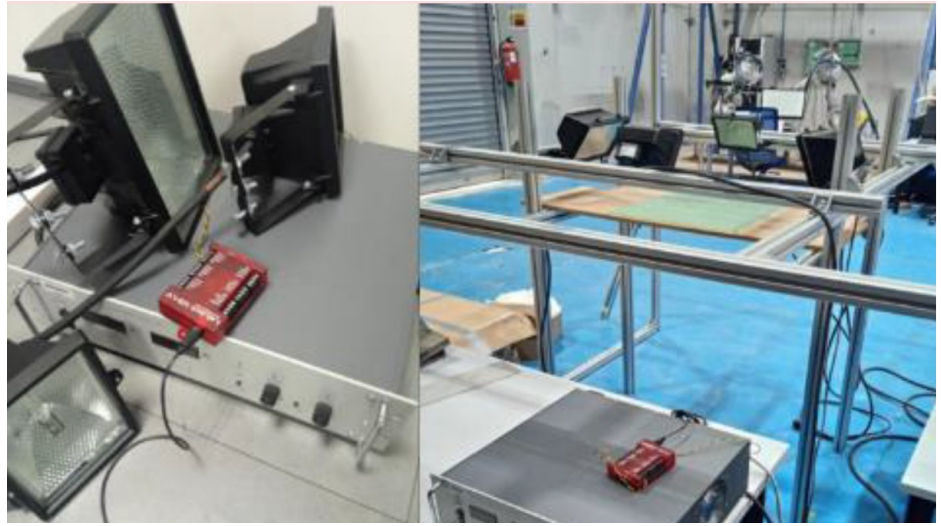
Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

WP2: Separation Decision making tool for demo cases

Smart decision tool methodology:

1. EoL CFRP and GFRP parts
2. Quality checking of EoL parts
3. Definition of requirements for reusing
4. Material identification
5. Dismantling and separation activities
6. Repairing/Reusing/Repurposing route
7. Recycling route



WP2: Separation Decision making tool for demo cases

Objectives:

1) Design of system for tracking quality & quantity of disassemble and separate multi-materials for reuse
2) Demonstration of an intelligent sorting system; separation of waste according to the specifications of the recycling

technologies

3) Improvement of methodologies/strategies for analysis, disassemble and separation of multi-material debris

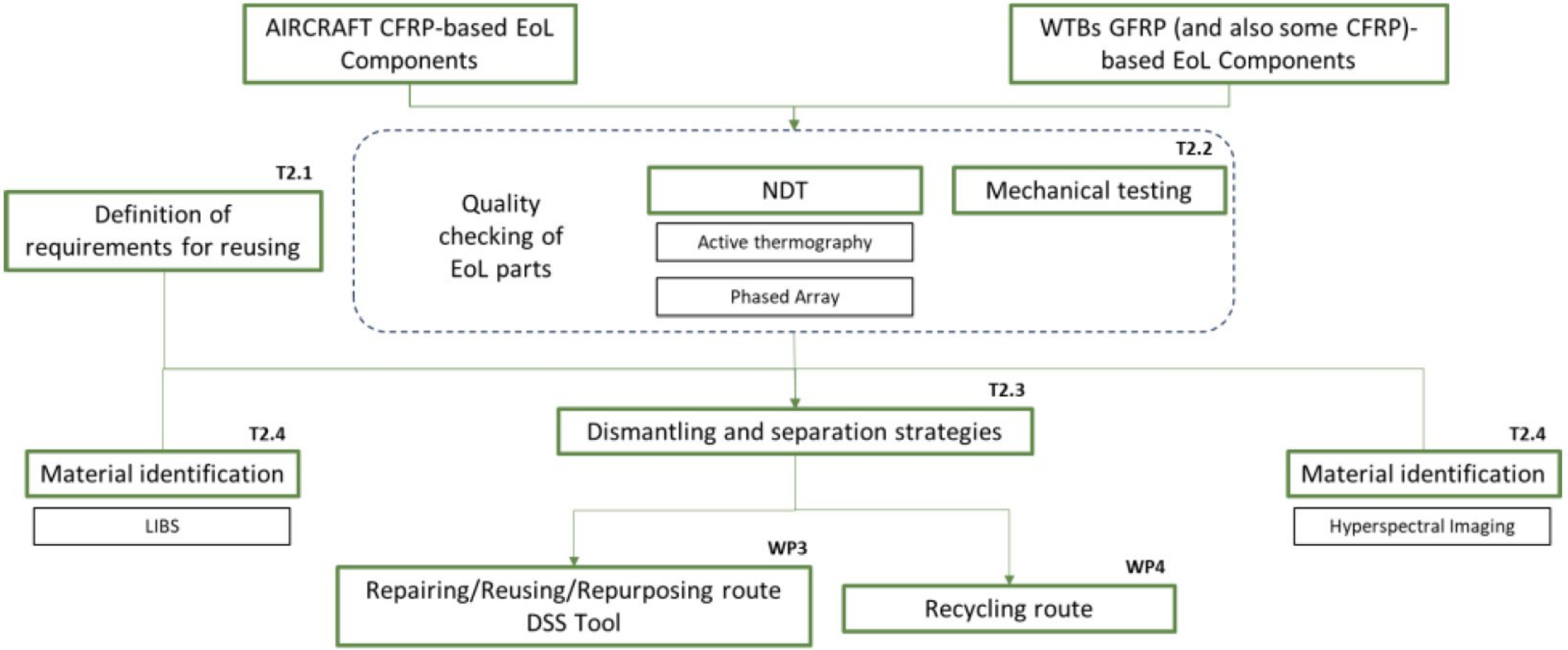
NDT Techniques used within EuReComp

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

WP2: Separation Decision making tool for demo cases

MS2 - Decision tool for Reuse or Recycling



Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

WP3: Crep: Circularity by repurposing and repair - design-assisted

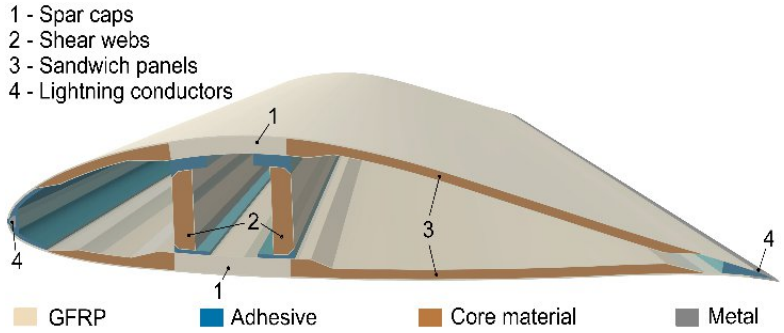
WP3: Crep: Circularity by repurposing and repair - design-assisted

Objectives:

1) Assessment of repairing technologies for products life-time extension and repurposing including the development of
new methods for repairs improvements

2) Demonstrator's design for the prevention and reduction of waste using advanced modelling strategies, evaluation
and validation

3) Development of business guidance on the safety assessment of reused and repaired components

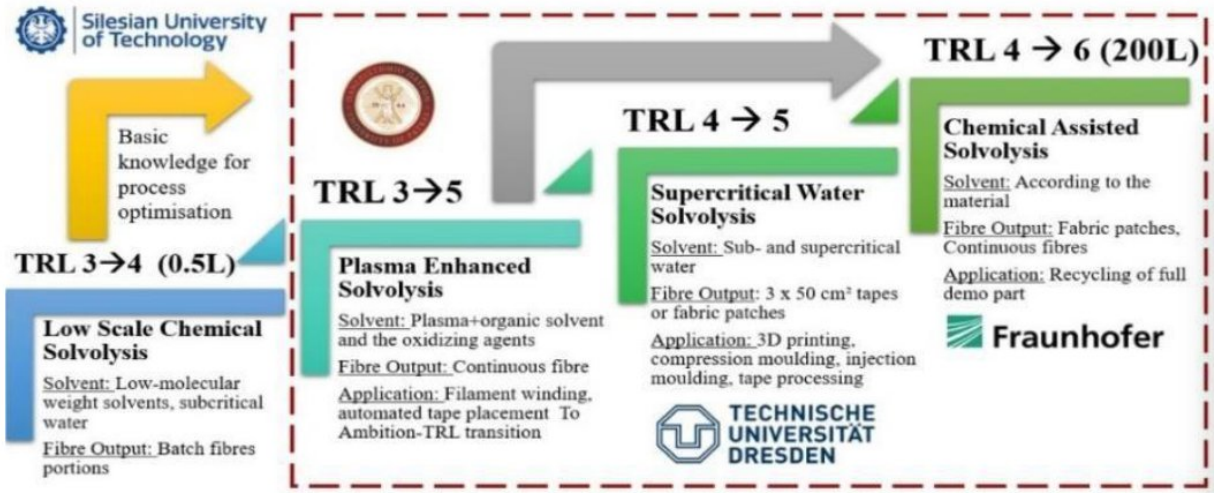


Float test with PV-floating system (HTWK, INEGI)

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

WP4: Circularity by recycling and reclamation incl. secondary raw materials



University of Patras

Continuous and short fibres reclaimed by plasma enhanced solvolysis

WP4: Circularity by recycling and reclamation incl. secondary raw materials

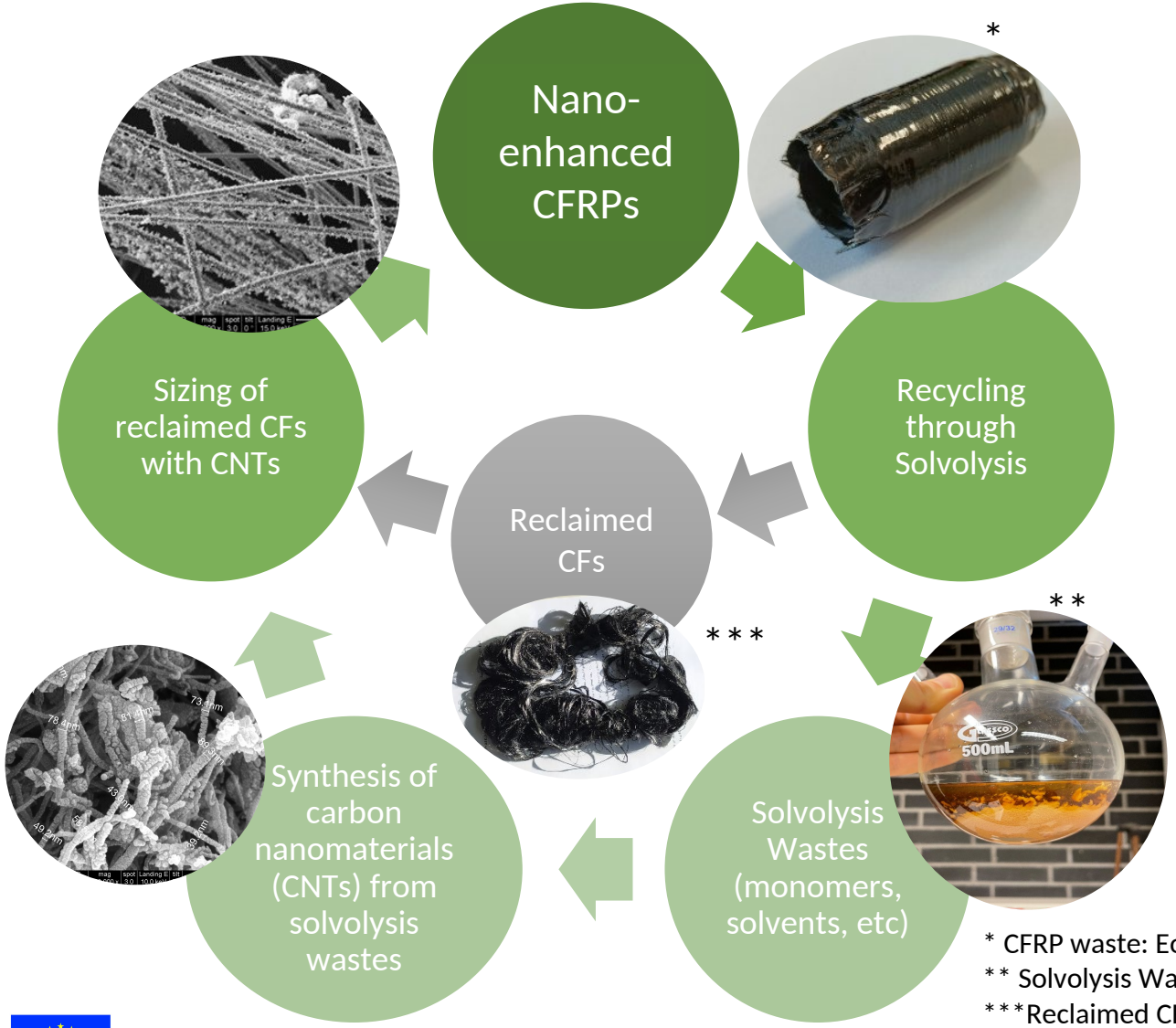
Objectives:

1) Optimization of solvolysis condition for fibre and matrix separation
2) Production of high-value long fibres for textile fabrics and continuous yarns
3) Recirculation for waste material streams minimization; Fractionation of dissolved matrix & solvents
4) Simulation of dissolution and waste treatment processes as well as the structural mechanical potential of the obtained fibre materials in new composites

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

Circularity: From CFRPs to Nano-Enhanced CFRPs



Advantages:

- **Exploitation of solvolysis wastes** (major issue of the recycling process)
- Synthesis of **high-added value nanomaterials** (e.g. CNTs) from waste streams
- **Enhancement** of reclaimed Carbon Fibres and properties **improvement**
- New **nano-enhanced CFRPs** produced from recycled materials
- **Circularity** in the composites value chain

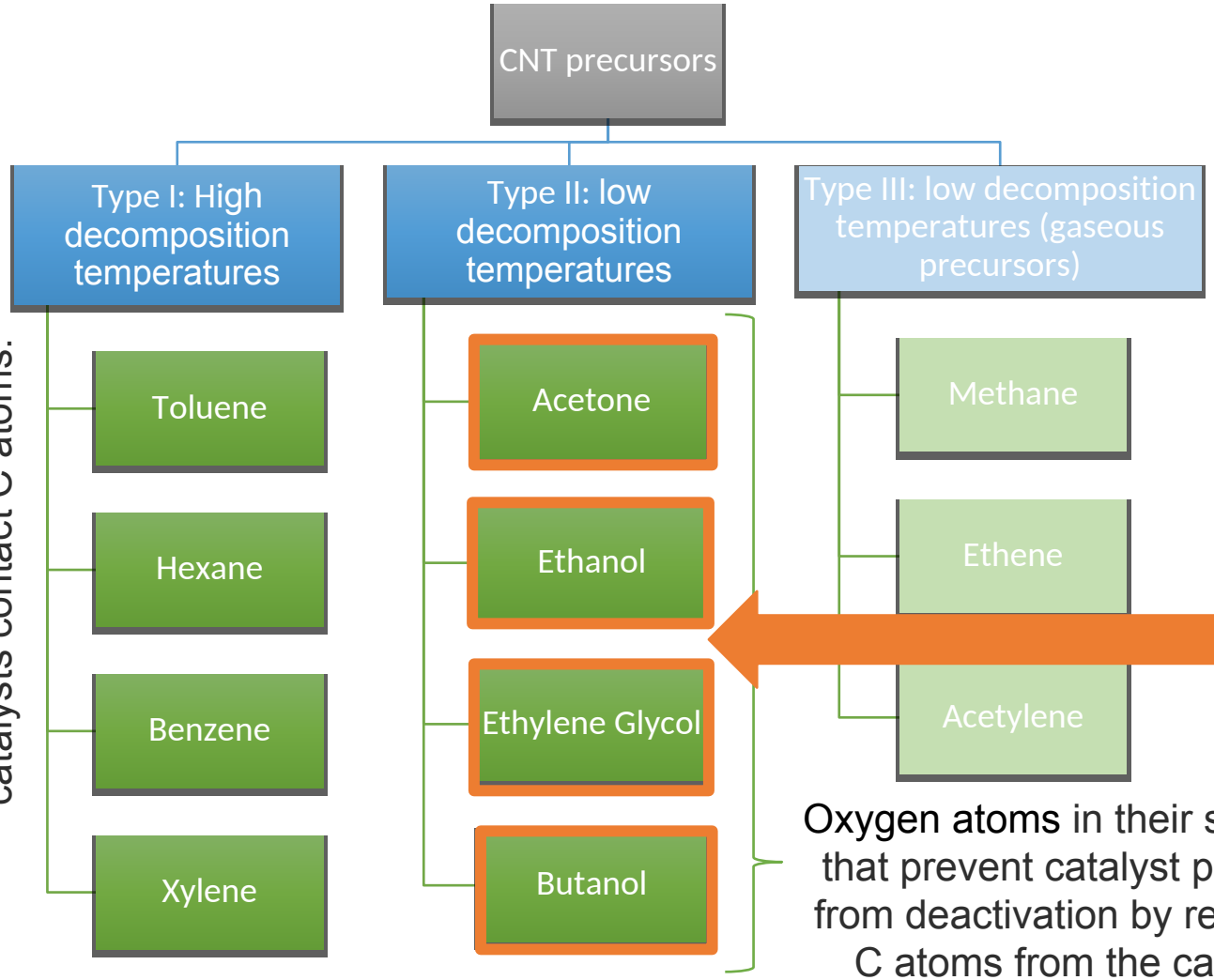
* CFRP waste: EoL part from B&T made by filament winding
** Solvolysis Wastes: By-product of Solvolysis process of SUT
***Reclaimed CFs: Achievement of UPATRAS through plasma enhanced solvolysis

Funded by the European Union

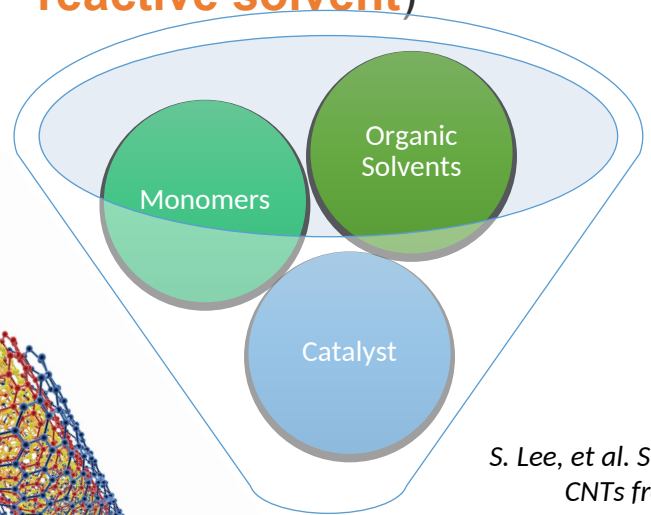
Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

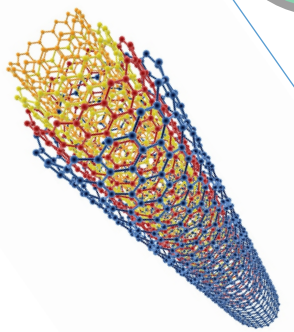
Solvolysis Wastes as Precursors for CNTs growth

Various organic precursors (hydrocarbons) in liquid form have been used to synthesize CNTs:



The resulting liquid waste byproduct from a CFRPs solvolysis process contain a mixture of water (in the case of supercritical water) and **organics** from the depolymerization of the thermoset resin (monomers and **excess reactive solvent**)





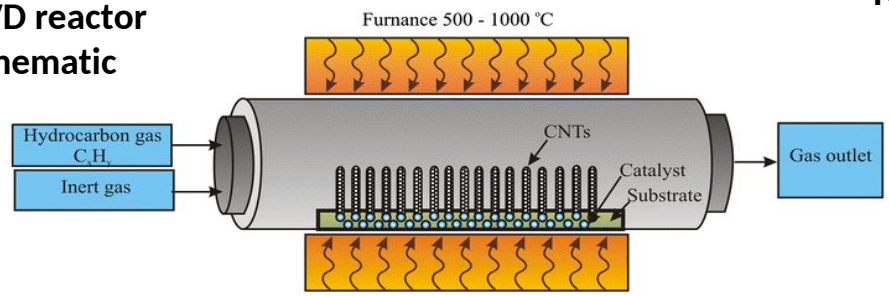
MWCNTs

S. Lee, et al. Synthesis of CNTs from carbon precursors with low decomposition temperatures using a direct spinning process, Carbon, 124, 2017, 219-227,

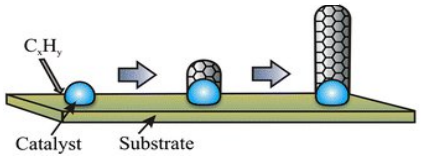
Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

Chemical Vapour Deposition Set-Up

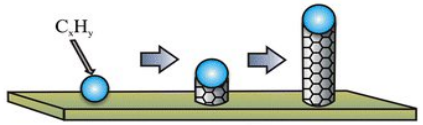
CVD reactor schematic



Base CNT growth

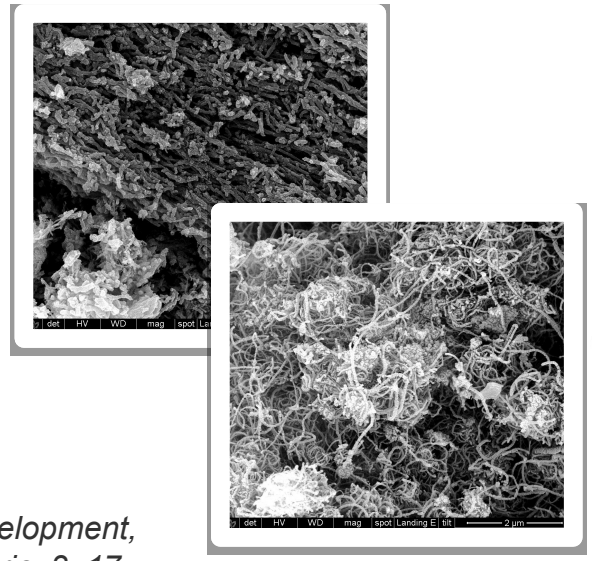


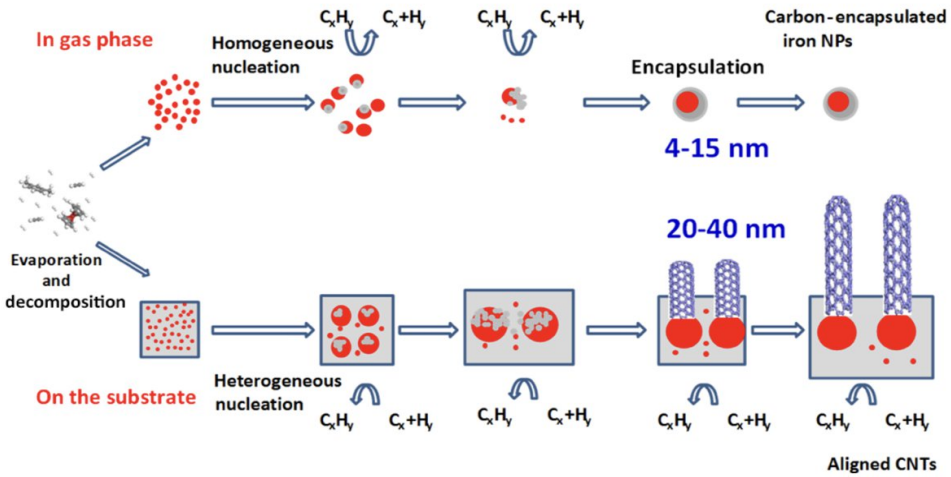
Tip CNT growth



Zaytseva & Neumann, Carbon NMs: production, impact on plant development, agricultural and environmental applications. Chem. Biol. Technol. Agric. 3, 17 (2016).

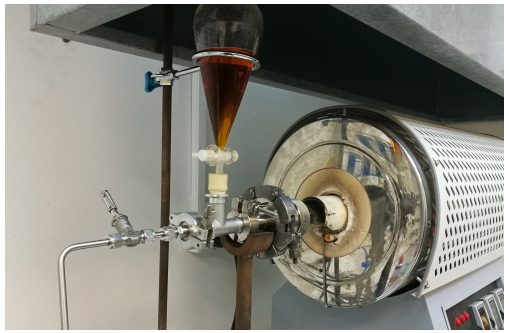
MWCNTs in entangled or aligned form





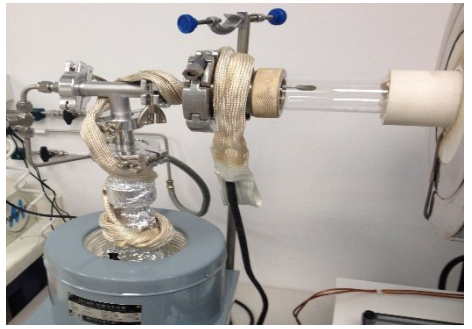
Y. Xu, et al.Evolution of Nanoparticles in the Gas Phase during the Floating CVD Synthesis of Carbon Nanotubes. J. Phys. Chem. C, 2018, 122 (11), 6437-46.

Different inlet alternatives to introduce the Solvolysis Liquid Waste in the CVD Reactor in R-NanoLab

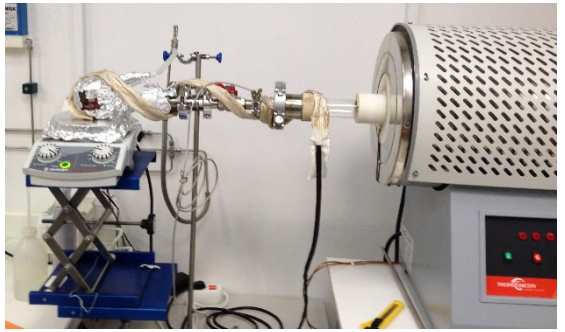


Introduction through separation funnel

Boiling in conical flask



Boiling in spherical flask



Boiling in two-necked spherical flask

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

WP5: Constituents reuse with advanced manufacturing technologies

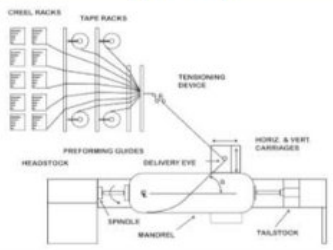
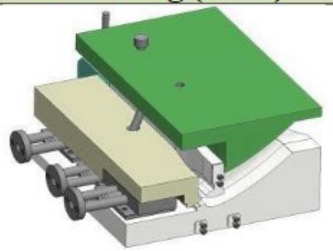
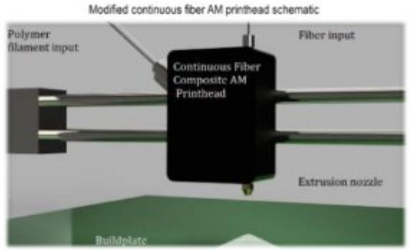
WP5: Constituents reuse with advanced manufacturing technologies

Objectives:

Achievement of circularity through EuReComp different remanufacturing technologies/routes:

1) Manufacturing of 2nd generation new products
2) Manufacturing of demonstrators covering various sectors/applications

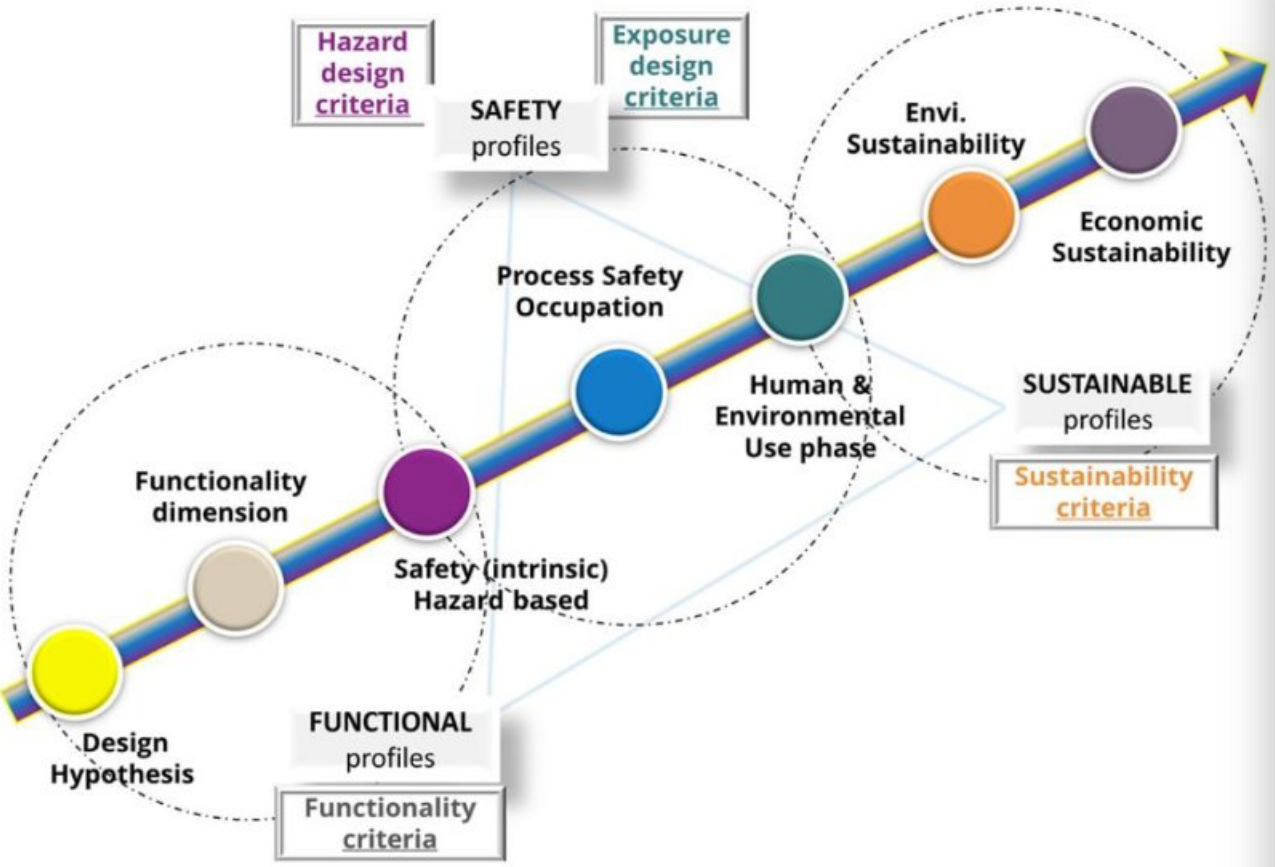
EuReComp 2nd Generation Demonstrators

Filament Winding (B&T)	Compression Moulding (DAL)	3D printing (BIO)	Vacuum Infusion (APM)
			
Automotive Shaft 	Formula Seat 	Steering Wheel 	Container Pontoon 

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

WP6: SEP Benchmarking: Safety-Environment-Performance



WP6: SEP Benchmarking: Safety-Environment-Performance

Objectives:

Holistic LCA of composite materials (WP1-5) and SEP Decision Tool

1) Cost evaluation; Cost of materials and manufacturing but also the wider implications of technology selection on company performance.

2) Market analysis; The whole life cycle will be assessed in terms of Sustainability, Impact & Performance

3) Risk assessment on innovative processes and recommendation of SbD guidelines

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

WP7: Training and life-long learning

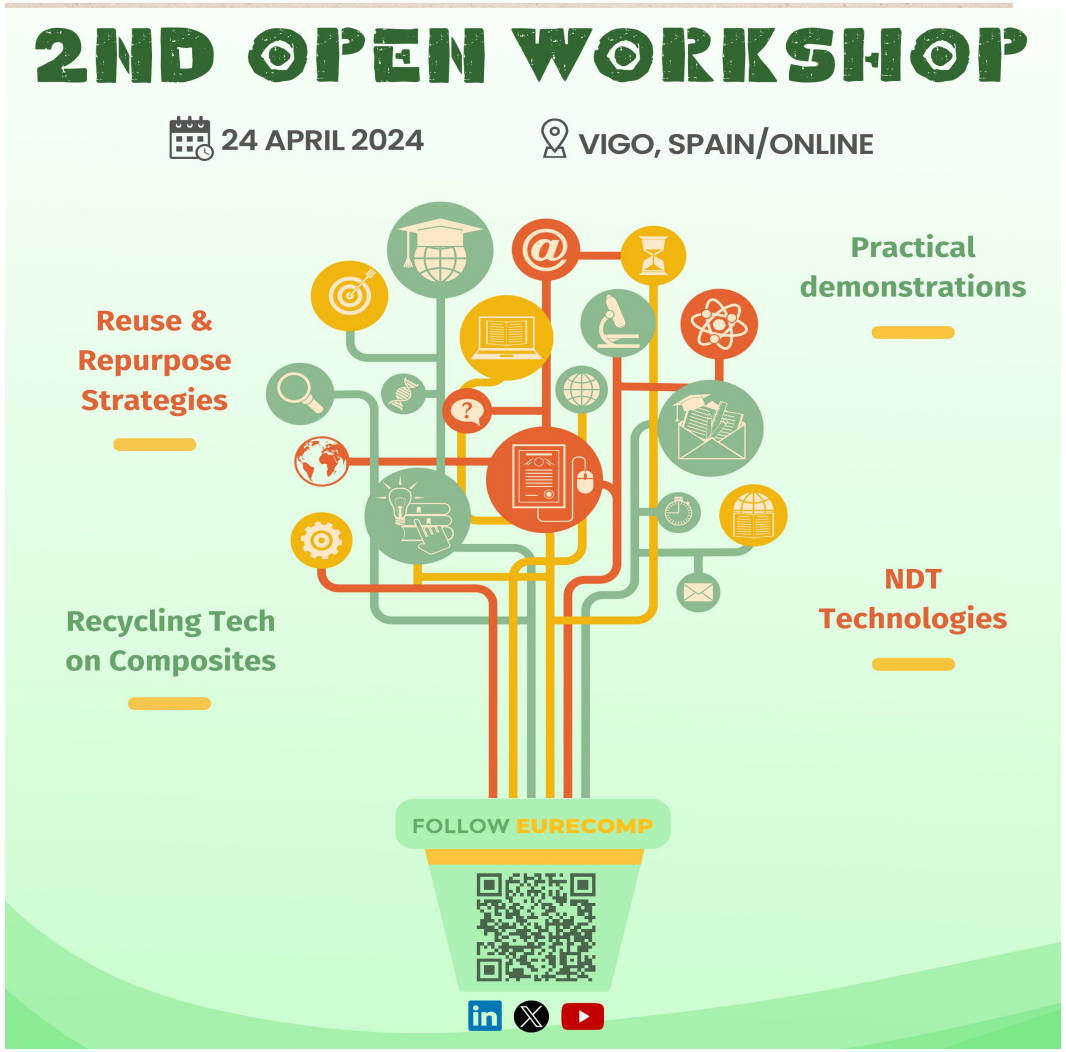
WP7: Training and life-long learning

Objectives:

1) Insurance of the recruitment and retention of skilled workers from current and future employee generations through a comprehensive training and life-long learning concept for the technologies developed in EuReComp

2) Modular training concept depending on technical/qualification level - from career changers to post-graduates

3) Innovative learning and teaching methods; blended learning, augmented reality, flexibly adjusted to individual focal points, learning tempos and regional social needs



Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

WP8: Communication, Dissemination & Exploitation

Special session:
"Advancements in Manufacturing Lightweight Structures"
https://www.icmr.org.uk

Where: 21st International Conference on Manufacturing Research (ICMR2024), Glasgow, Scotland
When: August 28-30, 2024
Abstract Submission Deadline: March 30, 2024
*Please, inform us if you are planning to contribute with a work for this Special Session, till the **15th of March**.*

WP8: Communication, Dissemination & Exploitation

Objectives:
Increase awareness and interest amongst stakeholders; further exploitation of EuReComp results
1) Creation effective communication & dissemination channels based on information needs of identified groups
2) Strengthen EU's industrial base and boost its competitiveness and open strategic autonomy

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

WP8: Communication, Dissemination & Exploitation

- Synergetic effect of nanomaterials in reinforcing fiber-based composite materials
- Smart polymeric nanocomposites
- Novel processing technologies for fiber-based composites
- Smart functionalities of fiber reinforced composites
- Multifunctional fiber-based polymer composites
- Modelling and simulation for fiber-reinforced polymer composites
- Recycling of thermoplastics and thermosets reinforced with fibers.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

EuReComp Webinar Series 2024

1.Challenges and pathway towards sustainable recycling, reuse or repair of large composite structures; a EURECOMP approach - Trompeta Kate, NTUA

2. Dismantle aircraft composite assemblies for recycling, according to aviation regulations; a EURECOMP approach - *Alexander Knorr, EFW* – **Mid of June 2024**

3. Quality checking of end-of-life composite parts; a EURECOMP approach - *David Castro, AIMEN* –**End of September 2024**

4. Reuse and repurpose of end-of-life high performance composite parts; a EURECOMP approach - *Carlos Carneiro, INEGI & Francisco Lahuerta Calahorra, ITAINOVVA* –**Early December 2024**

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

Meet our NTUA Team

Project Management Team

Prof. Costas Charitidis
Project Coordinator

Dionisis Semitekolos
Project Technical Manager

Dr. Kate Trompeta
Project Manager

Technical Implementation Team

Artemis Kontiza
Extrusion/3D printing

John Papadopoulos
CFs sizing

Stavros Anagnou
Extrusion/Sizing/Reycling

Christos Tsirogiannis
Extrusion

Vaggelis Tsimis
CVD

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

Thank you!

Dr. Kate Trompeta

ktrompeta@chemeng.ntua.gr

Project Manager, NTUA

Prof. Costas Charitidis

charitidis@chemeng.ntua.gr

Project Coordinator, NTUA

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.

Acknowledgment

The research leading to these results has received funding from the European Union's Horizon Europe Research and Innovation programme under Grant Agreement No 101058089.

Funded by
the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor HADEA can be held responsible for them.