This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement no. 101096858.

REFRESH: from end-of-use blades to new products

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Project Coordinator

JEC World 2025, R&I Projects
4-6 March, Paris

Photo by Nicholas Doherty on Unsplash

The REFRESH consortium

Horizon Europe
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11 partners from **5 countries:**

- Waste recycling and remanufacturing companies
- Engineering and consulting companies
- Research and development companies
- Access to stakeholders in the composites sector manufacturers

RINA is the project coordinator

EuCIA leads communication & dissemination activities

Methodology – The REFRESH concept

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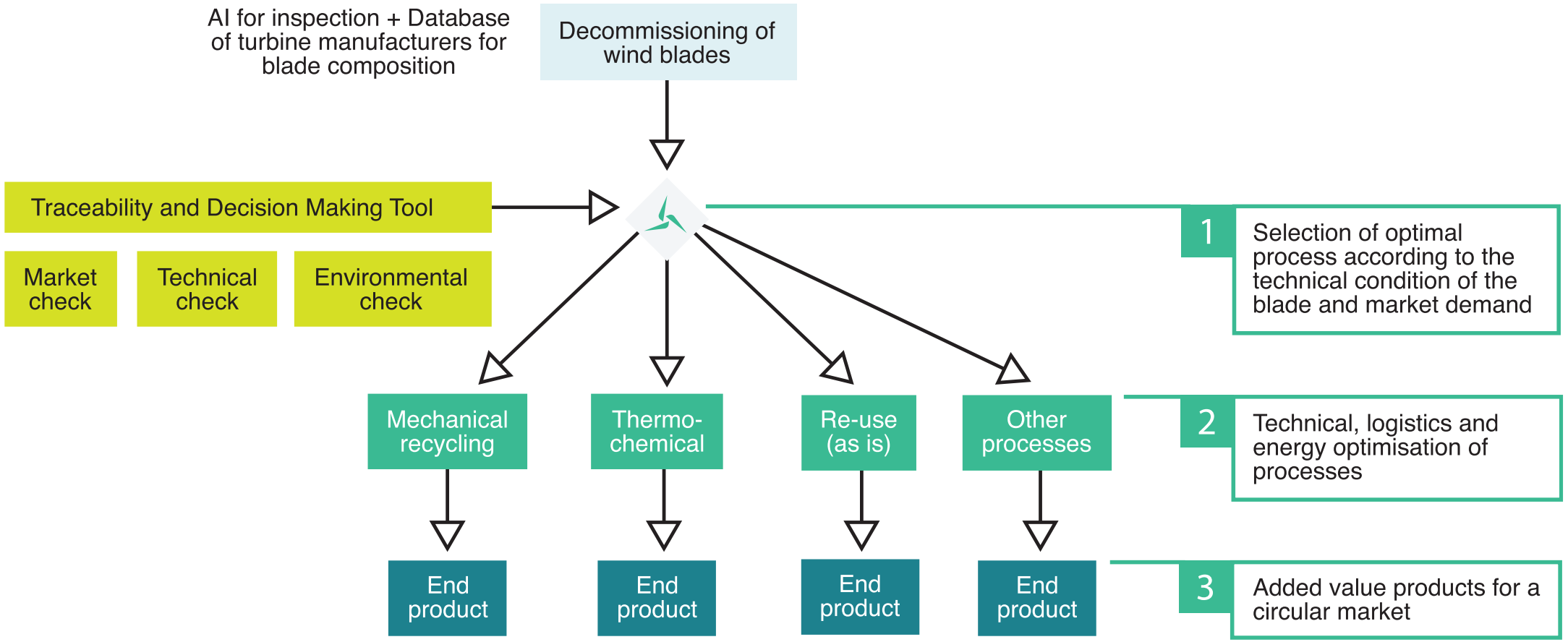

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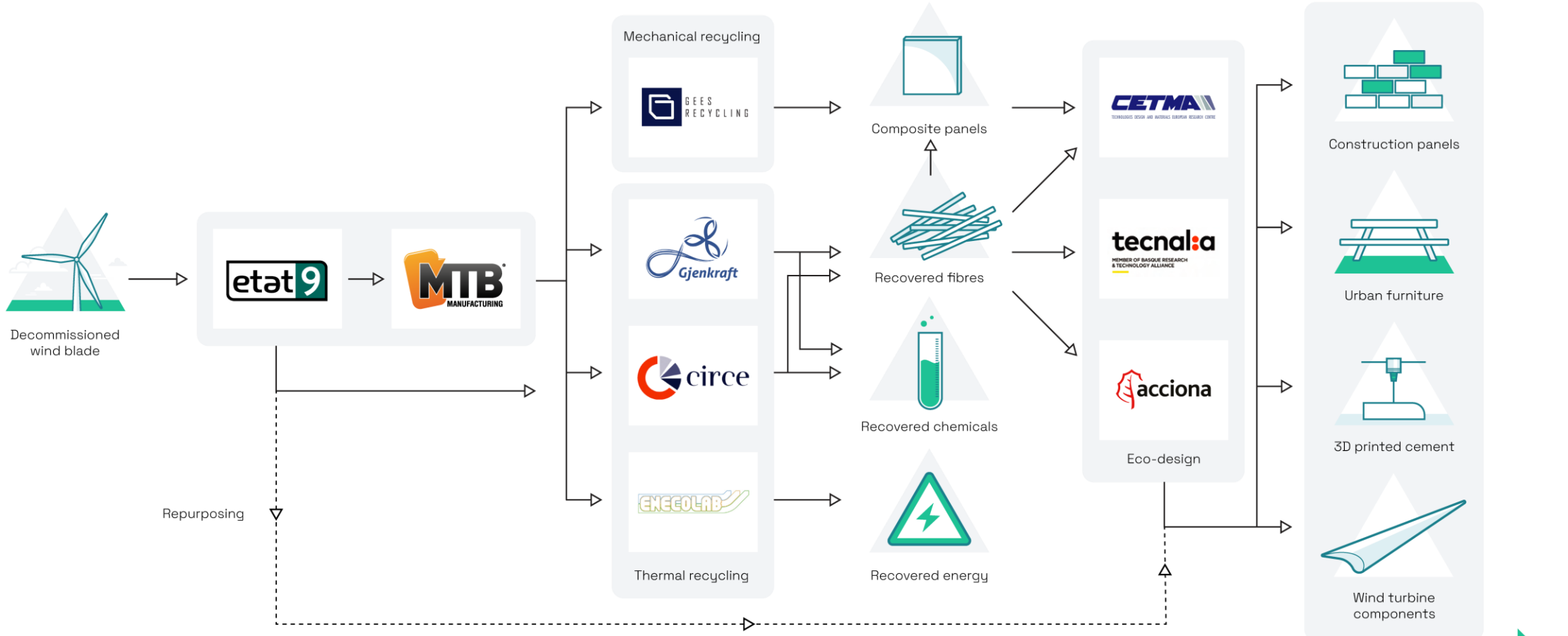
Methodology – The REFRESH value chain



Methodology – The REFRESH timeline

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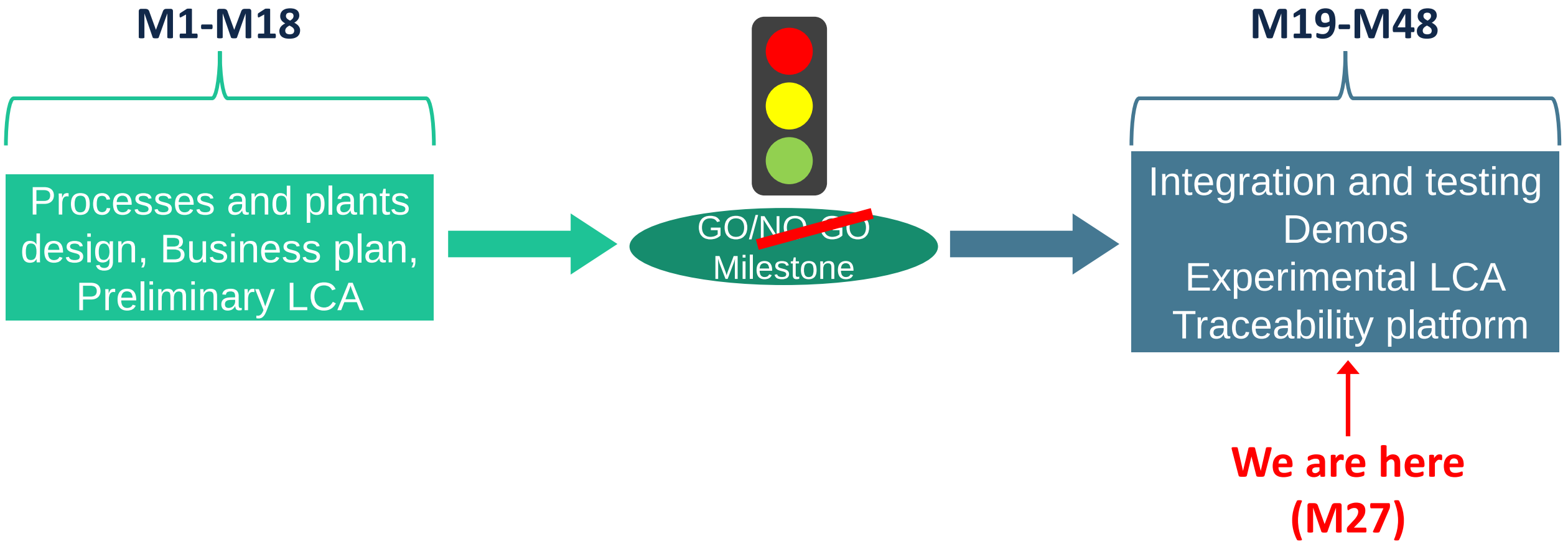

Dismantling and pre-cutting activities (ETAT 9)

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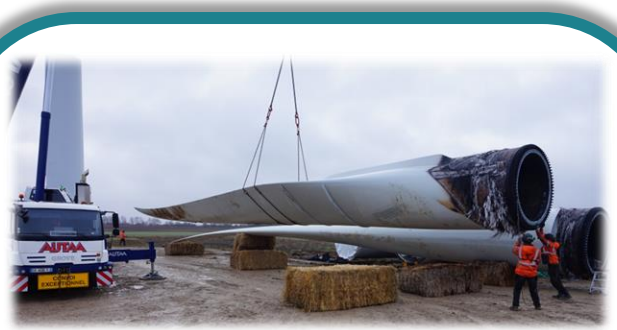
ETAT 9 activities focus on the **pre-cutting of blades.**



Dismantled blades

Circular saw cutting

Wire saw cutting

Dismantling and pre-cutting activities (ETAT 9)

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ETAT 9 activities focus on the **pre-cutting of blades**

Packaging

Temporary storage

Shipping

Shredding and sorting activities (MTB)

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MTB has developed a complete **range of shredding and mechanical sorting solutions** for the pre-treatment of wind turbine blades to obtain fractions that can be recycled downstream.

Shears solution

Complete wind turbine blades can be processed

Shredding & Granulation

From a few centimeters down to millimeters

Sorting

Various sorting solutions and engineering of complete pretreatment lines

Shredding and sorting activities (MTB)

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MTB feed the dismantled and cut wind blades from ETAT 9 into a **shear shredder**. The shredded pieces are downsized to be carried to the **sorting process**.

Composite « fine » mix

Composite « medium » mix
67% glass fiber composite
29% carbon fiber composite

Composite « gross » mix
87% glass fiber composite
10% carbon fiber composite

Mechanical recycling (GEES Recycling)

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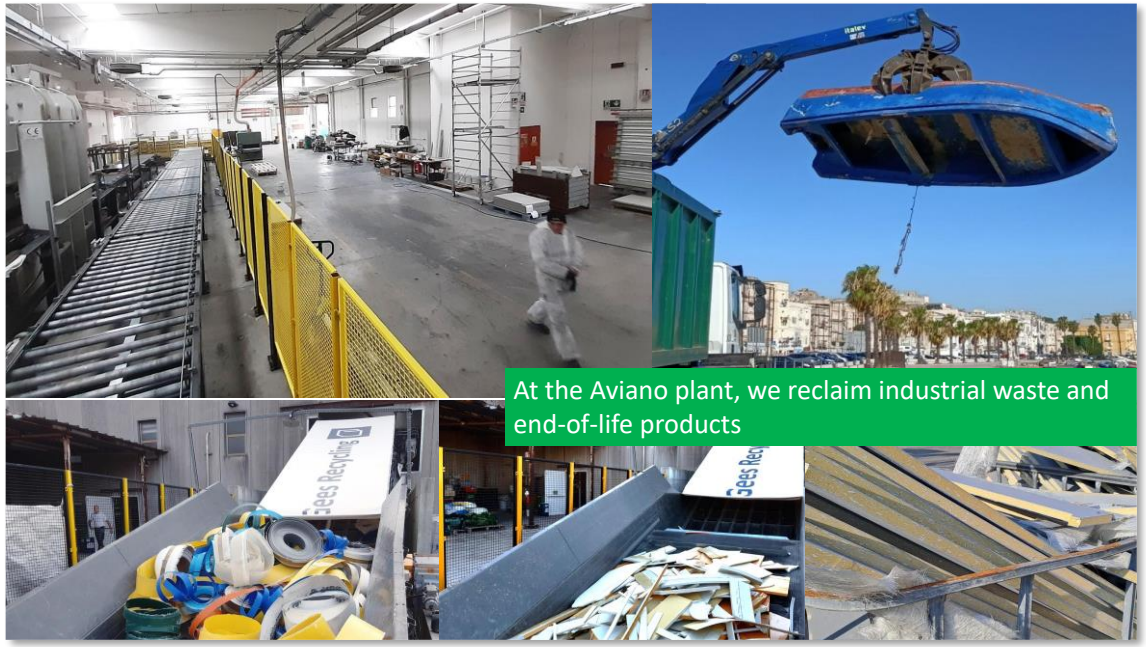
Gees Recycling has developed a **mechanical recycling process** for composites of any kind, rigid foams, core materials and other waste. Currently **>1800 t/y** are processed; in the REFRESH project this number will be increased to **>5500 t/y**.



At the Aviano plant, we reclaim industrial waste and end-of-life products

We convert waste management challenges into tailor-made construction materials

We convert waste management challenges into secondary raw materials and fillers

Thermo-chemical recycling (EnEcoLab)

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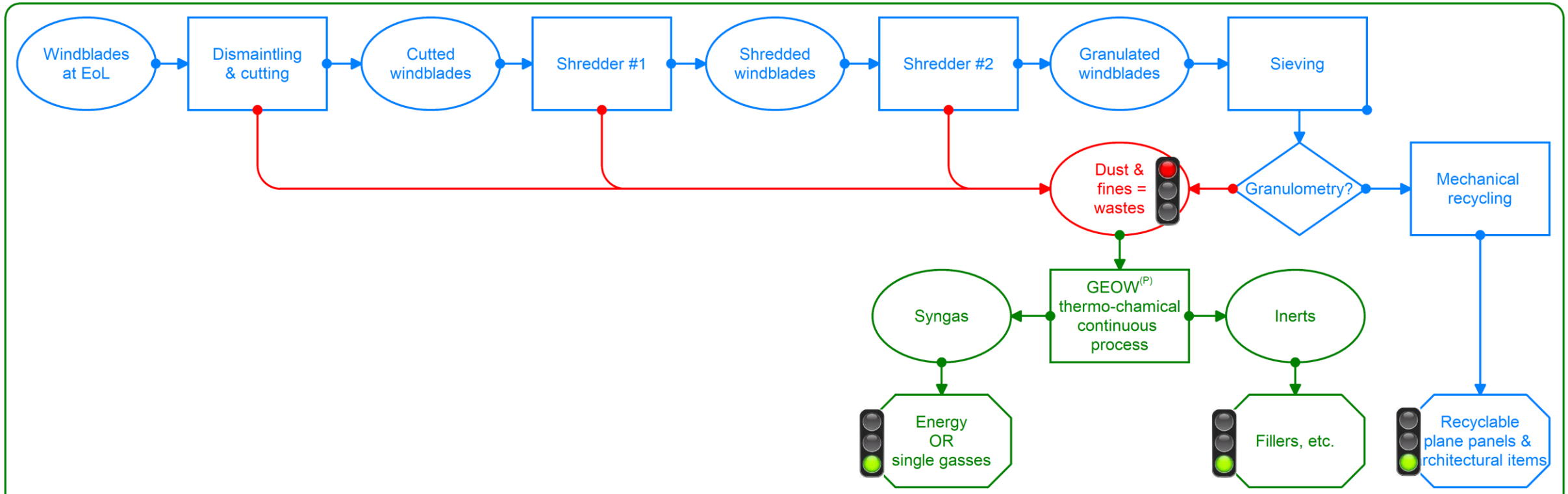
EnEcoLab has developed a **thermo-chemical recycling process** to close the EoL cycle of decommissioned wind blades, turning in syngas and inerts the not re-usable and not-recyclable dusts and fines generated by the previous mechanical treatments.



Thermo-chemical process of dusts and fines generated by the previous mechanical processes, Concept

Thermo-chemical recycling (EnEcoLab)

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Syngas composition, %:	
C_nH_m:	1,67
CH_4:	20,02
H_2:	21,54
CO:	35,12
CO_2:	16,82
O_2:	0,08
Other gasses:	4,76
LHV, Mj/Nm^3:	14,80
1 Nm^3 syngas = 0,413Nm^3 CH_4	
0,54 $l_{syngas}/gr_{material}$	

GEOW® continuous reactor, in progress to TRL 5

Residual solids, inert,
Ø 0 – 0,6 mm = 82 %

Initial material: GJENKRAFT, GRP dusts and fines from EoL wind blades, inert portion 31,23%

Final material: 56,33% in weight on the initial, process efficiency 81,90% (organic portion transformed)

MW-pyrolysis and solvolysis (CIRCE)

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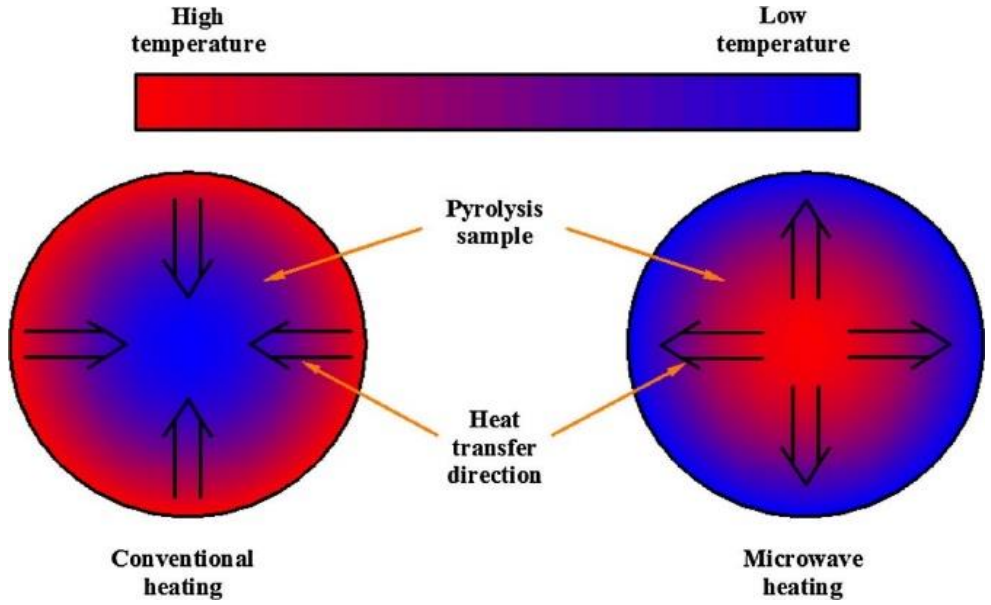
CIRCE develops two thermochemical routes for the valorization of wind blade waste based on **microwave-assisted pyrolysis** (MW-PYR) and **microwave-assisted solvolysis** (MW-SOL).

Technological benefits:

- Moderate energy consumption (**<10 MJ/kg FRP**)
- Preservation of mechanical properties (**lower T**)
- Resins recover for fuels, recycled resins or second-generation chemicals
- Fast and volumetric heating rates (**+ energy efficiency**)
- Potential power consumption from **100% renewable sources**



Microwave-assisted pyrolysis and solvolysis

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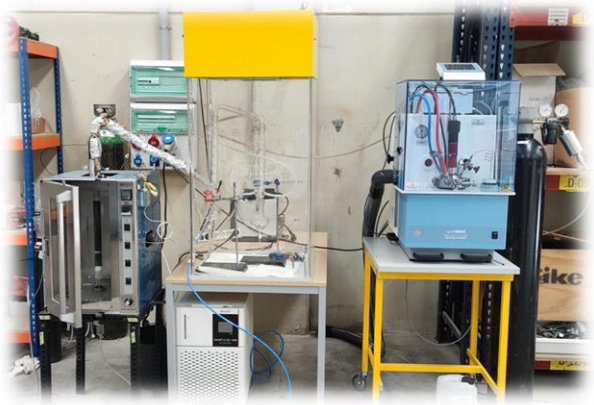
CIRCE develops two alternative energy-efficient thermochemical routes for the valorization of wind blade waste based on **microwave-assisted pyrolysis** (MW-PYR) and **microwave-assisted solvolysis** (MW-SOL).

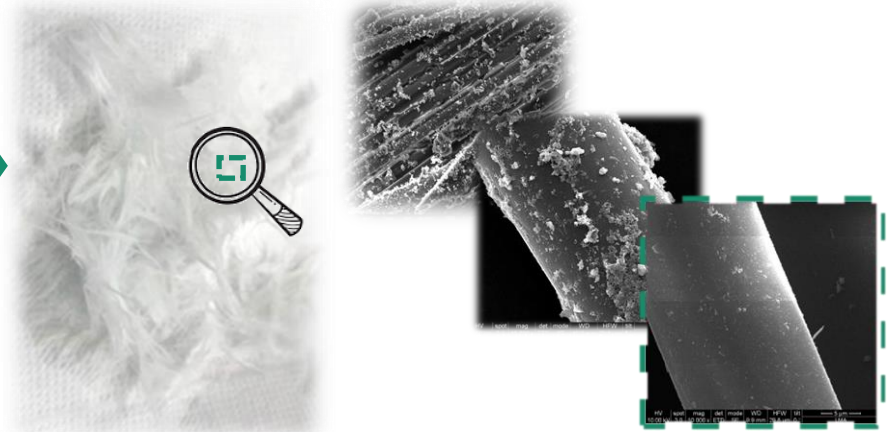


Bench MW-reactors

Continuous pilot MW-pyrolysis unit

EXPERIMENTAL ASSESSMENT ON CHEMICAL WTB RECYCLING

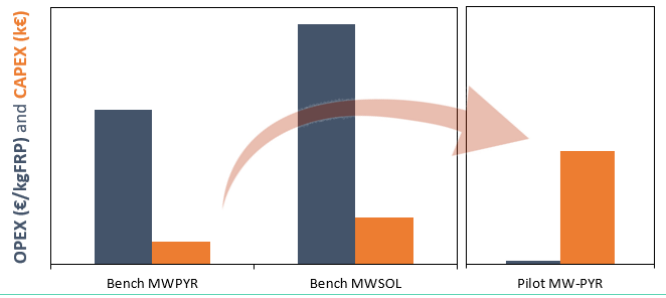
Shredded wind blade fiber-reinforced composites

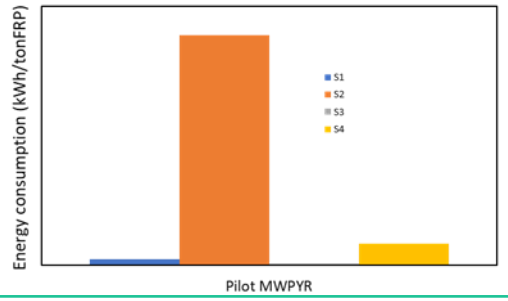


Recovered clean glass fibers without textural damage

Pyr-oils and syn-oils preserving building blocks

TECHNO-ECONOMIC ASSESSMENT (MWPYR vs MWSOL)





Thermal recycling – electrical pyrolysis process research and analysis (Gjenkraft)

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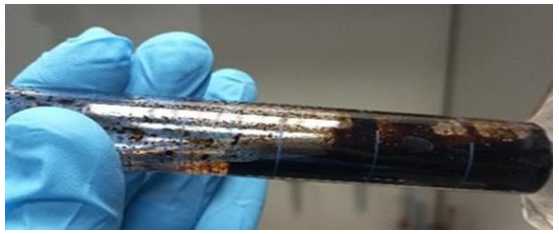
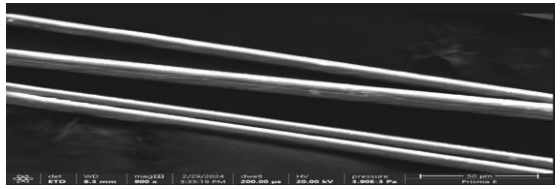
Progress

- Pyrolysis process research under various conditions
- Fiber cleaning: comparing methods for char/ash removal
- Mechanical property testing post-process
- Exploring fiber strength recovery techniques
- Scaling up: refining parameters in lab tests
- Defining final process parameters for implementation



Thermal recycling – large-scale machines design (Gjenkraft)

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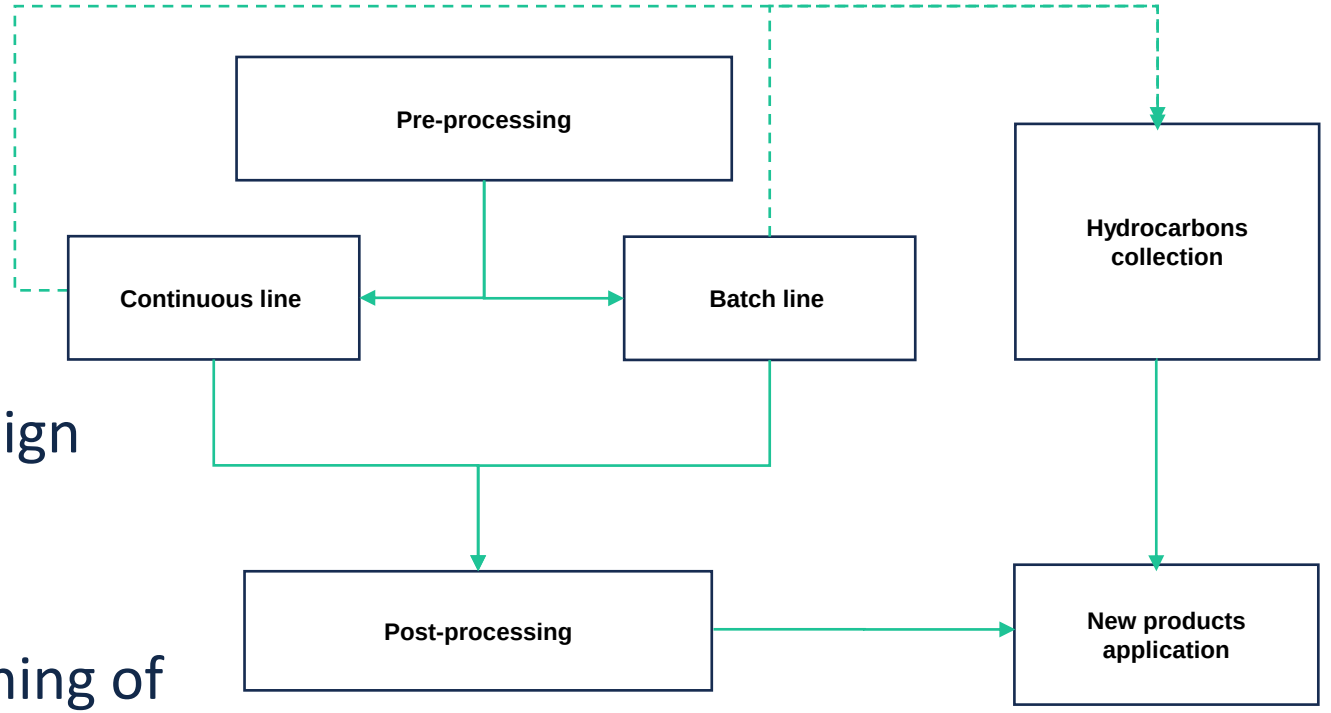
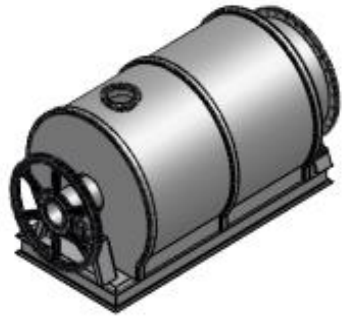
Progress

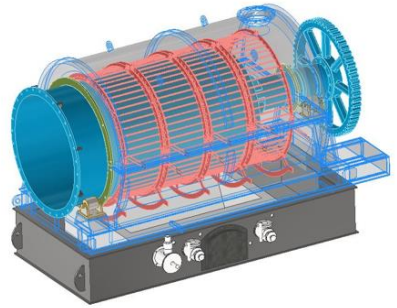
- LCA analysis & material balance
- Modification concept for existing batch reactor
- Detailed machinery and equipment design

Next steps

- Procurement, installation & commissioning of continuous line
- Procurement & upgrade of existing reactor
- Fiber production (glass & carbon) for partner testing







REFRESH eco-design strategy (CETMA)

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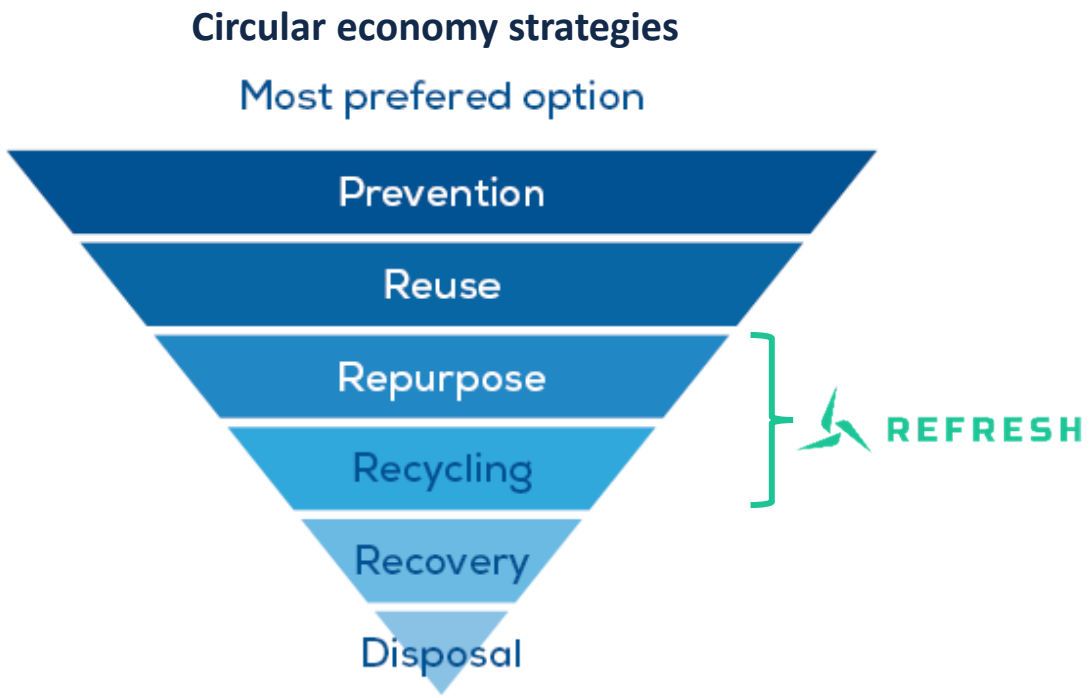

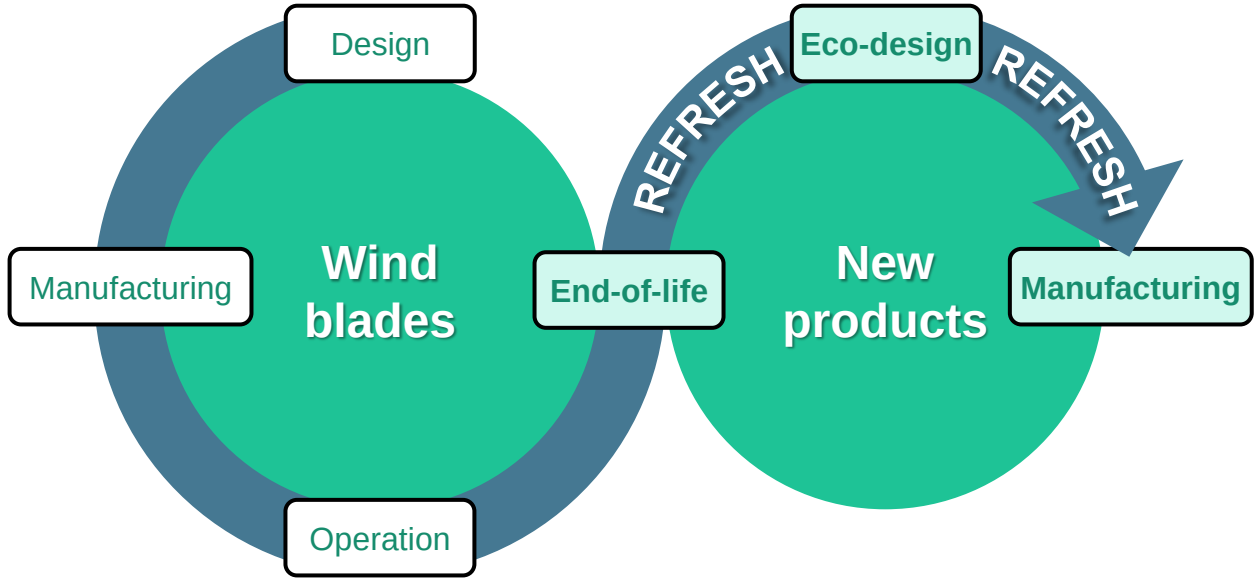

- Deployment of recycling technologies and repurposing strategies
- Development of recycled / repurposed products and markets

REFRESH eco-design strategy (CETMA)

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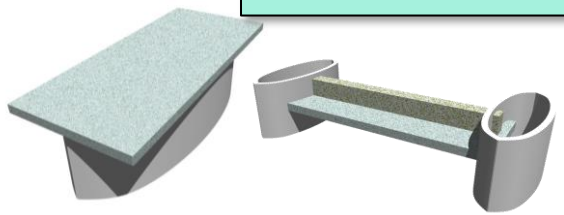
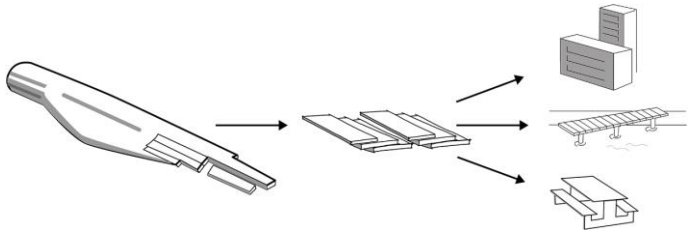
TRADITIONAL REPURPOSING APPROACH





ALTERNATIVE REPURPOSING APPROACH (JOUSTRA ET AL., 2021)

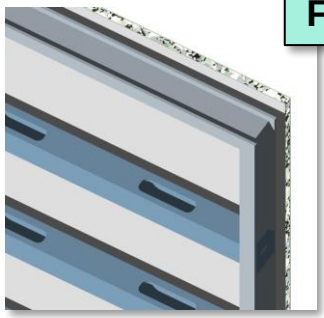
Repurposing of blade portions *with ETAT9*

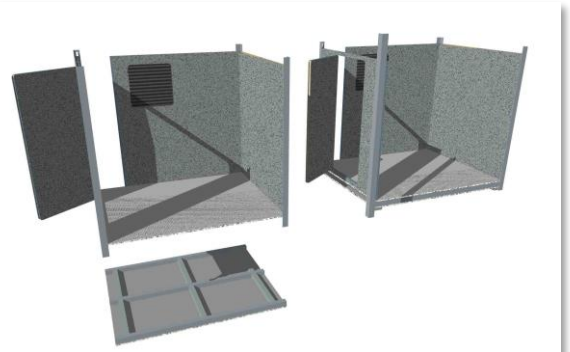
Mechanically recycled materials *with GEES*

Concrete structures *with TECNALIA*

Thermally recycled materials *with GJK*

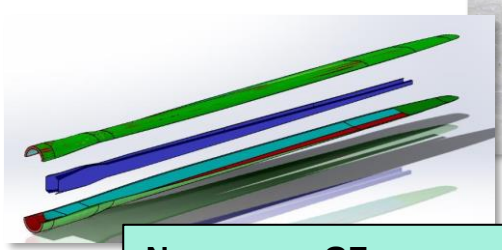
FORMWORK PANELS





EQUIPMENT SHELTER

NON-WOVEN GF INSULATION FOR BUILDING APPLICATIONS



NON-WOVEN GF MATT FOR WIND BLADE OUTER SKIN

ONSITE 3D PRINTED CONCRETE WIND TOWER

REFRESH preliminary LCA results (RINA-C)

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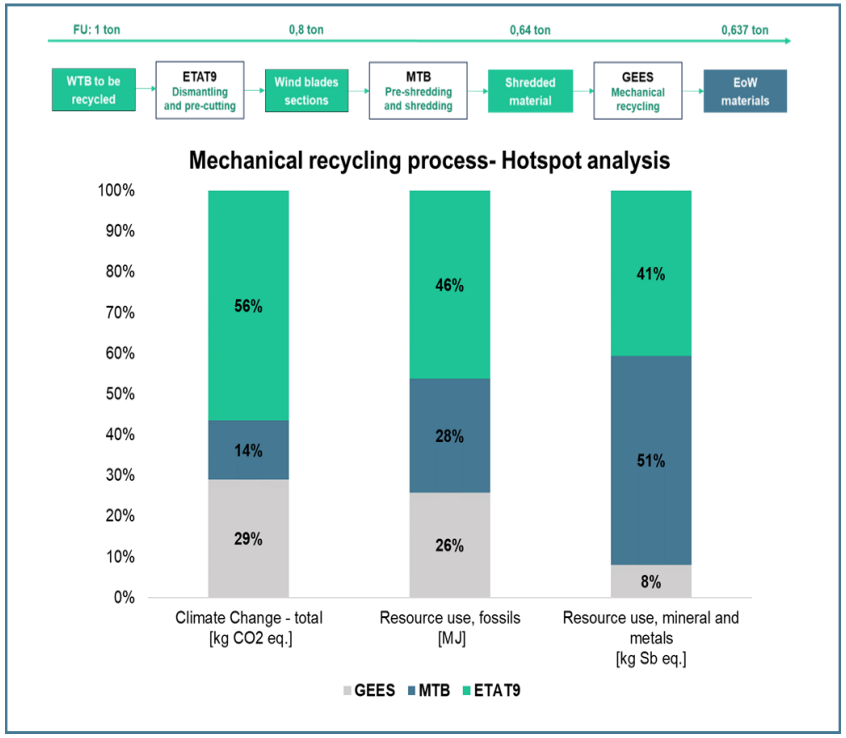
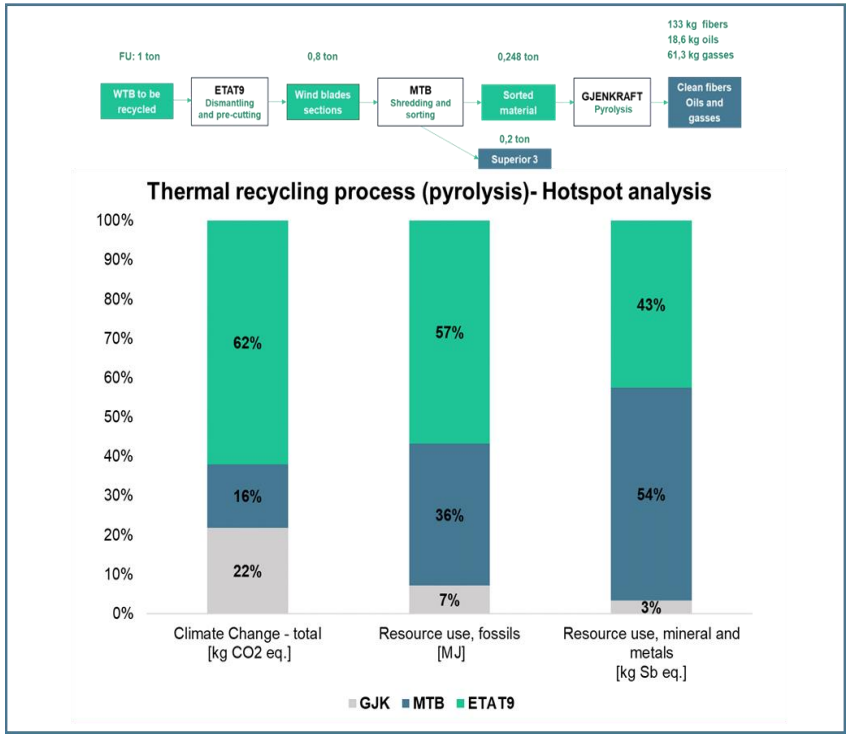
MECHANICAL



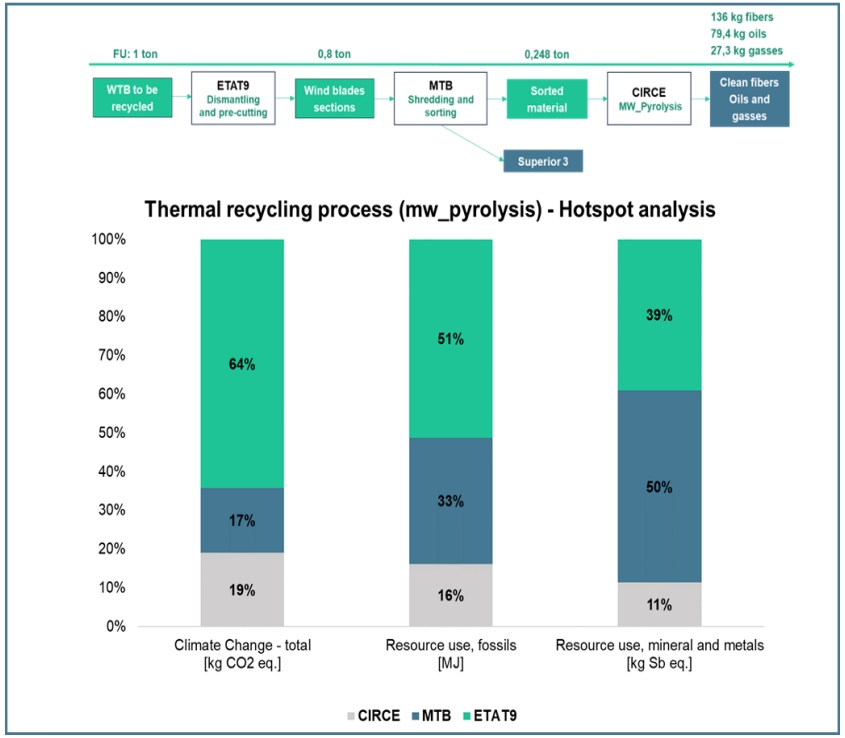
Environmental benefits of EoW materials (as ***substitute of epoxy resin materials***) from mechanical recycling value chain are ***3180 kg CO2eq.***

THERMAL E-PYROLYSIS



Environmental benefits of glass and carbon fibers (as substitute of ***virgin ones***) from thermal recycling value chain are ***1128 kg CO2eq.***

THERMAL MW-PYROLYSIS



Environmental benefits of glass and carbon fibers (substitute of ***virgin ones***) from thermal recycling value chain are ***1154 kg CO2eq.***

REFRESH smart tool for traceability (TECNALIA)

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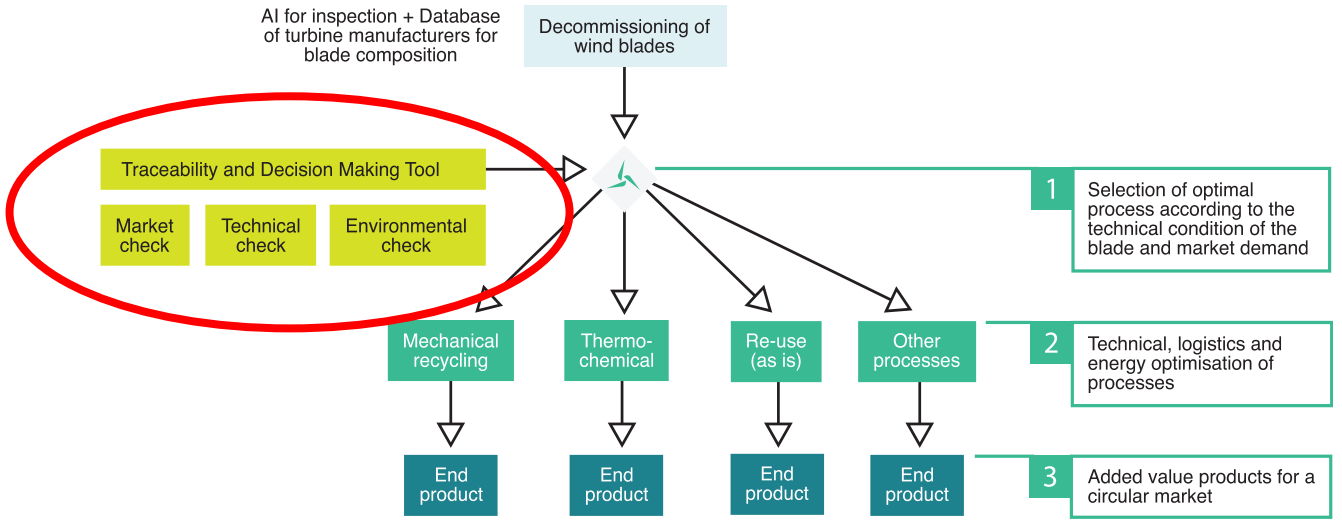
- ❖ Real-time tracking
- ❖ Transparent information sharing
- ❖ Secure data storage

Benefits:

- Enhanced quality control
- Improved efficiency
- Increased confidence and secondary materials acceptance
- Regulatory compliance

Data-driven decision-making tool



REFRESH smart tool for traceability (TECNALIA)

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Goal: to provide an **accurate and verifiable** set of information about the **products**

REFRESH smart tool for traceability (TECNALIA)

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- System integration
- Data accuracy
- Stakeholder participation
- Privacy concerns

- Cross-industry material exchange
- Fully transparent wind energy sector
- Further standardization and DPP
- Extended Producer Responsibility

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement no. 101096858

Thank you for your attention!

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Visit us on booth 6D114-03