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

REFRESH

New products from end-of-life wind blades

Andrea Tinti, CETMA

2nd stakeholder workshop
13 May 2026, online

Photo by Nicholas Doherty on Unsplash

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Private RTO
since 1994 in Brindisi (Italy)

Contract research and
advanced engineering services

1 **Advanced Materials & Processes Dept.**

2 **New Technologies & Design Dept.**

67 Employees

136	42	1396	20
Research projects	EU projects	Research contracts	Training projects

198 M€ Total budget

REFRESH project approach

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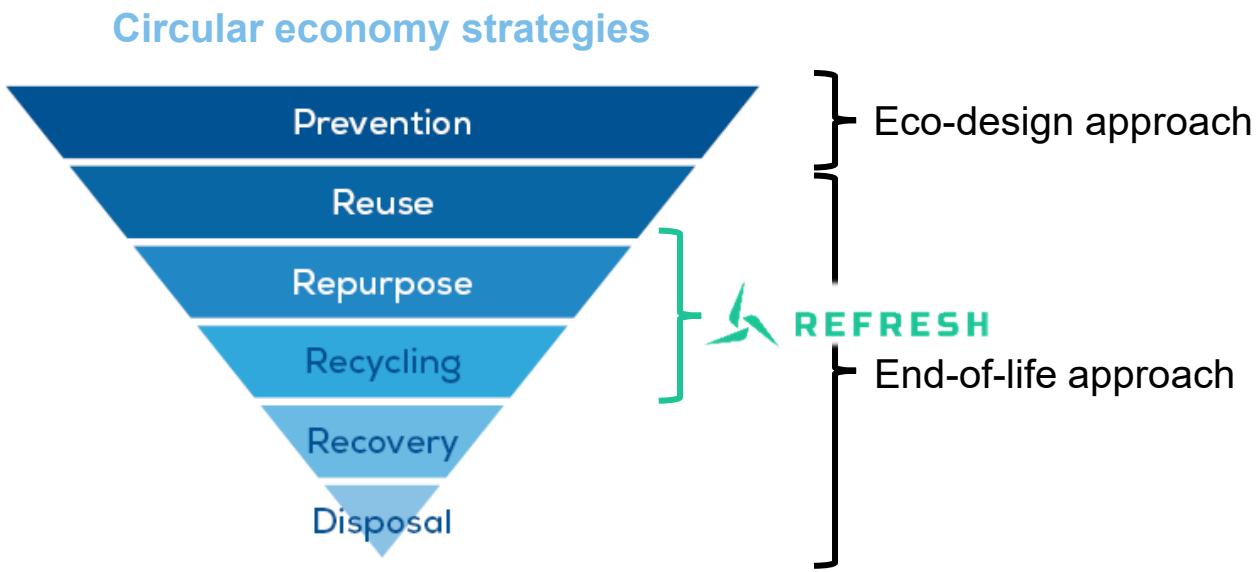

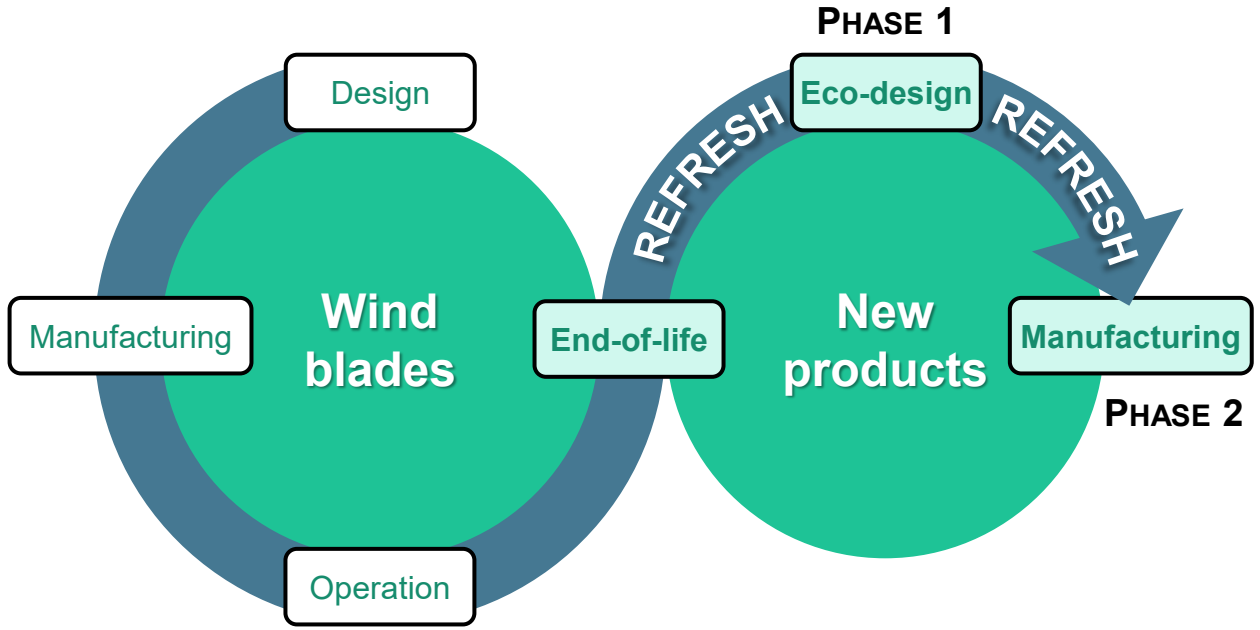

Recycling: recovery of materials

Re-use and re-purpose: recovery of components for the same or different applications

Development of new end-products

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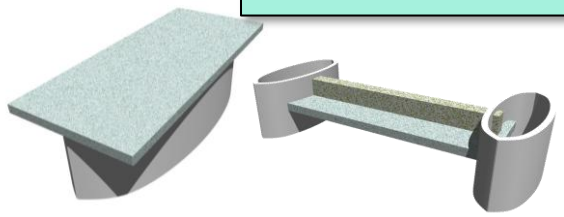
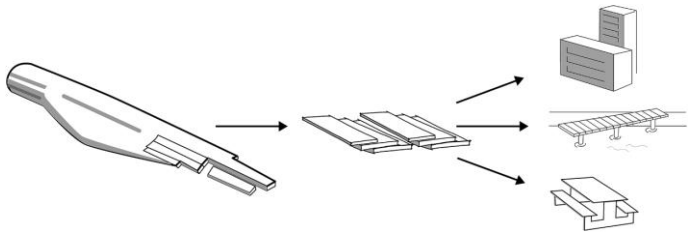
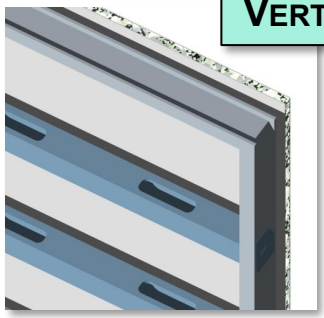
TRADITIONAL REPURPOSING APPROACH





ALTERNATIVE REPURPOSING APPROACH (JOUSTRA ET AL., 2021)

VERTICAL WALL FORMWORK



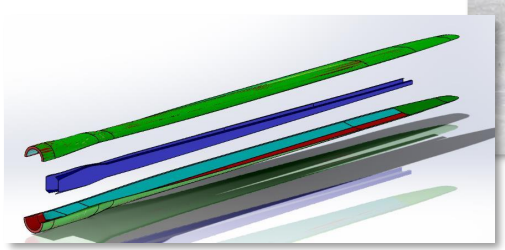
Repurposing of blade portions *with ETAT9*

Mechanically recycled materials *with GEES*

Concrete structures *with TECNALIA*

Thermally recycled materials *with GJK*

ONSITE 3D PRINTED CONCRETE WIND TOWER



NON-WOVEN GLASS FIBER MATT FOR NON-STRUCTURAL WIND BLADE COMPS

REFRESH

Thermal recycling

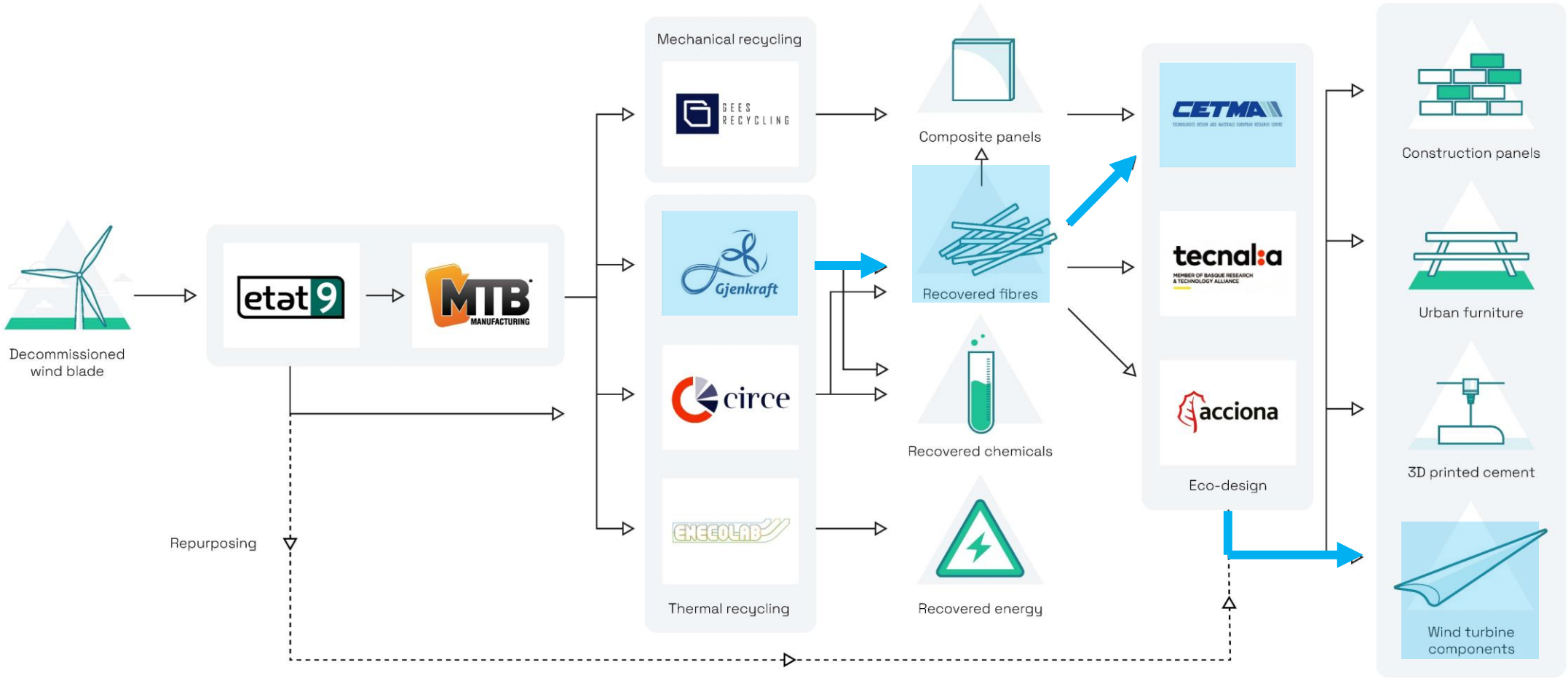
The circular wind blade

The REFRESH project

Communication & dissemination: EuCIA

Project coordinator: RINA

Co-funded by the European Union



REFRESH

Collection **and cutting** | Shredding and sorting | Recycling | New materials | New products | Applications

Reprocessing of thermally recycled glass fibers

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Pyrolyzed GF

TP binding fibers

- Developed **non-woven products** based on **thermally recycled glass fibers** (Gjenkraft, Norway)
- The reprocessing approach is based on **airlay + thermobonding technology** (Cormatex, Italy)
- With respect to **mechanical needle-punching**, where repeatedly needling causes the fibers to interlock and entangle, thermobonding relies on the adhesive effect of **thermoplastic binder**

Airlay

Thermobonding

Recycled matt produced at Cormatex

90-95% recycled content

Sizing coating application

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- Lost during pyrolysis, sizing of the fibers will enhance adhesion with the resin
- A formulation for epoxy and the related treatment procedure developed at CETMA has been used
- Effectiveness evaluated by mechanical testing of composite laminates with and without sizing

Vacuum infusion process

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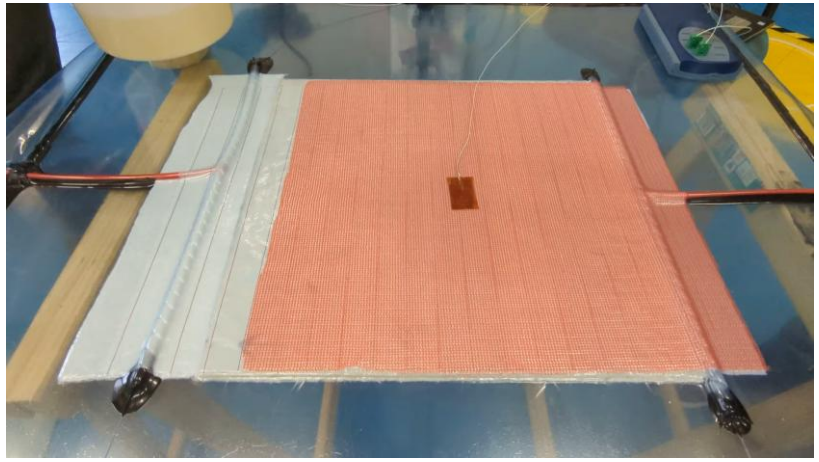

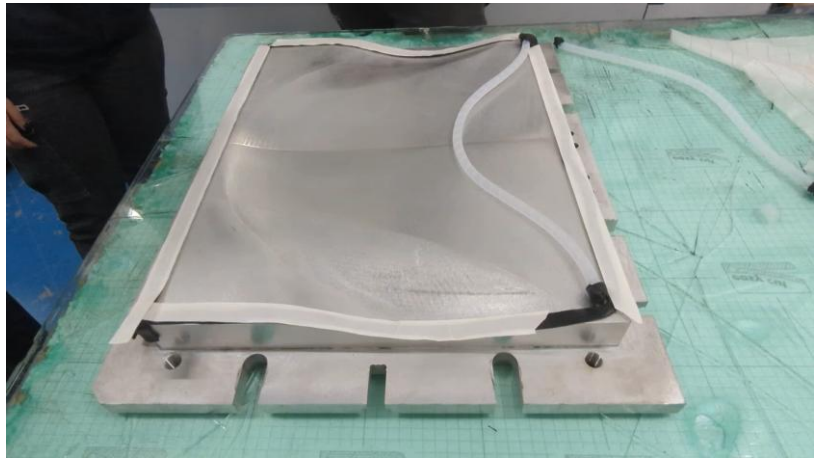

Property	Standard test method	Unit	REFRESH no sizing	REFRESH with sizing	Commercial virgin GF matt laminate
Density	ASTM D 792	g/cm^3	1,3 ± 0,0	1,3 ± 0,0	1,4
GF content	ASTM D 3171	%w	18 ± 1	19 ± 1	23,6
Tensile strength	ASTM D 638	MPa	63 ± 4	66 ± 6	76
Tensile modulus		GPa	5,5 ± 0,6	6,0 ± 0,3	6,7
Strain at break		%	1,4 ± 0,2	1,1 ± 0,3	1,5
…	…	…	…	…	…

- Properties close to commercial virgin GF matt laminates with similar areal weight and single ply thickness
- Low GF content → No noticeable effect of sizing
- Considering a ~25% increase in fiber tensile strength due to sizing application (previous studies) and a ~20%w fiber content, the expected increase of laminate strength is ~5%

The wind blade prototype

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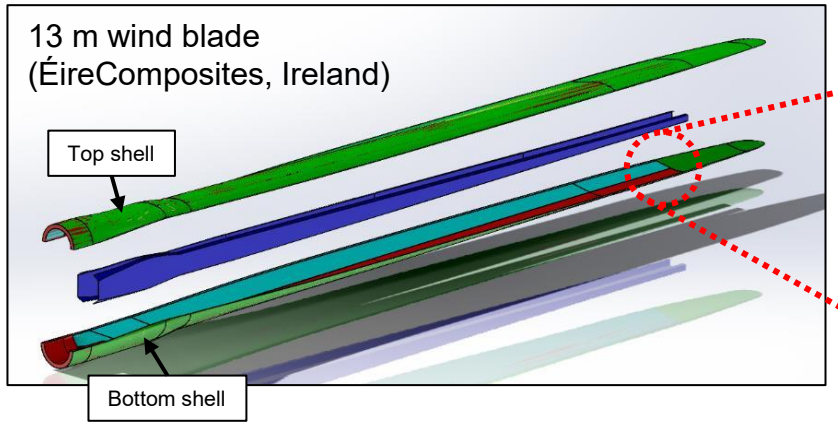
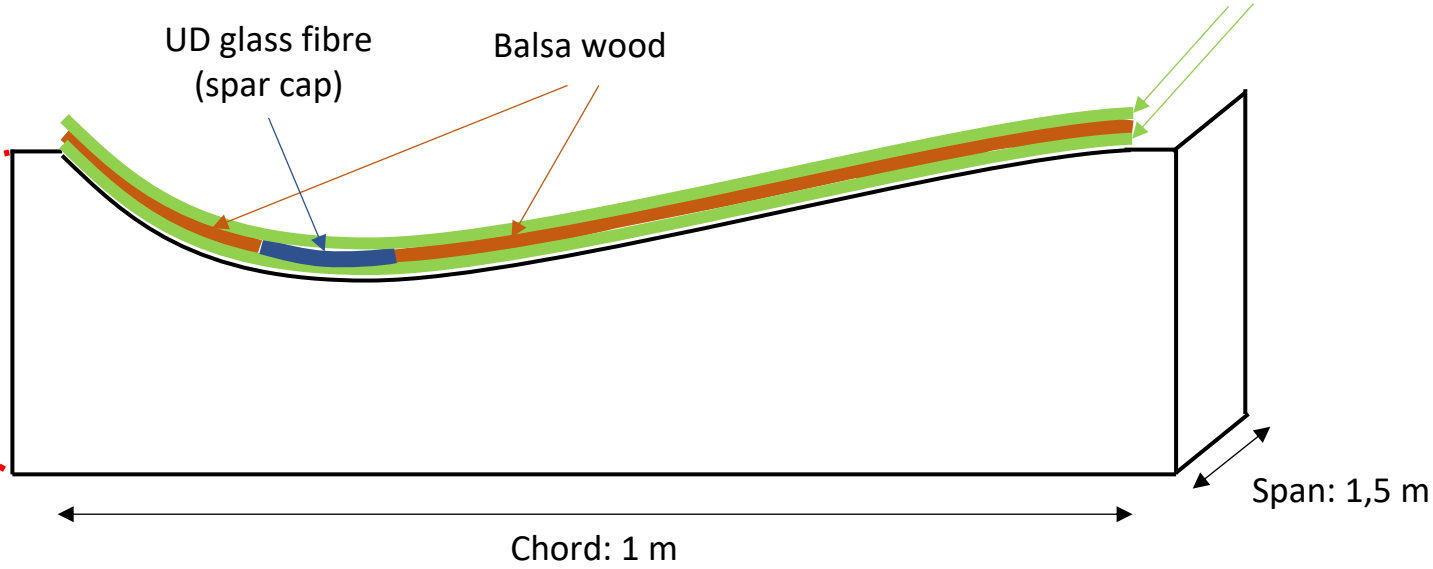
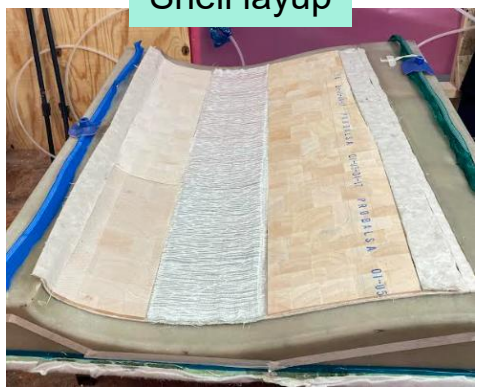
Application: non-structural wind blade element





Shell layup



Vacuum infusion

Demoulded shell

Final adhesively bonded wind blade section

The wind blade prototype

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JEC Innovation Planets 2026

EARTO
IMPACT
DELIVERED

2026 EARTO Innovation Awards Category Impact Expected Application Form

"IMPACT EXPECTED" innovation characteristics:

- ✓ social and/or economic relevance,
- ✓ innovative originality,
- ✓ not yet on the market as a final product/service,
- ✓ promises to have a great impact within the next five years

2026 Timetable

- ✓ 3 November 2025: Launch of the call for applications
- ✓ 30 January 2026: Deadline for applications
- ✓ Early March 2026: Internal Jury Task Force
- ✓ Early April 2026: External Jury Meeting
- ✓ 10 June 2026: Innovation Awards Ceremony

Work in progress / Next steps

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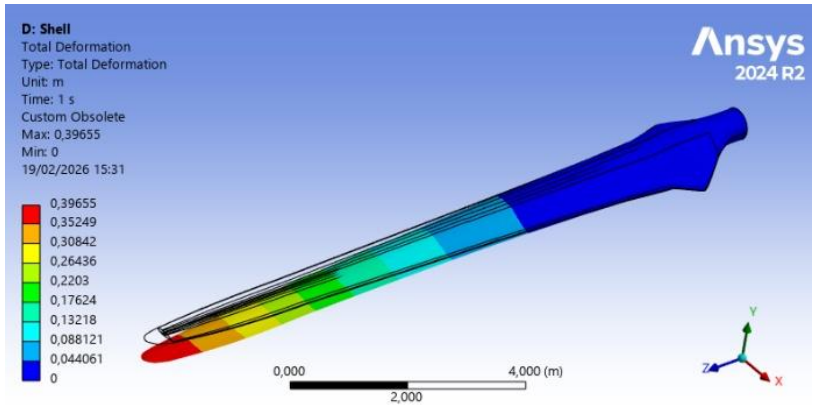
- Numerical validation of the mechanical performance

Full blade | Displacement

ORIGINAL



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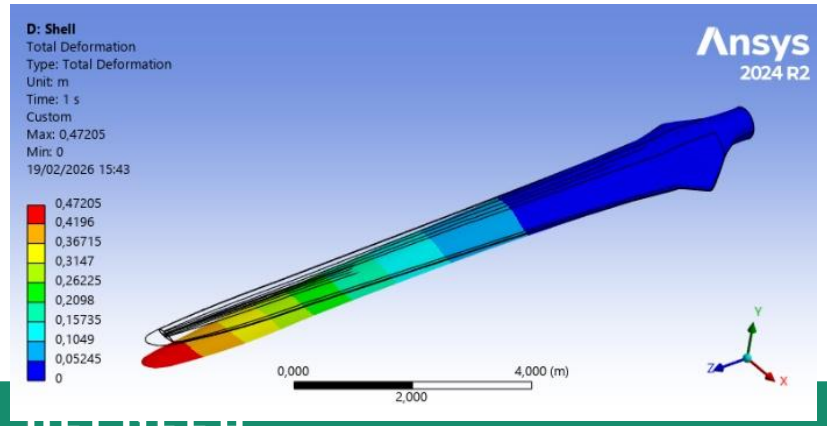
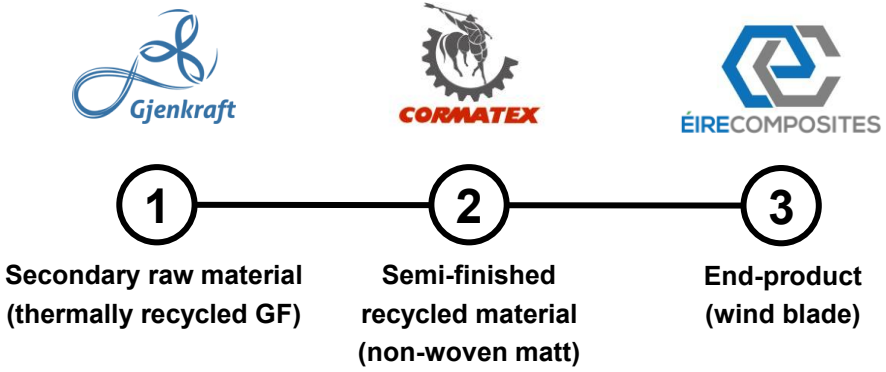


- LCA and LCC analysis along the whole value chain of the product



REFRESH

Mechanical recycling

The vertical wall formwork

CETMA
TECHNOLOGIES DESIGN AND MATERIALS EUROPEAN RESEARCH CENTRE

GEES RECYCLING

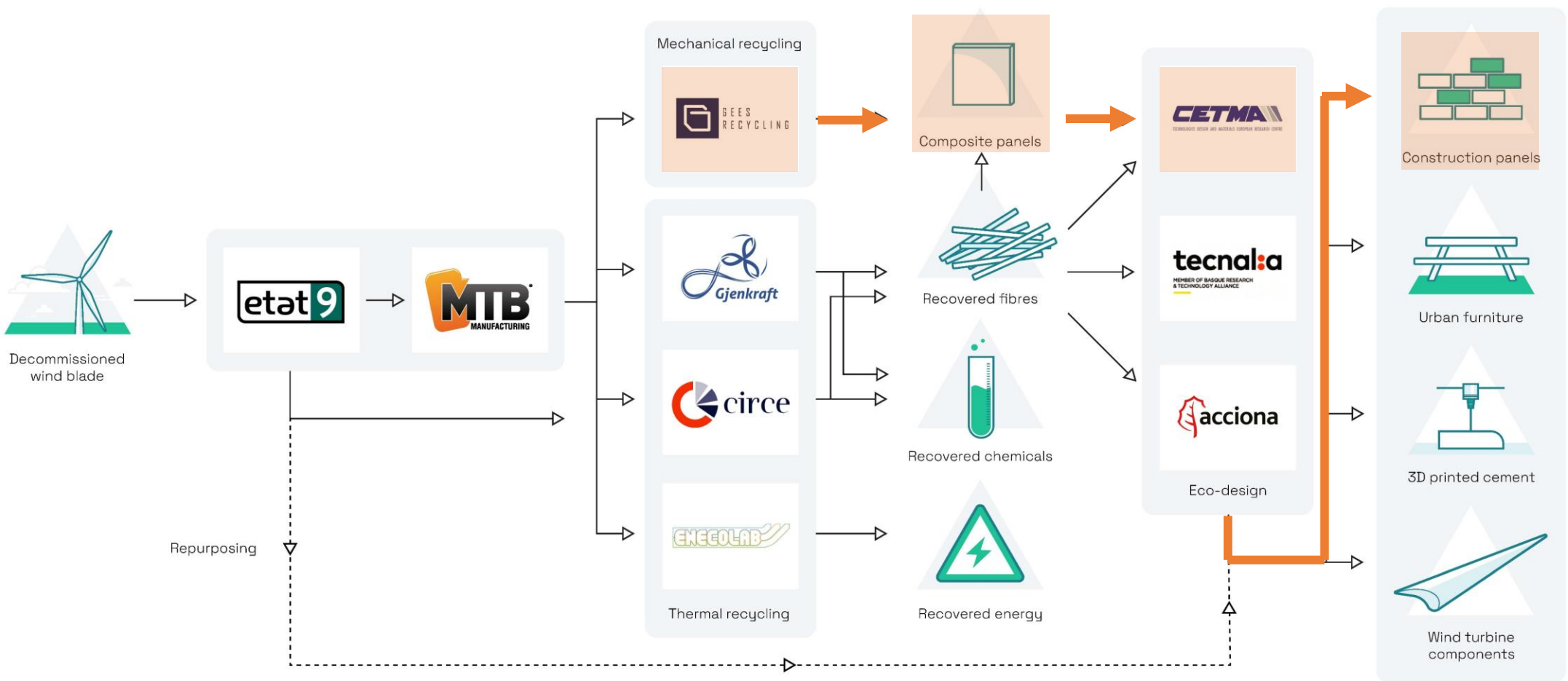
Photo © Doka GmbH

The REFRESH project

EuCIA — Communication & dissemination

RINA — Project coordinator

Co-funded by the European Union



REFRESH

Collection **and cutting** → Shredding and sorting → Recycling → New materials → New products → Applications

Mechanical characterization of GEES recycled materials

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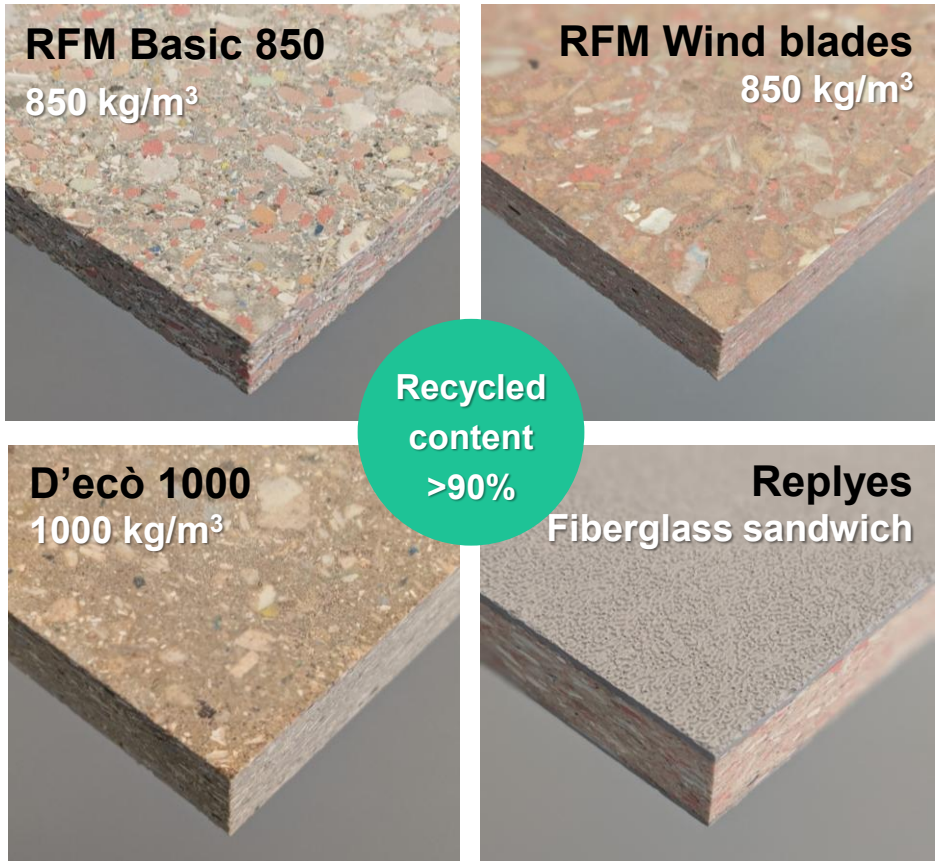
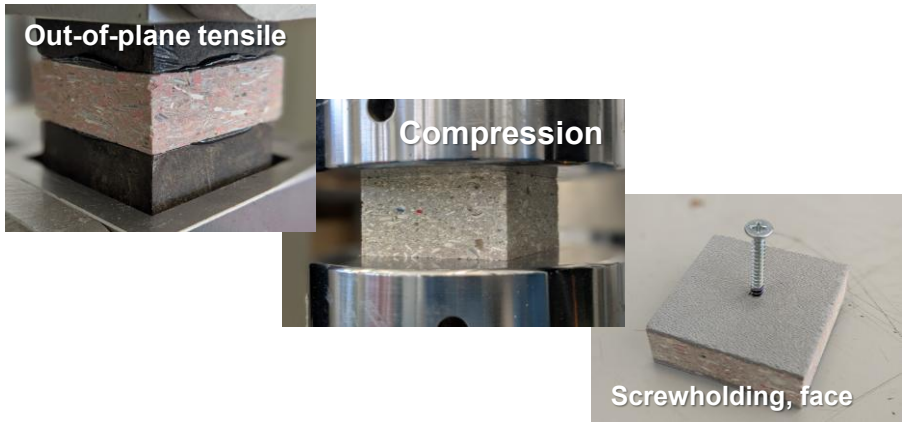
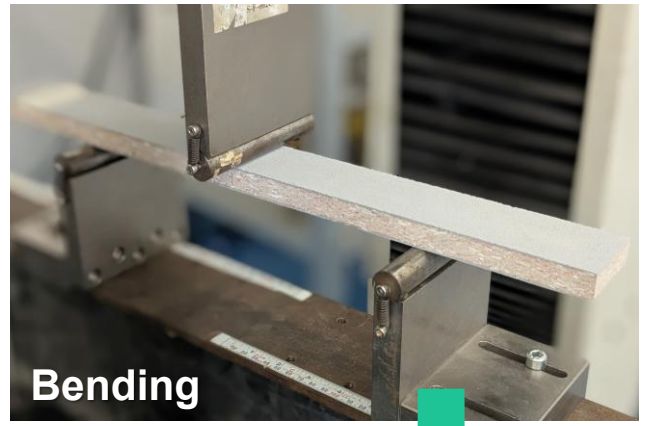
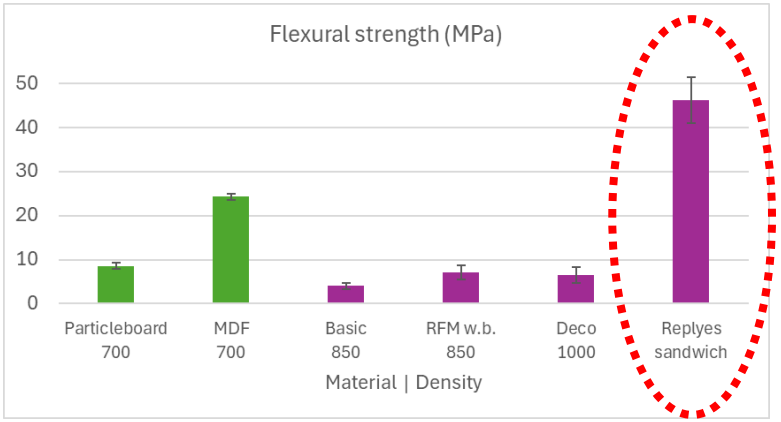
GEES products

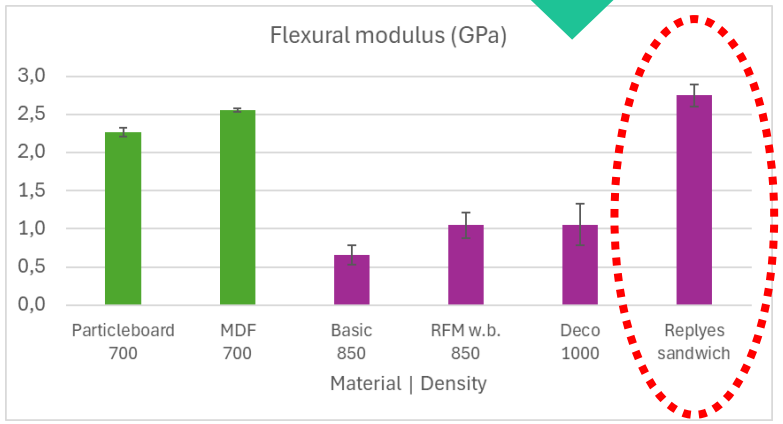


Testing campaign









Replyes (FG sandwich) best solution for structural apps

The vertical wall formwork

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PERFORMANCE REQUIREMENTS

- ❑ Maximum lateral fresh concrete pressure as defined by DIN 18218 **[Class B ≤ 40 kN/m²]**

the higher the formwork permitted pressure

▼

the higher the fresh concrete column
(*hydrostatic pressure* = *concrete density* x *height*)

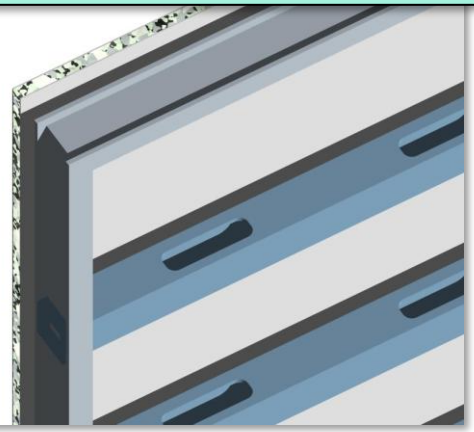
▼

depending on the concrete curing time,
the higher the pouring rate

- ❑ Surface flatness tolerance as specified in DIN 18202 **[Group 6 ≤ 5 mm up to 1 m span]**

VERTICAL FORMWORK (E.G. TO POUR NEW WIND BLADE CONCRETE FOUNDATION)

Sheets: plywood core + plastic coating → GEES recycled panels + fiberglass skin
Frame: powder-coated aluminium → commercial pultruded profiles

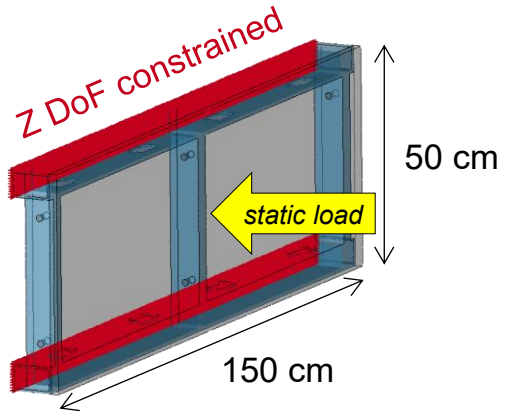


The vertical wall formwork

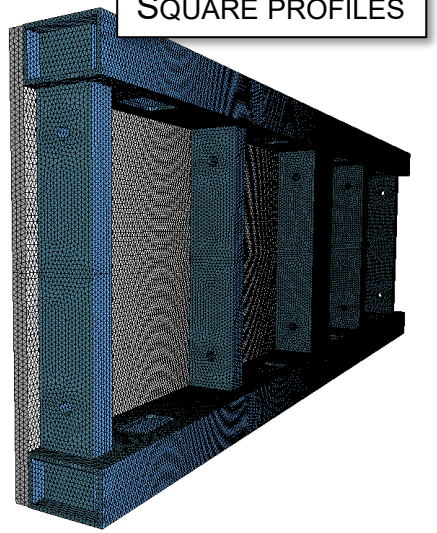
Formwork config		Applied pressure (kN/m²)	Concrete column (m)	Max deformation (mm)	
Sheet	Frame			Sheet	Frame
Replyes 1 mm skin	Square aluminum no. 3 vertical	40	1,6	5,2	0,09
Replyes 1 mm skin	Square pultruded no. 2 vertical	12,5	0,5	5,5	0,31
Replyes 1 mm skin	Square pultruded no. 3 vertical	40	1,6	5,6	0,46
Replyes 1 mm skin	Square pultruded no. 5 vertical	40	1,6	2,4	0,40
Replyes 2 mm skin	Square pultruded no. 3 vertical	40	1,6	4,0	0,39
Replyes 2 mm skin	Square pultruded no. 5 vertical	40	1,6	1,8	0,38
Replyes 2 mm skin	Square pultruded no. 5 vertical	60	2,4	2,0	0,45
Replyes 2 mm skin	Square pultruded no. 5 vertical	200	8	3,8	0,86
Replyes 2 mm skin	Square pultruded no. 5 vertical	250	10	4,0	0,90
Replyes 2 mm skin	«C» pultruded no. 4 vertical	40	1,6	4,3	1,24
Replyes 2 mm skin	«C» pultruded no. 4 vertical	60	2,4	4,8	1,42

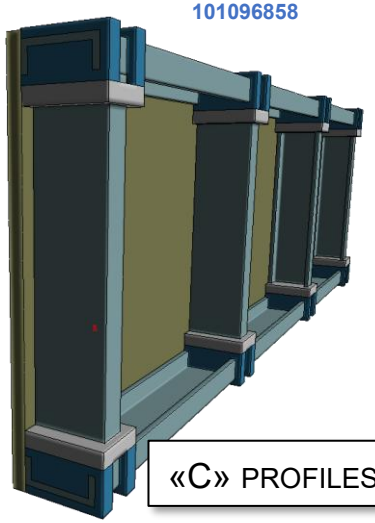
Optimum

VIRTUAL TESTING SCHEME



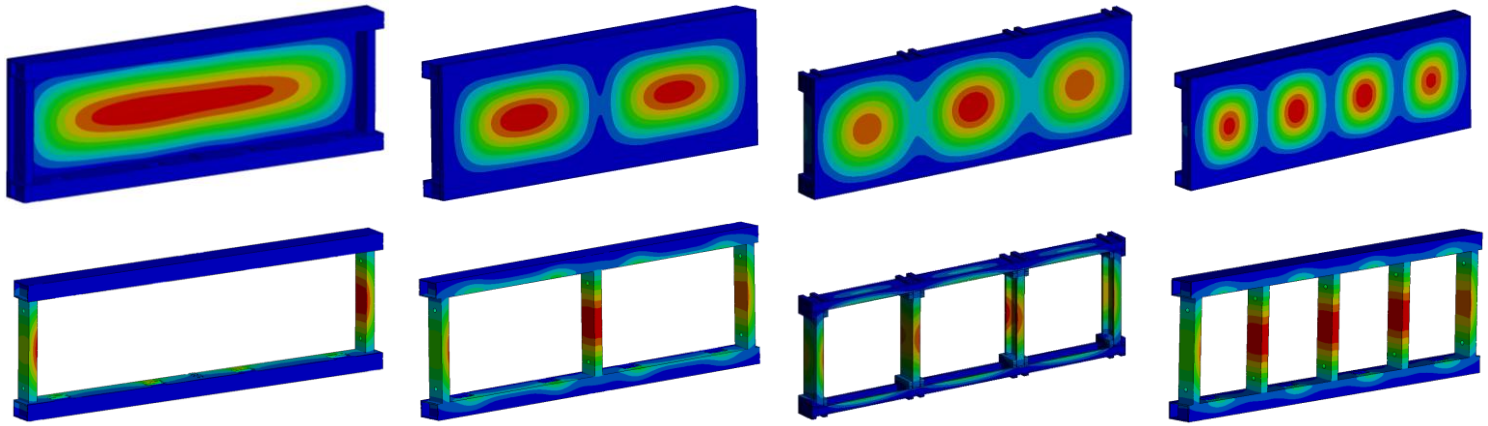
SQUARE PROFILES





«C» PROFILES

SHEET AND FRAME OUT-OF-PLANE DEFORMATION
NO. OF VERTICAL PROFILES FROM 2 TO 5



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Work in progress / Next steps

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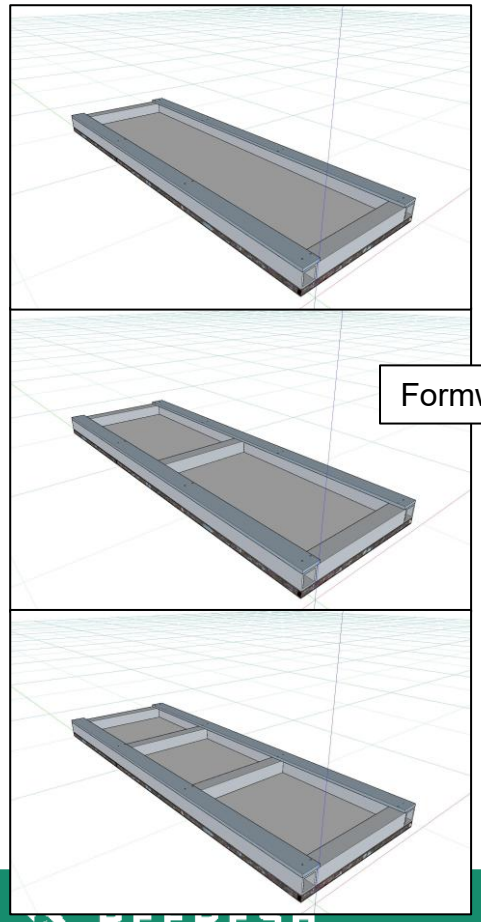
- Manufacturing of the formwork elements by GEES based on the optimum numerically modelled design
- Experimental validation first at CETMA lab scale and then through real testing on worksite environment



Formwork demo panels

Testing layout of pouring a vertical concrete wall

REFRESH

Repurposing

The picnic table | The crash cushion

CETMA
TECHNOLOGIES DESIGN AND MATERIALS EUROPEAN RESEARCH CENTRE

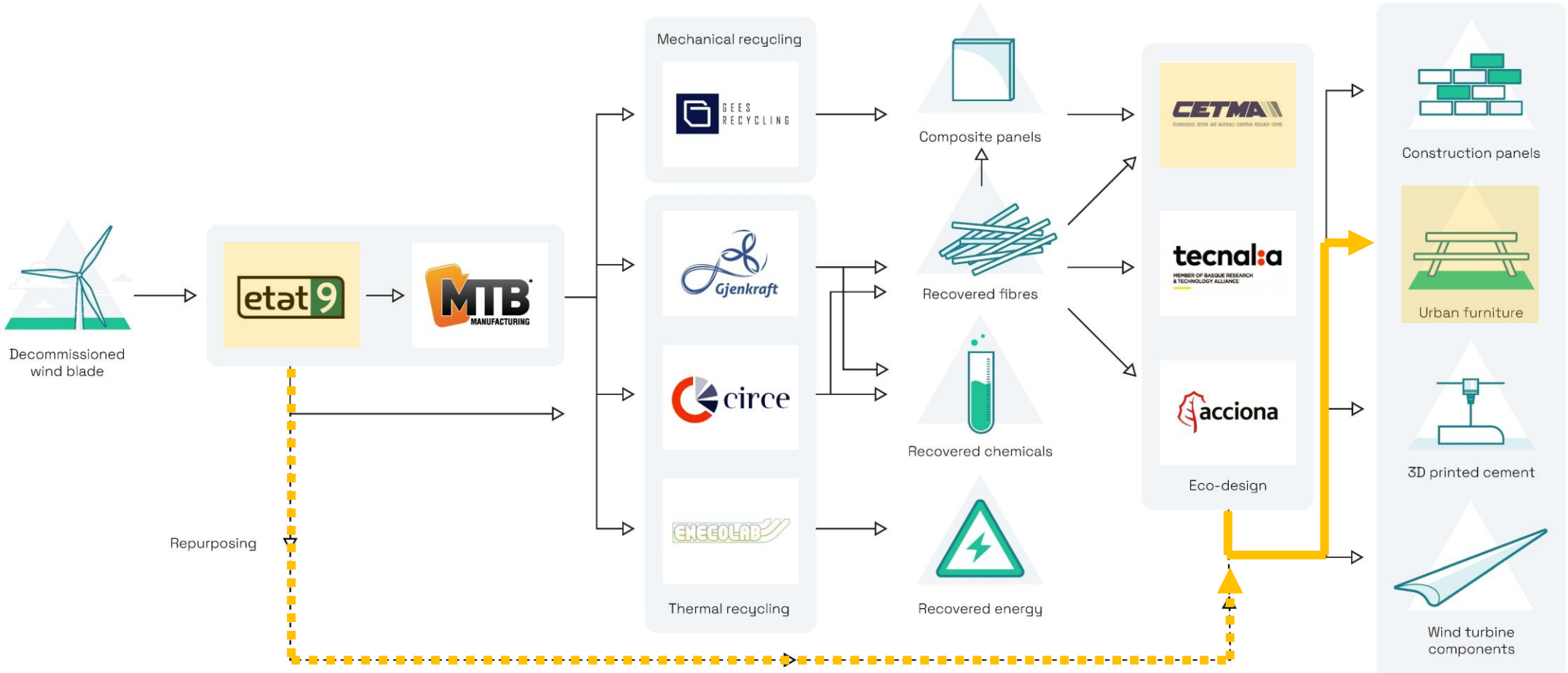
etat 9

The REFRESH project

EuCIA — Communication & dissemination

RINA — Project coordinator

Co-funded by the European Union



REFRESH

Collection **and cutting** | Shredding and sorting | Recycling | New materials | New products | Applications

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Repurposing strategy

Traditional repurposing approach

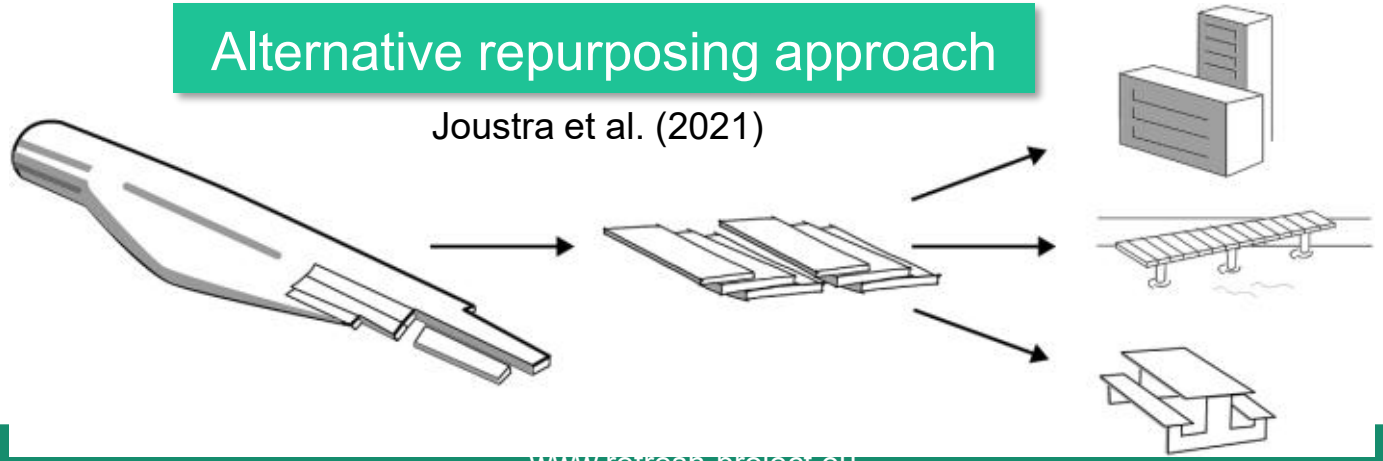
Bicycle and pedestrian bridge in Szprotawa, Poland
(Source: GP Reblade)

Playground Wikado in Rotterdam, The Netherlands
(Source: Superuse Studios, photo © Denis Guzzo)

Bike shed in Aalborg, Denmark
(Source: Re-Wind project, WindEurope Report, 2020)

Alternative repurposing approach

Joustra et al. (2021)



The picnic table

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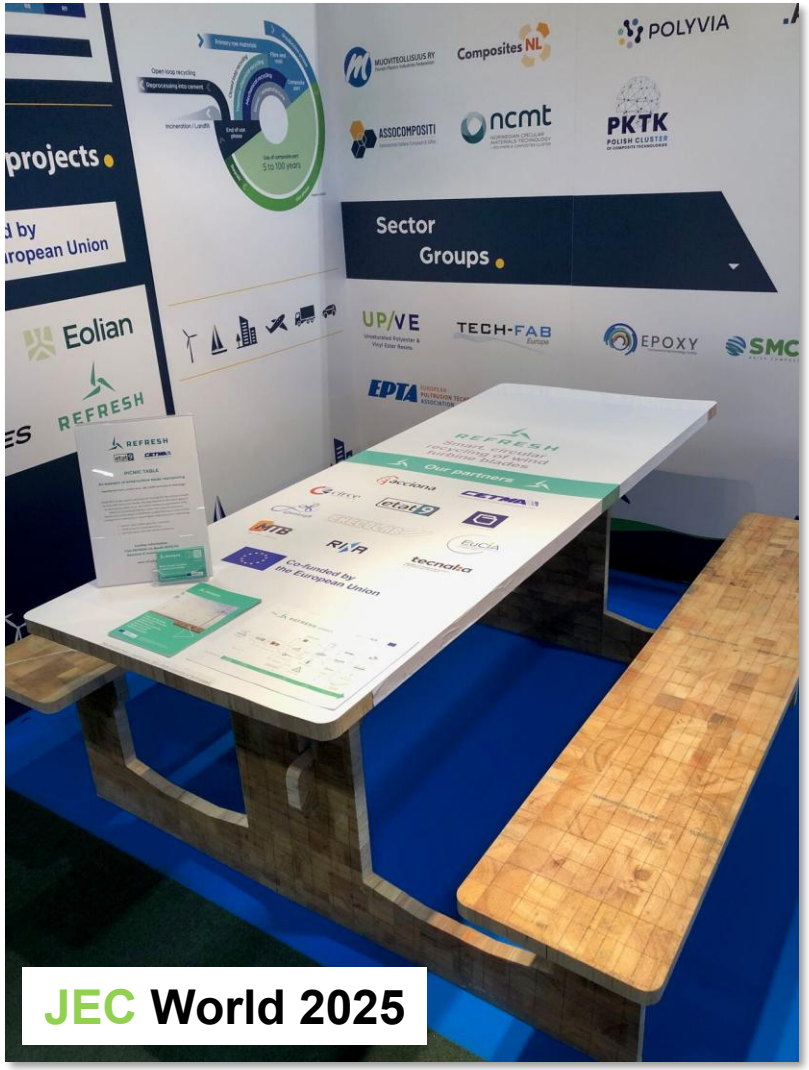
- This table explores an alternative approach to repurposing (*J. Joustra et al., 2021*) which involves the **segmentation of the blade into standardized elements** rather than using full blade parts
- Reproduction of this design was the REFRESH project's first step in exploring repurposing strategy prior to **developing an original prototype**

Structure:
Balsa/FG sandwich panels
Waterjet cut
Mech. fastener joining

Top:
GEES mech. recycled panel



The crash cushion

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- Not a «simply» self-supporting urban furniture but a structural application: **the crash cushion**
- In the broad topic of **road restraint systems**, kinetic crush cushions are designed to absorb the impact energy through friction i.e. material deformation, so they could take advantage of the residual mechanical performance of end-of-life composite components

Kinetic crush cushion
Impact energy absorbed through friction

Inertial crush cushion
Impact energy absorbed through momentum transfer

The crash cushion

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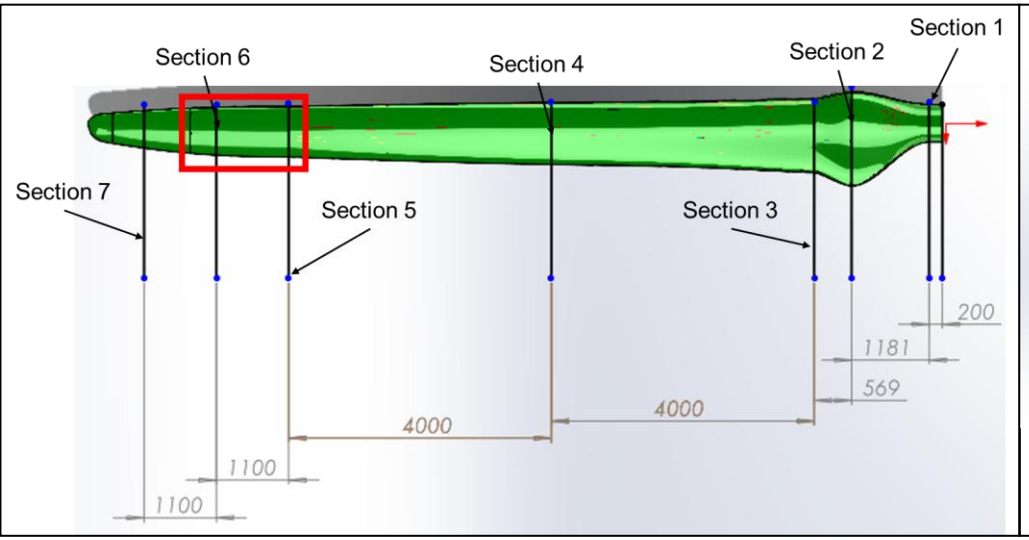
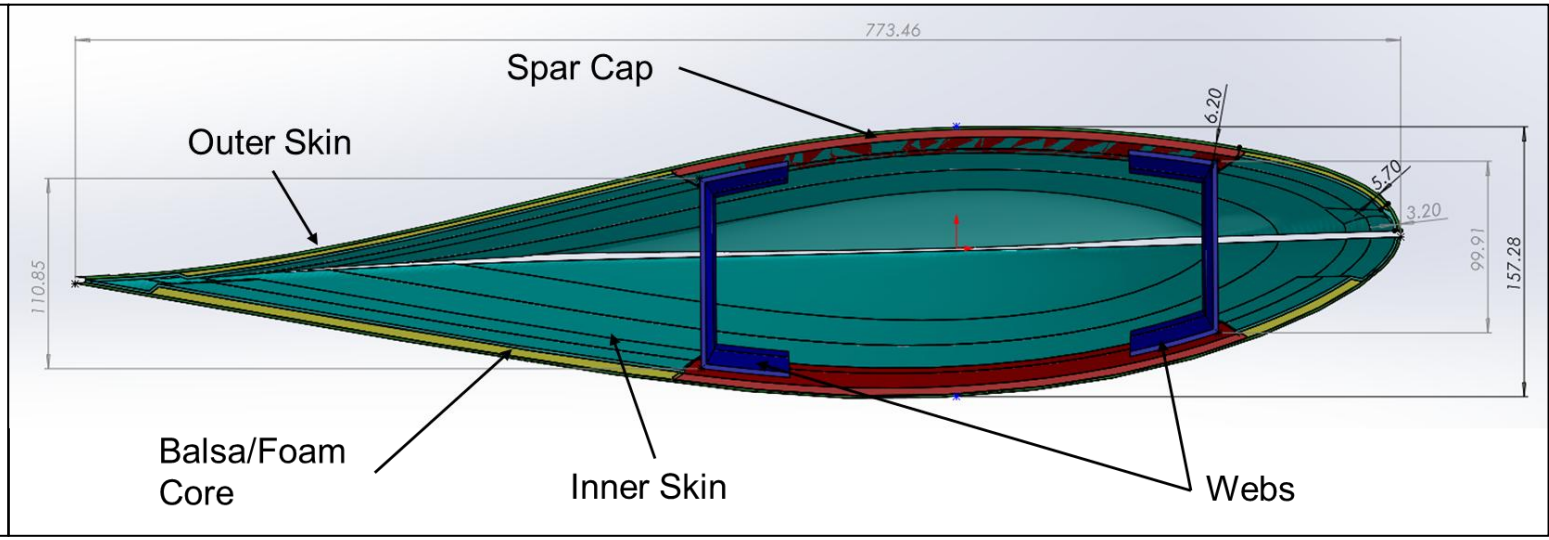
- According to EN 1317-3, crash cushion shall be tested under certain impact test criteria – where the **angle of approach**, the **vehicle mass** and the **impact speed** are the main parameters – finally defining the **performance level**
- A numerical study has been developed to evaluate the technical feasibility of the proposed concept i.e. a **crash cushion based on EoL wind blades**
- **Blade model:** ÉireComposites 13 m wind blade





The crash cushion

Impact speed = **56 km/h**
Total mass = **1.090 kg**

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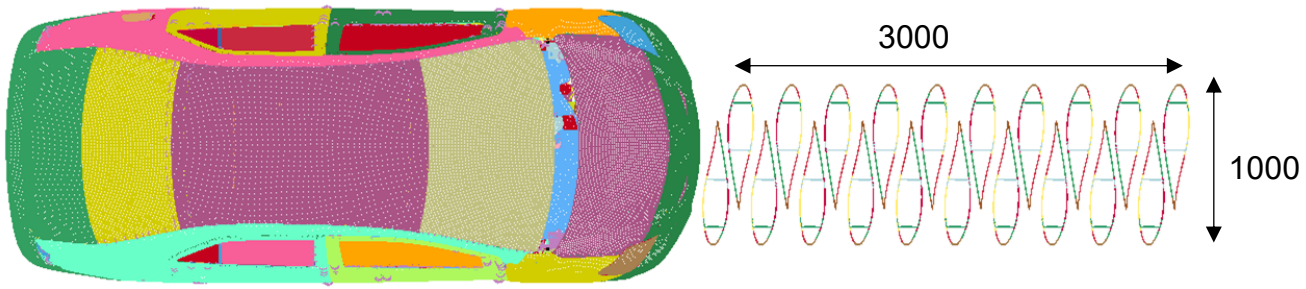
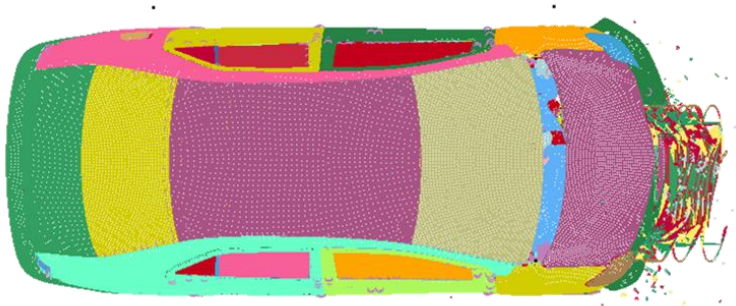
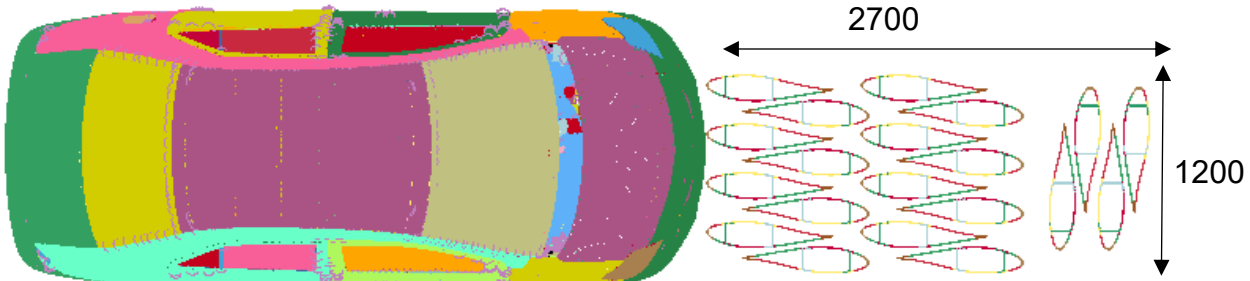
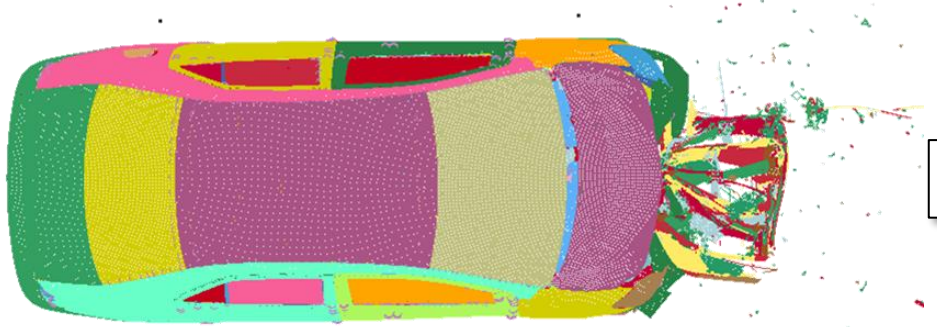




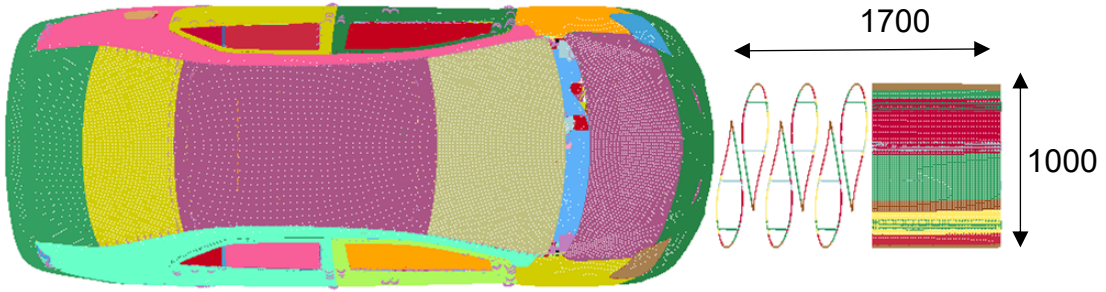
Total average acceleration

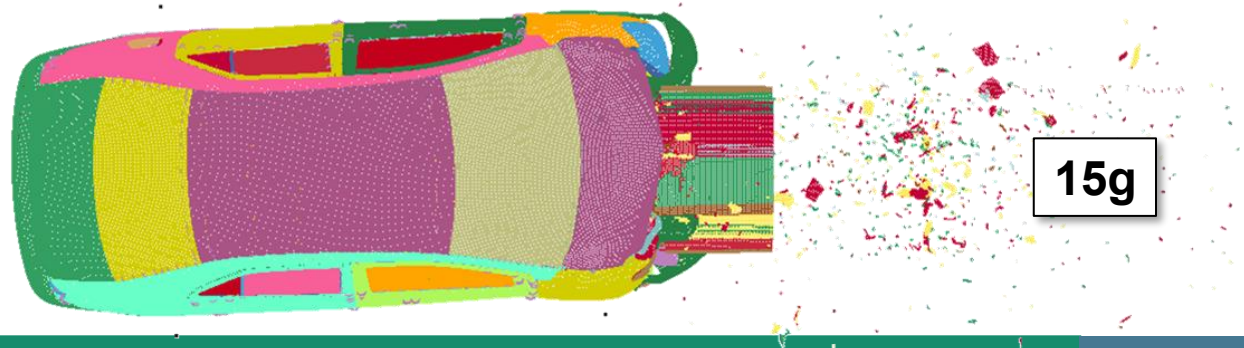
6g





10g





15g

The crash cushion

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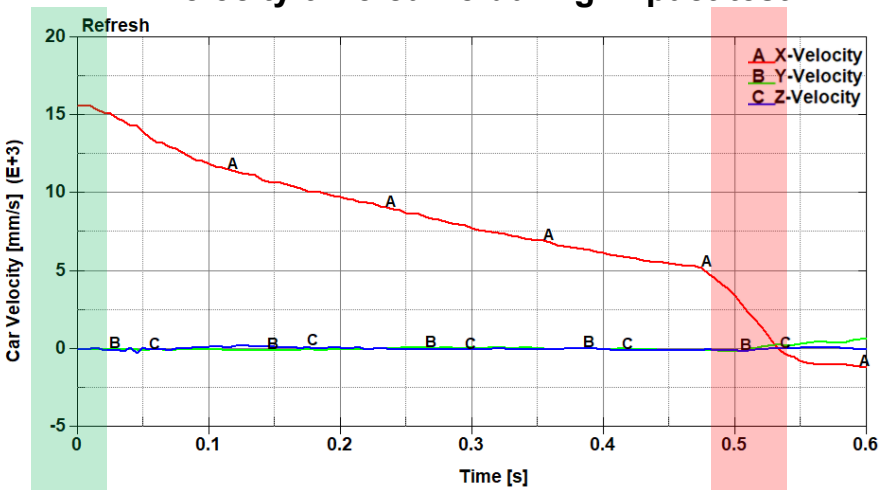
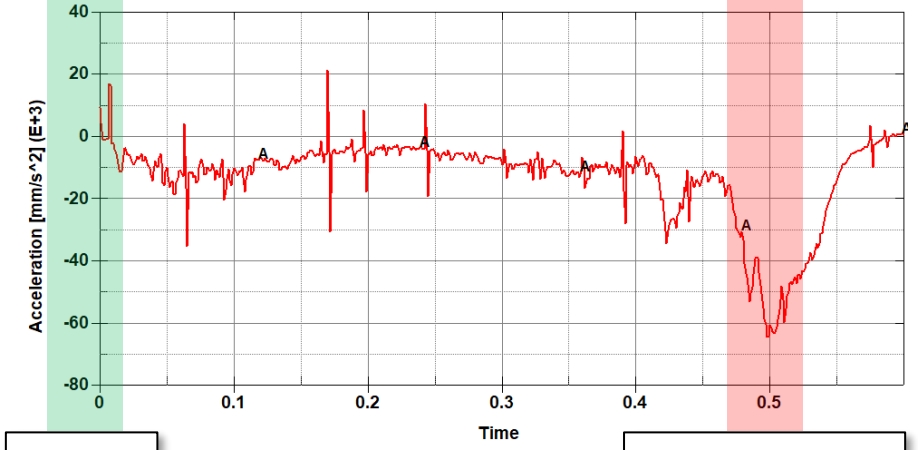
EN 1317-3

Impact severity levels	Index values		
A	ASI ≤ 1,0	THIV ≤ 44 km/h in tests 1,2 and 3 THIV ≤ 33 km/h in tests 4 and 5	PHD ≤ 20 g
B	ASI ≤ 1,4	THIV ≤ 44 km/h in tests 1,2 and 3 THIV ≤ 33 km/h in tests 4 and 5	PHD ≤ 20 g

Velocity-time curve during impact test



Acceleration-time curve during impact test



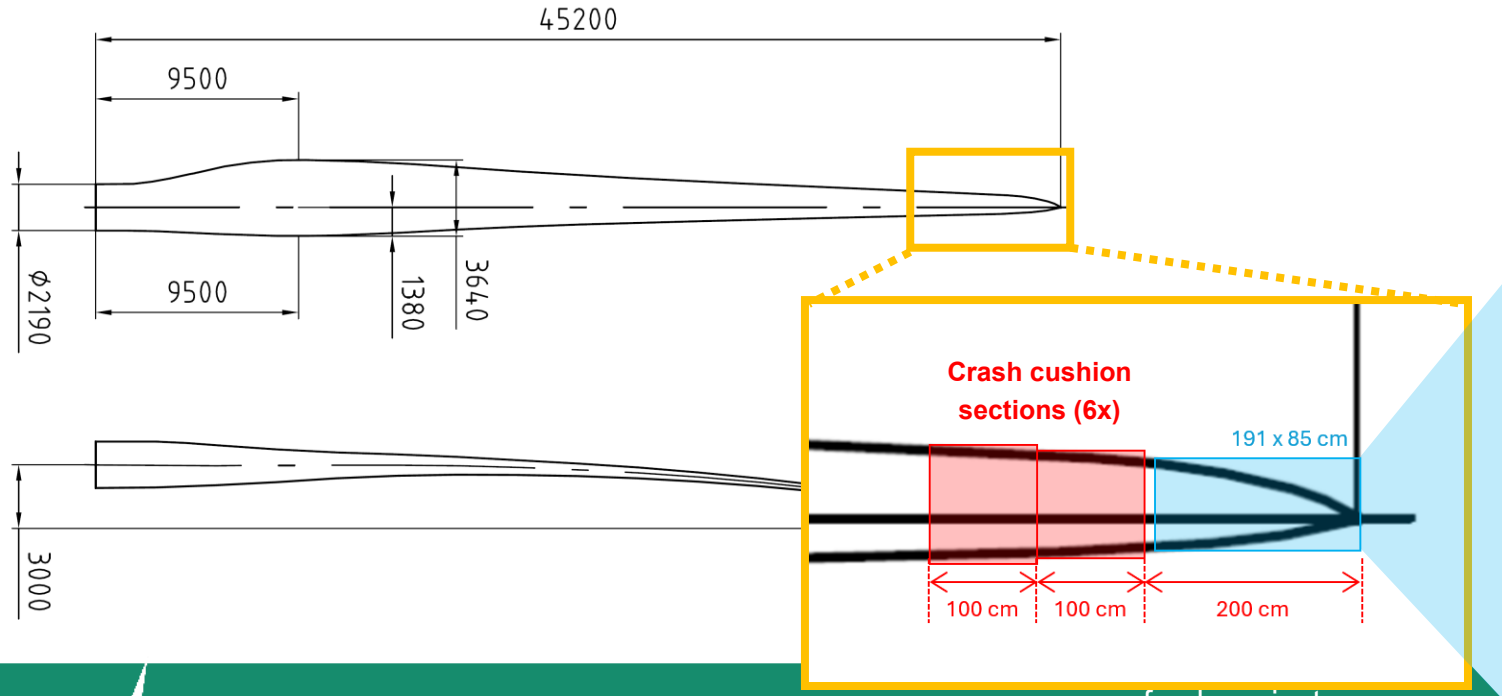
Impact

Complete stop

Work in progress / Next steps

Horizon Europe
101096858

- To replicate virtual testing on crash cushion made of tip sections from longer blades:
  same overall size / shape but tougher internal structure → less sections for the same stopping power
- To assembly a demonstrative prototype for communication purpose by using up to n. 6+6 sections recovered from 6 wind blades 45 m long during ETAT9 dismantling worksite held in Apr/May 2026
- No real testing



Conclusions

The ambition of CETMA was to turn REFRESH technologies into new end-products

Recycling and repurposing of end-of-life wind blades are established strategies

Market is ready for new circular products based on recovered composites

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REFRESH

Thank you for your attention!

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