PLASREC

III International seminar on Plastics Recycling

10 - 11 December | Valencia • Spain

The Myth of the Non-Recyclability of Composite Materials: REWIND Project

HELENA ABRIL LANZUELA

AEMAC

SPANISH ASSOCIATION OF COMPOSITE MATERIALS (AEMAC)

Founded in 1993 by Spanish Universities and RTOs

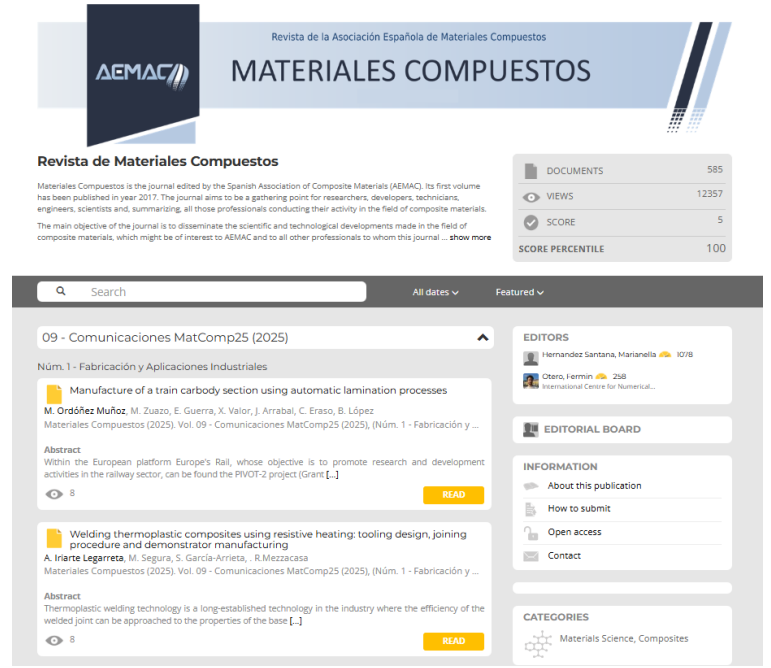
1st National Conference on Composite Materials (MATCOMP),1995.
16th Edition MATCOMP25, in Barcelona, 2025.

Conference Proceedings published from 1995 to 2015

Materiales Compuestos magazine, launched in 2017

Open Access Journal hosted on Scipedia since 2020

Indexed in Compendex (Enginnering Village, Elsevier) in 2025



ELSEVIER Engineering Village

PLASREC
III International Seminar on Plastics Recycling

EVOLUTION AEMAC MEMBERS

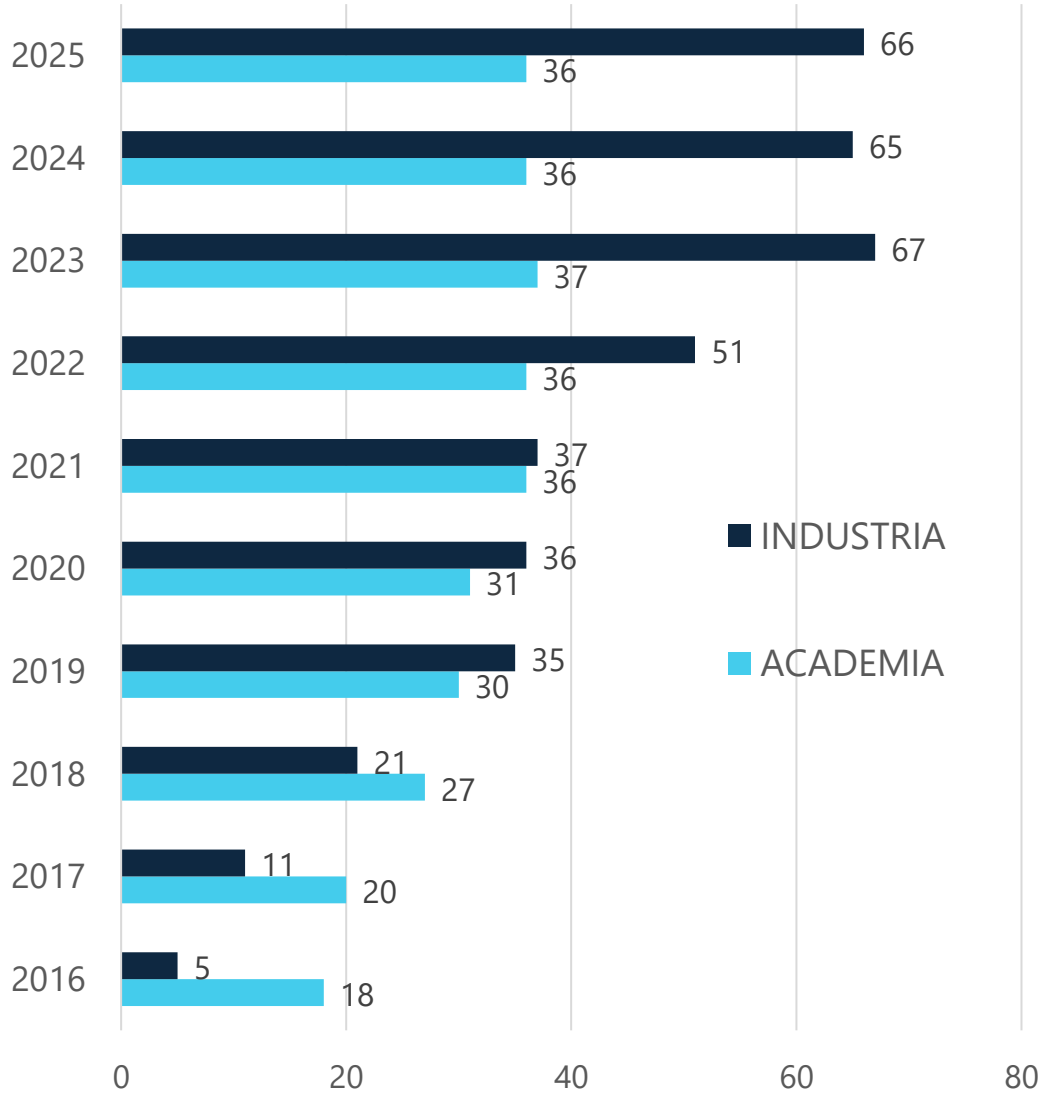
1993/2014 – 12 founders/20 members

2016 – 23 members. 78% Academia – 22 % Industry

2025 – 102 members. 35% Academia – 65% Industry

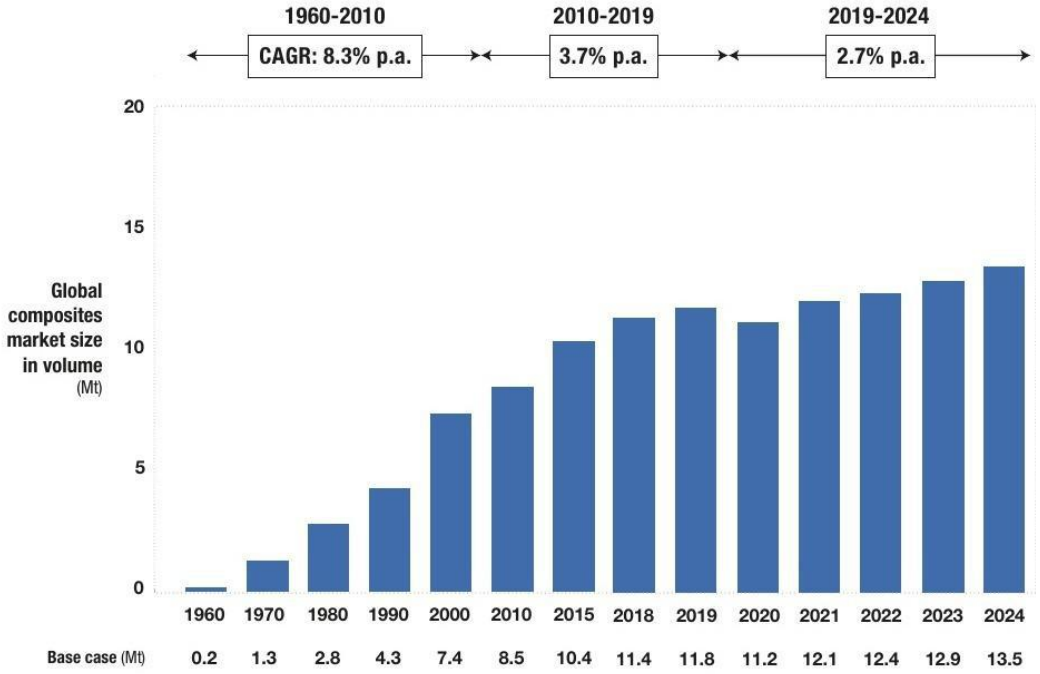
Being the institution of reference for Composite Materials in Spanish language

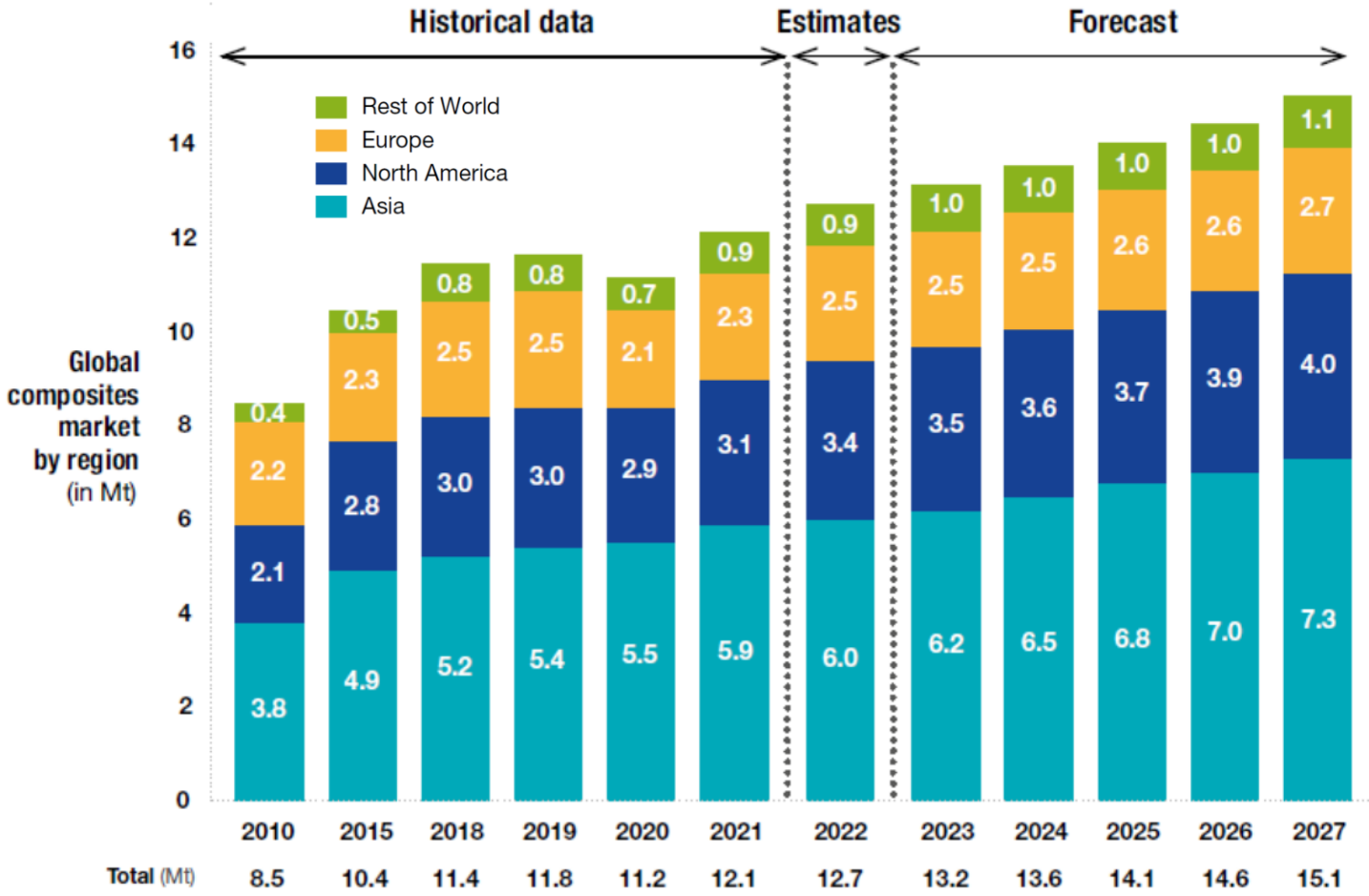
PLASREC
III International Seminar on Plastics Recycling



COMPOSITE MATERIALS - MARKET

Evolution of Composite Materials Market in Volume (Mt)

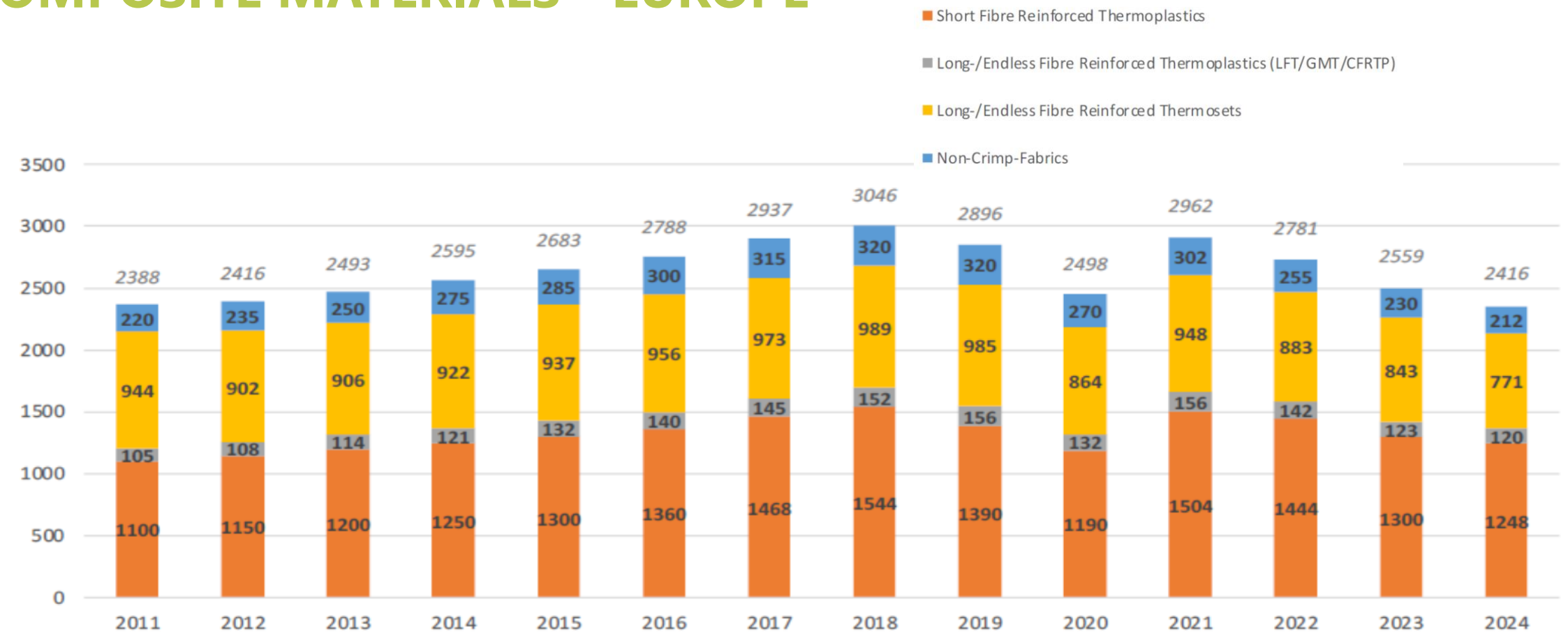




PLASREC
III International Seminar on Plastics Recycling

JEC Observer March 2025 – CAGR (Compound Annual Growth Rate – 8,3% - 2,7%)
Sources: Lucintel, Interviews, Estin & Co

COMPOSITE MATERIALS - EUROPE

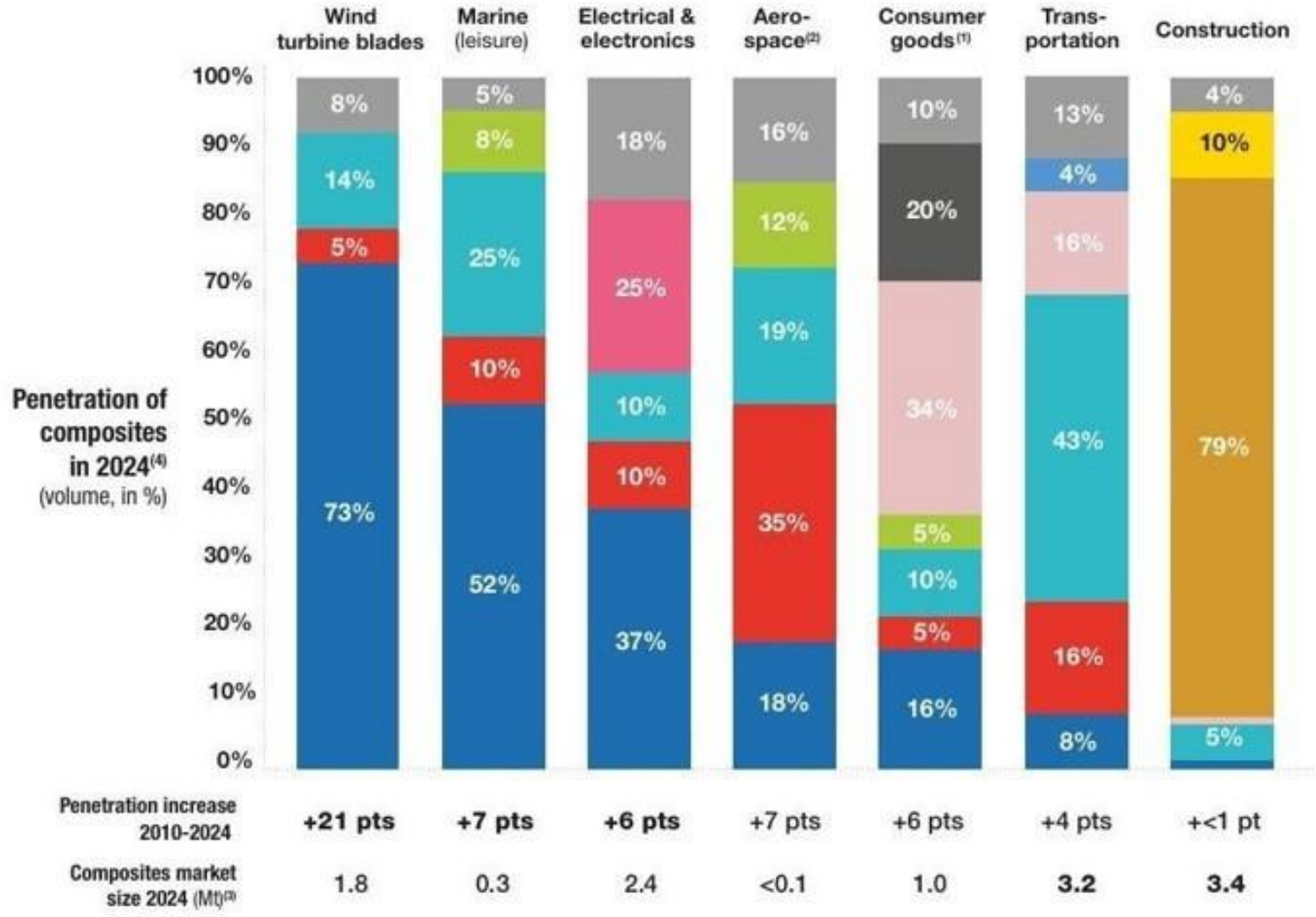


PLASREC
III International Seminar on Plastics Recycling

AVK Report 2025 – The European composites production volumen (KT) fell by 5,4% in 2024. The market is declining and falling back to the level of 2012

COMPOSITE MATERIALS – BY APPLICATION

Wind Turbine Blades – 73%

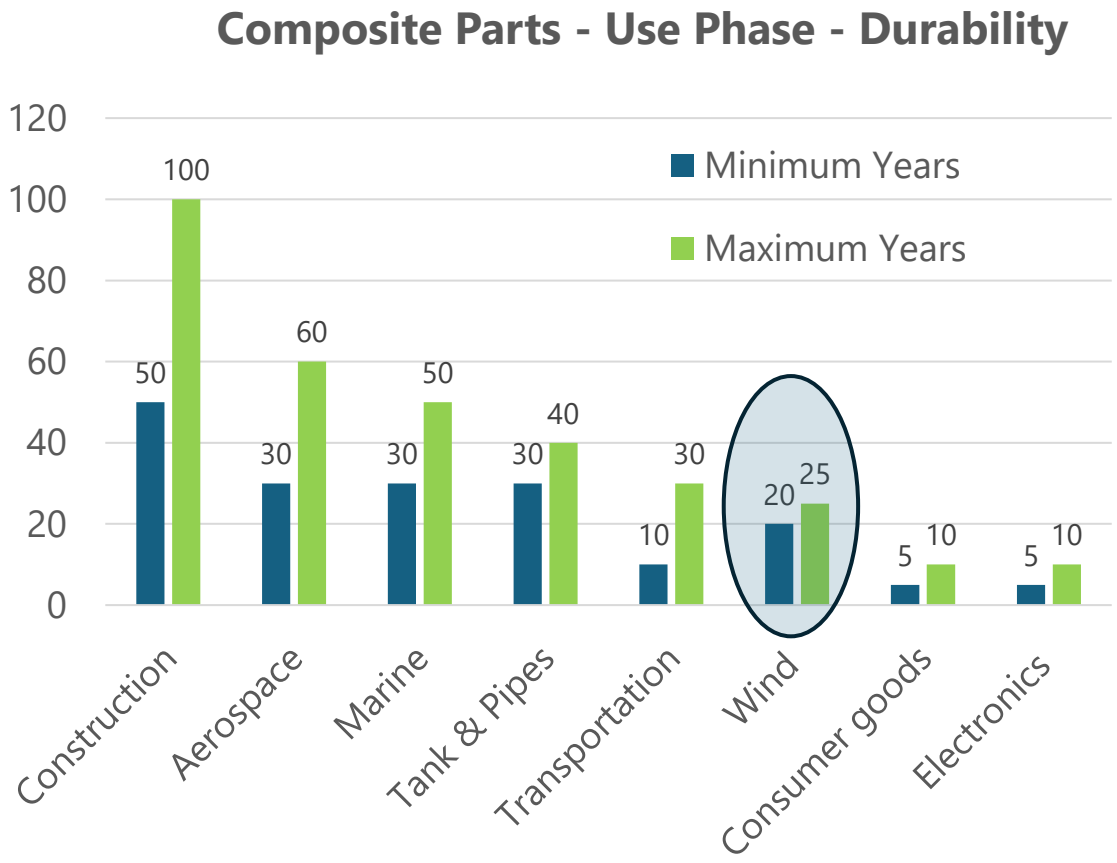


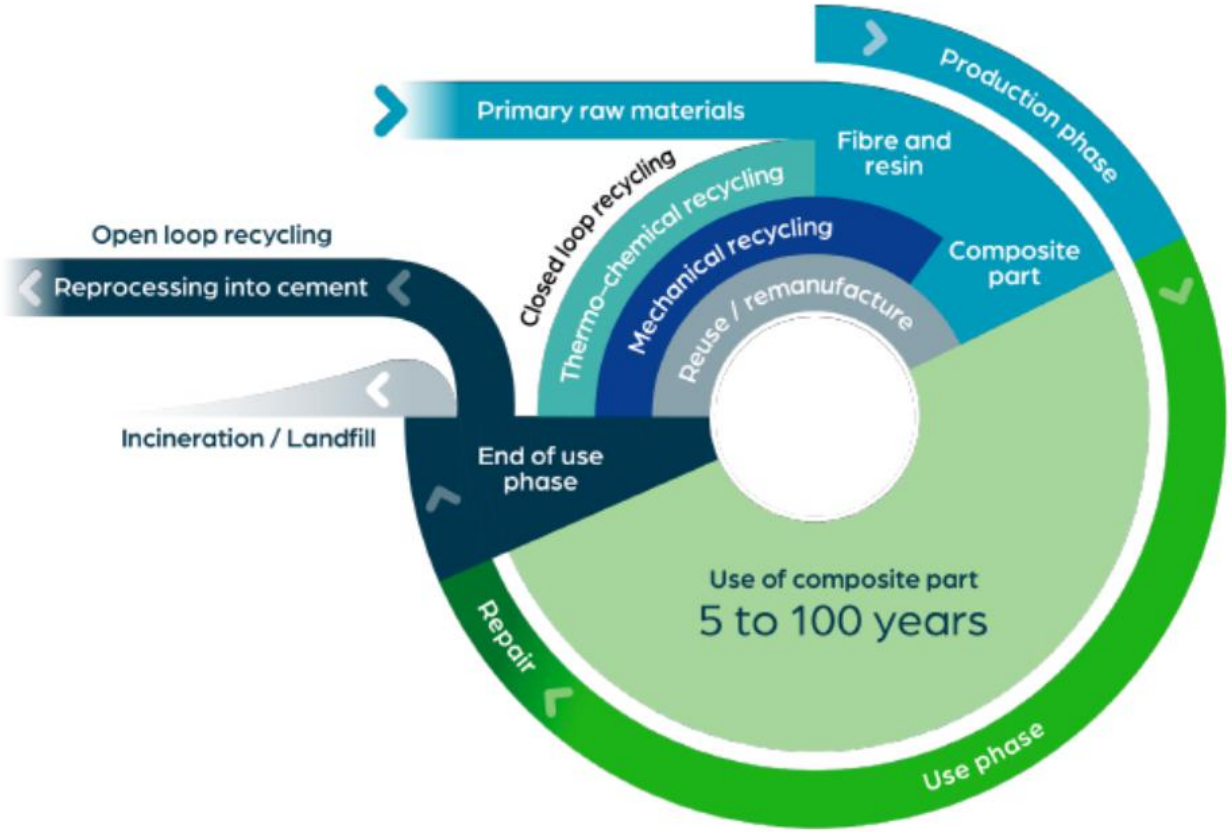
JEC Observer Report, March 2025 – Penetration of Composites in Volume (%)
Sources: Lucintel, Interviews, Estin & Co

The Myth of the Non-Recyclability of Composite Materials: REWIND Project

PLASREC
III International Seminar on Plastics Recycling

COMPOSITE MATERIALS – CIRCULAR ECONOMY





PLASREC
III International Seminar on Plastics Recycling

EUCIA, "The value of Composites to Circular Economy. Why Composites are truly Circular?" Composites can be re-used both Closed and Open Loop Processes. 2024

COMPOSITE MATERIALS – HIGH MECHANICAL PROPERTIES

1. **Lightweight** (Density 1,5-2 g/cm3)
2. High Strenght/Stifnness – to – weight ratios
3. Impact, Fatigue & Creep Resistance
4. **Chemical & Corrosion Resistance**
5. **Durability**
6. Geometric Flexibility
7. Integration Components
8. Electrical Dual (Insulating GF or conductive CF)
9. Low Thermal Expansion
10. Acoustic properties

1. Cost
2. Anistropic properties
3. Difficult Recycling

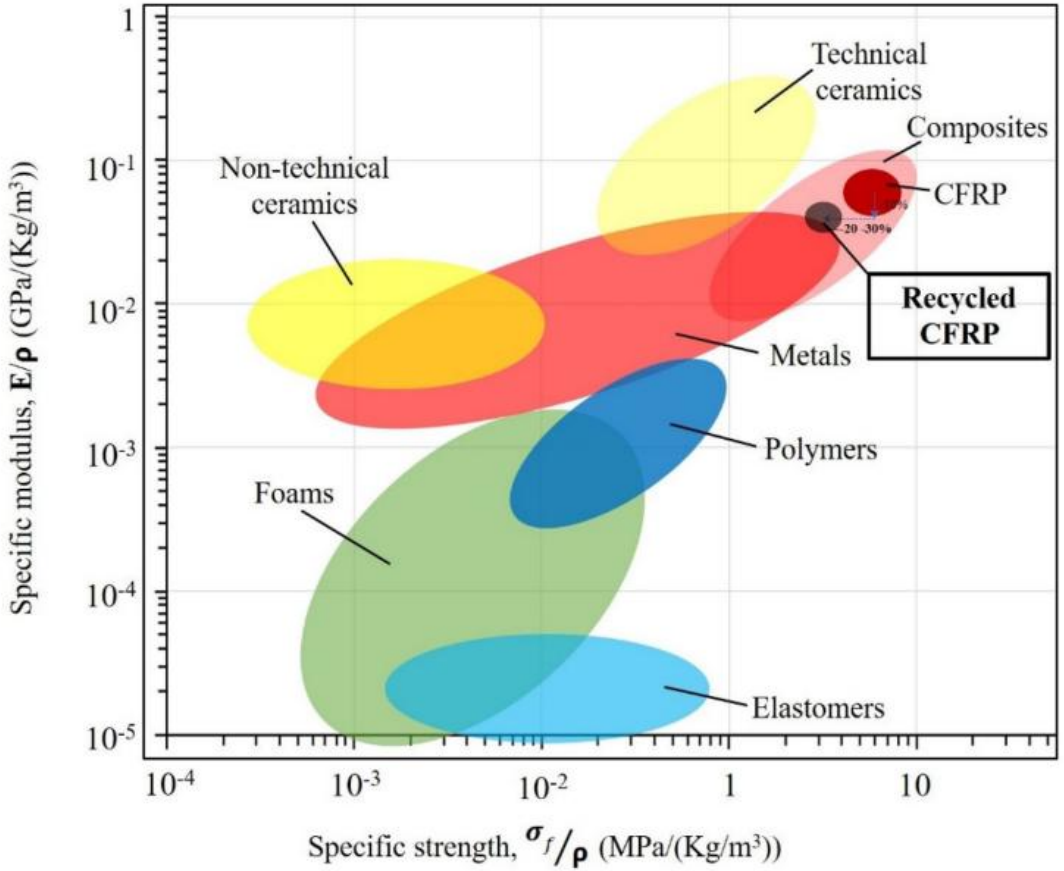


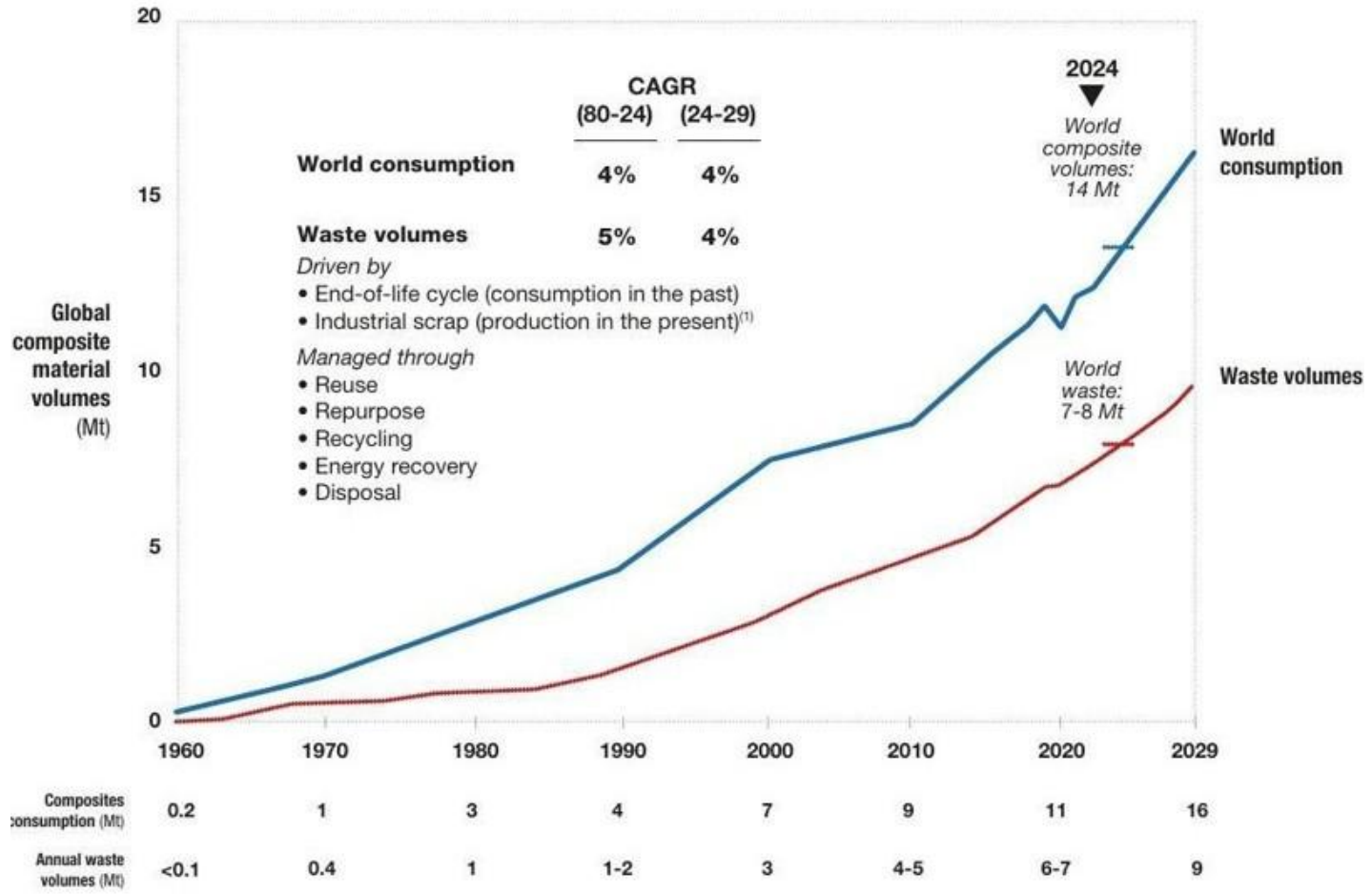
Figure 16. Schematic material property chart (Ashby diagram) of specific modulus versus specific strength showing the positioning of the different families of materials involving the recycled panel addressed in this study.

Source: W. Ballout et al. High performance recycled CFRP composites based on reused carbon fabrics through sustainable mild solvolysis route. Nature, 2022

PLASREC
III International Seminar on Plastics Recycling

COMPOSITES MATERIALS : RECYCLING

Global composite Material Waste Volumes 2024		
	Waste Management (Mt)	
	(p.a.)	%
End-of-life demand	6,8	91%
Scrap	0,7	9%
Total Waste	7,5	100%
Reuse	0,4	5%
Repurpose	<0,1	<1%
RECYCLING	0,3	4%
Recovery (Energy)	2,4	32%
Disposal (landfill, incineration)	4,4	58%
Total	7,5	100%



JEC Observer Report, 2025 – Global consumption on composite materials (V, Mt) vs the volumen of composite materials waste depends upon SCRAP Production & the EoL cycle for consumption. Sources: EUCIA, Lucintel, IMF, World Bank, Desk Research, Estin & Co

PLASREC
III International Seminar on Plastics Recycling

COMPOSITE MATERIALS: RECYCLING

Mechanical – Grinding (used as filler and structural re-use) (8-9)

Thermal – Pyrolysis, Microwave-assisted Pyrolysis (6-7), High Voltage Pulse Fragmentation, Fluidized Bed Process (6-7), Gasification, Incineration (8-9)

Chemical – Solvolysis (6-7), Supercritical Solvolysis, Pressolysis (Pressure Methods), Catalytic Depolymerization (3-4), Electrochemical (4-5)

Biological – Enzymatic recycling, Microbial assisted degradation

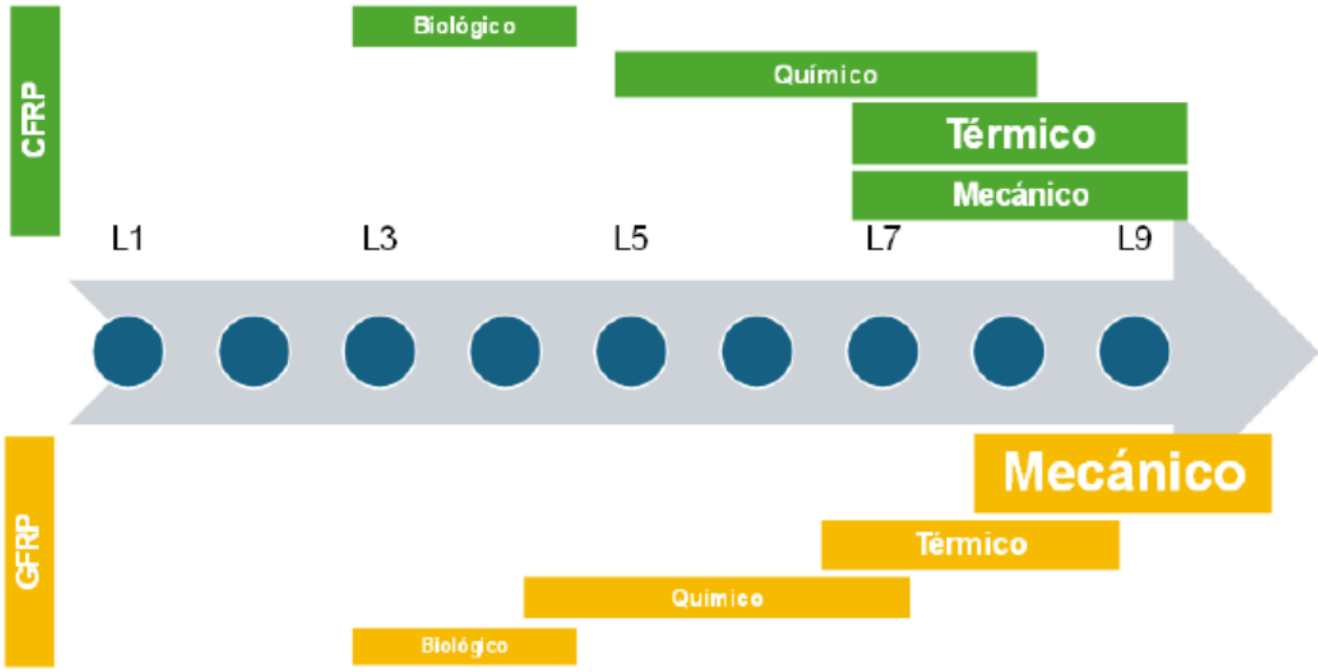


Figura 1: *Nivel de madurez de la tecnología (L1-L9) y grado utilización (según tamaño). Rangos promediados de varias referencias [7] [8] [4]. GFRP - Compuestos reforzados con fibra de vidrio / CFRP - Compuestos reforzados con fibra de carbono.*

AEMAC. "Libro Blanco de Sostenibilidad de Materiales Compuestos" – Chapter n°6 "Management of Composite Materials at the end of use. Current situation. March, 2025

PLASREC
III International Seminar on Plastics Recycling

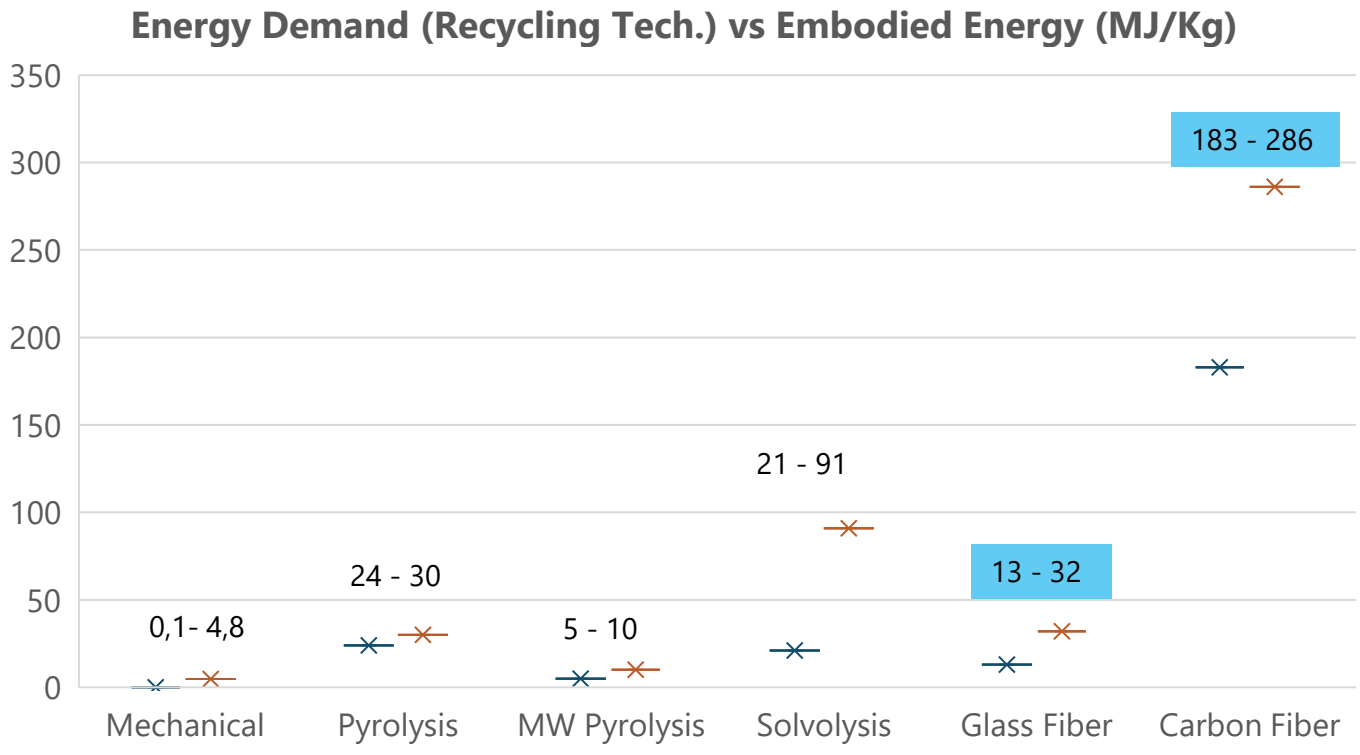
COMPOSITE MATERIALS: RECYCLING

CARBON fiber composites

They require less energy than the material embodied energy (manufacturing process) which ranges from **183 to 286 MJ/Kg**. This make them economically and environmentally sustainable

GLASS fiber composites

Only mechanical & MW Pyrolysis are sustainable. The embodied energy from **13 to 32 MJ/Kg** is lower than the energy required for processing by pyrolysis and solvolysis.



Amaechi, C.V. et al. (2019) Economic Aspects of Fiber Reinforced Polymer Composite Recycling. Encyclopedia of Renewable and Sustainable Materials, 2, 377-397.

PLASREC
III International Seminar on Plastics Recycling

COMPOSITE MATERIALS: ECOSYSTEM

Cement Europe · EBI European Boating Industry · EPOXY · EuCIA · GLASS FIBRE EUROPE · UP/VE Unsaturated Polyester & Vinyl Ester Resins · Wind EUROPE · cefic

JEC CONNECTING THE WORLD WITH COMPOSITES · ECCA European Circular Composites Alliance by EuCIA · European Commission

AEMAC ASOCIACIÓN ESPAÑOLA DE MATERIALES COMPUESTOS · AIMPLAS PLASTICS TECHNOLOGY CENTRE

PLASREC
III International Seminar on Plastics Recycling

SUSTAINABILITY WORK GROUP

Created in 2023 by AEMAC

- **White Book of Sustainability of Composite Materials**

State of art technology and sustainability projects on composite materials in Spain. 24 Chapters + 2 Technical Annex. Collaboration of 22 AEMAC's members

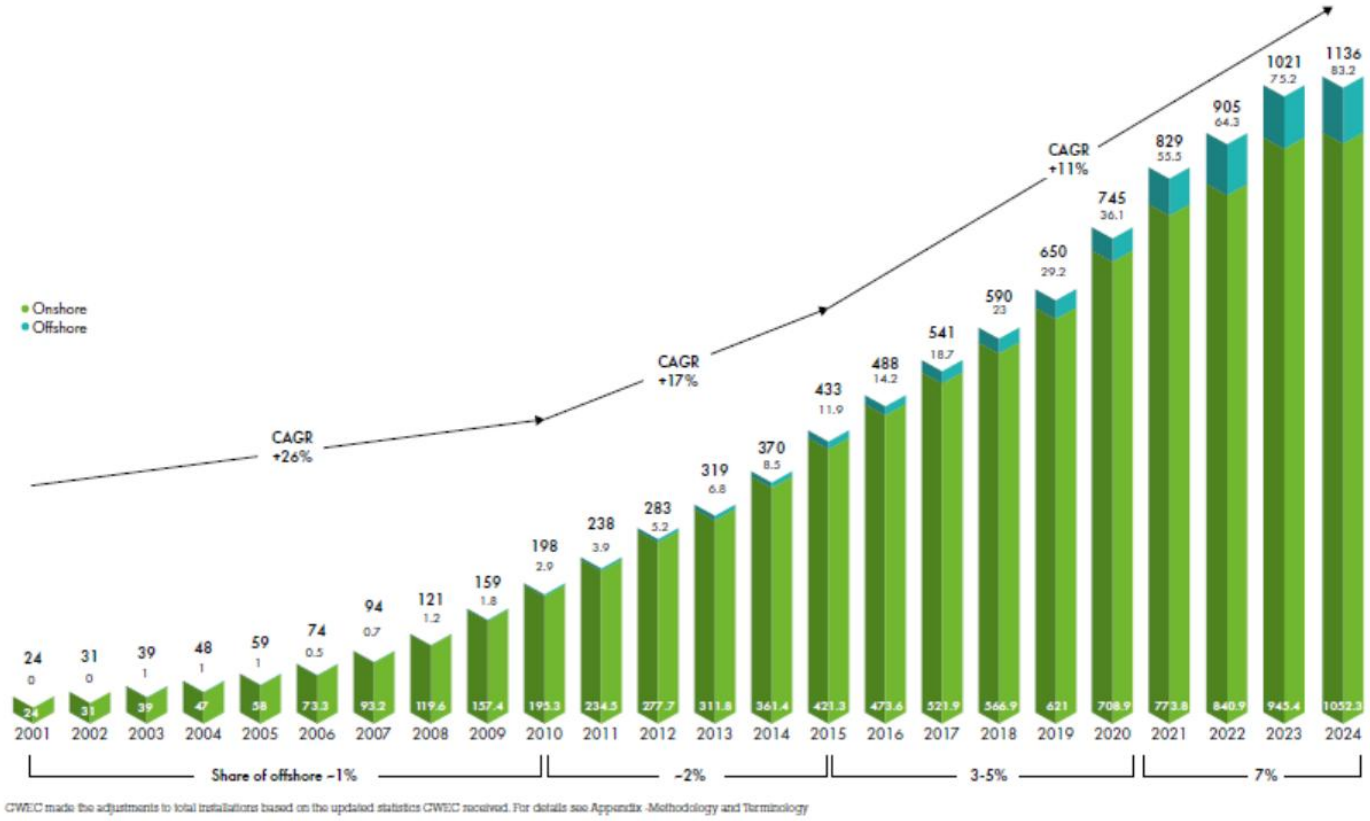
- **Coordination 4 work sub-groups – R&D projects**

IMPLICIT – Recovery and reuse of raw materials (thermoplastics, PA, PE, PP, PET) from auxiliar manufacturing materials in automotive, street furniture, rPET synthesis. Coordinated by AIMPLAS, with AEMAC members: Eurecat, Tecnalia & Leartiker

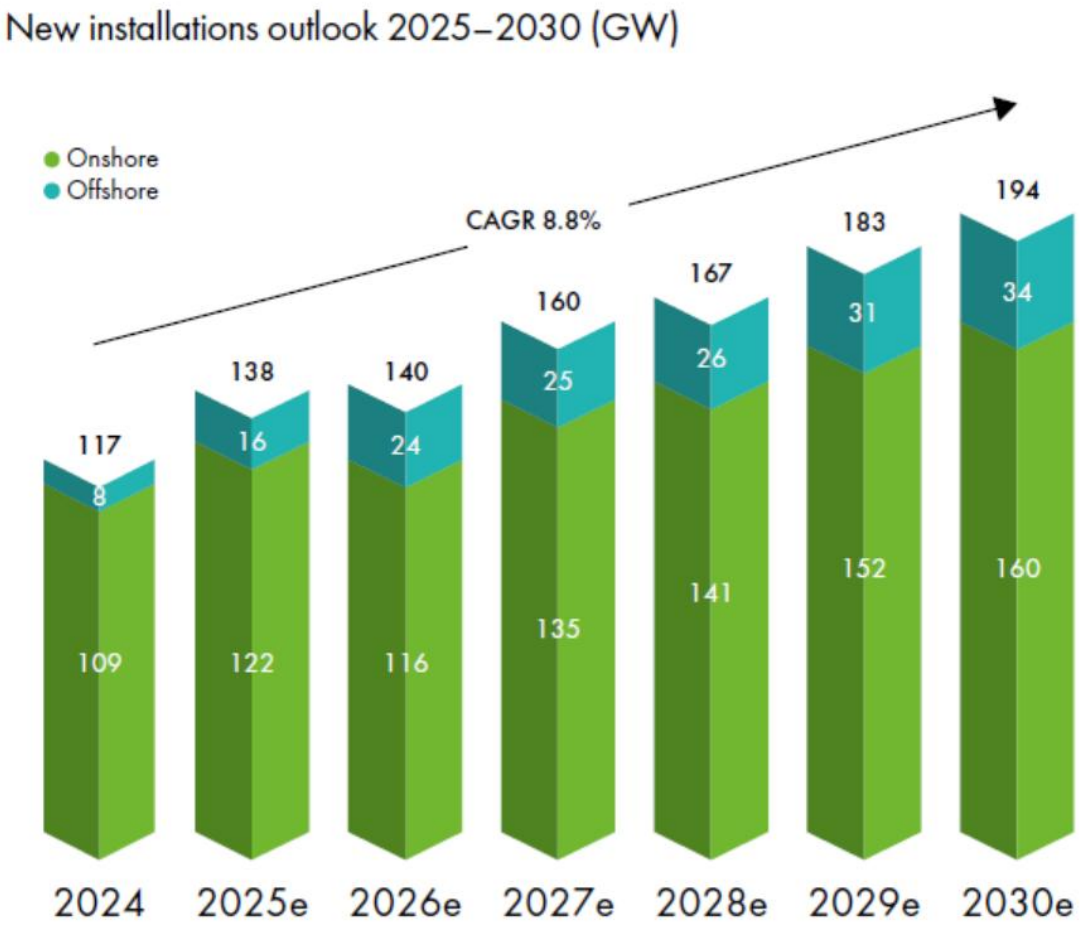
PLASREC
III International Seminar on Plastics Recycling

WIND ENERGY

Historical development of total instalations (GW)



GWEC made the adjustments to total installations based on the updated statistics GWEC received. For details see Appendix -Methodology and Terminology



GWEC's Market Outlook, 2025. Industry perspective on expected installations of new capacity over next five years. Global Wind Energy Market is expected to grow 8,8% annually.

WIND ENERGY – MARKET

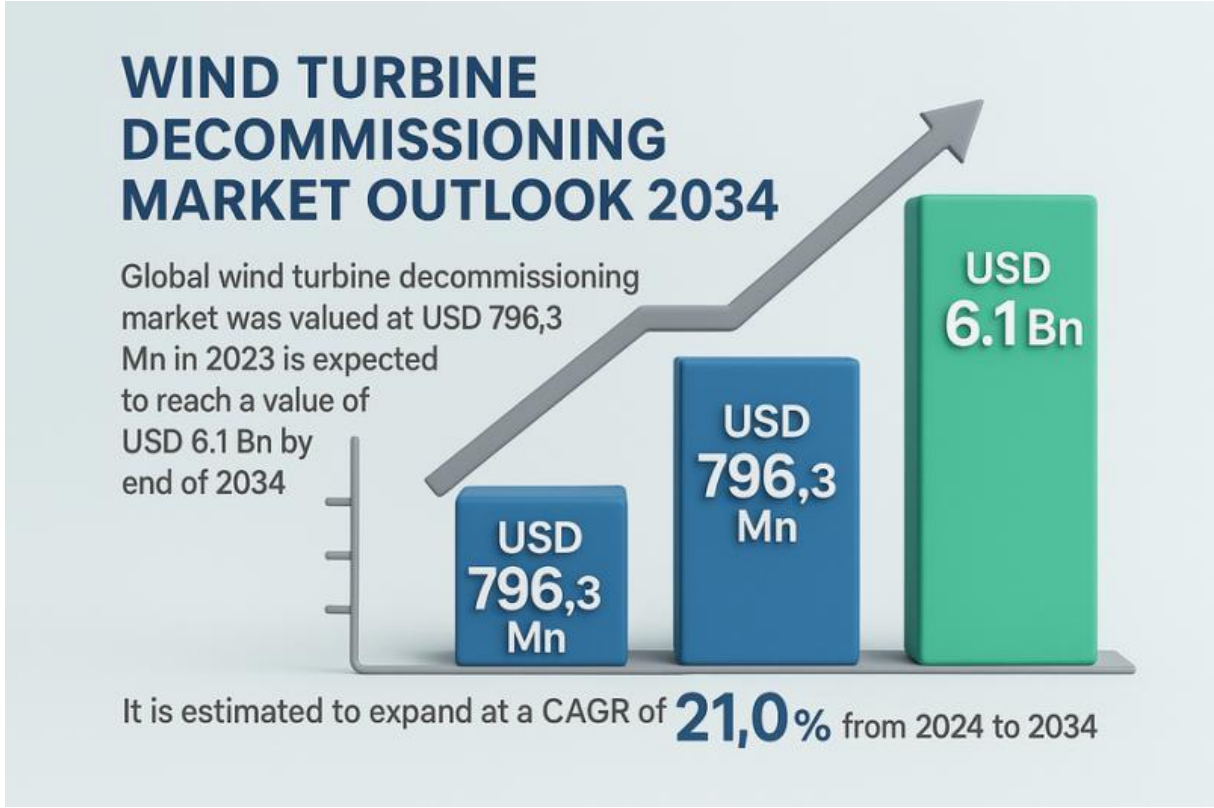
Europe leads the world (45% market share)

- Early wind farm installations now aging, driven by mature markets (Denmark, Germany, UK)
- Strict environmental policies on waste (EU Comision)
- Growing focus on recycling and repowering projects

- Increasing need to dismantle, recycle, or upgrade older turbines as they reach the EoL (OEMs).
- Rising investments in material recovery technologies, and large-scale repowering initiatives (Governments, R&D)

US is the 2nd market (30%)

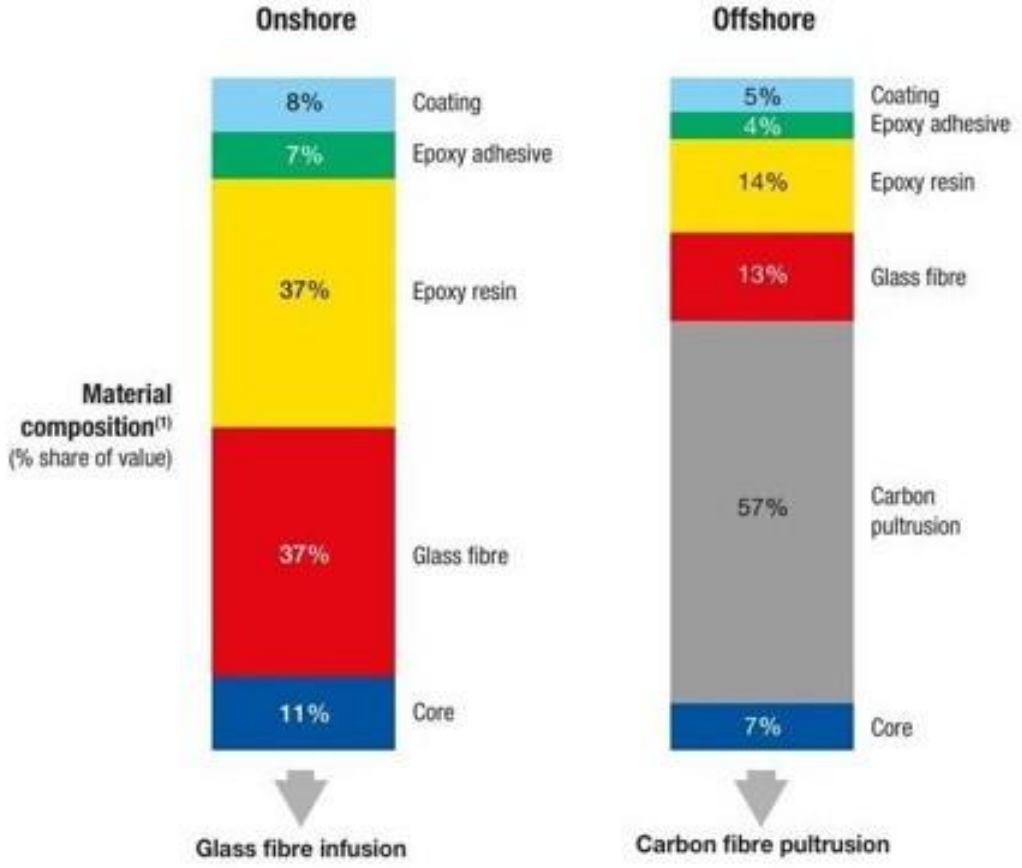
- Tax Credits driving activity

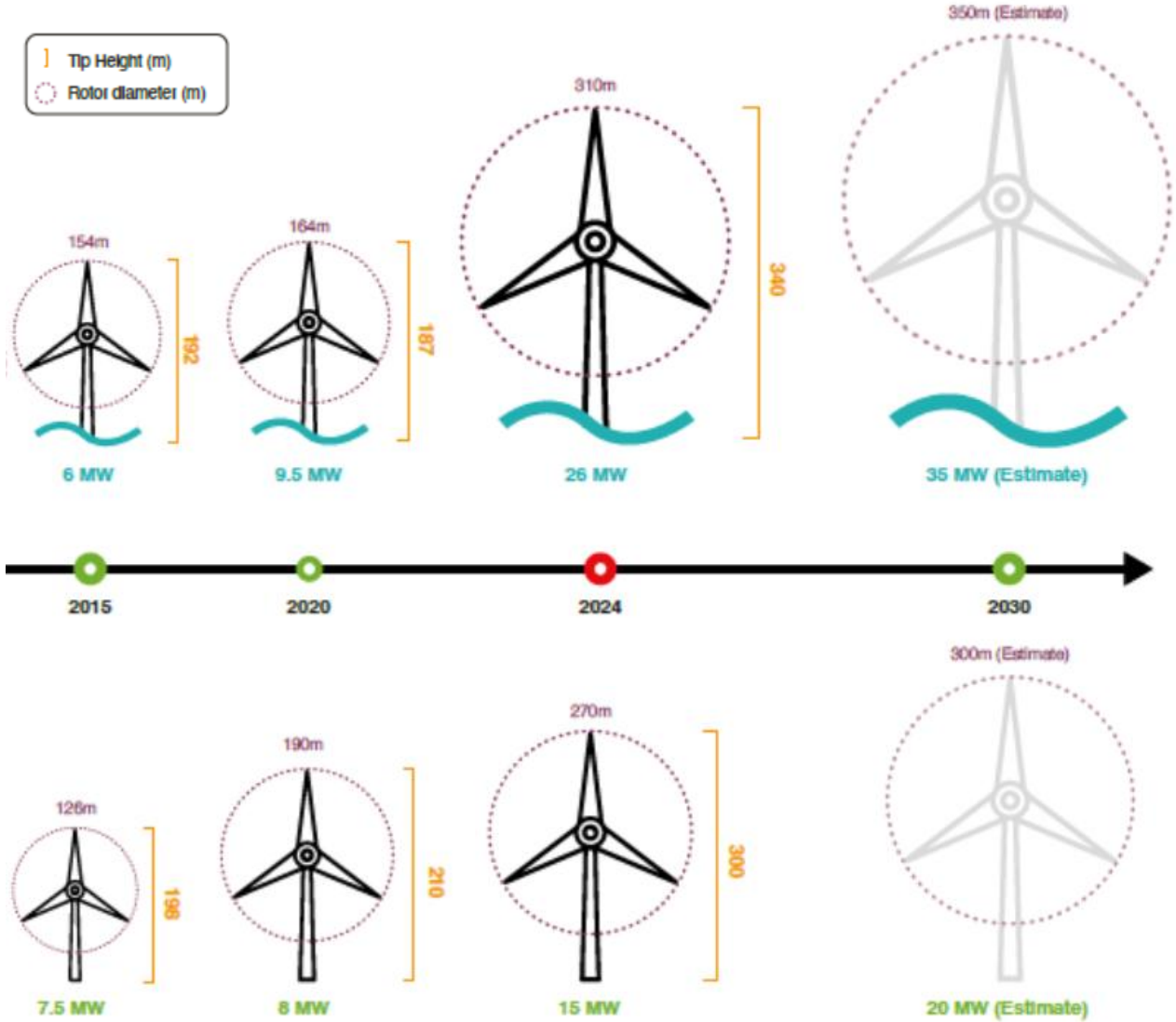


Source: OpenPR – Press Release from Transparency Market Research

PLASREC
III International Seminar on Plastics Recycling

WIND ENERGY – MATERIALS





PLASREC
III International Seminar on Plastics Recycling

Source – JEC Observer Report 2025 – Materials used are different and the manufacturing processes.
GWEC's Market Intelligence, 2025 – Trend of onshore & offshore turbine size (270m – 310m, 2024)

WIND ENERGY – EoL WTB

REUSE –Second-hand market (refurbished blades & turbines) is blooming, **continuing their service.**

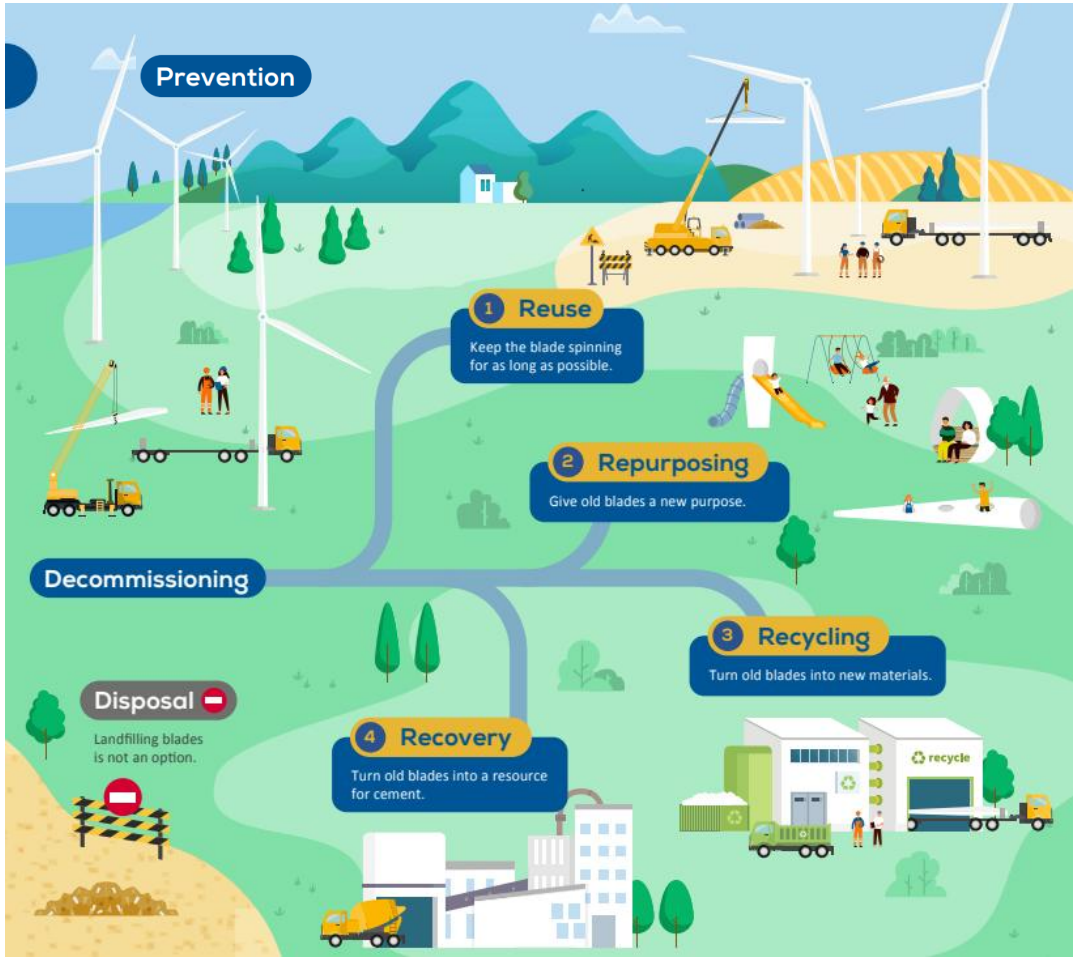
REPURSPOSING – Sections transformed into bridges, playgrounds, **valuable solutions.**

RECYCLING – Mechanical (powder & fibers) Thermal & Chemical (fibers & resins for **new industrial applications**)

RECOVERY – Fibers used as raw materials in cement, Resin provides energy. **Saves up to 0,8T CO2/1T Blade waste**

PREVENTION - Maintenance and repairs **extend the service life of turbines**

The wind industry has self-imposed a landfill ban for 2026 to make sure no blade is left behind



Source: Wind Europe – Blade Circularity – November 2025.

PLASREC
III International Seminar on Plastics Recycling

The Myth of the Non-Recyclability of Composite Materials:

REWIND

PLASREC
III International Seminar on Plastics Recycling

WIND ENERGY – REWIND PROJECT

Started in 2024/2028

Funded by the European Climate, Infrastructure and Environment Executive Agency (CINEA)

Coordinated by AIMPLAS

14 members from 7 countries

Efficient Decommissioning, Repurposing and Recycling to Increase the Circularity of end-of-life Wind Energy Systems.

PLASREC
III International Seminar on Plastics Recycling

REWIND

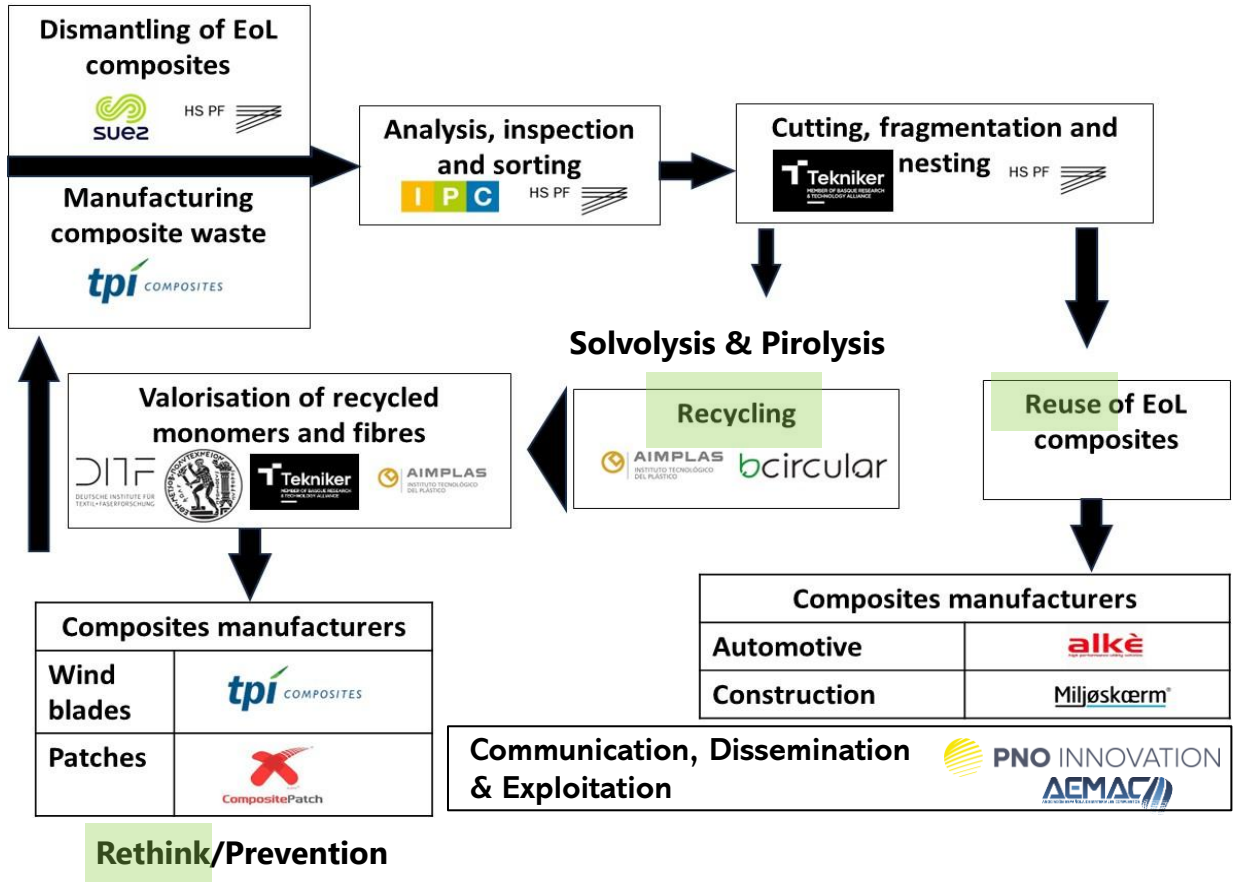
FUNDING

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 the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them. Grant Agreement Nº101147226 - REWIND - HORIZON-CL5-2023-D3-02

Funded by the European Union

WIND ENERGY – REWIND – VALUE CHAIN

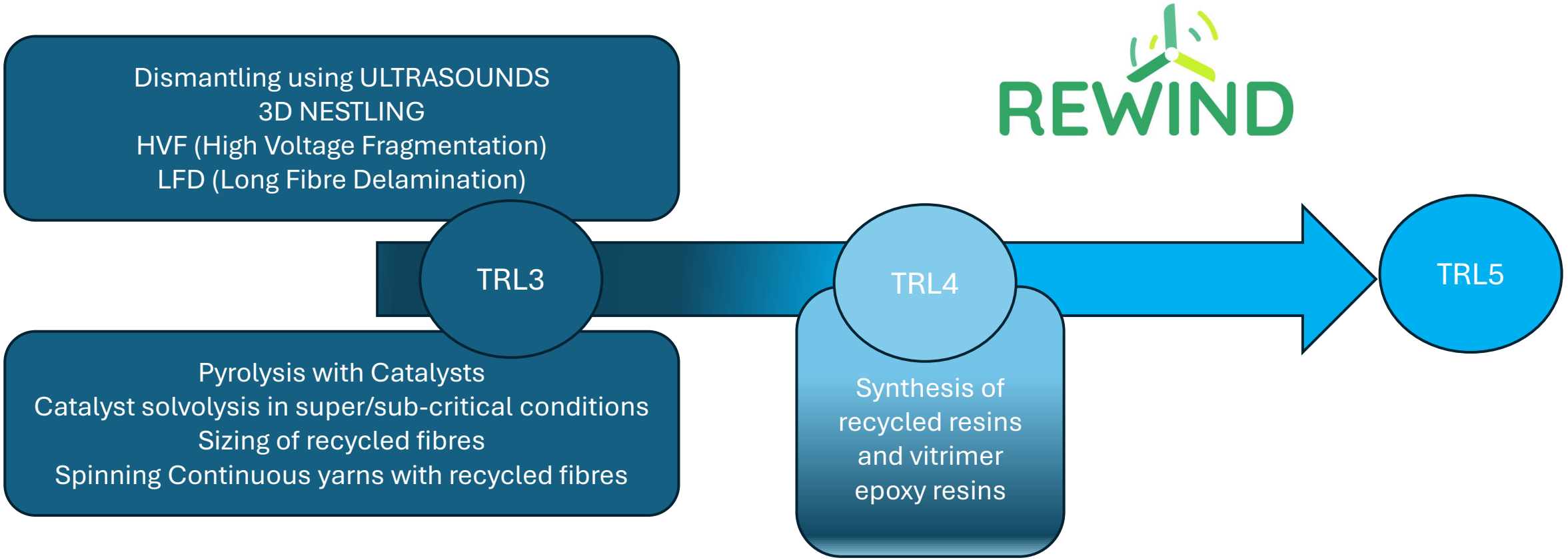
1. Demonstrate efficient technologies for **decommissioning** EoL WT and **sorting.**
2. **Repurpose** of EoL composite in **automotive, construction**
3. Develope **cost-effective composites recycling technologies** to improve properties and performance of the retrieved materials.
4. Produce good quality **yarns and fabrics from the r-fibres** coated with the appropriate sizing.
5. Use **secondary raw materials (recycled fibres & resins)** for the manufacturing of new composite within **WE sector.**
6. Improve **environmental & economic sustainability** of processes and products.
7. **Maximize socio-economic impact**, including stakeholder engagement and social acceptance.



PLASREC
III International Seminar on Plastics Recycling

REWIND

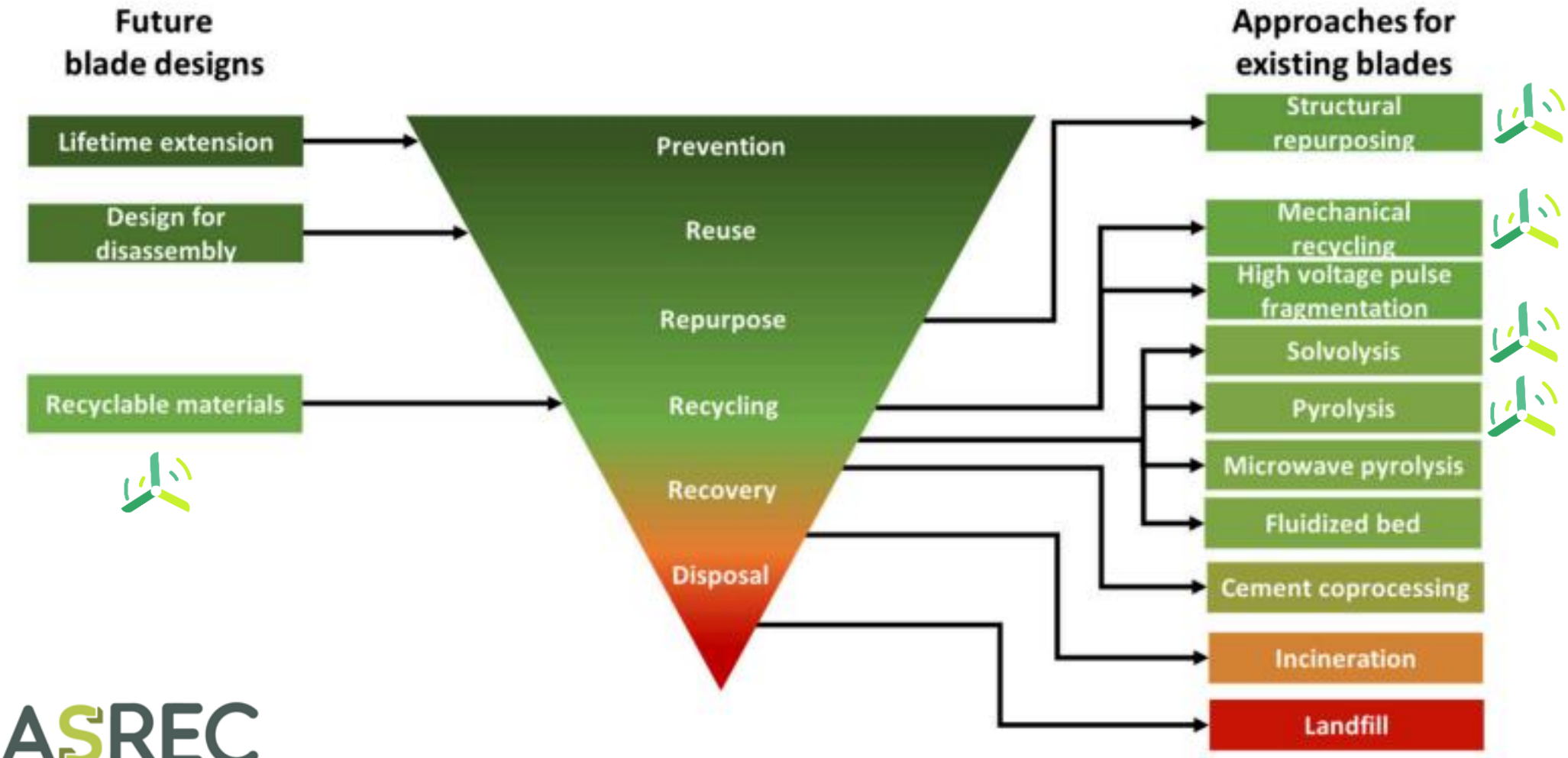
WIND ENERGY - REWIND – TRL



PLASREC
III International Seminar on Plastics Recycling

From TRL3 (Technology Readiness Level) to TRL4 & TRL5

WIND ENERGY – FUTURE BLADES - REWIND

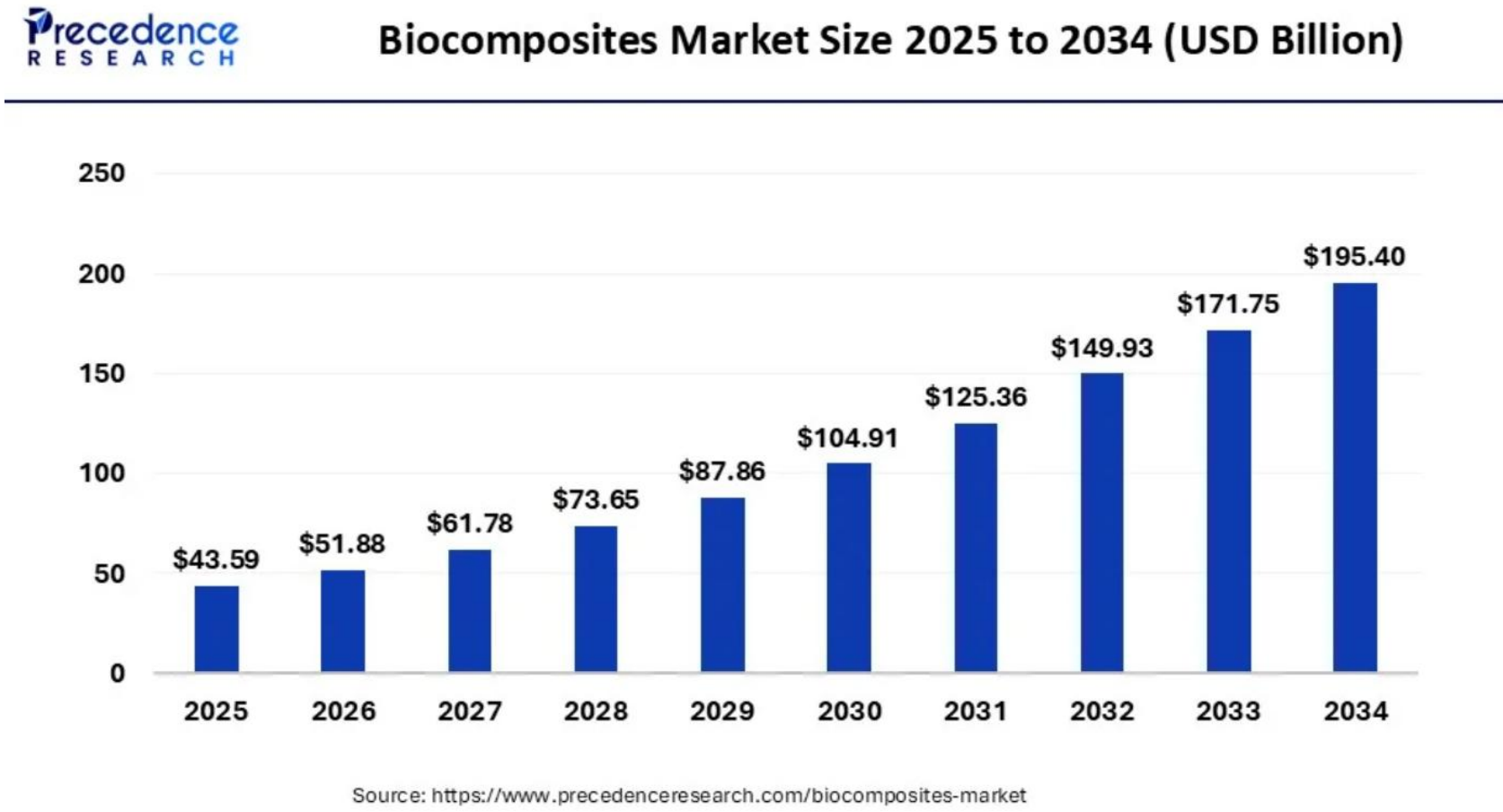


Source: ACS Sustainable Resource Management, 2024. Approaches developed for wind turbine blades reaching end-of-life, arranged from high (top of the inverted pyramid) to low circularity

WIND ENERGY – FUTURE BLADES

¿Are COMPOSITES good materials for the future BLADES?

- Lifetime extensión ✓
- Design for disassembly ✓
- Recyclable Materials ✓



Source: https://www.precedenceresearch.com/biocomposites-market

PLASREC
III International Seminar on Plastics Recycling

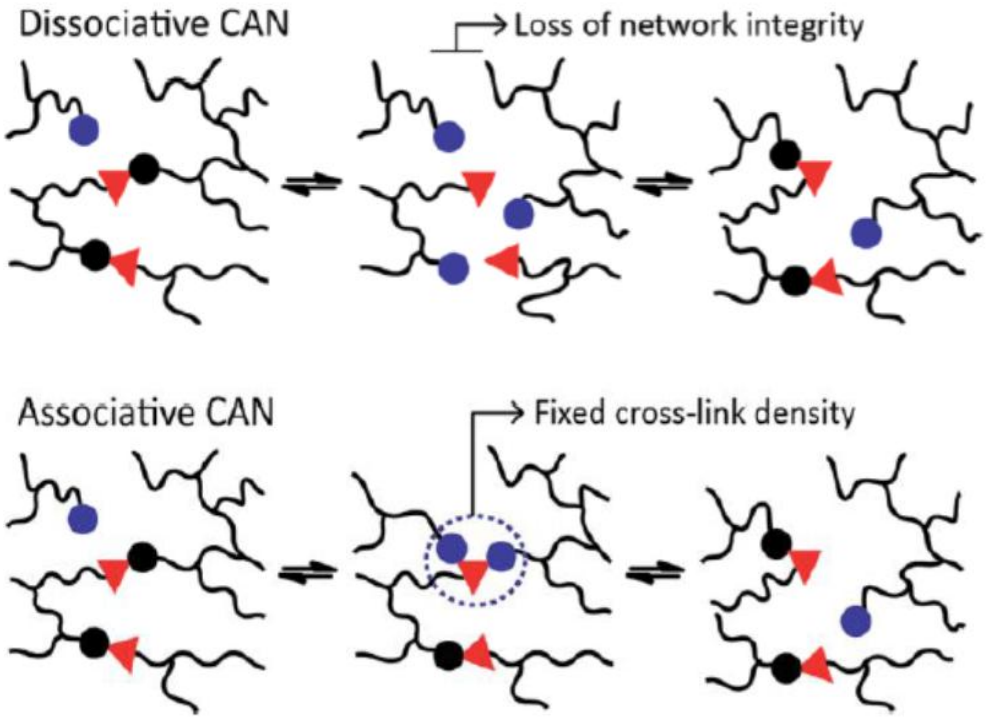
NEW SOLUTIONS (ECO-COMPOSITES)

BIO-RESINS

- BIO-EPOXY – Supersap, IB2 (soy oil, catechins, etc.)
- RECYCLED EPOXY – EzCiclo/Cleaver, PlaNkton
- THERMOPLASTICS – Elium (Arkema), Akelite (ICTP-CSIC)
- VITRIMERS – Cidetec, URV

Reduced hazardous emissions. Robust mechanical performance. Enhanced recyclability potential.

High production cost. Restricted Bio-based content. Constrained recyclability performance.



CAN (Covalent Adaptable Networks)

PLASREC
III International Seminar on Plastics Recycling

NEW SOLUTIONS (ECO-COMPOSITES)

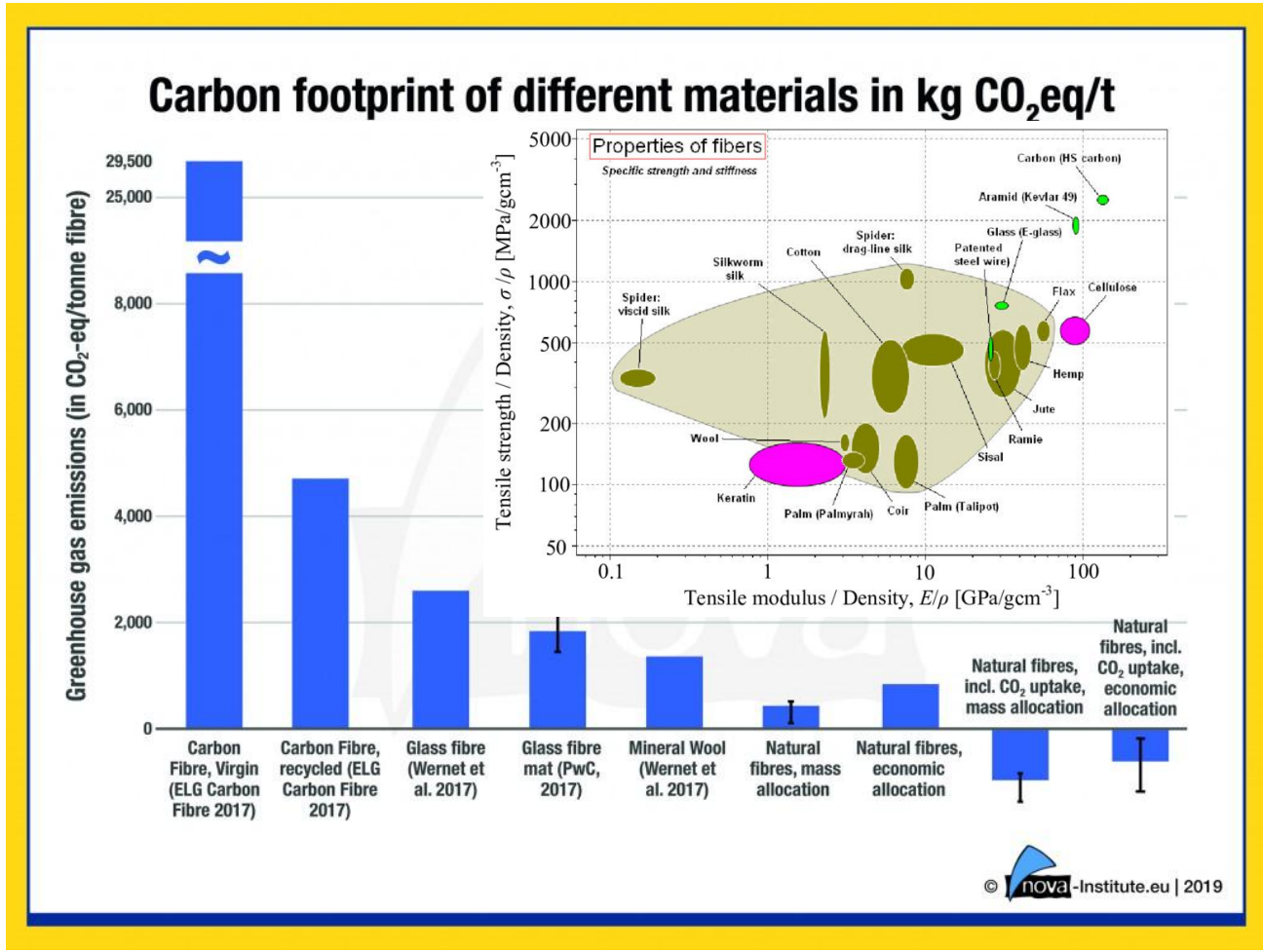
NATURAL FIBERS

- VEGETAL – Flax, jute, hemp, wood
- MINERAL – Basalt, Brucite
- ANIMAL – Wool, Silk

BIO-BASED CARBON FIBERS (Lignin, Cellulose)

Low density. Good mechanical properties. Acoustic/Thermal insulation. Facilitated processing

High moisture absorption. Poor adhesion fiber-resin interfacial. Low Thermal resistance.



Source: Ashby. The CES Edupack Database of Natural and Man-Made Materials. Cambridge Univ. 2008/ Nova Institute GmBH, Natural Fibers show outstandingly low CO2 footprint compared to Glass & Mineral fibers, 2019

PLASREC
III International Seminar on Plastics Recycling

NEW OPPORTUNITIES – RECYCLING COMPANIES

ENERGY LOOP - IBERDROLA & FCC

1st WTB Recycling Plant in Spain

- Investment - €10M, 100 employees
- Cortes (Navarra) – June 2025
- Capacity: 10 KT per year – 5,000 WTB
- Repowering – Albacete 500 W, 30 m (5 MW, 60 m)
- 2,500 WTB Recycled in 2025

EnergyLoop – Video

CONCLUSIONS

- **REUSE (reporpuse)** of EoL WTB in **construction & automotive applications.**
- **RECYCLING** – **Chemical Technologies.** Catalytic Pyrolysis & Solvolysis (superb & sub-critical conditions)
- **RETHINK** using **secondary raw materials in WBT & Patches for Prevention.**

REWIND

Improve
European Competitiveness
Recyclability of EoL WTB

More Options to
Wind Europe Skateholders
Cement Co-processing
Mechanical Recycling

Debunk
The Myth of the Non-Recyclability of Composite Materials

www.rewind-project.eu

PLASREC
III International Seminar on Plastics Recycling

PLASREC

III International seminar on Plastics Recycling

10 - 11 December | Valencia • Spain

Thank you!

Helena ABRIL LANZUELA

helena.abril@aemac.org

674362236 - www.aemac.org