

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

Sustainability analysis for each process/end-product

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2° Stakeholder Workshop

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Photo by Nicholas Doherty on Unsplash

REFRESH preliminary LCA results (RINA-C)



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The LCA methodology follows internationally standardized procedures ISO 14040/14044

Innovative REFRESH recycling processes
Recycling processes vs. linear disposal technology
Environmental benefits arise from secondary raw materials
Functional unit (FU): **1 ton of wind turbine blades to be recycled (WTBR)**



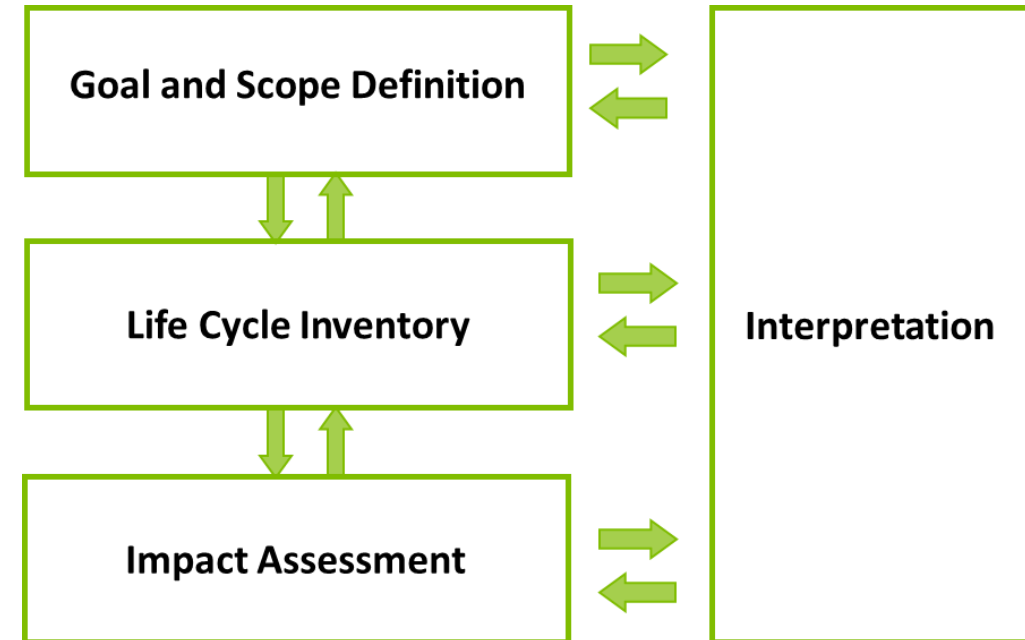
The inventory data are based on high-quality **experimental measurements** obtained through on-site testing.
Ecoinvent and Sphera LCA databases



Resource Consumption
Global Warming Potential
Waste production



Environmental Life Cycle Assessment (E-LCA)



Hotspot analysis
Comparison with linear disposal
Preliminary environmental benefits

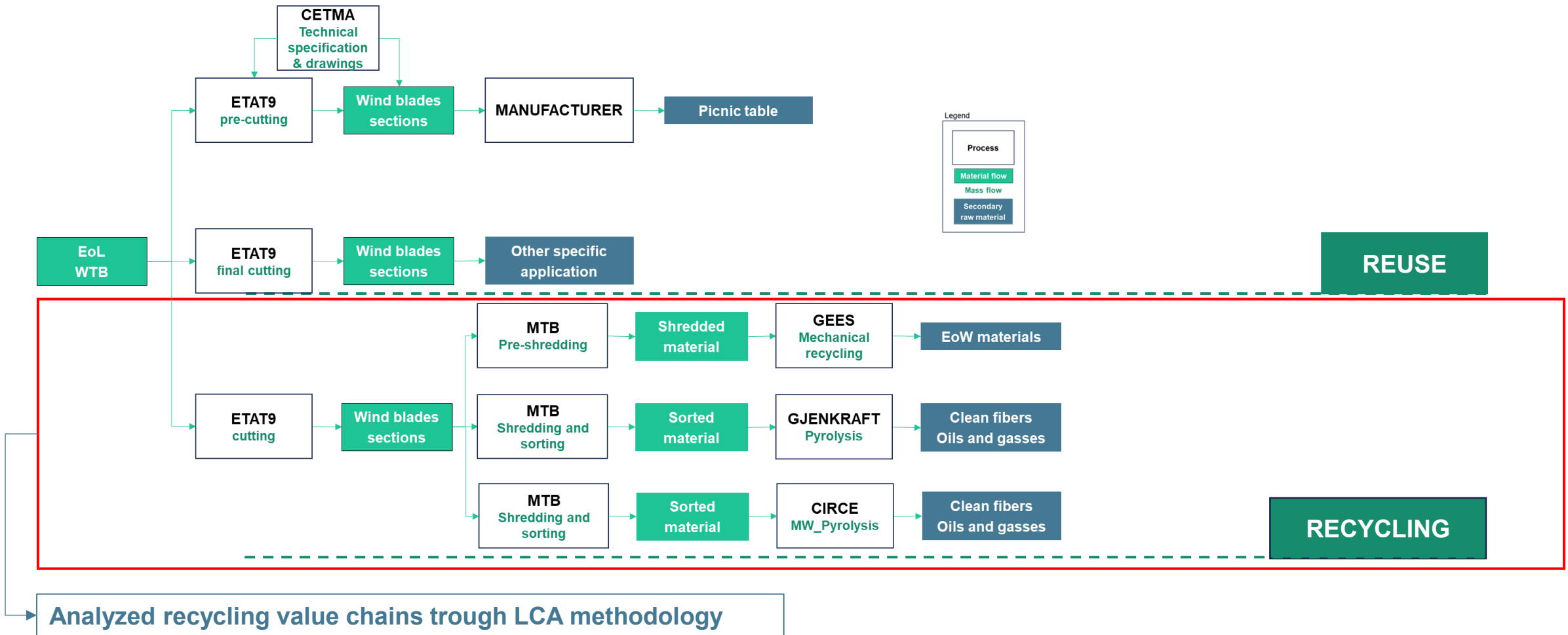


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System boundaries applied in LCA study and REFRESH recycling value chains



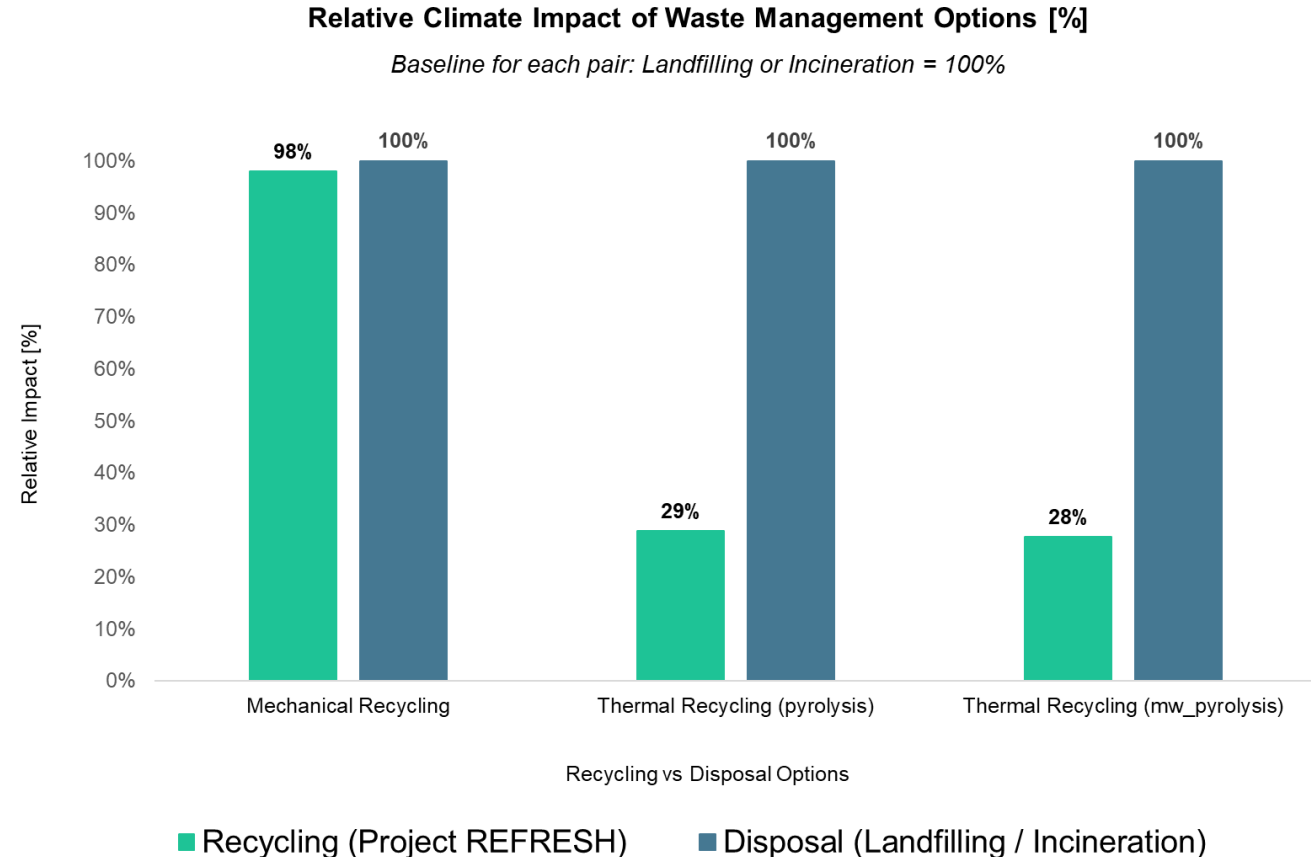
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Recycling vs. traditional disposal methods

- In the Climate Change impact category, all REFRESH recycling process show **lower environmental impacts** than landfilling or incineration.
- Recycling produces **secondary raw materials** capable of substituting virgin production.
- This substitution effect leads to further avoided greenhouse gas emissions upstream, **amplifying the climate benefits** beyond those shown by the direct process impacts.



Values normalized to disposal (100%). Lower % indicates reduced climate impact compared to baseline.

REFRESH preliminary LCA results (RINA-C)



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Recycling processes produce secondary raw materials. All recycling routes deliver large climate benefits, because we avoid virgin production.

Mechanical recycling delivers **the largest net reduction**

- 2939 kg CO₂eq

End-of-Waste (EoW) materials application in the lightweight industry replacing **virgin epoxy resin**.

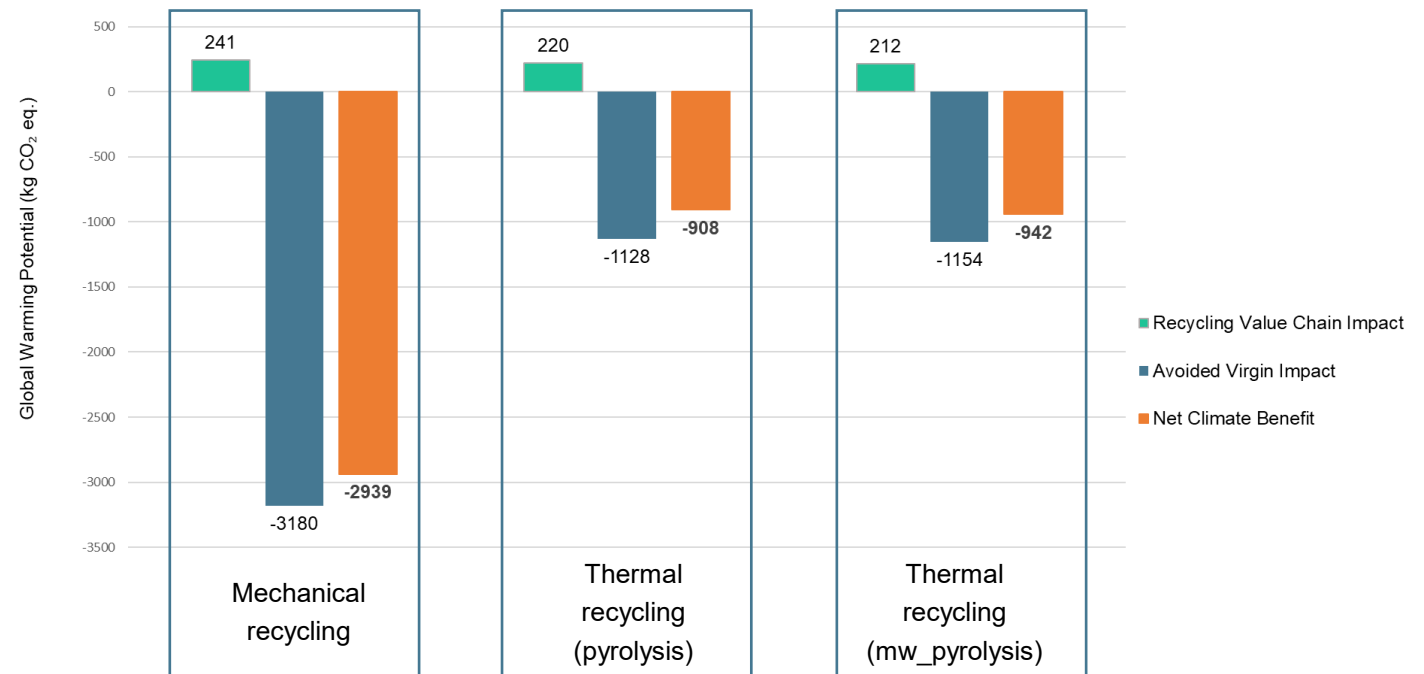
Thermal routes also deliver substantial net reductions

- 908 kg CO₂eq - pyrolysis

- 942 kg CO₂eq – mw_pyrolysis

Recycled materials substitute **virgin glass and carbon fibers**.

Environmental Performance of REFRESH Recycling Value Chains



Refresh Recycling Value Chains

Benefits calculated assuming equivalent output across all value chains. Net Climate Benefit = Avoided Virgin Impact + Process Impact.

By-product environmental credits are not included. Actual benefits would be even higher when accounting for by-product substitution effects.

One of RINA's role in REFRESH



Sustainability analysis

- Life Cycle Assessment (LCA) of REFRESH **recycling processes and value chains**, based on experimental data and ISO 14040/44-compliant methodology.
- **End-product sustainability assessment**, including the LCA of a wind turbine blade manufactured with recycled glass fibres (blade-to-blade approach).
- Life Cycle Costing (LCC) to support the evaluation of **economic performance** and **industrial scalability** of REFRESH solutions.
- Social Life Cycle Assessment (S-LCA) framework applied to assess potential **social impacts along the recycling value chains**.



Looking ahead

*By the end of the project (December 2026), a **final publication** will be released, presenting the consolidated sustainability results of REFRESH Project, including LCA, LCC and S-LCA outcomes, as well as the end-product sustainability assessment.*



Press release

[REFRESH wind turbine blade recycling processes show promising environmental benefits](#)



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Thank you for your attention!

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