

Composites

Cradle to Cradle

Industrial Transformation Roadmap

Navigating Towards Sustainability in the Polymer-Based Composite Industry

As industries increasingly turn toward sustainable practices, the development of a Polymer-Based Composite Circular Transformation Roadmap has become essential to addressing the challenges of recycling and circularity in composite materials. Due to their strategic importance for several industries such as aeronautics, automotive, construction and space, the Transformation roadmap will focus on Organic Matrix Composites (OMCs), also known as Fiber Reinforced Plastics (FRPs). These advanced materials, created by combining fibers that provide structural strength with a polymer matrix that binds them together, are valued across industries for their excellent weight-to-performance ratio.

Despite the disruption caused in 2020 by the COVID-19 pandemic, growth prospects for the composites market remain robust as the mid-term projections forecast an annual growth rate of +7,6% from 2020 to 2027. Indeed, the industry is driven by the development of new technologies and applications, such as hydrogen-powered vehicles and offshore wind energy. The market for offshore wind turbines, for example, is set to grow by 11% between 2020 and 2024, boosting demand for composite materials¹.

However, the very properties that have driven the widespread adoption of polymer-based composites across various industries also pose a significant challenge: how to ensure their circularity?

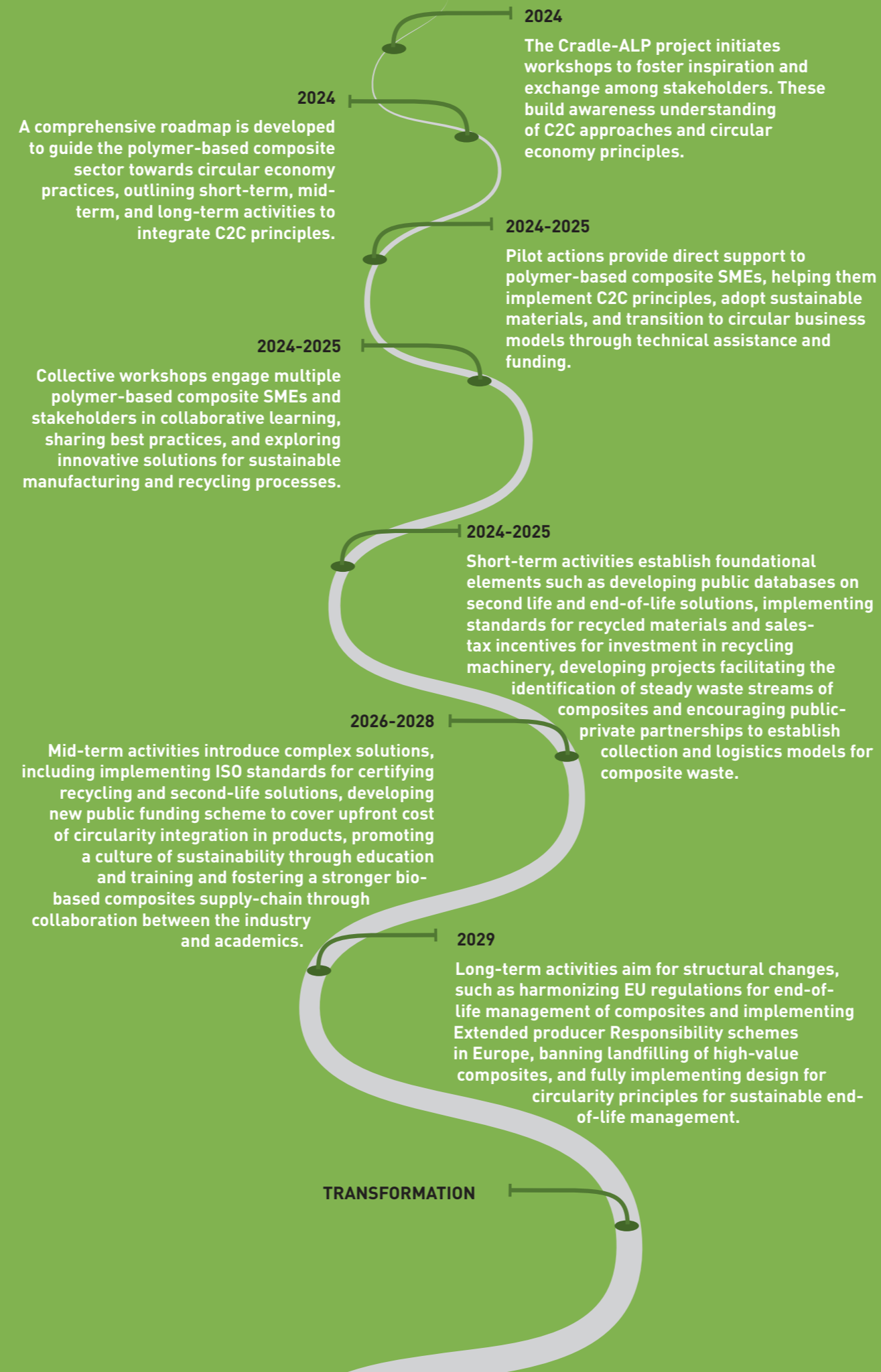
Indeed, the industries often rely on complex composite materials that are difficult to recycle due to their heterogeneous nature and strong bonding agents. In Europe, it is estimated that 683,000 tons of composite waste will be generated in 2025 not counting the already accumulated untreated waste². At the same time, the global annual FRP recycling capacity is estimated to be less than 100,000 tons and the current recycling infrastructure may not support advanced processes, leading to high costs and limited recovery. Additionally, the industries face regulatory and technical barriers that inhibit large-scale adoption of circular practices.

To better comprehend and answer the circularity challenges, experts from industry, business support organizations, and research institutions developed a circular transformation roadmap for the polymer-based composites industry, under the umbrella of the Cradle-ALP project, which is a part of the Interreg Alpine Space programme.

In alignment with the Landfill Directive part of the EU Circular Economy Package adopted in 2018, the Cradle-ALP polymer-based composites working group elaborated the following vision that will guide stakeholders throughout the roadmap: to reduce landfill disposal of composites waste to just 10% of total waste by 2035.

¹ GREC - Guide du Recyclage et de l'Ecoconception des Composites, ADEME, IPC, CETIM, IFTH, May 2022

² CSR Europe Composite Materials: A Hidden Opportunity or the Circular Economy, The New Materials and Circular Economy Accelerator Think Tank



The Cradle-ALP Transformation Roadmap

This roadmap is designed to guide the industry through a strategic and phased approach to achieving significant environmental and economic benefits, ultimately reducing the use of virgin raw materials and the landfill disposal of composites waste by enhancing their sustainability throughout their life-span.

The roadmap's timeframe spans from 2024 to 2034, with short-term, mid-term, and long-term goals. This structure provides a strategic approach to achieving circularity:

- **Short-Term (2024–2026):** The short-term goals aim to establish the foundational elements of the roadmap, such as developing public databases, implementing Extended Producer Responsibility (EPR) schemes, and identifying suitable plant fibers for composites. These activities are designed to kickstart the circular transition by addressing immediate challenges and creating a knowledge base.
- **Mid-Term (2026–2029):** The mid-term goals build on the short-term initiatives by introducing more complex solutions, like implementing ISO standards, promoting financial cooperation, and advocating for bio-sourced materials. This timeframe allows for the development of infrastructure, business models, and standards to support circularity.
- **Long-Term (2029–2034):** The long-term goals focus on deeper structural changes, such as aligning EU regulations, banning landfilling of high-value composites, and implementing design-for-circularity practices. This timeframe enables the industry to transition into a sustainable future with a consistent legal and business framework.

Ultimately, Cradle-ALP seeks to drive the transition to a circular economy, leveraging collaboration and innovation to promote sustainable practices among SMEs. This ambitious project aims to secure a resilient, eco-friendly future for the Alpine region, aligning economic growth with environmental stewardship.

Transformation Roadmap for Composites

Short-term (2024-2025)	
Technology	<p>Comprehensive public resource on second life and end-of-life solutions:</p> <ul style="list-style-type: none"> Development of public database of existing mature technologies for recycling composites. <p>Extend use of biosourced materials:</p> <ul style="list-style-type: none"> Identify suitable plant fibers for composites and determine optimal processing techniques. <p>Implementation of circular design practices:</p> <ul style="list-style-type: none"> LCA databases populated with reliable data based on ISO14040 standards.
Business Model Approaches	<p>Business models to extend the use of biosourced materials:</p> <ul style="list-style-type: none"> Encourage collaboration between manufacturers, plant fiber suppliers, and research institutions to establish a strong supply chain for biobased composites. <p>Financial support for managing end-of-life composite waste:</p> <ul style="list-style-type: none"> Increase tax relief for investment in recycling machinery to support enterprises. <p>Promotion and support of business cases for managing waste composites:</p> <ul style="list-style-type: none"> Promotion of success stories and successful business cases for circularity in composites.
Legal and Political Framework	<p>Harmonization of EU regulation for dismantling and end-of-life management:</p> <ul style="list-style-type: none"> Implement Extended Producer Responsibility schemes on composites industries. <p>Comprehensive and transparent standards:</p> <ul style="list-style-type: none"> Implement and enforce standards for composites recycled materials according to CEN/TR 15353. <p>Market for recycled composites:</p> <ul style="list-style-type: none"> Identification of steady composites waste streams for creation of adapted recycling structures. Sales tax relieve for investment in recycling machinery.

Mid-term (2026-2028)	
Technology	<p>Comprehensive public resource on second life and end-of-life solutions:</p> <ul style="list-style-type: none"> Development of public database of second-life solutions for composites materials. <p>Extend use of biosourced materials:</p> <ul style="list-style-type: none"> Infrastructure is developed for waste-to-energy recovery of biomaterials. <p>Implementation of circular design practices:</p> <ul style="list-style-type: none"> Implement design practices prioritizing modularity, easy disassembly, and material separation. <p>Monitoring & enhancing composites aging:</p> <ul style="list-style-type: none"> Smart and structural health monitoring system for real-time detection of polymer aging.
Business Model Approaches	<p>Business models to extend the use of biosourced materials:</p> <ul style="list-style-type: none"> Market created for biobased composites by encouraging adoption among manufacturers and increasing consumer demand. <p>Training and harmonization of eco-design practices:</p> <ul style="list-style-type: none"> Foster a culture of sustainability within the composites industry through education and training programs focusing on eco-design. <p>Financial support for managing end-of-life composite waste:</p> <ul style="list-style-type: none"> Encourage public investment in new dismantling technologies by developing financial solutions covering the significant upfront costs. <p>Promotion and support of business cases for managing waste composites:</p> <ul style="list-style-type: none"> Encourage public-private partnerships (PPPs) to establish collection and logistics models for composite waste.
Legal and Political Framework	<p>Harmonization of EU regulation for dismantling and end-of-life management:</p> <ul style="list-style-type: none"> Aligned European regulations across countries based on standards, creating a consistent framework for composite product dismantling. <p>Standardisation for compliance:</p> <ul style="list-style-type: none"> Develop and implement ISO standards that certify what is recycling, reusing. <p>Market for recycled composites:</p> <ul style="list-style-type: none"> Reinforce financed cooperation between research institutes and industry to develop and upscale end-of-life/recycling solutions. <p>Extend use of biosourced materials:</p> <ul style="list-style-type: none"> Advocate for Waste-to-energy recovery for biomaterials on a policy level as incineration of biobased material is less energy-demanding.

Long-term (2029-2033)	
Technology	<p>Comprehensive public resource on second life and end-of-life solutions:</p> <ul style="list-style-type: none"> Development of a public database of technical properties of recycled composite materials. <p>Extend use of biosourced materials:</p> <ul style="list-style-type: none"> Low-density biobased materials replace difficult-to-remove materials for easier dismantling. <p>Implementation of circular design practices:</p> <ul style="list-style-type: none"> Each composite product produced is dismantlable by design. <p>Monitoring & enhancing composites aging:</p> <ul style="list-style-type: none"> Mature technologies available to assess condition and performance of composite materials at their end-of-life to determine their suitability for reuse.
Business Model Approaches	<p>Training and harmonization of ecodesign practices:</p> <ul style="list-style-type: none"> Create harmonized Design for Circularity Guidelines for stakeholders along the value-chain. <p>Promotion and support of business cases for managing waste composites:</p> <ul style="list-style-type: none"> Implement pilot projects and models for composite waste collection in major industrial areas.
Legal and Political Framework	<p>Harmonization of EU regulation for dismantling and end-of-life management:</p> <ul style="list-style-type: none"> Ban landfilling for certain types of composites waste (high-value waste) to ensure development of a market for secondary materials and recycling solutions. <p>Develop comprehensive and transparent standards to ensure safe and sustainable practices:</p> <ul style="list-style-type: none"> Transparent information on hazardous additives and substances used in the composites sector. <p>Implementation of a market for recycled composites:</p> <ul style="list-style-type: none"> Implement EU regulations requiring to include recycled content in new composites products.

Interreg



Co-funded by
the European Union

Alpine Space

Cradle-ALP



CAMERA DI COMMERCIO
PADOVA
il futuro a portata di impresa



UnimART
Fondazione Università di Padova



Cradle-ALP

Contact person:
Andrea Galeota
progetti@pd.camcom.it

You can find out more about the project at:
<https://www.alpine-space.eu/project/cradle-alp/>