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Alpine Space

Cradle-ALP

Integrated Industrial Transformation Roadmap: A Cradle-ALP Vision

The Vision

To secure a resilient, eco-friendly future for the Alpine region by aligning industrial growth with environmental stewardship.

This roadmap guides SMEs through a phased transition toward circular economy practices based on Cradle-to-Cradle (C2C) principles.

Common Industrial Pillars

- **Technological Innovation:** Leveraging AI, IoT, and digitization to track material lifecycles and optimize resource usage in real-time.
- **Bio-Based Transition:** Replacing fossil-based resources with biogenic, renewable, and certified sustainable materials across all sectors.
- **Design for Circularity:** Implementing eco-design and “Design-for-Circularity” as standard practices to ensure products are durable, repairable, and fully recyclable.
- **Collaborative Ecosystems:** Fostering cross-sector partnerships between industry, academia, and waste management to close material loops.



Shared Implementation Timeline

- **Short-Term (2024–2025):** Establishing foundational elements, including public databases of recycling technologies and initiating pilot actions for SMEs.
- **Mid-Term (2026–2028):** Scaling complex solutions, implementing ISO/standards for sustainable production, and expanding educational programs.
- **Long-Term (2029–2034):** Achieving structural changes through harmonized EU regulations, banning landfilling of high-value waste, and full market integration of circular products.

Comprehensive Consolidated Roadmap

The European manufacturing landscape - including textiles, chemicals, composites, packaging, and wood-furniture - is a vital economic engine employing millions and generating hundreds of billions in turnover. Despite their differences, these sectors face identical challenges: fierce international competition, high labor costs, and the urgent need to comply with strict EU environmental regulations.

To overcome these challenges, the Cradle-ALP project identifies several “cross-cutting” elements that apply to all industrial transformations:

- **Transparency and Digitalization:** All sectors prioritize the use of Digital Product Passports and IoT to enhance supply chain transparency and material recovery.
- **Regulatory Harmonization:** A collective push for aligned EU-wide regulations on waste management and sustainability to ensure a level playing field for SMEs.
- **Financial & Market Incentives:** Advocacy for Extended Producer Responsibility (EPR) schemes and tax incentives (such as reduced taxes for recycling machinery) to drive investment in circularity.
- **Educational Excellence:** Broadening training on eco-design and circular business models for both current employees and the future workforce.

Integrated Action Plan (2024–2034)





Integrated Action Plan 2024-2034

Phase I: Foundations (2024-2025)

- **Pilot Actions:** Provide direct technical and financial support to SMEs to test C2C principles and adopt sustainable materials.
- **Knowledge Sharing:** Develop comprehensive public databases of mature recycling and end-of-life technologies.
- **Material Assessment:** Identify suitable plant fibers and certified sustainable sources to replace hazardous or fossil-based materials.

Phase II: Scaling and Standards (2026-2028)

- **Certification:** Implementation of ISO standards (e.g., ISO 14040) for sustainable production and certification of recycled content.
- **Infrastructure Development:** Scaling up technologies for material recovery and establishing specialized facilities for bio-based production.
- **Consumer Engagement:** Launching communication campaigns to inform consumers about the environmental impact of their choices and promote circular products.

Phase III: Structural Transformation (2029-2034)

- **Zero Waste Policy:** Banning the landfilling of high-value materials (composites, textiles, wood) to ensure these remain in the economic loop.
- **Market Leadership:** Introducing innovative, circular materials into the global market at competitive prices.
- **Full Integration:** Standardizing Life Cycle Assessments (LCA) and tax laws within the EU to incentivize sustainable business models permanently.

Conclusion

By consolidating these efforts, the Alpine industrial core transitions from a linear “take-make-waste” model to a circular, resilient ecosystem. This transformation ensures that the region remains a leader in high-quality, sustainable production, securing long-term growth and environmental health.



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**CRADLE-ALP PROJECT IS CO-FUNDED BY THE EUROPEAN UNION THROUGH THE
INTERREG ALPINE SPACE PROGRAMME.**



Textiles

Cradle to Cradle Industrial Transformation Roadmap

Navigating Towards Sustainability in the Textile Industry

The textile sector is considered an “important part of the European manufacturing industry” according to the European Union. In 2021, 1.3 million Europeans were employed in a job considered part of the textiles industry and the turnover of the same year sat at €147 billion, which puts it at a little more than half of the turnover of the plastics industry in the same year¹. A little less than half is the amount of textile waste that is generated per capita in Europe in comparison to plastic waste: 16kg of textile waste (in 2020)² in comparison to 36.1kg of plastic packaging waste (in 2021)³. In 2020, out of almost 7 million tons of total textile waste, a little over 80% came from clothing or household textiles that had been used, making it post-consumer waste. It is difficult to estimate the numbers of pre-consumer waste as minimal data is available from member states. However, it is assumed that up to 9% of all textiles available in the European market are destroyed before even being sold to the consumer. That percentage amounts to almost 600 000 tons of textiles that are produced to essentially be immediately discarded.

In addition to the topic of waste, the European textile industry is facing substantial challenges, as laid out by the European commission. These include:

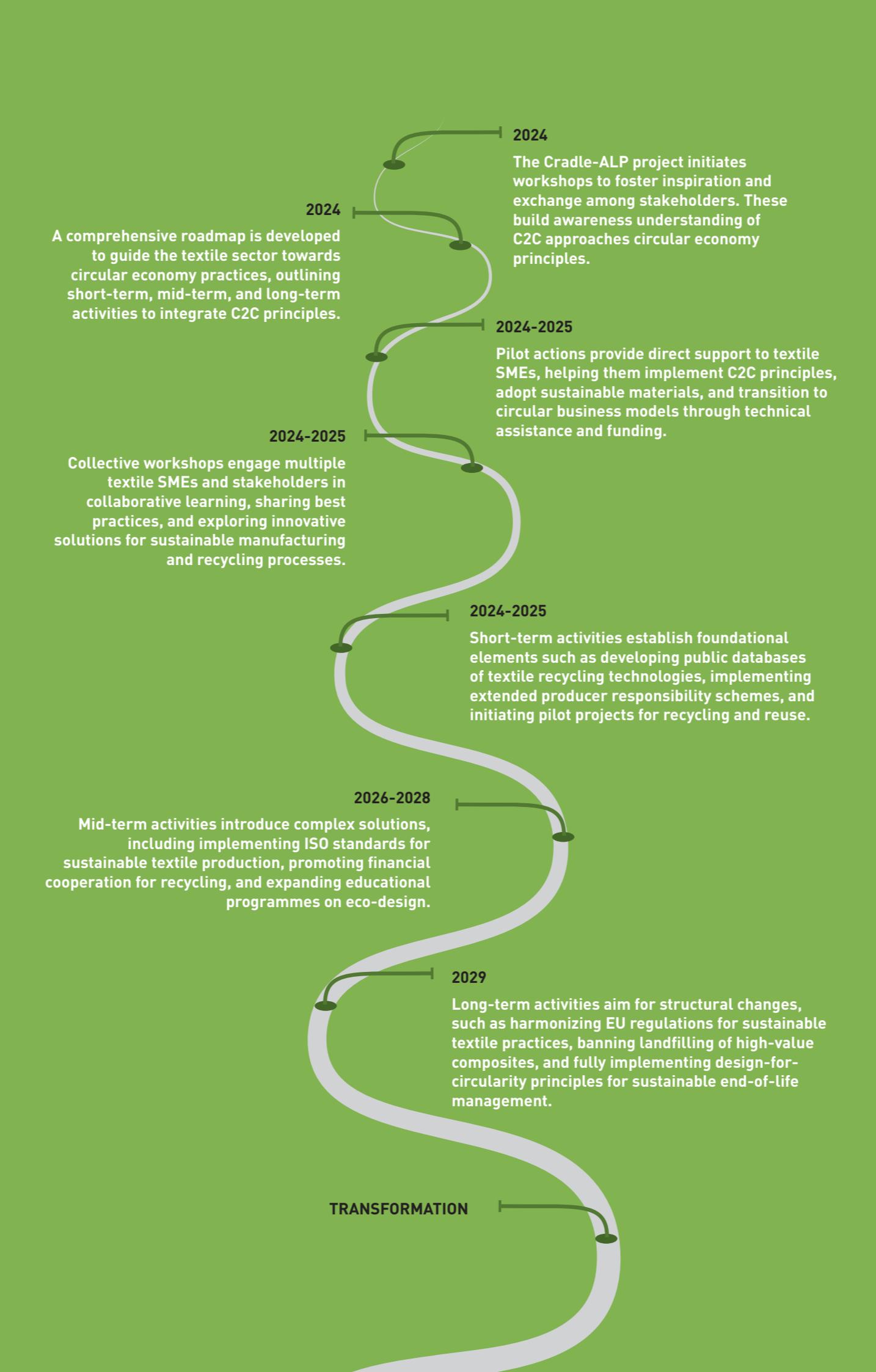
- Low profit margins
- Fierce international competition
- High labor costs
- High costs of compliance with existing environmental and chemical legislation

While all these factors are of course valid and understandable disadvantages, the European Union, and the players within should not be discouraged in their efforts to continue fostering a strong textile industry. Especially in terms of specialization and high-quality production that integrates new materials, the EU has a significant advantage over textile sectors in other countries or regions. In addition, directives like the Waste Framework Directive add new guidelines to the handling, sorting and recycling of textile waste. This directive introduced Extended Producer Responsibility (EPR), which holds producers accountable for the entire lifecycle of textile products. By January 1, 2025, Member States are required to implement textile waste collection systems. Under the umbrella of the Cradle-ALP project, which is a part of the Interreg Alpine Space programme, experts from industry, business support organizations, and research institutions developed a transformation roadmap for the textile industry, which guides companies through the whole adaptation process.

1 https://single-market-economy.ec.europa.eu/sectors/textiles-ecosystem/textiles-leather-fur_en

2 <https://www.eea.europa.eu/publications/management-of-used-and-waste-textiles#:~:text=The%20EU%2D27%20generated%20an,up%20in%20mixed%20household%20waste>

3 <https://www.europarl.europa.eu/topics/en/article/20181212ST021610/plastic-waste-and-recycling-in-the-eu-facts-and-figures#:~:text=Each%20person%20living%20in%20the,was%2016%2C13%20million%20tonnes>



The Cradle-ALP Transformation Roadmap

This roadmap is designed to guide the industry through a strategic and phased approach to achieve significant environmental and economic benefits, ultimately reducing the ecological footprint of textile materials. The roadmap was developed considering two focal points: non-fashion textiles (e.g.: fibers for carpets) and functional wear (e.g.: outdoor clothing, work wear etc.).

In 2024, the Cradle-ALP project initiates workshops to foster inspiration and exchange among stakeholders, building awareness and understanding of C2C approaches and circular economy principles. Collective workshops engage multiple SMEs from the textile industry and stakeholders in collaborative learning, sharing best practices, and exploring innovative solutions for sustainable manufacturing and recycling processes.

From 2024 to 2025, pilot actions provide direct support to textile SMEs, helping them implement C2C principles, adopt sustainable materials, and transition to circular business models through technical assistance and funding. Short-term activities establish fundamental elements like the funding of research for use of recycled fibres in clothing, promotion of mono-material use and initiating pilot projects for recycling and reuse.

In the mid-term, from 2026 to 2028, more complex solutions are introduced, including the automation of sorting technologies for materials, the building up of logistics for the collection of textiles and the development of financial incentives for textile recycling. Between 2029 and 2033, long-term activities aim for structural changes, such as the establishment of a dedicated waste industry for textiles with reliable certification systems.

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 Textile

Transformation Roadmap for Textile			
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Transformation Roadmap for Textile			
Technology	Mid-term (2026-2028)	Long-term (2029-2033)	
Technology	<p>Sorting of materials and resources:</p> <ul style="list-style-type: none"> Develop sorting lines that sort for material and not only quality for second-hand. <p>Research & development:</p> <ul style="list-style-type: none"> Research funding for use of recycled fibers in clothing. <p>Mono materials:</p> <ul style="list-style-type: none"> Promote use of mono-materials to manage recycling better. <p>Transparency & awareness building:</p> <ul style="list-style-type: none"> Increase transparency in supply chains and introduce product passports. 	<p>Sorting of materials and resources:</p> <ul style="list-style-type: none"> Implement automated sorting technologies for materials. <p>Research & development:</p> <ul style="list-style-type: none"> Increase research on biobased fibers and niche products. 	<p>Research & development:</p> <ul style="list-style-type: none"> Introduce innovative materials into the market ensuring they are competitively priced. Develop technologies and processes for efficient material recovery aiming for zero waste.
Business Model Approaches	<p>Transparency & awareness building:</p> <ul style="list-style-type: none"> Raise interest/awareness through good design & marketing. <p>Promote textiles in the loop:</p> <ul style="list-style-type: none"> Promote textiles that can be kept in the loop already. <p>Design for circularity:</p> <ul style="list-style-type: none"> Innovative pilot projects close to the end-user and workshops for designers and recyclers. <p>Dealing with fast fashion:</p> <ul style="list-style-type: none"> Promote good quality textiles and make fast fashion less attractive. <p>Recycling & re-usability:</p> <ul style="list-style-type: none"> Find partners for recycling of mixed materials in order to diversify expertise. Conduct a scenario analysis study. <p>Investment & incentives:</p> <ul style="list-style-type: none"> Introduce a repair bonus similar to Austrian regulation for old electronical appliances EAG. <p>Logistics & recovery:</p> <ul style="list-style-type: none"> Develop logistics structure to get textiles from consumer households. 	<p>Transparency & awareness building:</p> <ul style="list-style-type: none"> Showcase good practice examples, e.g. in material & resources, design for circularity, etc. <p>Recycling & re-usability:</p> <ul style="list-style-type: none"> Highlight the economic benefit of textile recycling through academic research. <p>Materials:</p> <ul style="list-style-type: none"> Encourage use of mono-materials not only for technical clothing but also for fashion items. <p>Logistics & recovery:</p> <ul style="list-style-type: none"> Build up logistics for collection of textiles. 	<p>Transparency & awareness building:</p> <ul style="list-style-type: none"> Strengthen networks to support widespread adoption of best practices. <p>Recycling & re-usability:</p> <ul style="list-style-type: none"> Implement 2nd and 3rd use of textiles, emphasizing reuse and recycling. <p>Materials:</p> <ul style="list-style-type: none"> Establish more textile recycling companies and integrate other sectors. <p>Investment & Incentives:</p> <ul style="list-style-type: none"> Incentivise the development of new business models, e.g. concept stores for secondhand fashion.
Legal and Political Framework	<p>Regulatory measures & taxation:</p> <ul style="list-style-type: none"> Implement regulatory measures like taxes to promote sustainable clothing. <p>Funding & incentives:</p> <ul style="list-style-type: none"> Fund projects for digital product passes for textiles. <p>Transparency, education & awareness:</p> <ul style="list-style-type: none"> Start education earlier to raise awareness and counteract fast fashion. 	<p>Regulatory measures & taxation:</p> <ul style="list-style-type: none"> Reduce taxation for recycled fibers and implement restrictions and laws at the EU level. <p>Funding & incentives:</p> <ul style="list-style-type: none"> Develop financial incentives for textile recycling. <p>Transparency, education & awareness:</p> <ul style="list-style-type: none"> Include voluntary targets for recycled fiber in big companies and continue awareness efforts. 	<p>Regulatory measures & taxation:</p> <ul style="list-style-type: none"> Enforce Corporate sustainability due diligence directive (CSDDD) and national supply chain laws. <p>Funding & incentives:</p> <ul style="list-style-type: none"> Develop financial incentives for textile recycling. <p>Transparency, education & awareness:</p> <ul style="list-style-type: none"> Continue education and awareness building efforts for children and adults. <p>Recycling & waste industry:</p> <ul style="list-style-type: none"> Establish a dedicated waste industry for textiles with reliable certification systems.



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Hochschule für Technik und Architektur Freiburg



Cradle-ALP

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You can find out more about the project at:
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Chemistry/Materials

Cradle to Cradle

Industrial Transformation Roadmap

Navigating Towards Sustainability in the Chemical and Material Sector

The chemical industry is an important European industry sector supplying essential raw materials to numerous downstream industries. The transformation of the chemical and material sector transitioning to more sustainable production methods is crucial to reduce carbon dioxide emissions and to achieve climate neutrality by 2050.

As our modern world depends on the materials manufactured by the chemical industry this sector will have to play an important role in solving urgent global societal challenges such as raw material shortages, exacerbated by geopolitical conflicts, global warming due to increased CO₂ emissions, access to sustainable mobility and renewable energy as well as environmental pollution and work safety issues due to hazardous chemicals.

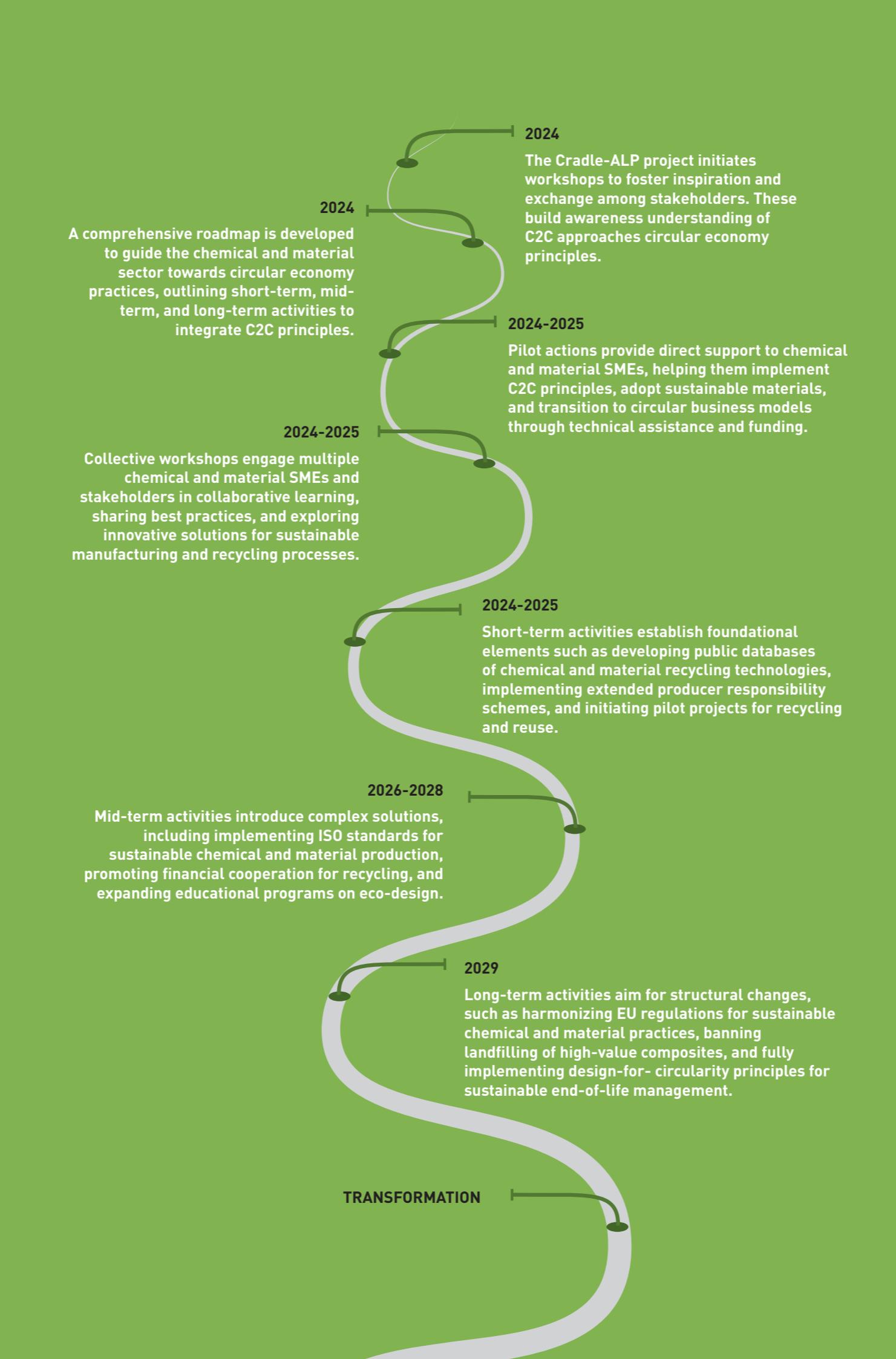
The chemical and material sector can contribute by driving technological and material innovations for waste recycling, CO₂ capture and utilization, delivering products for e-mobility and renewable power generation, developing environmentally safer and sustainable chemicals, and thus the creation of resilient value networks for a functional circular economy.

However, the chemical industry still has considerable hurdles to overcome on its path to sustainability such as high energy consumption, fossil resource dependency, and a lack of sustainable, renewable chemicals replacing established products. Especially when it comes to bio-based/renewable or recycled raw materials experts point to current barriers such as resource consistency and quality, cost competitiveness and regulatory uncertainty.

Despite these challenges, there are promising drivers for a circular economy. Regulatory enforcement, technological innovations, and waste management improvements offer opportunities. The development of consistent and reliable standards are seen as a crucial factor basis in the advancement of the circular economy. Applying digitization is regarded as a driver to advance circular economy across the value chains.

To speed up the transition to a circular economy, harmonizing legislation and waste regulations across Europe and standardizing life cycle assessments are considered important. Taxation policies and funding innovations can incentivize the development of sustainable industry practices, while effective communication and outreach are key to involving consumers and sharing best practices.

Under the umbrella of the Cradle-ALP project, funded by the Interreg Alpine Space Programme, experts from industry, business support organizations, and research institutions have developed this transformation roadmap for the chemical and material sector. The roadmap highlights that while the necessary technologies for the transition to a sustainable and circular economy based on renewable resources appear to be available, finding the right technology and business partners and gaining access to (raw) materials and services remain critical.



The Cradle-ALP Transformation Roadmap

The Cradle-ALP transformation roadmap for the chemical and material sector illustrates the challenges and requirements of the industry and intends to guide SMEs in their transformation towards sustainability. It lays out critical actions and requirements, embracing circular economy principles and cradle-to-cradle approaches, and replacing fossil-based resources with renewable raw materials.

In 2024, the Cradle-ALP project initiated workshops to foster inspiration and exchange among stakeholders, building awareness and understanding of cradle-to-cradle (C2C) approaches and circular economy principles. Collective workshops engaged multiple chemical and material sector SMEs and stakeholders in collaborative learning, sharing best practices, and exploring innovative solutions for sustainable manufacturing and recycling processes.

The outcomes are arranged on a **technological, business model and legal/political level** and segmented in short-, mid- and long-term actions to be taken to drive the development of the circular economy.

Short-term activities (2024 to 2025) demand activities to be started timely by companies and politics such as prioritizing chemicals and materials for circular economy as well as technical innovations for recycling processes, taking advantage of digitization, harmonizing the legislation on sustainability and circular economy, and expanding the public funding landscape for sustainable business.

In the mid-term, from 2026 to 2028, more complex solutions need to be addressed including the full implementation of taxes on carbon and/or waste to incentivize sustainable business models, the harmonization and standardization of LCA, the establishment of data sharing platforms with standardized content as well as the availability of specialized infrastructure, facilities and support services for scale-up and production. In addition, the access to biogenic, renewable and recyclable resources and the development of technical innovations for the recycling processes need to be addressed.

Between 2029 and 2033, long-term activities aim for structural changes, such as harmonizing EU regulations for sustainable practices and tax laws.

The Cradle-ALP project will provide support and assistance to chemical and material SMEs with pilot actions helping to implement C2C principles, to adopt sustainable business approaches, and to shape the transition to circular business models.

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 Chemistry/Materials

Short-term (2024-2025)			Mid-term (2026-2028)			Long-term (2029-2033)		
Technology	Technology		Technology	Technology		Technology	Technology	
	Technology	Technology		Technology	Technology		Technology	Technology
	<p>Prioritizing chemicals and materials for circular economy:</p> <ul style="list-style-type: none"> • Research and produce a list of positive and negative materials that can/can't be produced with recycled materials • Registration system for CO₂ values of chemicals and materials <p>Prioritizing chemicals and materials for circular economy:</p> <ul style="list-style-type: none"> • Prioritizing the recycling of high-impact chemicals <p>Technical innovations for recycling processes:</p> <ul style="list-style-type: none"> • Create awareness, inform and educate end-product manufacturers on impact of design choices <p>Consistent standards/standardization:</p> <ul style="list-style-type: none"> • Develop reliable standards for recyclate qualities <p>Provide infrastructure facilities services:</p> <ul style="list-style-type: none"> • Reevaluate the role of university service centers to focus on specialized fields <p>Advance digitization:</p> <ul style="list-style-type: none"> • Explore possibilities of digital material IDs for chemicals <p>Develop web portal for circular economy & LCA:</p> <ul style="list-style-type: none"> • Standardization of LCAs to enable comparability between used tools and results • Data model with standardized content, "LCA Wikipedia" 		<p>Access to biogenic & recyclable resources:</p> <ul style="list-style-type: none"> • Identify new sources of feedstock for bioeconomy • Increase accessibility to recycled feedstocks <p>Technical innovations for recycling processes:</p> <ul style="list-style-type: none"> • Develop harvesting and recovery of feedstocks from feedstock producers • Design for recycling based on specific external impact to trigger the recycling process <p>Develop advanced recycling:</p> <ul style="list-style-type: none"> • Expand chemical recycling options and applications <p>Provide infrastructure facilities services:</p> <ul style="list-style-type: none"> • Develop optimized processes for biobased chemicals and extend facilities for development scale-up and production • Establish specialized service centers tailored for SMEs to access analytic services • Consider creating organizations with a hybrid profit/non-profit model to offer services required by companies <p>Develop web portal for circular economy & LCA</p> <ul style="list-style-type: none"> • Data sharing platform/ information system for standardized content 					
Business Model Approaches	<p>Business & profitability:</p> <ul style="list-style-type: none"> • Rethinking sales targets and margins regarding development of cradle-to-cradle systems <p>Public funding for circular economy models:</p> <ul style="list-style-type: none"> • Expand funding landscape for circular economy and bioeconomy activities 		<p>Business Model Approaches</p> <p>Novel branding/ marketing opportunities:</p> <ul style="list-style-type: none"> • Research on novel branding possibilities in line with circular value chains <p>Incentivize business models:</p> <ul style="list-style-type: none"> • Implement taxes on carbon and/or waste to provide economic incentives to manufacturers to use sustainable alternatives 					
Legal and Political Framework	<p>Harmonization of legislation on sustainability, circular economy & LCA:</p> <ul style="list-style-type: none"> • Uniform rules for LCA and carbon footprint calculations • Legislative initiative to develop the requirement for uniform use of LCA • Set up an EU working group to determine guidelines necessary to speed up circular economy • Legal regulation to continuously increase proportion of sustainable components in products <p>Chemical and waste regulations:</p> <ul style="list-style-type: none"> • Stimulate use of biobased chemicals by transparent information on EU chemical regulations • Stimulate biobased chemical/material innovations through temporary exclusions from chemical regulations during upscaling process • Develop predictable and binding targets for recycling quotas • Harmonize waste regulation to support trans-European recycling <p>Novel types of funding:</p> <ul style="list-style-type: none"> • Higher funding rates for regional, national and EU programs • Set up funds for collaborative R&D projects of academia and industry allowing companies to get development services paid <p>Taxation & harmonization of tax laws:</p> <ul style="list-style-type: none"> • Cost reduction for biobased/ recycled materials through tax reduction <p>Communication and outreach:</p> <ul style="list-style-type: none"> • Providing best practices for SMEs on sustainability reporting/ monitoring standardized tools and access to experts 		<p>Harmonization of legislation on sustainability, circular economy & LCA:</p> <ul style="list-style-type: none"> • European-wide LCA targets and standardization • Legislative initiative to make circular economy a requirement <p>Taxation & harmonization of tax laws:</p> <ul style="list-style-type: none"> • Establish circular economy fee • Develop taxation for products with positive LCA impact <p>Communication and outreach:</p> <ul style="list-style-type: none"> • Develop and implement campaign to improve communication between policy makers and industry • Develop and implement communication campaign to inform consumers about the environmental impact of their purchasing choices 			<p>Harmonization of legislation on sustainability, circular economy & LCA:</p> <ul style="list-style-type: none"> • Tools to verify sustainability claims to avoid greenwashing <p>Taxation & harmonization of tax laws:</p> <ul style="list-style-type: none"> • Harmonization of tax laws within the EU 		

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Cradle-ALP

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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?

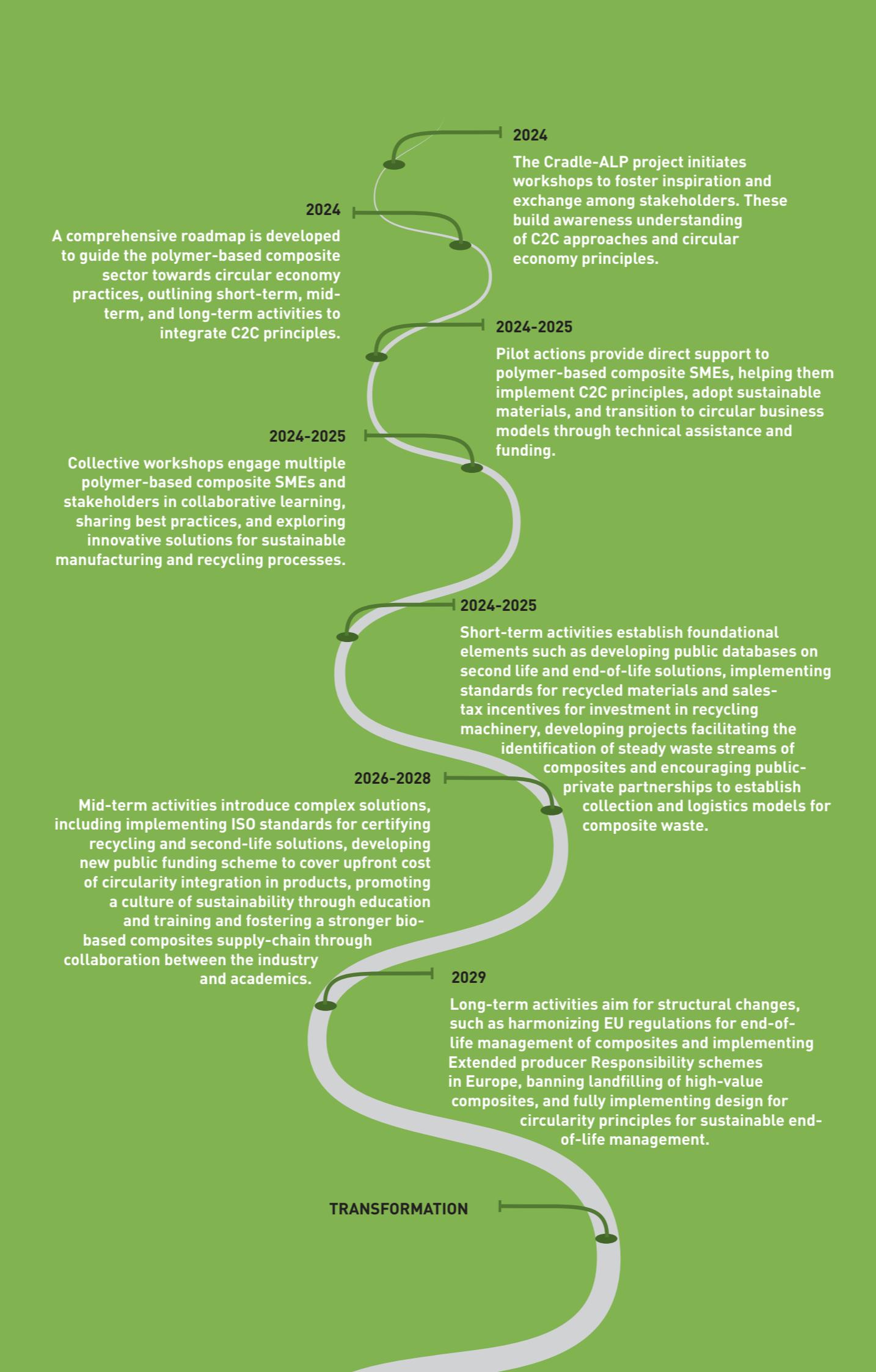
Indeed, the industries often rely on complex composite materials that are difficult to recycle due to their heterogeneous nature and strong bonding agents. In Europe, it is estimated that 683,000 tons of composite waste will be generated in 2025 not counting the already accumulated untreated waste². 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

Transformation Roadmap for Composites			
	Short-term (2024-2025)	Mid-term (2026-2028)	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 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. 	<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. 	<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>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. 	<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. 	<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"> 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. 	<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. 	<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.

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Packaging

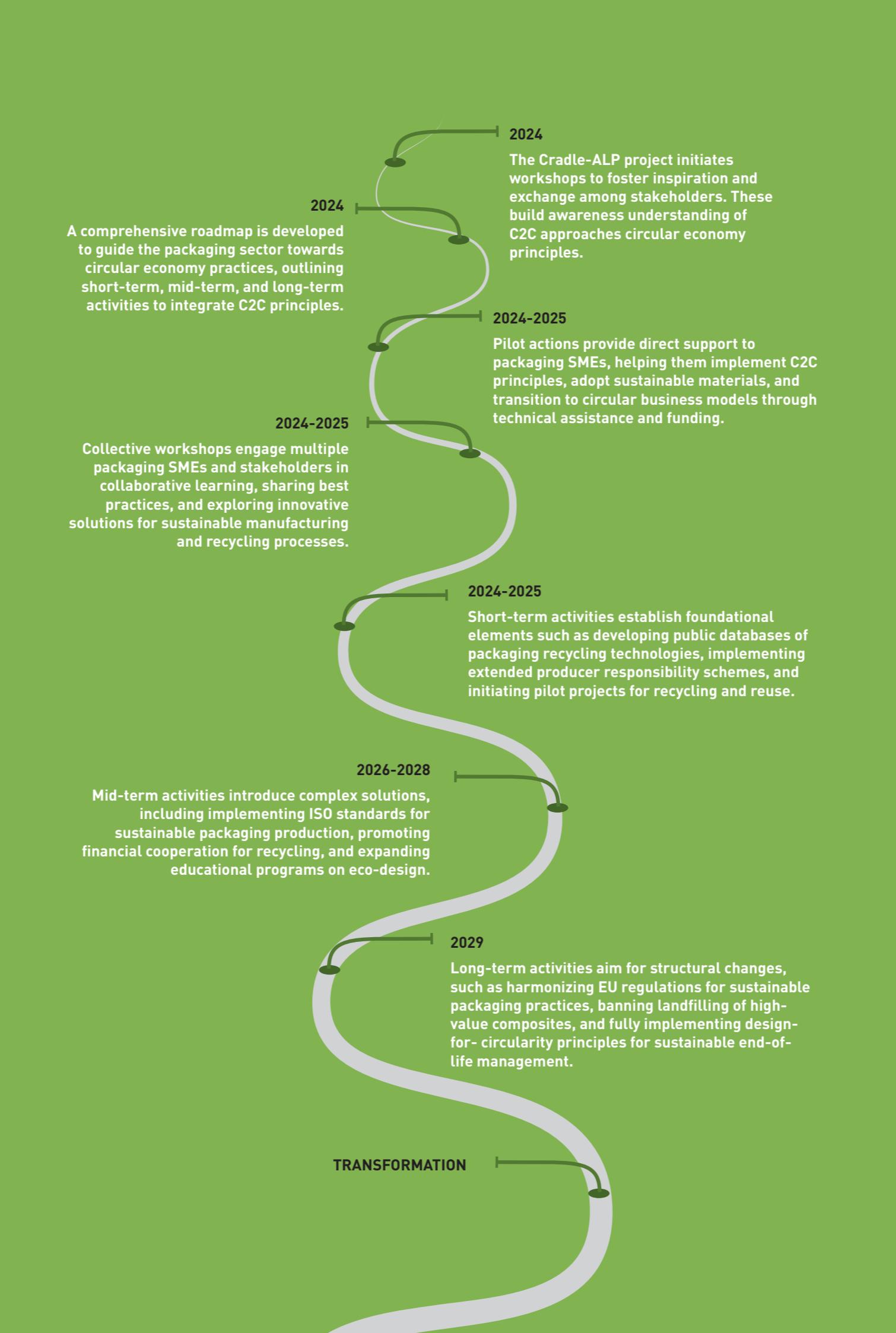
Cradle to Cradle Industrial Transformation Roadmap

Navigating Towards Sustainability in the Packaging Industry

The packaging industry is a vital component of the global economy, serving as a critical interface between manufacturers, consumers, and waste management systems. However, this industry faces significant challenges related to waste management and environmental sustainability. In 2021, the European Union (EU) generated an estimated 188.7 kg of packaging waste per inhabitant, illustrating the vast scale of this issue. The range of waste generated varied significantly across member states, with figures ranging from 73.8 kg per inhabitant in Croatia to a staggering 246.1 kg per inhabitant in Ireland. For the EU Alpine Space countries, the numbers are unfortunately closer to Ireland's: Germany 236.7 kg, Italy 229.9 kg, France 197.7 kg, Austria 164.3 kg, and Slovenia 134.0 kg per inhabitant (source: [Eurostat](#)).

From 2010 to 2021, the dominant materials in packaging waste were paper and cardboard, accounting for 34.0 million tons in 2021. Plastics followed with 16.1 million tons, and glass with 15.6 million tons. The total volume of packaging waste increased by 16.4 million tons, representing a 24.2% rise from 2010 to 2021. This upward trend is a major concern for sustainability advocates and policymakers alike. During the same period, the amount of packaging waste per inhabitant rose from 154.0 kg to 188.7 kg. Despite efforts to improve recycling rates, which peaked at 67.6% in 2016, there was a decline to 64.0% by 2021. However, recovery rates, including energy recovery, showed a positive trend, increasing from 77.9% in 2010 to 80.0% in 2021 (source: [Eurostat](#)). The EU's targets for packaging waste recycling and recovery, as set by the Packaging Waste Directive, require a minimum recovery rate of 60% and recycling rates between 55% and 80%.

These figures underscore the importance of tools and materials that would help outline a comprehensive strategy to transition towards a circular economy. Under the umbrella of the Cradle-ALP project, which is a part of the Interreg Alpine Space programme, experts from industry, business support organizations, and research institutions developed a transformation roadmap for the packaging industry.



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 ecological footprint of packaging materials. Given their impact, emphasis was placed on the two most dominant materials - paper and cardboard, and plastics.

In 2024, the Cradle-ALP project initiates workshops to foster inspiration and exchange among stakeholders, building awareness and understanding of cradle-to-cradle (C2C) approaches and circular economy principles. Collective workshops engage multiple packaging SMEs and stakeholders in collaborative learning, sharing best practices, and exploring innovative solutions for sustainable manufacturing and recycling processes.

From 2024 to 2025, pilot actions provide direct support to packaging SMEs, helping them implement C2C principles, adopt sustainable materials, and transition to circular business models through technical assistance and funding. Short-term activities establish foundational elements such as developing public databases of packaging recycling technologies, implementing extended producer responsibility schemes, and initiating pilot projects for recycling and reuse.

In the mid-term, from 2026 to 2028, more complex solutions are introduced, including implementing ISO standards for sustainable packaging production, promoting financial cooperation for recycling, and expanding educational programs on eco-design. Between 2029 and 2033, long-term activities aim for structural changes, such as harmonizing EU regulations for sustainable packaging practices, banning landfilling of high-value composites, and fully implementing design-for-circularity principles for sustainable end-of-life management.

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 Paper Packaging

Transformation Phases and Milestones		
Strategic Pillars		Timeline
Technology	Short-term (2024-2025)	
	Mid-term (2026-2028)	
	Long-term (2029-2033)	
Business Model Approaches	Employee Training and Awareness:	
	Product Redesign for Recyclability:	
	Business Model Approaches	
Legal and Political Framework	Compliance with Certifications and Standards:	
	Development of Recycling Regulations:	
	Legal and Political Framework	

Transformation Roadmap for Plastics Packaging

Short-term (2024-2025)			Mid-term (2026-2028)			Long-term (2029-2033)		
Technology	Strategic Focus		Technology	Strategic Focus		Technology	Strategic Focus	
	Initiatives	Objectives		Initiatives	Objectives		Objectives	Objectives
Business Model Approaches	Material Assessment and Optimization: <ul style="list-style-type: none">Assess the use of alternative materials and technologies for plastic packaging.Identify optimization opportunities such as increasing the use of recycled plastics.Develop cost-effective recycling processes to reduce production costs.Use environmentally friendly technologies (reducing the amount of chemicals, reducing the consumption of water and electricity,) Development of Deinking and Impurity Removal Technologies: <ul style="list-style-type: none">Improve technologies for ink removal and contamination reduction in recycling.Address contamination and material mixture challenges to enhance recycling efficiency.		Technology	Implementation of Advanced Recycling Technologies: <ul style="list-style-type: none">Invest in advanced recycling technologies like chemical recycling to enhance material recovery.Develop better sorting and identification technologies to streamline recycling processes. Enhancement of Production Processes: <ul style="list-style-type: none">Improve efficiency in production processes to reduce energy consumption.Invest in R&D for biodegradable plastics and other sustainable materials.		Technology	Development of Biodegradable and Compostable Plastics: <ul style="list-style-type: none">Invest in research and development of biodegradable and compostable plastic alternatives.Explore new sustainable materials and applications.Develop technologies for complete material recovery to close the loop.	
Legal and Political Framework	Consumer Awareness and Education: <ul style="list-style-type: none">Launch campaigns to educate consumers on sustainable packaging options.Promote the benefits of recycled and recyclable plastics.Establish partnerships for material recycling. Supplier Collaboration: <ul style="list-style-type: none">Engage with suppliers to source sustainable plastic materials and develop closed-loop systems.Promote best practices for sourcing and material usage.		Business Model Approaches	Circular Economy Business Models: <ul style="list-style-type: none">Develop business models that incorporate recycling and reuse of plastic packaging.Implement innovative pilot projects to test and refine new sustainable packaging solutions. Consumer Engagement and Transparency: <ul style="list-style-type: none">Educate consumers on proper disposal and recycling.Foster collaboration across the value chain to promote transparency and traceability.		Business Model Approaches	Extended Producer Responsibility (EPR) Implementation: <ul style="list-style-type: none">Advocate for EPR programs to shift waste management responsibility to producers.Invest in infrastructure for collection and recycling of plastic packaging materials.Promote industry-wide best practices for circularity.	
Business Model Approaches	Compliance with Certifications and Standards: <ul style="list-style-type: none">Obtain certifications for sustainable plastics packaging.Develop clear sustainability guidelines and harmonize regulations to support recycling initiatives.		Legal and Political Framework	Development of Recycling Regulations: <ul style="list-style-type: none">Work towards comprehensive regulations for plastic recycling.Introduce financial incentives for sustainable practices.		Legal and Political Framework	Policy Advocacy and Industry Collaboration: <ul style="list-style-type: none">Collaborate with industry associations and government agencies to advocate for policy reforms.Share best practices to drive collective action towards circularity.Establish clear and measurable sustainability targets to guide industry practices.	

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Cradle-ALP

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Wood and Furniture Cradle to Cradle Industrial Transformation Roadmap

Navigating Towards Sustainability in the Wood-Furniture Sector

The wood-furniture sector represents a vital part of the European manufacturing landscape, playing a key role in both employment and economic output. According to Eurostat, in 2021, over 1 million Europeans were employed in this sector, with the industry generating approximately €96 billion in turnover, making it a significant contributor to the EU economy, comparable in size to the automotive parts industry¹. In terms of raw material consumption, wood remains a cornerstone, with Europe processing more than 3 million cubic meters of wood annually to meet the demands of the furniture sector alone².

Despite its economic importance, the wood-furniture industry faces growing pressure to transition towards more sustainable practices. One critical issue is the management of waste: in Europe, over 10 million tons of wood waste are generated each year, with a significant portion coming from furniture production and post-consumer products³. Though recycling rates for wood are relatively higher than other materials, a large share of this waste still ends up in landfills or is incinerated.

Additionally, the sector is grappling with several environmental and economic challenges. Key among them are:

- Deforestation and sourcing of sustainable wood materials⁴
- The impact of climate change on the availability of raw materials
- Rising energy costs
- Compliance with strict EU environmental regulations, such as the EU Timber Regulation (EUTR) and the Circular Economy Action Plan⁵.

To navigate these challenges, the EU has introduced initiatives aimed at promoting sustainability in the wood-furniture sector. For instance, the Horizon Europe research and innovation program supports projects that focus on eco-design, material efficiency, and the use of bio-based alternatives⁶. In parallel, industry-led roadmaps are emerging, guiding businesses towards adopting circular economy principles, reducing waste, and increasing the use of certified sustainable wood sources⁷.

These measures are part of a larger shift within the EU's Green Deal framework, which aims to make the European wood-furniture sector more resilient, competitive, and environmentally sustainable. The transformation towards a circular economy is not just an opportunity for reducing the sector's environmental footprint but also a pathway to innovation, new business models, and long-term growth.

1 <https://ec.europa.eu/eurostat/web/main/data/database>

2 https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Wood_products_-_production_and_trade#Secondary_wood_products

3 https://ec.europa.eu/environment/topics/waste-and-recycling/wood-waste_en

4 https://ec.europa.eu/environment/forests/wood-based-products_en

5 <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R0995>

6 <https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-results-platform>

7 <https://ec.europa.eu/environment/circular-economy/>

The Cradle-ALP Transformation Roadmap

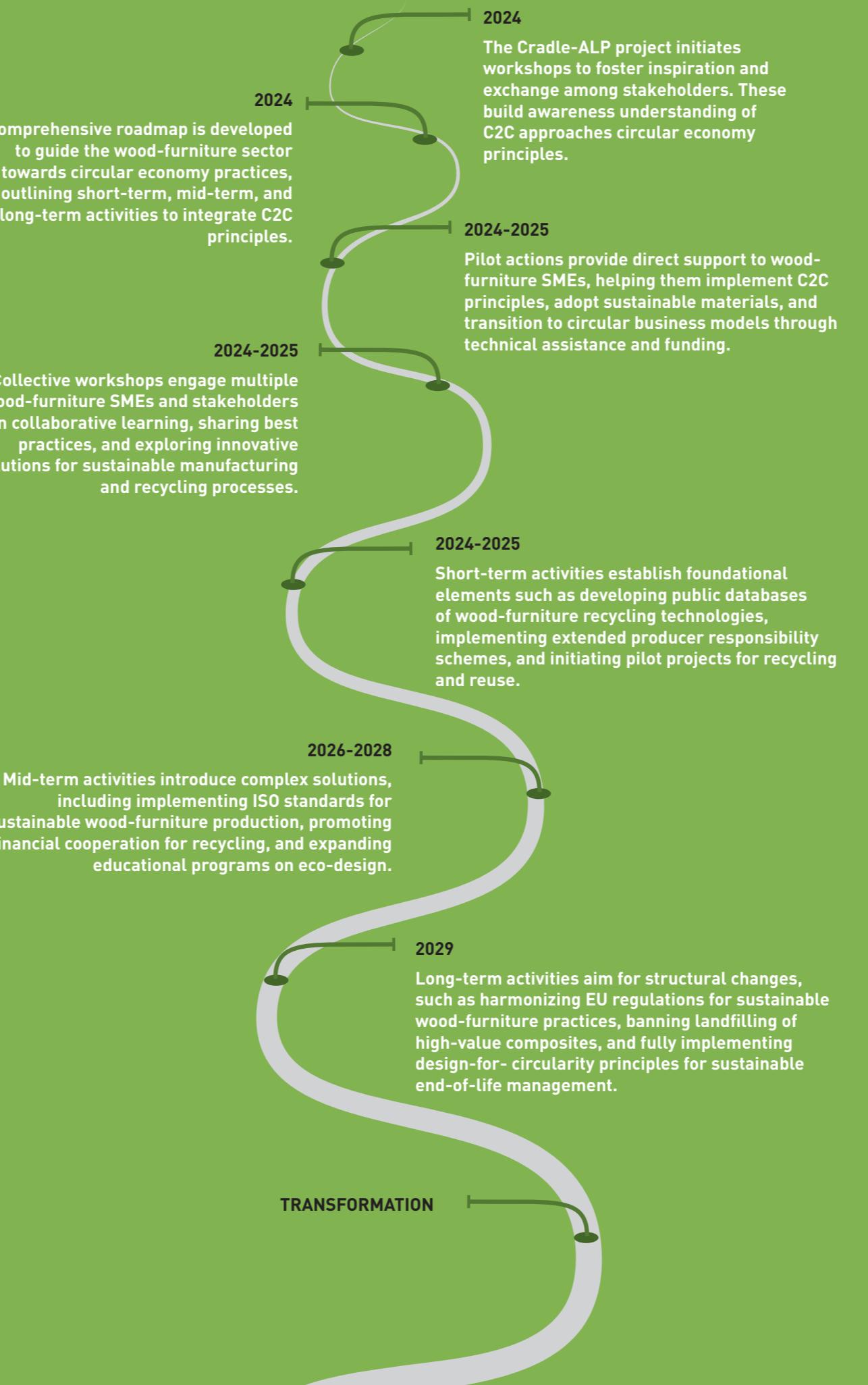
Wood-Furniture Sector Transformation Roadmap

This roadmap is designed to guide the wood-furniture sector through a strategic and phased approach, aiming to achieve significant environmental and economic benefits by reducing the industry's ecological footprint. The roadmap focuses on integrating circular economy practices and sustainability, including the use of certified materials and innovative technologies.

2024-2025 marks the start of pilot projects aimed at testing and validating the use of materials from certified sustainable sources. During this period, impact assessments will be conducted to evaluate the effects of these practices on biodiversity and local communities. Additionally, artificial intelligence (AI) and Internet of Things (IoT) systems will be introduced to optimize material usage and manage resource flows and waste in real-time.

From **2026 to 2028**, the roadmap envisions scaling advanced technologies for lifecycle management. Integrated systems for efficient product tracking and end-of-life management will be developed. This phase will also focus on research and development of new sustainable materials, promoting cross-sector collaborations to drive innovation.

Finally, from **2029 to 2033**, the introduction of innovative sustainable materials into the global market will be prioritized, encouraging widespread adoption of circular practices. The sector will work toward developing closed-loop supply chains where recycled materials are continuously reintegrated into production cycles. On the regulatory side, supply chain agreements enforcing sustainable forestry practices will be strengthened, supported by balanced economic incentives that encourage sustainable innovation.



Transformation Roadmap for Wood-Furniture Sector

Transformation Roadmap for Wood-Furniture Sector			
Strategic Pillars		Implementation Phases	
Strategic Pillar	Key Focus Area	Implementation Phases	
		Short-term (2024-2025)	Mid-term (2026-2028)
Technology	<p>Pilot Projects for Certified Sustainable Sourcing</p> <ul style="list-style-type: none"> Launch pilot projects to test and validate the use of materials from certified sustainable sources. <p>Evaluate Impacts on Biodiversity and Local Communities</p> <ul style="list-style-type: none"> Conduct impact assessments to understand the environmental and social implications of sustainable sourcing practices. <p>AI for Material Optimization</p> <ul style="list-style-type: none"> Implement AI pilot projects to optimize material usage in production processes. <p>IoT for Resource and Waste Management</p> <ul style="list-style-type: none"> Deploy IoT systems to monitor resource flow and manage waste output in real-time. 	<p>Scaling Advanced Technologies for Lifecycle Management</p> <ul style="list-style-type: none"> Expand AI and IoT systems across the industry to standardize lifecycle management and recycling processes. <p>Integrated End-of-Life Product Management Systems</p> <ul style="list-style-type: none"> Develop and integrate systems for efficient tracking and management of products at the end of their lifecycle. <p>Innovative Sustainable Material Development</p> <ul style="list-style-type: none"> Invest in R&D to create new sustainable materials that reduce environmental impact and improve efficiency. <p>Collaborative R&D Initiatives for Material Innovation</p> <ul style="list-style-type: none"> Foster cross-industry collaborations for the development and testing of sustainable materials. 	<p>Market Introduction of Innovative Materials</p> <ul style="list-style-type: none"> Launch innovative sustainable materials into the global market, ensuring cost competitiveness and accessibility. <p>Widespread Adoption of Circular Materials</p> <ul style="list-style-type: none"> Encourage industry-wide adoption of sustainable materials through partnerships and policy support. <p>Advanced Material Recovery Technologies</p> <ul style="list-style-type: none"> Implement advanced technologies for efficient material recovery and recycling, targeting zero waste. <p>Closed-Loop Supply Chains</p> <ul style="list-style-type: none"> Develop closed-loop systems where recycled materials are consistently reintegrated into production cycles.
Business Model Approaches	<p>Knowledge Sharing</p> <ul style="list-style-type: none"> Facilitate knowledge exchange between wood/furniture and other sectors such as textiles, construction, and electronics to compare circular economy practices. <p>Resource Pooling</p> <ul style="list-style-type: none"> Develop shared pools of resources, including tools, research, and best practices to support circularity. <p>Innovation Promotion</p> <ul style="list-style-type: none"> Foster collaborative innovation by forming partnerships between academia, industry, and government to address sustainability challenges. <p>Education and Skill Development</p> <ul style="list-style-type: none"> Create educational programs focused on sustainability and circular economy practices within the wood/furniture sector, especially promoting alternatives to using wood as energy source. <p>Research and Development</p> <ul style="list-style-type: none"> Drive research initiatives to tackle key challenges in material reuse, lifecycle analysis, and sustainable production. 	<p>Expanded Collaborative Networks</p> <ul style="list-style-type: none"> Scale existing partnerships and integrate new sectors such as waste management and recycling industries to enhance circularity. <p>Circular Design and Production Standards</p> <ul style="list-style-type: none"> Develop and implement standardized guidelines for circular product design, focusing on modularity, reparability, and material recovery. <p>Circular Supply Chain Integration</p> <ul style="list-style-type: none"> Build circular supply chains that connect material sourcing, manufacturing, and end-of-life processes through sustainable practices. <p>Consumer Awareness and Engagement</p> <ul style="list-style-type: none"> Launch widespread consumer education campaigns to promote awareness of circular products and practices. <p>Circular Economy Certification Programs</p> <ul style="list-style-type: none"> Introduce certification programs that recognize companies, products, and practices adhering to circular economy principles. 	<p>Global Collaborative Networks</p> <ul style="list-style-type: none"> Strengthen and globalize partnerships to ensure widespread adoption of circular practices across borders and industries. <p>Standardized Reverse Logistics Systems</p> <ul style="list-style-type: none"> Fully integrate reverse logistics into supply chains, making product return, refurbishment, and recycling routine. <p>Circular Business Models</p> <ul style="list-style-type: none"> Promote circular business models such as product-as-a-service, take-back programs, and extended product lifecycles. <p>Full Lifecycle Product Tracking</p> <ul style="list-style-type: none"> Promote adoption of advanced tracking technologies for end-to-end monitoring of materials and products throughout their lifecycle.
Legal and Political Framework	<p>Engage with Policymakers</p> <ul style="list-style-type: none"> Build relationships with government bodies to advocate for policies supporting circularity in the wood/furniture sector. <p>Develop Financial Incentives</p> <ul style="list-style-type: none"> Collaborate to create financial mechanisms like subsidies, tax breaks, or grants for businesses using sustainable practices. <p>Pilot Regulatory Programs</p> <ul style="list-style-type: none"> Initiate pilot programs to test policies that promote sustainable manufacturing and circular economy principles. 	<p>Mandate Material Safety Disclosures</p> <ul style="list-style-type: none"> Implement regulations that require comprehensive disclosure of material safety and environmental impact. <p>Establish Environmental Labeling Standards</p> <ul style="list-style-type: none"> Create standardized labeling systems for product sustainability, enabling consumers to compare environmental impacts. <p>Enforce Supply Chain Audits</p> <ul style="list-style-type: none"> Introduce regulations that mandate regular audits of material sourcing and manufacturing processes for sustainability. 	<p>Sustainable Sourcing and Deforestation</p> <ul style="list-style-type: none"> Strengthen supply chain agreements that enforce sustainable forestry practices and introduce digital monitoring systems for transparency. <p>Educational Partnerships and Research</p> <ul style="list-style-type: none"> Develop industry-academic partnerships to drive ongoing research and innovation in circular economy practices. <p>Balanced Economic Incentives and Disincentives</p> <ul style="list-style-type: none"> Adjust market pricing mechanisms to include both economic disincentives for unsustainable practices and incentives for sustainable innovation. <p>Digital Integration of Supply Chains</p> <ul style="list-style-type: none"> Simplify and digitally integrate supply chains using advanced technologies like IoT and AI to enhance efficiency and sustainability. <p>International Policy Alignment</p> <ul style="list-style-type: none"> Work towards establishing global policy alignment to harmonize circular economy standards across borders.

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