



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.

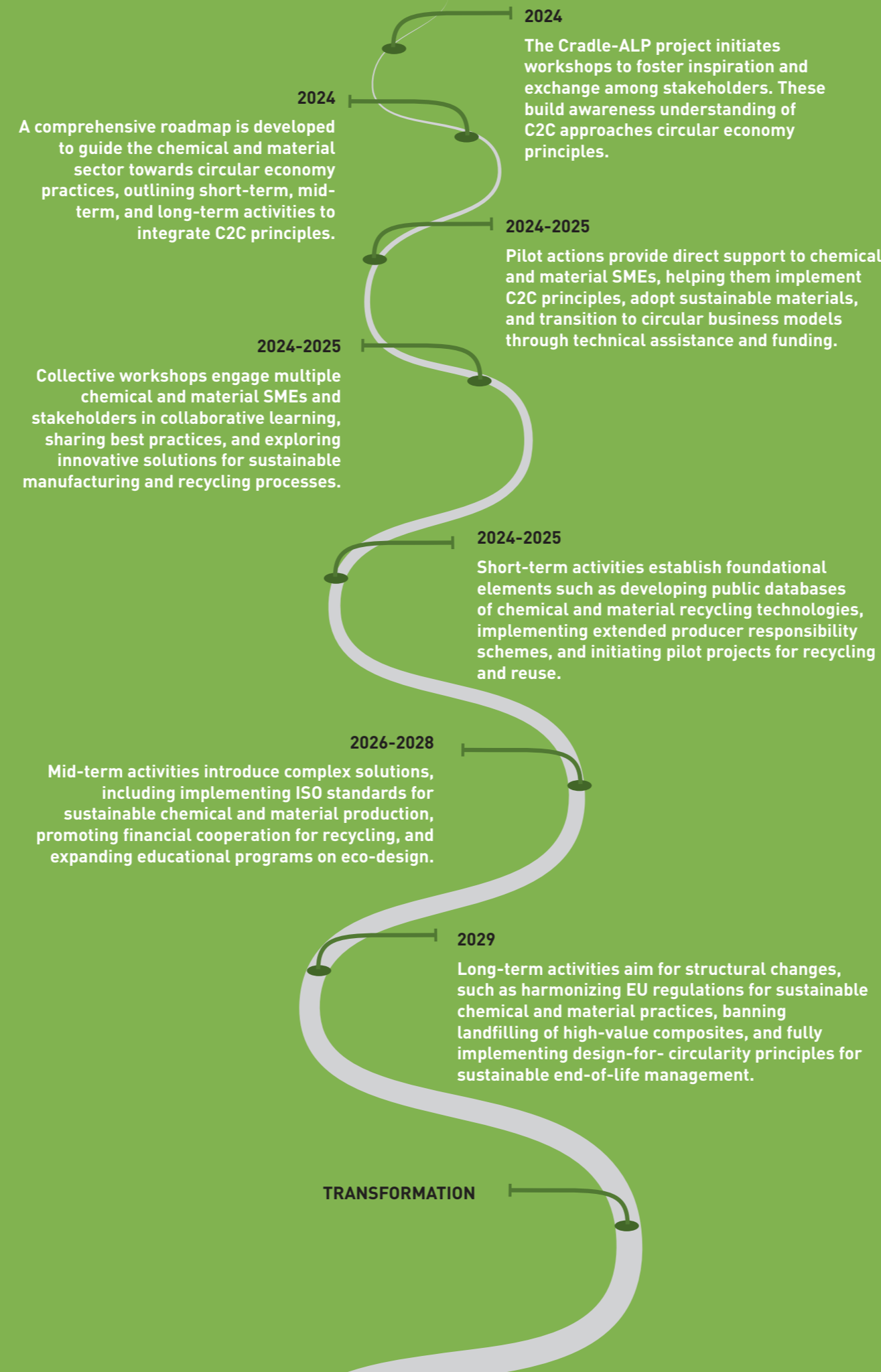
The chemical and material sector can contribute by driving technological and material innovations for waste recycling, CO₂ capture and utilization, delivering products for e-mobility and renewable power generation, developing environmentally safer and sustainable chemicals, and thus the creation of resilient 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)	
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 recycle 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"
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
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

Mid-term (2026-2028)	
Technology	<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>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"> 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

Long-term (2029-2033)	
Technology	
Business Model Approaches	
Legal and Political Framework	<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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You can find out more about the project at:
<https://www.alpine-space.eu/project/cradle-alp/>