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Sectoral Cradle2Cradle industrial transformation roadmaps

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1. Summary

The roadmap for paper/plastic packaging sector is a comprehensive report that consolidates the findings of a study examining market trends and factors influencing the packaging industry, particularly focusing on the introduction and utilization of the Cradle2Cradle certificate. The primary objectives of this report are to identify, categorize, and elucidate these trends and forces while providing a structured framework to facilitate strategic planning for corporate and industrial transformation.

Drawing upon data collected from various roadmapping workshops organized by project partners across different countries in March 2024, the report encompasses insights gathered from industry stakeholders and experts. These workshops attracted more than 30 delegates from diverse paper packaging-related organizations, with participation from representatives across Austria, Italy, and Slovenia.

Following these workshops, the initiative will extend to engage in personal outreach and individual meetings with numerous companies within the paper packaging sector. Through these engagements, the project aims to ascertain the prevailing circumstances within individual companies and discern their specific needs concerning the implementation of Cradle2Cradle practices.

During these interactions, the advantages of adopting and implementing the Cradle2Cradle certificate will be presented to the companies. Collaboratively, the project team and the companies will explore the potential avenues for integrating the certificate into their operations, fostering a deeper understanding of the benefits and feasibility of such implementation within their respective organizations.

2. Introduction to Cradle-ALP project

Cradle-ALP aims for mainstreaming cradle to cradle (C2C) approaches, circular design and circular substitutions (from the alpine region) for linear products in industrial processes, in different industrial sectors. The Alpine Space is abundant in natural resources and possesses the technology necessary to replace fossil raw materials and toxic substances in production with sustainable, eco-friendly alternatives. This transformation facilitates the reintegration of

materials and products into a healthy, closed-loop cycle after use. The focus of this project shall be on the substitution of chemical and fossil based/unsustainable materials with more circular, sustainable, and bio-degradable ones.

First, the partners will build a broad awareness and understanding in the public, the relevant industries as well as among stakeholders from policy and innovation intermediaries, for the opportunities, barriers, and mechanisms of the transformation of industrial products towards higher circularity by means of C2C approaches, circular design, and circular substitutions. Business support providers shall be trained to accompany the transformation of businesses along more circular value chains.

In a second step, the partners will explore in details and test opportunities for implementing C2C approaches, circular design, and circular substitutions along specific value chains in the chemistry/plastics and wood/forestry sectors supported by digital technologies. Building on a thorough multidimensional (technology, policy, economy, etc.) roadmapping exercise, transnational groupings of stakeholders – including businesses – will be installed, with the aim to transfer the C2C roadmaps into industrial practice along exemplary value chains.

Finally, the partners will work towards ensuring a transnational policy convergence towards transnational S4 strategies in the priority sectors of the project and initiate common cross border funding instruments for the industrial C2C transformation.

3. Objectives and Scope of the Transformation Roadmap Packaging Sector

The objective was to develop a transformation roadmap for the packaging sector that showcases existing and emerging technologies (both digital and engineering) and processes. At the same time, it aims to highlight legal and normative recommendations and requirements that can facilitate the transition of industrial practices towards a circular economy. This includes exploring the substitution of traditional technologies with environmentally friendly technologies and sustainable materials (bio-based and/or recyclable alternatives).

The roadmap has three primary objectives:

- To identify and categorize the major trends and forces influencing the packaging industry over the next ten years.
- To disseminate comprehensive information about the nature and implications of these trends and forces, including identifying areas of competitive risk and opportunities for innovation.
- To provide a structured framework to support strategic planning, decision-making, and collaboration within the packaging industry.

It is essential to note that the professional opinions collected at workshops, public events and individual meetings served as the sole source of information included in the roadmap. The roadmap aims to serve as a resource to stimulate thought and discussion on the potential evolution of the packaging sector and the impact of industrial transformation, rather than offering a prescriptive view of how the industry will evolve.

4. Roadmapping Procedure & Participating Organisations

As the first step, we organized a workshop with an external expert support group to identify gaps, barriers, drivers, and potentials for the packaging sector, and to prioritize the challenges we want to tackle. Based on this knowledge, we organized three transnational workshops to elaborate on possible future solutions for these challenges. We invited participants from academia, the business sector, and BSOs to participate and help us develop a roadmap with their inputs. We used a Mural whiteboard, following the same procedure and engaging the participants in three exercises:

- 1) **Identifying potential gaps and barriers** in knowledge, technology limitations, market structural barriers, regulatory limitations, public acceptance or other gaps and barriers preventing the industry to address the challenges and achieve the vision set-out following the experts' workshop.
- 2) **Defining solutions and key activities** to implement in order to overcome the gaps and barriers previously identified. Those key activities must concern each component of the

industrial sector, including technology development and deployment, development of business models and market opportunities, development of regulations and standards, policy formulation, creation of financing mechanisms, and public engagement.

- 3) **Assigning the solutions and key activities** according to their field (Technology, Business Model, legal/political) and their time-frame (short-term, mid-term, long-term) and voting on the activities that are the most important to implement and achieve.

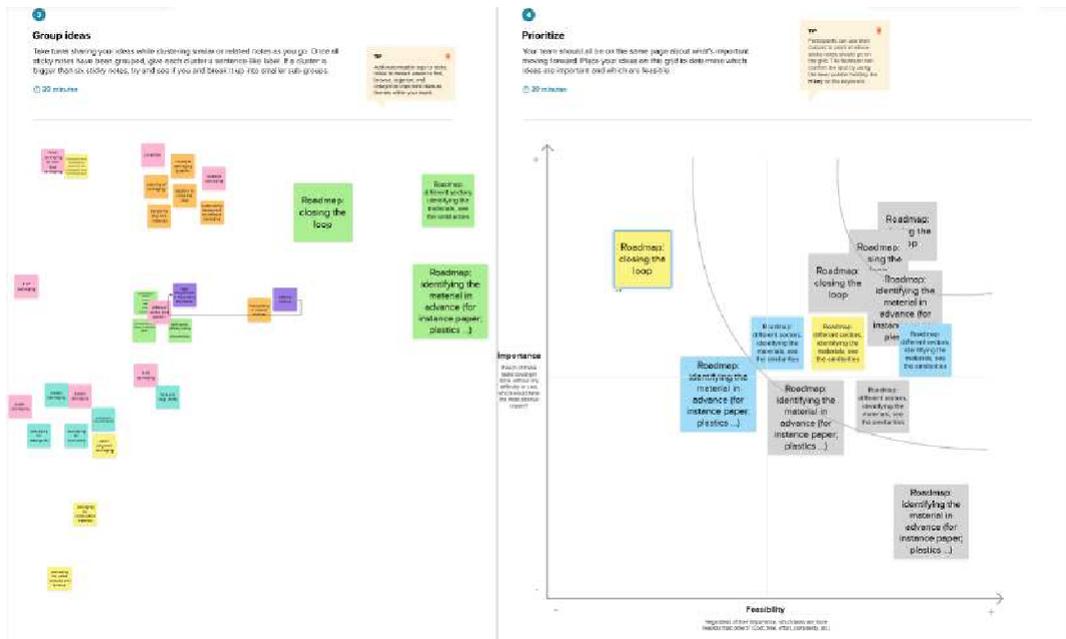


Figure 1: Exemplary screenshot showing results of discussions with external expert support group

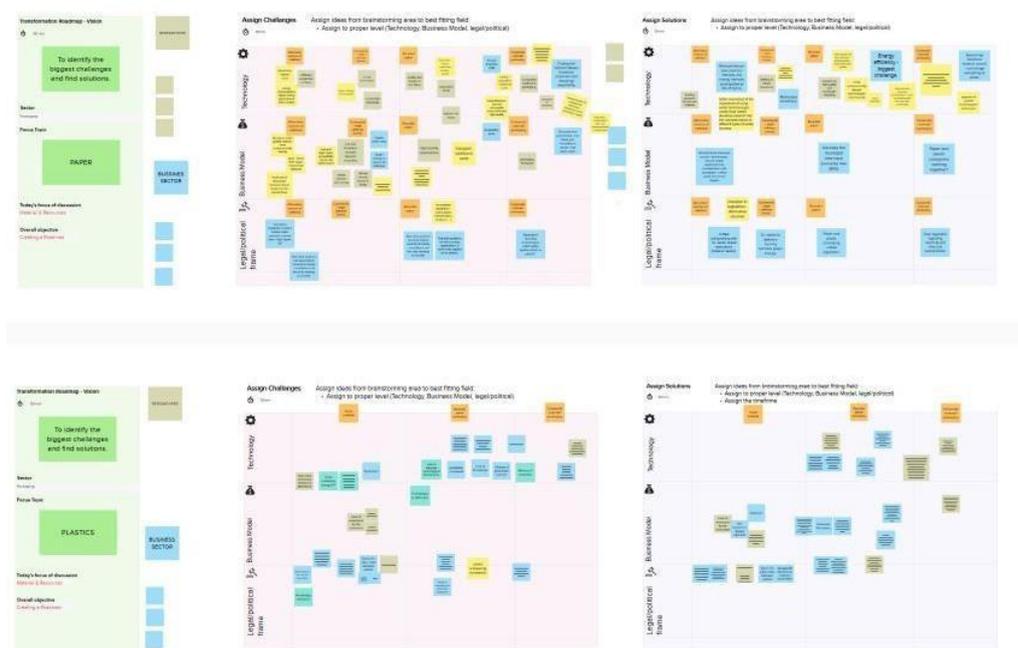
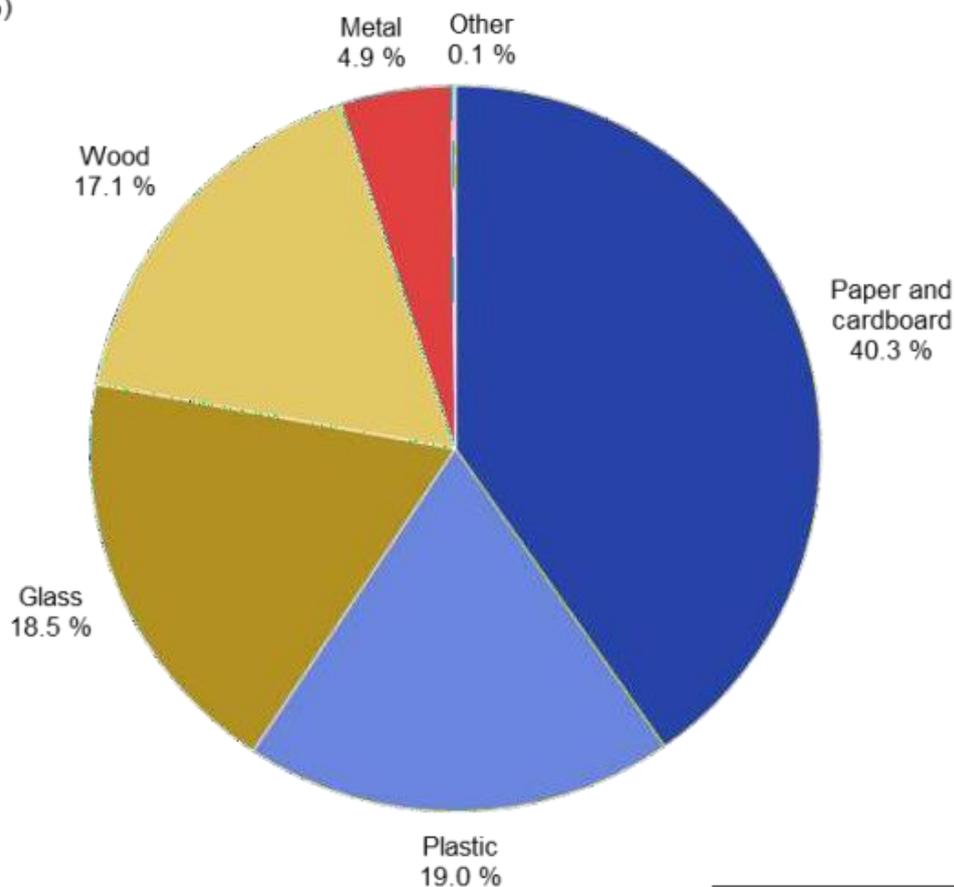


Figure 2: Exemplary screenshot showing results of discussions of one of the workshops

5. Challenges in the industrial sector - gaps & barriers analysis

In 2021, the [EU](#) generated an estimated 188.7 kg of packaging waste per inhabitant. This quantity varied between 73.8 kg per inhabitant in Croatia and 246.1 kg per inhabitant in Ireland. Paper and cardboard (40.3 %), plastic (19.0 %), glass (18.5 %), wood (17.1 %) and metal (4.9 %) are the most common materials of packaging waste in the EU. Other materials represented only 0.1 % of the total volume of packaging waste generated in 2021 (source: [Eurostat](#)).

Packaging waste generated, by packaging material, EU, 2021
(%)



Note: Eurostat estimates.

Source: Eurostat (online data code: env_waspac)



For our roadmapping process, we have decided to focus on the two most used materials: paper and cardboard (40.3%) and plastic (19.0%). The gaps and barriers analysis was the starting point of the roadmapping process. Firstly, we identified them internally and later on with external experts. Proceeding from this, we organized three workshops with already

predefined challenges. This gave us the opportunity to explore in more detail the so-called gaps and barriers.

The focus of our first workshop was on materials and resources used in packaging sector. Before we started with the workshop, the facilitators already prepared Mural. Since we have decided to work on two different materials, we had decided prior to the workshop to prepare two canvases, one for the experts on paper packaging, one for the experts on plastics packaging. The group working on a paper packaging focused on 4 preselected topics – alternative sources of cellulose, commercial / virgin cellulose, recycled paper, and composite material in packaging. The participants were asked to assign firstly challenges and later the solutions in the frame of these topics in the fields of technology, business model and legal/political frame. The group working on a plastic packaging took the same approach, but with some other topics in the focus: virgin material, recycled plastic in packaging, composite material in packaging.

The focus of the second workshop was on ecodesign. At the beginning, we made a short recap of the first one. Afterwards, we continued with the main topic of the second workshop: ecodesign. As before the first workshop, we had also prepared Mural for the second one. Once again, we asked our participants to think about the main topic within three fields: technology, business model, and legal/political framework. We asked them to identify both challenges and solutions.

The third and the last workshop was on sorting, collecting, and recycling. We decided to merge experts and representatives of business sector that cover either paper or plastic packaging together, as we realized in the first two workshops that the challenges and solutions of both groups intersect. Additionally, we wanted to enable people from different sectors to see the challenges and solutions that others face, and perhaps find ideas for their own sectors as well.

Below, we will present the results of these workshops, including both the challenges and their solutions.

Summary of identified challenges and solutions regarding paper packaging

Technological Challenges

Analyzing the technological challenges outlined in the provided points sheds light on several key issues facing the development and implementation of sustainable packaging solutions:

1. Cost Implications:

Additional bleaching requirements and the consumption of large amounts of chemicals contribute to higher production costs. This suggests that while environmentally friendly alternatives may offer benefits in terms of sustainability, they may come at a higher economic cost. **Investment in research to develop more cost-effective bleaching methods and chemical alternatives that reduce overall production costs would be beneficial.** The use of biodegradable dyes and coatings (natural ingredients) can reduce the use of chemicals in the deinking process, addressing the high chemical costs for paper mills (paper recycling). **Upgrading existing systems for collection, sorting, and processing, as well as improving the quality of raw materials (lowering the costs of removing impurities), is essential.**

2. Material Complexity:

The presence of different properties of fibers and uncertainty about packaging materials indicate the complexity of working with alternative sources and composite materials. This complexity can lead to challenges in ensuring consistent quality and performance of packaging materials. **Development of advanced material characterization techniques and standardized processes to ensure consistent quality and performance when using alternative sources and composite materials.**

3. Energy Consumption:

Higher energy consumption during pre-treatment, as well as the consumption of suitable chemicals, underscores the energy-intensive nature of the packaging production process. **This highlights the importance of exploring energy-efficient technologies and processes to mitigate environmental impact, upgrading existing systems for collection, sorting, and processing; using better quality raw materials (lowering the costs of removing impurities); reducing electricity consumption; and closing the circuits for water and materials within the industry are essential to achieving lower energy consumption.**

4. Adaptation Needs:

The need for technology adaptation suggests that existing manufacturing processes may not be fully compatible with alternative materials or recycling methods. **This highlights the importance of investing in research and development to innovate and upgrade technologies suitable for production of sustainable packaging.**

5. Deinking and Impurity Challenges:

Issues such as ink removal, low fiber quality, and contamination of equipment pose significant challenges in the recycling process. These challenges can affect the quality of recycled materials and increase the complexity and cost of recycling operations. **Upgrading existing deinking processes and reducing the use of chemicals, which are characterized by high costs and are environmentally unfriendly, are essential.**

6. Sorting and Material Identification:

Sorting and collection complexities, as well as uncertainty about packaging materials, point to challenges in the recycling infrastructure and processes. **Improving sorting technologies and enhancing material identification methods are essential for streamlining recycling operations and increasing the recyclability of packaging materials.**

Summary of identified challenges and solutions regarding paper packaging

Business Challenges

Analyzing the business challenges listed provides insight into the market dynamics and consumer perceptions influencing the adoption of sustainable packaging solutions:

1. Consumer Demand:

There is a notable increase in customer interest in environmentally friendly options. This indicates a growing market opportunity for sustainable packaging solutions driven by consumer preferences for eco-friendly products. **Cost-reduction strategies and economies of scale to make sustainable packaging materials more price competitive with virgin cellulose are needed.**

2. Price Competitiveness:

The need for lower prices compared to virgin cellulose highlights the importance of cost competitiveness in the adoption of alternative packaging materials. Price sensitivity among consumers can influence their purchasing decisions, emphasizing the need for economically viable sustainable packaging options. **Investment in cost-reduction strategies and economies of scale to make sustainable packaging materials more price competitive with virgin cellulose is needed.**

3. Local Focus:

Emphasizing local use for reduced transport costs and environmental impact reflects a trend towards sustainability and localization in supply chains. **This suggests an opportunity for businesses to differentiate themselves by promoting locally sourced and produced packaging materials.**

4. Consumer Awareness:

Poor customer awareness of the benefits of alternative sources and recycled paper indicates a gap in consumer education and communication. **Businesses need to invest in marketing and educational efforts to increase consumer awareness and promote the benefits of sustainable packaging options.**

5. Supply Chain Considerations:

Consideration of sustainable supply chains underscores the importance of integrating sustainability principles throughout the packaging supply chain. **This includes sourcing raw materials responsibly, reducing waste, and minimizing environmental impact throughout the production process.**

6. Circular Business Models:

The need for circular business models indicates a shift towards a more circular economy approach, where resources are kept in use for as long as possible through recycling and reuse. **Adopting circular business models can create opportunities for businesses to reduce waste, enhance resource efficiency, and meet sustainability goals.**

7. Customer Education:

Providing comprehensive information to customers and addressing poor knowledge about composite packaging is essential for building trust and confidence in sustainable packaging options. **Businesses should focus on transparent communication and education initiatives to empower consumers to make informed choices.**

Summary of identified challenges and solutions regarding paper packaging

Legal Challenges

Analyzing the legal challenges outlined provides insight into the regulatory landscape and policy uncertainties impacting the development and adoption of sustainable packaging solutions:

1. Legislative Variability:

Changing legislation across different markets poses challenges for businesses operating in multiple regions. Compliance with varying regulations adds complexity and can increase costs for packaging manufacturers and distributors. **Harmonization of regulations across markets and enabling of standardized compliance requirements would simplify operations for businesses and reduce their costs.**

2. Sustainability Strategy Ambiguity:

The lack of clear goals for sustainability strategies creates uncertainty for businesses seeking to align their operations with regulatory expectations. Without clear guidelines, companies may struggle to develop and implement effective sustainability initiatives. **Development and dissemination of clear, specific, and actionable sustainability guidelines that help businesses align their strategies with regulatory expectations would be beneficial.**

3. Undefined Regulatory Challenges:

The presence of unspecified challenges in this area suggests a lack of clarity or understanding regarding specific legal requirements or obstacles. This ambiguity can hinder compliance efforts and impede progress towards sustainability objectives. **Collaboration among industry stakeholders and regulatory bodies to identify and clarify unspecified legal requirements would ensure businesses to have a clear understanding of compliance obligations.**

4. Unclear Sustainability Goals:

Unclear sustainability goals at the regulatory level may lead to confusion and inconsistency in sustainability practices across industries. **Clear and measurable sustainability targets are necessary to guide businesses and promote accountability.**

5. Incomplete Legislation:

Incomplete legislation regarding wastepaper creates regulatory gaps and uncertainties in waste management practices. Lack of comprehensive regulations may hinder efforts to promote recycling and circular economy principles. **Development of comprehensive waste management regulations that address all aspects of the recycling process, promoting more effective recycling practices and supporting circular economy initiatives on EU level would be beneficial (as little of possible differences among countries would be extremely helpful).**

6. Recycling Policy Uncertainty:

Uncertainty about which recycling policy applies, whether for paper or plastics, adds complexity to waste management processes. **Clear guidelines are needed to determine appropriate recycling practices and ensure compliance with regulatory requirements.**

In conclusion, the technological challenges highlighted underscore the need for innovation and investment in research and development to address key barriers in the development and adoption of sustainable packaging solutions. This includes developing energy-efficient processes, upgrading existing systems for collection, sorting, and processing, improving the quality of raw materials (lowering the costs of removing impurities), reducing electricity consumption, and minimizing environmental impact.

Additionally, collaboration across industries and stakeholders is essential for overcoming these challenges and driving progress towards a more sustainable packaging ecosystem. The business challenges highlight the importance of aligning business strategies with sustainability goals, responding to consumer demand for eco-friendly products, and addressing market barriers such as price competitiveness and consumer awareness. Businesses that prioritize sustainability, invest in innovation, and engage with stakeholders across the supply chain can capitalize on the growing demand for sustainable packaging solutions and drive positive environmental impact. The legal challenges highlight the importance of regulatory clarity, consistency, and alignment with sustainability objectives. Businesses need clear and stable regulatory frameworks to navigate compliance requirements, drive innovation, and invest in sustainable packaging solutions effectively. Collaboration between policymakers, industry stakeholders, and advocacy groups is essential to address regulatory uncertainties and promote the development of robust and effective sustainability policies.

Summary of identified challenges and solutions regarding plastic packaging

Technological Challenges

Analysing the technological challenges in plastic packaging provides insight into the complexities and obstacles involved in transitioning to more sustainable alternatives:

1. High Initial Investment for Alternatives:

The high upfront costs associated with adopting alternative materials (not virgin) or technologies may deter companies from investing in sustainable packaging solutions. **Financial incentives, subsidies, or grants to support companies in offsetting the high initial costs of adopting alternative materials or technologies should be provided.**

2. Consumer Demand for Convenience:

Consumer preference for convenient single-use packaging presents a challenge in promoting more sustainable packaging options that may require behavioral changes or compromises in convenience. **Innovative sustainable packaging solutions that maintain or enhance convenience, potentially integrating reusable or easily recyclable designs that appeal to consumers' desire for ease of use should be developed and marketed.**

3. Technological Infrastructure Limitations:

The lack of adequate technological infrastructure poses challenges in implementing advanced recycling processes or alternative material production methods, limiting the scalability of sustainable packaging solutions. **Investment in advanced technologies should be accompanied with financial benefits.**

4. Material Availability and Knowledge Gap:

Challenges related to material availability and lack of knowledge highlight the need for research and development efforts to expand the range of sustainable materials and improve understanding of their properties and applications. **Collaboration between researchers and industry while also educating industry stakeholders would be beneficial to overcome this gap.**

5. Production Process Changes:

Implementing sustainable packaging solutions may require significant changes to existing production processes, posing challenges in terms of feasibility, scalability, and compatibility with existing infrastructure. **Industry collaboration and knowledge sharing to support the adaptation of existing production should be facilitated.**

6. Quality and Consistency Issues:

Variability in biochemical, mechanical, and chemical-physical characteristics of alternative materials can impact product quality and performance, leading to challenges in ensuring consistent standards and meeting consumer expectations. **The development of stringent standards and quality control measures for alternative materials that meet or exceed those of traditional materials is needed.**

7. Contamination and Material Mixture:

Contamination and the mixture of materials present challenges in recycling processes, as they complicate sorting and separation efforts, reducing the efficiency and effectiveness of recycling operations. **Advanced sorting and cleaning technologies to effectively separate and decontaminate mixed materials, enhancing the efficiency and effectiveness of recycling processes need to be implemented.**

Summary of identified challenges and solutions regarding plastic packaging

Business Challenges

Analyzing the business challenges in plastic packaging sheds light on several critical issues hindering the adoption and implementation of sustainable practices:

1. Consumer Awareness and Knowledge Gap:

Lack of awareness and knowledge among consumers, particularly younger generations, about sustainable packaging options and their environmental impact poses a significant barrier. **Education and awareness campaigns are needed to bridge this gap and promote informed consumer choices.**

2. Value Chain Gaps:

Gaps in the value chain between actors, including manufacturers, suppliers, retailers, and consumers, hinder the seamless integration of sustainable packaging solutions. **Collaboration and communication among stakeholders are essential to address these gaps and ensure a holistic approach to sustainability.**

3. Citizens' Awareness and Material Incidence

Citizens' lack of awareness regarding materials and their impact on the value chain highlights a broader societal issue. **Efforts to raise awareness and promote transparency in the supply chain are necessary to foster responsible consumption habits.**

4. Greenwashing:

The prevalence of greenwashing, where companies misrepresent their products as more environmentally friendly than they are, undermines consumer trust and confuses decision-making. **Clear and transparent labeling and certification schemes can help combat greenwashing practices.**

5. Low Profitability:

The profitability of sustainable packaging solutions remains a concern for businesses, particularly in comparison to conventional packaging options. **Investment in research, development, and innovation is needed to improve the cost-effectiveness of sustainable alternatives.**

6. Upcycling Opportunities:

Considering upcycling opportunities in the value chain presents a potential solution to address gaps in recycling processes and maximize resource utilization. **Exploring innovative ways to repurpose materials can create additional value and contribute to circular economy principles.**

7. Plastic Processing Concessions:

Regulatory challenges, such as plastic processing concessions, add complexity and uncertainty to the business environment. **Clear and consistent regulations are needed to provide a conducive framework for sustainable packaging initiatives.**

8. Reuse Packaging Examples:

Limited examples of paper products as reuse packaging and the challenges associated with reusing boxes highlight the need for innovation and investment in circular packaging solutions. **Businesses should explore opportunities to design products with reuse and longevity in mind.**

Summary of identified challenges and solutions regarding plastic packaging

Legal Challenges

Analyzing the legal challenges in plastic packaging provides insights into the regulatory hurdles and policy complexities impacting the adoption of sustainable practices:

1. Dependence on Non-EU Countries:

Dependence on non-EU countries for plastic materials poses challenges in terms of supply chain resilience, geopolitical risks, and environmental sustainability. **Diversifying sourcing options and promoting domestic production can mitigate these risks.**

2. Lack of Binding Standards:

The absence of binding standards for sustainable packaging materials and practices hinders consistency and comparability across the industry. **Clear and enforceable standards are needed to guide businesses and ensure accountability.**

3. Greenwashing:

Greenwashing practices, where companies misrepresent their products as environmentally friendly, undermine consumer trust and create market distortions. **Robust regulations and enforcement mechanisms are necessary to combat greenwashing and promote transparency.**

4. Legislative Complexity and Fragmentation:

The complexity and fragmentation of legislation at national and international levels present challenges for businesses navigating regulatory requirements. **Simplifying and harmonizing legislation can streamline compliance efforts and promote consistency.**

5. Plastic Processing Concessions:

Regulatory challenges such as plastic processing concessions add administrative burden and uncertainty for businesses operating in the plastic packaging industry. **Clear and predictable regulatory frameworks are essential to provide a conducive business environment.**

6. Social Problem: Awareness of Waste Separation:

Lack of awareness and understanding among the general public about waste separation practices complicates recycling efforts and leads to contamination of recycling streams. **Public education campaigns and infrastructure improvements are needed to address this issue.**

7. CO2 Calculations and Material Sourcing:

Requirements for CO2 calculations and material sourcing present additional challenges for businesses in terms of compliance and reporting. **Standardized methodologies and guidelines can facilitate accurate measurement and reporting of environmental impacts.**

8. Adoption of Closing Loop Systems:

The adoption of closing loop systems, which promote circular economy principles, is hindered by cost considerations and technological barriers. **Financial incentives and support mechanisms can encourage businesses to invest in closing loop systems and accelerate the transition to a circular economy.**

In conclusion, overcoming the technological challenges in plastic packaging requires a concerted effort from stakeholders across industries, including researchers, manufacturers, policymakers, and consumers. Investment in research and development, technological innovation, and infrastructure upgrades is essential to drive progress towards a more sustainable packaging ecosystem. Additionally, raising awareness and fostering collaboration between industry players can facilitate the adoption of innovative solutions and accelerate the transition to more sustainable packaging practices. Addressing business challenges in plastic packaging requires a multifaceted approach that involves collaboration between stakeholders, investment in innovation, and regulatory support. By addressing gaps in the value chain, improving profitability, and prioritizing consumer education, businesses can drive positive change towards more sustainable packaging practices. In conclusion, addressing legal challenges in plastic packaging requires coordinated efforts from policymakers, businesses, and other stakeholders to develop clear and consistent regulatory frameworks, promote transparency and accountability, and incentivize sustainable practices. Collaboration and dialogue between industry players and regulators are essential to overcome regulatory hurdles and drive progress towards a more sustainable packaging industry.

In the face of these challenges, a comprehensive roadmapping process can offer a structured approach to navigate the complexities of the sustainability journey. By bringing together stakeholders from across industries and disciplines, a roadmap provides a framework for collaboration, innovation, and strategic planning. Through collective action and strategic alignment, stakeholders can chart a course towards a more sustainable packaging ecosystem, where environmental stewardship and economic viability converge for the benefit of present and future generations. In the next chapter, we will present the vision for our roadmap.

6. Vision of the Transformation Roadmap(s) Packaging

The first step of the Cradle-ALP roadmapping process was to define a vision that guides the involved stakeholders and experts (businesses, public authorities, academics, etc.) in each industrial sector to a joint understanding of what the ideal future scenario in the specific industrial sector should be. It refers to a clear and inspirational description of the future state that an industry aims to achieve. The vision formulates a hypothetical objective or, generally speaking, an idea of how the future is imagined.

To provide such a frame for discussion, the project partners discussed ideas for sectoral visions with external experts. Based on the input of the experts, the following vision was elaborated for the packaging sector:

"To help SMEs redesign their processes and/or products with the aim of positive social, economic, and environmental impact."

7. Roadmap structure – topics, levels, time scale

Based on the findings from the workshops, we have designed a roadmap outlining short-term, mid-term, and long-term activities for SMEs in the paper and plastics packaging industries to transform their businesses towards a more circular approach. The roadmaps are structured into three layers summarizing activities in:

- Technologies (Raw materials, processing)
- Business Model approaches
- Legal and Political Framework & General Aspects

The roadmap assumes a time scope of ten years, divided into three segments:

- Short-term: 1-2 years (2024-2025)
- Mid-term: 3-5 years (2026-2028)
- Long-term: 6-10 years (2029-2033)

8. Transformation Roadmap(s) Packaging

TRANSFORMATION ROADMAP FOR PAPER PACKAGING

Technology

Short-term (2024-2025):

1. Material Assessment and Optimization:

- Assess the materials used in packaging production.
- Identify optimization opportunities like reducing material usage, increasing recyclability, or incorporating recycled content.
- Develop cost-effective bleaching methods to reduce production costs.

2. Supplier Engagement and Collaboration:

- Engage with suppliers for sustainable raw materials and closed-loop systems.
- Collaborate on material recycling or take-back programs.
- Establish partnerships for alternative sources of cellulose, recycled paper, and composite materials.

3. Improvement of Deinking and Impurity Removal Technologies:

- Enhance technologies for ink removal and contamination reduction to improve the quality of recycled materials.

Mid-term (2026-2028):

1. Closed-Loop Systems Implementation:

- Establish closed-loop systems for packaging materials.
- Collaborate with stakeholders to implement these systems.
- Improve sorting and material identification methods to streamline recycling processes.

2. Investment in Recycling Infrastructure:

- Invest in or partner with recycling facilities.
- Explore innovative recycling technologies like chemical recycling.
- Develop energy-efficient production processes to mitigate environmental impact.

Long-term (2029-2033):

1. Circular Design Integration:

- Integrate circular design principles into product development.
- Collaborate with design experts and research institutions.
- Develop biodegradable and compostable packaging alternatives.

Business Model Approaches:

Short-term (2024-2025)

1. Employee Training and Awareness:

- Provide training on circular economy principles and sustainable packaging.
- Foster a culture of sustainability within the organization.
- Promote customer awareness about the benefits of recycled paper.

2. Product Redesign for Recyclability:

- Evaluate and redesign packaging for recyclability.
- Encourage local sourcing to reduce transport costs and environmental impact.

Mid-term (2026-2028):

1. Consumer Education and Engagement:

- Launch education campaigns on recycling and proper disposal.
- Implement labeling initiatives for recyclable packaging.
- Promote transparency and traceability in the supply chain.

2. Circular Economy Business Models:

- Establish circular business models that incorporate recycling and reuse.
- Promote best practices in materials and resources design for circularity.

Long-term (2029-2033):

1. Extended Producer Responsibility (EPR) Implementation:

- Advocate for EPR programs to shift waste management responsibility to producers.
- Participate in EPR schemes and invest in collection and recycling infrastructure.
- Foster industry-wide collaboration for circularity.

Legal and Political Framework

Short-term (2024-2025):

1. Compliance with Certifications and Standards:

- Obtain certifications for sustainable packaging like FSC for paper products.
- Develop clear sustainability guidelines and harmonize regulations across markets.

2. Development of Recycling Regulations:

- Work towards comprehensive waste management regulations.
- Introduce financial incentives for sustainable practices.

Mid-term (2026-2028):

1. Standardization of Compliance Requirements:

- Collaborate with regulatory bodies to clarify compliance requirements.
- Develop and disseminate clear and actionable sustainability guidelines.

Long-term (2029-2033):

1. Industry Collaboration and Advocacy:

- Collaborate with industry associations and government agencies for policy reforms.
- Share best practices to drive collective action towards circularity.
- Establish clear and measurable sustainability targets to guide industry practices.

TRANSFORMATION ROADMAP FOR PLASTICS PACKAGING

Technology

Short-term (2024-2025):

1. Material Assessment and Optimization:

- 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.

2. Development of Deinking and Impurity Removal Technologies:

- Improve technologies for ink removal and contamination reduction in recycling.
- Address contamination and material mixture challenges to enhance recycling efficiency.

Mid-term (2026-2028):

1. Implementation of Advanced Recycling Technologies:

- Invest in advanced recycling technologies like chemical recycling to enhance material recovery.
- Develop better sorting and identification technologies to streamline recycling processes.

2. Enhancement of Production Processes:

- Improve efficiency in production processes to reduce energy consumption.
- Invest in R&D for biodegradable plastics and other sustainable materials.

Long-term (2029-2033):

1. Development of Biodegradable and Compostable Plastics:

- 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.

Business Model Approaches

Short-term (2024-2025):

1. Consumer Awareness and Education:

- Launch campaigns to educate consumers on sustainable packaging options.
- Promote the benefits of recycled and recyclable plastics.
- Establish partnerships for material recycling.

2. Supplier Collaboration:

- Engage with suppliers to source sustainable plastic materials and develop closed-loop systems.
- Promote best practices for sourcing and material usage.

Mid-term (2026-2028):

1. Circular Economy Business Models:

- Develop business models that incorporate recycling and reuse of plastic packaging.
- Implement innovative pilot projects to test and refine new sustainable packaging solutions.

2. Consumer Engagement and Transparency:

- Educate consumers on proper disposal and recycling.
- Foster collaboration across the value chain to promote transparency and traceability.

Long-term (2029-2033):

1. Extended Producer Responsibility (EPR) Implementation:

- 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.

Legal and Political Framework

Short-term (2024-2025):

1. Compliance with Certifications and Standards:

- Obtain certifications for sustainable plastics packaging.
- Develop clear sustainability guidelines and harmonize regulations to support recycling initiatives.

Mid-term (2026-2028):

1. Development of Recycling Regulations:

- Work towards comprehensive regulations for plastic recycling.
- Introduce financial incentives for sustainable practices.

Long-term (2029-2033):

1. Policy Advocacy and Industry Collaboration:

- 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.

These roadmaps provide a structured and detailed plan to guide the paper and plastics packaging sectors towards a more sustainable and circular economy by focusing on key technological advancements, business model innovations, and regulatory frameworks. For easier understanding, we have placed the goals of the roadmaps into a table according to their timeline.

Transformation Roadmap for Paper Packaging

Time Frame	Technology	Business Model Approaches	Legal and Political Framework
Short-term (2024-2025)	<p>Material Assessment and Optimization:</p> <ul style="list-style-type: none"> - Assess the materials used in packaging production. - Identify optimization opportunities like reducing material usage, increasing recyclability, or incorporating recycled content. - Develop cost-effective bleaching methods to reduce production costs. <p>Supplier Engagement and Collaboration:</p> <ul style="list-style-type: none"> - Engage with suppliers for sustainable raw materials and closed-loop systems. - Collaborate on material recycling or take-back programs. - Establish partnerships for alternative sources of cellulose, recycled paper, and composite materials. 	<p>Employee Training and Awareness:</p> <ul style="list-style-type: none"> - Provide training on circular economy principles and sustainable packaging. - Foster a culture of sustainability within the organization. - Promote customer awareness about the benefits of recycled paper. <p>Product Redesign for Recyclability:</p> <ul style="list-style-type: none"> - Evaluate and redesign packaging for recyclability. - Encourage local sourcing to reduce transport costs and environmental impact. 	<p>Compliance with Certifications and Standards:</p> <ul style="list-style-type: none"> - Obtain certifications for sustainable packaging like FSC for paper products. - Develop clear sustainability guidelines and harmonize regulations across markets. <p>Development of Recycling Regulations:</p> <ul style="list-style-type: none"> - Work towards comprehensive waste management regulations. - Introduce financial incentives for sustainable practices.
Mid-term (2026-2028)	<p>Closed-Loop Systems Implementation:</p> <ul style="list-style-type: none"> - Establish closed-loop systems for packaging materials. - Collaborate with stakeholders to implement these systems. - Improve sorting and material identification methods to streamline recycling 	<p>Consumer Education and Engagement:</p> <ul style="list-style-type: none"> - Launch education campaigns on recycling and proper disposal. - Implement labeling initiatives for recyclable packaging. - Promote transparency and traceability in the supply chain. 	<p>Standardization of Compliance Requirements:</p> <ul style="list-style-type: none"> - Collaborate with regulatory bodies to clarify compliance requirements. - Develop and disseminate clear and actionable sustainability guidelines.

	<p>processes.</p> <p>Investment in Recycling Infrastructure:</p> <ul style="list-style-type: none"> - Invest in or partner with recycling facilities. - Explore innovative recycling technologies like chemical recycling. - Develop energy-efficient production processes to mitigate environmental impact. 	<p>Circular Economy Business Models:</p> <ul style="list-style-type: none"> - Establish circular business models that incorporate recycling and reuse. - Promote best practices in materials and resources design for circularity. 	
Long-term (2029-2033)	<p>Circular Design Integration:</p> <ul style="list-style-type: none"> - Integrate circular design principles into product development. - Collaborate with design experts and research institutions. - Develop biodegradable and compostable packaging alternatives. 	<p>Extended Producer Responsibility (EPR) Implementation:</p> <ul style="list-style-type: none"> - Advocate for EPR programs to shift waste management responsibility to producers. - Participate in EPR schemes and invest in collection and recycling infrastructure. - Foster industry-wide collaboration for circularity. 	<p>Industry Collaboration and Advocacy:</p> <ul style="list-style-type: none"> - Collaborate with industry associations and government agencies for policy reforms. - Share best practices to drive collective action towards circularity. - Establish clear and measurable sustainability targets to guide industry practices.

Transformation Roadmap for Plastics Packaging

Time Frame	Technology	Business Model Approaches	Legal and Political Framework
Short-term (2024-2025)	<p>Material Assessment and Optimization:</p> <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. <p>Development of Deinking and Impurity Removal Technologies:</p> <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. 	<p>Consumer Awareness and Education:</p> <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. <p>Supplier Collaboration:</p> <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. 	<p>Compliance with Certifications and Standards:</p> <ul style="list-style-type: none"> - Obtain certifications for sustainable plastics packaging. - Develop clear sustainability guidelines and harmonize regulations to support recycling initiatives.
Mid-term (2026-2028)	<p>Implementation of Advanced Recycling Technologies:</p> <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. 	<p>Circular Economy Business Models:</p> <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. <p>Consumer Engagement and</p>	<p>Development of Recycling Regulations:</p> <ul style="list-style-type: none"> - Work towards comprehensive regulations for plastic recycling. - Introduce financial incentives for sustainable practices.

	Enhancement of Production Processes: - Improve efficiency in production processes to reduce energy consumption. - Invest in R&D for biodegradable plastics and other sustainable materials.	Transparency: - Educate consumers on proper disposal and recycling. - Foster collaboration across the value chain to promote transparency and traceability.	
Long-term (2029-2033)	Development of Biodegradable and Compostable Plastics: - 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.	Extended Producer Responsibility (EPR) Implementation: - 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.	Policy Advocacy and Industry Collaboration: - 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.

9. Conclusion and Next Steps

The transformation roadmap for the packaging sector aims to provide a clear and actionable framework to guide SMEs towards a more sustainable and circular economy. The workshops highlighted that while technologies for a circular economy are sufficiently developed, the main challenges lie in finding the right partners and accessing necessary raw materials and services. The participating SMEs expressed optimism about circular business models, provided that a clear and reliable legal framework is established. Overcoming cost disadvantages of bio-based and recycled products compared to fossil-based ones remains a significant challenge. Furthermore, addressing the lack of knowledge and differing waste and recycling regulations across EU countries is crucial.

Future Actions for Cradle-ALP Consortium Partners

To support SMEs in the packaging sector, the Cradle-ALP consortium partners should focus on the following actions during the planned pilot phases (May 2024 to April 2025):

- Identifying and Connecting Partners: Help SMEs find and connect with the right business and technology partners to foster collaboration and innovation.
- Circular Business Model Ideation: Provide best practice examples and facilitate the ideation process for developing circular business models.
- Business Analysis for Transformation: Assist SMEs in analyzing their current business practices to start the transformation process towards circular models.
- Knowledge Acquisition: Provide SMEs with detailed information and support regarding national and regional circular economy legislation.

The transformation roadmap serves as a foundational tool to raise awareness among SMEs about the need to rethink their manufacturing processes and business models. It also aims to offer targeted support through the Cradle-ALP partner network, helping SMEs identify the right technology or business partners within the Alpine region. By addressing these challenges and leveraging the outlined solutions, the packaging sector can move towards a more sustainable and circular future.

10. Annex

All images seen in this document were either created by the authors or taken by the authors during the various workshops conducted. Therefore, all copyrights are owned by the authors.

The content of chapter 5 partially builds on information that can be found here:

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Packaging_waste_statistics#Waste_generation_by_packaging_material