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CURIOST ACTION PLAN

DELIVERABLE 3.3.2

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Circular design and development of Sustainable products in 4 key sectors in Central Europe

Version 1

May 2026



CURIOST ACTION PLAN

Deliverable 3.3.2.

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1. EXECUTIVE SUMMARY CURIOST ACTION PLAN

The CURIOST Action Plan (CAP) provides a comprehensive and structured framework to accelerate the transition towards circular economy and sustainable product development across Central and Eastern Europe (CEE). Building on the integration of European policy objectives, national and regional Smart Specialisation Strategies, and the specific needs of SMEs and small mid-caps, the CAP translates analytical findings into a coherent set of actionable measures. Its primary objective is to strengthen innovation capacity, resource efficiency and long-term competitiveness in four key manufacturing sectors of strategic importance for the participating regions, namely mechanics and mechatronics, plastics, packaging, and construction and building.

At its core, the Action Plan follows a multi-level governance approach that combines transnational coordination with regionally tailored implementation pathways. The proposed actions are designed to be implemented collaboratively by a wide range of actors, including regional and national public authorities, innovation agencies, clusters, research institutions, and business support organisations, in close cooperation with SMEs and industrial stakeholders. This multi-actor approach ensures that the measures respond both to policy objectives and to practical business needs, thereby bridging the gap between regulatory frameworks and industrial application.

The CAP is structured around a set of interrelated action areas that address the key challenges identified across partner regions. These include strengthening capacities and skills related to circular product design, fostering innovation and research activities, supporting the adoption of digital technologies, enhancing cooperation platforms and knowledge exchange, as well as improving framework conditions such as regulatory clarity and access to finance. In line with the SMART principle, all proposed measures are formulated as specific, measurable, achievable, relevant and time-bound interventions, ensuring a high level of practical applicability and impact orientation.

Implementation is envisaged along a phased timeline that reflects both the urgency of action and the need for long-term structural change. In the short term, the focus lies on awareness raising, knowledge transfer, and the initiation of pilot activities that demonstrate the feasibility of circular approaches. In the medium term, successful pilot initiatives are expected to be scaled up and integrated into broader innovation ecosystems, supported by strengthened cooperation networks and expanded funding opportunities. In the long term, the CAP aims to contribute to a systemic transformation of industrial practices in line with European climate and circular economy objectives, thereby embedding circular principles into mainstream product development and value creation processes.

The financial framework underpinning the Action Plan is based on a combination of European, national, regional and private funding sources. In particular, the European Regional Development Fund and Interreg programmes play a key role in supporting implementation, complemented by national funding schemes, institutional own resources and private sector co-financing. The level of required investment varies depending on the scale and complexity of the individual actions,

ranging from small-scale activities such as training measures and knowledge transfer formats to larger innovation and pilot projects requiring more substantial financial resources. This diversified funding approach is designed to leverage public support as a catalyst for additional investments and to ensure the scalability and long-term sustainability of the proposed measures.

Through its integrated and multi-level design, the CURIOST Action Plan is expected to generate significant impacts across the participating regions. It will contribute to strengthening regional innovation ecosystems, increasing the uptake of circular product design principles, improving resource efficiency and reducing waste generation. At the same time, it enhances the competitiveness and resilience of SMEs and small mid-caps in CEE by enabling them to adapt to evolving regulatory requirements and market conditions. By anchoring its recommendations in existing policy and funding frameworks, the CAP ensures that its effects extend beyond the project duration and support a lasting transformation towards sustainable industrial development in Central and Eastern Europe.

This executive summary provides an aggregated overview of the main objectives, implementation logic and expected impacts of the CURIOST Action Plan. Detailed information on specific actions, including the definition of activities, responsible institutions, implementation timeframes as well as estimated costs and funding sources, is presented in the country-specific “concrete actions” tables within the respective national chapters. These tables provide the operational backbone of the Action Plan and enable a differentiated and context-sensitive understanding of the proposed measures across the partner regions.

2. CIRCULAR ECONOMY AND PRODUCT DESIGN IN CENTRAL & EASTERN EUROPE

In a global environment where geopolitical upheavals, ongoing conflicts, economic fragility, social tensions and the need to balance competitiveness with ecological transformation are simultaneously shaping political agendas, it is clear how quickly and in how many ways pressing crises can distract attention from long-term priorities (1). This is why the present CURIOST Action Plan emphasises the importance of a clearly focused, practice-oriented approach: by adhering to circular strategies and targeted political measures, sustainable competitiveness and resilient structural change can be achieved in the economic area of Central and Eastern Europe (CEE).

The CURIOST Action Plan takes up this constellation and transfers it to the industrial reality in CEE: it combines current EU policy frameworks, national and regional (Smart Specialisation) strategies and the needs of SMEs into a targeted package of measures that strengthens sustainable product development in key industries and provides guidance to political decision-makers. Precisely because numerous urgent issues — from conflicts and supply chain risks to climate change — overlap the political and economic sphere of action, the present Action Plan creates a clear, structured basis for remaining capable of action despite this complexity and for systematically driving forward long-term transformation.

Achieving a fundamental sustainability transformation — one that becomes a real competitive advantage — requires a comprehensive rethinking of all relevant aspects of the manufacturing process. Circular economy offers a powerful response by shifting away from the traditional linear model of “take-make-waste” and instead promoting resource efficiency and closed material loops. By designing products for durability, reuse, and recycling, and by enabling smarter value chains, circular economy principles help reduce environmental pressure while increasing industrial resilience and competitiveness. In this way, circularity is not only an ecological necessity but also a strategic solution to strengthen single enterprises, sectors and whole economies and support long-term societal well-being.

Still, manufacturing companies — particularly SMEs and small mid-caps — face significant challenges in transforming product development processes, business models and value chains. At the same time, these companies represent a key lever for achieving the objectives of the European Green Deal and the Clean Industrial Deal and for strengthening regional competitiveness and innovation capacity. Identified improvement options and innovative approaches need to prove their technical and economic feasibility to justify the risk of changing the existing well-established traditional processes in production. This might be one of the main reasons why innovation in product design and changes in the basic product development procedures are so difficult to introduce and implement in manufacturing companies, especially in SMEs and small midcaps. The initial stage in the product lifecycle is considered the most sensible and untouchable one and is therefore often overlooked. However, enhancing the sustainability focus on this early stage can have an enormous impact on all subsequent stages of manufacturing and usage in terms of economic AND ecological sustainability which can be proven by means of business case analysis.

Moreover, innovation in the field of sustainable product development opens pathways to increasing the corporate sustainability for companies of different sizes, starting from SMEs up to midcaps, and in different sectors of production.

Therefore, the CURIOST project aims to enable SMEs and small mid-caps to exploit their potential in innovative sustainable product development and to benefit from matching circular business cases in four manufacturing sectors of high relevance for the participating regions:

- mechanics and mechatronics,
- packaging,
- plastics,
- and construction and building.

The CURIOST Action Plan (CAP) serves as a key instrument for ensuring the sustainable transfer and long-term uptake of project results at regional, national and transnational policy levels. It is designed to support policymakers and innovation ecosystems in fostering the transition towards sustainable and circular product development among SMEs and small mid-caps across Central and Eastern Europe.

2.1. Specific Framework Conditions and Challenges in Central and Eastern Europe

Central and Eastern Europe represents a highly diverse yet strategically important macro-region within the European Union. The CURIOST project area includes countries with long-established industrial bases and strong innovation ecosystems, such as Austria, Germany, Poland and Italy alongside countries whose economic performance and innovation indicators remain below the EU average (2). This heterogeneity is one of the defining characteristics of CEE and has significant implications for the design and implementation of policy measures supporting sustainable product development and the circular economy.

In several CEE countries, SMEs and small mid-caps operate in more challenging conditions compared to their counterparts in Western Europe. While manufacturing remains a backbone of regional economies, many companies face limited access to financial resources, weaker innovation support and infrastructure. Public support schemes for innovation and sustainability are often fragmented, underfunded or insufficiently aligned with the specific needs of SMEs, particularly in relation to circular product design and new business models.

Moreover, disparities in administrative capacity and policy implementation persist across the region. Although EU-level strategies and regulatory frameworks provide a common direction, their translation into effective national and regional measures varies considerably. In some CEE regions, circular economy policies are still evolving and lack concrete operational instruments, clear prioritisation or connections to business needs. This creates uncertainty for companies, limits awareness and reduces the uptake of support instruments, eventually hindering sustainable innovation practices.

Financial constraints represent another critical challenge. SMEs and small mid-caps often face high capital costs, limited access to financing and reduced capacity to invest in long-term innovation projects. Investments in sustainable and circular product development, which may require upfront costs, new competencies and changes in established processes, are therefore perceived as particularly risky. Without targeted policy support and tailored financial instruments, these companies may struggle to engage in the green transition at the required scale and speed.

At the same time, Central and Eastern Europe offers significant opportunities. The region hosts a strong manufacturing base, skilled workforce and high potential for upgrading value chains through innovation and sustainability. Many SMEs are deeply embedded in regional ecosystems and global supply chains, making them important multipliers for change. Leveraging these strengths requires coordinated action across different policy levels and policy fields, as well as transnational learning and exchange of best practices.

The present CURIOST Action Plan addresses these specific framework conditions. By combining transnational cooperation with region-specific action proposals, it supports convergence within CEE while respecting regional diversity. The inclusion of regional chapters allows for tailored responses to differing levels of economic development, institutional capacity and support structures. At the same time, the CURIOST Action Plan promotes mutual learning and fosters cohesion and balanced development within the CEE area.

In this context, the CURIOST Action Plan is not only a tool for promoting sustainable product development but also a strategic contribution to reducing regional disparities, strengthening innovation ecosystems and enhancing the resilience and competitiveness of SMEs and small mid-caps across Central and Eastern Europe.

2.2. the CURIOST project

The CURIOST project is funded by the INTERREG Central Europe Programme and is built on the understanding that circular economy is a critical enabler for innovative, resilient and sustainable industrial development. The geographical scope of the Action Plan is Central and Eastern European countries: Austria, Croatia, Germany, Hungary, Italy, Poland and Slovakia. The corresponding project partners are listed in Table 1.

Table 1: The CURIOST Consortium

Partner Number	Name of the organisation in English	Country (NUTS 0)
1	Business Upper Austria	Austria (AT)
2	ConPlusUltra FlexCo	Austria (AT)
3	Development and Training Centre for the Metal Industry – Metal Centre Čakovec	Croatia (HR)

4	STEP RI science and technology park of the University of Rijeka Ltd.	Croatia (HR)
5	Bayern Innovativ	Germany (DE)
6	Cluster of Environmental Technologies Bavaria	Germany (DE)
7	Chamber of Commerce and Industry of Pécs- Baranya	Hungary (HU)
8	MESAP Innovation Cluster	Italy (IT)
9	Science and Technology Park - Envipark	Italy (IT)
10	South Poland Cleantech Cluster Ltd.	Poland (PL)
11	University of Economics in Bratislava	Slovakia (SK)

The CURIOST project addresses a project region within CEE in which some of the partners, e.g. from Austria, Germany and Italy, already bring in some experience regarding the introduction of circular approaches in their company networks, while some other partners can be considered as the most ambitious support institutions from less advanced CEE countries, like Croatia, Hungary, Poland and Slovakia, that are just at the beginning of taking up the circularity paradigm.

By combining practical, company-level innovation activities with structured policy development, the CURIOST project followed a two-fold approach: first, developing and testing a comprehensive strategy with at least 140 SMEs and small mid-caps, and second, transforming this strategy into a jointly developed and policy-relevant Action Plan to be adopted and implemented by decision-makers to serve local businesses. Its main goal is to initiate the change in all sectors of the partner regions in CEE, which will eventually result in creating an universal solution of matching business cases, that has the potential of accelerating the green transition in the CEE economy.

The CURIOST Action Plan – development and structure

The present CURIOST Action Plan is the main strategic project output (O.3.1) addressing regional, national and transnational policy levels. Its development has been embedded in a transnational co-creation process involving project partners, associated partners and key RIS3 stakeholders. Through targeted “Policy meets Business” workshops (A.3.4) and structured peer-review processes with the project partners (A.3.3), the CURIOST Action Plan bridges the gap between business needs and policy frameworks, ensuring that recommended measures are both strategically aligned and practically applicable. At the transnational level, the CAP also serves as a briefing and decision-making basis for discussions on circular economy and sustainable product development in CEE and beyond, contributing to EU-level policy debates.

The CURIOST Action Plan is an evidence-based policy tool designed to turn analysis into targeted action. Its overall architecture is grounded in a transnational aggregation of strategic frameworks addressing the CEE project area, combining the analysis of Smart Specialisation Strategies at national and regional levels (derived from D3.1.1) with an assessment of the latest EU-level legal

and policy framework relevant to circular economy and sustainable product development (D3.1.2). Building on this strategic foundation, the CAP is organised into a common transnational framework complemented by dedicated regional chapters. These regional chapters are informed by a systematic evaluation of regional needs and guidance for action planning (D3.3.1) and reflect both territorial and sector-specific particularities across the four targeted manufacturing sectors. Concrete, implementable measures are consolidated in concrete actions chapters, which translate strategic priorities into operational recommendations for policymakers and governance institutions. In line with Interreg requirements, all proposed actions follow the SMART principle and are designed to be specific, measurable, achievable, relevant and time bound (see Figure 2). Additionally, each chapter is summarized in a graphic, whose country-specific keywords translate the aggregated SWOT results of D3.1.1 into concise, action-oriented messages. This aims to reflect both national framework conditions and the strategic response of the CURIOST Action Plan.

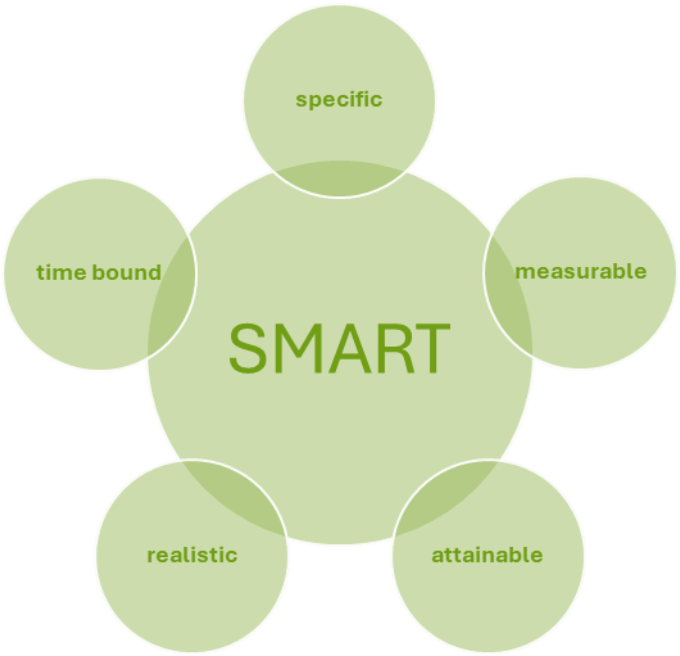


Figure 1: the SMART principle (3)

Through this structured approach, the CAP connects EU and national policy objectives with regional implementation realities, ensuring a clarity of purpose, consistency across partner regions and practical relevance for supporting SMEs and small mid-caps throughout CEE.

Overall, the CURIOST Action Plan, together with the project's methodology and the established network of public and private stakeholders, forms a comprehensive package of instruments to accelerate the uptake of sustainable and circular product development in CEE. By anchoring project results in policies, RIS3 strategies and future regional innovation support instruments, the CAP ensures impact well beyond the project lifetime.

3. EU REGULATORY AND STRATEGIC FRAMEWORK

The strategic framework of the CAP is underpinned by selected EU policies and regulations that are binding and applicable across all EU member states. The project partners selected certain directives and strategies most relevant in the context of the CURIOST project in CEE.

Key horizontal initiatives include e.g. the New Circular Economy Action Plan, which sets the overarching policy direction for resource efficiency, circularity and sustainable product design. This is complemented by regulatory proposals such as the Eco-design for Sustainable Products Regulation and the European Strategy for Plastics in a Circular Economy, which establish concrete requirements and incentives for improving product sustainability and circular performance. In addition, sector-specific regulatory frameworks — such as the proposed regulations on construction products, packaging and packaging waste, and machinery — define harmonised conditions for market access and place increasing obligations on manufacturers. Together, these instruments form the common regulatory baseline for the CURIOST Action Plan and provide the reference framework for aligning regional policy measures with EU-level ambitions.

3.1. Regulations

In recent years, the European Union has taken significant strides in shaping corporate sustainability, environmental protection, and product safety through a series of directives and regulations. This chapter provides an analysis of European regulations that are important for the four sectors the CURIOST project is referred to. As some of the regulations have only recently come into force and many member states are still in the transition phase towards implementation, this framework serves foremost as an overview of the relevant policies within the CURIOST project. Since a great majority of companies across the entire European Union are SMEs and small midcaps, these obligations are highly relevant for them to accordingly adjust their business models.

The CURIOST consortium found the following regulations as the most relevant for the project scope, which are analysed in more detail in the following chapters, as well as the country wise implementation:

- Directive on the reduction of the impact of certain plastic products on the environment (Single Use of Plastics Directive) (4)
- Eco-Design for sustainable product regulation (5)
- Regulation for laying down harmonized conditions for the marketing of construction products (the Construction Products Regulation or CPR) (6)
- Regulation on packaging and packaging waste (7)
- Regulation on machinery (8)

The subsequent regulations are also pertinent to some extent to the project context. However, at the time of developing the CURIOST Action Plan, they had either not yet been determined by the European legislator or been implemented in all member states. Consequently, due to

regulatory uncertainty and/or limited relevance, these regulations have only been further examined in those country chapters, where the regulations have already been implemented to some extent, apart from the short examination here:

- The Corporate Sustainability Reporting Directive (CSRD) (9)
- The Corporate Sustainability Due Diligence Directive (CSDDD) (10)
- Directive on common rules on promoting the repair of goods (11)
- Energy performance of buildings (12)
- Circular Economy Act (13)

Although there are support mechanisms in place for some of these legislations, notable differences remain among the member states. For the **CSDDD** and **CSRD**, certain member states have already translated them into national legislation and developed instruments of support for enterprises. For example, Austria and Italy have developed digital tools while national frameworks and legislation are prepared to support companies in sectors with complex supply chains (mechatronics or plastics). The goal is to make the process easier with internal controls, stringent reporting and to assess the sustainability performance of companies more effectively. For example, Hungary does not have a national equivalent of the CSRD which means companies should follow EU directives. Unfortunately, that can cause difficulties for domestic companies and compliance procedures due to a lack of clear guidance. Such examples of already developed instruments could be used as a role model for countries that are still adapting and developing processes for implementing the legislation. Parallel, due to the CSRD's regulatory insecurities, the VSME standard is gaining more attention for SMEs and small midcaps.

The same applies for the **Directive Common rules on promoting the repair of goods**. Austria and parts of Germany have established support systems, while other member states are set to implement policies requiring governments to support repairs via vouchers or repair spaces.

The **Energy Performance of Buildings Directive** is significant to the construction industry, particularly regarding the integration of recycled materials into building processes. While Poland or Austria have already started a renovation wave, developing one stop shops for the energy performance of buildings, other countries are trying to find a right path to implement the directive into national legislation. The success of implementation depends on the country specific context, such as the level of development of the construction sector, infrastructural circumstances concerning new construction or renovation, skilled work force and external factors such as earthquakes in Croatia, which produced issues of construction waste management.

It should also be noted that the **Circular Economy Act** — currently being developed by the European Commission — will become highly relevant to the topics addressed by the CURIOST project once it is enacted. As the Act is still in progress at the time of writing, further details are not provided here.

To conclude, in the observed area of CEE, we can see many differences in the project partner's countries regarding the level of development of certain sectors or following and implementing EU

regulations. It is important to note that there is a foundation for cooperation, role modelling and uptake of good practices among partner countries and beyond.

3.1.1. Directive EU 2019/904 on the reduction of the impact of certain plastic products on the environment (Single Use Plastics Directive)

The Single Use Plastics Directive has been in force since July 2nd, 2019, and has since been incorporated by several member states into national law. The directive aims to reduce environmental and health impacts caused by single use plastics and to support the transition to a circular economy across the EU. It also seeks to ensure smooth functioning of the EU market by harmonizing rules for plastic products.

Some of the key measures introduced are:

- Reduction of consumption for specific single-use plastic items.
- Restrictions on placing certain products on the market, including bans.
- Product requirements, such as design standards or material specifications.
- Mandatory labelling for products containing plastic.
- Extended producer responsibility, covering waste management and cleanup costs.
- Separate collection systems to improve recycling rates.
- Awareness-raising measures for consumers.

The directive applies to Single-use plastic products listed in its annex, oxo-degradable plastics, which break down into microplastics and fishing and aquaculture gear containing plastic. There is no minimum plastic content threshold. Even products with a thin plastic coating, such as paper cups with plastic lining, fall under the directive. The Directive is highly relevant to the CURIOST project, as it is directly related to two of the examined sectors, plastics and packaging.

3.1.2. Eco-design for sustainable product Regulation

The **Eco-design for sustainable products Regulation** (5) is particularly important in the context of the CURIOST project and the topic of sustainable product development. The regulation aims to establish comprehensive requirements for new Eco-design standards to enhance (R-)principles of circular economic practices: product durability, reliability, repairability, upgradability, reusability, recyclability, and refurbishment. It should also address the presence of hazardous chemicals in products, promote energy and resource efficiency, minimize waste generation, and increase the use of recycled content in products, all while maintaining high standards of performance and safety. Furthermore, Eco-design requirements should proactively target practices that contribute to premature obsolescence.



Figure 2: Digital Product Passport (109)

This regulation is supposed to enable the establishment of repairability or durability scores for products where such scores are deemed appropriate for the purpose of providing environmental benefits and clearer information for consumers. The regulation requires the issuing of a **Digital Product Passport** (Figure 2) which will be a valuable tool for making information available to all actors along the value chain. To that end, it is important that the digital product passport be user-friendly, and that the data contained therein be accurate, complete, and up to date. The digital product passport should, where necessary, be complemented by non-digital forms of transmitting information. Manufacturers of products will be responsible for following standards set by this regulation and regarding information and descriptions that enter the digital product passport. In the context of the Eco-design regulation relevant provisions are establishing user-friendly websites where access to data included in digital product passport will be available. In further stages, the CE marking should indicate the product´s conformity with the regulation, which should be applied to all products on the internal market. Green procurement gets more attention through implementing this regulation. Most importantly, improvements will be visible for consumers and manufacturers, since it should be ensured that products do not become prematurely obsolete, that spare parts and information on repair are available for all products, as well as software and operating systems updates.

3.1.3. Regulation on packaging and packaging waste

Packaging is one of the main users of virgin materials (40% of plastics and 50% of paper used in the EU is destined for packaging) and accounts for 36 % of municipal solid waste. Data from Eurostat and market data reports show increased use of packaging design characteristics that may inhibit recycling. Packaging is 'unrecyclable' when it is not or cannot be collected separately, while it poses challenges for state-of-the-art sorting and recycling processes in the EU (14).

The **Regulation on packaging and packaging waste** (7) complements the Regulation on Ecodesign for Sustainable Products to establish additional or more detailed requirements for packaging, particularly in relation to packaging minimisation when the design or re-design of products can lead to environmentally less impactful packaging. The Regulation should apply to all packaging placed on the market in the European Union and to all packaging waste, regardless of the type of packaging or the material used. Packaging should be designed, manufactured and commercialised in such a way as to allow for its reuse or high-quality recycling, and to minimise its impact on the environment during its entire life cycle and the life cycle of products, for which it was designed.

In relation to the different packaging materials, the lowest input of recycled materials is in plastic packaging. To address these concerns in the most appropriate manner, it is necessary to increase the uptake of recycled plastics, by establishing mandatory targets for recycled content in plastic packaging at different levels depending on the contact sensitivity of different plastic packaging applications and ensuring that the targets become binding by 2030. Waste prevention is the most efficient way to improve resource efficiency and to reduce the environmental impact of waste. It is therefore important that economic operators take appropriate measures to reduce the waste generation by eliminating excessive packaging and restrict the use of certain packaging formats, extending the life span of packaging, re-designing products so that no packaging or less packaging can be used, including bulk sales, and by shifting from single use packaging to reusable packaging. Producers should be able to exercise those obligations collectively, by means of producer responsibility organisations taking up the responsibility on their behalf. Economic operators who put non-compliant packaging on the market or who do not comply with their obligations should be subject to penalties to increase public trust in packaging placed on the market. It is therefore necessary that member states lay down effective, proportionate and dissuasive penalties in national law for failure in order to comply with this regulation.

Thanks to this regulation the measures cover the full life cycle of packaging, environmental sustainability and labelling, to allow its placing on the market, as well as for the extended producer responsibility, collection, treatment and recycling of packaging waste. This regulation contributes to the efficient functioning of the internal market by harmonising national measures on packaging and packaging waste in order to avoid obstacles to trade, distortion and restriction of competition within the Union, while preventing or reducing the adverse impacts of packaging and packaging waste on the environment and human health, on the basis of a high level of environmental protection. The Regulation does not affect just manufacturers and industry stakeholders, but also consumers and their habits.

3.1.4. Regulation for laying down harmonized conditions for the marketing of construction products (the Construction Products Regulation or CPR)

The **Construction Products Regulation** (6) ensures the smooth functioning of the single market and the free movement of construction products in the EU. It does so through harmonised technical specifications, which provide a common technical language on how to test and communicate the

performance of construction products (e.g. reaction to fire, thermal conductivity or sound insulation).

The two general objectives of the Construction Products Regulation revision are to:

- achieve a well-functioning single market for construction products and to
- contribute to the objectives of the green and digital transition, particularly the modern, resource-efficient and competitive economy.

The Regulation should develop and apply assessment methods for calculation of the environmental sustainability of construction products. Important in the context of the CURIOST project is the provision of 3D printing datasets, where 3D printing of construction products should have a safety level like one ensured for ordinary construction products. These objectives can be better achieved at Union level by establishing a harmonised assessment framework for the performance of construction products and certain product requirements for the protection of human health and safety and of the environment.

3.1.5. Regulation on machinery

The **Regulation (EU) 2023/1230 on machinery** (8) represents a significant step forward in machinery safety regulations within the European Union. This new regulation, set to replace the existing Machinery Directive 2006/42/EC by January 20, 2027, introduces a comprehensive framework designed to enhance safety standards, streamline compliance processes, and foster innovation in the machinery industry. One of the key changes brought about by the new regulation is the expansion of its scope. It now covers a wider range of machinery products, including those not previously considered by the Machinery Directive. This expanded scope aims to address emerging technologies and to ensure that all machinery placed on the EU market meets high safety standards. The new regulation also introduces a more stringent risk assessment process for manufacturers. This process requires a detailed evaluation of potential hazards associated with machinery, leading to the implementation of effective risk mitigation measures. Additionally, the regulation mandates the creation of comprehensive technical documentation, which serves as a valuable reference for both manufacturers and users. Conformity assessment procedures have been streamlined under the new regulation. Manufacturers will be required to demonstrate compliance with essential health and safety requirements through various means, including self-declaration, third-party conformity assessment, or a combination of both. This approach aims to reduce administrative burdens while ensuring that only safe machinery reaches the market. Market surveillance activities have also been strengthened under the new regulation. Competent authorities will be empowered to conduct more rigorous checks on machinery products to verify compliance with safety standards. This increased oversight will help to identify and address potential safety issues, ensuring that non-compliant machinery is removed from the market. For businesses operating within the EU, the new regulation presents both challenges and opportunities. While it imposes stricter requirements, it also provides a clear and harmonized regulatory framework that can facilitate international trade. Manufacturers, importers, and

distributors will need to adapt their processes to comply with the new rules, but this investment in safety and compliance can also lead to long-term benefits.

In conclusion, Regulation (EU) 2023/1230 marks a significant milestone in machinery safety within the EU. By introducing a more comprehensive and rigorous regulatory framework, the EU aims to create a safer working environment and protect consumers from potential hazards. As the implementation date approaches, businesses should proactively prepare for the changes and embrace the opportunities presented by this new era of machinery safety.

3.2. Action plans and strategies

Several EU-wide Action Plans and strategies that relate to the CURIOST project were identified by the project partners. This chapter provides detailed descriptions of some of these plans and explains how they connect to the project's focus and sectors.

3.2.1. New Circular Economy Action Plan

The European Commission's **New Circular Economy Action Plan** (15) outlines key steps for transitioning the EU into a circular economy. It suggests improvements across various industries, with several measures especially relevant to the CURIOST project:

Packaging

In line with the Green Deal, the New Circular Economy Action Plan (CEAP) commits to reinforcing the essential requirements for packaging in view of making all packaging reusable or recyclable by 2030, and to consider other measures to reduce (over)packaging and packaging waste, drive design for reuse and recyclability of packaging, reduce the complexity of packaging materials and introduce requirements for recycled content in plastic packaging. Reducing negative environmental impacts of packaging waste was supported by civil society and stakeholders as well. The specific objectives are:

- to reduce (over)packaging and packaging waste, by setting targets and other waste prevention measures
- to promote a circular economy for packaging in a cost-effective manner, by developing design for re-use and recyclability of packaging, including considering restrictions on the use of some packaging materials for certain applications, where alternative reusable products or systems are possible, or consumer goods can be handled safely without packaging
- to promote the use of recycled content in packaging and to consider reducing the complexity of packaging materials, including the number of materials and polymers used. There are three policy options based on the external analysis and research:
    - Option 1 sets out measures to increase standardisation and establishes clearer essential requirements that tend to be pre-requisites for measures in other groups.

- Option 2 sets mandatory targets for waste reduction, re-use for certain sectors and minimum recycled content in plastic packaging, requirements to ensure full recyclability by 2030 and harmonised product rules.
- Option 3 sets higher mandatory targets than Option 2 and additional product requirements.

The Commission suggests mandatory requirements for packaging to enter the EU market and is considering additional measures focusing on this issue.

Plastics

The key goal of the European Commission is to reduce the presence of microplastics in the environment by taking a set of measures and establishing a framework on the use of plastics and added microplastics in all relevant stages of product lifecycle.

Furthermore, the Commission will address emerging sustainability challenges by developing a policy framework on:

- sourcing, labelling and use of bio-based plastics, based on assessing where the use of bio-based feedstock results in genuine environmental benefits, going beyond reduction in using fossil resources,
- the use of biodegradable or compostable plastics, based on an assessment of the applications where such use can be beneficial to the environment, and of the criteria for such applications.

The framework will aim to ensure that labelling a product as 'biodegradable' or 'compostable' does not mislead consumers to dispose of it in a way that causes plastic littering or pollution due to unsuitable environmental conditions or insufficient time for degradation.

Construction and building

The European Commission promotes measures to improve the durability and adaptability of built assets in line with the circular economy principles for buildings and developing digital logbooks for buildings, considering a revision of material recovery targets set in EU legislation for construction and demolition waste and its material-specific fractions and promoting initiatives to reduce soil sealing, rehabilitate abandoned or contaminated brownfields and increase the safe, sustainable and circular use of excavated soils.

The Circular Economy Action Plan highlights the importance of consumers having access to information about the repairability and durability of products.

Mechanics and mechatronics

Since mechanics and mechatronics is not listed as a separate sector in the document, the paragraph on Electronics and Information and Communication Technology will serve as a good example for the sector. Emphasis is on promoting longer product lifetimes, making electronics as a priority sector for implementing the "right to repair", with stronger restrictions of hazardous substances in electrical and electronic equipment.

3.2.2. RESourceEU Action Plan

The **RESourceEU Action Plan** (16) outlines the European Commission's approach to strengthening the EU's security of supply for critical and strategic raw materials — a priority for the sectors relevant to the CURIOST project. Its core objectives are to reduce resource dependencies on third countries, diversify and secure supply chains, scale up recycling and circular use of materials, and support innovation and investment across industrial value chains. Although the Action Plan is horizontal, its measures are particularly relevant for material-intensive and manufacturing sectors that are exposed to supply risks and sustainability requirements, such as analysed within the CURIOST project:

Mechanics and Mechatronics

The mechanics and mechatronics sector is highly dependent on critical raw materials such as rare earth elements, lithium, nickel, copper, and advanced alloys used in motors, sensors, electronics, and automation technologies. The Action Plan's focus on supply chain resilience, domestic processing capacity, and diversification of sourcing, directly supports the sector's operational stability. In parallel, EU support for research, innovation, and material substitution encourages more efficient designs and reduced reliance on scarce inputs, strengthening long-term competitiveness.

Packaging

For the packaging sector, the Action Plan is mainly relevant through its reinforcement of circular material flows and improved access to secondary raw materials. Measures to strengthen recycling capacities, retain valuable waste streams within the EU, and stimulate demand for recycled materials help reduce dependence on virgin raw materials. These actions complement EU packaging sustainability rules by supporting the availability of high-quality recycled material needed to meet recyclability and recycled-content requirements, while increasing resilience against raw material price volatility.

Plastics

The plastics sector benefits from the Action Plan's emphasis on recycling, material efficiency, and substitution. By improving the availability and quality of secondary raw materials and supporting innovation in alternative feedstocks, the Plan helps to address both supply risks and regulatory pressures. Strengthened domestic recycling markets and circular value chains enable the plastics industry to reduce reliance on fossil-based primary inputs while maintaining industrial performance and competitiveness.

Construction and Building

The construction and building sectors are strongly affected by the Action Plan due to its high consumption of raw materials such as metals, minerals, and construction products. Actions promoting recycling, reuse, and better valorisation of construction and demolition waste contribute to reducing primary material demand and environmental impacts.

Together with broader EU initiatives on construction products and digitalisation, the RESourceEU Action Plan supports a more resilient, resource-efficient, and circular construction ecosystem aligned with the green transition.

3.2.3. European strategy for plastics in circular economy

According to the **Strategy for plastics in circular economy** (17), emphasis should be placed on a smart, innovative and sustainable plastics industry, where design and production fully respect the needs of reuse, repair and recycle, brings growth and jobs to Europe while helping to cut EU´s greenhouse gas emissions and dependence on imported fossil fuels. By 2030, all plastic packaging placed on the EU market should be either reusable or recyclable in a cost-effective manner. The strategy aims to recycle more than half of plastic waste generated in Europe, while continuing to invest and modernize recycling capacities. That way recycled plastics can become a valuable feedstock for industries, both at home and abroad, while other industries, such as the chemical industry, work closely with recycled plastic to help them find wider application for their outputs. In the European Union, citizens, governments and industry support more sustainable and safer consumption and production patterns for plastics.

4. COUNTRY-PERSPECTIVES

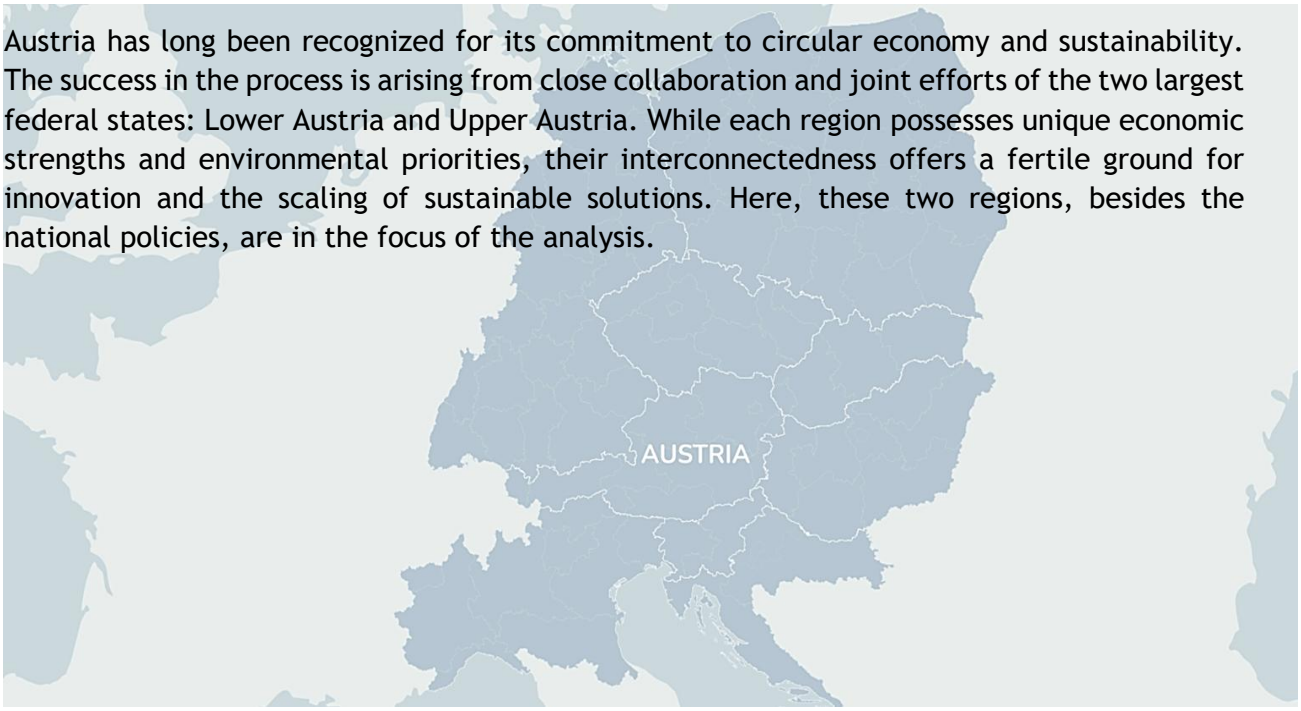
The transition towards a circular economy in CEE takes place within diverse national and regional contexts shaped by differing policy frameworks, sectoral structures, and levels of implementation of EU regulations. Against this background, the CURIOST project addresses the need for a differentiated, country-specific perspective that complements the transnational analysis and supports targeted action at regional level.

This chapter presents the **country perspectives** of the CURIOST Action Plan. Each country-section follows a common structure to ensure comparability and coherence: it starts with a policy analysis outlining the implementation of European regulatory framework in the respective countries followed by the most relevant national and regional strategies and regulations, and an assessment of regional needs. A sector-focused analysis identifies major challenges and opportunities within the four selected sectors, resulting in specific recommendations and actions customized for each country's unique context. These recommendations may target the region, individual countries, policy makers, or certain sectors, depending on the preferences and needs identified by each project partner during their analysis. At the end of each chapter an individualized graphic provides a visual overview of the key priorities and action areas for the respective country. They summarise the main findings of the analysis and illustrate the intervention areas, showing the respective focuses, the gaps and the opportunities each country has identified. Results from previous conducted SWAT analysis are included there as well (D 3.1.2). As such, the graphics complement the textual content and support a structured understanding of the proposed measures within the national context.

Together, these country chapters translate the previous transnational CURIOST framework into actionable, place-based pathways for advancing circular economy and sustainable product development across Central and Eastern Europe.

4.1. Austria

Austria has long been recognized for its commitment to circular economy and sustainability. The success in the process is arising from close collaboration and joint efforts of the two largest federal states: Lower Austria and Upper Austria. While each region possesses unique economic strengths and environmental priorities, their interconnectedness offers a fertile ground for innovation and the scaling of sustainable solutions. Here, these two regions, besides the national policies, are in the focus of the analysis.



In Figure 3 the results from the Austrian chapter are summarized.

Austria	Focus	Gaps	Opportunities
§ Regulation	EU-aligned policies	Fragmented implementation	funding + policy coordination
Regional needs	SME support	Limited capacities	Regional ecosystems
Sectoral needs	Circular design	Low adoption	Pilot markets
! Concrete Actions	Living labs	Missing incentives	Policy pilots

Figure 3: Summary of the Austrian perspective

4.1.1. policy analysis

implementation of EU policies

As a member state, Austria must adapt the EU-level policies to its national context. Several here described policies have already been incorporated.

Regarding the plastics and packaging sectors, Austria has actively incorporated the EU´s Single Use of Plastics Directive (Einwegkunstoffrichtlinie) and made amendments to its Waste Management Act (Abfallwirtschaftsgesetz 2002) (18). This legislative action has led to significant changes in the Austrian market:

- Banning of various single-use plastic products such as cutlery, plates and straws.
- Federal standardization for plastic and metal packaging collection in the yellow bin or yellow bag introduced in 2025.
- Introduction of a deposit system for plastic bottles also introduced in 2025.

These measures have been well received by the public and have helped decrease plastics and packaging waste, contributing to the achievement of EU recycling targets (19).

Innovation plays a crucial role in Austria's implementation of the Single Use of Plastics Directive. The government has established funding programs to support businesses in developing alternatives to single-use plastics, fostering a culture of innovation in sustainable packaging solutions which helps in achieving the directive's goals.

The European Regulation on Machinery proposed to replace the existing Machinery Directive that updates machinery safety in the digital age. Austria aligned its national machinery safety regulations with the proposed EU Machinery Regulation, including updates to its Machinery Safety ordinance (Maschinen-Sicherheitsverordnung) (20). The focus of Austria's implementation efforts has been on addressing the new challenges posed by AI systems in machinery. Comprehensive guidelines are provided to manufacturers for assessing risks associated with machinery that includes AI elements. These guidelines help to ensure that safety measures evolve alongside technological progress and integrate strong cybersecurity standards into the overall approach to machinery safety.

In the context of Common rules on promoting the repair of goods, it is important to mention the Repair-bonus program, which represents a significant step towards the extension of the lifespan of electronic and electrical devices. The program ended in 2025 after the elections in 2024 and was continued in a limited version as the “Geräte-Retter-Prämie” (Device Rescue Bonus) in 2026 (21). This initiative demonstrates the government's practical approach to sustainability by offering citizens financial support for repairs.

Austria has only recently formally implemented the CSRD through the Austrian Sustainability Reporting Act (Nachhaltigkeitsberichtsgesetz, “NaBeG”), which entered into force on February 19th, 2026, (22). In the context of digitalization, many digital platforms are being developed for enhancing efficiency and compliance, particularly in recognizing the digital future of corporate

reporting. Austria is in the process of developing a digital platform to facilitate the submission and access of sustainability reports. Additionally, acknowledging the unique challenges faced by smaller companies, Austria has established support programs and simplified standards for SMEs, aiming to aid their compliance with CSRD requirements without imposing unnecessary burdens.

national policy analysis

The **government programme for 2025-2029** places a special focus on the circular economy and aims to expand the legal framework in line with the circular economy strategy (see below). Austria is to become a pioneer for circular technologies and circular production processes. To this end, the market for such products and services is to be systematically developed and regulatory barriers removed through the reform of laws and regulations.

On national level, in 2023 the Austrian government introduced a **waste prevention plan** (Bundes-Abfallwirtschaftsplan) (23), (24). This program aims to encourage companies as well as consumers to reduce or prevent waste that contaminates the environment. Around 90 regulations were introduced, which affect construction waste, food waste, re-use and prevention in companies, organisations and households. In general, the existing regulations and policies aiming at fostering circular economy in the plastic industry in Austria are focused on waste management and packaging management. The regulations highlight the importance of reducing and reusing plastics and extending the end-of-life phase of plastic resources and products.

The success of Austria's approach lies in its comprehensive integration of regional and national policies, supported by concrete action plans and monitoring systems. This coordinated effort has positioned Austria as a model for other EU member states in implementing circular economy principles across multiple sectors while maintaining economic competitiveness and innovation leadership.

Austria has a long-established, varied **subsidy system**. Several subsidies target SMEs and small mid-cap companies, supporting their sustainable transformation. The bill proposes to increase the budget for the circular economy by 10 million euros to 100 million euros.

The **aws Growth Investment Programme (SME & Technology)** (25) supports Austrian SMEs in implementing growth-oriented and innovative projects that accelerate the shift toward resource efficiency and the replacement of fossil-based materials. It is co-financed by the European Union’s EFRE-program and the Just Transition Fund. The scheme prioritizes investments that introduce renewable, natural, or bio-based alternatives into production processes, thereby strengthening sustainable value chains and market uptake of low-impact products. Eligible SMEs located in Lower Austria, Upper Austria, and (previously) Vorarlberg can apply within the programme period 2025–2027, contributing directly to Austria’s transition toward a circular and resource-efficient economy.

The **Austrian Climate and Energy Fund** (Klima- und Energiefonds) is a national funding institution that supports Austria’s path to climate neutrality by 2040. Through financial support, expert guidance, and targeted programmes, it advances climate-friendly technologies, services, and systems while raising awareness for the challenges of climate change. Especially relevant is the

funding opportunity “FTI-Initiative für die Transformation der Industrie” (FTI Initiative for the Transformation of Industry) (26), where innovative industrial projects with a focus on circular economy, CO_2 reduction and transformative production processes are promoted. Looking ahead, the 2026 programme will continue to advance these efforts.

The federal government's **"Kreislaufwirtschaft allgemein” (Circular Economy in General) funding programme** supports companies in implementing measures that promote recycling, reuse, circular design and resource-efficient production processes. It is part of Austria's Circular Economy Strategy and aims to close material cycles, reduce waste and promote innovative circular business models. The funding is provided by the “Kommunalkredit Public Consulting GmbH” (Federal Environmental Fund) (27), a central funding agency that finances projects in the areas of climate, environmental and resource protection, thereby supporting the transformation to a sustainable, circular economy. This funding is particularly relevant for CURIOST, as the project itself supports the development of sustainable products and circular business models in key industries such as mechanics, packaging, plastics and construction, and empowers SMEs to develop resource-efficient, recyclable solutions – precisely those areas of innovation that are financially strengthened by the funding.

During the years in Upper Austria many calls for funding have been published fostering innovation and digital transformation. Funding schemes for Upper Austria SMEs, coordinated by the Chamber of Commerce Upper Austria, supported:

- Digital Starter (support for first digital transformation measures in SME)
- Consultancy “ÖKO-Plus” (assessment and advice reg. resource reduction, energy efficiency, production efficiency in SME)
- Circular Economy in the construction sector
- Technology and innovation programs for labs, start-ups, and financing products for circular solutions.

S3-strategy

In Austria, S3 is not an isolated national document, but **part of a policy framework** for research, technology and innovation strategies, which is jointly developed and implemented by the federal government and the federal states. Austria started its implementation early on and integrated the principles in many regional strategies, which are referencing one another (28). The project’s focus here lies on the national execution of these strategies and on the regions of Lower and Upper Austria. Some of the policies in the field, relevant to the CURIOST project, are The Austrian Circular Economy Strategy (29), the Lower Austrian Economic Strategy 2025 (30) and the Vision for Upper Austria 2030 (31), containing targets and concrete measures for transformation. Focal points will be executed to reform the Austrian economy and society into a climate-neutral, circular economy by 2050. The industrial sectors that are relevant for the CURIOST project are analysed as follows: plastics, packaging electrical and electronic devices in the context of mechatronics and mechanics.

- Regarding plastics and packaging industry, which is topic of many European policies, it is important to have in mind that Austria has a strong packaging industry and is a global leader in machine manufacturing for the plastics industry which means that innovations in this area can increase competitiveness of the Austrian economy and support circular economy.
- Relevancy for electrical and electronic devices in the context of CURIOST project has emphasis on sustainable production and life cycle of the devices. To establish a future sustainable, resource- efficient industry Austria needs to focus on faster transfer to circular economy to achieve change in the market regarding production, use and recycling. Through this support, this strategy fosters innovation and technological development, driving innovation and creating new business opportunities.
- Construction and buildings: Austria aims to make buildings more durable through maintenance and renovation with emphasis on energy efficiency. Components should be reusable and easier to recycle. Strategy recons using more recycled materials in construction and designing buildings that can be easily taken apart and reused.

The Austrian **National Strategy for Circular Economy** (29) has identified industries and sectors that need concrete sets of measures for achieving standards of sustainability and circular economy. At national level it supports horizontal approach and relevant industrial sectors that are enabling competitiveness on national and international markets. The strategy aims to reduce resource consumption, while increasing resource productivity and circularity rate at the same time. Developed protocols of monitoring and evaluation are issuing progress reports on circular economy every two years. This way the strategy aims to create a regulatory environment that encourages and incentivizes circular economy practices such as eco-design regulations. Since such efforts for transitioning to circular economy are visible at national level, further analysis will show the efforts made at regional level in Lower and Upper Austria.

The **National Industrial Strategy** (32) launched in 2026 aims to boost long-term growth and revive economic and technological expertise. For the first time, it highlights key technologies, supports their advancement from research to market, and incentivizes industrial investment and innovation. The strategy includes 117 measures across seven action areas to promote innovation, build resilience, and enhance Austrian industry's competitiveness. Circular Economy has been marked as one of the main action fields (see as follows).

The strategy outlines seven action fields, which are partly relevant to CURIOST:

- Research, technology & innovation: promoting research and development, strengthening RTI cooperation and targeted programmes for technological advancement.
- **Energy**: Ensuring a competitive and stable energy supply for industrial value creation, including energy pricing policy and security of supply. Energy is relevant to all companies, therefore also in the CURIOST context, especially since it is targeting the manufacturing sectors.

- **Education, skilled workers & labour market:** Expanding qualifications, training in future technologies, skilled worker development and labour market measures. This is relevant to the CURIOST context, as many SMEs and small midcaps lack skilled workers (see also in the following chapters)
- **Circular economy, bioeconomy & transformation**: Promoting sustainable production models, resource efficiency and circular value chains. As circular economy is the baseline of the CURIOST project, this action field is especially relevant.
- **Infrastructure, mobility & economic resilience:** Expanding physical and digital infrastructure, strengthening logistical capacities and increasing resilience to external shocks. Infrastructural frameworks are highly relevant to the sectors targeted by CURIOST.
- Europe & geopolitical challenges: Strengthening European cooperation, geopolitical capacity to act and integration into strategic value creation networks.
- Debureaucratisation & financing: Removing administrative barriers, making procedures more efficient and improving financing conditions for businesses.

Since the strategy is very new by the time of the development of the CURIOST Action Plan the concrete effects of the strategy will have to show in the future. A monitoring system is planned.

Austria's **Bioeconomy Strategy** (33) focuses on the sustainable transformation of the economic system by promoting the replacement of fossil raw materials with renewable and bio-based resources, thereby contributing to the achievement of national climate and sustainability goals. It identifies six strategic target areas – including reducing dependence on non-renewable raw materials, promoting innovation, economic development and social transformation – which form the framework for concrete measures in the subsequent Bioeconomy Action Plan (34). The action plan, updated in 2023, is divided into eleven thematic areas and comprises over 110 measures based on scientific research, value creation networks and technology-oriented solutions to strengthen bio-based product development and circular economy approaches across industry. In the context of the CURIOST project, it can be deduced that the strategic guidelines for substituting fossil-based materials, promoting innovative bio-based materials, improving resource efficiency and integrating bioeconomic value chains into existing production processes are particularly relevant for mechanics & mechatronics, packaging, plastics and construction – supplemented by measures for research and technology development, market development for bio-based products, and educational policy and social transformation processes to strengthen the acceptance and market integration of these solutions.

The **Economic strategy of Lower Austria** (30) focuses on creating solutions and innovations, especially encouraging innovative, high-quality production and products, digitalization and developments made to protect climate and environment. Objectives are set to transform Lower Austria as the region that can be a highly innovative business location supporting sustainable growth. Lower Austria is home to numerous manufacturing companies and innovative enterprises that create products and services. In the context of the CURIOST project and in the Lower Austrian economic strategy as well, intelligent and innovative, high-quality products are drivers of

international competitiveness. To achieve all other objectives and goals, significant governmental support and restructuring will be necessary, especially for traditional companies and approaches. The technology and innovation programme will provide support for innovation labs, start-up indicators, programmes for networking and developing technologies. Business development will provide advice and support for export and internationalization matters, while financing products support investments and innovation funding and modern financing products. Even though the implementation can be challenging and difficult to follow, the region of Lower Austria favours a horizontal industry policy approach over a sector-specific one, because the region is rich with enterprises in wide range of industries and business models.

The **Upper Austrian Economic strategy UpperVISION2030** (31) has a strong focus on technology driven innovation, with a rapid transfer of research results into business applications. There are four main objectives, whereas only one directly refers to one of our 4 target sectors, namely mechanics and mechatronics:

- Digital transformation: value chains are transformed by digitalization and AI (not directly relevant to the CURIOST project's context)
- Efficient and sustainable industry and manufacturing: in that field, the reuse of components or their recyclability in terms of a holistic product life cycle by promoting recycling-compatible product design is tackled. Circular economy is not explicitly named, but the reduction of material consumption, and the cascading or coupled use of raw and residual materials can be considered as a contribution to circular economy as well. The sub-topic "efficient production processes" tackles all 4 CURIOST target sectors.
- Systems and technologies for people (not relevant to the CURIOST project's context)
- Connected and efficient mobility: Upper Austria has a strong automotive supplier industry, which is matching with the two CURIOST sectors mechanics and mechatronics and plastics.

To sum up, mechanics and mechatronics and plastics are strong industries in Upper Austria and therefore the RIS3 focuses on these sectors, while monitoring is done annually with reviewing implemented measures and related impact using defined indicators. Packaging can be seen as part of the plastics sector (other packaging materials play no role in Upper Austria). Focus is rising on the construction sector and its transformation to circular economy.

4.1.2. regional needs

Upper Austria:

Upper Austria is recognized as the leading industrial state in Austria. It is home to a significant portion of the country's industrial production and employment, making it a key driver of the national economy. Unfortunately, as many regions and countries of Europe, the working-age population of Upper Austria is declining. This demographic shift is projected to result in a shortage of 127,000 skilled workers by 2030. That is why the new strategy "Arbeitsplatz OÖ 2030" (35) (working place Upper Austria 2030) focuses on qualification, activation of the existing workforce

potential, and the recruitment and retention of skilled workers to support technological progress and digitalization. Intercultural competencies and foreign languages are also emphasized.

Strategic goals for an efficient and circular economy:

- Maintaining and expanding the technological lead of companies at the location to continue successfully placing innovative products and services in national and international markets.
- Increasing the efficiency of Upper Austria's economy and industry, and positioning Upper Austria as a region for "Responsible Technologies & Management"
- To tackle future challenges in Upper Austria's economic and research sectors, key technologies and core competencies in mechatronics, materials, and information and communication technology will be continuously developed.
- Integrating existing technologies will generate new knowledge through research, with a focus on rapid application. Information and communication technology is vital in a digital economy, aiming to convert data into value. Prioritizing new technologies like AI and data-driven modelling will enhance various applications.
- Innovations in materials will combine traditional and digital methods for safe, durable, and recyclable products. Mechatronics will optimize processes and products using advanced technologies. Technical innovations will require interdisciplinary expertise, incorporating societal, ethical, legal, and artistic aspects early in the process.

Key points for achieving an efficient and circular economy are to ensure supply security and affordability and environmental compatibility to reduce fossil fuel consumption. In detail:

- Technological flexibility: Developing processes to increase flexibility in raw material usage and enable cascading or coupled use of raw and residual materials for added value.
- Efficiency and sustainability: Enhancing process and production efficiency and sustainability using new technologies like Big Data, AI, and data-driven modeling, under the concept of "Responsible Technologies."
- Recycling and lifecycle: Incorporating component reuse and recyclability into holistic product lifecycle design.
- Energy focus: Concentrating on energy storage, distribution, and efficient consumption, and integrating sectors like electricity, heat, transport, and industry through new technologies and system innovations.

Relevant strategic flagship project in Upper Austria: “Kunststoffstandort 2030+” (Plastics hub 2030+):

- Promoting a Positive Image of Plastics
    - Improve the perception of plastics through education and transparent communication.

- Highlight the diverse applications and ecological aspects of plastics.
- Focus on reducing plastic waste with innovative technologies.

> Transitioning to a Circular Economy:

- Replace the linear economic model in the plastics industry with a circular one.
- Promote research and development of innovative recycling technologies.
- Establish closed loops for plastic products and implement sustainable production processes.
- Ensure plastics are designed for circularity, efficiently used, and resource-conserving recycled.

Lower Austria:

Lower Austria is home to a varied range of business types, featuring a high proportion of SMEs. It encourages innovative, high-quality production and products, digitalization and developments made to protect climate and environment. Objectives are set to transform Lower Austria as the region that can be a highly innovative business location supporting sustainable growth. Lower Austria is home to numerous manufacturing companies and innovative enterprises that create products and services. In the context of the CURIOST project and in the Lower Austrian economic strategy as well, intelligent and innovative, high-quality products are drivers of international competitiveness. To achieve all other objectives and goals, significant governmental support and restructuring will be necessary, especially for traditional companies and approaches. Technology and innovation programmes will provide support for innovation labs, start-up indicators, programmes for networking and developing technologies. Business development will provide advice and support for export and internationalization matters, while financing products support investments and innovation funding and modern financing products. Since the region is rich with enterprises in a wide range of industries and business models, Lower Austria favours a horizontal industry policy approach over a sector- specific one.

4.1.3. sector analysis

In the same way, the specific needs of the 4 sectors mechanical engineering, packaging, plastics, and construction & building which might be common in some of the participating regions, are addressed with appropriate actions.

Specific sectoral needs in Austria

> Expertise and Skills needed: Specialists in (digital) circular product development and advanced technological skills are crucial for economic success, including experience in metalworking, mechatronics, and digitalization.

> Sustainability Commitment needed: Strong internal commitment to sustainability enhances a company's image and reputation, gaining stakeholder trust and positioning as reliable players.

- Transformation Levels: Most companies are at transformation levels 1 and 2, lagging other sectors into adopting circular economic practices.
- Collaboration and Support needed: Cooperation, partnerships, and regulatory support from other companies, institutions, and political frameworks are essential.
- Financial Challenges: Investing in innovative technologies is key but challenging, including advancements in production and new digital business models.
- Strategic Prioritization: Many companies have not prioritized the circular economy strategically, leading to slow implementation of changes and innovations.
- Traditional Mindsets: Slow adaptation of processes due to traditional mindsets hinders rapid adoption of sustainable practices.
- Economic Uncertainties: Economic fluctuations and uncertainties in financing sustainable measures pose significant obstacles, including market volatility and price pressure.

mechanics & mechatronics

To build a sustainable, resource-efficient industry, Austria should speed up its shift to a circular economy in mechanics and mechatronics. This approach encourages innovation, technological progress, and new business opportunities. Early interventions like designing for recycling and repair, reuse-focused construction, and reducing material complexity are needed, as shown by best practice companies already prototyping these ideas. However, there remains insufficient political support for these initiatives. Priority areas include enhancing energy and material efficiency, optimizing processes and accelerating sustainability expertise among product developers.

packaging & plastics

In line with European regulations dealing with plastics and packaging, reducing packaging material and increasing the share that is reusable, as well as introducing sustainable design of plastic products, similar measures will be encouraged in Austria. Further on, federal standardization of the packaging collection, separate collection of plastics and packaging will be introduced, with expansion and modernization of sorting facilities. In January 2025 Austria introduced the deposit system for plastic bottles.

construction & building

Austria aims to make buildings more durable through maintenance and renovation with emphasis on energy efficiency. Components should be reusable and easier to recycle, by using more recycled materials in construction and designing buildings that can be easily taken apart and reused. According to experts, one of the main barriers to implementing the circular economy in the construction industry is the documentation requirements, which are perceived as burdensome. The slow implementation of EU directives into national law was also criticized. To improve the comparability of materials, clear accounting standards across the entire life cycle and a uniform CO_2 assessment are advocated. Economic reasons – especially a lack of financial resources – are observed as the most important internal barrier to implementing the circular economy. External

barriers mainly relate to technological challenges, unclear legal frameworks, low availability of recycled materials and lack of market demand. The early consideration of dismantling and reuse strategies in planning and tendering, as well as the importance of long-term regulatory frameworks, were highlighted as particularly conducive (36).

4.1.4. concrete actions

In this chapter, concrete actions for the Austrian context are presented. The proposed actions are meant to be realistic and aim in accelerating circular economic adoption, improving skills, and fostering innovation in SMEs and small midcaps. They require strong SME engagement and financial support. Outputs can be training programs, funding access, cooperation platforms and digital integration, while outcomes are an increased competitiveness, reduced waste and improved sustainability. Stronger SME resilience and compliance with EU goals are seen as positive impacts.

Table 2: concrete actions for Austria

Action	**Subjects** *(Who is implementing the actions)*	**Objectives** *(What do we want to achieve?)*	**Target groups**	**Tasks & Activities** *(What activities are necessary to achieve the objectives?)*	**Success criteria** *(What are the main results you expect? How do you define the success of the activity?)*	**Time Frame** *(By when do the tasks need to be completed to trigger the change?)*	**Estimated Costs**	**Resources needed** *(What or who can help or will be responsible to achieve the tasks/objectives? Time, costs?)*	**Funding possibilities**
1. Innovative & strong partnerships and collaboration	+ Regional, national governments + European Union	+ Apply for government grants and subsidies to support circular economy initiative + Engage with policymakers	+ SMEs and small midcaps + Clusters + R&D institutions	Engage with Regional and National Governments: + Apply for government grants and subsidies to support circular	+ Engage with region and national governments (secure subsidies and grants to suppose circular economy	+ Engage with regional and national governments: immediately/ as soon as relevant opportunities arise	+ 16000 EUR per year	+ Consulting fee + Application costs + Personnel costs + Cluster membership costs	+ Upper Austria: contact Biz-up/ F&I for R&D funding advice + General incentive: funding of costs of R&D or innovation

		to advocate for supportive regulations and incentives + Stay updated on EU funding programs for SMEs + Regularly apply for grants and subsidies to support sustainable practices and innovation + Collaborate with partners and clusters to strengthen applications and learn from benchmarks + Use EU advisory services to navigate the application process and improve submissions. Ensure compliance with EU regulations to maintain future funding eligibility. +Understandin g circular		economic initiatives. + Advocate for supportive regulations and incentives by engaging with policymakers. Collaborating with the European Union: + Stay updated on EU funding programs for SMEs. + Regularly apply for grants and subsidies to support sustainable practices and innovation. + Ensure compliance with EU regulations to maintain future funding eligibility. Work with SMEs and Small Midcaps: + Collaborate with partners and clusters to strengthen	initiatives, influence policy makers to implement supportive regulations and incentives, establish a productive relationship with key government officials and agencies) + Work with other SMEs and small midcaps (initiate collaborative R&D projects, build strong networks and partnerships, participate in cluster initiatives to develop cross-sectoral industrial value chains, establish robust monitoring and evaluation of your initiatives to ensure success for your initiatives)	+ Work with other SMEs and small midcaps and partner with cluster and R&D institutions: as soon as possible, to ensure middle-term success for joint projects (2-3 years)	+ n.a. + 800 EUR per year + 300 EUR per year / company + 300 EUR per year / company + 1000 EUR per year / company	+ Time horizon: immediately - 2-3 years (R&D-projects)	projects (regional, national, European funding) and turnover with circular products as soon as they are ready to market

		design: How to integrate recyclability and reuse into product lifecycle design		applications and learn from benchmark + Engage in joint research and development projects to foster innovation. + Partner with Clusters and R&D Institutions: + Form strategic alliances to leverage collective expertise and resources. + Participate in European Cluster Partnerships for Innovation to develop new cross-sectoral industrial value chains Focus on the societal impact of circular economy within partnerships and joint projects			+ n.a. + 300 EUR per year / company + 300 EUR per year / company + 300 EUR per year / company		

				+ Create incentive systems for circularity + Establish (and promote) the importance of circularity and its implementation in society			+ 6000 EUR per year + 4000 EUR per year Notice: some actions are combinable and will reduce the costs.		
2. Innovation, flexibility and knowledge transfer	+ SMEs and small midcaps + national and European legislators + Product designers and engineers + consumers + legislators + producers and manufacturers + recycling facilities + waste management companies + employees	+ Create products that are adhere with circular principles + Establish ambitious goals for recycling different types of waste in production line + implement recycling programs to develop and promote recycling initiatives and alternatives within the organization + Business Model Skills & Trainings: Transitioning	+ Consumers + Producers + Companies along value chain	+ invest in R&D + collaborate with R&D institutions + choose materials that are recyclable + conduct life cycle assessments + implement design principles + train design teams on sustainable design + develop EPR programs + engage with policymakers to advocate EPR regulation + establish take-back	+ high recyclability rates + design for disassembly possibility of data-driven adjustments	+ internal (design principles, monitoring and reporting, material selection: 6-12 months + R&D projects: 1-3 years	overall, 1 PE – appr. 70k-90k EUR per year /company	+ Internal costs: personnel, prototyping, + External costs: expert, tools/software audits, training programs	+ R&D funding (regional, national European) + other fundings or incentives (regional, national, European)

		from linear to circular models, including reverse logistics and closed-loop systems + Skills: Mechatronics, materials innovation, and advanced manufacturing techniques for circularity		programs for consumer + partner with recycling facilities + set clear, measurable recycling goals + report on recycling performance to stakeholders + educate employees and encourage them to raise awareness + Establish people for circular product development in companies + Channel the overall added value of circular models to the target groups					
3. digital integration	SMEs, small midcaps	+ Allocate resources to develop new technologies and sustainable practices + Adopt advanced technologies,	+ Consumers + Producers + Companies along value chain	+ Investment in R&D + Training programs for employees + Implement IoT devices + Implement AI analytics	+ traceability of products and material + availability of detailed product information (DDP)	+ R&E projects: 1-3 years + Trainings: immediately and ongoing + Implementation of IoT and AI: 1-2 years	overall, 1 PE – appr. 70k-90k EUR per year /company	+ Internal costs: personnel, prototyping + External costs: experts, tools/software audits, training programs	+ R&D funding (regional, national European) + other fundings or incentives (regional, national, European)

		utilize IoT, AI, Big data, 3D printing for resource efficiency and waste reduction and predictive analytics to optimize resource use and enhance efficiency		+ implement systems to track recycling + use blockchain to ensure traceability and transparency in recycling process + stay informed about Digital Product Passport (DDP) + use digital tools to integrate supply chain management implement predictive maintenance systems to extend product lifecycles and reduce waste	+ data sharing along value chain + higher awareness with use of materials and product lifecycles	+ DDP: immediately and ongoing +Implementation of supply chain management and predictive maintenance systems: 1-2 years			

4.2. Croatia

Croatia's main strategic priorities at the political level for sustainable production and the circular economy are outlined through national frameworks, sector-specific initiatives, and alignment with EU regulations. These priorities aim to foster innovation, resource efficiency, and environmental sustainability, in line with Croatia's National Development Strategy 2030 and the EUs "Smarter Europe" Goals, which emphasize innovation, green transitions, and regional industrial modernization. For Croatia, two regions were analysed, North Croatian region and Primorje – Gorski Kotar County, by two partners Metalska Jezgra Čakovec and STEP RI.



In Figure 4 the results from the Croatian chapter are summarized.

Croatia	Focus	Gaps	Opportunities
§ Regulation	Emerging frameworks	Weak enforcement	Policy harmonisation
Regional needs	Awareness building	Skills shortage	Knowledge transfer
Sectoral needs	Manufacturing SMEs	Technology access	Innovation uptake
! Concrete Actions	Stakeholder workshops	Limited monitoring	Capacity building

Figure 4: Summary of the Croatian perspective

4.2.1. policy analysis

implementation of EU-directives

Croatia has transposed several relevant EU-Regulations into national law. For example, Croatia transposed the CSRD into national law through amendments to the Accounting Act (37), the Audit Act and the Capital Markets Act, adopted on July 12th, 2024, and in force since July 27th, 2024, (38).

Croatia incorporated the main provisions of the Single Use of Plastics Directive into its national legislation through the Waste Management Act and a specific Regulation on Packaging and Waste Packaging, Single-Use Plastic Products, and Fishing Gear Containing Plastics (OG 137/23) in 2021. As a result, several single-use plastic products were banned from being placed on the market in Croatia as of July 1st, 2021, which transposed the Single-Use Plastics Directive into national law. These products include cotton bud sticks, various eating utensils, plates, straws, beverage stirrers, balloon sticks, and food and beverage containers made from expanded polystyrene (EPS), as well as products made from oxo-degradable plastic. Additionally, certain products such as sanitary pads, tampons, wet wipes, and tobacco products with filters must now carry specific labelling that conforms to the Commission Implementing Regulation (EU) 2020/2151. This regulation, which came into effect across the EU on July 3rd, 2021, dictates the labelling requirements for single-use plastic products to inform consumers about the plastic content and the environmental impact of improper disposal. This regulation is directly applicable in Croatia and does not require transposition into Croatian national law.

The fourth iteration of the Energy Performance of Buildings Directive (EPBD) aims to accelerate building renovations, reduce energy consumption, and promote renewable energy use in buildings, helping the EU achieve a net 55% reduction in greenhouse gas emissions by 2030 and climate neutrality by 2050. Buildings are significant in this transition, accounting for 40% of energy consumption and 36% of GHG emissions. The recast EPBD, effective from May 28, 2024, includes goals such as ensuring all new buildings are zero-emission by 2030 and public sector buildings by 2028.

Key objectives include:

- Reducing average primary energy use of residential buildings by at least 16% by 2030 and 20-22% by 2035.
- Renovating 16% of the worst-performing non-residential buildings by 2030 and 26% by 2033.
- Deploying solar energy in all new residential buildings by 2030.
- Decarbonizing heating systems and phasing out fossil fuels.

To support implementation, the construction sector will need more skilled workers, and national building renovation plans should address existing barriers. Funding will come from national measures, EU structural funds, and European Investment Bank instruments. Croatia began implementing the EPBD in 2008, with the Ministry of Construction and Physical Planning (MCPP) and the Ministry of Economy responsible for different aspects. The Building Act (OG 153/2013,

20/2017, 39/2019, 125/2019) of 2013 set the legislative basis for the EPBD, and amendments in 2019 transposed most parts of the Directive (EU) 2018/844.

For sector specific policies in Croatia, it is important to mention construction and building, plastics and packaging in terms of waste management and mechanics and mechatronics. Therefore, Construction Products Regulation (CPR) Regulation (EU) No 305/2011 is transposed by Law on Construction Products which sets strict standards for safety, sustainability and performance, ensuring compliance with national and other EU regulations. Promoting recycled and recyclable materials, reducing waste and encouraging energy-efficient products, the law supports more sustainable building industry. Long Term Strategy for the Renovation of the National Building Stock by 2050 aims to support the renovation of residential and non-residential buildings to achieve high energy efficiency and decarbonization by 2050. It aligns with national and European plans for energy efficiency and climate change, providing a comprehensive roadmap for transforming Croatia´s building stock into an energy-efficient and sustainable sector by 2050.

Concerning the sectors of plastics and waste management, plastics sector is heavily regulated to ensure the transition to a circular economy, with a strong focus on waste reduction, recycling, and minimizing environmental impact. Of particular importance is the Waste Management Plan of the Republic of Croatia for the period 2023–2028, which includes the Waste Prevention Plan. Waste management is regulated by the Waste Management Act (Official Gazette No. 84/2021) and subordinate legislation. For example: The Regulation on Waste Management (Pravilnik o gospodarenju otpadom) is a key piece of legislation in Croatia that provides detailed guidelines and procedures for the management of waste across various sectors, including the plastics sector. By ensuring that plastic waste is properly separated at the source, the regulation facilitates the recycling and reuse of materials. One of the most significant aspects of the regulation for the plastics sector is the emphasis on Extended Producer Responsibility (EPR), that holds producers accountable for the entire lifecycle of their products, including the post-consumer phase. Ther Regulation on the Register of Environmental Pollution establishes a comprehensive framework for the systematic tracking, reporting, and management of environmental pollution in Croatia. It mandates the creation of a national register that records emissions to air, water, and soil, as well as waste generation and disposal, covering a wide range of pollutants. The Regulation on Packaging and Waste Packaging (Pravilnik o ambalaži i otpadnoj ambalaži, published in the Official Gazette Nos. 88/15, 78/16, 116/17, 14/20, 144/20) is a key regulatory framework in Croatia that governs the management of packaging and packaging waste. This regulation aligns with European Union directives and aims to minimize the environmental impact of packaging by promoting recycling, reuse, and sustainable packaging practices.

For the mechanics and mechatronics sector relevant policies include REACH Regulation (Regulation (EC) No 1907/2006); REACH (Registration, Evaluation, Authorisation, and Restriction of Chemicals) which regulates the use of chemical substances in the EU. It is particularly relevant for the mechanics and mechatronics sector, where various chemicals are used in manufacturing processes and product development. Another relevant directive is Industrial and Livestock Rearing Emissions Directive (IED 2.0) - Directive 2024/1785. For the mechanics and mechatronics sector, IED 2.0 introduces more stringent environmental requirements, particularly for companies involved in the

production of machinery and equipment used in industrial and agricultural processes. Manufacturers will need to ensure that their products support compliance with these new standards, which may involve the development of more energy-efficient and low-emission technologies.

To conclude, several national regulations influence the sectors in Croatia to align with the European Union´s broader goals of sustainable product development and the circular economy. Key regulations are: Environmental Protection Act, Waste Management Act, Energy Efficiency Act, Law on Chemicals (Zakon o kemikalijama), Law on Construction Products, Low carbon development strategy of the Republic of Croatia.

national policy analysis

Croatia has developed several other initiatives and plans that support the transition to a circular economy and sustainable development. The **National Recovery and Resilience Plan 2021-2026** (39) includes measures for green urban renewal, the development of green infrastructure, and circular management of buildings and spaces. It also supports the reduction of waste disposal through the construction of waste transfer stations and improvements in biowaste collection and treatment systems. In the realm of digitalization, which is crucial for enabling circular economy practices, Croatia has shown progress. According to the 2022 Digital Economy and Society Index (DESI) (40), Croatia performed above the EU average in the “Integration of digital technology” dimension, ranking 14th among 27 EU countries. Croatian enterprises, particularly SMEs, are taking advantage of online commerce opportunities, with 29% of SMEs selling online (above the EU average of 18%). This digital integration enhances the capacity for sustainable product development and circular economy practices across various sectors and therefore, Croatia developed **Digital Croatia Strategy for the period until 2032** (41). Further on, Waste Management Plan for the Republic of Croatia 2023-2028 is important for transition to circular economy at national level, since waste management levels are still under European average. Financial support for these initiatives comes from multiple sources. Croatia benefits from the European Union's Cohesion Fund, which supports projects aimed at improving waste management and promoting circular economy practices. The National Recovery and Resilience Plan allocates 20.4% of its funds for the digital transformation of society, providing a significant lever for economic growth and sustainable development. Additionally, the World Bank provides technical assistance to help Croatia integrate circular economy principles into its waste management strategies. Compatible with the S3 strategy´s support in construction sector, the World Bank is supporting these efforts by assisting the Ministry in developing a five-year Circular Economy Action Plan for the construction sector (2022-2026). This plan aims to reduce waste generation, maximize the economic value of unavoidable waste, and minimize environmental impacts. It's designed to serve as a model for other sectors in Croatia, illustrating effective application of circular economy principles.

In addition to these measures, Croatia has introduced new funding opportunities to accelerate the green and digital transition, particularly within the framework of the circular economy. Notably, the new programme "Support to R&D for Green and Digital Transition" (42) offers subsidies aimed at fostering research and development activities related to sustainability and digital innovation.

Furthermore, dedicated grants have been launched to support SMEs in adopting circular economic practices, with a particular focus on key sectors such as plastics, construction, and waste management. Unlike similar schemes in other countries, these calls are open to a broad range of circular economy activities, including the use of secondary raw materials and other "R" strategies beyond recycling. The goal is to enhance the overall transition towards a more resource-efficient and sustainable economy, encouraging innovation and the uptake of circular practices across the Croatian industry.

Despite these positive developments, challenges remain. The transition to a circular economy requires a shift in mindset and practices across all sectors of the economy. SMEs, which are crucial in driving innovation and adopting new technologies, still face challenges such as a digital skills gap, regulatory complexity, and difficulties in accessing larger markets. Addressing these issues will be crucial for the successful implementation of circular economy principles across the focus sectors. While implementation challenges exist, the strategies in place demonstrate Croatia's commitment to aligning with EU goals for a greener, more circular economy. The success of these efforts will depend on continued support for innovation, effective policy implementation, and the ability to overcome the challenges faced by businesses, particularly SMEs, in adopting new sustainable practices.

S3-strategy

Some of the most important Croatian policies endorsing transformation to circular economy include the Waste Management Plan (2023-2028), the Circular Economy Action Plan for Construction and Demolition Waste (2022- 2026), the National Development Strategy 2030 prioritizing a green and circular economy, sector specific measures and emphasizing Integration of Digital Technologies with Digital Croatia Strategy 2032.

Croatia's Smart Specialisation Strategy (S3) 2021–2029 serves as a cornerstone of the country's innovation and industrial transformation agenda. It outlines seven thematic priority areas (TPAs) (43):

1. Personalised health care
2. Smart and clean energy
3. Smart and green mobility
4. Security and dual-use (awareness, prevention, response, remediation)
5. Sustainable and circular food
6. Customised and integrated wood products
7. Digital products and platforms.

These TPAs aim to improve competitiveness, foster innovation-driven growth, and accelerate green and digital transitions. To address regional disparities in innovation and industrial modernization, Croatia has developed Industrial Transition Plans (ITPs) for its three NUTS 2 regions — Pannonian, Adriatic, and Northern Croatia. These plans, part of the Integrated Territorial Programme 2021–2027, aim to boost economic resilience, improve innovation capacity, and guide

investments in digital and green transitions. They serve as a basis for regionally tailored support, particularly in less developed areas below 75% of EU GDP per capita: These ITPs align with S3 priorities and create new opportunities for deploying circular business models in the key sectors addressed by CURIOST, including construction, plastics, packaging, and mechatronics. However, their effective implementation depends on stronger cross-sectoral collaboration, better coordination between regional stakeholders, and targeted capacity-building for SMEs.

Croatia's Smart Specialization Strategy (S3) plays a crucial role in the country's transition towards a circular economy and sustainable development. Introduced in 2016 and revised for the 2021-2027 period, S3 provides a framework for innovation-driven growth while addressing environmental challenges. This summary focuses on how the S3 and related policies support circular economy principles and sustainable development, particularly in the sectors of mechanics, plastics, packaging, and construction. The S3 strategy identifies several Thematic Priority Areas (TPAs), with "Energy and Sustainable Environment" emerging as a key focus. This TPA accounted for a third of all S3 projects implemented between 2016 and 2021, highlighting Croatia's commitment to fostering innovation in clean energy technologies and environmental sustainability. The strategy aims to develop smart energy systems that optimize the coordination of electricity, heat, and gas networks, promoting resource efficiency and reducing environmental impact.

For the sector specific strategies, the S3 strategy also addresses the plastics and packaging sectors through its alignment with the European strategy for plastics in the circular economy. Croatia is actively implementing measures to reduce plastic waste, increase recycling of plastic packaging, and enhance producer responsibility. These efforts are crucial for transitioning these sectors towards more sustainable practices and reducing their environmental footprint.

In the mechanics sector, which overlaps with areas like automotive and production machinery, the S3 strategy promotes innovation and sustainability through the development of competitiveness clusters. These clusters serve as important policy tools for smart specialization and strengthening national industries. They encourage collaboration between academia, research institutions, and businesses, fostering innovation in areas such as energy-efficient manufacturing processes and the development of sustainable materials and products. The S3 strategy's implementation has faced some challenges, including delays in policy adoption and the slow establishment of sectoral governance bodies. These issues initially hindered the full utilization of European Structural and Investment Funds for research, development, and innovation. However, despite these setbacks, the strategy has initiated positive changes in Croatia's innovation system, especially among small and medium-sized enterprises (SMEs) who are supported, ensuring they have the resources needed to innovate and grow.

Regarding construction sector, Croatia has made significant strides in incorporating circular economy principles. The strategy promotes green, modular construction with eco-friendly materials like stone and wood, supporting sustainable building practices. Devastating earthquakes prompted the government to prioritize the management of construction and demolition waste, with a 60% recovery rate for construction waste in 2020 and it is pushing for further improvements.

Looking ahead, the 2021-2027 S3 strategy aims to boost research and innovation activities that are crucial for regional development with emphasis on balanced territorial development. The strategy identifies five priority areas: Health and quality of life, Energy and sustainable environment, Transport and mobility, Security, and Food and bioeconomy. These areas are crucial for driving research and innovation activities that support equal regional development and the transition to a more sustainable and circular economy. Croatia has been actively implementing its S3 Strategy to support various industry sectors. Nevertheless, the previous Croatian Smart Specialization Strategy 2016–2020 had some challenges: complex intervention logic, limited integration, and broad objectives. The strategic objectives and instruments often addressed broad, horizontal issues rather than specific challenges within thematic and sub-thematic priority areas. The new strategy has been improved in terms of clarity, integration, and focus on specific challenges. As part of the programming of the Integrated Territorial Program 2021-2027, plans for the industrial transition of Pannonian, Northern, and Adriatic Croatia were drawn up with tailored support. Regarding the monitoring and evaluation, it includes activities such as data collection, preparation of annual reports, and the introduction of corrective measures when necessary. It also emphasizes the importance of transparency and accountability in the use of public funds. By examining the effectiveness of the program and other introduced interventions, the system will ensure proper identification of deficiencies and problems in implementation.

In conclusion, Croatia's S3 strategy, along with complementary policies and initiatives, provides a comprehensive framework for supporting the transition to a circular economy and sustainable product development. The focus on key sectors like energy, environment, construction, and digital technologies positions the country to make significant progress in sustainability and resource efficiency with additional focus to regional development, despite the encountered challenges in implementation.

4.2.2. regional needs

Croatia’s regional context is shaped by both strengths and systemic challenges:

- Strong alignment with EU climate, energy, and circularity goals.
- Clear strategic direction via S3 and development plans.
- Emerging best practices in circular product innovation (as mapped in A.1.3).
- Fragmented implementation across sectors and governance levels.
- Limited circular economy uptake among SMEs.
- Underdeveloped infrastructure for secondary raw materials and eco-design.
- Gaps in SME-targeted support for transitioning toward sustainable products.

These TPAs aim to improve competitiveness, foster innovation-driven growth, and accelerate green and digital transitions. To address regional disparities in innovation and industrial modernization, Croatia has developed Industrial Transition Plans (ITPs) for its three NUTS 2 regions—Pannonian, Adriatic, and Northern Croatia. These plans, part of the Integrated Territorial

Programme 2021–2027, aim to boost economic resilience, improve innovation capacity, and guide investments in digital and green transitions. They serve as a basis for regionally tailored support, particularly in less developed areas below 75% of EU GDP per capita: These ITPs align with S3 priorities and create new opportunities for deploying circular business models in the key sectors addressed by CURIOST. However, their effective implementation depends on stronger cross-sectoral collaboration, better coordination between regional stakeholders, and targeted capacity-building for SMEs.

4.2.3. sector analysis

Concerning sector specific needs, the partners identified that Croatia's circular economy transition requires targeted interventions across key sectors to address systemic gaps and leverage emerging opportunities. Both Croatian partners focus on three sectors: construction and building, mechanics/mechatronics and plastics.

construction & building

The regional construction sector shows early steps towards circular transformation, particularly in material reuse and energy-efficient production. While comprehensive regional data on the sector's involvement in circular practices is limited to a sample of best practices, local examples demonstrate promising initiatives in material innovation and recycling—especially in the use of recycled asphalt for road surfaces and water-based waterproofing solutions in construction materials. These examples stem primarily from research institutions and SMEs experimenting with low-carbon materials and energy-efficient processes. Croatia's construction sector requires training programs for architects and engineers on circular principles to bridge existing skills gaps, comply with EU regulations, and adopt sustainable practices effectively. These programs will play a pivotal role in achieving national sustainability goals while enhancing competitiveness within the European market. Vocational training programs currently focus on energy efficiency but do not adequately cover circular economy principles like deconstruction, bio-based materials, or waste minimization strategies.

packaging & plastics

The regional plastics sector best practices include SMEs engaged in the production of consumer goods, packaging components, and technical parts for sanitary systems. While the sector is subject to increasing regulatory and market pressure to improve its environmental performance, circular transformation is still at an early stage. As for innovation in Circular Product Design Biodegradable plastic production remains limited, R&D funding for such innovations remains limited with only 8% of NRRP funds allocated to circular SMEs. Croatian firms need support to develop reusable or refillable packaging systems, aligning with EU goals to reduce single-use plastics. Regarding consumer education and awareness, a recent survey revealed that 62% of households do not separate plastic waste due to unclear guidelines and lack of awareness campaigns. Nationwide education initiatives are needed to encourage proper waste segregation and recycling habits.

mechanics & mechatronics

The regional mechanics and mechatronics sector include SMEs engaged in metalworking, process automation, and industrial system maintenance. These companies often operate across multiple industries and are known for their focus on performance, reliability, and technological competence. Although circularity is not yet a strategic priority for most of these firms, several of their existing practices—such as long product lifespans, energy-efficient upgrades, and integrated maintenance services—have the potential to evolve into circular business models. It is identified that companies possess the technological base to support circular transformation, but lack dedicated incentives, knowledge or customer demand to justify the shift.

4.2.4. concrete actions

The following Table 3 outlines concrete actions for Croatia's circular economy transition, detailing specific tasks, objectives, target groups, and required resources for key sectors. It identifies responsible stakeholders, sets success criteria, and suggests suitable time frames for implementation, while highlighting available funding possibilities to ensure effective progress. The approach is designed to address sectoral needs and to accelerate circular economy through coordinated efforts and targeted support.

Table 3: concrete actions for Croatia

Action	**Subjects** *(Who is implementing the actions)*	**Objectives** *(What do we want to achieve?)*	**Target groups**	**Tasks & Activities** *(What activities are necessary to achieve the objectives?)*	**Success criteria** *(What are the main results you expect? How do you define the success of the activity?)*	**Time Frame** *(By when do the tasks need to be completed to trigger the change?)*	**Estimated Costs**	**Resources needed** *(What or who can help or will be responsible to achieve the tasks/objectives? Time, costs?)*	**Funding possibilities**
1. SME Circular Transformation Toolkit	Metal Centre Čakovec (MCC)	Equip SMEs with practical knowledge and real-world examples of circular economic implementation.	SMEs in construction, plastics and mechanics, Educational Institution	Developing a guide of best practices and experiences from SMEs selected by CURIOST, with concrete steps for applying circular principles in SMEs.	SMEs equipped with the skills needed to adopt circular design in business	End of 2026	1.000 - 1.700 EUR	Staff members of MCC for content developing and coordination	Own resources

2. Integration of Digital Tools	Metal Centre Čakovec (MCC)	To build SMEs' basic knowledge of digital tools that support progress toward circular product development.	General public, SMEs, Manufacturer	+ Developing a guide on using IoT-enabled tools in manufacturing to help companies improve resource efficiency and strengthen their circular economic practices. + Availability of the guide through digital platforms/online sessions	Stakeholders equipped with the knowledge needed to adopt digital tools in business	Guide developed and delivered by end of 2026	1.600 – 2.300 EUR	Staff members of MCC for content development and coordination	Own resources
3. Knowledge transfer	Metal Centre Čakovec (MCC)	Supporting stakeholders by delivering relevant funding opportunities	General public, SMEs	Conduct ongoing research to identify relevant funding programs and actively disseminate this information to stakeholders through targeted channels (through newsletters or online platforms).	Regular updates	On a monthly basis through 6 months	1.250 – 1900 EUR	Staff members of MCC for content development and coordination	Own resources

4. Organization of a practical training module for SMEs on circular product development	STEP RI (internal staff, possibly in collaboration with local experts)	To build SME awareness and basic knowledge about circular product development and business models	SMEs from the construction, plastics, and mechatronics sectors in the STEP RI region	Develop a short training module (2–3 hours); include local examples; deliver in-person or online; share basic self-assessment tool	At least one session held; 10+ SMEs reached; post-training feedback indicates usefulness	Training developed and delivered by end of 2026	2.500 – 5.000 EUR	1 trainer, 1 staff member for coordination, small budget for materials or online delivery	CURIOST project budget, internal STEP RI resources
5. Identification and promotion of circular innovation pilot cases developed by regional SMEs	STEP RI	To highlight and promote circular practices already emerging in the region to encourage peer learning	SMEs interested in circular transformation, regional stakeholders	Identify 2–3 SME cases from CURIOST; prepare short summaries or visual profiles; share via website/newsletter; optionally present at event	At least 2 regional cases published and shared: positive engagement via views, shares, or SME feedback	Published by mid of 2026	1.000 – 2.500 EUR	1 staff member for content development; communications support; no major costs	CURIOST communication budget; internal STEP RI resources
6. Mapping and sharing of existing funding sources and circularity-related support programmes	STEP RI, external experts	To improve SME awareness of current funding opportunities for circular product development	SMEs in traditional sectors (construction, plastics, mechatronics)	Identify national, regional, and EU-level support schemes relevant to circularity; summarize in a 1–2-page factsheet; share via STEP RI newsletter and website	Factsheet produced and distributed; positive feedback or inquiries from SMEs	By mid of 2026	1.500 – 3.500 EUR	1 staff member for research and formatting; internal communication support; no major external costs	CURIOST project budget; internal STEP RI resources

4.3. Germany (Bavarian region)



Germany belongs to the group of countries, where ambitious efforts in transforming the industry towards circular economy can be seen by a long time. Besides the national implementations, there are many regional and local initiatives which are committed to this aim (44). Though, for the scope of the project, the focus lies on the region of Bavaria, one of Germany's 16 federal states, as it is one of the regions addressed by the CURIOST project.

In Figure 5 the results from the German chapter are summarized.

Germany	Focus	Gaps	Opportunities
§ Regulation	Advanced regulation	High complexity	Standard setting
Regional needs	Industry integration	SME overload	Scaling solutions
Sectoral needs	High-tech manufacturing	Incremental innovation	Lead markets
! Concrete Actions	Policy alignment	Regulatoric pressure	Replication models

Figure 5: Summary of the German perspective

4.3.1. policy analysis

implementation of EU-directives

Within CURIOST, the key sectors of Germany (Bavaria) are oriented to mechanics and mechatronics, plastics and construction and building. The following policies are based on EU legislation and are relevant for the project CURIOST. It is also indicated for which sector the policies are relevant.

The equivalent to the EU-Supply Chain Act (Lieferkettengesetz) (45) is the German Supply Chain Due Diligence Act which regulates corporate responsibility for compliance with human rights in global supply chains. This includes, for example, protection against child labour, the right to fair wages and environmental protection. People in supply chains, companies and consumers benefit from fair globalization. The law initially came into force in 2023 for companies with at least 3,000 employees, and from 2024 applied to companies with at least 1,000 employees in Germany. First, companies must identify, assess and prioritize the risks in their supply chains. Based on the results, a policy statement is published, and measures are taken to prevent or minimize violations of human rights and damage to the environment. The law sets out which preventive and remedial measures are necessary. Other obligations include the establishment of complaint channels for people in the supply chain and regular reporting on supply chain management. Despite considerable resistance, particularly from parts of the German government, the EU member states agreed on an EU-wide directive on supply chain law (Corporate Sustainability Due Diligence Directive; CSDDD) on March 15, 2024. As soon as the directive for a European supply chain law is adopted, the governments of the respective countries are required to transpose it into national law. Existing supply chain laws, such as the German Supply Chain Due Diligence Act must then be adapted to the content of the directive (46). The Supply Chain Act is relevant for all sectors.

The German ordinance banning single-use plastics (Einwegkunststoffverbotsverordnung/ EWKVerbotsV) (47) is relevant for the plastics sector. The ordinance is the first step towards implementing the Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment (Single-Use Plastics Directive). The directive provides numerous measures to reduce the consumption of certain single-use plastic products, limits the careless disposal of these products in the environment and improves the management of plastic as a resource. The Regulation implements Articles 5 and 14 of the Directive. Article 5 requires EU Member States to ban the placing on the market of certain single-use plastic products listed in Part B of the Annex to the Directive (cotton buds, cutlery, plates, straws, stirrers and balloon sticks made of plastic, as well as to-go food containers, beverage cups and containers made of expanded polystyrene (also known as polystyrene)) and, in general, products made of oxo-degradable plastic. In addition, Article 14 of the Directive requires EU Member States to adopt provisions on penalties for the bans. The regulation implements the provisions one-to-one. Following referral to the German Bundestag and approval by the Bundesrat, the ordinance came into force on July 3rd, 2021.

The Building Energy Act (Gebäudeenergiegesetz, GEG) (48) is based on the European Energy Performance of Buildings Directive (EPBD) and is relevant for the sector construction and building.

The GEG integrates requirements from the EPBD into German law. It combines regulations on energy saving, the use of renewable energies and the energy requirements for buildings. Its aim is to implement the so-called 65% renewable energy target as intended to initiate the switch to climate-friendly heating systems and thus reducing dependence on fossil fuels. The goal is that, in future, new heating systems will only be installed if they generate at least 65% of the heat provided using renewable energies. The new GEG requirements for renewable heating have been in force since January 1, 2024, gradually initiating the switch to a climate-friendly heat supply that is predictable, cost-effective and stable in the medium to long term. By 2045, the use of fossil fuels for heating in buildings will be phased out. From this date at the latest, all heating systems must be powered entirely by renewable energies.

The “Right to Repair” (Reparaturgesetz) (49) is currently a draft of a repair law to ensure the availability of spare parts and repair instructions: No repair without spare parts. It is part of the German implementation of the Ecodesign Directive. The law will oblige manufacturers to provide free and transparent repair information for consumers and professionally competent repairers. In addition, manufacturers must keep spare parts for products in stock for at least ten years and make them available within 14 days at a reasonable price so that the repair is also financially worthwhile compared to a new purchase. The law is due to be implemented by July 2026, therefore only a draft is available at the time of the development of the CAP. Nevertheless, there already exists a fragmented repair bonus system in some federal states of Germany (50), which is a publicly funded support program to prevent electronic waste. It is intended to create financial incentives to make repairs to electrical devices cheaper and more desirable for consumers. In line with the motto “Repairing instead of throwing away”, there is currently a regionally limited subsidy for the repair of notebooks, smartphones, tablets, washing machines, dishwashers and other defective electrical appliances. Reimbursement of part of the repair costs incurred can be applied for after the repair has been completed. The aim of this promotion, which was first successfully launched in Austria, is to increase the lifespan of household appliances, which helps to reduce waste, protect the environment and strengthen local repair businesses. The funds for this come from the state. The bonus was paid in Berlin (51) and Thuringia (52), but both funds were eventually finished by the end of 2025. The Bavarian repair bonus was rejected in 2022, and only single communities are providing such (53). However, consumer advocates are calling for a nationwide subsidy. In conclusion, the repair law is relevant for the sector mechanics & mechatronics.

national policy analysis

Germany, and particularly the Bavarian region, has been at the forefront of implementing policies to support the transformation towards a circular economy and sustainable product development and has taken several measures at national level that differ from EU legislation. This analysis examines key national and regional strategies that are shaping the future of sustainability in Germany, with a focus on the sectors of mechanics and mechatronics, plastics, and construction and building.

One prominent example is the Supply Chain Duty of Care Act (Lieferkettensorgfaltspflichtengesetz) (54). This law obliges larger companies to check their

supply chains for human rights and environmental violations. Companies must ensure that no child labour, forced labour or environmental destruction takes place along their entire supply chain. German companies are under a lot of pressure when it comes to sustainability and legislation, but as with any challenge, there are also risks and opportunities.

The Digital Plan Bavaria has 200 measures in seven fields of action. One of the topics “digital building” includes a comprehensive introduction of the Building Information Modeling method and digital workplace for building construction. Another topic covered by Digital Plan Bavaria is “climate protection” with different projects and measures, e.g. The Future and the Bavarian Center for BlockChain aim to initiate joint projects based on blockchain technology, e.g. for the recycling of digital devices or electronic waste. Particular attention will be paid to the resource-saving use of blockchains.

Germany offers a range of regional funding instruments and initiatives that are relevant to the advancement of Circular Economy (CiE) approaches in CURIOST-related sectors. At the state level, North Rhine-Westphalia supports collaborative circular innovation through the “Kooperationszusammenschlüsse für eine Circular Economy” programme (55), administered by the Efficiency Agency NRW on behalf of the Ministry for the Environment, which specifically targets inter-company cooperation and systemic solutions. Bavaria provides several complementary funding schemes, including the “BayBioökonomie-Scale-Up” programme (56), the Bavarian Transformation Fund (57) supporting the structural transformation of the regional economy, and publicly funded research initiatives such as the Fraunhofer Circonomy Hub for Circular Carbon Technologies (58). In addition, the Bavarian Ministry of Environment has been supporting Repair Cafés (59), (60) since autumn 2024, strengthening repair, reuse, and consumer-oriented circular practices. Beyond funding programmes, local and research-driven initiatives further illustrate Germany’s CiE ecosystem, such as the City of Munich’s “Circular Munich” initiative (61). Finally, instruments like the Bavarian Resource Efficiency Award (62) underline the policy linkage between resource efficiency and broader circular economy objectives, even if resource efficiency represents only one component of comprehensive CiE strategies.

S3-strategy

The **National Circular Economy Strategy** (NKWS) (63) is a cornerstone of Germany's approach to sustainability. This strategy, drafted in June 2024, sets ambitious goals to reduce primary raw material consumption and close material cycles. It aims to maximise the use and reuse of materials, preserving their value and promoting resource efficiency to enhance the country's industrial resilience and innovation. A life cycle perspective is central to this - starting with product design, through production and consumption, logistics through to recycling, reparability and reuse. All stages of value creation are geared towards circularity. This guiding principle is in line with the Circular Economy Action Plan of the European Union (EU) and supports the goals of the German Sustainability Strategy (Deutsche Nachhaltigkeitsstrategie) (64). For example, only 13 % of the materials used today are secondary raw materials. The aim is to double this figure by 2030, in line with the EU’s objective. Another example is waste reduction: 10 % less waste per capita by 2030 and 20 % less by 2045, both compared to 2020. The German Circular Economy Strategy could therefore serve as a model example — even though it was developed under the

previous federal government, and it remains to be seen how it will be put into practice. In short, the German Circular Economy Strategy aligns with the EU Circular Economy Action Plan and supports the objectives of the German Sustainability Strategy.

For sector specific measures in the construction & building sector, the federal government will implement binding guidelines and criteria on circularity in federal procurement, incorporating considerations of environmental impact. It will engage companies and associations in the building materials industry to discuss ways to increase the supply of recycled aggregates, particularly through higher-value utilization of construction waste and excavated soil. Additionally, the government will promote digital platforms for the collection and evaluation of used components. An implementation concept will be developed in collaboration with the construction industry.

For the plastics sector the strategy aims to increase the use of bio-based plastics and improve recycling rates, with only 35% of plastic waste currently recycled. The recycling of plastics is also made more difficult by the enormous variety of plastic types and combinations with a wide range of additives. Concrete measures in this sector are limiting the variety of materials for plastics, strengthening the proportion of recycled plastics, removing barriers to the use of recycled materials through standardization, optimized results for plastics and to research funding with emphasis on R&D projects. The strategy lists mechanics and mechatronics under digitalization rather than separately. There is an initiative for developers and designers jointly with stakeholders to develop standards for the effective use of digital tools for circular design especially as open-source solutions. Digital Product Passport initiative is publicly funded by national authorities and ministries. Funded projects support the introduction of product passports, low threshold offers and services are being developed for SMEs as part of specific funding program to develop Product Passport at early stage of EU regulation.

Concerning Bavaria, as the German focus of the CURIOST project, it has several relevant strategies in the field. The **Bavarian Sustainability Strategy** (65) was created on the foundations of the UN's SDGs, while the most important part regarding the CURIOST project is SDG 12 "Sustainable consumption and production". It emphasizes the further development of circular economy through the efficient use of resources and increased use of secondary raw materials, transition to sustainable and bio-based economy, reduction in the consumption of natural resources and raw materials (construction sector), and reduction of packaging and packaging waste. The **Bavarian Bioeconomy Strategy** (66) is encompassing a lot of important industrial sectors, also ones relevant to the CURIOST project. For the sector of construction and building measures include, that renewable raw materials can also be used to produce insulating material, concrete additives can be made from biogenic raw materials and bio-based asphalt are being tested. Climate protection continues through building with wood, whereas Bavaria is above the national average for timber construction. Also, bio-based chemicals and polymers can serve as alternatives to conventional plastics.

The Free State of Bavaria decided in July 2024 to create a **Bavarian Circular Economy Strategy** (BayKWS) (67), which is currently still under development. BayKWS is intended to pave the way for a sustainable and resource-conserving economic system in Bavaria and thus establish a clear orientation for the Bavarian economy. In this important priority area, the Free State of Bavaria is

relying on voluntarism, self-responsibility, and cooperation. government. For this reason, BayKWS is being developed in close cooperation between stakeholders from the industry and the state government. A regional Bavarian strategy can specifically address the local economic structure to meet the different requirements and potentials of the sectors. BayKWS focuses on six different sectors, including “mobility”, “metal & mechanical engineering”, “construction & infrastructure” and “plastics & packaging”, and is therefore highly relevant to the CURIOST project’s context.

The "Mission RC20/25" (68), which is of great relevance to the construction sector, is to be mentioned in this context. In order to strengthen awareness and to exploit the potential of recycled building materials, the Bavarian state government adopted the "Mission RC20/25 - Bavaria sets on environmental protection" package of measures for the increased use of recycled building materials on 29 March 2022. It aims to increase the proportion of construction waste processed in recycling plants by 20 % by 2025, viewing this as a task for society as a whole. The Free State of Bavaria will act as a role model by promoting the use of recycled building materials in construction projects carried out by the state as far as is technically and economically feasible, by encouraging Bavarian local authorities to adopt the same approach, by proposing to all departments exemplary projects or construction projects that can be carried out using recycled building materials, and by promoting recycled building materials in the context of urban development.

The Bavarian Innovation Strategy, an updated edition of RIS3 strategy, continuously scrutinizes and optimizes existing priorities through evidence-based monitoring, which is even more closely integrated into the governance structures of strategic innovation policy. This will make it possible to adapt Bavaria's innovation strategy to developments in research, the economy and society - as well as challenges such as the coronavirus pandemic - and ensure that funds continue to be used in a targeted manner to transform the economy in the long term. The topic “materials” is relevant for CURIOST project, especially the area “sustainable use of raw materials”: The growing demand for raw materials and energy makes the search for new answers regarding resource efficiency and the circular economy become increasingly important. Key topics here include design for recycling/disassembling of materials science. The sector mechatronic is addressed in the topic “digitalisation”: Bavaria has internationally recognized technological strengths in the fields of Industry 4.0, robotics and mechatronics.

To conclude, Germany, and as shown the region Bavaria, have established a robust policy framework to support the transition to a circular economy and sustainable product development. The combination of national strategies like the German Circular Economy Strategy and regional initiatives in Bavaria creates a comprehensive approach that addresses key sectors and leverages technological innovation. While these policies set ambitious goals and provide a clear direction, the true test will be in their implementation. The success of this transition will depend on the ability of businesses to innovate, the effectiveness of government support, and the willingness of consumers to embrace new products and practices. As these strategies continue to evolve, they are likely to serve as models for other regions and countries seeking to implement circular economy principles. The emphasis on digitalization, bioeconomy, and sector-specific approaches provides a blueprint for balancing environmental sustainability with economic growth and innovation. For German companies, the national approach to sustainability legislation is quite a

challenge, but also a huge opportunity. They can position themselves as pioneers in sustainability, but they must also be careful not to collapse under the financial and bureaucratic requirements.

4.3.2. regional needs

Both the federal government of Germany and the state government of Bavaria have defined, or are in the process of developing, circular economy strategies featuring specific goals, indicators, and measures. Effectively putting these strategies into practice and meeting the targets presents the key challenge, demanding engagement from both the business sector and the wider public.

Currently, the main cross-sectoral challenges for implementing CiE activities are:

- **Financial Constraints**: SMEs often face difficulties in obtaining financial support from the government or EU initiatives for essential initial investments.
- **Administrative Burdens**: Significant documentation requirements and excessive bureaucracy can hinder the adoption of sustainable practices.
- **Regulatory Disadvantages**: Strict EU regulations may create a competitive disadvantage for businesses within the EU on the global market. This is further compounded by imported products from non-EU countries that may not adhere to the same environmental administrative obstacles, e.g. enormous documentation requirements/excessive bureaucracy can hinder the implementation of sustainable measures
- **Limited Awareness of Circular Economy Benefits**: Many SMEs lack a comprehensive understanding of the importance of the circular economy. Consequently, economic growth targets are frequently pursued without adequate consideration of environmental impacts.

4.3.3. sector analysis

Within the CURIOST project, the Bavarian project partners BI and UCB are focusing on the sectors of mechanics and mechatronics, plastics and construction, as these three sectors are of high relevance for the Free State of Bavaria. They have been focusing on sector-specific priority intervention areas, on the assumption that these will lead to more impact and have identified various challenges for implementing CiE activities within these sectors.

mechanics & mechatronic

For the mechanics and mechatronics sector, the implementation of take-back systems for broken components presents several significant challenges. Chief among these are the high costs associated with transportation, as well as complex import and export regulations. Additionally, both customers and manufacturers are required to invest considerable effort: customers must return the defective components, while manufacturers have to undertake the reconditioning or recycling of these parts. Furthermore, there is limited acceptance and a general lack of knowledge or resources regarding the use of advanced technologies such as 3D printing and AI-supported solutions. These innovative methods could help to reduce production waste and conserve resources during prototype development, yet their adoption remains low within the sector.

Plastics & packaging

In the plastics and packaging sector, the adoption of recycled materials remains limited, largely due to hesitance among key decision-makers like CEOs and designers. Their reservations often stem from concerns about the perceived lower quality and higher costs associated with recycled materials, as well as rigid standards regarding properties such as color. Additionally, sustainable bioplastics are not being leveraged to their full potential. While biobased plastics offer a promising alternative to conventional, fossil-based options, their effectiveness is influenced by sourcing and recycling conditions. Unlocking their full benefits requires greater investments, expanded research efforts, and increased awareness among both businesses and consumers.

construction & building

The construction sector faces major obstacles to implementing circular economy principles. One of the main challenges is the high cost involved in creating circular buildings and the economic inefficiency of recycling construction waste, particularly when the recovered material yields are low. Additionally, the sector is hampered by a complicated legal landscape, where excessive regulations and lengthy approval processes make it difficult to launch and develop recycling initiatives.

4.3.4. concrete actions

Table 4 outlines concrete actions for BAVARIA which can be implemented or supported by the project partners BI and UCB - to promote circular economy practices across key sectors. It details the necessary interventions, identifying who is responsible for implementation, the objectives of each action, and the target groups. It also specifies the tasks and activities required, defines success criteria, and sets time frames for completion. Furthermore, the table highlights the resources needed and discusses potential funding possibilities to support these initiatives.

Table 4: concrete actions for Germany (Bavaria)

Action	**Subjects** *(Who is implementing the actions)*	**Objectives** *(What do we want to achieve?)*	**Target groups**	**Tasks & Activities** *(What activities are necessary to achieve the objectives?)*	**Success criteria** *(What are the main results you expect? How do you define the success of the activity?)*	**Time Frame** *(By when do the tasks need to be completed to trigger the change?)*	**Estimated Costs**	**Resources needed** *(What or who can help or will be responsible to achieve the tasks/objectives ? Time, costs?)*	**Funding possibilities**
1. Knowledge Transfer in Reverse Logistics	BI and UCB in cooperation with Bavarian chambers, industry associations, sector experts, and experienced companies.	The aim of this action is to actively encourage companies to develop and implement reverse logistics systems for their products, components, and packaging. A particular focus is placed	Primarily mechanics and mechatronics companies located in Bavaria.	Organisation of a dedicated conference on reverse logistics Presentation of successful industry case studies Facilitation of knowledge exchange between	Companies apply the acquired knowledge in practice Establishment or expansion of reverse logistics systems within companies Increased engagement of	Planned for 2027 or 2028, depending on the availability of funding.	25.000 – 40.000 EUR	Support from Bavarian ministries Contributions from experts and practitioners Organisational and logistical resources for the conference	Regional, national, or European funding programmes Participation fees

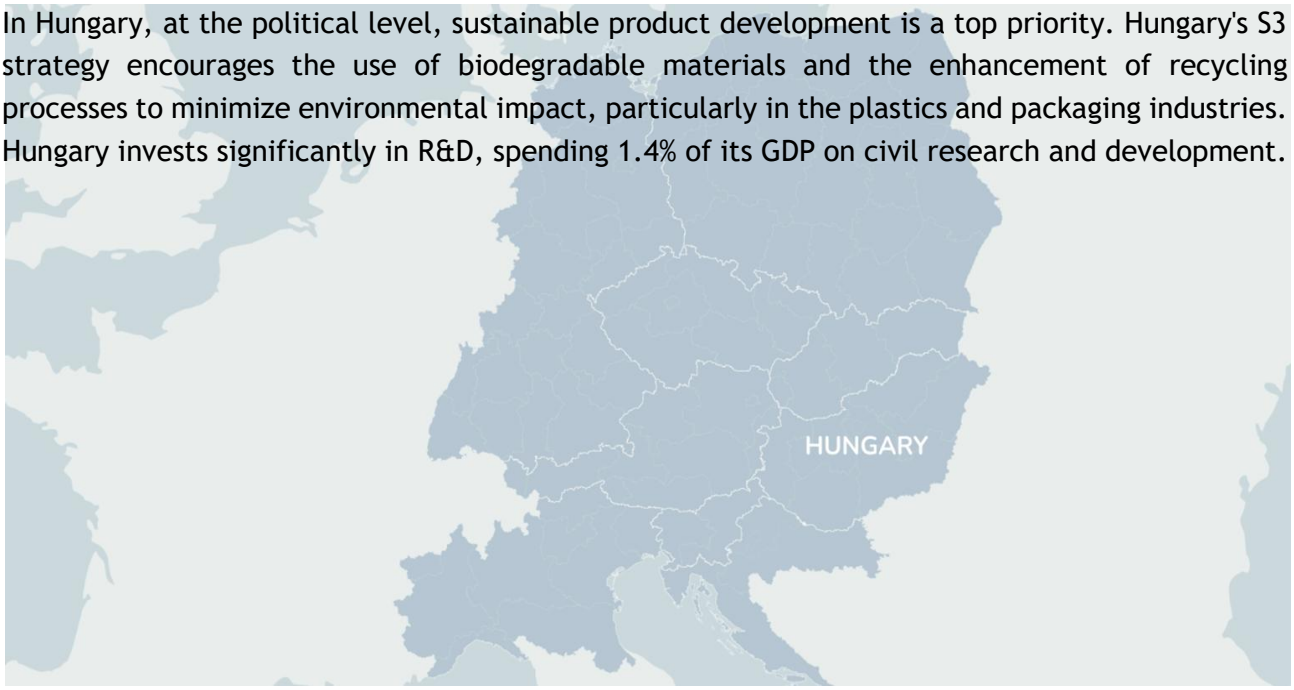
		on demonstrating the potential of AI solutions		companies, experts, and stakeholders Discussion of challenges and potential solutions in implementation	companies with reverse logistics concepts				
2. Increasing Acceptance of Recycled and Biobased Plastics	BI and UCB in cooperation with Bavarian chambers, networks, clusters, and associations.	This action aims to raise awareness of the benefits of recycled and biobased plastics among both companies and consumers. The goal is to promote the use and acceptance of recycled or biobased material alternatives.	Companies in the plastics sector in Bavaria (especially CEOs, product designers, injection moulding companies, and suppliers of biobased materials) Consumers	For the business sector: organisation of webinars to provide knowledge and practical insights For consumers: implementation of an image and awareness campaign Development and dissemination of informational materials and best practice examples	Increased knowledge within companies and a shift towards more sustainable materials Higher use of recycled or biobased plastics in products Increased willingness among consumers to purchase products made from more sustainable materials	Planned for 2027 or 2028, depending on the availability of funding.	Webinars: 5.000 – 8.000 EUR Awareness campaign: 20.000 – 25.000 EUR	Support from Bavarian ministries Communication and marketing resources Expert input and high-quality content	Regional, national, or EU funding programmes Participation fees Co-financing by companies
3. Sharing Best Practice Examples in	BI and UCB in cooperation with Bavarian	To promote knowledge exchange and	Public and private clients Architects	Organisation of field trips to best	Increased awareness and understanding	Planned for 2027 or 2028,	15.000 – 17.000 EUR	Support from chambers of crafts,	Regional, national, or

Circular Construction	chambers, networks, clusters, and associations.	awareness in the field of circular construction. The action seeks to showcase innovative approaches and successful best practice examples while supporting their transferability to other projects and stakeholders.	Craft enterprises Businesses and public authorities	practice companies Use and dissemination of results from the Interreg project “RiBa” Facilitation of exchange between different stakeholder groups	of circular construction principles Integration of circular approaches into construction projects Growing number of stakeholders implementing circular solutions	depending on the availability of funding.		chambers of architects, and municipal associations Organisational resources for study visits and events	European funding programmes
4. Support of Regional and National Circular Economy (CiE) Activities	BI and UCB in cooperation with Bavarian chambers, networks, and clusters.	To improve the flow of information regarding CiE initiatives and measures within the frameworks of the National Circular Economy Strategy (NKWS) and the Bavarian Circular Economy Strategy (BayKWS). The aim is to better integrate Bavarian	Bavarian companies Other relevant stakeholders in the field of CiE	Organisation of webinars and events Dissemination of information via newsletters and social media Provision of up-to-date information on funding opportunities, platforms, and advisory services	Increased participation of Bavarian stakeholders in CiE activities Improved access to funding and support measures Stronger networking within the circular economy ecosystem	Start 2027 – ongoing (continuous activity) Depending on the availability of funding	20.000 – 25.000 EUR per year	Support from national and federal ministries Communication and networking capacities	Regional, national, or European funding programmes

		stakeholders and facilitate their access to relevant initiatives and funding opportunities.							

4.4. Hungary

In Hungary, at the political level, sustainable product development is a top priority. Hungary's S3 strategy encourages the use of biodegradable materials and the enhancement of recycling processes to minimize environmental impact, particularly in the plastics and packaging industries. Hungary invests significantly in R&D, spending 1.4% of its GDP on civil research and development.



In Figure 46 the results from the Hungarian chapter are summarized.

Hungary	Focus	Gaps	Opportunities
§ Regulation	Policy alignment	Missing best practices	Knowledge exchange
Regional needs	Stakeholder engagement	Low awareness	Peer learning
Sectoral needs	SME manufacturing	Limited circular skills	Training formats
! Concrete Actions	Action refinement	Low ownership	Capacity building

Figure 6: Summary of the Hungarian perspective



4.4.1. policy analysis

implementation of EU-directives

The European Union realized several policies that are important in Hungary's green transition. Policies like the Single-Use Plastics Directive (69) and Construction Products Regulation (70) help drive eco-friendly innovation, reduce waste, and foster sustainability across Hungary's industries.

Hungary has aligned its national legislation with the **Corporate Sustainability Reporting Directive (CSRD)** (9) by updating its Accounting Act (Act CVIII of 2023) (71) to reflect the requirements of Directives (EU) 2022/2464 and 2025/794. The directive emphasizes standardized reporting using European Sustainability Reporting Standards (ESRS), digital tagging of sustainability data, and external assurance to ensure the reliability of disclosed information. The **amending Directive (EU) 2025/794**, which further refines and extends the CSRD framework, was adopted on **15 April 2025**. This legislative update incorporates ESG reporting obligations for companies, including SMEs, and reflects Hungary's transposition of Directive (EU) 2022/2464 and Directive (EU) 2025/794 into national law.

For the **Corporate Sustainability Due Diligence Directive** (CSDDD) (10) there is no Hungarian equivalent, it applies directly in Hungary, thus Hungarian companies must report in accordance with the EU regulations. Hungarian companies with foreign parent companies, as part of their supply chain are already aware of the regulation and show efforts to comply with it, but this cannot be said about Hungarian SMEs. They lack adequate knowledge of the rules, and they face difficulties in attempting to comply with them thus awareness raising among them would be essential to reach the goals.

Inappropriate (too short or postponed) deadlines for implementing new rules and regulations is reducing the impact of the measures and hindering the success of the regulations.

The Hungarian counterpart of the **Reduction of the impact of certain plastic products on the environment Directive** ((EU) 2019/904) (4) is the 301/2021 (VI. 1.) governmental regulation (72) about extended producer responsibility, prohibition of single-use plastic products, promoting alternative resources for plastics and reduction targets and reporting obligations. This regulation aligns with broader EU objectives to reduce plastic waste and promote sustainable practices across various sectors.

Hungary, like other EU Member States, must comply with the **Packaging and Packaging Waste Directive** ((EU) 2025/40) (7), which imposes recycling quotas and waste reduction targets on packaging materials, encouraging innovation in the packaging industry. Hungary's official alignment with this regulation is published in the Hungarian Official Gazette (Magyar Közlöny) (73), specifically in the 2025. évi LXVII. törvény and related government decrees. Hungary's 2025 legislation introduces mandatory recyclability, reuse, and composability standards for all packaging placed on the market, in line with Regulation (EU) 2025/40. The Act sets progressive targets for packaging reuse and bans certain single-use formats, aiming to reduce environmental impact and harmonize with EU circular economy goals. It also mandates digital labelling and traceability systems for packaging materials, ensuring compliance and transparency across the supply chain. As a result, Hungary has introduced a plastic bottle deposit system, which can be

seen as a Hungarian success story for sustainability. More about this can be read in the national policy analysis.

Hungary has begun implementing **Directive (EU) 2024/1799 on the Right to Repair** (11) through a new legislative act, Act LXXVIII of 2025 on the Repair of Consumer Goods and Promotion of the Circular Economy, published in the Official Gazette on June 27, 2025 (74). The Act introduces mandatory repair obligations for manufacturers and sellers of consumer goods, aligning national law with EU circular economy goals. The Hungarian Parliament adopted the "2025. évi LXXVIII. törvény a fogyasztási cikkek javításáról és a körforgásos gazdaság előmozdításáról" (Act LXXVIII of 2025 on the Repair of Consumer Goods and Promotion of the Circular Economy). This law mandates that manufacturers must offer repair services and spare parts for key product categories (e.g. washing machines, smartphones, vacuum cleaners) even after the warranty period. It also introduces a national repair platform and standardized repair information forms, ensuring transparency and accessibility for consumers.

The EU 2024/1275 regulation or **Energy performance of buildings Directive** (12) is a key element in the EU's efforts in promoting circular economy as it fosters the environmental performance of all buildings. It describes standards for energy efficiency, waste reduction and for the use of resources and requires assessment regarding the sustainability of the buildings from the building to the demolishing stage. Its main concern is the use of environmentally friendly materials and solutions. As it is mandatory the Hungarian regulations align with this EU regulation. The 191/2009 Government Decree Act on Energy Efficiency (75) regulates energy performance and emphasizes the use of sustainable building materials, and waste reduction throughout the complete construction lifecycle. It mandates stricter controls on environmental impacts, focusing on resource efficiency, recycling of construction materials, and reducing emissions. Hungary's implementation includes minimum energy performance requirements, inspections of HVAC systems and financial incentives to support compliance with the regulations and to promote sustainable building practices. Despite of the achieved progress, the building industry and the regulations face many challenges. All Hungarian buildings must have an Energy Performance Certificate that is also used in the conclusion of purchase contracts. It is important to mention, that the Hungarian legal environment allows procurement entities to consider green criteria into their purchasing processes, however they are only obligatory in the public catering and road transport sectors. This situation highlights the importance of the commitment of officials towards green economy.

EU Innovation Fund (76): This funding program supports research and development in sustainable technologies and practices in Hungary, particularly in mechanics, construction, and materials science.

Through these policies, Hungary is encouraged to embrace sustainable product development and move towards a more resource-efficient, low-carbon economy.

national policy analysis

Hungary has numerous strategies, which are all interlinked and have common goals, they force the transition to a greener economy and promote practices to reduce environmental impact. But they operate at different levels and with varying degrees of specificity and outline detailed actions

and targets only for key industries like automotive, agriculture, energy, and ICT. These plans are informed by national priorities and are designed to boost the competitiveness and innovation capacity of these sectors. The strategies support the transition to a greener economy with several methods and initiatives, often facilitating but occasionally hardening the opportunities of SMEs operating in the four key sectors within the CURIOST project. There are initiative steps taken by SMEs that are responding to foreign partners' sustainability requirements and customer needs. While efforts are made to foster green innovation, there are still gaps in the ecosystem.

In Hungary the **National Sustainable Construction Economy Strategy** (77) endorses the efficient use of resources to reduce the construction industry's environmental impact. It focuses on the use of sustainable building materials, promotes innovative technologies and energy saving solutions. It encourages the development of sustainable building material and innovative technologies to reduce carbon emissions. The strategy addresses the importance of education and encourages collaboration between industry stakeholders, government and research institutions.

Hungary's **Research, Development, and Innovation Strategy's** (78) key development areas are technology development, scientific research connected with the close cooperation between universities and participants from the industry sector. The focus is, just like in the other strategies, on the innovation in environmental technologies and the use of renewable energy.

The Hungarian **National Energy and Climate Plan** (79), aligning with the above-mentioned strategies, focuses on achieving energy security, reducing greenhouse gas emissions and increasing the use of renewable energy sources. It promotes energy efficiency, encouraging the adoption of green technologies, and fostering innovation in sustainable practices. Collaboration between academia, industry, and government should be stronger, and there is a need for more robust support networks for startups and SMEs in green sectors. The adoption of these new, sustainable technologies requires supportive infrastructure, such as renewable energy grids or recycling facilities. These necessary infrastructures are underdeveloped in most Hungarian regions, which poses a significant challenge to the green transition.

The National Smart Specialisation Strategy was written for the programming period 2021-27. More on this strategy can be read in the following subchapter.

Although, the Hungarian national strategies are available, they are also rather theoretical and too general, and do not contain quantifiable goals, exact timeframe for the implementation, as well as no tangible indicators. The Strategies developed in the last 5 years have made substantial progress in promoting digitalization, with digital technologies being a cornerstone of the country's innovation strategy. The circular economy is gaining momentum, but its implementation is less advanced, with significant room for improvement in infrastructure and awareness. While there is notable support for early-stage innovation, scaling these innovations to market-ready products and services remains a challenge. This is often due to limited access to venture capital and market development resources. The aspects of the COVID pandemic were already considered, however the effects of the latest international economic events (Ukrainian-Russian war, energy crisis, economic effects of the sanctions against Russia) are not considered. The main challenges that need to be addressed include closing the digital divide, enhancing the circular economy

infrastructure, and streamlining support mechanisms to make them more accessible and effective for all businesses, particularly SMEs.

Regarding the packaging sector and based on Eurostat data (80), Hungary faced serious challenges with packaging waste. Hungarian households generated packaging waste above the European average while the recycling proportion stayed way below it. Most of the packaging material used is paper, plastic and glass. Plastic packaging was the biggest problem, as its recycling rate remained low. There was an urgent need for centralized and coordinated actions and effective regulations from the government to reach the European standards and to be able to reduce the use of single-use packaging. In Hungary, 3.2 billion bottles, cans, and glass containers were circulated annually, that is 333 items per person. That was, before a new deposit return system (DRS) operated by MOHU (Hungarian Waste Management Organization) in 2024 was introduced. By September 2025, the system has surpassed 3 billion returned beverage containers (bottles, cans, and glass containers), with daily returns averaging 15 million items and a peak rate of 200 items per second. The system incentivizes recycling by offering 50 HUF per returned piece, which can be redeemed as cash, coupons, or charitable donations. MOHU aims to reach a 90% return rate by 2027, inspired by Slovakia's 70% and the Baltic countries' 90% rates. Consumers have received over HUF 120 billion in store vouchers, and the rate for PET bottle returns stands over 90%, which makes **MOHU's REpont system now one of the most efficient in Europe.** Here are some additional points describing the success of the system:

- Mohu has around 3,000 DRS machines that are operating at over 95% capacity.
- Manual returns are available at 1,700 points around the country.
- Retail impact: Small shops benefit from increased foot traffic and compensation; large chains face reduced fees under new tiered system
- Environmental Impact - The system has significantly reduced landfill waste and improved Hungary's recycling rate, which was previously around 30%.
- Returned containers are reprocessed into new packaging, supporting circular economy goals.
- MOHU plans further expansion and integration with charity donation options and mobile app features (81) (82).

Hungary, and here in the focus the University of Pécs, provides extensive educational opportunities for students to prepare for the sustainable transition. An enhancement in sustainability related STEM can be observed. The Faculty of Business and Economics at the University of Pécs offers sustainability-focused courses through its dedicated Sustainability Centre. These courses emphasize sustainable development, circular economy, and responsible business practices, integrating theory with real-world applications. The centre also supports research and innovation projects that align with the UN Sustainable Development Goals and Hungary's green transition strategy. There is a basic elective online course available for university students called "Sustainability in the 21st Century". This course helps plant the seeds in university students that no matter what field they work in, sustainability should always be considered.

The University of Pécs Faculty of Business and Economics offers two specialized sustainability and ESG-focused programs:

1. “Fenntarthatósági beszámolás és adatelemző specialista” (Accredited ESG Consultant /Sustainability Reporting Data Analysis Specialist) (83)

- A postgraduate program starting in autumn 2025, aimed at professionals who want to master ESG reporting and data-driven decision-making.
- Covers corporate sustainability reporting (CSRD), ESG analytics, and tools like Power BI.
- Duration: 2 semesters, with 60 credits. Tuition: 400,000 HUF/semester

2. ESG “Tanácsadó mikrotanúsítvány” (ESG Consultant) (84)

- A micro-certification program focused on ESG compliance, sustainability law, and performance measurement.
- Duration: 2 semesters, 200 hours, with 60 credits. Tuition: 400,000 HUF/semi-kid.

subsidies

In 2024, Hungary increased sustainability-related subsidies for SMEs in plastics, packaging, building, and mechatronics, driven by new ESG regulations and circular economy goals. The overall funding picture shows growth, especially in green innovation and waste reduction.

Subsidies for sustainability-related projects have increased in 2024, especially for SMEs in sectors like plastics, packaging, construction, and mechatronics. This growth is tied to Hungary’s alignment with EU Green Deal/Clean Industrial Deal goals and its national ESG regulation (Act CVIII of 2023), which mandates environmental and social responsibility reporting for companies.

In 2024, more programs launched focusing on the circular economy and ESG compliance. Priorities have shifted from broad innovation to clear sustainability goals like carbon reduction, waste management, and resource efficiency. SMEs now face ESG reporting requirements that affect subsidy eligibility.

The Hungarian Recovery and Resilience Plan (“Helyreállítási és Ellenállóképességi Terv”) allocates approximately 2,300 billion HUF (€ 5.8 billion) in strategic development funding by 2026, with over 48% dedicated to climate goals and sustainability and 29.8% for digital transformation. SMEs can benefit from targeted support in green energy (492 billion HUF for renewable energy and energy efficiency programs), circular economy (43 billion HUF to support waste reduction, recycling, and sustainable industrial practices), and sustainable transport (558 billion HUF for zero-emission buses and railway modernization). The plan emphasizes renewable energy expansion, green innovation, energy retrofitting, energy efficiency, and the transition to a circular economy — all relevant to SMEs in plastics, packaging, construction, and mechatronics sectors.

Hungary’s 2025 updates to the **GINOP Plusz** (85) and **KEHOP Plusz** (86) programs include new funding calls that support circular economy initiatives, eco-design, and green manufacturing technologies. These calls aim to boost the competitiveness and sustainability of Hungarian SMEs and industrial players, particularly in disadvantaged regions. The programs are part of the EU-

funded Széchenyi Plan Plus (2021–2027), aligning with the EU Green Deal/Clean Industrial Deal and national climate goals.

S3-strategy

The **Hungarian Smart Specialization Strategy** (S3) (87) emphasizes sustainable product development across key sectors, including plastics, packaging, construction, and mechanics, with a focus on innovation and environmental responsibility. In 2025 it was supplemented with a new Programme Strategy that introduces updated funding calls and monitoring tools to support regional innovation and circular economy goals. This update does not replace the original S3 strategy but enhances its implementation framework. The 2025 Programme Strategy (88) was officially published by the National Research, Development and Innovation Office (NKFIH) in January 2025.

In the plastics and packaging industries, Hungary aims to reduce environmental impact by promoting the use of biodegradable materials and enhancing recycling processes. This approach is aligned with the EU's circular economy goals, targeting a reduction in single-use plastics and encouraging the development of eco-friendly alternatives. The strategy also encourages research and development in the creation of advanced, sustainable packaging solutions that reduce waste and carbon footprints throughout the product lifecycle. One of the main advantages of the Hungarian S3 strategy is that it meets the specific regional needs and addresses the most important issues. It includes a wide range of stakeholders: industry members, local governments and the academic representatives of universities were invited in the creation process of the strategy. Regional and international cooperation is encouraged by the strategy. The country has conducted comprehensive assessments to pinpoint key sectors where regions can excel, such as advanced manufacturing, agriculture, health, and information and communication technology.

In the construction and mechanical sectors, Hungary's S3 strategy supports the adoption of green technologies and sustainable materials to minimize the environmental impact of infrastructure and manufacturing projects. The strategy focuses on energy-efficient buildings, incorporating materials that lower energy consumption, as well as sustainable urban planning. In the mechanical industry, innovation is geared towards the production of energy-saving machinery and the optimization of industrial processes to reduce resource use. By integrating sustainability into these key sectors, Hungary aims to boost its competitiveness while addressing the global challenges of resource depletion and climate change. The scope of monitoring and implementation process is comprehensive that ensures the continuous tracking of progress. It includes regular data collection, adaptive management and regular evaluations to ensure that the strategy adapts to challenges and remains relevant. It not only supports existing industries but also focuses on innovation, promotes cluster development and enhances research and development activities. The S3 strategy prioritizes issues such as renewable energy, sustainable agriculture and waste management, thus it can be considered as enabler of circular economy and sustainable product development. It encourages especially the participants of the plastic industry to consider green technologies and to adopt to sustainable practices, to reduce waste and use the resources efficiently. It supports the creation of environmentally friendly materials and enhances recycling procedures; thus, it forces the green transition. The strategy’s measurable impact is tied to financial and legislative support (grants and incentives) as Hungarian companies highly depend on these.

In conclusion, Hungary only has national strategies since regional or city-level strategies are unnecessary given the size and degree of the economic development of the country. There are some sector-specific strategies currently under development that would provide the necessary guidance and substantial financial support to SMEs to make meaningful progress toward sustainability. The Hungarian S3 strategy promotes innovative concepts but also relies on the current system by trying to develop areas of deficiency. Regardless of the available theoretical strategies, in some cases there are delays in establishing governmental institutions to fulfil the described duties. Absent or frequently reorganized authorities hinder the execution of duties. By focusing on smart specialization, it encourages regions to develop niche areas of expertise, fostering cutting-edge innovation rather than simply maintaining the status quo. It has been particularly important for regions traditionally dependent on a few industries, helping to create new growth opportunities and reduce vulnerability to economic shocks.

It is important to mention here that Hungary has elected a new government in April 2026, where new institutions and ministries are setting up and reallocation of tasks and responsibilities are going on. Therefore, development in these matters might be expected in coming years.

4.4.2. regional needs

The S3 strategy emphasizes innovation, environmental responsibility, and sustainable development across several key sectors, including plastics, packaging, construction, and mechanics. The S3 strategy is aligned with European Union (EU) regulations, making it instrumental in fostering green transition while addressing the specific sector needs and challenges faced by the country. The National Research, Development and Innovation Agency manages nationwide the implementation and monitoring of S3 strategy. Moreover, there is a significant emphasis on research and development for advanced sustainable packaging solutions.

The strategy encourages innovation that minimizes waste and carbon footprints throughout product life cycles, thereby enhancing Hungary's competitiveness. The strategy further identifies the need for sector-specific initiatives. Key sectors for growth include advanced manufacturing, agriculture, health, and information and communication technology (ICT). In the construction and mechanical sectors, the S3 strategy actively supports the adoption of green technologies and sustainable materials, emphasizing the importance of energy-efficient buildings and innovative machinery designed to minimize environmental impact. However, the country faces several sector-specific needs that must be addressed to realize its sustainability goals. For instance, companies have expressed a strong need for clear strategic guidance and significant financial support as they transition towards sustainable practices. The current landscape reveals a critical requirement for sector-specific strategies that can provide Small and medium-sized enterprises (SMEs) with the frameworks and resources necessary for meaningful progress. Moreover, the underdeveloped infrastructures for recycling and renewable energy pose significant challenges to the green transition in Hungary. Without adequate support systems for startups and SMEs in green sectors, the country risks falling short of its sustainability objectives. Awareness and education are also paramount in this effort. Increased awareness of sustainability among the civil society, the next generation who become the buyers of the future is crucial. Also, the knowledge of relevant regulations is necessary, especially among small and medium-sized enterprises. A gap

exists in knowledge regarding EU directives, which could hinder compliance and progress toward sustainability. Raising awareness and providing education about EU directives will be critical in ensuring compliance and fostering a culture of sustainability across sectors. Another major challenge is the access to finance. While funding opportunities are available, they are often insufficient or challenging for smaller enterprises to access. This limited financial support hinders SMEs' ability to invest in green technologies and commit to sustainable operations, which are necessary for achieving Hungary's broader environmental goals. Moreover, majority of Hungarian SMEs lack the foreign language knowledge and the confidence to enter the international market that hinders their development and experience exchange with economically more developed European companies. Inconsistent and ever-changing regulatory environment causes uncertainty and frustration among SMEs that can lead to inconsistencies, making it difficult to navigate the transition to sustainable practices effectively.

4.4.3. sector analysis

Hungary’s performance in circular economy indicators reflects certain strengths in societal behaviours, but weaknesses in business operations. The country has a circularity rate of 8.7%, which is below the EU average of 12.8%. Recent efforts to bolster the circular economy culminated in a national strategy published in 2023. This strategy aligns with the 2030 Agenda for Sustainable Development and the ambitions outlined in the European Green Deal, aiming to transition Hungary's economy toward more sustainable practices.

mechanics & mechatronics

Hungary's mechanics and mechatronics sectors are experiencing notable progress, boosted by cross-border investments and a favourable geographical position within Central Europe. The Hungarian government promotes research and development initiatives to drive advancements in automation and robotics. Despite the advancements, there is a lag in the pace of transformation toward circular economy practices in this sector compared to plastics and packaging. Continued investment in training and education is required to ensure that the workforce can meet the demands of an evolving market. In the mechanics and mechatronics industries, there is a strong demand for greater Research and Development (R&D) spending to investigate new manufacturing methods that prioritize sustainability. The development of supportive infrastructure (e.g.: renewable energy grids) is needed to leverage Hungary’s geographical location by attracting more international investments focusing on sustainable practices. The Hungarian industrial automation market, encompassing mechanics and mechatronics, is projected to grow at a compound annual growth rate (CAGR) of 10.2% from 2024 to 2030. This growth is driven by substantial investments from global automotive manufacturers such as Mercedes, BMW, Audi, and CATL, leading to increased demand for automation technologies in manufacturing that could facilitate the needed support.

plastics

The plastics industry in Hungary faces considerable challenges, primarily due to rising energy costs that have led to increased production expenses. Therefore, financial incentives are needed to support companies in adopting energy-efficient technologies and exploring alternative energy

sources. Hungarian companies are struggling to maintain profitability and long-term viability; thus, governmental support is essential for their survival. Transitioning to sustainable practices is essential, but companies need incentives and regulatory support to innovate effectively. Although some firms are exploring energy-efficient technologies and alternative energy sources, the expansion of single-use plastics underscores the critical need for international agreements. Hungary has implemented several regulations to address environmental concerns associated with plastics although there is still a strong need for more improvement i.e.: Environmental Product Fee (since 1995), Extended Producer Responsibility (EPR) (since 2023), Single-Use Plastics Ban, Green Public Procurement (GPP). Furthermore, the industry requires a shift in focus from recycling to reducing production of single-use plastics. There is an urgent need for comprehensive regulations that mandate reductions in plastic production and encourage innovation in biodegradable materials. It is essential to establish international partnering cooperation to establish recycling frameworks, as current recycling rates remain insufficient, with only 10% of global plastic waste being recycled. The Hungarian plastic industry comprised approximately 1,684 enterprises in 2022 achieving a turnover of €5.1 billion in the same year. Additionally, companies need access to the latest market developments and energy policies to monitor changes affecting their operations. A strong professional cooperation between stakeholders, policymakers and civil society is important to facilitate a cultural shift around plastic usage and promote a more sustainable mindset.

construction & building

The biggest challenges that the Hungarian construction industry faces is the declining demand and high inflation. Labor migration due to unfavourable economic situation and the low quality of vocational training are strengthening the shortage of specialists resulting in a supply-driven market. In June 2024, production volume in construction fell by 6.4%, signalling systemic issues. The National Federation of Hungarian Building Contractors has advocated for stimulating demand through improved financing conditions and public investments. Encouraging public-private partnerships and supporting local product usage can help stabilize the market. Increasing recycling rates of construction materials, aiming for a minimum 70% reuse and recycling of construction waste, remains a fundamental goal in the National Waste Management Plan. In the building and construction industry, a pressing need is to stimulate demand for sustainable practices and enhance financing conditions for eco-friendly projects. The sector is struggling with high inflation rates and a decline in municipal contracts, necessitating increased public investment and the creation of public-private partnerships to revitalize market stability.

There is also a critical requirement for improved recycling and reuse rates in construction materials, with the aim of achieving a minimum of 70% recycling of construction and demolition waste. Establishing new recycling centres and implementing a tracking and monitoring system for waste materials will significantly enhance the sector's circularity. Moreover, the industry requires greater emphasis on the use of local products to reduce dependency on imports. Initiatives that promote the integration of sustainable building materials - alongside comprehensive eco-design guidelines - will facilitate the construction of energy-efficient infrastructure and contribute to minimizing environmental impacts. Finally, enhancing workforce skills through targeted training

programs in sustainable construction practices is crucial to fostering a knowledgeable labour force capable of implementing these new approaches effectively.

packaging

In the packaging industry of Hungary, there is a growing emphasis on sustainability driven by consumer demand. Companies are introducing biodegradable and recyclable materials while adapting to the evolving local and EU regulations. Innovative packaging solutions are needed to ensure safe shipping in the recently fast-growing online commerce and enhance customer experiences. Cutting-edge technologies such as automation, IoT-enabled packaging, and digital printing are becoming more common that helps companies meeting increasing consumer demands for sustainability and the international requirements while improving operational efficiency. An immediate need is the development of sustainable recyclable and biodegradable packaging materials. In the packaging induction the adaptation of new materials is a key to competitiveness. Another critical need is for clear and consistent regulatory guidelines concerning packaging waste. Businesses require support in navigating EU regulations while simultaneously managing local compliance requirements. Educational initiatives aimed at both businesses and consumers can enhance awareness and acceptance of new packaging solutions. There is a strong need for collaboration between industry players to share best practices and innovations, which can foster a more significant collective shift toward sustainability in packaging processes.

As Hungary advances its national strategy aligned with the EU Circular Economy Action Plan, it must prioritize building the necessary infrastructures, improving access to funding, and fostering cooperation among businesses, governmental agencies, and educational institutions. The road to transformation is indeed challenging, but with a committed approach, strong investment in education and technology, and a supportive policy environment, Hungary can successfully navigate the transition and secure a sustainable future for its key sectors.

4.4.4. concrete actions

The activities outlined in Table 5 focus on implementing concrete actions across Hungary's sectors — mechanics, mechatronics, plastics, construction, and packaging — to advance sustainability and circular economy practices. These actions include fostering research and development, promoting energy-efficient technologies, expanding recycling and reuse initiatives, adopting biodegradable and recyclable materials, and enhancing vocational and professional training. Stakeholders such as governmental bodies, industry leaders, and educational institutions are tasked with executing these initiatives. The objectives are to stimulate market stability, improve environmental outcomes, increase competitiveness, and ensure workforce readiness. Key tasks involve building infrastructure, introducing eco-design guidelines, establishing comprehensive regulatory frameworks, and supporting collaboration and knowledge-sharing. Success will be measured by increased recycling rates, reduced single-use plastics, greater use of sustainable materials, improved demand for eco-friendly products, and a skilled workforce. Dedicated resources and funding possibilities, including public and private investments, are essential to achieve these objectives within defined time frames.

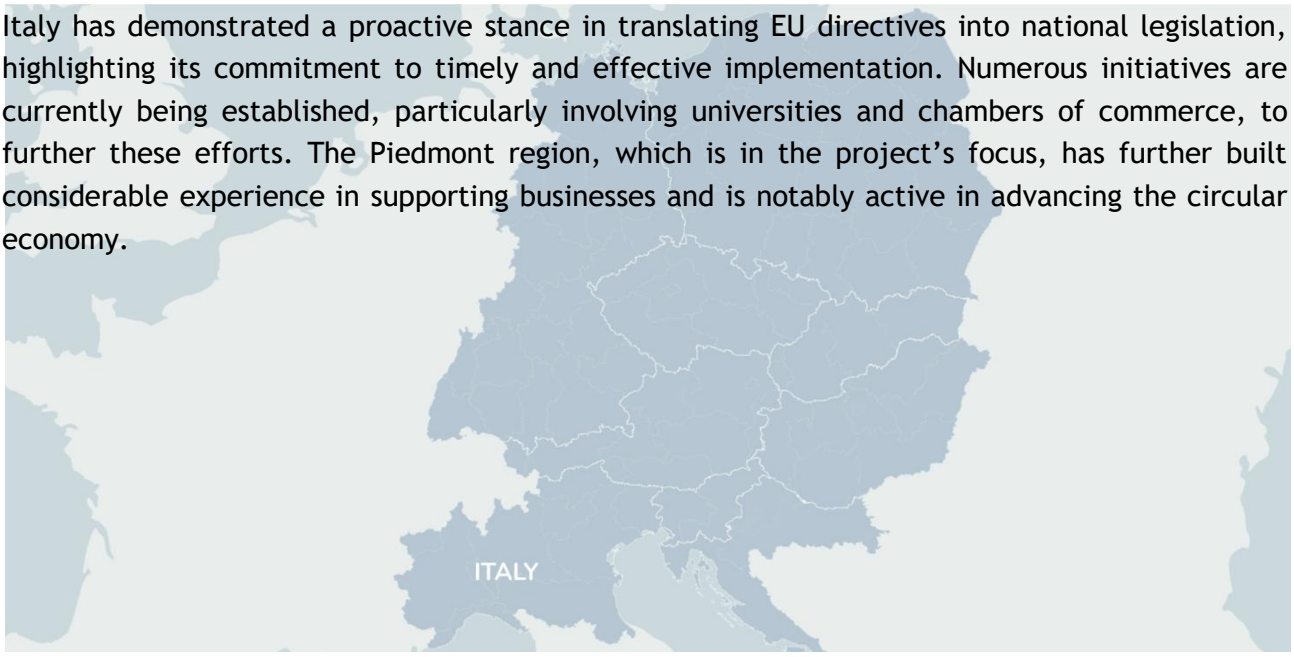
Table 5: concrete actions for Hungary

Action	**Subjects** *(Who is implementing the actions)*	**Objectives** *(What do we want to achieve?)*	**Target groups**	**Tasks & Activities** *(What activities are necessary to achieve the objectives?)*	**Success criteria** *(What are the main results you expect? How do you define the success of the activity?)*	**Time Frame** *(By when do the tasks need to be completed to trigger the change?)*	**Estimated Costs**	**Resources needed** *(What or who can help or will be responsible to achieve the tasks/objectives? Time, costs?)*	**Funding possibilities**
1. Awareness raising on regulations	Hungarian Government and Regulatory Bodies	Harmonization of policy frameworks	SMEs and stakeholders	1. Review and analyse existing EU directives to establish a harmonized national framework. 2. Organize workshops with stakeholders to	Clear national equivalents for CSDDD and CSRD published. Higher compliance rates among	1 year from the start of the initiative	1. min. EUR 5000 2. 1500-2000 EUR each workshop	Government agencies, regulatory bodies, legal consultants for reviewing legislation.	EU funding programs for regulatory development, national budget allocations.

				discuss compliance issues. 3. Develop official guidelines that clarify the obligations of businesses regarding sustainability directives.	local companies. Improved clarity for businesses on their regulatory obligations.		3.min. EUR 5000	Cost of workshops and consultations.	
2. Awareness raising on circular economic practices	Industry Associations and NGOs	Inform stakeholders about the advantages of circular economy	General public, SMEs, Producers	1. Organize a series of awareness-raising campaigns (webinars, workshops, newspaper articles) focused on sustainability practices. 2. Create educational materials and best practice templates for SMEs. 3. Knowledge sharing platform for SMEs and stakeholders.	Increased consumer demand for sustainable goods. At least 50 SMEs implementing best practice guidelines within the year.	9 months from the start of the initiative	1. 1500-2000 EUR each campaign element 2. min. EUR 5000 3. min. EUR 30.000	Collaborations with educational institutions, media partnerships for promotion, and training experts. Costs for promotional materials and events.	EU support grants, partnership with NGOs for sustainability projects.
3. Improve workforce skills on circular economy	Educational Institutions and Research Centers	Enhance sustainability related STEM.	Students (primary, secondary and university students), who are the future workforce	1. Develop the curriculum to contain sustainability and circular economy subjects. 2. Conduct training sessions for educators on the importance of sustainable practices. 3. Foster partnerships between industries and educational institutions for hands-on experience.	Improved skillsets in the workforce aligned with market needs. Increase in student enrollment in sustainability-related disciplines.	18 months from the start of the project	1. min. EUR 5000 / institution 2. 2000-3000 EUR / training session 3. min. EUR 1000/ action	Educational funding programs, industry partnerships for practical training setups.	Government funds for education improvements, grants from educational foundations.

4.5. Italy (Piedmont region)

Italy has demonstrated a proactive stance in translating EU directives into national legislation, highlighting its commitment to timely and effective implementation. Numerous initiatives are currently being established, particularly involving universities and chambers of commerce, to further these efforts. The Piedmont region, which is in the project's focus, has further built considerable experience in supporting businesses and is notably active in advancing the circular economy.



In Figure 47 the results from the Italian chapter are summarized.

Italy	Focus	Gaps	Opportunities
§ Regulation	Strategic planning	Implementation gap	Regional strategies
Regional needs	Industrial transition	Coordination deficits	Cluster synergies
Sectoral needs	Traditional industries	Low circular skills	Design innovation
! Concrete Actions	Roadmaps	Limited follow-up	Structured monitoring

Figure 7: Summary of the Italian perspective

4.5.1. policy analysis

implementation of EU-directives

The European Union (EU) has implemented several policies and regulations to promote sustainable product development and the transformation to a circular economy, which are particularly relevant to the Piedmont region for sectors such as mechanics & mechatronics, packaging, and plastics. The combination of EU-policies with national and regional strategies provides a comprehensive framework for supporting sustainable product development, circular economic transformation, and innovation in the Piedmont region's targeted sectors. These policies guide the region towards greater sustainability and competitiveness, particularly in the mechatronics, plastics, and packaging industries. Some of the most relevant policies are connected to: EU Green Deal/Clean Industrial Deal and Circular Economy Action Plan, EU Taxonomy for Sustainable Activities, ESPR Regulation, Waste Framework Directive, EU´s Plastic Strategy and support for innovations.

Starting with the **Reduction of the Impact of Certain Plastic Products on the Environment** (Directive (EU) 2019/904) (4), Italy transposed this directive through Legislative Decree No. 196/2021, which introduces restrictions on the use of single-use plastics and mandates producers to cover the costs of waste management, awareness campaigns, and data collection. This directive significantly impacts the Italian plastics and packaging sectors by driving a shift towards biodegradable materials and encouraging innovation in product design to reduce plastic use. Companies are required to adapt their production processes to comply with these regulations, potentially leading to increased costs but also opportunities for growth in sustainable products.

The **Common Rules on Promoting the Repair of Goods** Directive (11) (Directive 2024/1799) aims to promote the repair of goods as a part of the circular economy, reducing waste and extending the lifespan of products. It includes provisions for ensuring that consumers have access to repair services and spare parts. Italian considerations recon national repair initiatives: Italy has been proactive in encouraging repair and reuse through various national initiatives and regional programs. For instance, the Italian Ministry of Environment has supported repair initiatives as part of broader circular economic strategies.

Concerning the **Corporate Sustainability Reporting** (Directive 2022/2464) (9) Italy had already implemented similar requirements under Legislative Decree No. 254/2016, which aligned with the previous Non-Financial Reporting Directive. With the adoption of the CSRD in 2024, Italy updated its legislation to meet the new, more stringent requirements. The CSRD significantly impacts large Italian corporations, requiring them to enhance transparency and integrate sustainability into their business strategies. This will affect sectors such as mechatronics, where companies must report on their environmental impact, supply chain sustainability, and efforts to reduce carbon footprints.

Corporate Sustainability Due Diligence Directive (CSDDD) (Directive 2022/0071 (COD)) (10) on Italian Considerations of National Due Diligence Framework: Italy has been developing frameworks to support corporate responsibility and sustainability. This includes the implementation of voluntary guidelines and codes of conduct that align with the EU's broader goals. Therefore, future

impact will be: Once adopted, this directive will require Italian companies to enhance their due diligence processes, particularly in sectors with complex supply chains such as mechatronics and plastics. This will necessitate stronger internal controls and possibly lead to increased costs associated with compliance.

national policy analysis

National and regional policies in Italy and in Piedmont region, act as enablers of change towards a sustainable and circular economy. These policies are designed to be interlinked rather than contradictory, supporting sectors such as green chemistry, advanced materials, and sustainable manufacturing. National strategies are regularly updated to reflect global challenges like climate change, technological advancements and geopolitical events, ensuring that they remain relevant and effective in promoting a circular economy.

The transformation is not solely driven by SMEs and small midcaps but is supported by comprehensive policy measures. These measures include the development of secondary raw materials markets, fiscal tools, and regulatory frameworks to encourage eco-design, reuse, and recycling practices. They leverage regional strengths to promote industrial symbiosis and sustainability. There is substantial financial and legislative support for sustainability and circular economy initiatives in both national and regional contexts. The Italian government has implemented tax incentives, subsidies, and grants to promote the use of recycled materials, sustainable product design, and industrial symbiosis. However, challenges remain, including the need for continuous investment in innovation, the alignment of regional and national priorities, and the effective dissemination of knowledge and best practices among SMEs. The development level of national and regional strategies regarding circular economy, digitalization, and innovation is advanced, with clear targets and measurable outcomes. The Piedmont ERDF Regional Programme for the 2021-27 programming period, approved by Decision C (2022) 7270 of 7 October 2022, with an allocation of almost EUR 1.5 billion, supports the Piedmont system in tackling the major development challenges, combining the relaunch of competitiveness with sustainable and inclusive growth. The programme is in line with S3 strategy and EU targets and goals, enhancing and promoting research, technological development and innovation.

At the national level, the Italian **National Strategy for the Circular Economy** (89) provides a comprehensive framework to drive circular business models, enhance waste reduction, and foster secondary raw material markets. This strategy supports regional implementation through financial incentives, regulatory measures, and capacity-building initiatives, ensuring a smooth transition of local industries to circular and sustainable production practices.

Key policy measures include:

- Development of secondary raw materials markets to reduce reliance on virgin materials
- Fiscal incentives and subsidies to encourage eco-design, industrial symbiosis, and resource efficiency
- Regulatory frameworks to promote recycling, reuse, and extended producer responsibility schemes

- Support for green chemistry and advanced materials, particularly relevant to Piedmont's strong industrial base

The **National Sustainable Development Strategy** (NSDS) (Strategia Nazionale per lo Sviluppo Sostenibile (2022) (90) serves as Italy's main coordination framework for sustainable development, aligned with the EU 2030 Agenda's four principles: integration, universality, transformation, and inclusion. The strategy is structured around two main sections: the "5 Ps" (People, Planet, Prosperity, Peace, Partnership), which outline Italy's sustainable development priorities through 15 Strategic Choices and 55 National Strategic Objectives, and the "Sustainability Vectors", which are enabling conditions such as policy coherence, culture, and participation for sustainability. The NSDS also features an integrated monitoring system and includes two annexes: the National Action Plan for Policy Coherence for Sustainable Development, and the updated Regulation of the national Forum for Sustainable Development, both developed in collaboration with national and international partners.

Piedmont's **Regional Sustainable Development Strategy** (SRSvS) (91) aligns with national and European sustainability goals, particularly those set out in the EU Circular Economy Action Plan and Agenda 2030. The Documento Strategico Unitario (DSU) ensures coherence between different policy frameworks, strengthening Piedmont's approach to sustainability and resource efficiency.

Italian national and regional strategies are increasingly tailored to address the specific strengths of sectors. Here, the sectors relevant to the CURIOST project are examined:

mechanics & mechatronics:

The field of Smart Factory (Fabbrica Intelligente) is significantly integrated with various other specialization areas, including mechanics and mechatronics. This area involves automation and control systems, artificial intelligence, information systems, software engineering, industrial engineering, and robotics.

Plastics:

Italy is noted for its production and recycling of plastics. In 2020, Italy consumed around 6.5 million tons of plastics, with a substantial portion used in packaging. Approximately 2.2 million tons of plastic packaging were consumed, with 48.7% being recycled and 44.6% used for energy recovery. However, Italy is still working to meet the EU's recycling target of 55% by 2030. Italy is a leader in producing compostable bioplastics, having established an Extended Producer Responsibility (EPR) system for organic recycling of such materials. This is expected to significantly contribute to the overall plastic recycling goals.

Packaging:

The packaging sector, particularly plastic packaging, plays a critical role in Italy's economy. The country has implemented extensive measures to improve the collection, recycling, and reuse of plastic packaging. New technologies and systems are being developed for the efficient separation and recycling of plastics from other materials. The country operates through a well-regulated consortium system, with organisations like CONAI, COREPLA, and POLIECO playing key roles in managing plastic waste. CONAI coordinates efforts for all packaging materials, including plastic,

while COREPLA focuses specifically on the collection and recycling of plastic packaging. POLIECO oversees the recycling of polyethylene (PE) materials outside of packaging. These consortia aim to meet ambitious recycling targets set by both national and European Union regulations. Technological advancements in Italy have been central to its recycling efforts. New systems like Ecostar's advanced screening technologies are used in plastic treatment plants to improve the separation and processing of plastic materials. This has contributed to a growing market for secondary raw materials derived from plastic waste. Italy's commitment to achieving a circular economy is also reinforced by policies such as Extended Producer Responsibility (EPR), which requires producers to finance the recycling and recovery of the packaging they introduce to the market. These efforts are supported by the National Recovery and Resilience Plan (which funds recycling initiatives and innovations in packaging waste management), contributing to both environmental sustainability and economic growth.

S3-strategy

Italy provides an analysis of the S3 strategies in the Piedmont region and on national level. The S3 strategies in Italy and Piedmont specifically target areas of regional excellence, for Piedmont the focus lies on sectors like automotive and aerospace, which is relevant for the mechanics and mechatronics sector regarded in the CURIOST project. This targeted approach ensures investments and policies focus on sectors with strong innovation and growth potential. National and regional strategies are crafted to be complementary, promoting synergies rather than contradictions, thereby enhancing their effectiveness in driving sustainable and innovative economic development.

The Italian **National Smart Specialization Strategy** (92) aligns with EU strategies by focusing on innovation and competitiveness in strategic sectors. For Piedmont, this includes supporting innovation in mechatronics and plastics, particularly in the development of sustainable and circular economy technologies.

The **Smart Specialisation Strategy (S3) for the Piedmont region** (93) is a key driver of innovation and sustainable economic growth, addressing sector-specific needs, fostering collaboration, and promoting research and development. It includes various actions to support green technologies and solutions, such as initiatives in advanced materials for batteries and bioeconomy, which underscores the strategy's commitment to sustainability and is aligned with broader European initiatives like the Green Deal/ Clean Industrial Deal. In the Piedmont region, the S3 strategy is designed to address sector-specific needs while fostering broad collaboration and regional innovation. Piedmont’s S3 focuses on leveraging regional strengths in key sectors such as aerospace, mobility, advanced manufacturing, medical technologies, innovative textiles, and advanced materials for batteries. Thematic platforms and partnerships facilitate targeted innovation, ensuring that businesses, research institutions, and policymakers work in synergy to maximize impact. A robust governance and monitoring system supports the continuous refinement of the strategy. Key institutions such as NUVAL (Piedmont Region’s Public Investment Assessment and Verification Unit) and IRES (Institute for Socio-Economic Research) provide data-driven insights, ensuring that S3 remains aligned with real-time regional needs. Regular evaluations help integrate feedback from stakeholders, maintaining the strategy’s responsiveness and

effectiveness. S3 also plays a fundamental role in the circular economy transition, particularly through investments in green technologies, the bioeconomy, and low-carbon innovations. This aligns with the European Green Deal and broader EU sustainability objectives, reinforcing Piedmont's position as a leader in sustainable industrial transformation.

The strategy identifies key Systems of Innovation Priority (Sistemi Prioritari dell'Innovazione) which includes sectors like aerospace, mobility, and advanced manufacturing. These priorities align closely with the mechanics and mechatronics sector, where the region has a strong industrial base, particularly in automotive and smart manufacturing. The S3 strategy endorses both innovative concepts and the current state of the art by promoting projects that renew product and service offerings while also supporting existing high-tech industries. This dual approach helps balance immediate industrial needs with long-term innovation goals, ensuring comprehensive economic development. The focus on reskilling and upskilling further supports this by preparing the workforce for future technological advancements and industry shifts. The monitoring and implementation process of the S3 strategy is comprehensive, designed to foster continuous regional innovation. The governance framework involves regular monitoring and evaluation to ensure the strategy's objectives are met and to make necessary adjustments based on real-time data which ensures that S3 strategy is responsive to regional needs and enhances innovation capacity across the territory.

Following, the strategy is analysed regarding the focus sectors within the Italian context of the CURIOST project:

Mechanics and mechatronics:

The Mechanics & Mechatronics sector in Piedmont is crucial to the region's strong industrial base, particularly in automotive and manufacturing. The S3 strategy for Piedmont emphasizes the need for innovation in advanced manufacturing, particularly through the integration of smart manufacturing technologies, such as robotics, automation systems, and artificial intelligence. This is aimed at enhancing production efficiency and product quality, key components of maintaining competitiveness in industries such as automotive, aerospace, and high-tech manufacturing. Additionally, research and development (R&D) is highlighted as critical to sustaining growth and fostering new technologies in mechatronics. The region supports this through investment in automation and control systems, industrial engineering, and software engineering, aligning with national goals for smart factories and automation technologies.

The Mechanics & Mechatronics sector is highlighted within the context of the region's strong industrial capabilities. Key points include:

- Automotive and Manufacturing: The region has a significant presence in the automotive industry, which drives demand for advanced mechatronics solutions.
- Advanced Manufacturing: Emphasis is placed on the development and integration of smart manufacturing technologies, including robotics and automation systems that enhance production efficiency and product quality.

- Research and Development: The document underscores the importance of continuous R&D in mechatronics to maintain competitiveness and foster innovation within the sector.

Plastics:

Piedmont's plastics sector plays a significant role in the transition towards a more sustainable and circular economy. As part of the Green Chemistry focus within the S3 strategy, Piedmont is emphasizing the development of bioplastics and sustainable materials derived from renewable sources. This aligns with Italy's leadership in producing compostable bioplastics and developing biomass-to-plastic conversion technologies. Additionally, recycling and circular economy approaches for plastics are fundamental in addressing the region's commitment to reducing plastic waste. Specific needs in this sector include enhancing plastic material separation and recycling technologies, promoting eco-design in plastic products, and improving industrial symbiosis to facilitate the re-utilization of plastic waste. These innovations support the goal of reducing the environmental impact of plastic production and consumption, a challenge that Piedmont, like the rest of Italy, is working to address in line with EU recycling targets.

The plastics sector is addressed primarily within the framework of sustainable and green chemistry initiatives:

- Green Chemistry: Efforts are directed towards developing bioplastics and sustainable plastic materials derived from renewable resources. This includes the conversion of biomass into plastics and other chemical products.
- Recycling and Circular Economy: Technologies for the separation, recycling, and re-utilization of plastic materials are a focal point, aimed at minimizing waste and promoting a circular economy approach.

Packaging:

The packaging sector in Piedmont, particularly in plastics, is increasingly focused on sustainable materials and smart packaging solutions. The S3 strategy places significant emphasis on developing eco-friendly packaging materials, such as biodegradable and recyclable options, to reduce the environmental footprint of packaging waste. Moreover, the region is investing in smart packaging innovations, which incorporate technologies such as sensors and indicators that extend product shelf life, improve consumer interaction, and enhance product tracking. These advancements are integral to collaborative initiatives across the agriculture, food production, and logistics sectors, aiming to create a more sustainable packaging ecosystem. Additionally, the region is focusing on developing new technologies for industrial waste reuse, particularly for packaging materials, to minimize waste and promote a circular approach.

The packaging sector is discussed in several contexts, particularly focusing on sustainability and innovation:

- Sustainable Materials: The development of eco-friendly packaging materials is a priority, with a focus on biodegradable and recyclable options.

- Smart Packaging: Innovations in packaging are geared towards enhancing product shelf life, reducing environmental impact, and incorporating smart features such as sensors and indicators for better product tracking and consumer interaction.

In summary, the S3 strategy for the Piedmont region is a multifaceted framework that addresses sector-specific needs, fosters broad collaboration, drives regional innovation, supports sustainable development, and aligns with other strategic initiatives to ensure comprehensive regional growth and sustainability.

4.5.2. regional needs

Despite significant advancements, Piedmont faces several challenges in accelerating the transition to a circular economy:

- Investment in innovation: continuous funding is needed to support R&D in sustainable materials and processes.
- SME engagement: while large companies often lead the way, ensuring small and medium-sized enterprises have access to knowledge, financing, and best practices remains crucial.
- Regulatory alignment: harmonizing regional, national, and EU regulations can be complex, requiring greater coordination and policy coherence.
- Skills development: Reskilling and upskilling the workforce are essential to meet the demands of emerging circular industries.

However, opportunities for growth and transformation are vast, particularly through European initiatives such as the S3 Industrial Modernisation Platform, which enhances cross-regional cooperation in sustainability and industrial innovation.

4.5.3. sector analysis

mechanics & mechatronics

The state of the art in sustainable and circular product development within the mechanics and mechatronics sector is evolving rapidly, driven by technological innovations and increasing market demand for eco-friendly solutions. Best practices include integrating resource recovery models, where companies focus on reducing waste through recycling, reusing materials, and optimizing energy efficiency. Virtuous enterprises showcase a commitment to sustainability through the development of technologies that monitor energy consumption, reduce carbon footprints, and minimize material waste; prime examples of how circular principles are being applied are the integration of IoT solutions for real-time energy consumption tracking or the innovative use of additive manufacturing to minimize material waste in metal production.

However, despite these advancements, there are significant gaps and challenges in fully realizing the potential of circular transformation in the sector, such as internal resistance from customers who are unwilling to absorb the costs of sustainability measures, making it difficult to justify sustainable investments despite their long-term benefits, struggles with sourcing sustainable raw

materials, which limits its ability to reduce the environmental impact of its production processes, or overcoming supply chain dependencies that complicate the implementation of sustainable practices across the entire production cycle. These barriers highlight a key issue: the internal challenges in advancing sustainability beyond regulatory compliance, which affects companies' ability to leverage sustainability as a central business driver.

Externally, companies in this sector face regulatory and market uncertainties. Inconsistent sustainability standards, complex regulations, and slow-moving bureaucratic processes hinder progress, especially when competitors who do not prioritize sustainability can offer lower-priced products. These challenges underscore the need for a harmonized regulatory framework to ensure fair competition and enable businesses to scale sustainable innovations.

To successfully address these challenges, a market readiness assessment is crucial. The mechanics and mechatronics sector in Piedmont is well-positioned to adopt sustainable products, given the region’s strong manufacturing base and the growing demand for eco-efficient solutions. However, there is a need for industry collaboration and investment in sustainable supply chains to overcome the identified barriers. These companies must adapt their business models to integrate circular principles, such as resource recovery and waste minimization, into their everyday operations. Furthermore, the sector must address market readiness by promoting the development of green technologies, facilitating knowledge exchange on best practices, and supporting the training of employees to implement sustainable practices across all stages of production.

The key characteristics of the targeted sector in Piedmont reveal a commitment to sustainability, but also significant hurdles in fully realizing circular transformation. These include the need to better integrate circular economy principles into core business strategies, address customer perceptions of the value of sustainability, and overcome supply chain limitations. The state of the art in sustainable and (digital) circular product development within the mechanics and mechatronics sector is evolving rapidly, driven by technological innovations and increasing market demand for eco-friendly solutions. Best practices include integrating resource recovery models, where companies focus on reducing waste through recycling, reusing materials, and optimizing energy efficiency. Virtuous enterprises showcase a commitment to sustainability through the development of technologies that monitor energy consumption, reduce carbon footprints, and minimize material waste; prime examples of how circular principles are being applied are the integration of IoT solutions for real-time energy consumption tracking or the innovative use of additive manufacturing to minimize material waste in metal production. However, despite these advancements, there are significant gaps and challenges in fully realizing the potential of circular transformation in the sector, such as internal resistance from customers who are unwilling to absorb the costs of sustainability measures, making it difficult to justify sustainable investments despite their long-term benefits, struggles with sourcing sustainable raw materials, which limits its ability to reduce the environmental impact of its production processes, or overcoming supply chain dependencies that complicate the implementation of sustainable practices across the entire production cycle. These barriers highlight a key issue: the internal challenges in advancing sustainability beyond regulatory compliance, which affects companies' ability to leverage sustainability as a central business driver.

plastics & packaging

The chemical industry today is strongly committed to environmental sustainability. Considered by many to be a sector that produces polluting products, according to the latest Greenitaly Report, the chemical industry in Italy is the leading industrial sector in terms of the number of companies (60%) investing in new products and technologies with greater energy savings and/or lower environmental impact. An analysis conducted by UnionCamere Piemonte (Union of the Chambers of Commerce in the Piedmont Region) in 2023 has revealed the state of the art of the circular economy in the Region. **Two out of three** companies are familiar with the principles of the circular economy (66,8% of the total companies interviewed), and among that, chemical and plastic enterprises, as well as the electric and electronic companies, have greater awareness. The main reasons for companies to apply circular economy principles are:

- Economic circumstances
- To be compliant with more restrictive regulations planned for the near future in order not to lose the opportunity to compete
- To achieve greater visibility and/or improve corporate image
- To create new partnerships and opportunities
- To enter new markets

The Unioncamere Piemonte survey shows that, among the obstacles faced by the companies in implementing circular paths, the first are economic and financial, such as the lack of public funds and subsidised financial loans (41.5% of the companies surveyed). Bureaucratic and administrative obstacles and a lack of available skills are cited by 26.9% and 21.9%, respectively. Technological barriers are a problem for 19.1% of companies and 9.9% complain about resistance to change. In line with these results, most of the respondents interviewed for the SWOT analysis confirmed that the lack of investment (public and private), trade markets, and competition from countries outside the EU are the main challenges, together with EU regulation and bureaucracy. On the other side, the SWOT analysis revealed that the recycling process, in particular for plastic and packaging, is an enormous opportunity for the companies both from an economic point of view and in terms of communication and brand identity.

From the point of view of technology readiness, the mechanical recycling of plastic is a very well-known process and is considered environmentally friendly but with higher costs of investments. Companies tend not to invest and prefer to outsource the technology. Bioplastic and biobased products (also for packaging) have the same performance of "traditional" products and could be easily replaced. The costs, also in this case, are higher: companies need economic support to sustain these types of investments. Moreover, the respondents interviewed outlined the clearness of EU and National laws and regulations, especially in terms of the definition of the “end of waste”.

4.5.4. concrete actions

Table 6 outlines a structured framework for implementing actions related to plastics and packaging in the context of the circular economy. It details key aspects such as the actions to be taken, the subjects responsible for carrying them out, objectives to be achieved, target groups, necessary tasks and activities, success criteria, time frames for completion, required resources, and potential funding opportunities. This approach ensures clarity regarding roles, timelines, and support needed to achieve sustainable change in the sector.

Table 6: concrete actions for Italy

Action	Subjects (Who is implementing the actions)	Objectives (What do we want to achieve?)	Target groups	Tasks & Activities (What activities are necessary to achieve the objectives?)	Success criteria (What are the main results you expect? How do you define the success of the activity?)	Time Frame (By when do the tasks need to be completed to trigger the change?)	Estimated costs	Resources needed (What or who can help or will be responsible to achieve the tasks/objectives ? Time, costs?)	Funding possibilities
1. Develop and implement targeted training events and webinars for SMEs	Sistema Poli Innovazione Piemonte (Regional meta-cluster), regional government, universities, industry associations, training providers, SMEs	+ Equip SMEs with knowledge in sustainable product development, circular design, and circular economy principles + Implement awareness workshops in specific	SMEs in mechanics, mechatronics, plastics, packaging	+ Develop training events or webinars tailored to sector needs (circular design, waste reduction, energy efficiency) + Partner up with universities, industry associations, and training	+ 20+ SMEs trained in circular economy principles + Improved EU sustainability compliance and enhanced competitiveness in the green market	12-24 months	Unitary cost: 1,500 – 3,000 EUR	+ Industry experts, trainers, sustainability mentors, event organizers	+ Horizon Europe + National Innovation Grants + Private sector co-funding

		companies, which are not aware yet of the need of the pathway, with showcase of opportunities		organizations for workshops and webinars + Promote hands-on mentorship and real-life case studies to demonstrate sustainable practices					
2. Strengthen regional circular networks	Sistema Poli Innovazione Piemonte (Regional meta-cluster), regional government, regional stakeholders, suppliers, industry clusters, SMEs	Facilitate network and access to knowledge on sustainable and circular practices and promote circular actions	SMEs in mechanics, mechatronics, packaging, plastic	+ Build partnerships with regional stakeholders + Implement Network to facilitate access to knowledge + Promote opportunities on incentives and funding for SMEs adopting circular procurement practices	+ 5+ regional stakeholder partnerships + Increase awareness in SMEs in adopting circular practices	12-24 months	Overall, on yearly basis, 120,000 – 150,000 EUR	+ Industry clusters, suppliers, sustainability experts + Regulatory bodies to ensure compliance	+ EU funding (LIFE-Programme, Horizon Europe) + National Development Funds
3. Coordinate thematic focus groups on S3 regional priorities	Sistema Poli Innovazione Piemonte (Regional meta-cluster), regional government, Industry associations, academic institutions, Competence	Coordinate 6 thematic focus groups (one per S3 Regional priorities) to verify the coherence od the regional activities and discover new	SMEs in mechatronics, mechanics, plastics, packaging, other	+ Establish cross-sector collaborative meetings for best practice sharing and joint R&D + Foster partnerships with academic institutions for research on	+ 6 collaborative thematics focus groups created + 30+ SMEs participating in knowledge-sharing events and workshops	12-24 months	Overall, on yearly basis, 120,000 – 150,000 EUR	+ Industry associations, academic institutions, innovation hubs	+ EU Regional Development Fund (ERDF) + Interreg Europe + Private sector and regional government support

	innovation Centers, local businesses	industrial needs and trajectories		sustainable manufacturing + Strengthen regional partnerships between clusters to support circular innovation, funding, and networking events					
4. Support the local development and the research and innovation of companies	Sistema Poli Innovazione Piemonte (regional meta-cluster), regional government, industry associations, academic institutions, competence innovation centers, local businesses	Finance innovation and research	SMEs, start-up and big companies (it depends on the types of funds)	Regional calls that finance research &development Regional Calls that finance young talent/support training and development of skills in the companies	Number of projects financed and relative amount in terms of R&D	EU programming period	Unitary R&D Call budget: 80 MEUR Unitary Skills Call budget: 20 MEUR	Regional Department Staff, in collaboration with regional entities	ERDF funds for the Region

4.6. Poland (Malopolska region)



Poland places significant emphasis on the S3 Strategy (Smart Specialisation Strategy), green transition, cleantech transition, circular economy, and recycling as key pillars for its sustainable development and economic competitiveness.

In Figure 4 the results from the Polish chapter are summarized.

Poland	Focus	Gaps	Opportunities
§ Regulation	Transition policies	Inconsistent application	Regulatory clarity
Regional needs	Industrial regions	Support instruments	Regional investments
Sectoral needs	Resource efficiency	Process optimisation	Cost-saving measures
! Concrete Actions	Policy dialogue	Fragmented actors	Strategic coordination

Figure 8: Summary of the Polish perspective

4.6.1. policy analysis

implementation of EU-directives

For Poland, an analysis of four regulations and directives that have already been implemented or will soon be enacted in the Polish legal system, one for each analysed industry is described.

For the sector of **mechanics and mechatronics**, the most relevant document is the **Regulation (EU) 2023/1230 of the European Parliament and of the Council of 14 June 2023 on machinery and repealing Directive 2006/42/EC of the European Parliament and of the Council and Council Directive 73/361/EEC.** The European Union has also indicated the need to ensure a higher level of protection for workers and consumers. Since production automation requires a complex planning process, the new regulation places greater emphasis on machine safety at the design stage. Another reason for introducing changes is to encourage machine manufacturers to introduce innovations. Increasing the competitiveness of European machine manufacturers on the global market is very important for the entire industrial sector. Unfortunately, the Machinery Directive did not keep up with progress, which caused difficulties in implementing appropriate safeguards in machines. Manufacturers are obliged to ensure that their machines meet all safety and health requirements. The new Regulation (EU) 2023/1230) is a major challenge for the machinery sector, but also an opportunity to improve the quality and competitiveness of products. In order to prepare for the new regulations, manufacturers and users of machinery should familiarise themselves with the content of the directive and check whether their machines meet the new requirements. Level of responsibility also lies on importers and distributors which are responsible for ensuring that machines placed on the market meet the requirements of Regulation. If necessary, appropriate measures should be taken, such as adapting the design, changing the labelling or updating the documentation. In addition, it is necessary to monitor legal and technical developments and use available sources of information and support. Therefore, all participants in the supply chain must cooperate with market surveillance authorities and the products must comply with the regulation. In the event of non-compliance corrective actions are expected, such as withdrawing the products or modifying them. To conclude, the revision of the Machinery Directive is an important step towards ensuring a high level of safety and health protection for machinery users and supporting the development and competitiveness of the machinery sector in the EU. This revision also aims to facilitate adaptation to changing market and technological conditions and promote sustainable development and digital transformation. At the same time, the new directive will pose a challenge for economic operators who will have to adapt to the new requirements and incur additional costs related to conformity assessment, technical documentation, marking and product updates.

For the sector of **packaging**, it is important to review **Act of 13 July 2023 amending the Act on the management of packaging and packaging waste** and certain other acts implemented in Poland and national legislation. The purpose of the Act was to implement the provisions of Directive 2019/904 into the Polish legal system. The so-called Plastics Directive (SUP Directive), within the scope of the obligation of the member state contained in Article 9 paragraph 1 of that Directive to ensure the selective collection of packaging waste generated from single use plastic

bottles for beverages with a capacity of up to 3 l (including their caps and lids) at the level of 77% in 2025 and 90% in 2029. The basic duties of the entity representing under the deposit system include:

- selective collection of packaging and packaging waste to achieve the required levels of selective collection.
- collection of packaging and packaging waste from retail and wholesale trade units and other points collecting packaging and packaging waste covered by the deposit system.
- transport of packaging to the entity introducing products in beverage packaging or directly introducing products in beverage packaging and packaging waste to a waste processing plant.
- settlement of deposits with retail and wholesale trade entities and other points collecting packaging and packaging waste covered by the deposit system, in particular financing of deposit payments for the end user.
- financing of the costs of collecting packaging and packaging waste by the entrepreneur running a retail
- wholesale trade entity and another point collecting packaging and packaging waste covered by the deposit system.

Starting from October 1, 2025, Poland has implemented a Deposit Refund System (DRS), which plays a crucial role in meeting the EU's circular economy objectives and increasing the recycling rates of packaging waste. The new legislation stems from the transposition of the Single-Use Plastics (SUP) Directive, under which businesses placing products on the market is required to meet new obligations related to the increased collection of packaging waste and the use of recycled content in new single-use plastic packaging.

The new regulations will affect a wide range of businesses placing beverages on the market in packaging. The DRS covers three types of beverage packaging:

- Reusable glass bottles up to 1.5 litres,
- Single-use plastic bottles up to 3 litres, including caps and lids,
- Metal cans up to 1 litre.

The primary objective of the new system is to ensure that Poland meets the required selective collection targets – as early as 2025, the mandatory collection rate for PET bottles is set at 77%, increasing to 90% by 2029. Companies that do not participate in the system may be subject to product fees. Businesses are facing significant financial and logistical challenges in the coming years. While participation in the DRS will not be mandatory for the key stakeholders – beverage producers and importers – the situation differs for retailers, including micro and small enterprises, who are required to collect deposits. Specifically:

- Small shops (up to 200 m^2) are required to collect deposits and accept returned glass bottles,

- Large shops (over 200 m²) are additionally required to accept all returned packaging and refund the deposit to consumers.

The DRS is implemented nationwide, without the need for a receipt, and independently organized by businesses. This means that beverage producers/importers may:

- Establish and fund a DRS operator, or
- Join an existing operator by entering into an appropriate agreement.
- Polish law allows for multiple operators to manage the DRS, which may pose additional challenges in terms of settlement processes, system interoperability, and tax compliance.

Setting up the logistics of the DRS is a complex and time-consuming task. Generally, smaller retailers will need to collect deposits, while larger retailers must also accept returned packaging from consumers. This is only part of the logistical framework that must be in place for the system to function effectively. A key current challenge is raising awareness and competence among businesses regarding the operation of the DRS, especially the legal and tax obligations that applies to various types of entities and when these obligations will come into force.

Disregarding provisions of this Act is subject to penalties and sanctions. To conclude, the SUP Act still leaves many doubts regarding interpretation. The first and most important step for an entrepreneur will be to determine whether these provisions apply to them at all, and only then which obligations they will have to fulfil, as well as uncertainty about the final amount of the deposit which makes preparation in advance difficult.

For the sector of **plastics** in Poland, relevant is **Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment (Single Use Plastics).** The Act introduces several systemic changes aimed at reducing the amount of waste generated from plastic products or those containing plastics and their impact on the natural environment (considering the aquatic environment and human health). Every entrepreneur whose activity in any way (e.g. production, intra-community acquisition/delivery and import/export, use for business, sale) is related to the use of single-use plastics should analyse whether and how the new obligations apply to them. The most important changes introduced by the amendment concerning single-use plastic products are: reductions in the use of plastics (beverage cups, lids, covers, food containers), prohibition on placing on the market (cotton buds, cutlery, plates, straws, containers made of expanded polystyrene), labelling, financing the costs associated with the management of waste, raising environmental awareness. The amendment to the Act, even though work on it has been underway for a long time, means that many entrepreneurs will have to introduce changes to their activities and incur additional fees, and in the case of some obligations, it may prove problematic to implement, e.g. in the context of the obligation to ensure selective collection of bottles. Effective implementation and clear communication will be key to overcoming resistance and ensuring that the benefits of the directive are fully realized. There must be a balance between companies producing plastics and other actors vocalizing the prevention of the use of plastics for real solutions for plastic pollution.

For **construction and building** as a sector in Poland the revised **Energy Performance of Buildings Directive - EPBD (EU/ 2024/ 1275)** is important for implementation. Some of the most important tools introduced by the EPBD to achieve ambitious climate goals include:

- zero-emission construction of new buildings
- obligation to take action to improve the energy performance of a building during each so-called “major renovation”
- promotion of electricity generation using photovoltaic panels mounted on roofs
- introduction of so-called “renovation passports”
- promotion of solutions for the development of infrastructure for the needs of sustainable mobility
- new rules for preparing energy performance certificates for buildings (introduction of classes A to G)
- creation of one-stop-shops for energy performance of buildings.

The above review of the requirements of the new EPBD directive shows that it contains several regulations of a different nature, the primary purpose of which is to rationalise energy consumption in buildings. In addition to regulations shaping energy standards for buildings and stimulating and obliging them to improve, there are requirements for providing information on energy efficiency, as well as solutions supporting the process of improving energy efficiency. The regulations described vary depending on the type of buildings, technical systems they contain, their size and ownership status. The new directive does not contain any provisions that would result in the deprivation or restriction of ownership rights. In addition, there are no provisions in it that would make the possibility of selling or renting a building dependent on its energy efficiency. Minimum requirements regarding energy performance have been in force for new buildings for several decades and are tightened with progress in construction and user requirements. The level of energy efficiency of a building is disclosed at the stage of its sale, similarly to the case of energy-consuming devices.

Poland is actively implementing the new EU Energy Performance of Buildings Directive (EPBD), focusing on introducing unified A-G energy certificates by mid-2026, stricter performance standards (Class E by 2030, Class D by 2033), mandatory PV on roofs, phasing out fossil fuels, and developing renovation roadmaps (NBRPs) by late 2025, though experts note massive investment (trillions of PLN) is needed to meet goals like zero-emission buildings by 2028.

Key Implementation Aspects are:

- Unified EPCs: Poland is working on legislation for a standardized A-G energy certificate system, with an A+ option for superior performance, to be ready by May 2026.
- Stricter Performance Targets: Residential buildings must reach at least Energy Class E by 2030 and Class D by 2033, with earlier deadlines for public buildings.

- Zero-Emission Buildings (ZEB): New constructions must be ZEB from 2028, and deep renovations are encouraged.
- Renewable Energy: Mandatory PV installation on specific roof categories and a ban on gas boiler subsidies after 2025 are key.
- National Building Renovation Plan (NBRP): Poland submitted its draft by December 2025, detailing its long-term renovation strategy.

Some challenges and costs regarding the implementation of the Directive are:

- Financial Burden: Experts estimate adapting Polish buildings to the new standards could cost up to 2.5 trillion PLN, covering thermal modernization, heating system upgrades, and PV installation (94).
- Legal Framework: The Ministry of Development and Technology, with support from the Building Research Institute (ITB), is responsible for transposing the directive into national law, a process that is still ongoing.

The deadline for Poland to fully implement the new EPBD requirements, including the A-G energy classification is in May 2026, therefore the implementation is not yet concluded at the time of writing.

national policy analysis

Poland's approach is largely shaped by EU directives and regulations, which it then transposes and implements at the national level. Key overarching policies and strategies include:

- **Roadmap for Transition Towards a Circular Economy** (2019) (95): This document, prepared by the Interdepartmental Circular Economy Group, outlines actions to maximize the value of resources and minimize waste. It identifies priorities in sustainable industrial production, sustainable consumption, bioeconomy, and new business models. It emphasizes innovation, industry-science cooperation, and the development of a secondary raw materials market.
- **National Waste Management Plan** (96): This plan sets out objectives and measures for waste prevention, preparation for re-use, recycling, and other recovery methods, aligning with the EU waste hierarchy.
- **Energy Policy of Poland until 2040** (97): While traditionally focused on fossil fuels, the updated strategy includes a gradual shift towards renewable energy sources (RES) and nuclear energy, acknowledging the need for a green transition. It sets targets for RES in the energy mix and for greenhouse gas (GHG) emission reductions.
- **National Recovery and Resilience Plan (NRRP)** (98): Poland's NRRP allocates a significant portion of funds (over 46%) to support the green transition. This includes investments in offshore wind energy, energy-efficient building renovations, green hydrogen technologies, and sustainable mobility.

- **Poland's S3 Strategy** (99): This strategy identifies key areas for smart specialization, many of which align with the green transition and circular economy principles. These include green technologies and capacities, Sustainable agriculture and food, Innovative industry.

Circular Economy and Recycling in Poland gains the momentum in shifting from a linear to circular economy model. Key initiatives and policies include:

- Waste Hierarchy Implementation: Prioritizing waste prevention, re-use, recycling, and finally, disposal.
- Extended Producer Responsibility (EPR): Encouraging producers to take responsibility for their products throughout their lifecycle, including design for recyclability.
- "Circular Economy in Municipalities" Program: A pilot program launched to promote circular economy practices at the local level.
- Polish Circular Hotspot (PCH): An initiative established to support businesses, cities, and the government in the transition to a circular economy by developing strategies and action plans.
- Support for Recycling Infrastructure: Investments are needed to improve waste collection, sorting, and recycling capacities (100), (101).

For Poland and Malopolska region, three of the analysed strategies are covering a variety of sectors which is crucial for economic transformation. Even though it emphasizes the principle of bottom-up approach, increasing the engagement of local business and institutions, as well as clusters and innovation centres, due to its complexity, the document may face practical implementation challenges, especially in small and medium-sized enterprises. The iterative creation process allows the document to be flexible and adaptable to changing market and technological conditions, but changes in regional or European policy may affect the documents implementation. As mentioned in further analysis it should be pointed that implementation of strategies depends heavily on European and other external funding which may be subject to uncertainties. On the one hand, strong policy support at the regional, national and EU levels can provide a conducive environment for successful transformation to circular economy. On the other hand, resistance from business to adopt the new practices could slow down the transition.

S3-strategy

For Poland, specifically for Malopolska region, an analysis of Malopolska RIS (Regions Innovation Strategy), S3 (Smart Specializations Strategy) and Circular Economy Strategy is conducted. This analysis intended for the CURIOST project was performed based on the SWOT analyses of 3 strategic documents approved by the board of the Malopolska Region.

While the strategy is very well integrated with national and European strategic documents it also covers a wide range of sectors, including Life Science, Sustainable Energy, ICT, Chemistry, and Creative Industries, ensuring a broad base for innovation. Despite that, certain challenges are also present, such as high dependency on European funding programs, uneven digitalization development level and infrastructural gaps.

The Malopolska Intelligent Specialization strategy determines directions of the region's development. They support the collaboration of science and business which opens door for innovation. As a result of the research, which included a document analysis, expert consultations, consultations with PPO stakeholders, meetings with representatives of other regions (Polish and foreign), and targeted workshops, a document entitled "Assumptions and Model of the Entrepreneurial Discovery Process for the Implementation of the Regional Innovation Strategy Małopolska 2030" was created. In accordance with the recommendations presented in the document, the new PPO model consists of the following Platforms:

- Healthy Society
- Sustainable Energy and Industry
- Availability of Services and Comfort of Living
- Advanced Materials, Processes, and Devices

The reconfigured Platforms are based on the order of individual fields within smart specializations. This means that a given Platform may include fields derived from different smart specializations. The new model was therefore based on the actual flows of knowledge and contacts occurring across various disciplines. This is intended to ensure even better and more effective collaboration during the implementation of PPO tasks. As in previous years, the regional PPOs are intended to provide a forum for discussion and strengthen the innovation ecosystem through a series of recommendations, analyses, and ideas. The tasks assigned to PPO participants, particularly the operators and facilitators within each Platform, can be broadly divided into implementation tasks (concerning the shaping, management, and organization of the Platform), animation tasks (involving engaging and activating stakeholders for specific goals), and reporting tasks (providing feedback in the form of delivering specific results resulting from the animation).

The existence of the Małopolska Specialization Platforms is not only aimed at fulfilling specific PPO obligations in accordance with the criteria set by the European Union, but above all, offers tangible benefits for its participants. These benefits stem largely from the networking effect, which, through the cooperation established within the Platforms, leads to closer ties among the associated entities. This creates future opportunities for:

- joint research projects
- access to new technologies
- improved flow of industry information
- improved employee qualifications
- designing products based on actual market needs
- the ability to influence the strategic directions of the region's innovation policy

For the Małopolska Region, the management knowledge gained from the Platforms will primarily enable it to adequately respond to current needs and trends resulting from the dynamically changing world of innovation using available instruments (such as European Funds for Małopolska).

None of the industries we focus on in the CURIOST project (mechanics and mechatronics, packaging, plastics and construction) are fully represented among the intelligent specializations of the Malopolska Region. Nevertheless, many elements included can be considered in the context of the industries selected for the CURIOST project. Positive aspects of the Specialization document are that it covers a wide range of specializations, supporting interdisciplinarity and development of collaboration between various sectors of the economy, science, and administration, and supports bottom-up approach with increased engagement of local businesses and institutions. On the other hand, the document is very extensive and complex, which may hinder its understanding and assimilation by individuals not directly involved in innovative processes. Due to its complexity, the document may face practical implementation challenges, especially in small and medium-sized enterprises.

The **Circular Economy Strategy of Malopolska region** suggests the undertaking of actions in the development of the Circular Economy Program. It develops a new approach to implementation of this policy. Supporting actions aimed at more economical use of resources and raw materials, understood more broadly, including issues such as decarbonization, promoting the idea of cooperation for social development, spreading the reuse of products, reusing water, heat, or promoting the sharing of goods and services, is one of the challenges for the region and a necessity for the Małopolska economy. Shifting the linear economy towards circular economy is embedded in the strategic plans of the European Union and Poland. One of the fundamental assumptions of Circular Economy is avoiding product waste, promoting environmentally friendly technical and organizational solutions, saving and managing space, sharing, and increasingly using secondary raw materials. This requires supporting actions in the field of sustainable consumption and production; hence the presented actions and the Circular Economy Program are directed both to the residents of Małopolska and entrepreneurs, NGOs, scientists, and administration employees. The programme aims to reduce waste by promoting recycling, reusing and repair of products. The aim is to optimize the use of raw materials and energy, which is to lead to a reduction in the consumption of natural resources and reduction of greenhouse gas emissions. It supports the development of new technologies and innovative solutions that can contribute to the achievement of the objectives of the circular economy. This may include the development of new materials, production processes or waste management systems. The programme assumes cooperation between various sectors of the economy, including industry, public administration, non-governmental organisations and the local community. Such cooperation aims to create synergies and joint action for sustainable development.

The **Regional Innovation Strategy of the Malopolska Region 2030** (RIS 2030) (102) is a tool for implementing the Development Strategy of the Małopolska Region 2030 (SRWM 2030) in economy. The Innovation Strategy also integrates, in connection with the smart specializations of the region, selected activities in education, entrepreneurship, competitiveness, digitalization and circular economy, which are included in SRWM 2030. Regional Innovation Strategy 2030 is a document that describes in detail the Development Strategy of the Malopolska until 2030. It develops and implements one of the objectives of the main strategy: an innovative and competitive economy. The main goal of the Regional Innovation Strategy is to increase the level of innovation in the region by 2030.

The Regional Innovation Strategy 2030 also proposes a set of goals and actions to achieve them in the following areas:

- further building Innovation base, potential and image of the region
- strengthening innovation and supporting industrial transformation of enterprises
- building trust, communication and diffusion of knowledge in the innovation ecosystem

To conclude, the regional innovation strategy (RIS) for the Małopolska Region 2030, Malopolska Smart Specialization Strategy (S3) and Circular Economy Program for Malopolska 2030 all include measures to support the growth and development of SMEs, including access to funding, training, and networking opportunities. The strategies place a strong emphasis on increasing investment in R&D activities. This includes both public and private sector investments and fostering partnerships between academia and industry to drive innovation. The strategies place a strong emphasis on promoting circular design and the development of sustainable products in all 4 sectors included in CURIOST project. Simultaneously, they encourage the adoption of circular economy principles in mechatronics, plastics, packaging and building and construction (retrofitting buildings). This includes promoting the use of recycled materials, designing products for longer life cycles, and facilitating the reuse and remanufacturing of products. Overall, the 3 strategies for the Małopolska Region 2030 aim to foster innovation and sustainability across these key sectors by providing support for research and development, facilitating collaboration between stakeholders, and promoting policies that encourage circular design and sustainable product development.

4.6.2. regional needs

There are several challenges regarding the implementation of circular economic principles Poland and the examined region Malopolska are facing. They can be clustered into several points:

1. Cost of Transition to Circular Economy
   - Investment in Green Technologies: The shift towards a circular economy and sustainable practices requires significant investments in new technologies, equipment, and processes, particularly in plastics and packaging. These investments can be expensive for manufacturers, particularly SMEs that may struggle to access financing or lack the resources to implement such changes.
   - Higher Production Costs: Green technologies, recycling processes, and sustainable raw materials tend to come at a premium. This can increase production costs in sectors like packaging and construction, making it difficult for companies to maintain profitability while also adopting environmentally friendly practices.
2. Supply Chain and Material Shortages
   - Global Supply Chain Disruptions: Like other European countries, Poland's manufacturing sector has faced disruptions in global supply chains, especially during the COVID-19 pandemic and geopolitical tensions like the war in Ukraine. This has led to delays in obtaining critical materials such as construction steel, plastics, and packaging components.

3. Public Awareness and Consumer Behaviour
   - Low Consumer Awareness: There is still a lack of widespread understanding among consumers in Poland regarding the importance of circular economy practices, such as recycling and sustainable construction materials. This impacts market demand for sustainable products and packaging.
   - Behavioural Change: Encouraging both consumers and businesses to adopt circular economy principles (e.g., reducing waste, reusing materials) is challenging, especially when it requires changes in established habits, such as the way packaging is disposed of or how buildings are constructed and demolished.
4. Technological and Innovation Gaps
   - Lack of Advanced Technologies: While Poland's manufacturing sector is adopting newer technologies, there are still gaps in the adoption of high-end technologies like automation, AI, and digitalization in industries like construction and packaging. This limits productivity and the ability to quickly adapt to new sustainability standards.
5. Competitive Pressure and Market Dynamics
   - Cost-Competitive International Market: Polish manufacturers, especially in plastics and packaging, face pressure from countries with lower production costs. Countries outside the EU, where environmental regulations are less stringent, can offer cheaper alternatives, making it harder for Polish companies to compete on price, even if they are more sustainable.
   - Market Demand for Green Products: While demand for environmentally friendly products is growing, there is still a significant portion of the market in Poland and beyond that is price-sensitive and not yet fully willing to pay a premium for green or recycled products. This mismatch between market demand and sustainable production capacities can lead to slow adoption.
6. Environmental and Climate Change Pressures
   - Carbon Emission Reduction: Poland's manufacturing industry is under pressure to reduce carbon emissions as part of EU climate goals. While industries like construction and plastics contribute significantly to emissions, transitioning to low-carbon technologies and processes can be capital-intensive and complex.

4.6.3. sector analysis

For the sector analysis, the sectors packaging, plastics, construction and building are in the focus. For all these sectors, a skilled labour shortage can be observed:

- Technicians and Engineers: The manufacturing sectors, particularly those transitioning to more sustainable practices, need skilled workers who are well-versed in green technologies, sustainability practices, and recycling processes. However, there is a

shortage of professionals with expertise in these areas, which slows down the pace of transformation.

- Training Needs: Manufacturers in sectors like plastics, packaging, and construction need workers with specific skills in new technologies, circular economy processes, and green building techniques. While some training programs are available, there remains a gap in highly specialized education and training focused on sustainability and innovation.

packaging & plastics

- Plastics and Packaging Regulations: Poland's strict adherence to EU regulations on plastic waste management, such as the ban on single-use plastics and the introduction of deposit return schemes, poses significant challenges for manufacturers. These regulations increase the complexity of production processes and lead to higher costs associated with compliance.
- Extended Producer Responsibility (EPR): Producers in Poland are facing increasing EPR obligations. The responsibility for waste collection, recycling, and reuse of packaging materials can strain manufacturers, especially small and medium-sized enterprises (SMEs), as they must manage these logistics and contribute financially to waste management systems.
- Raw Material Availability: The availability of sustainable raw materials is still a challenge in Poland. In the plastics sector, manufacturers are struggling to secure adequate supplies of recycled plastics or bio-based materials that meet both environmental standards and quality requirements.
- Recycling Infrastructure: While Poland has made strides in improving recycling rates, the infrastructure and technology for recycling in sectors like plastics and packaging are still developing. Efficient waste sorting, processing, and recycling systems are necessary to meet the EU’s circular economy goals.
- Quality of Recycled Materials: In the plastics and packaging industries, one of the persistent challenges is the inconsistency in the quality of recycled materials. This can make it difficult for manufacturers to incorporate recycled content into their products without compromising product quality.

construction & building

- Building Waste Recycling: In the construction sector, while efforts are being made to reuse building materials, there are still barriers in terms of sorting and recycling construction waste effectively. The lack of efficient waste processing facilities for construction and demolition debris remains a bottleneck.
- Innovation in Construction Materials: The building and construction sector faces challenges in developing and incorporating innovative, sustainable materials. The availability of affordable green alternatives, like recycled or bio-based materials, is still limited in Poland, hindering efforts to reduce the environmental impact of construction activities.

- Sustainability and Carbon Footprints: In construction, using traditional building materials like cement and steel is carbon intensive. Transitioning to more sustainable alternatives while maintaining cost efficiency and structural integrity presents a major challenge.

4.6.4. concrete actions

The following table outlines concrete actions planned for Poland to address challenges in plastics, packaging, and the construction sector. It details specific activities, responsible parties, objectives such as improving recycling rates and promoting sustainable materials, and identifies the target groups involved. The table also sets out the required tasks and activities, success criteria, timelines for completion, resources needed, and potential funding sources to support the effective implementation of these initiatives.

Table 7: concrete actions for Poland

Action	**Subjects** *(Who is implementing the actions)*	**Objectives** *(What do we want to achieve?)*	**Target groups**	**Tasks & Activities** *(What activities are necessary to achieve the objectives?)*	**Success criteria** *(What are the main results you expect? How do you define the success of the activity?)*	**Time Frame** *(By when do the tasks need to be completed to trigger the change?)*	**Estimated costs**	**Resources needed** *(What or who can help or will be responsible to achieve the tasks/objectives? Time, costs?)*	**Funding possibilities**
1. Fostering Collaboration and Networking	SPCleantech + external Partners	Connecting companies from different parts of the value chain	SMEs and small midcap companies, universities and research centres, technical experts,	Partner meetings, workshops, events, networking, trainings	Creation of consortium, working groups and partnerships 3-5 partnerships in 12 months	On continuous basis with some results after 12 months	30 000 EUR per year	SPCleantech with participating partners, own financing,	Own resources, local, regional funding programs

			business support institutions, NGOs						
2. Supporting Access to Funding and Investment	SPCleantech + external Partners	Providing information and guidance on available funding opportunities	SMEs and small midcap companies	Monitoring, researching, providing information by mails, newsletters, social media and personal contacts	Regular monthly update on available funding programs	On continuous basis	6000 EUR per year	SPCleantech	Own resources
3. Offering support in preparing funding applications	SPCleantech + external Partners	Providing Expertise and guidance	Consortia consisting of project partners applying for external funding	Personal guidance, meetings, clusters information channels	Completed applications to local, regional, national or EU calls for projects	Supporting 4 applications in 12 months	8 000 EUR /application 6 applications per year = 48 000 EUR	SPCleantech, universities and other external advisors	Own resources, local or regional funding schemes for preparing applications

4.7. Slovakia (Bratislava region)



Sustainable production and the circular economy are key pillars of the Slovak Republic's transition to a greener and more competitive economy. This chapter provides a review of existing national documents and policies that define Slovakia's strategic direction in these areas, considering the European framework and the current needs of the industrial (business) sector.

In Figure 9 the results from the Slovakian chapter are summarized.

Slovakia	Focus	Gaps	Opportunities
§ Regulation	Policy updates	Weak monitoring	Post-project tracking
Regional needs	Governance support	Institutional capacity	Policy learning
Sectoral needs	Supplier industries	Low innovation culture	Value-chain upgrading
! Concrete Actions	Monitoring plans	Project dependency	Long-term frameworks

Figure 9: Summary of the Slovakian perspective

4.7.1. policy analysis

implementation of EU-directives

Slovakia has detected implementation challenges of directives related to packaging and plastics. In November 2022, the European Commission proposed a revision of Directive 94/62/EC of the European Parliament and of the Council on packaging and packaging waste to improve the prospects of achieving the goal set by the European Green Deal and the new Circular Economy Action Plan to make all packaging on the EU market reusable or recyclable in an economically achievable way by 2030. From 2030 onwards, recyclability will be based on design criteria for recycling that ensures the circular use of the resulting secondary raw materials of sufficient quality to replace primary raw materials. Based on an analysis by the Environmental Policy Institute (September 2023, updated April 2024), waste management in Slovakia continues to lag behind most EU countries. The lack of a long-term waste management strategy and a lack of data have led to a confusing situation. An example is the ban on landfilling untreated municipal waste, which has been postponed several times due to a lack of capacity for its processing. Packaging and plastics are represented in a positive light in this statistic, thanks to some of the measures taken.

Regarding plastics regulation in the Slovak Republic, several European regulations have been transposed into national legislation. The **Directive on the reduction of the impact of certain plastic products on the environment** was transposed to Slovak legislation with measures to reduce plastics:

- charging for plastic bags (since 2018)
- ban on single use plastic packaging (since 2021)
- deposit of PET bottles (since 2022)

Deposited beverage packaging in Slovakia reached 92% in the second year of operation, which showed that the project had positive environmental impact and was extremely successful and well accepted in the population. In the area of plastics and packaging, the Bratislava Region has a similar policy to the rest of Slovakia, as environmental policies regarding plastics and packaging are managed at the national level, mainly through the Waste Act and European Union regulations. However, in the Bratislava Region, certain specifics are manifested due to dense urbanization and higher population concentration. Key points of plastics and packaging policy in the Bratislava Region are:

- Act No. 79/2015 Coll. on Waste: this Act regulates the management of packaging and plastic waste throughout Slovakia, including the Bratislava Region. It focuses on waste prevention, recovery and recycling. The Bratislava Region is a leader in the implementation of plastic waste and packaging collection through recycling programs
- Directive 94/62/EC on packaging, Single-Use Plastics Directive, new Directive on plastic & packaging 40/25 (12/24) is now going to be implemented
- Separate collection and recycling of plastics: separate collection of plastics is actively implemented in Bratislava, which is mandatory for all residents. In cooperation with city

districts and waste companies, plastic packaging and other materials are collected for recovery and recycling. At the same time, the region supports educational activities to motivate residents to properly sort waste.

- Single use plastics and reducing their consumption: The Bratislava Region, in accordance with nationwide and European regulations (e.g. the EU Single-Use Plastics Directive), is working to reduce the consumption of single-use plastics.
- Promoting the circular economy: Circular economy projects are also supported in the Bratislava Region. The region invests in technologies and initiatives that enable the effective recovery of plastic waste and its reuse. Recycling and recovery centres in the region help process not only plastic waste from Bratislava, but also from the surrounding regions.
- Supporting local entrepreneurs and reducing plastic waste: local businesses are encouraged to use alternatives to plastic packaging and switch to eco-friendly packaging. For example, some restaurants and cafes in Bratislava have switched to using compostable or returnable packaging.

Further on, in the Slovak Republic, emphasis has increased in recent years on the introduction of common rules to support the repair of goods, which is related to the wider European context. Repairs are an important part of the transition from a linear to a circular economy that focuses on maximizing resource use and minimizing waste. In Slovakia, the implementation of these rules is governed by legislation that is gradually being adapted to EU directives and national initiatives. To protect consumers in the field of repairs of goods, there are several legal regulations that regulate warranty conditions, liability for defects and the possibility of repairing products. The basic legal framework is enshrined in the Civil Code, specifically in Act No. 40/1964 Coll., and in the Consumer Protection Act No. 250/2007 Coll. These laws ensure that consumers have the right to have goods that break down within the warranty period repaired, either free of charge or at a fair price.

As part of the National Strategy for the Circular Economy, measures are being prepared to promote recycling, reduce the consumption of plastics and other single-use products, and at the same time emphasize repairs and renovations. The circular economy is seen as a key element in achieving sustainable development, as extending the life cycle of products reduces the burden on natural resources and the environment. The Slovak government is therefore taking measures to support small and medium-sized enterprises engaged in repairs and renovations, as well as to educate consumers about the importance of repairs and a longer lifespan of products. This policy is closely linked to European initiatives such as the European Green Deal and the European Circular Economy Action Plan, which support Member States in taking action to reduce waste production and promote sustainable solutions.

It is also important to highlight that there are notable difficulties for Slovak companies in accessing European funding, such as the **Capitalisation Call for Central Europe** (103). These challenges stem from past issues with national agencies, including the absence of clear strategic plans, as well as insufficient skills required for preparing successful applications for

new funding opportunities. As a result, Slovak businesses often struggle to benefit from these financial resources, which could otherwise support their efforts in innovation and sustainability.

national policy analysis

For Slovakia and in the Bratislava region, the focus here is on the plastics and packaging sectors. In the plastics and packaging sectors, which fall under the umbrella of innovative industry, Slovakia is pushing for a transformation in the production character of its industry. The government's strategy emphasizes the need for a high share of original innovations and research and development activities. This approach aims to significantly increase the added value of production and related services, potentially revolutionizing how plastics and packaging are produced and used in Slovakia. The Slovak government is placing a strong emphasis on digital transformation, as outlined in Slovakia's **Digital Transformation Strategy 2030** (104). This strategy focuses on innovative technologies such as artificial intelligence, the Internet of Things, and blockchain, which have the potential to drive sustainability and circularity in all four target sectors.

The **Intelligent Industry Action Plan of the Slovak Republic** (105) further supports these efforts by providing support for industrial, service, and trade enterprises. It aims to create better conditions for the implementation of digitization, innovative solutions and increasing competitiveness. To achieve the goals, activities such as reducing bureaucratic burdens, amending legislation, defining standards, changing educational programs and the labour market, and co-financing research are conducted.

Further on, in **Envirostrategy 2030** (106), in each substantive area, the identification of problems and current targets is followed by framework measures to improve the current situation (e.g. increase fees, increase standards, improve awareness). Regional innovation policies are also aligned with broader European objectives within the framework of cohesion policy, which ensures better access to European funds and programs that can accelerate innovation development in the Bratislava region. From the point of view of the four sectors of the CURIOST project, the most references are to the issue of recycling (waste management, waste sorting, its subsequent recovery, efficient use of energy from waste), green construction, insulation and repair of building cladding, installations of support for renewable energies, reduction of energy consumption).

Despite significant government investment in transformation, Slovakia lacks a dedicated emphasis on green transformation, with initiatives primarily targeting energy-related areas rather than the circular economy. Small and medium-sized enterprises within the plastics and packaging sectors receive minimal support, as there are no new funding opportunities available. Many businesses demonstrate willingness to adapt, yet they often lack access to adequate financial resources. Strategic planning for long-term objectives is absent, as actions tend to be influenced by electoral cycles, with limited top-down strategic engagement. Oil dependency, especially concerning Russia, poses substantial challenges, and current mitigation measures remain insufficient. The prevailing focus continues to be on energy, while other relevant topics are comparatively neglected. Recycled materials incur costs at least twice those of conventional alternatives. Additionally, the resilience plan predominantly allocates funding towards new construction and renewable energy projects.

To conclude, from a circular economy perspective, the packaging situation in the Bratislava Region reflects a broader trend that includes both challenges (high consumption and production, insufficient recycling infrastructure, low recycling rates, lack of financial resources and therefore motivation for business) and opportunities related to the transition to sustainable and environmentally friendly solutions. The same applies for the plastics sector; it includes several challenges (insufficient recycling infrastructure, low sorting and recycling rates, lack of incentives for SMEs) and opportunities for improvement. As the most developed region of Slovakia, the Bratislava Region has significant potential for the development of the circular economy, but this potential has not yet been fully exploited. Continued investment in recycling technologies, strengthening infrastructure and raising awareness among residents and businesses are key to a successful transition to a circular plastics economy.

S3-strategy

On national level, Slovakia has a significant number of important policies brought for transformation to circular economy such as the **Smart Specialization of the Slovak Republic 2021-2027 (hereinafter referred to as "SK RIS3 2021+")** (107). This strategy enhances the Slovak economy by increasing research and innovation capacity and building excellence in sectors with the greatest competitive advantage. It represents a strategic document defining goals, policies and measures in the field of research, development and innovation. At the end of 2024, the final version of the update of the SK RIS3 2021+ smart specialization strategy was presented. Key focus areas or domains are:

- Domain 1: Innovative industry for 21st century which is highly relevant for Slovakian industry and production by encouraging innovations, research and development activities which would increase added value of production
- Domain 2: Mobility for 21st century
- Domain 3: Digital Transformation of Slovakia, Healthy Society, Healthy Food and Environment.

From the point of view of the objective orientation of the CURIOST project, it is important to highlight the following:

Domain 1: Innovative Industry for the 21st Century

- Domain Target – i) to support innovative solutions and development in the field of advanced technologies and materials applicable in industry and environmental protection; ii) increase the energy efficiency of industry, reduce environmental impacts, including by further improving the energy mix towards carbon-free and low-carbon energy; iii) to promote the circular economy, local production, resource efficiency and innovations that increase the stability and security of the country's economy.
- Priority axis 1.2 – Processing of raw materials and semi-finished products – a significant shortcoming for Slovakia's ability to increase the share of waste processed and the use of secondary raw materials is the absence of recycling capacities that would enable the use of secondary raw materials, especially in areas such as plastics, metals and other materials,

which represent a significant share of total waste in Slovakia (wood, paper and cardboard, glass, textiles, tires, construction waste, etc.). According to the EU's objectives and initiatives, the share of secondary raw materials in the economy is expected to increase in the coming years. For Slovakia, this means the need for further development and innovation in the field of recycling and the use of secondary raw materials.

Slovakia's approach to sustainable development and circular economy is strongly characterized by meeting EU-requirements, in order to focus on innovation, research, and digital transformation. The government's policies aim to create an ecosystem where sustainable practices are not just encouraged but are integral to the country's economic growth. By emphasizing the need for original innovations and increased R&D activities, Slovakia is positioning itself to become a leader in sustainable industrial practices.

The **S3 strategy for the Bratislava region** (108) intends to support innovative concepts. It aims to increase the competitiveness of the region by focusing on promoting innovation, research and development in areas that have a high potential for future growth and that can contribute to the transformation of industries in the region. The key areas are digital technologies and IT, biotechnology, green technologies and creative industries, which are focused on the development of new solutions and technologies. This includes innovative concepts in the field of artificial intelligence, renewable energy sources, or innovative materials and techniques. Regional and national action plans also include projects that address waste minimization, recycling and resource efficiency, areas where new approaches and technologies are needed. Traditional sectors such as the automotive industry also benefit from the S3 strategy, but even in these sectors, support is oriented towards innovation, such as the transition to electromobility or the development of intelligent transport systems. Digitalization is one of the key areas that Slovakia focuses on. The Bratislava Region, as a centre of IT and technological innovation, has a high potential for digitalization in various sectors. Digitalization is at an advanced level in the Bratislava Region, with many businesses using digital technologies to optimize processes, improve products and services, and increase competitiveness. The IT sector is one of the leaders in digitalization at the national level, with many innovations coming from this region. Nevertheless, the implementation of digital technologies in traditional industries is still gradual and limited.

4.7.2. regional needs

The transition to sustainable production and the circular economy (CE) is a complex process that requires not only technological innovations and legislative frameworks, but also a change in social and economic behaviour. Although the Slovak Republic has adopted several strategic documents that support the development of circular models and green innovations, practice shows that several key conditions for successful implementation are still missing. The most fundamental challenges include insufficient financial and methodological tools for evaluating the sustainability of products, low demand for ecological and recycled products, and the need for systematic education in the field of CE.

- Lack of financial and methodological tools for sustainability assessment: One of the main obstacles to effective support of sustainable production in Slovakia is the lack of

availability of tools that would allow companies to objectively assess the environmental impacts of their products throughout their life cycle – from the extraction of raw materials to their disposal or recycling. At the same time, there is a lack of a uniform national framework or standardized guidelines that would provide companies with guidance on how to approach the assessment of the environmental performance of their products. This leads to low transparency in the market.

- Low demand for recycled and eco-friendly products: This trend is determined by several factors. First, it is the low public awareness of the benefits of the CE and the environmental impacts of normal consumption. Consumers often do not have enough information to distinguish a truly sustainable product from one that only uses "green" marketing. At the same time, perceptive price sensitivity, typical especially for the Slovak market, also plays a role – organic products are often more expensive, as they do not benefit from the same economic benefits as mass-produced alternatives. Without significant incentives or policies to promote such products, for example in the form of public procurement or VAT reductions on sustainable products, demand for them is limited. The underdeveloped market for recycled materials, together with legal and technical barriers to their use, means that recycled content in products continues to be the exception, not the rule.
- The need for education and awareness of CE: Slovakia has long suffered from insufficient systemic education in the field of environmental sustainability. Education is equally important for entrepreneurs, local governments and public institutions, which can be important actors of change.

4.7.3. sector analysis

In Slovakia is attention on two sectors – plastics and packaging. The Slovak Republic has made some progress in the circular economy in recent years, but it still faces a number of financial and non-financial challenges.

plastics

In 2022, Slovakia produced just under 27 kg of plastic waste per capita and ranked eighth in the recycling ranking with 15.93 kg, just above the European average. A positive factor is that the proportion of recycled plastic waste is gradually increasing. However, the amount of waste itself is still growing while recycling has increased by 5.6 percent compared to 2010, the volume of plastic waste produced from packaging has increased by a third. The main problem remains the quality and price of recycled plastics compared to newly produced materials. The situation is also complicated by the fact that there are many types of plastics. Their processing is then much more difficult, more expensive, and the final product does not have the quality that would be expected. Between 2023 and 2025, Slovakia has made significant progress in plastic management, mainly through legislative measures and initiatives aimed at increasing recycling and reducing plastic waste. Since January 2022, Slovakia has introduced a deposit system for PET bottles and cans, which has led to a significant increase in their return. According to OECD data, the return rate of this packaging increased from 70% in 2022 to 92% in 2023, prematurely meeting the EU's target of

achieving a 90% return by 2029. In accordance with the EU's Single-Use Plastics Directive (SUP), Slovakia has taken several measures: from 3rd of June 2024, it is prohibited to place beverage packaging on the market without firmly attached plastic lids; From 1st of January 2025, new PET bottles must contain a minimum of 25% recycled plastic, increasing to 30% from 2030. In October 2024, the Ministry of the Environment of the Slovak Republic announced a call from the Slovakia Programme to support the preparation of waste for reuse and recycling, with an allocation of almost €30 million. The aim is to build new recycling capacities for biodegradable and construction waste, which will contribute to reducing the amount of plastic waste ending up in landfills. Eligible applicants are persons authorized to do business in the field of waste management, as well as municipalities and cities, self-governing regions, associations of natural or legal persons, but also non-profit organizations providing generally beneficial services. Despite the financial support, SMEs faced several challenges in the field of plastics recycling. In 2023, there was a significant slump in the recycled plastics market, which led to a reduction in production and a reduction in work shifts in some companies. The situation began to improve at the beginning of 2024 in anticipation of the mandatory blending of recycled material into PET bottles from 2025. Increasing imports of recycled plastics are also a particular concern for European plastics processors, which threatens the EU recycling industry and can increase the overall carbon footprint as an unintended consequence. The price volatility of the primary raw material PET, which fluctuates around the level of EUR 1,150 per tonne, but in the past fell to EUR 650 and in 2022 was at EUR 1,800, also has a significant impact on the economy of processors.

packaging

In the period from 2023 to 2025, the Slovak packaging industry is undergoing significant transformations because of adapting to new environmental regulations and growing sustainability requirements. The transition to a circular economy brings significant challenges, especially when it comes to redesigning packaging to meet new standards of recyclability and the introduction of more sustainable materials. The use of more sustainable packaging material and systems is already a heavy financial burden, especially for smaller companies – companies need to find the means to develop new products, modify production lines and implement effective recycling systems. A positive trend is the growing recycling rate of packaging waste in Slovakia. In 2023, the recycling rate for municipal waste reached 51.3%, with packaging waste achieving a success rate of 72%. This increase is the result of expanded producer responsibility and improvements in collection and recycling infrastructure. Small and medium-sized enterprises in the packaging industry in Slovakia are currently facing several challenges, which result from the changing regulatory framework, growing environmental requirements and changing consumer behaviour. Given their size, limited capacities and financial capabilities, SMEs are particularly vulnerable to these changes.

One of the biggest challenges is adapting to stricter European and national regulations, which result mainly from the Single-Use Plastics Directive and the upcoming EU Packaging and Packaging Waste Regulation (PPWR). Businesses are expected to use packaging that is lighter, recyclable, or made from renewable or compostable materials. However, SMEs often do not have sufficient capacity to develop new types of packaging, test their functionality or certify them to the required standards. (Solution: SMEs often rely on external cooperation – either with larger companies,

packaging suppliers, research institutions or clusters such as the Slovak Plastics Cluster or the Food Chamber of Slovakia. It is such partnerships that enable the sharing of know-how and access to innovation).

Switching to eco-friendly materials, changing the design of packaging or investing in new production technologies represent a significant financial burden. SMEs, which often operate with lower margins and have limited access to credit, may find it difficult to implement these changes without external support. (Solution: SMEs are trying to optimise packaging design to meet environmental requirements, but at the same time not to increase production costs. There is also a growing interest in minimalist, resealable or reusable packaging that combines functionality with an environmental aspect.)

SMEs do not have enough storage space for new types of packaging materials, face supply chain disruptions (especially for bioplastics and specialty films) or do not have sufficiently flexible production lines to process new types of packaging. (Solution: Flexibility is becoming a key trend – SMEs are investing in smaller, modular lines or looking for hybrid solutions that allow for transitions between different packaging. At the same time, cooperation networks are being created, where several SMEs share logistics or production capacities.)

4.7.4. concrete actions

Table 8 outlines concrete actions the project partner of Slovakia proposes to implement in order to advance its plastics and packaging sectors towards a circular economy. Key measures include implementing and improving financial incentives and regulations to support the transition to circular economy, raising awareness and spreading knowledge on ecological thinking and building strong cooperations among stakeholders for the transition. The actions target SMEs and industries, municipalities, and the general public. Success is defined by the completion of missing strategies, with funding provided through government programs and collaborative initiatives.

Table 8: concrete actions for Slovakia

Action	**Subjects** *(Who is implementing the actions)*	**Objectives** *(What do we want to achieve?)*	**Target groups**	**Tasks & Activities** *(What activities are necessary to achieve the objectives?)*	**Success criteria** *(What are the main results you expect? How do you define the success of the activity?)*	**Time Frame** *(By when do the tasks need to be completed to trigger the change?)*	**Estimated Costs**	**Resources needed** *(What or who can help or will be responsible to achieve the tasks/objectives? Time, costs?)*	**Funding possibilities**
1. improve financial support	National Executive (Government, Parliament, Ministry of Finance of the Slovak Republic)	Setting up financial incentives as a support tool for the transition to CE	Entrepreneurs, cities and municipalities	1. Tax legislation and its adaptation in the areas of CE. 2. Incentives for recycled materials. 3. Support for investments in the modernization of sorting and recycling technologies.	Modification of tax legislation in the field of income tax. Creation of a financial framework for CE support. Abolition of direct and indirect regulations limiting CE.	1 year from the start of the initiative	15 MEUR per year Alternative: small-scale pilot calls for investments in the circular economy – 5-10 MEUR per call	The highest state authorities of the Slovak Republic, business interest associations, NGOs	EU funds, financial instruments to support the transition to CE, rationalization of the tax burden. Recovery and Resilience Plan.

2. improve implementation framework	State administration bodies (Ministry of the Environment of the Slovak Republic, Ministry of Informatization, Regional Development and Investments of the Slovak Republic, Ministry of Economy of the Slovak Republic)	Draft implementing regulations, methodological recommend-dations	SMEs and their business associations	1. Develop concepts for financing green technologies and grant schemes for CE. 2. Holding round tables with the participation of SME representatives on the barriers to CE development. 3. Development of the National Method for Life Cycle Assessment (LCA). 4. Update the system of eco-labels and eco-labelling of products. 5. Standardization of ecodesign requirements.	Completion of missing strategies and action plans. Update old plans and reflect on the current status. Elaboration of methodological recommendations.	1 year from the start of the initiative	3,5 MEUR per year Alternative: expert projects (analyses, LCA methodologies) - 1-2 MEUR/call	Cooperation of all stakeholders, including universities that are dedicated to CE (from a technical, economic or technological point of view).	Existing financial support schemes created in the relevant ministries, special EU funds, Recovery and Resilience Plan.
3. scientific & educational cooperation networks	Interest Associations in the field of CE, university	Building cooperation networks for the implementation of research,	SME	1. Creation of knowledge transfer and consulting platforms.	More intensive information flow (social networks). Developing examples of	9 months from the start of the initiative	4 MEUR/year Alternatives: Horizon Europe	Universities and research institutions, trade union agencies, interest	National financial resources for research and development. Research

		development and knowledge transfer		2.Discussion forums – collection of research input and preparation of technical solutions. 3.Organization of thematic conferences (events)	good practice and promoting them. Creation of (digital) educational materials. Activation of the activities of CE interest associations and their visibility.		(smaller projects), Interreg, Slovakia Operational Program (research and innovation) – 4-6 MEUR per call, once a year	associations of entrepreneurs.	schemes HORIZON, Interreg Europe, Interreg DANUBE, Interreg Central Europe.
4. building a knowledge base on circular economic principles	Ministry of Education, Science, Research and Youth of the Slovak Republic, primary/secondary/higher education	Systematic building of environmental literacy	Students	1. Preparation of electronic materials with a focus on sustainability. 2. Organising knowledge competitions, professional events and creative workshops. 3. Support for sustainability-oriented study programmes. 4. In cooperation with SMEs in the field of Olympics, organization of short-term internships, educational excursions.	Regarding the nature of the activity, it is possible to reach a relatively wide audience (without limitation) – the output should be reports on the activities carried out.	12-18 months from the start of the initiative	6 MEUR/year Alternatives: Erasmus+, Operational Program Slovakia (Education) Interreg (pilot activities) – 4-6 MEUR per call; 1-2 calls per year	Ministry of Education, Science, Research and Youth of the Slovak Republic, Slovak Accreditation Agency for Higher Education, State Pedagogical Institute	National financial resources for research and development. Research schemes HORIZON, Interreg Europe, Interreg DANUBE, Interreg Central Europe.

				5. Creating ambassador positions to spread ideas about sustainability.					
5.Awareness raising	Industry, interest associations, NGOs	Building awareness of the right ecological thinking	General public	1. Campaigns, educational videos, portals about good and bad practice. 2. Webinars, newsletters – intensive use of social networks.	Number of affected entities and shares	9 months from the start of the initiative	2 MEUR/year Alternative: small projects with a budget of 50,000–200,000 EUR, one call for proposals per year, and a total budget of 1.5–2 MEUR	Association of Entrepreneurs of Slovakia, Slovak Chamber of Commerce and Industry, other interest associations and NGOs	National financial resources intended for research and development, support of culture and education. Recovery and Resilience Plan.

5. PRIORITY INTERVENTION AREAS, STRATEGIC RECOMMENDATIONS & BEST PRACTICE POLICIES

In this chapter, the most influential and frequently used **priority intervention areas** for all project partners and partner countries are summarized and **strategic recommendations** to address these 8 priority intervention areas are proposed. Also, a collection of country wise **best practice policy examples** across the examined project area is presented.

8 Priority Intervention areas

The following **8 priority intervention areas** can bring meaningful change to transformation to circular economy and sustainable production. They are visualized in Figure 10.



Figure 10: Eight Priority Intervention Areas to unlock Circular Economy Potential

1. Support for training of qualified personnel and SMEs in sustainable product development, business models and circular product design
2. Engagement in European/regionally funded projects, facilitating the access for SMEs to EU funding to boost investments for circular transformation
3. Cross regional cooperation platforms – collaborative platforms and industry networks for knowledge sharing and best practices exchange
4. Harmonization and legislative clarifications and standardization of product sustainability assessment methodologies
5. Market support and strengthening the innovation capacities of companies
6. Raising awareness and education, advocacy activities and providing expertise
7. Focus on supply chain sustainability and raw materials sourcing
8. Integration of digital tools and AI to endorse the transformation to circular economy

The priority intervention areas assume that interventions and actions proposed will lead to stronger impact in transformation to adopting (digital) circular economy practices and sustainable

product development. In addition, there are also cross-sectoral actions proposed for stronger impact across all sectors simultaneously.

1. Support for training of qualified personnel and SMEs in sustainable product development, business models and circular product design

An important and often emphasized priority area among project partners, who detected that SMEs and medium-sized enterprises lack knowledge and skills to fully integrate sustainable and circular practices into their business models. Targeted training programs empower companies, while building competences is essential for overcoming internal barriers. This intervention area aims to increase awareness among SMEs and competences through targeted training programs, peer learning and sector-specific guidance tools. Lacking the expertise in circular design and digital tools usage (Iot), faulting waste reduction strategies are hindering the circular transition. Therefore, the improvement of practical knowledge can facilitate compliance with EU sustainability goals and accelerate transformation.

2. Engagement in European/regionally funded projects, facilitate the access for SMEs to EU funding to boost investments for circular transformation

Critical funding gap persists, particularly for SMEs in essential sectors like construction, plastics and manufacturing which is limiting the scalability of pilot projects. Providing information and guidance on available funding opportunities, update members on relevant national, European and regional funding programs, supporting green transition and circular economy initiatives is becoming essential for successful transformation. Accompanied to it, support in preparing funding applications and proposals for grants is highly relevant. The goal is to connect companies with potential investors interested in circular economy solutions as well as explore opportunities for establishing regional green financing mechanisms in collaboration with local financial institutions. Creation of AI based tool would be beneficial for usage of funding programmes with focus to simplify the understanding of EU directives and regulations, as well as to facilitate access to funding programmes for SMEs through improving compliance and operational efficiency.

3. Cross regional cooperation platforms – collaborative platforms and industry networks for knowledge sharing and best practices exchange

Cross-regional cooperation platforms are vital for transformation to a circular economy, as they address fragmented efforts and promote collaboration among academia, industry, and public authorities. By fostering partnerships through virtual hubs, cross-border initiatives, and digital tools, these platforms can significantly enhance knowledge sharing, infrastructure development, and policy alignment. This collaborative approach will reduce regional disparities and make Central Europe a leader in circular transformation. Organizing awareness-raising campaigns, information days, webinars, and other educational initiatives targeted at the public and the future generation can effectively boost demand for sustainable goods. Compiling successful circular economy initiatives and technologies, connecting to research institutions in targeted sectors, create matchmaking events, creating joint projects are just some of the ideas through which collaboration can be used for endorsing circular transformation.

4. Harmonization and legislative clarifications and standardization of product sustainability assessment methodologies

Too many regulations create a substantial compliance burden on domestic businesses, as they face challenges due to the absence of clear guidance and support tailored to local contexts. Harmonisation of sustainability policy framework, encompassing all regulations and directives related to the topic of circular economy is important for companies because it facilitates regulatory compliance, access to finance and enhances competitive advantage. One step forward was introduced by European Commission recently with presenting Omnibus package for reducing administrative burdens on the companies falling under scope for sustainability reporting. Further on, introduction and standardization of product sustainability assessment methodologies is encompassing development of national methodologies for life cycle assessment of plastics and packaging in accordance with European standards, introduction of eco-labels to support informed customer decisions and standardization of eco-design requirements, as well as hosting information webinars on digital product passport (DPP), as part of Eco-design regulation.

5. Market support and strengthening the innovation capacities of companies

Market support for recycled and eco-friendly products is gaining attention in the circular transformation. Promotion of green public procurement, defining minimum environmental criteria for procurement, creating stable market incentives for recycled materials, raising awareness towards consumers while focusing on benefits and safety of recycled and environmentally friendly products are just some of measures used for market regulation of circular products. Creating platforms for companies to present their innovative offerings to potential customers and partners, as well as including relevant stakeholders in the process are important future steps. Since there are companies already participating and developing circular solutions, such as recycled construction materials, they can face challenges in bringing them to market. Companies need support to move beyond pilot or prototype stage, which will enable transition from concept to market-ready circular products and services by connecting innovators with funding, infrastructure and end users.

6. Raising awareness and education, advocacy activities and providing expertise

Improving access to information about available support and funding opportunities is a way to start with education on circular transformation. By conducting awareness campaigns, broader business community and the public are being informed about the benefits of the circular economy. Clusters, platforms, innovation parks should represent the interests of companies in discussions with regional and national policymakers regarding regulations and support mechanisms for the circular economy. Such organisations have enough influence and knowledge to act as facilitators and knowledge hubs and can contribute to the adoption of sustainable solutions and circular practices. This circular transformation should be accompanied with education activities in schools and universities, offering deeper understanding of the links between the economy, industry and natural resources. Education activities should have systematic support from the state and educational institutions. Awareness raising campaigns for circular economy, including campaigns

motivating consumers, promoting recycling, reuse and supporting sustainable productions should be more often and target broader public.

7. Focus on supply chain sustainability and raw materials sourcing

One of the primary barriers faced by companies is the difficulty in sourcing sustainable raw materials. This challenge is critical for facilitating the transition towards circular business models, as access to sustainable materials is fundamental for reducing the environmental impact of manufacturing processes. Companies need support in developing sustainable supply chains, including sourcing of recycled or bio-based raw materials and fostering partnerships with suppliers who can meet these sustainability requirements. The region's strong industrial base offers opportunities to integrate regional circular supply chains, reducing reliance on virgin materials and supporting the resource recovery model. Strengthening the sustainable raw material infrastructure would significantly boost market readiness and accelerate the adoption of circular principles in the sector. Targeting businesses and consumers with education on usage of bio-based plastics and recycled plastics and dissemination of success stories on circular construction with recycled building materials should be implemented as well.

8. Integration of digital tools and AI to endorse the transformation to circular economy

Integration of AI or 3D tools is especially relevant in the sector of mechanics and mechatronics with focus on 3D printing, artificial intelligence and reverse logistics. Transformation to circular economy can be achieved by stronger usage of digital tools in the mechatronics sector. Other digital solutions are also available for different sectors, such as implementing AI Analytics, implementing systems to track recycling, using blockchain, using digital tools to extend product lifecycles and reduce waste, as well as offering digital solutions such as digital product pass and education about it.

Strategic recommendations

The strategic recommendations that support sustainable and circular product development are listed, but not limited to:

1. Identifying the status of sectors development level and needs in particular regions and countries
   - Harmonised policy frameworks
   - Sector specific strategies as templates
   - Best practices templates for replication actions
2. Share good practices and knowledge
   - Awareness raising campaigns (also for consumers), organising info-days, webinars
   - EU regulations: support SMEs in their understanding of eco-design requirements, digital product passports, and sustainability reporting
   - Strengthening digital skills
   - Exchange of experiences, peer learning

3. Coordinated Pilot Actions and Demonstrations
   - Sector-specific actions for strengthening targeted sectors
   - Supporting innovations, development of practical solutions
4. Regional cooperation
   - Support for development of clusters (European, regional, national)
   - Involvement of different stakeholders – academia, SMEs, Small Midcaps, governments
5. Ensure financial support
   - Stronger incentives for traditional companies
   - Funding information: How SMEs can access EU and national funding for circular transformation

Best practice examples

An exemplary approach to promoting sustainability and circular economy principles in the plastics and packaging sector is the implementation of robust framework conditions such as the plastic bottle deposit system. This system, which has been successfully adopted in several partner countries including Hungary, Germany, and Austria, incentivizes consumers to return used plastic bottles for recycling by providing a monetary deposit. By ensuring that a high proportion of bottles are collected and reintroduced into the recycling stream, this practice significantly reduces plastic waste, supports resource recovery, and encourages responsible consumer behaviour. The wide adoption of such schemes across multiple nations underscores their effectiveness and transferability as a best practice in supporting sustainable supply chains.

In Austria, the commitment to sustainable packaging is further demonstrated through the development of a dedicated roadmap for sustainable packaging in Upper Austria. This strategic document lays out specific targets and measures to reduce packaging waste and increase the use of recyclable and environmentally friendly materials. Another notable initiative is the repair bonus system, which, although primarily aimed at end consumers, offers financial incentives for repairing products rather than discarding them. Originally introduced in Austria, this system has also been adapted on a regional level in Germany, highlighting its cross-border applicability and the potential for broader European impact.

Hungary provides another strong example of best practice by prioritising sustainability within higher education. The University of Pécs, for instance, has established a dedicated Sustainability Centre offering a range of courses focused on sustainability-related STEM (Science, Technology, Engineering, and Mathematics) fields. By integrating sustainability into academic curricula and fostering new skills among students, Hungary is actively contributing to the development of a workforce equipped to address the challenges of circular economy transformation.

These examples illustrate how both policy frameworks and educational initiatives, when tailored to national and regional contexts, can serve as effective best practices for advancing sustainability and circularity. The plastic bottle deposit system stands out as a model that has been successfully

implemented across several countries, demonstrating its value as a transferable approach to reducing waste and closing material cycles in the plastics sector.

To conclude, project partners defined the status and difficulties in their respective project regions and targeted four sectors, which hinder the successful transformation to circular economy and sustainable product development. That is why they pointed out 8 priority intervention areas, that can make more impact and stronger market change in the industrial transformation to circular economy. Concrete actions per partner country serve as a foundation for future policy recommendations. Emphasize is on the concrete actions of collaborations, raising awareness about circular economy, training SMEs and small midcaps on sustainable production and integration of digital solutions in transformation to circular economy and sustainable product development. Best practice examples provide inspiration by demonstrating what can be achieved and how these ideas might be applied across different European countries. Enhancing the clarity and accessibility of policy for SMEs and small midcaps facilitates their engagement with European, national, and regional funding opportunities, thereby fostering innovation and the development of pilot projects.

6. CONCLUSION

The CURIOST Action Plan is embedded in the evolving European legal and policy framework that defines the direction for sustainable and circular product development across all EU Member States. By integrating the analysis of the latest European and national regulations and policy initiatives with Smart Specialisation Strategies, innovation and circular economy strategies of the partner regions and an assessment of regional SME and small mid-cap sectoral needs, the Action Plan provides a comprehensive "big picture" of high-potential fields for intervention. This integrated perspective enables the identification of policy actions that can be effectively implemented at regional level while remaining aligned with EU-wide objectives and regulatory requirements. The recommended measures are developed from both a transnational and regional perspective and demonstrate high transferability beyond the project area, supporting broader European uptake.

Support instruments that can be extracted from the analysis include national strategies on digitalization, sustainability, bioeconomy and sector specific strategies that are well aligned and compatible with S3 and RIS3 strategies in most countries. S3 strategies support collaboration between different actors — academia, research institutions, companies — and encourage forming clusters and innovation parks. In partner countries such as Austria, Poland, and Hungary, the focus is on a horizontal approach across industries to transition to a circular economy. In contrast, Croatia, Italy, Slovakia, and Germany favour a sector-specific strategy, identifying particular sectors or priority areas that are either leading or require additional support to shift toward sustainable practices. National and regional development levels also vary: Hungary for example currently only has national strategies without a regional emphasis, while Croatia, Austria, Germany, and Poland have developed strategies specifically designed to promote balanced regional development. In case of Poland, regional strategies of the Malopolska region provide comprehensive sets of measures and goals to transform the region to circular economy practices, with priority areas and specializations that contribute to the development of the region. All measures and proposals require financial means to be successfully implemented — therefore almost all partner countries benefit from European funds intended for enhancing sustainability, innovations, green solutions and circular economy, as well as from National Recovery Resilience Plans for specific countries. To sum up, support instruments are highly developed through S3, RIS3, circular economy strategies and other relevant strategies, which means that countries and regions recognize the European Union's guidance towards transformation to circular economy and sustainable development.

Main challenges that emerge from the analysis recon resistance of SMEs and small midcaps from implementing digital technologies and innovations in sustainable production because of the reluctance of traditional industries. High operational expenses and costs of implementing sustainability practices may hinder the ability to fully participate in transition. Even though many opportunities emerge, companies are careful in navigating through the financial and bureaucratic requirements. Other issues include delays in policy adoption and missing of sectoral governance bodies which hinders the full utilization of funds and execution of implementation and monitoring

measures. While certain countries have only national, horizontal approaches, the need arises for sector specific strategies to develop niches of expertise and innovation rather than maintaining the status quo. Raising awareness and educational campaigns should get more attention as it is necessary to change corporate organizational cultures and mindsets which requires time.

For the analysed sectors in the CURIOST project — plastics, packaging, construction and building, mechanics and mechatronics — main challenges include level sector development, infrastructural development, funding and support for transformation and external factors. High plastic consumption, combined with inadequate waste collection and recycling infrastructure, leads to a high amount of plastic waste ending up in landfills or incinerators rather than being recycled. The main barriers to recycling plastic packaging are mixed material composition and contamination with food or other substances. The construction sector is increasingly focusing on sustainable practices, particularly in highly developed countries such as Austria and Germany, where there are ongoing efforts to utilize recycled materials in building processes and improving energy efficiency in buildings. This trend is also extending to other nations, including Poland, which is introducing innovative solutions for the construction industry, and Croatia, which is implementing effective practices for managing construction waste. For the mechanics and mechatronics sector, challenges such material complexity and limited incentives for circular solutions, remain due to high performance and safety requirements which slow down the adoption of resource-efficient and circular practices. Transitioning towards circular product development requires a stronger focus on design for durability, repairability and recyclability, as well as improved integration of reuse and take-back systems across value chains.

To conclude, national/regional policies and strategies established a good path forward for transition to circular economy and sustainability, while the real implementation of proposed measures and goals lacks behind due to implementation challenges. One reason identified by the CURIOST project is that discussions on implementing circular economy practices in the examined sectors mainly focus on helping SMEs comply with EU regulatory frameworks and national regulations, instead of widening the discussion to include further dimensions. Therefore, factors like existing market opportunities, or financial incentives resulting from implemented CE practices receive less attention, despite being as important (see Figure 11).



Figure 11: Dimensions of Circular Economy within the CURIOST project.

Such challenges can be resolved with concrete policy instruments, raising awareness and sufficient funding, and by transferring best practices from individual countries to others. Differences exist among partner countries, in their level of preparedness for transformation to circular economy and sustainable development, but a common striving forward by improving national policy framework is visible.

Therefore, the CURIOST consortium proposes to implement the CURIOST Action Plan to tackle the mentioned gaps and challenges in the implementation of circular economic practices in CEE. Detailed actions to tackle those challenges can be found in the "concrete actions" tables per country. In this way the untapped potential of circular economy can be addressed, and systemic action can get started (see Figure 12).



Figure 12: Circular Economy Potential in CEE

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