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STRATEGIES FOR SUSTAINABLE PLASTIC MANAGEMENT IN CENTRAL EUROPE

Interreg Central Europe project CE0200857 GreenChemForCE

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Content

Chapter 1

1. Introduction and purpose of the strategy

1.1. Background and project context

The GreenChemForCE project is an Interreg CENTRAL EUROPE initiative that aims to make the chemical industry in Central Europe more sustainable and competitive by supporting a transition from linear to circular production systems and by reducing environmental pressures associated with materials and processes [1]. Within this broader agenda, the project focuses on three core themes: sustainable management of plastics, carbon dioxide management in industry, and greener production of fine chemicals [2].

Interreg CENTRAL EUROPE is a transnational cooperation programme that supports joint solutions to shared challenges among regions from nine European Union (EU) Member States—Austria, Croatia, the Czech Republic, Germany, Hungary, Italy, Poland, Slovakia, and Slovenia. The programme covers 81 regions and a population of around 148 million people. These regions host a dense concentration of manufacturing industries, transport corridors, and urban centres, and are strongly integrated into European and global value chains for plastics and plastic-containing products [3].

Work Package 1 (WP1) of GreenChemForCE addresses the sustainable management of plastics. It is structured around analysing the current state of plastic production, use, and waste management in Central Europe (Deliverable D.1.1.1 – Analysis report); and developing a Strategy for sustainable plastic management in Central Europe (Deliverable D.1.1.2), which this report represents [4,5].

Deliverable D.1.1.1 provides a data-driven baseline on plastic flows, existing infrastructure, policies, and initiatives in the programme area. Building on this foundation, Deliverable D.1.1.2 translates the insights into a coherent, action-oriented strategy aligned with EU policy frameworks and regional development needs.

The strategy is consistent with the European Strategy for Plastics in a Circular Economy and the EU Circular Economy Action Plan (2020), both of which call for plastics to be designed, produced, used, and recycled in ways that minimise resource use and environmental impacts, and support the EU's long-term sustainability objectives [6–9].

1.2. Rationale for sustainable plastic management in Central Europe

Plastics are indispensable to modern economies, yet current production and consumption patterns are unsustainable. In the European Union, plastic packaging waste alone reached about 16.16 million tonnes in 2022, of which only around 40.7% was recycled; per capita packaging waste increased by almost 8 kg per person between 2012 and 2022. Despite decades of progress, plastics remain largely dependent on fossil feedstocks, and a significant share of plastic waste is still incinerated or landfilled rather than kept in high-value cycles. [4,5].

Recent data show that Europe's position in the global plastics system is under pressure. Europe's share of global plastics production has fallen from roughly 22% in 2006 to about 12% in 2024, while the share of "circular plastics" (from recycling and bio-based sources) in European production has stagnated at around 15.4% [10]. At the same time, policy and market expectations are accelerating: by 2030, all plastic packaging placed on the EU market should be reusable or recyclable in a cost-effective manner under the EU plastics strategy.

Central Europe sits at the crossroads of these challenges and opportunities:

- It hosts a strong manufacturing base (automotive, construction, packaging, consumer goods) that both **depends on plastics** and **generates significant plastic waste streams**.
- It is deeply embedded in cross-border supply chains within the EU and towards neighbouring regions, making **harmonised approaches to standards, recycling quality and logistics** particularly important.
- Many Central European regions still face **gaps in waste infrastructure and recycling capacity**, especially for complex or contaminated plastic fractions [10].

At the same time, EU regulatory and policy frameworks are becoming more demanding and more supportive of circular solutions. The **European Strategy for Plastics in a Circular Economy**, the 2020 **Circular Economy Action Plan**, the **Single-Use Plastics Directive (EU) 2019/904**, and upcoming regulations on packaging and packaging waste, eco-design and sustainable products are reshaping the operating conditions for plastic producers, users and waste operators [6,7,11].

For Central Europe, the rationale for a dedicated strategy is therefore threefold:

1. **Environmental and climate urgency** – reduce plastic leakage to the environment, cut greenhouse gas emissions over the entire life cycle of plastics, and minimise human and ecosystem exposure to hazardous substances [12,13].
2. **Industrial competitiveness and resilience** – use circular value chains, waste valorisation, and sustainable feedstocks to safeguard the region's industrial base and create new business opportunities in recycling, eco-design, bio-based materials, and digital solutions.

3. **Social acceptance and innovation capacity** – respond to public concern about plastic pollution while strengthening skills, jobs, and innovation in green chemistry and sustainable product design.

This strategy offers a regional response to these drivers, tailored to Central Europe's specific context while aligned with EU-wide ambitions and frameworks.

1.3. Scope, boundaries, and definitions used in this strategy

Figure 1 provides a high-level visual of the transition from a linear "make-use-dispose" model to circular plastic value chains, and positions the four strategic pillars as the enabling levers for change. The key takeaway is that durable circularity requires coordinated progress on regulation, collaboration, skills, and technology—not a narrow focus on end-of-life treatment.

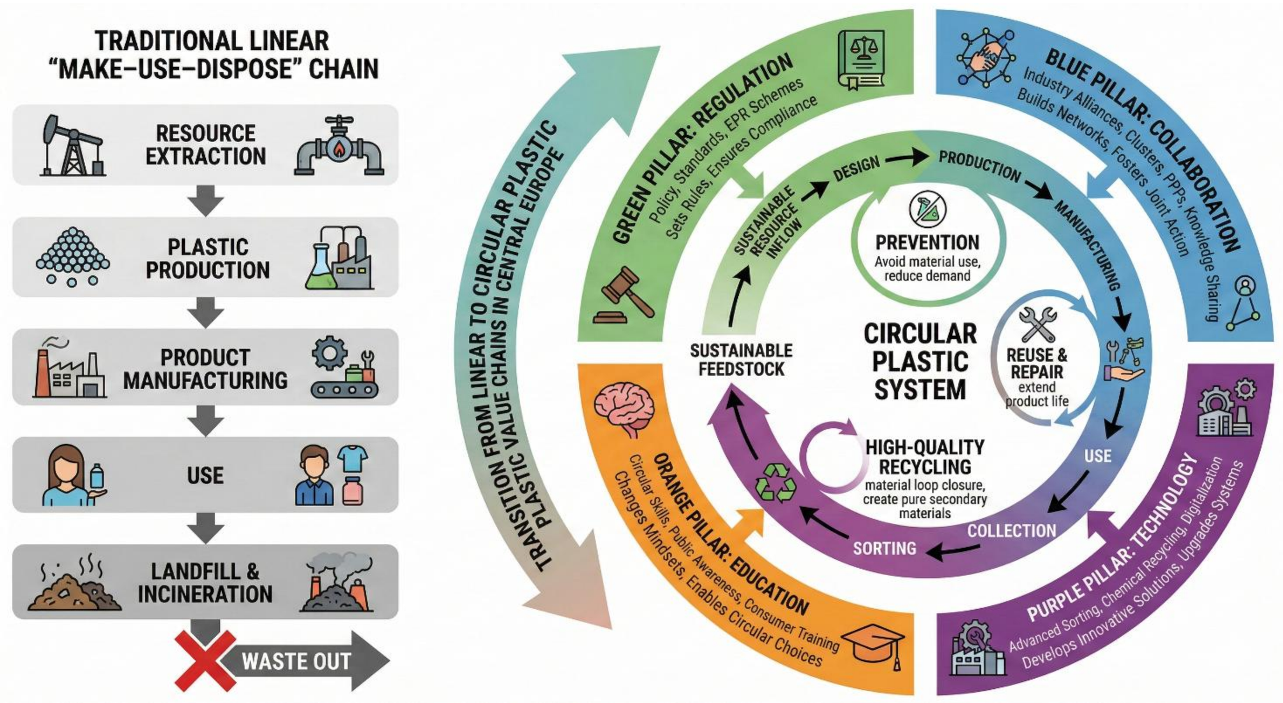

Figure 1: From linear to circular plastic value chains in Central Europe.

1.3.1. Geographical and institutional scope

The strategy covers the Interreg CENTRAL EUROPE programme area, i.e., all regions of Austria, Croatia, the Czech Republic, Hungary, Poland, Slovakia, and Slovenia, as well as participating regions in Germany and Italy, as defined in the programme documents.

Institutionally, the strategy targets public authorities (EU, national, regional and local), industry actors along plastic value chains and their associations, business-support organisations and cluster initiatives, universities and research or training providers, and civil society organisations active in environmental protection, consumer issues and social innovation.

1.3.2. System boundaries and material scope

The strategy adopts a life-cycle systems perspective, covering feedstock extraction and polymer production through product design and use to collection, sorting, recycling, recovery and final disposal [14]. It addresses conventional fossil-based plastics (e.g., polyolefins, polyethylene terephthalate (PET) and polyvinyl chloride (PVC)), recycled plastics and secondary raw materials, and bio-based and other non-petroleum-based plastic materials used as substitutes or complements to conventional polymers [15,16].

While the main emphasis is on **macro-plastics and material flows in key sectors** (e.g., packaging, construction, automotive, electronics), the strategy also considers linkages to microplastics and chemical safety where relevant to policy and design choices, without attempting to provide a full toxicological assessment [17].

1.3.3. Key concepts and working definitions

For the purpose of this strategy, the following working definitions are used:

- **Sustainable plastic management** – the set of policies, business practices, technologies and behaviours that ensure plastics and plastic products are designed, produced, used and managed in ways that minimise environmental impacts, support climate neutrality, conserve resources and protect human health over their life cycle.
- **Circular plastic value chains** – value chains in which material and product loops are kept in use at their highest possible value for as long as possible, through prevention, reuse, repair, remanufacturing, and high-quality recycling, in line with EU circular economy principles [6,7].
- **Waste and by-product valorisation** – the transformation of plastic waste and production by-products into valuable secondary raw materials, energy carriers, or new products through mechanical recycling, chemical recycling, and industrial symbiosis, provided these routes deliver verifiable environmental benefits [18].
- **Sustainable resources and feedstocks** – recycled plastics and non-petroleum-based carbon sources (e.g., bio-based feedstocks, captured CO_2-based feedstocks) used in ways that are consistent with sustainability criteria, including land use, biodiversity, and climate impacts [19].
- **Sustainable product design / eco-design** – design approaches that incorporate life cycle thinking and green chemistry, aiming to reduce resource use, enable reuse and

recycling, avoid hazardous substances, and improve the environmental performance of plastic products across their life cycle.

These concepts are operationalised in the strategy through four strategic pillars: regulatory framework and governance; regional collaboration and value-chain partnerships; education, skills and behavioural change; and technology, innovation and infrastructure.

The technical themes – circular value chains, waste valorisation, sustainable resources, and eco-design – are addressed systematically within and across these pillars.

To keep a clear line of sight between the strategic pillars and the technical focus areas, Table 1 provides a concise mapping used throughout the report.

Table 1: Mapping strategic pillars and the technical focus areas used throughout the report.

Strategic pillar	Circular value chains	Waste and by-product valorisation	Sustainable resources and feedstocks	Sustainable product design / eco-design
Pillar 1 - Regulatory framework and governance	Targets and incentives for prevention, reuse and high-quality recycling.	Clear waste/by-product rules and quality criteria to support high-value recycling routes.	Recycled-content obligations and safeguards for credible, sustainable feedstocks.	Eco-design requirements, labelling and rules that remove substances hindering circularity.
Pillar 2 - Regional collaboration and value-chain partnerships	Cross-border coordination of standards, logistics and market expectations.	Industrial symbiosis and recyclate platforms that connect waste streams to end users.	Joint sourcing and demand pooling for recycled and alternative feedstocks.	Co-creation networks and shared guidelines that align designers, producers and recyclers.
Pillar 3 - Education, skills and behavioural change	Skills and behaviour needed to implement prevention, reuse and correct separation.	Training on safe handling, quality control and evaluation of valorisation options.	Literacy on life-cycle trade-offs and credible claims for recycled and alternative feedstocks.	Eco-design competences and tools embedded in vocational education, training and practice.
Pillar 4 - Technology, innovation and infrastructure	Collection, sorting and recycling infrastructure that enables closed-loop material flows.	Modern recycling and upgrading technologies for higher-quality secondary materials.	Processes and quality assurance to integrate recycled and non-fossil feedstocks safely.	Digital tools and testing infrastructure to support circular design and traceability.

The mapping highlights that progress on any technical theme depends on coordinated action across all four pillars.

1.4. Target audiences and intended use of the document

Given the diversity of stakeholders in Central Europe, this strategy is written to be accessible while remaining technically robust. It is intended as a shared reference for policymakers and public authorities, companies and their associations, business-support organisations and clusters, universities and research or training providers, and civil society organisations—supporting strategy development, investment planning, capacity building and stakeholder dialogue [6,7].

In practical terms, it helps stakeholders identify priority areas for action and collaboration, understand how regulatory, technological, educational and collaborative interventions reinforce each other, and develop roadmaps and project concepts aligned with EU and national policy directions and suitable for relevant funding programmes (e.g., Interreg, Horizon Europe, LIFE, cohesion policy funds, and national schemes).

1.5. Structure of the report

The report first summarises the baseline and problem statement for plastic value chains in Central Europe (Chapter 2) and then sets out the strategic framework and four-pillar model used throughout the document (Chapter 3). Chapters 4–7 detail recommendations under the four pillars, structured across the four technical themes. Chapter 8 synthesises cross-cutting priorities and synergies across priority value chains. Chapter 9 presents the implementation roadmap, governance approach and monitoring logic. Chapter 10 distils the conclusions and key messages, while Chapters 11–12 provide condensed summaries for decision-makers. Chapter 13 lists the references.

This structure is designed to help readers quickly locate the sections most relevant to their role while maintaining a coherent narrative from diagnosis to implementation.

Chapter 2

2. Baseline and problem statement for plastic value chains in Central Europe

This chapter summarises the current situation of plastics in Central Europe, drawing on the analysis in Deliverable D.1.1.1 and on recent European studies and statistics. It highlights where plastic value chains remain largely linear, where circular practices are emerging, and which systemic gaps the strategy will need to address in subsequent chapters [4,5].

2.1. Overview of plastic production and consumption in Central Europe

At the EU-27 level, plastics remain deeply embedded in the economy. A recent material flow analysis by the Joint Research Centre (JRC) estimates that in 2022, the EU-27 plastics value chain produced around **57.9 million tonnes of plastics**, met a consumption of **about 62.8 million tonnes** (≈139-140 kg per person), and generated roughly **42.5 million tonnes of post-consumer plastic waste** [3].

Most plastics are still produced from fossil feedstocks. Bio-based plastics represent only about **1-2 % of production**, and plastics made from recycled polymers account for less than 10 % of total output, in line with global estimates that only around **9.5 % of plastics produced in 2022 were made from recycled material**. This confirms that the European plastics system is only weakly circular and still strongly dependent on fossil resources [4,5].

In terms of **applications**, recent EU-level analyses show that p**ackaging** accounts for roughly one-third of plastic consumption and an even larger share of plastic waste. **Building and construction** is the second-largest application, followed by automotive, electrical and electronic equipment (EEE), agriculture, and **textiles** [20].

These patterns are mirrored - and in some sectors amplified - in Central Europe, which combines:

- a strong **manufacturing base** (automotive, machinery, consumer goods),
- important **logistics and retail hubs**, driving packaging use, and
- rapidly modernising **infrastructure and construction sectors**.

The Interreg CENTRAL EUROPE area includes countries such as Austria, Croatia, Czechia, Germany, Hungary, Italy, Poland, Slovakia and Slovenia, all of which are significant users and, in some cases, producers and converters of plastics. This concentration of industrial activity means that Central Europe is both:

- a hotspot of plastic demand and waste generation, and
- a priority region for piloting circular solutions in areas such as packaging, automotive components, construction products and technical plastics.

However, the overall material flow is still dominated by a **linear "make-use-dispose" pattern**. The majority of plastics entering the system are virgin fossil-based polymers; only a modest fraction re-enters as recycled material, and a large share of post-consumer plastics is still incinerated or landfilled rather than kept in circulation [15,16].

2.2. Sectoral profiles of key plastic-using value chains

This section profiles the main plastic-using value chains in Central Europe and summarises typical polymers, product lifetimes and waste pathways that shape circularity options. Table 2 provides a comparable snapshot across sectors, linking material choices and service lifetimes to the waste streams that need to be managed.

Table 2: Materials, lifetimes, and waste streams (Central Europe - typical EU patterns)

Sector	Main plastic types used (typical)	Typical product lifetimes	Main waste streams (where plastics end up)
Packaging	Polyethene (PE: low-/high-density), polypropylene (PP), polyethene terephthalate (PET), polystyrene (PS), and smaller shares of polyvinyl chloride (PVC).	Minutes to months (dominant single-use formats).	Municipal packaging waste (separately collected + mixed residual); commercial & industrial packaging waste; litter/leakage (where collection fails).
Construction	PVC (major), PE/PP (pipes, membranes), expanded polystyrene (EPS) and polyurethane (PUR) (insulation foams) [21].	Decades: many building plastics stay in use for 30–50+ years; pipes commonly 50+ years; PVC window profiles can reach multi-decade service lives.	Construction & demolition waste (mixed mineral + plastics); separate streams for PVC profiles/pipes, insulation foams, membranes; legacy additives in older stock (important for renovation waves). [21]
Automotive	Mainly PP plus PUR, polyamide (PA/nylon), PE, ABS/SAN, PET; also PVC, polycarbonate blends in components [3].	~15–25 years typical vehicle lifespan range across Europe (longer in parts of Eastern/Central Europe) [22].	End-of-life vehicles: dismantling fractions (some parts) + automotive shredder residue containing mixed plastics; contamination and multi-material assemblies reduce recyclability [23].
Electrical and electronic equipment (EEE)	ABS, high-impact PS (HIPS), PP, PC/ABS blends; flame-retardant plastics are common in several categories [24].	~3–15 years depending on product group (e.g., smartphones shorter; large appliances longer) [25].	Waste electrical and electronic equipment (WEEE): plastics mixed with metals, cables; brominated flame-retardant plastics may be classified as hazardous, limiting recycling routes [26].
Textiles	Synthetic fibres: polyester (PET) dominant; also polyamide (nylon), polypropylene (PP), acrylic, elastane (polyurethane) [27].	Highly variable: many garments fall within a ~1–10-year range; examples (t-shirts) average ~4–5 years in consumer surveys [28].	Post-consumer clothing & household textiles; pre-consumer cutting waste; fibre shedding as microplastic emissions during use/washing (relevant to CE river basins) [27].
Agriculture	Mostly PE films (mulch, silage, greenhouse), PP (twines, nets), PE/PVC in irrigation and fittings (by application) [29].	Typically, months to a few years: agricultural plastics often ~5–60 months, greenhouse films around ~40–50 months in some assessments [30].	Used films and nets are often contaminated with soil/biomass; collection losses lead to on-field residues; low recycling rates where logistics/cleaning are weak [29].

2.2.1. Packaging

Packaging is the **largest single use** of plastics in Europe and Central Europe, covering food and beverages, household and personal care products, e-commerce, logistics and industrial packaging. It generates the **largest share of plastic waste, largely due to the prevalence of single-use items and extremely** short product lifetimes [20].

Key characteristics in Central Europe include:

- Rapid growth of **e-commerce and retail chains**, intensifying demand for transport and protective packaging.

- High prevalence of **single-use packaging** in food service and convenience sectors, despite tightening EU rules on certain single-use plastics.
- Strong existing infrastructure for **PET bottle collection and recycling** in several countries, but significantly weaker systems for films, mixed plastics and multi-layer packaging [14].

Circular practices are emerging through **deposit-return schemes**, lightweighting, recycled-content packaging and reusable solutions; however, these remain niche compared to the overall flow of disposable plastic packaging.

2.2.2. Building and construction

Plastics in building and construction are used in **pipes, insulation, window profiles, flooring, membranes and cables**. They typically have **long service lives (10–50 years)** and often remain embedded in buildings, which complicates tracking and end-of-life management [10].

In Central Europe, large renovation needs (e.g., for energy efficiency) and new infrastructure investment create both:

- a **growing stock** of plastic-containing building materials, and
- a future wave of **plastic-containing demolition waste** that is not yet systematically prepared for high-quality recycling.

Opportunities exist to integrate **eco-design and design-for-disassembly** into construction products and to develop specialised value chains for **window profiles, insulation materials, and pipe recycling, but these markets remain underdeveloped**.

2.2.3. Automotive

Central Europe is one of Europe's leading **automotive manufacturing regions**, with major vehicle and component plants in Germany, Czechia, Slovakia, Poland, Hungary, and Austria. Plastics are used extensively in vehicle interiors, exterior parts, under-the-bonnet components, and, increasingly, battery housings and lightweight structures [16].

The automotive sector has strong potential for **closed-loop plastic value chains**, but currently:

- most plastics from end-of-life vehicles (ELVs) are **shredded and incinerated** or landfilled,
- only a limited share is **sorted and mechanically recycled**, and

- advanced (chemical) recycling routes for complex automotive plastics are still at pilot or early commercial stages [16].

New EU requirements for recycled plastic content in vehicles and stricter ELV rules will prompt manufacturers in Central Europe to adopt higher levels of circularity, presenting both challenges and opportunities for innovation along the supply chain.

2.2.4. Electrical and electronic equipment (EEE), textiles, and agriculture

Other important plastic-using sectors include:

- EEE: casings, cables, connectors, and small components, often containing additives and flame retardants that complicate recycling.
- Textiles: synthetic fibres (polyester, polyamide, elastane) in clothing, workwear, and technical textiles, contributing to microplastic releases during washing and use [15,16].
- Agriculture: greenhouse films, mulching films, irrigation pipes, and bale wraps, particularly relevant for Central Europe's extensive agricultural regions.

These sectors are characterised by **heterogeneous material streams**, contamination, and diffuse end-of-life pathways, making the establishment of circular value chains more complex than in relatively homogeneous packaging streams.

2.3. Waste management and recycling performance in Central Europe

At the EU level, plastic packaging waste remains a major challenge. Recent Eurostat data show that in **2023**, the EU generated 79.7 million tonnes of packaging waste, of which about 19.8% **(35.3 kg per person)** was plastic packaging. The EU recycled **42.1% of this plastic packaging waste, up from 38.2**% in 2013, but still leaving a majority to be incinerated or landfilled [31].

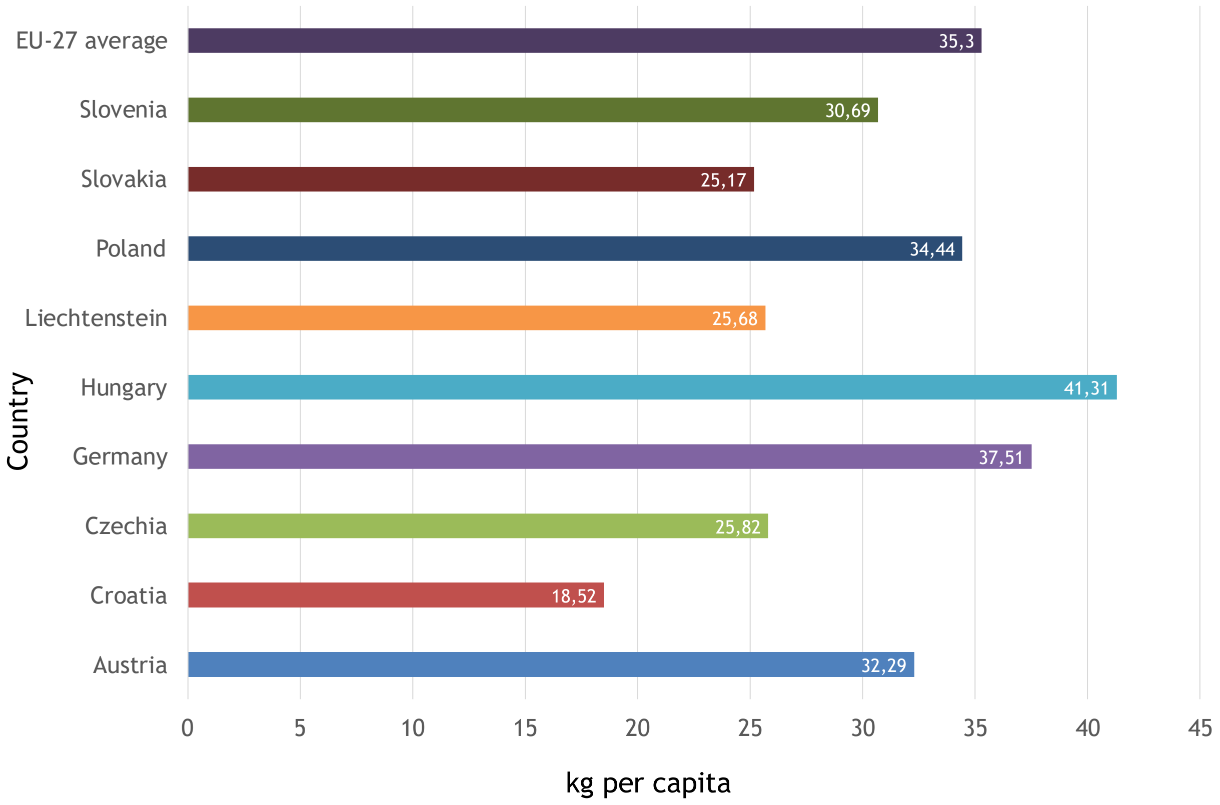

***Figure 2: Plastic packaging waste generated, 2023*.**

Across Central Europe, waste management and recycling outcomes vary widely. Some countries achieve plastic packaging recycling rates above 50% (for example, Slovakia reached approximately 54% in 2023), and several Central European countries—including Slovenia, Czechia and parts of Germany and Austria—also record comparatively high municipal waste recycling rates supported by separate collection and extended producer responsibility (EPR) schemes [4,5,16]. In contrast, Hungary and some neighbouring countries still report plastic packaging recycling rates of around 20-25% and rely more heavily on landfilling and low-grade energy recovery [4,5].

To make the scale of these differences transparent, Figure 2 summarises plastic packaging waste generation and Figure 3 shows recycling rates across Central European countries.

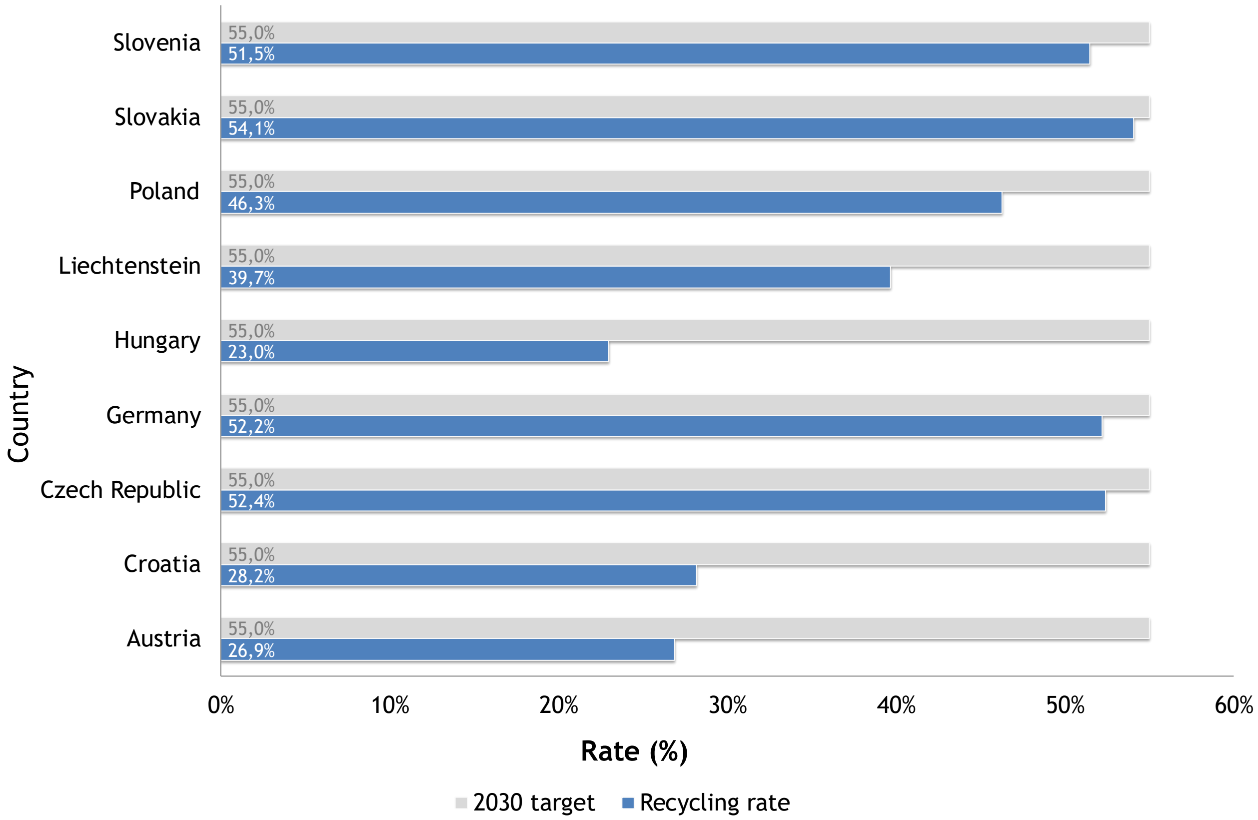

Figure 3: Plastic packaging recycling rate, 2023 [32,33].

A recent JRC analysis confirms that at the EU level, **incineration and landfilling still dominate plastic waste management**. In 2022, around 23.1 million tonnes of plastic waste were incinerated, compared to 11.4 million tonnes recycled, resulting in very modest net climate benefits from recycling compared to the overall emissions of the value chain [16].

For Central Europe, several structural issues stand out. First, some countries still lack sufficient sorting and high-quality recycling capacity, particularly for flexible packaging, mixed plastics and composite materials [14]. Second, EU waste management funding has not always prioritised prevention, reuse and high-value recycling, which can slow the shift away from disposal-oriented systems. Third, differences in landfill taxes, EPR implementation and enforcement create uneven incentives for circular practices across the region.

Empirical analysis of “circular economy efficiency” in selected Central and Eastern European countries confirms this heterogeneity. Potkány et al. show that while some countries are approaching EU averages in waste management efficiency, others remain far below, with high landfilling rates and limited recovery of secondary raw materials [34].

Overall, the current waste management performance in Central Europe is **not yet aligned** with the EU's circular economy and climate policy ambitions. Closing this gap will require interventions across all four pillars: regulatory reform, regional cooperation, capacity building, and technology deployment.

2.4. Existing circularity initiatives and business models

Despite these challenges, Central Europe hosts a growing number of initiatives and pilots that demonstrate how plastics can be managed more sustainably along the value chain. Interreg and other EU-funded projects include PLASTECO, supporting local and regional authorities in developing policy measures and action plans for more circular plastics, and PLASTIX, which develops eco-innovative solutions for plastic waste in coastal and urban areas (including Central European partners) [15,16].

In parallel, additional Interreg CENTRAL EUROPE initiatives on smart circular solutions for packaging, waste electrical and electronic equipment (WEEE), and construction materials provide practical models that GreenChemForCE can build upon. Industry-driven approaches are also emerging, including deposit-return-supported closed-loop recycling for beverage containers, increased use of recycled plastics in construction and automotive components, and early-stage industrial symbiosis routes that valorise mixed plastic waste through chemical recycling or other recovery pathways.

Table 3 synthesises current circular practices by sector and highlights where key barriers still prevent solutions from scaling in Central Europe.

Table 3: Circular practices, challenges, and opportunities (Central Europe – action-oriented).

Sector	Current circular practices (today)	Main challenges (why circularity stalls)	Key opportunities for circularity (what to scale next)
Packaging	Separate collection + mechanical recycling for “high-value” streams (PET bottles, PE/PP rigids); design-for-recycling guidance; deposit-return systems where implemented [35].	Mixed/flexible packaging is hard to sort; food-contact compliance and quality constraints; a large performance gap between countries in collection/recycling systems.	Expand reuse/refill where viable; harmonise sorting + quality specifications; scale advanced sorting (e.g., better identification of PE/PP formats); targeted solutions for flexibles [9].
Construction	PVC take-back and recycling schemes (profiles/pipes); selective demolition pilots; use of recycled polymers in non-critical applications [36].	Long lifetimes delay feedstock return; mixed materials and adhesives impede separation; legacy additives in older PVC and foams complicate safe recycling [21].	“Design for disassembly” and material passports; pre-demolition audits + separate collection of polymer-rich fractions; stable end-markets for recyclate in building products [21].
Automotive	Parts reuse + dismantling; emerging targets/approaches for higher recycled plastic content; specialist recycling of certain streams (e.g., PP-rich fractions) [37].	Mixed polymers, paint, fillers, and multi-material assemblies; shredder residue losses; weak demand signals for high-quality recyclate without standards/targets [37].	Standardise polymer choices and marking; design for easy dismantling; procurement commitments for recycled polymers; scale best-practice ELV plastics separation and washing [37].
EEE	WEEE collection systems; plastics separation in specialised plants; mandatory removal/management of certain hazardous fractions in some jurisdictions [38].	Flame-retardant additives can block recycling and trigger hazardous classification; complex product design; rapid innovation cycles and miniaturisation [26].	Scale “safe-by-design” substitution where possible; solvent/advanced processes for brominated plastics (where justified); design for repair/upgrade to extend lifetimes [39].
Textiles	Reuse/second-hand markets; repair; recycled polyester mostly made from PET bottles (not yet fibre-to-fibre at scale) [40].	Blended fibres and additives prevent high-quality recycling, collection and sorting gaps, microfibre shedding, and low economic value of mixed textile waste [40].	Scale fibre identification/sorting; design garments for durability and mono-material recycling; invest in fibre-to-fibre recycling capacity (PET/PA) and circular business models [40].
Agriculture	Collection schemes were organised; mechanical recycling of cleaner films; trials of biodegradable mulch films (context-dependent) [29].	Contamination with soil/biomass raises costs; dispersed generation (many small farms); leakage to soils if collection is inconvenient or expensive [29].	Regional collection hubs + incentives; film designs that ease cleaning (and standardised grades); targeted biodegradable use only where it demonstrably reduces harm and is properly managed [29].

2.5. Environmental, climate and socio-economic impacts

2.5.1. Environmental and climate impacts

The environmental burden of plastics in Europe is now well documented. The JRC’s 2025 assessment of plastics material flows in the EU-27 estimates that in **2022 the entire plastics value chain generated 252.1 million tonnes of CO_2-eq. emissions**. Packaging alone accounts for around **29 % of these emissions**, reflecting its high throughput and short lifetimes [4,5,15,16].

On a per-capita basis, this translates into approximately **564 kg CO_2-eq. per EU resident**, or around **4 kg CO_2-eq. per kilogram of plastic consumed**. In Central Europe, with its above-average industrial activity and high per-capita plastic consumption in some Member States, the climate footprint of plastics is particularly relevant to national and regional decarbonisation pathways.

Beyond climate change, plastics cause **multiple environmental impacts**:

- **Resource depletion**: High demand for fossil feedstocks and, increasingly, for bio-based resources, with implications for land use, biodiversity and water use [16].
- **Pollution and litter**: Mismanaged plastic waste contributes to macro- and microplastic pollution in rivers, soils, and marine environments. Central Europe's river basins (Danube, Elbe, Oder, Vistula, Po) act as conduits, transporting mismanaged plastics downstream and across borders [16].
- **Toxicity and additive concerns**: Many plastic applications rely on **additives, flame retardants, plasticisers, and pigments** that may pose risks to human health and ecosystems, and which complicate recycling [16].

At the end of life, the balance between **recycling and incineration** is critical. The JRC analysis shows that, in 2022, **recycling generated net savings of around 5.9 Mt CO_2-eq.**, while plastic incineration emitted **15.6 Mt CO_2-eq.**, highlighting the climate advantage of high-quality recycling over energy recovery [4,5].

Looking forward, a companion JRC study estimates that ambitious **circular-economy measures in the EU plastics sector could reduce greenhouse gas emissions by 75-84 Mt CO_2-eq. per year by 2050, compared with a scenario relying solely on energy-system** decarbonization. This underscores the mitigation potential of more circular plastic value chains - a key rationale for the strategy presented in this deliverable [13].

2.5.2. Socio-economic importance and risks

The plastics industry is economically significant in Central Europe. Across the EU, plastics production and conversion generate hundreds of thousands of jobs and an annual turnover of several hundred billion euros. Central European countries host a large share of polymer converters, toolmakers, and downstream manufacturers in the packaging, automotive, and technical plastics sectors [10].

At the same time, the **current linear model** carries socio-economic risks:

- **Exposure to volatile fossil feedstock and energy prices**, which can affect competitiveness and employment in energy-intensive segments.

- **Potential loss of competitiveness** if global markets and regulations accelerate towards circular and low-carbon plastics faster than Central European producers adapt [15,16].
- **Local environmental burdens**, such as landfills, incinerators, and litter “hotspots”, which can undermine quality of life, tourism, and regional attractiveness [15,16].

The JRC’s macroeconomic assessment suggests that a well-designed circular transition in the EU plastics sector could **reduce fossil resource use and energy demand** and improve the EU’s trade balance by around **€18 billion annually** by 2050, although it may entail **structural changes in employment and value added** that need careful management. For Central Europe, this underlines the importance of a **“just transition”** approach that supports workers, SMEs, and regions in adapting to new circular business models [41,42].

2.6. Key challenges, systemic gaps, and opportunity areas

The baseline analysis reveals several structural challenges that span Central European plastic value chains. These challenges align closely with the four strategic pillars that structure this strategy. Figure 4 summarises the baseline as a problem tree, linking root causes in plastic value chains to the environmental, climate and socio-economic impacts described above.

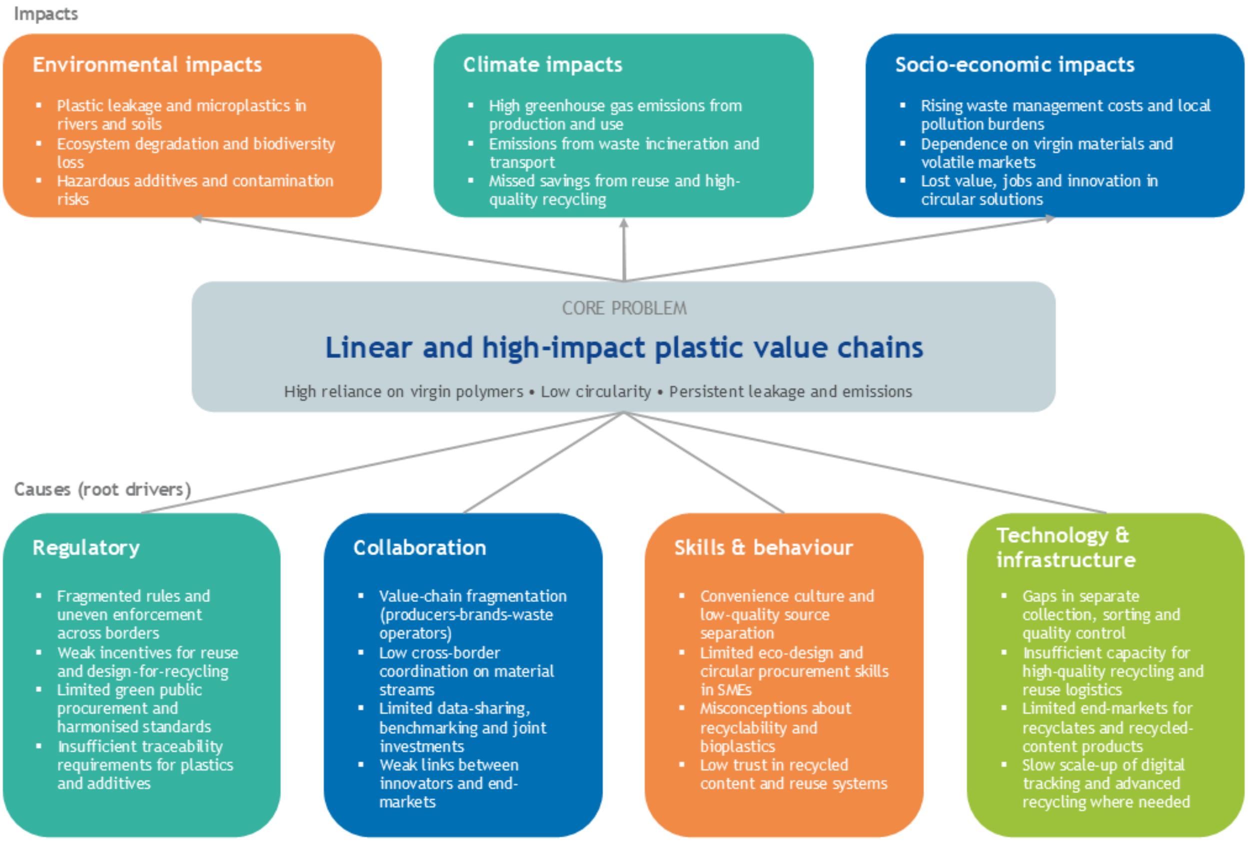

Figure 4: Problem tree for plastics in Central Europe.

Key takeaway: the main drivers cluster around governance, collaboration, skills and behaviour, and technology and infrastructure—highlighting why a coordinated four-pillar approach is needed.

2.6.1. Regulatory framework and governance

Despite significant progress under the **EU Plastics Strategy**, the **Single-Use Plastics Directive**, and recent updates to waste, packaging, and chemicals legislation, the regulatory framework for plastics remains complex and fragmented across Europe, particularly in Central Europe [11].

Key issues include:

- **Inconsistent implementation and enforcement** of EU rules (e.g., EPR obligations, landfill restrictions, eco-design requirements), leading to “patchwork” incentives for circular practices.
- Limited integration of **life cycle thinking, green chemistry, and circular design in sectoral regulations (e.g.,** construction, automotive, agriculture).

- Insufficient **data, monitoring, and transparency on plastic flows, additives, recyclate quality,** and trade, which hampers evidence-based policymaking [15,16,43,44].

However, this also creates opportunities to **streamline and align** regulatory instruments across Central Europe, building on EU-level frameworks and best practices.

2.6.2. Regional collaboration and value-chain partnerships

Plastics value chains are inherently cross-border: waste and recyclables often move between Central European countries, and many supply chains are regional or European rather than national [5]. However, cooperation between regions, municipalities and national authorities is still limited and often project-based, while value-chain collaboration among producers, converters, brand owners, retailers, waste operators and recyclers remains fragmented, with few shared roadmaps and investment pipelines.

Strengthened regional collaboration can help Central Europe to:

- coordinate standards and quality requirements for recyclates,
- pool demand for recycled and bio-based materials, and
- develop joint infrastructure (e.g., cross-border sorting and recycling hubs) that benefit several countries.

2.6.3. Education, skills and behavioural change

The transition to sustainable plastics is not only technological; it is also behavioural and organisational. Key gaps include limited awareness among businesses, public authorities and consumers of the full life cycle impacts of plastics and the benefits of circular solutions; a shortage of specialised skills in eco-design, sustainable polymer chemistry, advanced recycling technologies and circular business models; and persistent habits that favour convenience and low upfront cost over durability, reuse and repairability—particularly in packaging and consumer goods [16].

These gaps provide a strong rationale for targeted education, training and capacity-building programmes, anchored in Central Europe's rich network of universities, vocational education and training (VET) providers, innovation agencies and chambers of commerce.

2.6.4. Technology, innovation, and infrastructure

Finally, the baseline points to a mixed picture on technology and infrastructure. Proven collection, sorting and mechanical recycling systems exist, but often need modernisation and scaling—especially for more complex waste streams such as flexibles, multi-layer packaging, WEEE plastics and textiles [14]. Innovative solutions, including advanced (chemical) recycling, digital product passports, traceability tools and bio-based or recyclable material substitutes, are emerging but are not yet widely deployed [16]. Many regions also face investment gaps in high-quality treatment capacity, while a significant share of EU funding has historically focused on conventional infrastructure rather than prevention, reuse and high-value recycling.

Addressing these gaps will require coordinated investment strategies, technology roadmaps, and risk-sharing mechanisms that support innovation while avoiding lock-in to sub-optimal solutions.

Chapter 3

3. Strategic framework: circular plastic value chains and the four-pillar model

This chapter sets the conceptual foundation of the strategy. It clarifies what is meant by circular plastic value chains, explains why life-cycle thinking and green chemistry are the core reference frameworks, and shows how the four strategic pillars structure the transition from a linear "make-use-dispose" system to a circular, low-impact plastics economy in Central Europe.

3.1. From linear "make-use-dispose" to circular plastic value chains

The prevailing plastics system in Europe, including Central Europe, is still largely linear. Plastics are primarily produced from fossil feedstocks, converted into products, used—often for very short periods in the case of packaging—and then discarded, with a large share incinerated or landfilled, and only a modest fraction recycled at high quality. This pattern drives resource depletion, greenhouse gas emissions, and pollution, while failing to capture the full value of materials already in circulation [2,9].

The concept of the circular economy provides an alternative. The Ellen MacArthur Foundation [45] defines a circular economy as a system in which materials never become waste and nature is regenerated, and in which products and materials are kept in circulation through maintenance, reuse, refurbishment, remanufacture and recycling [15,16]. Applied to plastics, this implies that plastic products should be designed, used and managed so that: unnecessary and problematic materials are eliminated; the plastics that remain are reusable, recyclable or compostable; and all plastic items are kept at their highest value in the economy and out of the environment.

The **European Strategy for Plastics in a Circular Economy** explicitly frames plastics policy within this logic. It calls for all plastic packaging placed on the EU market to be reusable or recyclable in a cost-effective manner by 2030, for greater use of recycled plastics in new products, and for better design and separate collection systems that improve the economics and quality of plastics recycling [8,9] The 2020 Circular Economy Action Plan reinforces this direction by promoting a sustainable product policy framework, higher levels of circularity in key value chains and tighter linkages with the European Green Deal's climate and zero-pollution objectives [6,7].

For plastics in Central Europe, "going circular" therefore does not mean a narrow focus on recycling alone. It entails redesigning value chains to prioritise waste prevention and elimination of unnecessary plastics, extending product lifetimes through reuse and repair, enabling high-quality mechanical recycling where possible, and using chemical recycling or energy recovery only for residual streams where better options are not viable and where life cycle assessments confirm net environmental benefits [2,15,16,18,46].

The transition is illustrated in Figure 5, which contrasts a linear chain with a circular value chain and shows the four pillars as enabling conditions. The key takeaway is that recycling is only one loop in a wider system that must be designed to prevent waste and retain value upstream.

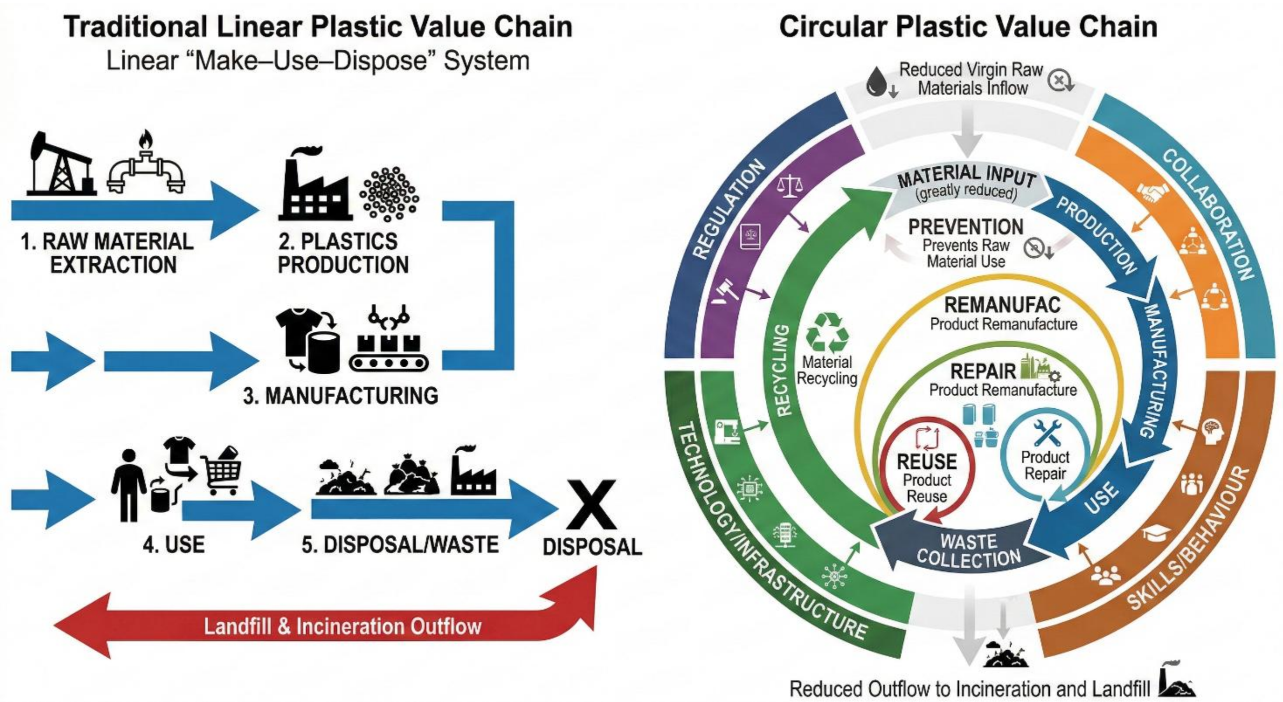

Figure 5: Linear versus circular plastic value chains.

In practical terms, a circular plastic value chain in Central Europe should minimise virgin fossil input through resource efficiency and, where appropriate, sustainable feedstocks; maintain material value through durability, reuse, remanufacturing and recyclability; ensure that products can be collected, sorted and recycled at suitable quality with transparent information on composition and additives; and prevent environmental leakage while reducing dependence on incineration and landfilling.

The strategic framework presented in this chapter translates these principles into a structured approach grounded in life-cycle thinking, green chemistry, and four mutually reinforcing pillars of change.

3.2. Life cycle thinking and green chemistry principles for plastics

Life cycle thinking is central to this strategy. It asks decision makers to move beyond the traditional focus on production sites or end-of-pipe treatment, and instead consider environmental, social and economic impacts across the entire life cycle of a product—from raw material extraction and processing, through manufacturing and distribution, to use, reuse, recycling and final disposal [16].

The key purpose of life cycle thinking is to avoid burden shifting. Improving one life cycle stage (for example, by reducing packaging weight) should not lead to disproportionate impacts elsewhere (such as unmanageable multi-layer structures that cannot be recycled or higher food waste due to inadequate protection). UNEP emphasises that a life-cycle approach helps identify practical interventions at each stage and supports collective responsibility among all actors in the chain, from designers to consumers and waste managers.

Life cycle thinking is operationalised through tools such as Life Cycle Assessment (LCA) and carbon footprinting, but its value extends beyond any single method. It provides the logic underpinning:

- eco-design requirements and sustainable product policies,
- choices between mechanical and chemical recycling options,
- the evaluation of bio-based and other non-petroleum feedstocks, and
- the design of monitoring and indicator systems for this strategy.

Alongside life cycle thinking, **green chemistry** provides a complementary framework for redesigning materials, processes, and products at the molecular and process level. The 12 Principles of Green Chemistry, formulated by Anastas and Warner (1998) [47], including prevention of waste, maximising atom economy, using safer chemicals and solvents, designing energy-efficient processes, using renewable feedstocks where technically and environmentally appropriate, and designing products so that they degrade into non-hazardous substances at the end of their life [16].

For plastics, green chemistry translates into questions such as:

- Can polymers and additives be designed to be less hazardous to humans and ecosystems, while still delivering the required functionality?
- Can renewable feedstocks be used without creating new environmental or social burdens, for example, through land-use change or competition with food production?
- Can polymerisation and processing routes be made more energy and resource-efficient?

- Can plastic formulations be designed from the outset for recyclability and safe circularity?

The strategic framework in this deliverable assumes that life-cycle thinking and green chemistry are not optional “add-ons” but essential design criteria. They shape how the four pillars are defined and how circular value chains, waste valorisation, sustainable feedstocks and sustainable product design are approached in the Central European context.

3.3. The four strategic pillars: overview and logic

To move from principles to implementation, the strategy is structured around four strategic pillars:

1. Regulatory framework and governance.
2. Regional collaboration and value-chain partnerships.
3. Education, skills and behavioural change.
4. Technology, innovation and infrastructure.

These pillars provide a practical way to organise what is a complex socio-technical transition. They reflect the insight, highlighted by the European Commission and many analysts, that the circular economy is not a single policy or technology, but a systemic change that combines product policy, market incentives, skills and innovation within a coherent framework [8,48].

The **first pillar**, regulatory framework and governance, sets the “rules of the game”. It encompasses EU legislation such as the plastics strategy, the circular economy action plan, waste and packaging directives, and forthcoming sustainable product regulations, as well as national and regional laws, economic instruments, and governance arrangements. Clear, predictable, and coherent regulation is needed to reward circular practices, penalise pollution, and create markets for secondary raw materials and sustainable plastic products [6,7,9,49].

The **second pillar**, regional collaboration and value-chain partnerships, acknowledges that plastics and their waste cross borders, and that no single actor can redesign value chains alone. Value-chain collaboration enables joint standard setting, the pooling of demand for recycled and bio-based materials, shared investment in infrastructure, and coordinated initiatives along supply chains, as emphasised in EU reports on plastics and the circular economy [2,7,15,16,45].

The **third pillar**, education, skills, and behavioural change, focuses on people. Without adequate skills in eco-design, green chemistry, and circular business models, and without behavioural shifts among producers, retailers, public authorities, and citizens, regulatory and technological measures will deliver only partial results. UNEP and other organisations underline that life cycle approaches and circular practices must be mainstreamed through education, vocational training and public awareness if they are to become the norm rather than the exception [15].

The **fourth pillar**, technology, innovation, and infrastructure, encompasses the physical and digital systems that enable circularity: collection and sorting infrastructure, mechanical and chemical recycling technologies, bio-based and alternative feedstock systems, and digital tools such as product passports and traceability platforms. The European plastics strategy and subsequent research initiatives emphasise that achieving a circular economy for plastics necessitates innovation across the entire spectrum, from materials science and process engineering to data and logistics [2,6,7,9,15,16,18].

The four pillars are strongly interdependent. Regulatory measures can only be effective if supported by appropriate technologies and skills. Technological innovation will not scale without coherent rules, financing, and cross-border collaboration. Behavioural change is unlikely without a supportive policy, infrastructure, and market context. The strategic framework, therefore, treats the pillars not as separate “silos” but as lenses through which each technical theme is examined and operationalised.

3.4. Integrating the four technical themes across the pillars

The strategy focuses on four technical themes: circular value chains, waste and by-product valorisation, sustainable resources and feedstocks, and sustainable product design / eco-design. Each theme is addressed through all four pillars, creating a matrix of interventions rather than isolated measures. Figure 6 summarises this logic as a simple pillar–theme matrix. The key takeaway is that no theme can be delivered by a single “type” of action: each requires aligned regulation, partnerships, skills and technology.

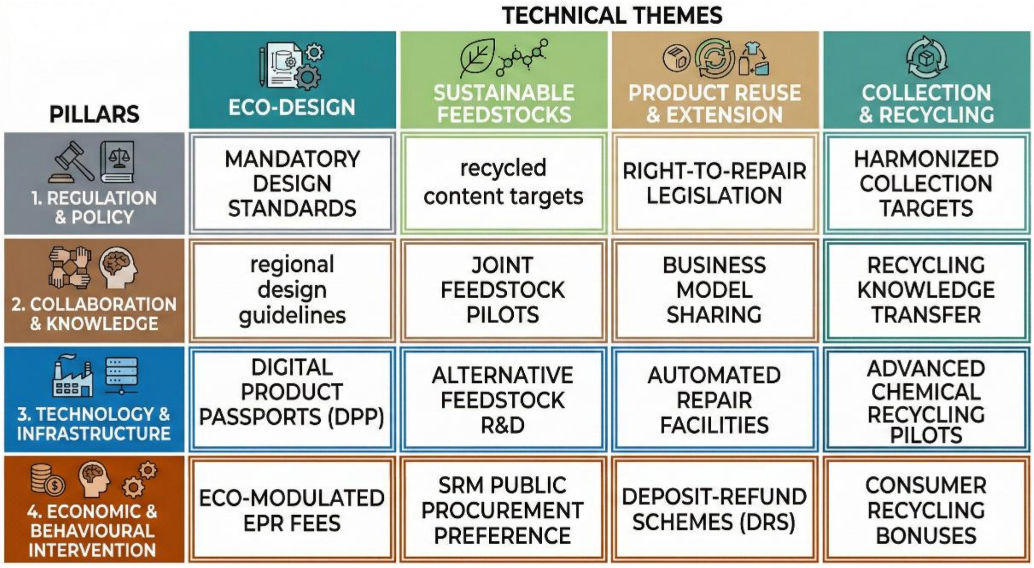

Figure 6: Strategic matrix linking pillars and technical themes.

3.4.1. Circular plastic value chains

Circular plastic value chains require that products and materials circulate at their highest possible value, minimising virgin input and waste generation. At the regulatory level, this involves targets and obligations for prevention, reuse, and high-quality recycling, extended producer responsibility (EPR) schemes that reward better design and collection performance, and restrictions on landfilling and low-value disposal. The EU's plastics strategy and Circular Economy Action Plan already point toward such measures, and Member States in Central Europe are progressively incorporating them into their national frameworks [6,7,50].

At the level of collaboration and partnerships, circular value chains are enabled by long-term contracts between producers, converters, brands, retailers, and recyclers; by cross-border initiatives that harmonise quality standards for recyclates; and by platforms that coordinate logistics, such as shared take-back and refill systems. In Central Europe, with its dense industrial and logistics networks, these collaborative structures can significantly reduce transaction costs and risks and help smaller firms participate in circular business models.

Education and behavioural change foster the uptake of new circular models—such as product-service systems, reuse schemes and repair services—by equipping companies and public authorities with the skills to design and operate them, and by aligning consumer expectations with longer-lasting, reusable products rather than disposable convenience. Finally, technology and infrastructure provide the means to collect, sort, and process plastic products in ways that maintain material value, for example, through advanced sorting, modular product design, and standardised components compatible with multiple reuse and recycling cycles [2,15,16,41,42,45].

3.4.2. Waste and by-product valorisation

Waste and by-product valorisation refers to transforming plastic waste and production residues into valuable secondary materials, energy carriers or new products, provided these routes deliver net environmental benefits. Mechanically recycled plastics are central to this theme, but chemical recycling and industrial symbiosis can play complementary roles where mechanical options reach their limits [2,51].

Regulatory and governance measures define when a material is considered waste or a by-product, set quality standards for recyclates, and distinguish genuine recycling from lower-value downcycling or mere energy recovery. They also determine the conditions under which chemical recycling outputs count as recycled content for regulatory purposes—an issue under active debate in EU policy processes.

Regional collaboration is particularly important for waste valorisation because high-quality recycling and symbiosis projects often require a critical mass that goes beyond local boundaries. Cross-border industrial networks can match waste streams from one sector with feedstock needs in another, for example, using plastic-rich production residues as inputs for plastics recycling, cement kilns, or chemical processes, where life cycle assessments confirm environmental gains.

Education and skills are essential for designing and operating safe, efficient valorisation processes, understanding the hierarchy of preferable "fates" for plastics, and accurately interpreting LCA results. Recent research on "plastics hierarchies of fates" emphasises the need to prioritize prevention, reuse, and high-quality mechanical recycling over pathways that lock in high energy use or pollutant releases [15,16,46,52,53].

On the technology and infrastructure side, waste valorisation requires investment in modern sorting and recycling facilities, quality monitoring systems, and, in some cases, the demonstration of chemical recycling technologies capable of handling complex streams while achieving verifiable climate and environmental benefits. It also relies on data systems that track material flows and enable transparency about the origins and quality of secondary materials [43,44].

3.4.3. Sustainable resources and feedstocks

Sustainable resources and feedstocks include recycled plastics and non-petroleum-based carbon sources, such as bio-based feedstocks and CO_2-based materials. The plastics strategy and related research highlight that switching feedstocks is not a panacea:

benefits depend on how the feedstock is produced, processed, and used over its life cycle [2,9,15].

Within the regulatory pillar, sustainable feedstocks are addressed through measures such as recycled content targets, sustainability criteria for bio-based materials, certification schemes, and alignment with renewable energy, land-use, and biodiversity policies. Governance arrangements need to ensure that increased demand for bio-based plastics does not drive deforestation, land-use change or pressure on food systems, and that claims about “biodegradability” or “compostability” are substantiated and compatible with local waste management systems [6,7].

Regional collaboration can facilitate shared sourcing strategies, for example, joint purchasing of recycled or bio-based polymers by clusters of companies, and cross-border projects that integrate biomass residues, captured CO_2, or other regional resources into plastic feedstock value chains, where LCAs show clear advantages. Collaboration across Central European regions can also help address critical raw material risks and supply security by jointly planning future feedstock portfolios [6,7].

Education and behavioural change help stakeholders understand the opportunities and limits of alternative feedstocks, avoiding simplistic messages such as “bio-based always means sustainable” or “recycled content is always better regardless of quality and safety”. Training in life cycle assessment and sustainability certification is essential here.

Technological innovation and infrastructure are necessary to process new feedstocks, such as through advanced polymerisation routes for bio-based monomers, processes that incorporate recycled content without compromising product performance, or technologies that utilise captured CO_2 in polymer production. These developments must be guided by green chemistry and life cycle thinking to prevent new lock-ins or shifts in burden [6,7].

3.4.4. Sustainable product design and eco-design

Sustainable product design and eco-design translate life cycle and green chemistry principles into concrete design decisions for plastic products. The forthcoming EU sustainable product policy framework, building on the Ecodesign for Sustainable Products Regulation, is expected to extend eco-design requirements beyond energy-related products to a wider range of material-intensive goods, including those containing plastics [8,49].

Regulatory frameworks can require that products meet criteria for durability, reparability, recyclability, and the responsible use of chemicals, and can support tools such as digital product passports that provide information on composition, repair, and recycling options. Governance measures can promote common design guidelines, harmonised labelling and interoperability of components and materials, which is particularly relevant in Central Europe's integrated manufacturing chains.

Collaboration among designers, material suppliers, brands, recyclers, and waste operators is crucial to ensure that design choices are compatible with existing and planned collection and recycling systems. Co-creation platforms, design sprints, and living labs can connect these actors and explore sector-specific solutions, for example, in packaging, construction, or automotive.

Education and skills development are vital to build a new generation of designers and engineers who are fluent in eco-design methods, LCA, and green chemistry. Universities, VET providers, and professional bodies in Central Europe can incorporate these topics into their curricula and continuing education programs, while awareness campaigns can help consumers recognise and value well-designed, circular products.

Technological and infrastructural enablers for eco-design include digital design tools that integrate environmental performance metrics, LCA databases tailored to plastics, and traceability systems that capture product and material information over time. These tools support more informed design choices and facilitate high-quality end-of-life treatment.

3.5. Guiding principles and criteria for prioritising measures

Given the breadth of potential interventions, the strategy requires clear guiding principles and criteria for prioritising measures. These principles ensure coherence across the four pillars and help Central European stakeholders focus resources where they can achieve the greatest impact.

First, measures should align with life cycle thinking and avoid shifting burdens between life-cycle stages or environmental impact categories. Priority is given to options that demonstrably reduce overall life-cycle impacts, supported, where feasible, by LCA or other robust assessment methods.

Second, interventions should **follow the waste hierarchy and circular economy logic**, prioritising prevention, the elimination of unnecessary plastics, reuse, and high-quality recycling over energy recovery and disposal, while recognising that some residual streams will still require safe treatment. Concepts such as plastics' "hierarchies of fates" provide useful benchmarks to judge whether proposed valorisation routes are genuinely sustainable [6,7,16,46].

Third, measures should be **evidence-based and adaptive**. They should draw on the best available scientific and technical knowledge, including EU research and innovation results on circular plastics [2], and be designed so they can be adjusted as technologies evolve, markets change, and new evidence emerges [15].

Fourth, the strategy should emphasise **systemic leverage and co-benefits**. Priority is given to actions that unlock broader changes across value chains—such as regulatory reforms that stimulate innovation, collaborative platforms that de-risk investment, or education initiatives that shift both professional practice and consumer behaviour—rather than isolated, one-off projects.

Fifth, measures should support a **just and inclusive transition**. They should consider impacts on workers, SMEs, and regions, and seek to create quality jobs and innovation opportunities in Central Europe while protecting vulnerable groups and communities [16].

Finally, the strategy adopts a **phased and pragmatic approach**. It recognises that starting points differ across countries and sectors, and that the pace of change will depend on local capacities, institutional contexts, and investment cycles. Short-term measures will focus on “no-regret” options and quick wins, while medium- and long-term measures will target bigger structural changes in product design, infrastructure, and market organisation.

Table 4 summarises these principles and clarifies what they imply for decision makers and practitioners in Central Europe. The key takeaway is that prioritisation should consistently reward prevention and high-value circularity, while safeguarding health, ecosystems and competitiveness.

Table 4: Guiding principles for prioritising measures [42].

Guiding principle	Explanation	Implications for Central Europe
Life cycle thinking	Assess impacts across the full life cycle (feedstocks, design, production, use, reuse, recycling and final treatment) to avoid burden shifting.	Use life cycle assessment and carbon footprinting to compare options (e.g., light-weighting versus recyclability). Prioritise actions that reduce overall impacts across countries and sectors.
Waste hierarchy and plastics "hierarchy of fates"	Prioritise prevention, elimination of unnecessary plastics, reuse and high-quality recycling over energy recovery and disposal; treat chemical recycling and incineration as last-resort options and justify them with evidence.	Expand prevention and reuse systems first, then enable high-quality mechanical recycling. Apply consistent criteria for when residual streams may be sent for chemical recycling or recovery.
Evidence-based and adaptive policymaking	Base decisions on robust data and the best available science; update measures as markets, technologies and evidence evolve.	Build monitoring (material flows, recycled-content uptake, leakage indicators) and regularly review targets. Pilot solutions and scale what works, avoiding technology lock-ins.
Systemic leverage and co-benefits	Focus on interventions that unlock wider change and deliver multiple benefits (climate, pollution prevention, competitiveness, jobs).	Align regulation, markets and infrastructure (e.g., extended producer responsibility design incentives, harmonised recyclate standards, product passports) and support cross-border value chains.
Just and inclusive transition	Ensure the transition is fair for workers, small and medium-sized enterprises, and regions; avoid shifting costs to vulnerable groups.	Provide training, re-skilling and targeted support for small and medium-sized enterprises. Use social criteria in infrastructure planning and in the phase-out of low-value disposal.
Phased implementation	Sequence actions pragmatically: start with no-regret steps and quick wins, then move to structural changes in design, markets and infrastructure.	Use a roadmap with short-, medium-, and long-term actions reflecting different starting points across Central Europe. Link early guidelines and pilots to later investments and binding targets.

Chapter 4

4. Pillar 1: Regulatory framework and governance

4.1. Overview of relevant EU and national policy frameworks

Sustainable plastic management in Central Europe is shaped primarily by the European Union's environmental acquis, which establishes a common baseline that Member States must transpose and implement. The core framework for waste and resource management is the Waste Framework Directive 2008/98/EC (WFD), which defines key concepts such as waste, recycling and recovery and establishes the waste hierarchy as the guiding principle for policy: prevention, followed by reuse, recycling, other recovery and, only as a last resort, disposal [54]. This hierarchy underpins all subsequent instruments that drive plastics away from linear "make-use-dispose" value chains and towards circular models.

For plastics specifically, the EU has built a dense web of interlinked instruments. The Single-Use Plastics Directive (EU) 2019/904 targets the plastic items most frequently found on European beaches, introducing market restrictions, design requirements (such as tethered caps) and separate collection and recycled content targets for beverage bottles (25% recycled plastic in PET bottles from 2025 and 30% in all plastic beverage bottles from 2030). The forthcoming transition from the historical Packaging and Packaging Waste Directive 94/62/EC to Regulation (EU) 2025/40 on packaging and packaging waste (PPWR) represents a major shift: from a minimum-harmonisation directive to a directly applicable regulation that sets binding requirements across the entire packaging life cycle, including recyclability, minimisation and mandatory recycled content in plastic packaging [3].

The regulatory picture is complemented by the new Waste Shipment Regulation (EU) 2024/1157, which tightens rules on exports of plastic waste, including a future ban on exports of non-hazardous plastic waste to non-OECD countries and streamlined procedures for intra-EU shipments destined for recovery. This is highly relevant for Central Europe, where cross-border movements of plastic waste and recyclates are common within regional value chains [12,55].

On the product side, the Ecodesign for Sustainable Products Regulation (ESPR), Regulation (EU) 2024/1781, establishes a horizontal framework for setting eco-design requirements for virtually all physical products placed on the EU market. It will progressively cover aspects such as durability, reparability, recycled content, material efficiency and the presence of hazardous substances, and it introduces the Digital

Product Passport as a key tool for transparency across supply chains [56]. Plastics and plastic-intensive product groups (packaging, electronics, automotive, construction products, textiles) are priority candidates for ESPR implementing measures.

Chemicals and product safety legislation, especially the REACH Regulation (EC) No 1907/2006 and regulations on plastic food-contact materials, set conditions for additives and substances in plastics and for the safe use of recycled plastics, for example, in food packaging. Initiatives such as ECHA's plastic additives mapping exercise and the 2023 REACH restriction on intentionally added microplastics further constrain the use of problematic substances and promote safer material cycles [12,15–17].

Beyond EU law, global processes increasingly shape expectations. The United Nations Environment Assembly's Resolution 5/14 ("End plastic pollution") launched negotiations for an international legally binding instrument on plastic pollution covering the full life cycle of plastics [15,16]. While negotiations have not yet produced a final treaty, the EU has positioned itself as a high-ambition actor, and future treaty provisions are likely to reinforce EU and national measures on production, design, chemicals and waste management.

Within this EU and global framework, Central European countries retain significant discretion in how they organise governance, economic instruments and enforcement. Differences in landfill taxes, incineration charges, extended producer responsibility (EPR) schemes, deposit-return systems and separate collection infrastructure translate into varying incentives along plastic value chains. Evidence from the European Environment Agency shows that strong landfill taxes and well-designed separate collection systems are critical success factors for high recycling rates, while weaker instruments correlate with persistent landfilling and low recycling performance [14-16,50].

For Central Europe, the strategic challenge is therefore not the absence of legislation, but rather how to use this evolving regulatory architecture coherently and ambitiously to drive a systemic shift to circular plastics.

Table 5 summarises the EU instruments most directly shaping plastics across their life cycle in Central Europe. It provides a shared reference point for the governance recommendations later in this chapter. EU policy is increasingly moving upstream—towards design, information and recycled-content obligations—so implementation capacity must shift accordingly.

Table 5: Overview of key EU policy instruments relevant to plastics in Central Europe.

Instrument	Type	Scope and main objectives	Key provisions relevant to plastics	Relevance for Central Europe
Packaging and Packaging Waste Regulation [57]	Regulation	EU-wide packaging sustainability + waste prevention	Recyclability rules; reuse targets; recycled-content requirements; harmonised labelling; stronger EPR	Highest impact on packaging markets and infrastructure investment
Single-use Plastics Directive [58]	Directive	Reduce the impacts of specific single-use plastic items	Bans/restrictions; marking; tethered caps; collection targets; EPR for clean-up/awareness	Drives anti-litter action and higher capture rates
Waste Framework Directive [59]	Directive	EU waste hierarchy + prevention and recycling framework	Separate collection duties; EPR minimum requirements; waste definitions/reporting	Foundation for national waste plans and EPR design
Landfill Directive [60]	Directive	Limit the environmental impacts of landfilling	Diversion pressure + technical rules for landfills	Critical where landfill dependence remains
Waste Shipment Regulation (recast) [61]	Regulation	Control waste shipments; prevent illegal exports	Stricter controls, digitalisation, and export conditions	Affects cross-border plastic waste/recyclate flows
REACH [62]	Regulation	Chemicals regulation for health/environment	Restrictions on additives/substances; information in supply chains	Key for “safe circularity” and recyclate quality
Microplastics restriction (REACH) [63]	Regulation	Reduce microplastic pollution	Limits intentionally added microplastics; info/reporting	Relevant for product reformulation and compliance
Pellet loss prevention [64]	Regulation	Prevent pellet losses across supply chains	Handling standards; risk management; documentation	Important for CE logistics and conversion hubs
POPs Regulation [65]	Regulation	Control persistent organic pollutants	Limits legacy flame retardants, etc.; strict waste rules	Major constraint for the recycling of legacy plastics
Ecodesign for Sustainable Products Regulation [66]	Regulation	Framework for product ecodesign + digital product passports	Future product rules (durability/recyclability/info); passport-enabled traceability	Enables eco-design + data infrastructure across sectors
EU Plastics Strategy [67]	Communication	Strategic direction for circular plastics	Drives measures on design, recycling markets, and pollution reduction	Sets narrative and policy coherence for CE actions

Table 5: (continued).

Instrument	Type	Scope and main objectives	Key provisions relevant to plastics	Relevance for Central Europe
Circular Economy Action Plan [68]	Communication	EU roadmap for circular product policy and markets	Sustainable product policy, secondary raw materials markets	Anchors, cross-cutting measures and funding alignment
Zero Pollution Action Plan [69]	Communication	Reduce pollution across media	Actions on litter/microplastics; monitoring and enforcement focus	Supports leakage prevention and monitoring priorities

Table 6 links the main regulatory levers to the strategy's four technical themes. This clarifies where EU drivers are already strong and where national measures can add traction. Key takeaway: product policy and chemical measures increasingly shape feedstocks, additives, and design choices, not only end-of-life performance.

Table 6: Mapping of regulatory levers to the four technical themes (EU focus, Central Europe relevance) [70-78].

Main regulatory lever	Circular value chains	Waste and by-product valorisation	Sustainable resources and feedstocks	Sustainable product design / eco-design
Waste hierarchy (Waste Framework Directive)	Sets the "direction of travel" from prevention → reuse → recycling; legitimises policy prioritisation of loop-closing measures over disposal.	Pushes recycling and high-value recovery ahead of energy recovery/landfill; supports end-of-waste/by-product thinking where it improves overall outcomes.	Encourages substitution of virgin inputs through prevention and reuse (less material throughput overall).	Drives design choices that enable prevention, reuse and recycling (e.g., fewer materials, easier disassembly).
Extended Producer Responsibility (EPR) + eco-modulation	Creates a financial feedback loop from end-of-life costs back to producers; improves collection, sorting and quality of recyclate.	Funds sorting and recycling capacity can incentivise higher-quality recycling if fees reward recyclability and recycled-content uptake.	Improves the availability and reliability of secondary raw materials by stabilising collection systems and markets.	Eco-modulated fees reward design for recycling (mono-materials, clear labelling, fewer problematic additives) and penalise hard-to-recycle formats.
PPWR (Packaging and Packaging Waste Regulation) incl. recycled content, recyclability & reuse	Harmonises packaging rules across the EU; sets a clear pathway to recyclable packaging and, where suitable, higher reuse, strengthening cross-border circular markets.	Raises demand for recycling outputs (especially post-consumer recyclate) and tightens requirements on packaging waste handling; can reduce low-value, mixed streams.	Mandatory recycled-content requirements reduce dependence on virgin polymers and create pull for high-quality recyclate.	Strong direct lever: design for recycling, packaging minimisation, restrictions on certain formats, and clearer information to enable sorting and reuse systems.
ESPR (Ecodesign for Sustainable Products Regulation) + Digital Product Passport	Builds a common EU framework to scale circular requirements beyond packaging, enabling more consistent value-chain coordination and traceability.	Supports high-value retention (repair, refurbishment, remanufacture); information requirements can improve recycling and reduce "downcycling."	Enables requirements on recycled content, resource efficiency and material footprints for product groups as rules are rolled out.	Core lever for durability, repairability, disassembly, material efficiency, and limiting "substances that inhibit circularity" via product requirements.

Table 6: (Continued)

Main regulatory lever	Circular value chains	Waste and by-product valorisation	Sustainable resources and feedstocks	Sustainable product design / eco-design
Waste Shipment Regulation (WSR)	Strengthens traceability and enforcement; reshapes the geography of circular flows (more pressure to manage waste within the EU).	Encourages investment in EU recycling by tightening export conditions; can constrain "easy export routes" that undermine domestic valorisation.	Improves security of feedstock for EU recyclers (less leakage of valuable waste); requires proof of environmentally sound management abroad.	Indirect design signal: when exports are harder, producers face stronger incentives to place recyclable, high-value materials on the market.
Landfill diversion/landfill limits (Landfill Directive revisions)	Forces systems away from disposal and toward collection and treatment pathways that enable circularity.	Makes landfill the least attractive outlet; increases pressure to expand sorting/recycling and manage residues responsibly.	Reduces the "cheap disposal" option, improving the business case for using recycled feedstock and circular supply chains.	Encourages designs that reduce residual waste (e.g., fewer composite materials that are rejected).
Single-Use Plastics rules (SUP measures incl. product bans, design & EPR for litter costs)	Targets high-litter items and shifts systems toward reuse/alternatives where feasible; strengthens accountability across the value chain.	Reduces problematic waste streams; EPR for litter costs can fund better collection and awareness, improving material capture.	Increases incentives to reduce reliance on certain single-use formats and to substitute with reusable or recyclable solutions.	Directly influences product/packaging design (e.g., tethered caps, markings; bans on specific items), driving redesign and alternative delivery models.
Microplastics restriction (REACH) + spill/leakage controls	Reduces "leakage" from products into the environment—critical for credible circularity (circular does not mean dispersed).	Limits the use of intentionally added microplastics; promotes better containment and end-of-life handling for microplastic-releasing uses.	Encourages safer material choices (substitution away from intentionally added microplastics) and better control along supply chains.	Forces redesign of formulations/products to avoid restricted microplastics and reduce shedding (performance + compliance by design).

Table 6: (Continued)

Main regulatory lever	Circular value chains	Waste and by-product valorisation	Sustainable resources and feedstocks	Sustainable product design / eco-design
Bioplastics framework (bio-based, biodegradable, compostable) and guidance	Clarifies where compostability adds real value (e.g., targeted organic-waste contexts), avoiding “false circularity” claims.	Can support valorisation routes only where appropriate infrastructure exists (industrial composting/organic recycling); discourages misrouting into plastics recycling streams.	Helps steer the responsible uptake of bio-based feedstocks (with clear claims and safeguards), reducing greenwashing risks.	Provides criteria for claims and appropriate use cases; supports “fit-for-purpose” design (e.g., compostable only when it improves outcomes).
Substances of concern controls (chemicals policy, including restrictions that affect recyclability)	Improves trust and functionality in secondary materials markets by reducing contamination barriers to circular flows.	Enables higher-quality recycling by limiting hazardous additives that create “legacy” problems and force downcycling or disposal.	Supports safer secondary feedstocks; reduces the risk that recycled content reintroduces restricted chemicals.	Drives substitution of problematic additives and promotes “clean material cycles,” supporting eco-design aligned with safe circularity.

4.2. Regulatory drivers for circular plastic value chains

Regulation influences circular plastic value chains at multiple points—from the design and marketing of products to collection, sorting, and recycling. Figure 7 locates the main regulatory drivers across the plastic life cycle and highlights where new requirements are expected to change incentives most strongly.

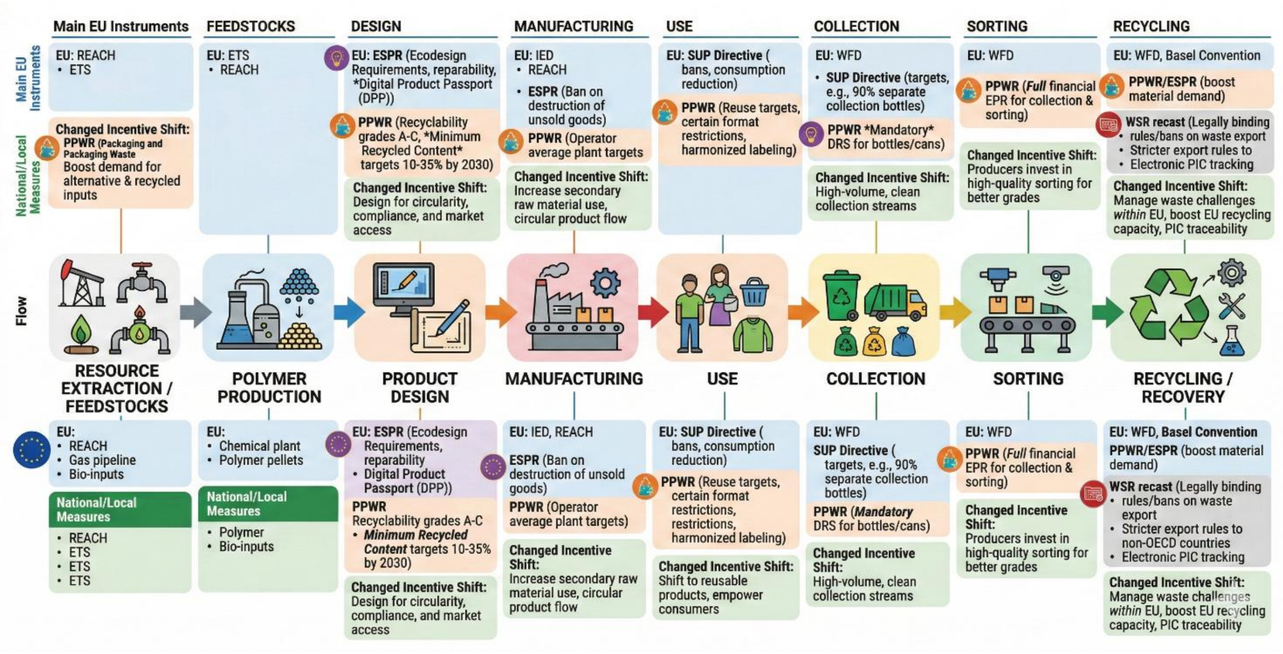

Figure 7: Regulatory drivers across the plastic life cycle.

4.2.1. Waste hierarchy, extended producer responsibility, and targets

The waste hierarchy is the conceptual backbone of EU waste and resource policy. It does more than rank options; it establishes a legal presumption in favour of prevention, reuse, and high-quality recycling over recovery and disposal. Under the WFD, Member States must take measures to promote options higher in the hierarchy and may depart from it only when justified by life cycle thinking and environmental considerations [54,79]. For plastics, this implies a progressive shift in policy priorities from managing waste volumes to reducing unnecessary plastic use, enabling refill and reuse models, and maximising the value of plastic already in circulation.

Extended Producer Responsibility is the main operational tool used to align economic incentives with the hierarchy. EPR makes producers financially and, in some cases, organisationally responsible for the end-of-life management of their products and packaging. The OECD's recent synthesis emphasises that well-designed EPR schemes establish a clear, predictable cost signal for producers and can stimulate upstream design changes by modulating fees based on recyclability, recycled content, or the presence of hazardous substances [15,16].

In Central Europe, the use of EPR for packaging is now mandatory under EU law; however, its design and effectiveness still vary significantly between countries. In some Member States, fee modulation already rewards easily recyclable mono-material packaging and penalises complex multi-layer structures; in others, fee structures remain relatively flat and provide limited design incentives. Recent policy debates at the EU level on extending EPR to additional product groups (for example, plastic products beyond packaging, certain construction products, and textiles) highlight both the opportunities and the complexity of designing schemes that effectively promote circularity across the full life cycle [16].

Binding EU targets complement EPR by placing clear obligations on Member States and, indirectly, on producers and waste operators. These include recycling targets for municipal and packaging waste under the WFD and packaging legislation, as well as specific collection and recycled-content targets for beverage bottles under the Single-Use Plastics Directive. For plastics, these targets create a measurable trajectory towards circular value chains; however, many Member States, including several in Central Europe, are at risk of missing upcoming milestones, which underscores the need for more ambitious implementation and enforcement [11,14–16,50].

4.2.2. Incentives and obligations for reuse and high-quality recycling

Achieving high-quality recycling and reuse requires more than targets. Economic instruments and regulatory obligations must make circular options more attractive than linear ones. The EEA has shown that landfill taxes, incineration taxes, pay-as-you-throw schemes and deposit-return systems are among the most effective instruments to reduce landfilling and increase separate collection of recyclables [15].

Recent experience from Central and Eastern Europe illustrates this point. Romania's nationwide deposit-return scheme for beverage containers, launched in 2023, has rapidly achieved collection rates of up to 94% in some months and has recovered hundreds of thousands of tonnes of high-quality materials [15]. This demonstrates how a well-designed, legally mandated system combining economic incentives, modern infrastructure and strong communication can transform collection performance within a short period.

EU law is increasingly embedding specific obligations to support reuse and high-quality recycling. The PPWR introduces detailed design-for-recycling criteria, minimum recycled content for plastic packaging, and binding reuse and refill targets in certain sectors [3]. These provisions directly address key technical bottlenecks identified in the literature, such as the incompatibility of many current packaging formats with established recycling processes and the persistent quality gap between recycled and virgin plastics.

For Central Europe, stronger regulatory emphasis on economic instruments and performance-based obligations offers a concrete pathway to accelerate the shift from down-cycling and energy recovery to closed-loop material recycling and reuse. Aligning national instruments with EU-level objectives and calibrating them to local economic conditions is critical to ensure both environmental effectiveness and industrial competitiveness.

4.3. Governance of plastic waste and by-product valorisation

4.3.1. Enabling industrial symbiosis and secondary raw material markets

Plastic waste and by-products can become valuable secondary raw materials when regulatory frameworks clarify their legal status, ensure environmental and health protection, and reduce transaction costs. The WFD introduces the concepts of "by-product" (a material that is not waste because it is an integral part of a production process and can be used directly) and "end-of-waste" criteria, which determine when a waste ceases to be waste after recovery [54]. Where these criteria are clear, predictable, and consistently applied, they facilitate investment in recycling facilities and industrial symbiosis arrangements.

Industrial symbiosis – the systemic exchange of materials, energy, and services between companies – has been recognised by the EU as a key mechanism for improving resource efficiency and circularity in industrial systems [15]. Typical exchanges include the sale of plastic offcuts, pellets, purge materials, or mixed plastic streams from one factory as feedstock for another, or the co-location of recycling plants next to plastic converters or waste sorting facilities.

In Central Europe, several cluster initiatives and regional programmes are already piloting industrial symbiosis for plastics and related materials. However, these initiatives often operate in a regulatory grey zone, where uncertainties about waste classification, liability, and permitting slow down scale-up. Developing harmonized, sector-specific "end-of-waste" criteria for common plastic streams and clarifying the conditions under which production residues can be treated as by-products rather than waste would significantly lower barriers to investment in high-value recycling and symbiosis projects.

4.3.2. Addressing barriers to cross-border waste and by-product flows

Central Europe is characterised by dense cross-border industrial linkages and, in many cases, limited national recycling capacity for specialised plastic streams. Efficient cross-border flows of plastic waste destined for high-quality recycling are therefore essential to realising economies of scale and ensuring that materials are treated in the most suitable facilities.

The new Waste Shipment Regulation (EU) 2024/1157 revises the rules governing shipments of waste both within and outside the EU. It tightens conditions for exports to non-OECD countries and will, from 2026, effectively prohibit exports of non-hazardous plastic waste to non-OECD destinations, while facilitating shipments of waste destined for recycling within the EU through more digitalised and risk-based procedures. This reflects an explicit policy choice to keep plastic waste within the EU and to ensure that it is treated in environmentally sound facilities [12,55].

For Central European stakeholders, the revised rules present both opportunities and challenges. On the one hand, they may stimulate investment in regional recycling and recovery capacity and reduce the risk of reputational damage associated with exports to poorly regulated destinations. On the other hand, they require national authorities to build administrative capacity for supervision and digital tracking, and they demand closer coordination between customs, environmental inspectorates and waste operators.

From a governance perspective, Central Europe would benefit from pragmatic, regionally coordinated approaches to implementing the Waste Shipment Regulation, including shared guidance on classification, common templates for documentation and joint training initiatives for authorities and operators. This would reduce transaction costs and uncertainty, making it easier for companies to structure cross-border value chains for recycled plastics and by-products [50,80].

4.4. Governance of sustainable resources and feedstocks

4.4.1. Recycled content requirements and standards

Mandatory recycled-content requirements are a powerful tool to create stable demand for secondary plastics and to close material loops. The Single-Use Plastics Directive introduced the first EU-wide recycled content targets for PET beverage bottles, while the PPWR generalises and extends recycled content obligations across a wide range of plastic packaging types, with differentiated targets for contact-sensitive and non-contact-sensitive applications and higher requirements in 2040 than in 2030 [11,80].

These requirements are complemented by rapidly evolving European standards on plastics recycling and recyclates (for example, the CEN standardisation work on recyclate quality and designation systems), which aim to make the quality of recycled plastics more predictable and comparable to that of virgin materials. Safety regulations, especially for food-contact materials, specify when recycled plastics may be used and under what conditions, thereby ensuring that circularity objectives do not compromise human health.

For Central European plastics producers and converters, these measures fundamentally reshape feedstock strategies. Companies will need to secure reliable access to high-quality recyclates, invest in material-compatible product design, and, in some cases, adapt processes to use chemically recycled feedstock where mechanical recycling cannot meet performance or safety requirements. Literature on recycling technologies highlights the potential and limitations of different routes – mechanical, chemical, and hybrid – and suggests that regulatory clarity on acceptance criteria for chemically recycled outputs will be crucial for investment decisions.

4.4.2. Policy frameworks for bio-based and non-petroleum-based plastics

Bio-based and non-petroleum-based plastics are often presented as alternatives to fossil-based polymers, but their sustainability depends on feedstock sourcing, production processes, performance in use and end-of-life options. The EU Bioeconomy Strategy and subsequent progress reports explicitly identify bio-based polymers and packaging as important components of a sustainable bioeconomy and emphasise the need for robust sustainability criteria and life cycle assessment to avoid indirect environmental trade-offs, such as land-use change or biodiversity impacts [15].

The European Commission’s 2022 communication on the EU policy framework for biobased, biodegradable and compostable plastics clarifies that these materials are not a blanket solution and that their use should be targeted to specific applications where they bring clear environmental benefits compared with conventional plastics. It emphasises the importance of credible labelling, clear guidelines on compostability and biodegradability, and seamless integration into existing waste management systems [50,80].

For Central Europe, this policy framework has two main implications. First, public authorities and industry should avoid simplistic “bio-equals-better” narratives and instead apply life cycle thinking to identify priority uses for bio-based plastics, for example, in certain food-contact or agricultural applications where contamination makes mechanical recycling difficult. Second, support for new bio-based feedstocks should be aligned with broader strategies on sustainable carbon cycles and climate neutrality, recognising that biomass is a limited resource and that long-lived products and material loops can play a role in carbon storage [14].

At the same time, emerging rules on microplastics and plastic pellet losses, such as Regulation (EU) 2023/2055, which restricts the intentional addition of microplastics, and proposed measures on pellet handling, illustrate how chemicals and environmental legislation are increasingly converging to address upstream pollution risks associated with all types of plastics, regardless of feedstock [17].

4.5. Regulatory support for sustainable product design and eco-design

4.5.1. Eco-design requirements, digital product passports and labelling

The ESPR marks a paradigm shift from energy-related ecodesign towards a broad, life-cycle-based approach to product sustainability. It allows the Commission to adopt delegated acts setting detailed requirements for specific product groups, including restrictions on certain materials and substances, minimum performance thresholds for durability and reparability, design-for-recycling criteria and minimum recycled content [56].

For plastics and plastic-intensive products, this regulatory framework provides a powerful lever to operationalise sustainable product design and eco-design principles developed in the literature and through voluntary initiatives. Authors reviewing EU plastics strategies note that design-phase decisions, such as polymer choice, colourants, additives, and multi-material combinations, determine the technical and economic feasibility of high-quality recycling and reuse. Under ESPR, such considerations will be translated into binding design requirements, supported by standardisation [12].

A central innovation is the Digital Product Passport (DPP), a digital record that will store relevant information on product composition, sustainability performance, and circularity-related characteristics. For plastics, DPPs can provide recyclers and waste operators with critical information on polymer types, additives, and previous uses, thereby enabling better sorting and risk management. They can also support public authorities in market surveillance and green public procurement, and empower downstream users to select products compatible with their circularity strategies [12].

Labelling and information requirements under ESPR and PPWR will complement DPPs by making key attributes such as recyclability, recycled content, and proper disposal routes visible to consumers and professional users. In Central Europe, aligning national labelling practices with EU rules and avoiding the proliferation of competing labels will be crucial in building trust and preventing confusion.

4.5.2. Integration with chemicals and product safety legislation

Eco-design requirements cannot be implemented in isolation from chemicals and product safety law. The presence of hazardous substances in plastics – including legacy additives in recycled materials – can undermine both environmental and human health objectives and limit the use of recyclates in sensitive applications. Reviews of plastic additives and EU regulatory initiatives highlight the complexity of this issue and the need for integrated approaches that consider both chemical safety and circularity [55,81].

In practice, this means that requirements introduced under ESPR and PPWR must be consistent with, and in some cases go beyond, the restrictions and authorisation regimes under REACH, the Classification, Labelling and Packaging (CLP) Regulation, and sector-specific rules (for example, on food-contact materials, toys, or construction products). The evolving EU policy on microplastics and persistent chemicals, along with planned measures on plastic pellets, further illustrates the shift towards a life-cycle approach to chemical risks in plastics [80].

For Central Europe, this integration presents both challenges and opportunities. On the one hand, plastics producers and converters must manage a complex regulatory landscape and invest in compliance systems, substitution of problematic additives, and traceability. On the other hand, stringent chemical safety requirements can create a competitive advantage for companies that invest early in safer, more circular material portfolios, particularly in sectors where customers and regulators are increasingly concerned about chemical exposure and product safety.

4.6. Governance models and institutional coordination in Central Europe

The regulatory instruments described above operate within multi-level governance structures that involve the EU, national governments, regions, municipalities, and various agencies. To deliver circular plastics outcomes, governance must connect product policy, chemical safety, waste systems, investment planning and enforcement in a coordinated way rather than as separate silos (Figure 8).

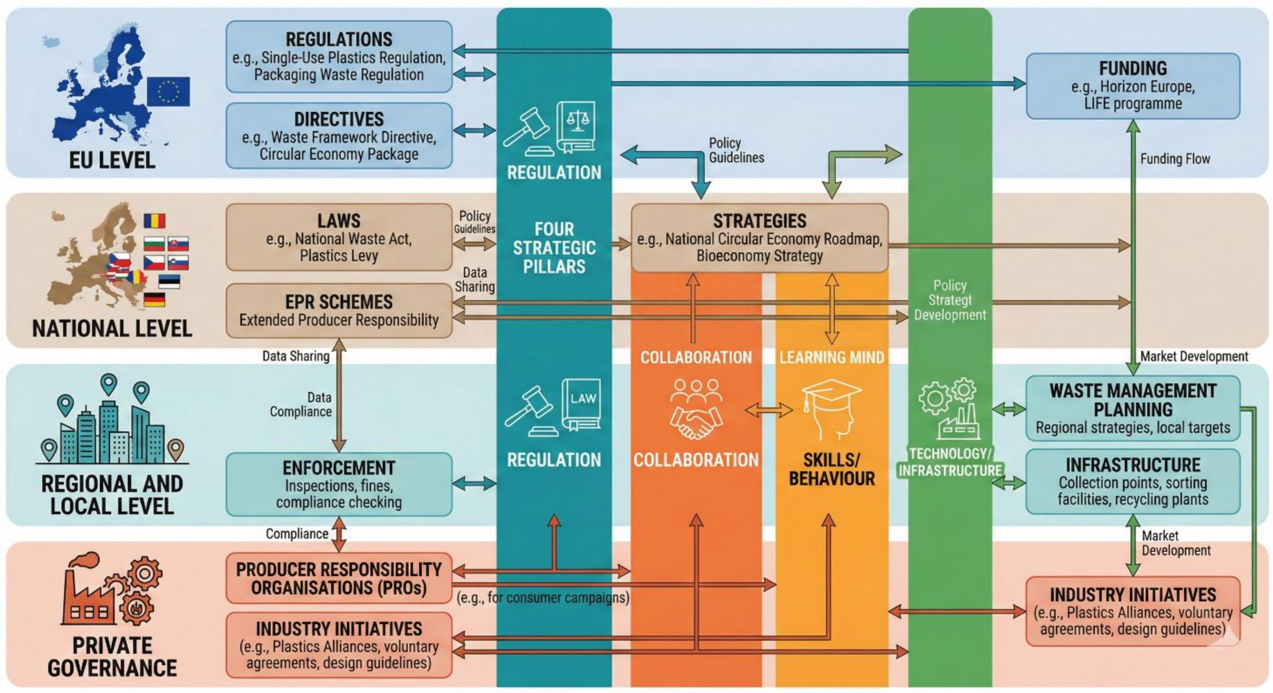

Figure 8: Governance architecture for sustainable plastics in Central Europe.

Key governance challenges identified in the analysis report (D.1.1.1) and in external studies include:

- Responsibilities across ministries (environment, industry, economy, and regional development) are fragmented or unclear, slowing cross-cutting implementation.
- Plastic-related measures are weakly integrated with climate, industrial and innovation strategies, reducing the leverage of coordinated investment.
- Municipal and regional capacity gaps—especially in smaller municipalities—limit effective separate collection, EPR oversight and local enforcement.
- Stakeholder participation and transparency mechanisms in EPR and waste planning are often insufficient, reducing trust and accountability.

At the same time, there are promising examples of multi-level, multi-stakeholder governance in the region, including cross-border Interreg projects and regional circular-economy initiatives. These examples show that coordination platforms can reduce duplication, accelerate learning and de-risk investment.

4.7. Priority regulatory and governance recommendations for the region

Based on the assessment above, priority directions emerge for strengthening plastics governance in Central Europe. The focus is to align EU obligations with national delivery capacity, while using economic instruments and coordination structures to prioritise prevention, reuse and high-quality recycling.

- Align national implementation plans with the evolving EU package (PPWR, ESPR, Waste Shipment Regulation, microplastics restrictions, and forthcoming product-specific measures) so that rules, timelines and enforcement are coherent across ministries and sectors [3].
- Strengthen and refine EPR schemes by adopting more ambitious eco-modulation, improving transparency and performance monitoring, and extending scope where appropriate to plastic-intensive product groups.
- Calibrate economic instruments and regulatory obligations to favour prevention, reuse and high-quality recycling over disposal, including effective landfill/incineration pricing and targeted instruments such as deposit-return where relevant [15].
- Mainstream industrial symbiosis and secondary raw material markets in waste and industrial policy, including clear end-of-waste pathways and practical guidance that reduces regulatory uncertainty for recyclate use.
- Establish governance structures suited to cross-cutting plastics policy, such as national “circular plastics councils” or inter-ministerial task forces with strong representation from industry, municipalities, and civil society [4,5].
- Build implementation capacity for local authorities and enforcement bodies through training, digitalisation of permitting and inspection, and targeted support for smaller municipalities.
- Mobilise public procurement and green finance instruments to create market pull for circular plastics solutions, including criteria on recycled content, design for recyclability and reduced packaging.

Taken together, these measures can position Central Europe as a proactive region in the EU-wide transition to sustainable plastics and provide enabling conditions for the cross-border collaboration mechanisms discussed in Chapter 5.

Chapter 5

5. Pillar 2: Regional collaboration and value-chain partnerships

This chapter explores how collaboration across regions and along the plastics value chain can accelerate the transition to circular plastics in Central Europe. It identifies key stakeholder groups, examines existing platforms and initiatives, and draws lessons for how Central Europe can organise partnerships around the four technical themes: circular value chains, waste and by-product valorisation, sustainable resources and feedstocks, and sustainable product design/eco-design.

5.1. Stakeholder landscape and value-chain mapping in Central Europe

Plastics in Central Europe are produced, transformed, used, and recovered through a dense web of organisations. A clear understanding of this landscape is essential for designing effective partnerships.

At the core of the value chain are polymer producers and plastics converters, often integrated into complex manufacturing networks within the packaging, automotive, construction, and electronics industries. Large multinational groups coexist with a substantial base of small and medium-sized enterprises (SMEs) and mid-caps, which dominate sectors such as packaging, technical plastics, and components for machinery and vehicles [10].

Recyclers and waste management operators form the backbone of post-consumer value chains. They include municipal waste companies, private waste management firms, specialised plastics recyclers, and companies that provide advanced sorting and processing technologies. Clusters such as Green Tech Valley in southern Austria illustrate how regional ecosystems can bring together technology providers, recyclers, and research institutions specialising in circular economy solutions, including advanced sorting and recycling of plastics [6,7].

Brand owners, retailers, and downstream users play a crucial role by defining product specifications, packaging formats, and purchasing criteria. Their design choices determine whether plastics are easy to reuse and recycle, the demand for recycled or bio-based content, and the viability of new business models such as refill, reuse, and product-service systems. Studies such as the ReShaping Plastics report and the Plastics Europe circular economy analyses emphasise that system-level change depends on coordinated decisions by all actors, not only on technical innovations at one stage of the chain [10].

Public authorities at national, regional, and local levels establish the regulatory framework, plan infrastructure and public services, and often serve as major purchasers of plastic-containing products. Business support organisations (BSOs), innovation agencies, and cluster organisations assist companies in developing capabilities, identifying partners, and securing finance. NGOs, consumer organisations, and trade unions bring additional perspectives, advocate for environmental and social safeguards, and can help ensure that circular solutions are credible and accepted.

In practice, many of these actors still operate in silos. Interviews and workshops with value-chain stakeholders in EU projects, including those focusing on non-packaging plastics, reveal recurring barriers: lack of mutual understanding of technical requirements, limited transparency on material flows and quality, misaligned economic incentives, and fragmented standards and labelling schemes [15]. Overcoming these barriers is precisely the task of Pillar 2: to create structured collaboration spaces where stakeholders can jointly design, test and scale circular solutions.

Table 7 maps the main stakeholder groups in Central European plastic value chains and highlights where each can accelerate circularity. The table shows that circular outcomes depend on coordinated action: producers, converters, brand owners, producer responsibility organisations, waste operators, authorities, civil society and research actors each enable different parts of the transition.

Table 7: Key stakeholder groups in Central European plastic value chains.

Stakeholder group	Typical roles and responsibilities	Main interests and constraints	Potential contributions to circular plastics	Examples of existing organisations or platforms in Central Europe
Polymer producers and feedstock suppliers (incl. petrochemicals and emerging circular feedstocks)	Produce virgin polymers; develop grades and additives; increasingly pilot recycled/bio-based feedstocks; coordinate with downstream users on specifications.	Competitiveness (energy/feedstock costs), regulatory certainty, stable demand, and acceptance of recycled-content accounting.	Scale up circular feedstocks; support recyclate quality standards; co-invest in sorting/recycling; align specifications with converters and brands.	Plastics Europe (industry association; CE engagement) Plastics Europe. "Contact Us [82]; "We Are Plastics" initiative (Germany) [83].
Converters and product manufacturers (packaging and technical parts)	Convert polymers into products (packaging, construction, automotive, EEE); implement eco-design changes; manage production scrap.	Cost pressure; performance/safety requirements; limited access to consistent high-quality recyclate; compliance burden.	Redesign for recyclability; reduce material complexity; increase recycled-content uptake; provide product/material data for traceability.	EuPC (European Plastics Converters) [84]; Circular Plastics Alliance (CPA) [85].
Brand owners, retailers and large buyers (incl. public procurement)	Specify packaging/product requirements; set recycled-content and recyclability criteria; influence consumer communication and collection behaviours.	Product safety and reputation risk; supply chain traceability; price volatility; risk of misleading claims.	Create demand pull for recyclates (offtake); harmonise design requirements; fund or co-design reuse/refill systems; share data requirements downstream.	CPA (cross-value-chain coordination) [85]; PRO Europe (packaging PRO network) [86].
Producer Responsibility Organisations (PROs) / EPR compliance schemes	Organise/finance collection, sorting, and recycling to meet targets; report/audit; set fees; coordinate with stakeholders (producers, municipalities, operators).	Fee stability; enforcement against free-riders; data quality; infrastructure gaps; contamination.	Eco-modulated fees to reward recyclability; invest in separate collection/sorting; education; transparent reporting; market development for secondary raw materials.	ARA (Austria) [87]; EKO-KOM (Czechia) [88]; Rekopol (Poland) [89]; SLOPAK (Slovenia) [90]; NATUR-PACK (Slovakia) [91]; (network context: PRO Europe) [86].

Table 7: (continued).

Stakeholder group	Typical roles and responsibilities	Main interests and constraints	Potential contributions to circular plastics	Examples of existing organisations or platforms in Central Europe
Public authorities and regulators (ministries, agencies, inspectorates, registers)	Set and enforce rules (EPR, reporting); permitting; compliance monitoring; national registers; sanctions.	Capacity constraints; fragmented responsibilities; data gaps; political acceptability of reforms.	Stronger enforcement; harmonised reporting; targeted funding/permitting for recycling capacity; clearer guidance on compliance evidence and data quality.	Slovenia packaging waste reporting (GOV.SI / ARSO framework) [92]; Croatia RPPO register (FZOEU) [93]; Hungary EPR system overview (KPMG) [94].
Municipalities and local waste management companies (public services)	Operate household collection; manage local contracts; deliver separate collection performance; and local communication.	Budget constraints, contamination, limited infrastructure, and citizen participation challenges.	Improve source separation; roll out convenience measures; deliver cleaner streams to sorters/recyclers; and implement local prevention actions.	Municipal cooperation is often enabled through national PRO systems (e.g., EKO-KOM in CZ) [88] and national reporting interfaces (e.g., Slovenia GOV.SI/ARSO) [92].
Private waste management operators (collection, logistics, sorting, treatment)	Run collection/sorting/transfer; manage residues; compliance documentation; operate cross-border logistics.	Investment risk; volatile gate fees and recyclate prices; regulatory complexity; social licence to operate.	Expand sorting capacity/quality; deploy advanced sorting; improve traceability/auditing; reduce losses and contamination.	FEAD (European Waste Management Association) [95]; Germany packaging compliance ecosystem context (e.g., Der Grüne Punkt - Packaging Act guidance) [96].

Table 7: (continued).

Stakeholder group	Typical roles and responsibilities	Main interests and constraints	Potential contributions to circular plastics	Examples of existing organisations or platforms in Central Europe
Mechanical recyclers and recyclate producers	Reprocess post-consumer/post-industrial plastics; certify quality; supply converters/brands; provide feedback on design-for-recycling.	Feedstock quality/availability; competition with virgin materials; energy costs; strict specs for sensitive applications.	Increase capacity and output quality; develop high-performance recyclates; provide transparency on quality and traceability; support standardisation.	Plastics Recyclers Europe [97]; Recycling Europe / EuRIC listing (platform entry) [98].
Chemical recycling and feedstock preparation actors (incl. refineries/chemicals)	Convert suitable waste streams into chemical feedstocks; integrate outputs into polymer production; require robust mass-balance and auditing.	Policy clarity on accounting, high CAPEX/permitting, sustainability scrutiny, and feedstock pre-treatment needs.	Treat hard-to-recycle streams (where justified); complement mechanical recycling; improve overall recovery while safeguarding environmental performance.	Cross-value-chain collaboration via CPA [85]; national system design influences investment signals (e.g., Hungary EPR context) [94].
Energy recovery and residual waste treatment operators (WtE, co-processing)	Treat non-recyclable residues; provide energy and volume reduction; manage ash/residues.	Risk of lock-in vs recycling targets; public acceptance; feedstock changes as recycling improves.	Managed outlet for unavoidable residues; collaborate on pre-sorting/diversion; system optimisation to avoid competing with recycling.	Sector representation context via FEAD [95].
Civil society, consumer organisations and cities' networks	Advocacy, watchdog role, behaviour change campaigns, municipal zero-waste strategies; pressure for enforcement and prevention.	Limited resources; political resistance; complex trade-offs (incineration vs landfill vs recycling).	Improve participation and sorting quality; promote prevention/reuse; increase accountability; support "just transition" measures.	ZWE: Zero Waste Europe (platform entry) [98]; Zero Waste Europe network [86].
Research, innovation and training actors (universities, applied research, clusters)	Technology development, pilots, testing and standards support; workforce skills and training; independent evidence generation.	Funding continuity; scaling challenges; need for access to industrial data and waste streams.	Demonstrate scalable sorting/recycling solutions; develop quality assurance methods; provide evidence for policy and investment choices.	Fraunhofer research news (packaging plastics recycling) [99].

5.2. Regional collaboration for circular plastic value chains

5.2.1. Cross-border platforms, clusters, and Interreg CENTRAL EUROPE initiatives

Central Europe has a strong tradition of transnational cooperation. The Interreg CENTRAL EUROPE Programme 2021–2027 explicitly identifies the circular economy as a specific objective, calling for strengthened cooperation along key value chains in sectors such as plastics, packaging, construction, and electronics. The programme emphasises knowledge exchange, pilot actions, and cross-sectoral linkages as levers for circular solutions [6,7].

Recent and ongoing Interreg CENTRAL EUROPE projects provide concrete examples. The CURIOST project supports SMEs and small mid-caps in the mechanics, packaging, plastics, and construction sectors in developing circular products and business models, with a strong emphasis on cross-regional learning and joint tools for sustainable design. interreg-central.EU+2 Environment Park+2. Other initiatives focus on circular plastics in agriculture, biocomposite packaging, and electrical and electronic equipment, helping to create new circular loops for sector-specific plastic streams and connecting companies, research, and public bodies across borders.

Regional and national clusters complement these EU-funded initiatives. Green Tech Valley in Austria, for example, brings together more than 300 companies and research institutes active in renewable energy and the circular economy, including firms specialising in plastics sorting and recycling technologies. Similar cluster organisations and technology parks exist in other Central European regions, focusing on plastics processing, waste management, advanced materials, and eco-innovation [6,7].

Together, these platforms demonstrate that Central Europe is already building the “soft infrastructure” for circular plastics: networks, trust relationships, joint projects, and shared tools. However, their reach is still limited relative to the scale of the plastics challenge. Many SMEs, municipalities, and smaller regions remain outside these networks, and knowledge often remains within individual projects rather than being systematically transferred to policy and industry practice.

Table 8 summarises major collaboration initiatives that Central European stakeholders can use to align targets, share tools and scale pilots.

Table 8: Overview of major collaboration initiatives relevant to Central Europe.

Initiative/platform	Geographic scope	Contribution (focus + relevance mapping)
Circular Plastics Alliance (CPA) [85]	EU-wide (incl. Central Europe)	Focus: market pull for recycled plastics; value-chain commitments/workstreams. Relevance: Themes CV-S, WV-S, SR-S, ED-M; Pillars P1-M, P2-S, P3-M, P4-S
Plastics Pact Network (WRAP/EMF) [100]	Global network; includes European pacts relevant to Central Europe	Focus: measurable targets (eliminate problematic plastics; design for reuse/recycling; scale recycling; increase recycled content). Relevance: Themes CV-S, WV-S, SR-S, ED-S; Pillars P1-M, P2-S, P3-M, P4-M.
European Plastics Pact (EPP) — *ceased operations* [101]	Pan-European voluntary coalition	Focus: pact goals on design, responsible use, recycling capacity, recycled content; status note. Relevance (legacy learning): Themes CV-S, WV-S, SR-S, ED-S; Pillars P1-M, P2-S, P3-M, P4-M.
CURIOST (Interreg CENTRAL EUROPE) [102]	Central Europe (project consortium)	Focus: SME support for circular product development (incl. plastics/packaging). Relevance: Themes CV-S, WV-M, SR-M, ED-S; Pillars P1-I, P2-S, P3-S, P4-M.
BIOECO-UP (Interreg CENTRAL EUROPE) [103]	Central Europe (project consortium)	Focus: circular bioeconomy value chains + consumer behaviour + policy support. Relevance: Themes CV-S, WV-M, SR-S, ED-M; Pillars P1-S, P2-S, P3-S, P4-M.
Green Tech Valley (cluster ecosystem) [104]	Regional (Austria; international)	Focus: an innovation ecosystem with a strong emphasis on recycling/circular tech. Relevance: Themes CV-M, WV-S, SR-M, ED-M; Pillars P1-I, P2-S, P3-M, P4-S.
Czech Circular Hotspot (INCIEN) [105]	National (Czechia) with international cooperation	Focus: cross-sector cooperation platform (public-private-academia). Relevance: Themes CV-S, WV-M, SR-M, ED-M; Pillars P1-M, P2-S, P3-S, P4-I.
Circular Economy Forum Austria [106]	National (Austria) with EU/international networking	Focus: multi-stakeholder learning/dialogue; business-policy-science exchange. Relevance: Themes CV-S, WV-M, SR-M, ED-M; Pillars P1-M, P2-S, P3-S, P4-M.
Slovenian Centre for Circular Economy (SCKG) [107,108]	National (Slovenia) with entry points & national network [SCKG_SCKG]	Focus: one-stop support (policy support, industrial symbiosis, training, technology transfer, tools). Relevance: Themes CV-S, WV-S, SR-M, ED-S; Pillars P1-S, P2-S, P3-S, P4-S.
BIOEAST Initiative [109]	Central & Eastern Europe (macro-regional cooperation) [BIOEAST_OFFICIAL]	Focus: macro-regional cooperation for circular bioeconomy (feedstocks, value chains, innovation). Relevance (for plastics strategy): Themes SR-S (and CV-M/WV-M via bio-based value chains); Pillars P1-M, P2-S, P3-M, P4-M.

Legend: CV (circular value chains); WV (waste & by-product valorisation); SR (sustainable resources & feedstocks); ED (eco-design). Strategic pillars: P1 regulation/governance; P2 collaboration; P3 skills/behaviour; P4 technology/infrastructure. Strength: S - strong, M - moderate.

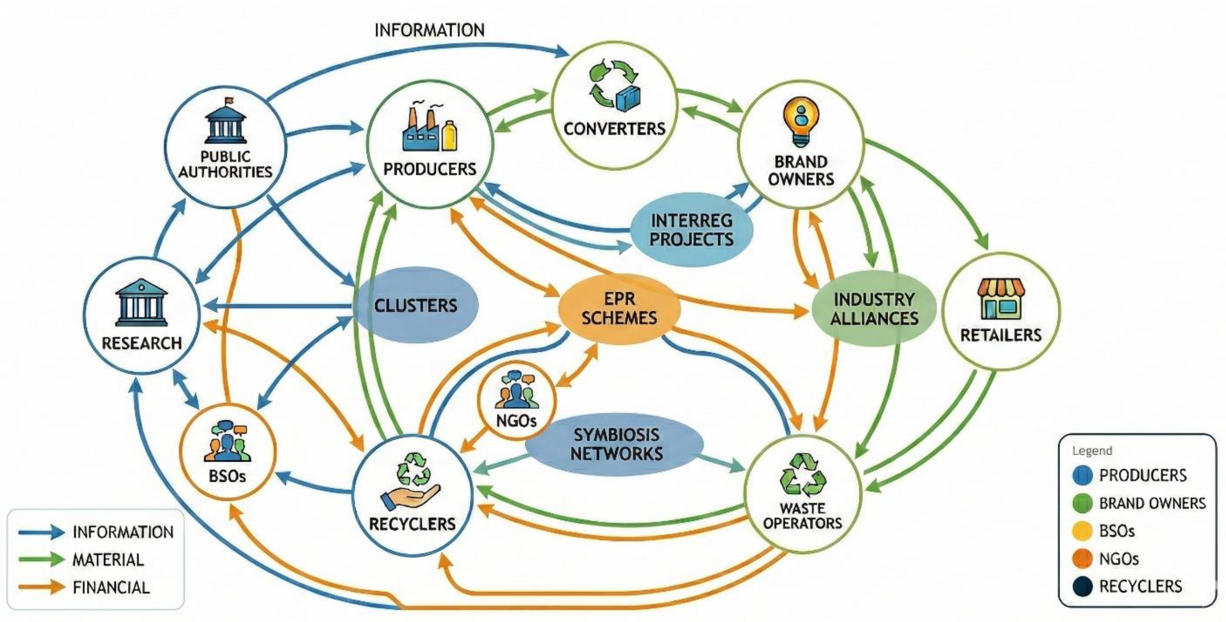

Figure 9: Collaboration map for circular plastics in Central Europe.

5.2.2. Harmonising standards, practices and expectations

A recurring message from industry, NGOs, and international organisations is that fragmented standards and practices across value chains and borders hinder investment and slow progress towards circularity. Reports from Plastics Recyclers Europe and Plastics Europe highlight that divergent definitions of recyclability, recycled content, and "design for recycling" create uncertainty for both producers and recyclers, as well as inconsistent EPR fee modulation and labelling schemes [50].

At the EU level, initiatives such as the Circular Plastics Alliance (CPA) and the European Plastics Pact (EPP) have been created precisely to align expectations and harmonise approaches. The CPA brings together more than 250 public and private stakeholders across the plastics value chain to boost the use of recycled plastics to 10 million tonnes in Europe by 2025. It has developed common monitoring methodologies, design guidelines, and value-chain roadmaps for selected product groups in packaging, construction, and agriculture. The European Plastics Pact, a frontrunner coalition of governments, companies and organisations, similarly defines a shared vision and targets, and explicitly frames itself as a platform for cross-border, cross-value-chain collaboration on plastics and packaging [43,44].

Central European actors participate in these initiatives, but there is scope to deepen their engagement and to translate high-level frameworks into concrete regional practices. Harmonisation does not mean that all countries and regions must adopt identical systems. It means agreeing on core definitions, performance indicators, and minimum requirements, so that circular products and secondary materials can move smoothly between markets and investments in design, sorting, and recycling are not undermined by inconsistent rules or expectations.

Collaboration under Pillar 2 should therefore focus on regional alignment around EU-wide concepts such as recyclability criteria, recycled-content calculation, data requirements for Digital Product Passports, and quality classes for recyclates. Doing so will reduce transaction costs, encourage cross-border investment in circular infrastructure, and help Central Europe to speak with a coherent voice in EU and global discussions on plastics.

5.3. Partnerships for waste and by-product valorisation

5.3.1. Industrial symbiosis networks and regional hubs

Industrial symbiosis – the practice whereby waste or by-products from one process become inputs for another – is a natural field for regional collaboration. Mapping studies of industrial symbiosis in Europe reveal a growing number of networks and case studies, particularly rich experiences in Italy and the Nordic countries, and a rising interest across Central Europe.

In the plastics field, symbiosis can take several forms. Plastic production residues and offcuts can be sold to nearby recyclers or compounders; mixed plastic streams can be used as feedstock in specialised mechanical or chemical recycling plants; and, in some cases, plastic-rich waste can substitute other materials in industrial processes, provided that life cycle assessments demonstrate net environmental benefits and that regulatory safeguards are met. The European Commission has recognised industrial symbiosis as a key means of turning waste into resources and has commissioned studies to identify waste streams with high symbiosis potential [18,110].

Central European regions are beginning to explore this potential. In Slovenia, for example, a national project on industrial symbiosis aims to develop models and digital tools to identify and implement symbiosis networks, including for plastics, starting in South-East Slovenia and scaling up nationally. Similar initiatives can be found in Austrian, Czech, and Polish industrial clusters, where waste management companies, recyclers, and manufacturing firms cooperate to valorise secondary raw materials.

The strategic challenge is to move from isolated symbiosis projects to structured networks integrated into regional development strategies, Smart Specialisation Strategies, and cluster activities. This requires collaboration between regional authorities, development agencies, business organisations and research institutions to identify priority sectors, map material flows, and create matchmaking and data-sharing platforms that connect potential “waste suppliers” with “resource users”.

5.3.2. Collaboration between waste operators, recyclers and end-users

Waste and by-product valorisation for plastics is only viable if waste operators, recyclers and end-users work together. Studies on barriers to plastics circularity in non-packaging sectors underline that recyclers often lack reliable information on material composition and quality, while manufacturers and brand owners are unsure whether recyclates can meet their performance and regulatory requirements.

Regional collaboration platforms can help bridge this gap by creating forums where waste operators, recyclers, and end-users jointly define quality specifications for recyclates, agree on sampling and testing protocols, and design long-term supply agreements that give all parties confidence to invest. The experience of the Circular Plastics Alliance is instructive: its monitoring work and value-chain roadmaps stress that achieving the 10-million-tonnes target for recycled plastics requires both stable demand and stable supply of suitable-quality recyclates, supported by transparent data and traceability [43,44].

Central Europe can build on this by establishing regional “recyclate platforms” that bring together polymer producers, recyclers, converters, and major users (for example, in packaging, construction, and automotive) to coordinate on feedstock needs, quality standards, and joint investments in sorting and recycling infrastructure. Clusters such as Green Tech Valley and sectoral initiatives in Austria and neighbouring countries already illustrate how convening power can be used to launch projects such as large-scale pilots for mixed-waste sorting and plastics recycling [14].

Digital solutions can further support collaboration. Emerging concepts such as digital industrial symbiosis platforms and material marketplaces enable companies to share information on available waste streams, material specifications and potential uses, lowering search and transaction costs. For plastics, linking such platforms with Digital Product Passports and EPR scheme data could provide a powerful tool to unlock regional waste valorisation opportunities.

5.4. Collaboration for sustainable resources and feedstocks

5.4.1. Shared sourcing of recycled and bio-based polymers

As regulatory requirements for recycled content in plastic packaging and other products become more stringent, competition for high-quality recyclates intensifies. The Circular Plastics Alliance and sectoral roadmaps predict strong growth in demand for circular plastics, but also highlight constraints in the availability of sorted plastic waste and sustainably sourced alternative feedstocks.

In this context, individual companies – especially SMEs – may struggle to secure long-term access to suitable recycled materials or to influence upstream supply chains. Regional collaboration enables pooling demand and developing shared sourcing strategies. For example, groups of packaging producers or brand owners in a region could jointly tender for recycled polyethene or polypropylene with specified quality standards, giving recyclers sufficient volume to invest in new capacity. Public procurement agencies could be part of these pools, committing to use products with certified recycled content in packaging, construction and other applications.

Similar logic applies to bio-based and other non-petroleum-based feedstocks. The EU Bioeconomy Strategy and the policy framework for biobased, biodegradable and compostable plastics stress that the use of such materials must be carefully targeted and based on robust sustainability criteria. Regional bioeconomy initiatives in Central Europe, including projects like BIOECO-UP, show how actors can collaborate to design new bio-based value chains, change consumer behaviour and support policy development [50,110].

By coordinating on which applications to prioritise for bio-based plastics, how to integrate agricultural and forestry residues, and how to align with waste management systems, Central European regions can avoid fragmented, small-scale projects and instead build robust, scalable feedstock systems that complement recycling rather than compete with it.

5.4.2. Regional approaches to critical raw materials and supply risks

The circular plastics agenda is closely linked to broader debates on critical raw materials, strategic autonomy and sustainable carbon management. Plastics Europe's transition roadmap emphasises that, by 2050, European plastics demand will increasingly be met by a mix of recycled plastics, sustainably sourced biomass and, to a lesser extent, carbon captured from industrial processes or the atmosphere [10].

For Central Europe, this raises strategic questions about the future "carbon feedstock mix" for plastics and how to manage associated risks. Regional collaboration can help by: mapping current and potential sources of secondary plastics, biomass and CO_2; assessing competition for these resources across sectors; and identifying where shared investments in infrastructure (for example, advanced sorting plants, biorefineries or CO_2 transport and utilisation infrastructure) make sense.

Collaboration is also needed to align regional strategies with EU-wide initiatives such as the EU Taxonomy for sustainable activities, the Sustainable Carbon Cycles communication and the emerging global plastics treaty, all of which will influence investment conditions and reporting requirements. Joint foresight exercises, scenario studies and investment roadmaps at the Central European scale would help stakeholders anticipate future feedstock dynamics and avoid lock-in to unsustainable or stranded assets.

5.5. Joint initiatives for sustainable product design and eco-design

5.5.1. Co-creation platforms, living labs and design networks

Sustainable product design and eco-design are intrinsically collaborative. Designers, material suppliers, brand owners, recyclers, waste operators and users must jointly explore how to reduce material use, eliminate problematic substances, enable reuse and ensure high-quality recycling. The forthcoming implementation of the Ecodesign for Sustainable Products Regulation (ESPR) will strengthen these links by making eco-design requirements and digital product passports central to market access for many plastic-intensive products.

In Central Europe, Interreg projects such as CURIOST provide early models for structuring collaborative eco-design. CURIOST supports SMEs and mid-caps in packaging, plastics, and construction in adopting circular product development processes, using joint vision documents, design guidelines, and pilot projects to translate circular economy principles into concrete design choices. Other initiatives create “living labs” or testbeds where companies can experiment with reusable packaging systems, modular product designs, or new material combinations in real-world settings, with user and waste manager feedback.

Regional co-creation platforms should be designed to be inclusive and practical. They need to engage not only large companies but also SMEs, designers, start-ups and public procurers. They should link design discussions with technical realities in waste management and recycling, ensuring that proposed solutions are compatible with existing or planned systems. And they should be embedded in education and training ecosystems, so that design students and young engineers gain hands-on experience with eco-design challenges relevant to Central European industries.

5.5.2. Common design guidelines, tools and innovation challenges

Value-chain collaboration can greatly accelerate the uptake of common design guidelines and tools. Initiatives such as RecyClass in Europe show how industry-led platforms can harmonise design-for-recycling criteria, testing protocols and recyclability assessments, thereby providing clear guidance to packaging designers and brand owners.

At the EU level, the Circular Plastics Alliance and the European Plastics Pact have also developed design principles for packaging and other plastic products.

Central Europe can leverage these resources by developing regional “design translation” projects that adapt EU-level guidelines to local conditions and product portfolios, and by promoting their use through cluster organisations, chambers of commerce, and innovation agencies. Joint development of digital tools – for example, simplified eco-design checklists, LCA templates, or material selection guides tailored to plastics – can help SMEs, in particular, apply complex criteria without requiring extensive in-house expertise.

Innovation challenges and competitions are another way to mobilise collaboration. Regional or transnational challenges can invite interdisciplinary teams to develop circular packaging solutions for specific sectors, modular components for construction products, or high-recycled-content parts for the automotive and electronics industries, with mentoring from industry and research partners. Experience from platforms such as the European Plastics Pact and global coalitions coordinated by organisations like WBCSD [49] suggests that such challenges can accelerate experimentation and crowd in new ideas, provided they are followed by support for scaling and market access.

5.6. Examples of good practice and lessons for Central Europe

Central Europe can draw inspiration from a growing body of good practice in collaborative plastics initiatives, both within and beyond the region.

At the European level, the Circular Plastics Alliance demonstrates how a large, diverse coalition can agree on shared targets, monitoring methodologies and product-group roadmaps, and how it can address both supply-side and demand-side constraints in recycled plastics markets. The Alliance’s focus on improving the design of 26 plastic products in packaging, construction, agriculture and home appliances that account for more than 60% of plastic waste collected in Europe illustrates the power of concentrating efforts on high-impact segments [43,44].

The European Plastics Pact offers complementary lessons. It shows how national governments, companies and NGOs can agree on a common vision and roadmap for plastics and packaging, with quantified targets and a shared reporting framework. It also provides a platform for participants to share case studies, tools and pilot results, thereby reducing duplication of effort and enabling faster diffusion of innovations [15].

Within Central Europe, cluster-based initiatives, such as the Senate for Circular Economy in Austria, demonstrate how major retailers, beverage producers, dairies and plastics manufacturers can collaborate on national circular economy strategies and pilot projects, supported by the national recycling organisation. Similarly, Interreg projects like CURIOST and BIOECO-UP illustrate how transnational partnerships can support SMEs in developing circular products and bio-based value chains, linking technical assistance with joint visioning and policy dialogues [6,7].

From these and other examples, several lessons emerge. First, effective collaboration requires clear, shared goals and metrics that all parties can commit to. Second, the value chain representation must be broad: initiatives that involve only one segment, such as recyclers or brand owners alone, tend to have limited impact. Third, neutral convenors – such as public authorities, cluster organisations or respected NGOs – can play a critical role in building trust and balancing interests. Fourth, data and transparency are essential: without robust information on material flows, quality and performance, it is difficult to design credible roadmaps or monitor progress [10].

5.7. Strategic collaboration priorities and recommended actions

Building on the analysis above, several strategic priorities emerge for regional collaboration and value-chain partnerships in Central Europe. These priorities are designed to reinforce the other three pillars and to operationalise the four technical themes in a coordinated way:

1. Consolidate and scale regional collaboration platforms on circular plastics. Interreg CENTRAL EUROPE and national programmes already support a range of projects and clusters, but their outputs need to be connected and sustained beyond project lifetimes. Establishing a Central European “Circular Plastics Partnership” that links clusters, Interreg projects, research networks and major companies could provide a stable framework for coordination, joint strategy development and dialogue with EU-level alliances such as CPA and the European Plastics Pact.
2. Develop joint value-chain roadmaps for key sectors. For packaging, construction, automotive and electronics, Central European stakeholders should jointly map current plastic flows, identify priority product groups, and define sector-specific pathways to circularity, aligned with EU policies and CPA roadmaps. These roadmaps should include targets for prevention, recyclability, recycled content and substitution by sustainable materials, backed by indicative investment needs and responsibilities across the value chain.
3. Create regional industrial symbiosis and recycling platforms. Building on existing projects and clusters, Central European regions should establish digital and physical platforms that systematically identify symbiosis opportunities, connect waste generators with potential users, and coordinate investments in sorting and recycling infrastructure. Integration with EPR schemes and public procurement

can provide stable feedstock and off-take for these platforms, making waste and by-product valorisation a mainstream business practice rather than a niche activity.

4. Coordinate regional strategies for recycled and bio-based feedstocks. Instead of competing for limited high-quality recyclates and biomass, Central European stakeholders should explore joint sourcing strategies, shared certification schemes and coordinated investment in feedstock-related infrastructure. This includes aligning regional bioeconomy strategies with plastics circularity goals and ensuring that new feedstock pathways are assessed using robust life cycle and sustainability criteria [50,110].

5. Mainstream collaborative eco-design and design-for-recycling. Central Europe should leverage ESPR, PPWR, and related initiatives by establishing regional eco-design support services, co-creation labs, and training programmes linked to universities and VET providers. Joint development and dissemination of design guidelines, digital tools and sector-specific examples will help SMEs and local authorities implement sustainable product design in practice. Coordination with recyclers and waste operators must be integral to these efforts.

6. Strengthen data-sharing and transparency across the value chain. Collaborative monitoring systems, inspired by the CPA and EU-level MFAs for plastics, should be developed at the Central European scale to track plastic flows, recycling performance, recycled content and the uptake of circular business models. Linking these systems to Digital Product Passports, EPR reporting and industrial symbiosis platforms will provide a robust evidence base for decision-making and enable more effective benchmarking and peer learning [43,44].

7. Ensure inclusive and just collaboration processes. Partnerships must include not only large companies and public authorities, but also SMEs, workers' representatives, NGOs and communities affected by waste and industrial activities. This is essential to ensure that the benefits and costs of the circular plastics transition are shared fairly and that solutions account for social, environmental, and economic dimensions. Global analyses of plastic value chains underline that fragmented, top-down efforts often fail to address equity and informal work issues; Central Europe has the opportunity to design more inclusive models from the outset [50,110].

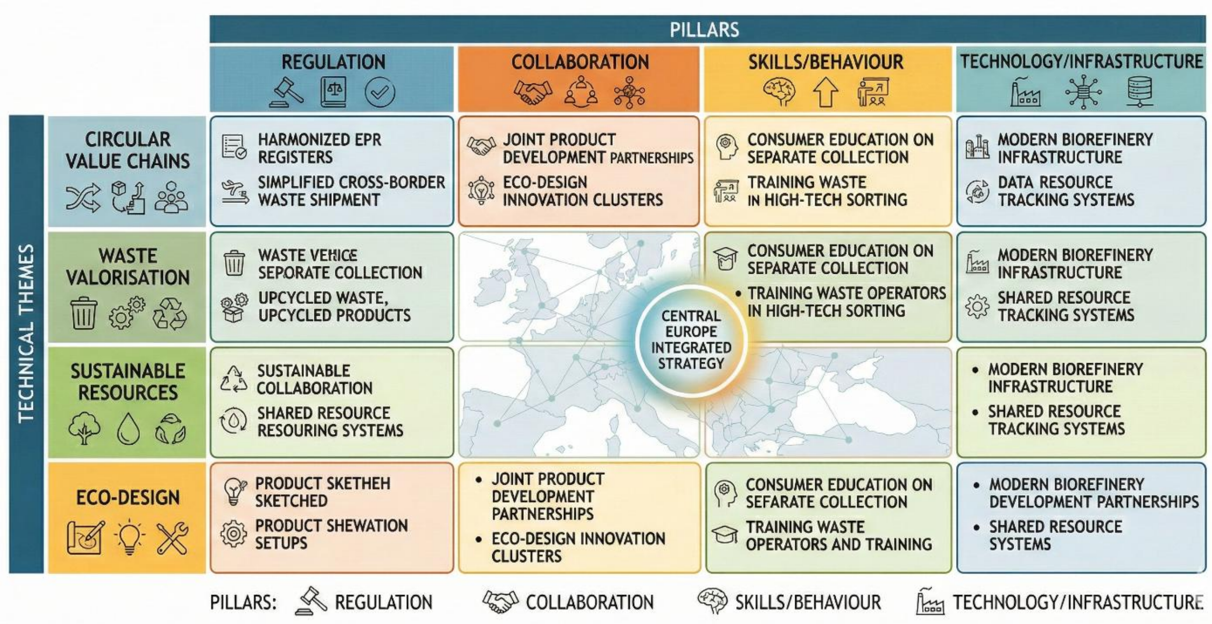

Figure 10: Matrix of collaboration priorities by pillar and technical theme

If implemented coherently, these collaboration priorities will anchor the technical transformations outlined in the other pillars in a strong web of relationships, platforms and shared commitments (Figure 10). They will help Central Europe move from isolated pilots and project-based cooperation to a durable, region-wide coalition for circular, low-impact and socially responsible plastic value chains.

Chapter 6

6. Pillar III: Education, skills and behavioural change

Pillar 3 addresses the human dimension of the transition to sustainable plastic management in Central Europe. Regulation, partnerships and technology only deliver at scale when people across the value chain have the right competencies and when institutions support lifelong learning and behavioural change.

The chapter summarises the skills needed for circular and sustainable plastics, shows how vocational education and training (VET) and higher education can respond, and identifies priorities for continuous professional development, public awareness and just transition.

6.1. Skills needed for circular and sustainable plastics in Central Europe

The shift from linear "make-use-dispose" plastics to circular value chains requires new combinations of technical, managerial and social competences. Research work on green skills and circular economy underlines that the transition affects all skill levels and occupations, not only specialised "green jobs" [15]. In the plastics context, this involves:

- understanding material flows and environmental impacts over the full life cycle;
- applying eco-design and green chemistry principles in product and process development;
- operating and optimising recycling, sorting and valorisation technologies;
- collaborating across departments, organisations and regions to close material loops;
- engaging customers and users in new consumption and service models.

6.1.1. Industry workforce, SMEs and start-ups

In companies, skills needs differ by function but share a common orientation towards systems thinking and circular business models. For Central European plastics producers, converters, recyclers and users, priority skill areas include [41,42]:

- Design products and processes for circularity (reuse, recyclability, durability) and for safe material cycles.
- Select recycled, bio-based or CO2-based feedstocks based on life cycle performance and compliance constraints.

- Operate and optimise collection, sorting and recycling processes, including quality control and contamination prevention.
- Use Life Cycle Assessment (LCA), carbon footprinting and eco-design tools to support decisions and credible claims.
- Manage product and material data for Digital Product Passports and extended producer responsibility (EPR) reporting.

Small and medium-sized enterprises (SMEs) and start-ups are often key sources of innovation, but they rarely have time or resources for sustained training. Targeted, SME-friendly programmes—short modules, mentoring and peer learning—are therefore essential to spread circular plastics capabilities across the region.

6.1.2. Public administration, regulators and inspectors

Public authorities, regulators and inspectors also need new competences to design, implement and enforce effective plastics policies. This includes:

- **Regulatory literacy on plastics and circular economy**: a solid understanding of the EU Single-Use Plastics Directive, packaging and packaging waste legislation, the forthcoming Packaging and Packaging Waste Regulation (PPWR), chemicals regulation and related climate and waste directives [6,7].
- **Analytical and evaluation skills**: the ability to interpret LCA and carbon footprint studies, assess circularity indicators, evaluate EPR scheme performance and use monitoring data (for example, on plastic bag consumption or packaging waste generation) to steer policy [13,52,53].
- **Market surveillance and communication skills**: competences to assess green claims, verify compliance with recyclability and recycled-content requirements, and communicate clearly with businesses and citizens. Consumer surveys show that many Europeans feel poorly informed about food packaging safety and environmental performance and look to public authorities for trusted guidance.
- **Partnership and facilitation skills**: capacity to convene stakeholders, support industrial symbiosis and value-chain collaboration, and integrate circular plastics considerations into broader regional development plans (see Chapter 5).

Investing in these skills can help close the gap between ambitious EU-level targets and on-the-ground implementation and strengthen public trust in the transition to sustainable plastics.

Table 9 summarises the competence needs that recur across stakeholder groups and links them to suitable training formats.

Table 9: Key competence needs for circular plastics by stakeholder group

Stakeholder group	Competence needs (technical + transversal)	Priority training formats	Themes
Industry operators (production, converters, recyclers, waste operators)	Sorting/quality control and contamination prevention; safe handling of additives/legacy substances; process optimisation for yield/quality; basic data capture & traceability (GreenComp: AS, EC) [42,111].	VET + workplace coaching + short CPD modules	CV, WV, ED
Engineers (process, materials, recycling, logistics)	Design-for-circularity engineering trade-offs; mass-balance/material flow analysis; LCA-aware decision support; recycling tech selection (mechanical/chemical) and limits (GreenComp: EC, SF) [42,111].	HE + CPD (micro-credentials)	CV, WV, SR, ED
Designers (product/packaging, industrial, service design)	Eco-design rules (durability, reuse, recyclability); mono-material and component design; labels/info for end-of-life; user-centred reuse systems (GreenComp: EV, SF, AS) [111].	HE + CPD + design sprints/labs	CV, ED, WV
Managers (operations, sustainability, procurement, quality)	Circular business models and KPIs; supplier engagement & recycled-content procurement; compliance planning and reporting; change management (GreenComp: EC, AS) [111,112].	CPD + executive workshops + peer learning	CV, SR, ED
SMEs (owners + multifunctional staff)	Practical compliance basics; “good enough” LCA/claims literacy; circular purchasing & partnerships; access to support instruments/funding (GreenComp: AS, EC) [111,112].	CPD (short, modular) + mentoring + toolkits	CV, WV, SR, ED
Public authorities (policy, waste planning, public procurement)	Policy design aligned with waste hierarchy; market-creation instruments (EPR, green procurement); monitoring/indicators; cross-border coordination (GreenComp: EC, SF, AS) [111].	CPD + peer exchange + learning-by-doing pilots	CV, WV, SR, ED
Inspectors/enforcement (environment, waste, product compliance)	Inspection of collection/sorting/recycling; evidence checks for claims/labelling; audit trails and documentation; risk-based enforcement (GreenComp: AS, EC) [111].	CPD + practical labs + joint exercises	WV, ED, CV
Teachers/trainers (VET & HE)	Curriculum integration for circular plastics; competence-based assessment; real-case teaching & labs; industry collaboration (GreenComp: SF, AS, EV) [42,111].	CPD + communities of practice + teaching toolkits	CV, WV, SR, ED
NGOs / civil society organisations	Plastics literacy (life cycle, leakage, toxics); evidence-based advocacy; citizen engagement and behaviour programmes (GreenComp: EV, SF, AS) [111].	Informal learning + workshops + campaigns	CV, WV, ED
Citizens/consumers	Recognising credible claims; correct separation behaviour; reuse/refill habits; acceptance of recycled-content products (GreenComp: EV, AS) [111].	Informal learning + public campaigns + community initiatives	CV, WV, ED

Abbreviations:

EV = Embodying sustainability values; **EC** = Embracing complexity; **SF** = Envisioning sustainable futures; **AS** = Acting for sustainability. **[GC_JRC2022]**
Technical themes: CV = circular value chains; **WV** = waste valorisation; **SR** = sustainable resources/feedstocks; **ED** = eco-design.

6.2. Integrating circular plastics and eco-design in vocational education and training (VET)

Vocational education and training (VET) is a crucial lever for equipping current and future workers with practical skills for circular plastics. Foresight on skills for the circular economy emphasises that VET can act as a “springboard” for green growth mindsets if curricula and teaching methods are adapted accordingly [6,7].

Across Central Europe, plastics-related VET programmes (e.g. polymer processing, mechanical engineering, machining, maintenance, packaging operations) can integrate circular and sustainable plastics topics in several ways [42,113]:

- Update curricula with circular economy basics, eco-design, green chemistry and plastics recycling, using modular and stackable learning units.
- Strengthen work-based learning (apprenticeships and dual systems) so learners experience real circular practices in companies.
- Use project-based learning with municipalities, waste operators and civil society to tackle local plastics challenges.
- Align assessment with competence frameworks such as GreenComp, covering both technical skills and systems thinking.

In Central Europe, coordinating curriculum updates through national VET agencies, chambers of commerce, and sectoral councils can help avoid fragmentation and ensure that circular plastics concepts are consistently embedded across countries and qualifications.

6.3. Higher education and research programmes on green chemistry and circular plastics

Universities and research institutes in Central Europe play a pivotal role in training specialists and generating new knowledge on sustainable plastics. Education for Sustainable Development (ESD) frameworks, including UNESCO’s ESD for 2030 roadmap, call for higher education to integrate sustainability across disciplines and to promote transformative learning approaches [113].

For plastics, this implies that programmes in chemistry, chemical engineering, materials science, product design, environmental science and business should:

- integrate **green chemistry** principles in polymer synthesis and processing courses, including safer monomers, catalysis, solvent use and end-of-life considerations;
- systematically apply **life cycle thinking** in design and engineering projects, assessing trade-offs between material choices, product functions and waste management options;
- offer interdisciplinary courses and project studios on **circular plastics systems**, where students from technical, design, economics and social science backgrounds work together on real-world challenges;
- collaborate with industry and public authorities to provide internships, joint theses and living-lab projects related to circular value chains, waste valorisation, sustainable feedstocks and eco-design.

Networks such as the Global Universities Partnership on Environment for Sustainability (GUPES) and European higher education initiatives on ESD and GreenComp offer platforms for sharing curricula, teaching materials and case studies.

Central European universities can strengthen their contribution by:

- integrating plastics-specific circular economy content into existing green chemistry and environmental programmes;
- establishing joint degree or micro-credential programmes with partner institutions in the region;
- aligning learning outcomes with both GreenComp and industry-defined skills needs (for example, those identified under the Pact for Skills).

6.4. Tailored educational and research pillar for Green Chemistry and circular plastics in Central Europe

This section integrates the Educational Pillar into the wider strategy and translates it into an operational capacity-building framework for sustainable plastic management in Central Europe. It complements the previous discussion on higher education by showing how Green Chemistry education, research-based learning and professional upskilling can directly support circular plastic value chains, waste and by-product valorisation, sustainable resources and feedstocks, and sustainable product design. The focus is deliberately practical: education should not remain an abstract sustainability concept, but should equip learners, companies, and public authorities with the competences needed to redesign plastic systems in line with green chemistry, life-cycle thinking, and eco-design principles [42,47,52,53].

The tailored analysis compares four institutional models represented in the GreenChemForCE partnership and its wider Central European environment. These models are not ranked as “good” or “bad”; rather, they illustrate different starting points from which universities and training organisations can strengthen Green Chemistry education for plastics circularity.

6.4.1. Comparative institutional models and lessons

- Vienna model - dedicated Green Chemistry degree pathway. The joint English-language Master's Study Green Chemistry, established by TU Wien, BOKU University and the University of Vienna, represents the most structured model. Its curriculum is explicitly designed around sustainable products and processes, circular economy, closed-loop recycling, technology assessment and interdisciplinary learning across three universities [114]. This model is particularly relevant because it provides a formal route for teaching sustainable polymers, recyclable and biodegradable materials, renewable raw materials, carbon dioxide as a feedstock, process engineering and sustainability assessment. The related GreenChem TechHub doctoral initiative further strengthens the research-to-education pathway by linking green chemistry, biotechnology and sustainable chemical engineering with industry-oriented doctoral training [115].
- Ljubljana model - integrated curriculum and research-based education. At the University of Ljubljana, Faculty of Chemistry and Chemical Technology, sustainability-related topics are embedded within broader study programmes in chemistry, biochemistry, chemical engineering, technical safety and doctoral education [116]. This model demonstrates how Green Chemistry can be mainstreamed through existing curricula, research projects, thesis work, and industry collaboration, rather than solely through a dedicated degree. For circular plastics, such integration is well suited to topics such as polymer recycling, circular materials, biomass valorisation, process intensification, carbon dioxide utilisation and applied life cycle assessment.
- Budapest model - research-driven specialisation. At Eötvös Loránd University, Green Chemistry is currently more visible through specialised research and thesis-level engagement than through dedicated formal coursework. The ELTE Catalysis and Organic Synthesis Research Group illustrates this research-driven pathway through activities in catalytic reactions, photoredox catalysis, solid-supported catalysis, and organic synthesis [117]. The lesson is that strong research groups can serve as entry points for Green Chemistry education, even where a full curriculum is not yet

established, provided that thesis topics, laboratory projects, and short teaching modules are deliberately connected to plastics circularity and sustainable materials.

- Prague model - targeted capacity-building opportunity. At Charles University, plastic-related Green Chemistry is less systematically embedded in the formal curriculum and is mainly evident through broader research or outreach activities in organic chemistry, catalysis, and materials-related fields. The GreenChemForCE-supported green chemistry outreach event for high school students shows that institutional interest and communication capacity already exist [118]. Charles University can therefore serve as a useful pilot case for stepwise capacity building: mapping existing expertise, introducing one dedicated master-level course or module, and gradually connecting research projects with sustainable polymer systems and plastic circularity.

Together, these four models show that Green Chemistry education in Central Europe should be developed as a layered competence ecosystem. Some institutions can offer dedicated degree programmes; others can embed Green Chemistry into existing study programmes, research projects, thesis topics, continuous professional development and outreach activities. The strategic aim is not institutional uniformity, but functional alignment around shared learning outcomes, practical case studies and transferable tools.

6.4.2. Core competence domains for the educational pillar

The educational pillar should focus on five competence domains that are directly linked to sustainable plastic management:

- green chemistry foundations, including the prevention of waste, safer chemical design, resource efficiency, renewable feedstocks and benign-by-design thinking [47];
- sustainable polymers and materials, including recyclable and biodegradable polymers, recycled-content materials, additive selection and compatibility with safe circularity;
- plastic recycling, depolymerisation, upcycling and waste valorisation, with clear differentiation between prevention, reuse, mechanical recycling, chemical recycling and energy recovery;
- life cycle assessment, carbon footprinting and eco-design, enabling learners to evaluate trade-offs, avoid burden shifting and support credible environmental claims [52,53,113];
- industrial symbiosis, circular business models and cross-value-chain collaboration, so that technical knowledge is translated into feasible implementation pathways for companies, clusters and public authorities.

These competence domains should be aligned with European sustainability competence frameworks and skills initiatives. GreenComp provides a useful reference for systems thinking, critical thinking, collective action and acting for sustainability [42], while the Pact for Skills offers a practical European model for upskilling and reskilling partnerships that connect companies, education providers, public authorities, social partners and chambers of commerce [119].

6.4.3. Recommended implementation pathway

The Tailored Educational Pillar should be implemented through a phased and modular pathway that can be adapted to different institutional starting points across Central Europe.

- **Map existing expertise and teaching content**. Each participating institution should identify courses, laboratories, research groups, thesis topics, and industrial collaborations that already address polymer chemistry, materials science, recycling, catalysis, chemical engineering, life cycle assessment, or the circular economy. This mapping will reveal where Green Chemistry content is already present and where targeted additions are needed.
- **Create a common modular learning unit on "Green Chemistry for Circular Plastics"**. This unit should be usable in master programmes, doctoral schools, vocational education, company training and summer schools. It should combine short theory blocks with applied case studies on packaging, construction plastics, automotive, electrical and electronic equipment plastics, agricultural films and polymer-rich industrial residues.
- **Develop project-based and thesis-based learning portfolios.** Students should work on real problems from companies, municipalities, recyclers, and public authorities, such as redesigning a plastic product for recyclability, comparing recycling options using life cycle assessment, or assessing the feasibility of using recycled or bio-based polymers in a specific application.
- **Establish micro-credentials and continuous professional development modules for SMEs and authorities.** Short, practice-oriented formats should cover eco-design checklists, recyclability assessment, LCA basics, regulatory compliance, credible green claims, recycled-content procurement and industrial symbiosis facilitation.
- **Use Charles University as a stepwise capacity-building pilot.** Instead of immediately creating a full degree programme, the pilot can start with an expertise map, one master-level Green Chemistry course with a plastic circularity module, a set of thesis topics, and a small living-lab format linked to GreenChemForCE case studies.

- Create a shared educational repository. Teaching slides, case studies, exercises, simplified LCA templates, reading lists and examples from partner institutions should be stored in a common GreenChemForCE knowledge hub so that materials remain available beyond the project lifetime.

The pathway should be designed according to the principles of Education for Sustainable Development: learner-centred methods, real-world problem solving, interdisciplinary cooperation, and empowerment to act in professional and civic contexts [120]. This will ensure that the educational pillar supports not only knowledge acquisition, but also practical behavioural and organisational change.

6.4.4. Expected contribution to the strategy

Integrating the tailored educational pillar strengthens the overall strategy in three ways. First, it connects Pillar 3 more explicitly with the technical substance by translating circular plastics, waste valorisation, sustainable feedstocks and eco-design into teachable competence domains. Second, it creates a practical bridge between universities, vocational education providers, companies and public authorities, making education a direct enabler of implementation rather than a supporting activity at the margins. Third, it provides a realistic improvement pathway for institutions with different levels of readiness: advanced partners can lead through structured curricula and doctoral training, while less specialised institutions can start with modular courses, research projects, outreach and professional training.

For Central Europe, this approach is strategically important. The region already has strong industrial, academic, and technological assets in chemistry, plastics processing, materials science, and the circular economy. The key challenge is to connect these assets into a coherent competence system that prepares students, workers, managers and public officials to make better decisions throughout the plastic life cycle.

6.5. Continuous professional development for companies and authorities

Given the speed of regulatory change and technological innovation, one-off education is not enough. Continuous professional development (CPD) is essential for updating the skills of workers, managers and public officials throughout their careers. The Pact for Skills, launched under the European Skills Agenda, explicitly calls for large-scale partnerships to mobilise upskilling and reskilling efforts for the green and digital transitions, including in energy-intensive sectors such as chemicals and plastics [41,42].

6.5.1. Training on LCA, carbon footprinting and eco-design tools

LCA, carbon footprinting and eco-design are core analytical tools for sustainable plastic management and a recurring requirement in EU regulations, corporate reporting and funding instruments. Yet many companies and authorities in Central Europe still report a lack of internal capacity to apply these tools effectively.

Priority areas for CPD include:

- **Introductory courses** that familiarise participants with basic concepts (functional unit, system boundaries, allocation, impact categories), main standards (e.g. ISO 14040/44, ISO 14067) and typical applications in plastics (packaging choices, product redesign, recycled-content assessment).
- **Applied workshops** using real company or municipal data to build simple LCA or carbon footprint models for plastic products and services, linked to decision-making on eco-design, procurement or policy instruments [52,53].
- **Tool-specific training** on commercial or open-source software, databases and simplified screening tools, with a strong emphasis on data quality, interpretation and communication of results to non-specialists.
- **Integration with design and innovation processes**, ensuring that LCA and eco-design are used early in product development and not only for ex-post justification.

Table 10 provides an indicative training matrix for key audiences in Central Europe.

Table 10: Indicative training matrix for Central Europe.

Target audience	Training objective	Main content topics	Duration & format	Delivery & funding (indicative)
Industry operators (production, converters, recyclers, waste operators)	Improve operational performance and quality for circular plastics	Sorting quality; contamination prevention; safe handling; basic data capture/traceability; circularity indicators	1-2 days + on-site coaching	Delivery: VET providers, clusters, industry associations, technology suppliers. Funding: ESF+ / national upskilling; employer co-funding; Interreg pilots
Engineers + Designers (product, packaging, process)	Enable circular-by-design solutions across products and processes	Design-for-reuse/recycling; mono-material/component choices; LCA basics for design trade-offs; recyclability requirements; end-of-life information	2-5 days modular CPD / micro-credentials + design sprints	Delivery: universities; RTOs; design schools; clusters/living labs. Funding: Erasmus+; ESF+; regional innovation vouchers; company budgets
Managers + SMEs (operations, sustainability, procurement, quality; SME owners)	Turn circular goals into implementable business decisions	Circular procurement & supplier engagement; compliance planning; credible claims; KPIs/reporting; partnership building	1-2 day workshop + short online modules + mentoring	Delivery: chambers, clusters, business support agencies, and universities. Funding: national/regional SME schemes; ESF+; private co-funding
Public authorities + Inspectors (policy, waste planning, procurement; enforcement)	Strengthen governance and enforcement capacity	Waste hierarchy implementation; EPR basics; GPP; monitoring indicators; inspection methods & audit trails; shipment risks	2 days + practical case clinics / joint exercises	Delivery: public administration training; inspectorates; universities; EU networks. Funding: national budgets; Interreg/TA; targeted EU support
Teachers/Trainers (VET & HE)	Scale skills via updated curricula and practical training	Competence-based teaching; case-based learning; lab exercises; industry collaboration; teaching toolkits	2-3 days training-of-trainers + resource pack	Delivery: teacher training institutes, universities, and VET networks. Funding: Erasmus+; national education funds
NGOs + Citizens (civil society, communities, consumers)	Improve plastics literacy and behaviour for reuse and correct separation	Credible claims & greenwashing basics; reuse/refill habits; correct separation; community repair/reuse options; citizen engagement	Micro-learning + campaigns (ongoing) + community workshops	Delivery: municipalities, NGOs, schools, media/community partners. Funding: municipal budgets; EPR awareness funds; national/regional grants; private sponsorship

Footnotes (abbreviations): VET = Vocational Education and Training; HE = Higher Education; CPD = Continuing Professional Development; RTOs = Research and Technology Organisations; SMEs = Small and Medium-sized Enterprises; LCA = Life Cycle Assessment; KPIs = Key Performance Indicators; EPR = Extended Producer Responsibility; GPP = Green Public Procurement; ESF+ = European Social Fund Plus; TA = Technical Assistance (programme support resources); EU = European Union

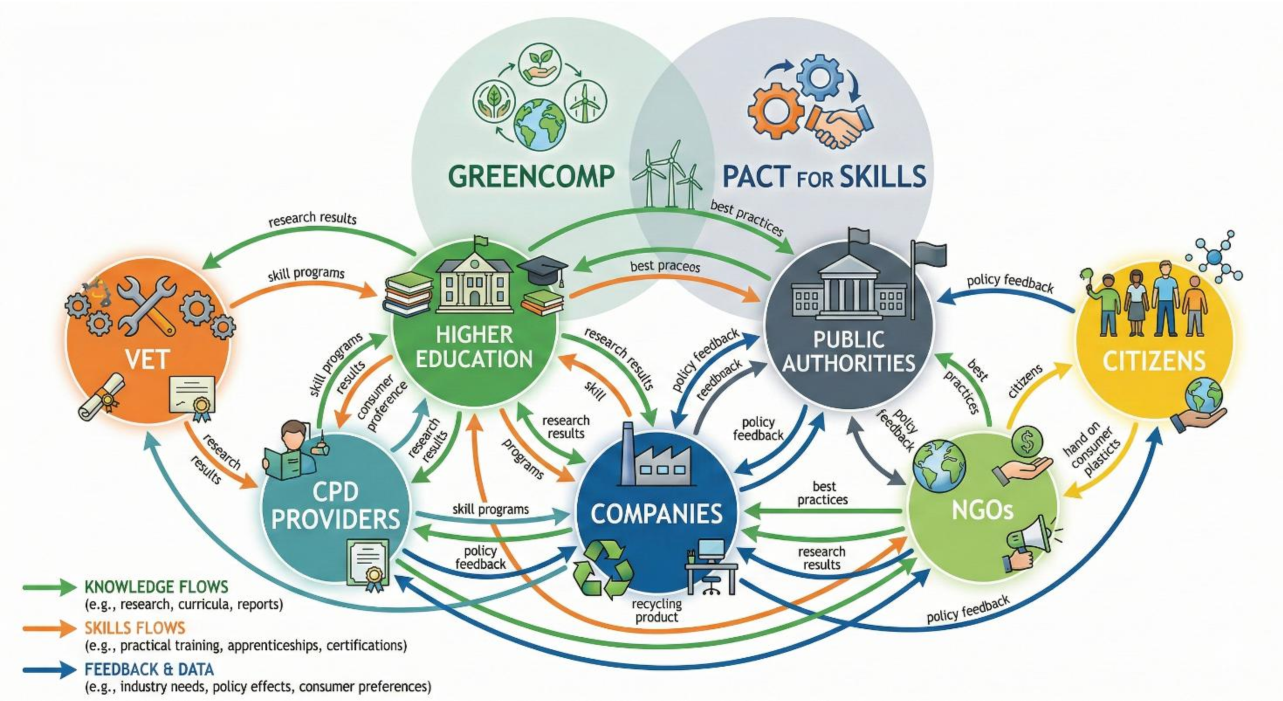

Figure 11: Competence ecosystem for sustainable plastics in Central Europe.

6.5.2. Skills for industrial symbiosis and value-chain collaboration

As discussed in Chapter 5, industrial symbiosis and cross-value-chain partnerships are central to waste and by-product valorisation, shared feedstock sourcing and joint eco-design. These collaborative processes require specific “soft” and “transversal” skills, which are often underestimated:

- **Systems thinking and problem framing**: seeing plastics not as isolated products, but as nodes in connected systems of materials, energy, regulation and behaviour. GreenComp and related OECD work highlight systems thinking as a core sustainability competence.
- **Facilitation, negotiation and conflict resolution**: managing diverse interests between companies, municipalities, NGOs and citizens when designing new collection schemes, reuse systems or siting recycling facilities.
- **Data-sharing and transparency skills**: understanding how to share sensitive information on material flows, quality and costs in ways that enable collaboration while protecting legitimate business interests.
- **Innovation and change management competences**: leading organisational change towards circular practices, including experimentation, learning from pilots and scaling successful solutions.

CPD programmes for industrial symbiosis and value-chain collaboration can be organised at the regional level, for example, through cluster organisations, innovation agencies, or Interreg partnerships. Blended learning formats that combine short online modules, peer-learning workshops and facilitated “symbiosis labs” are particularly suitable.

6.6. Public awareness and consumer behaviour

Consumers and citizens influence plastics value chains through purchasing choices, use patterns, sorting and return behaviour, and political support for ambitious policies. Education and awareness-raising are therefore essential complements to regulatory and technological measures [14].

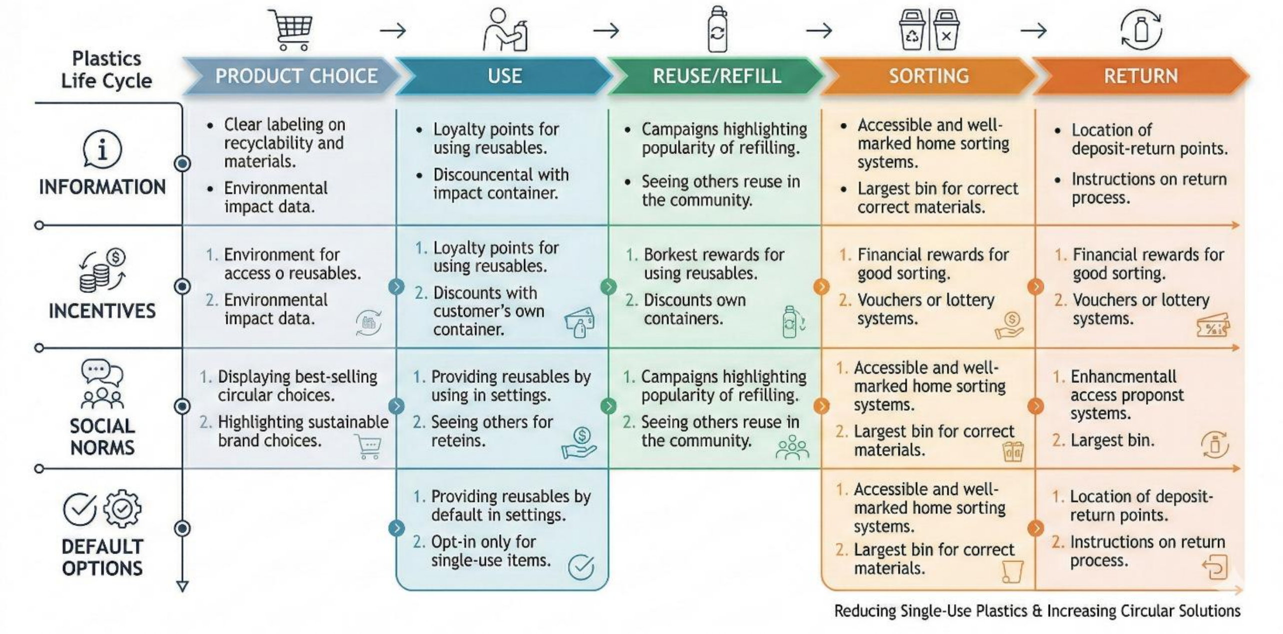

Figure 12: Behavioural levers along the plastics life cycle [11,14].

6.6.1. Reducing overuse of single-use plastics

Over the past decade, EU policy has taken important steps to curb single-use plastics (SUPs), notably through Directive (EU) 2019/904 on the reduction of the environmental impact of certain plastic products. Eurostat data show that consumption of lightweight plastic carrier bags in the EU fell from around 95 bags per person in 2018 to 67 in 2022 and 65 in 2023, but this is still above the 2025 target of fewer than 40 bags per person [4,5,11].

At the same time, total packaging waste and plastic packaging waste remain high, despite a recent slight decline. Eurobarometer and related studies indicate that a large majority of Europeans see environmental issues as having a direct impact on their lives and consider climate change and pollution serious problems, but there is often a gap between concern and everyday behaviour.

Educational and communication initiatives can help close this gap by:

- making the environmental and health impacts of single-use plastics visible and relatable (e.g. local litter, microplastics, marine pollution);
- explaining in simple terms how EU and national measures (SUP bans, EPR schemes, deposit-return systems) work and what citizens can do in practice;
- providing clear, harmonised guidance on sorting, reuse, and take-back schemes;
- promoting alternatives such as refill and reuse systems, durable products and service-based models.

Global initiatives such as UNEP's "Beat Plastic Pollution" campaign, the Tide Turners Plastic Challenge and UNESCO's Trash Hack education materials illustrate how youth-focused, action-oriented approaches can mobilise behavioural change around plastics. Central Europe can adapt these methods to local contexts, using schools, youth organisations and community groups as key multipliers.

6.6.2. Stimulating demand for circular and sustainable products

Behavioural change is not only about reducing single-use items; it also involves adopting and using circular, sustainable alternatives. Research on consumer preferences for recycled plastics reveals that most consumers who have used products made from recycled plastics are satisfied and willing to purchase them again; however, knowledge gaps and perceptions of quality and safety remain significant barriers. It was found that 93% of surveyed consumers of recycled plastic applications were satisfied with their purchases, suggesting substantial potential to increase demand if concerns are addressed [42,113].

More recent work on consumer acceptability of recycled packaging and products confirms that environmental concern, clear information, perceived quality, and trust in labels are critical drivers. At the same time, market surveys show that European consumers are increasingly attentive to packaging sustainability but still balance this against price and convenience.

To stimulate demand for circular and sustainable plastics, education and communication strategies should:

- Normalise circular products by showcasing high-quality examples with recycled content and well-designed reuse systems.

- Build trust with clear information on safety, performance and environmental benefits, and avoid confusing or unsupported claims.
- Use behavioural insights so the sustainable option is the easy default (e.g. reuse in canteens, refill stations in shops).
- Reward circular choices through incentives, loyalty schemes and feedback mechanisms that reinforce new habits.
- Engage citizens in co-creation so reuse and return systems fit real-world behaviour and local contexts.

Such measures link directly to the four technical themes: they can accelerate the uptake of circular business models, increase the availability and acceptance of waste-derived feedstocks, and shift demand towards eco-designed products.

6.7. Social innovation, inclusion and just transition

The transition to sustainable plastics in Central Europe will have social impacts: some jobs will change or disappear, new roles will emerge, and communities will be affected by changes in waste management infrastructure and industrial activities. Education and skills policies must therefore be aligned with principles of inclusion and just transition [41,42].

The European Year of Skills 2023 and related policy discussions stress that green and circular economy policies should create opportunities for all, including disadvantaged groups, and that vocational and adult learning systems must be accessible, affordable and tailored to diverse needs [6,7].

Social innovation initiatives – such as repair cafés, social enterprises that collect and upcycle plastics, community reuse schemes, or training programmes for vulnerable groups in recycling and eco-design – can deliver both environmental and social benefits. Position papers from social economy organisations highlight the potential of such initiatives to support circular economy goals while creating local employment and fostering social cohesion [6,7].

Key considerations for a just transition in the plastics sector include:

- ensuring that workers in conventional plastics production and waste management have access to reskilling and upskilling opportunities;
- involving trade unions and workers' representatives in regional skills partnerships and transition planning;

- designing ESD and CPD programmes that are inclusive in terms of gender, age, migration background and disability;
- supporting regions and communities facing structural change (e.g., decline of certain plastics production segments) with targeted training, entrepreneurship support, and social protection measures.

UNESCO's ESD Roadmap and related OECD work on sustainability competences emphasise that education should empower learners to understand the social dimensions of sustainability and to participate actively in shaping fair and inclusive transitions. For Central Europe, this means explicitly integrating just transition considerations into skills strategies for sustainable plastics.

6.8. Priority actions for education, skills and behavioural change

Based on the analysis above, Central European stakeholders can prioritise the following actions under Pillar 3. These actions are designed to support the other three pillars and operationalise the four technical themes (circular value chains, waste valorisation, sustainable resources and eco-design).

- Develop a Central European skills roadmap for circular plastics, linked to the four pillars and to regional labour-market needs.
- Embed circular plastics competences in vocational education and training (VET), including LCA, recycling technologies, eco-design and industrial symbiosis [50,51].
- Strengthen higher education and applied research on green chemistry and circular plastics through interdisciplinary courses and living labs.
- Scale continuous professional development (CPD) for companies and authorities on LCA, eco-design tools, circular business models and compliance, integrated with clusters and Interreg projects [15].
- Build collaboration competences (systems thinking, facilitation and negotiation) to support industrial symbiosis and value-chain partnerships.
- Run coordinated public awareness and behaviour-change campaigns, while ensuring inclusive access to training and just-transition support for affected groups.

If implemented coherently, these actions will ensure that Central Europe has the human capital, institutional capacity and public support needed to turn the vision of sustainable plastic management into reality. Pillar 3 thus provides the "social infrastructure" that underpins regulatory reforms (Pillar 1), regional partnerships (Pillar 2) and technological innovation and infrastructure (Pillar 4).

Chapter 7

7. Pillar 4: Technology, innovation and infrastructure

Pillar 4 focuses on the technologies, innovation ecosystems and physical infrastructure that make circular and sustainable plastic value chains technically and economically feasible in Central Europe. While regulation (Pillar 1), collaboration (Pillar 2) and skills and behaviour (Pillar 3) set the enabling conditions, it is ultimately the deployment of appropriate technologies and infrastructure that will determine whether plastic value chains can move from linear "make-use-dispose" models to circular systems based on waste valorisation, sustainable feedstocks and eco-designed products [41,42].

This chapter outlines key technology pathways for circular plastics, explores infrastructure needs, highlights innovation and funding mechanisms, and proposes strategic priorities for Central Europe. Throughout, it integrates the four technical themes: circular value chains, waste and by-product valorisation, sustainable resources and feedstocks, and sustainable product design / eco-design [14,18].

7.1. The role of technology and infrastructure in sustainable plastic management

The European Strategy for Plastics in a Circular Economy and the 2020 Circular Economy Action Plan explicitly emphasise innovation and modern infrastructure as core levers for increasing plastic recycling rates, reducing leakage and enabling high-quality secondary raw materials [6,7].

For Central Europe, the technological and infrastructural dimension of plastics circularity involves:

- **Collection and sorting systems** capable of delivering high-purity streams for mechanical recycling, chemical recycling and other recovery routes.
- **Recycling and valorisation technologies** (mechanical, thermochemical, chemical, biological) adapted to regional waste streams and industrial structures.
- **Production infrastructure** that can process recycled and alternative feedstocks (bio-based, CO_2-based) while maintaining product performance and safety.
- **Digital and data infrastructures** such as Digital Product Passports (DPPs), digital twins and traceability systems to support design-for-circularity, regulatory compliance and value-chain coordination [15].

The objective of Pillar 4 is not to promote one “silver bullet” technology, but to build a coherent and flexible portfolio that:

- prioritises prevention, reuse and high-quality recycling;
- recognises the complementary roles of mechanical and chemical recycling [10];
- supports the gradual substitution of fossil-based feedstocks where environmentally and socio-economically justified;
- embeds eco-design and life cycle thinking in technology development and deployment.

7.2. Technology pathways for circular plastic value chains

Recent reviews of plastic recycling technologies show rapid progress across mechanical, thermochemical, chemical and biological routes, but also stress that no single process can handle the diversity of plastic waste. A robust strategy for Central Europe, therefore, needs a combination of complementary pathways.

The transition to circular plastics in Central Europe requires a balanced portfolio of recycling and valorisation technologies, as different waste streams demand different technical solutions. Table 11 summarises the main technology families, their most suitable input streams, outputs, maturity levels and relevance for the region.

Table 11: Overview of key recycling and valorisation technologies for plastics.

Technology family	Best-fit input streams	Main outputs	TRL*	Key pros / key constraints	Relevance for Central Europe	Themes**
Mechanical recycling	Clean, well-sorted mono-material streams (e.g., PET bottles, HDPE/PP rigid; selected films)	Regranulate/pellets (secondary polymer)	8-9	Pros: mature, lowest energy, scalable now. Constraints: needs high-quality sorting; contamination lowers quality; limited for multilayers/complex products	High	CV, WV, SR, ED
Depolymerisation (to monomers)	Target polymers (mainly PET/PA/PMMA), pre-treated, can tolerate more than mechanical but not "mixed waste"	Monomers/oligomers → new resin	6-9	Pros: "virgin-like" quality for selected polymers. Constraints: economics/scale sensitive; chemical/energy inputs; wastewater/catalyst management	Medium-High	CV, WV, SR, ED
Pyrolysis (plastic-to-oil)	Mixed polyolefin-rich residuals; contaminated films (PVC/PET generally need control)	Oil/wax + gas/char (oil upgraded to feedstock)	6-8	Pros: uses streams hard to recycle mechanically. Constraints: upgrading needed; contaminants (chlorine/oxygenates); emissions control; needs stable offtake	Medium	CV, WV, SR
Gasification (to syngas)	Mixed residual plastics/RDF blends; difficult fractions	Syngas → chemicals/fuels or energy	6-9	Pros: feed flexible; can treat residual streams. Constraints: high CAPEX; complex gas cleaning; needs a large, stable supply and permits	Medium-Low	WV, SR, CV

Table 11: (Continued).

Technology family	Best-fit input streams	Main outputs	TRL *	Key pros / key constraints	Relevance for Central Europe	Themes **
Dissolution (solvent-based purification)	Selected polymers, some multilayers/composites where separation works	Purified polymer + separated residues	5-8	Pros: higher-quality polymer recovery from complex articles. Constraints: solvent management/safety; process specificity; cost/scale-up	Medium	ED, WV, SR, CV
Biological (enzymatic/microbial)	Narrow scope (mainly PET variants; some biopolymers case-by-case)	Monomers/intermediates	3-6	Pros: selective, potentially milder conditions. Constraints: early stage; slow/pretreatment needs; uncertain economics at scale	Low	SR, WV, ED

* **TRL** = Technology Readiness Level (indicative; depends on process and scale).

** Themes: **CV** circular value chains; **WV** waste & by-product valorisation; **SR** sustainable resources & feedstocks; **ED** eco-design.

While Table 11 The following Figure 13 provides a detailed comparison of technology options within a broader circular plastics system. It illustrates how mechanical, chemical and other valorisation routes can complement one another within an integrated regional technology portfolio.

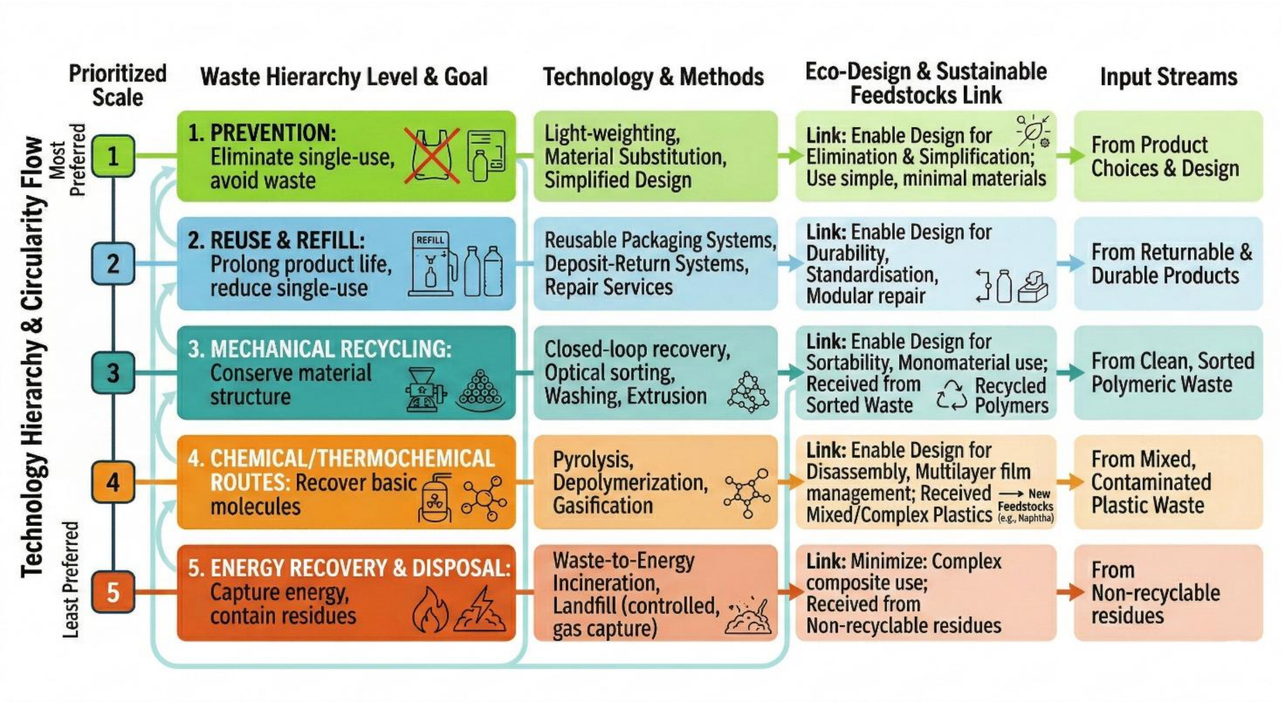

Figure 13: Technology portfolio for circular plastic value chains

7.2.1. Advanced collection and sorting

High-quality recycling and waste valorisation start with effective collection and sorting. Studies consistently show that improved sorting technologies for mechanical recycling yield some of the most significant environmental and economic benefits in plastic recycling systems [14].

Key technological directions include:

- **State-of-the-art sensor-based sorting** include Near-infrared (NIR), visible (VIS), X-ray fluorescence (XRF) and increasingly mid-infrared (MIR) and hyperspectral imaging for polymer type and colour identification. AI-enhanced robotic sorting systems that improve accuracy and adapt to changing waste compositions.
- Digital watermarking and tracer-based sorting: Digital watermarks (e.g. HolyGrail 2.0) embed imperceptible codes into packaging artwork, enabling much more granular sorting (by polymer, application, food vs. non-food, brand owner, etc.) when combined with imaging and NIR detection. Industrial trials in 2024 confirmed the technical feasibility of flexible packaging [14]. Tracer-based sorting uses fluorescent markers detectable by dedicated sensors to separate specific product categories or quality grades, potentially bypassing some traditional sorting steps.
- Integrated collection-sorting systems: Modern material recovery facilities (MRFs) that combine optical sorting, density separation and manual quality control with data

collection on composition and contamination. Integration with deposit-return schemes, separate collection of specific streams (e.g. PET, HDPE, films) and digital tracking systems.

For Central Europe, upgrading collection and sorting infrastructure is a prerequisite for all four technical themes: it provides clean feedstock for mechanical and chemical recycling, stabilises supply for recycled polymers and alternative materials, and creates the conditions for eco-design to translate into real circular outcomes [18,121].

7.2.2. Mechanical recycling and upgrading technologies

Mechanical recycling remains the backbone of plastic circularity due to its relatively low energy use and mature industrial base, especially for PET, HDPE and PP packaging. However, its performance depends heavily on feedstock quality and contamination levels.

Priority directions include:

- **High-efficiency washing, decontamination and filtration** to remove labels, organics, fillers and additives, enabling food-contact applications where authorised and maintaining material performance.
- **Solid-state polycondensation and other upgrading technologies** for PET and polyamides to restore intrinsic viscosity and mechanical properties, allowing recycled content in demanding applications such as bottles and fibres.
- **Compounding and reactive extrusion** to tailor material properties, incorporate compatibilisers for mixed streams and integrate additives that enhance recyclability and durability (while respecting chemical safety).

Mechanical recycling is particularly well suited to:

- relatively clean, mono-material flows (e.g. PET bottles, HDPE containers);
- in-house and post-industrial scrap;
- closed-loop systems where traceability and quality control are easier, such as bottle-to-bottle, tray-to-tray or crate-to-crate loops.

Building modern, well-connected mechanical recycling capacity in Central Europe is therefore a central element of the strategy, especially when coupled with eco-design measures that favour mono-material structures and design for recycling.

7.2.3. Chemical and thermochemical recycling

Chemical and thermochemical recycling technologies can complement mechanical recycling by treating mixed, contaminated, or multi-layer plastics that cannot be mechanically recycled.

Key technology families include:

- **Depolymerisation processes** (e.g., glycolysis, methanolysis, hydrolysis) that break polymers such as PET and polyamides back into monomers or oligomers, which can then be repolymerised into virgin-quality materials. PET depolymerisation is a particular focus of EU Innovation Fund and Horizon Europe projects, which aim to close the loop for food-contact and textile applications.
- **Thermochemical routes** such as pyrolysis and gasification, which convert mixed polyolefin streams into oils or syngas used as feedstock in steam crackers and refineries. Recent LCA studies suggest that pyrolysis can have significantly lower climate impacts than incineration with energy recovery, though performance depends strongly on plant design, energy mix and product allocation.
- **Solvent-based purification and dissolution technologies**, which selectively dissolve target polymers and remove contaminants to produce high-quality recyclate, particularly for complex multi-layer structures and textiles.
- **Emerging biological recycling routes** using enzymes or microorganisms to depolymerise specific plastics (notably PET), currently at early TRL but potentially attractive for mild conditions and selective depolymerisation.

There is, however, an active debate about the environmental performance, system boundaries and appropriate policy treatment of chemical recycling. Independent reviews and NGO reports highlight inconsistencies in some LCAs, as well as concerns over energy demand, emissions, and the risk of locking in incineration-like infrastructure [18,121].

For Central Europe, the strategic message is:

- Chemical and thermochemical recycling **should be developed as part of an integrated portfolio**, targeted at streams that cannot realistically be handled by prevention, reuse, or high-quality mechanical recycling.
- Investments must be **conditional on robust, transparent LCAs** and alignment with climate and resource-efficiency goals.
- Public funding should prioritise technologies that **enable true material circularity** (e.g., depolymerisation to monomers, high-quality feedstock for polymers) rather than fuel production that competes with direct fossil fuel phase-out.

7.2.4. Digitalisation, traceability and product data

Digitalisation is increasingly recognised as a key enabler for circular plastics. The EU's circular economy and ecodesign policies foresee the introduction of **Digital Product Passports (DPPs)** to provide structured information on product composition, origin, repairability, environmental footprint, and end-of-life options.

For plastics and plastic-containing products, DPPs and related tools can:

- support **eco-design** by making material choices and additives visible across the value chain;
- enable more accurate **sorting and recycling** by linking physical products (via QR codes, RFID tags or digital watermarks) with databases describing their composition;
- improve **regulatory compliance** with recycled-content, hazardous-substance, and extended producer responsibility (EPR) requirements;
- facilitate **industrial symbiosis** by providing reliable data on available secondary raw materials.

Pilot initiatives such as R-Cycle, HolyGrail 2.0 and industrial DPP demonstrations show that combining digital IDs with advanced sorting and recycling can significantly improve the quantity and quality of recyclates.

For Central Europe, investing in shared digital infrastructures and interoperability standards - rather than multiple incompatible proprietary platforms - is essential to avoid fragmentation and maximise benefits across borders.

7.3. Waste and by-product valorisation technologies

Waste and by-product valorisation links directly to industrial symbiosis (Chapter 5) but has a distinct technological focus in Pillar 4. It concerns the conversion of plastic waste and production residues into secondary polymers, chemicals or other high-value products, rather than low-value energy recovery.

Technological directions include:

- **Integrated plastic recycling clusters** that combine advanced sorting, mechanical recycling, chemical recycling and compounding on one site, allowing flexible routing of different waste streams to the most appropriate technology [18,121].
- **Nylon and engineering plastics regeneration** via depolymerisation and repolymerisation, as illustrated by Aquafil's ECONYL® process in Ljubljana and Arco,

which uses nylon 6 waste from carpets, textiles and fishing nets to produce recycled polymer chips and yarn with substantially reduced fossil resource use [15].

- **On-site recycling and digital twinning**, demonstrated in projects such as INCIRCULAR, where recycled plastics are processed into high-quality bioplastics directly at the Gorenje industrial site in Slovenia, supported by digital twins and advanced process control.
- **Upcycling to higher-value products**, for example, converting mixed plastic streams into speciality chemicals, construction materials or functional composites, as explored in several Horizon Europe projects and reviewed in recent literature[15].

Effective valorisation technologies must be integrated with robust environmental assessment (LCA) and economic analysis to avoid lock-in to sub-optimal solutions. Recent systematic reviews emphasise the need to evaluate recycling and valorisation routes simultaneously against environmental, economic and social criteria.

7.4. Technologies for sustainable resources and feedstocks

The move away from fossil-based, linear plastics requires not only better end-of-life systems, but also a transformation of upstream resource choices. The EU plastics strategy and CEAP highlight three complementary directions: increased use of **recycled plastics**, targeted deployment of **bio-based and biodegradable plastics**, and development of **alternative feedstocks** such as CO_2-derived monomers.

From a technological and infrastructural perspective, Central Europe should prioritise:

- High-quality recycled polymers as the main alternative feedstocks, supported by investment in processes that produce stable, specification-grade recyclates such as rPET, rHDPE, rPP and regenerated PA6 for demanding applications [15].
- Strong testing and certification infrastructure to verify mechanical performance, contaminant levels and food-contact safety, thereby increasing market confidence in recycled materials.
- Careful use of additives and stabilisers, ensuring they improve material performance without reducing recyclability or safety.
- Selective use of bio-based and biodegradable plastics only where they provide clear life-cycle benefits and do not create additional sorting or contamination problems.
- Research and innovation on advanced bio-based polymers that are compatible with existing recycling systems or with well-managed composting and digestion infrastructure.

- Development of CO_2-based polymers in line with GreenChemForCE's CO_2 management work in WP2, recognising that these materials only provide real benefits when produced with low-carbon energy and designed for circularity.
- Pilot investments supported by robust Life Cycle Assessment and techno-economic assessment to ensure that environmental burdens are genuinely reduced rather than shifted elsewhere.

A critical cross-cutting requirement is to align investments in new feedstock technologies with eco-design and regulatory frameworks to avoid the proliferation of materials that are challenging to sort, recycle, or communicate to consumers.

7.5. Technology for sustainable product design and eco-design

Eco-design and life cycle thinking are not only design practices; they increasingly rely on digital tools, testing infrastructure and data systems. Under Pillar 4, the focus is on technologies that enable designers, engineers, and companies to make informed, circular design decisions and turn them into production.

Key elements include:

- Integrated Life Cycle Assessment, eco-design and carbon footprint tools for early-stage product development and comparison of material, design and end-of-life options.
- Digital twins and simulation tools to optimise production, recycling and sorting systems before physical investment.
- Practical design guidelines and approved material libraries that support recyclability, reuse and compatibility with existing infrastructure.
- Regulatory support tools that check compliance, feed data into Digital Product Passports and enable standardised information exchange across the value chain.

7.6. Infrastructure and investment needs in Central Europe

Analyses of plastic recycling policy mixes and investment landscapes underline that achieving EU targets for plastic packaging recycling (e.g. 60% or more) will require substantial infrastructure upgrades and new facilities across collection, sorting, recycling and digital systems [14].

For Central Europe, key infrastructure needs include:

- Integration of Life Cycle Assessment, eco-design and carbon footprint tools into product development, allowing alternative materials, designs and end-of-life options to be assessed early in the design process.
- Linking environmental assessment with performance simulations, such as mechanical, barrier and thermal analysis, to identify solutions that balance functionality, circularity and environmental performance.
- Use of digital twins and simulation environments to test how recycled materials, design changes and process parameters affect product quality, scrap rates and energy use.
- Virtual commissioning and optimisation of sorting and recycling systems before physical investments are made, reducing risk and improving planning.
- Digitised design guidelines for recyclability and reuse, aligned with European Union requirements and industry platforms for circular product and packaging design.
- Material and component libraries with approved combinations that are compatible with existing or planned recycling infrastructure.
- Tools that automatically check compliance with eco-design criteria, recycled-content rules and labelling requirements, while also supporting integration into Digital Product Passports.
- Standardised data formats for sharing design and material information across the value chain, including manufacturers, converters, recyclers and public authorities.

Planning such infrastructure requires coordinated regional and national strategies. GreenChemForCE's transnational approach, combined with other Interreg and Horizon Europe projects (e.g. INCIRCULAR, Plastics Circularity Multiplier projects), provides a useful platform for joint road-mapping and pilot implementation [14,18].

The successful deployment of circular plastics technologies depends on a supportive infrastructure base across collection, sorting, recycling, quality control and data management. Table 12 outlines the main infrastructure areas, current gaps and priority actions needed to strengthen circular plastics systems in Central Europe.

Table 12: Infrastructure needs for circular plastics in Central Europe.

Infrastructure area	Status & key gaps (qualitative)	Priority focus (countries/regions)	Short-medium term actions + likely funding
Collection systems (separate collection, reuse/refill logistics) [58,122]	Mixed/uneven. Gaps: insufficient coverage and convenience; weak capture of films/flexibles; limited reuse/refill logistics; inconsistent data and contamination levels.	Metro areas + tourism corridors; cross-border catchments (Danube, Adriatic); countries with lower capture rates and high reliance on landfill/incineration.	Harmonise collection specs; expand separate collection for plastics; deploy reuse/refill pilots; fund local infrastructure upgrades. Funding: ERDF/Cohesion, RRF, national, EPR fees.
Sorting capacity (material recovery facilities, polymer-specific sorting, quality control) [57,59,123]	Bottleneck in many regions. Gaps: limited advanced sorting for films/complex packaging; insufficient quality assurance; weak separation of problem materials (PVC, multilayers, additives).	Industrial/logistics hubs (AT-CZ-PL-SK-HU-SI); cross-border feeder regions where waste flows depend on shipments.	Upgrade sorting lines (optical/NIR, film sorting, QC); establish “quality grades” for recyclate feed; and coordinate cross-border specifications. Funding: ERDF/Cohesion, private co-investment (offtake contracts), InvestEU/EIB-type finance (where used).
Mechanical recycling plants [57,67]	Core backbone, but stressed. Gaps: limited high-quality recycling of flexibles; inconsistent feedstock quality; need for decontamination and stabilisation to meet recycled-content market requirements.	Regions with strong plastics conversion + packaging demand; areas close to major sorting nodes to secure feedstock quality.	Expand capacity for PET/HDPE/PP and targeted films; invest in washing/de-inking/deodorisation; tighten contracts between sorters and recyclers. Funding: private + ERDF/Cohesion, national green industry schemes; demand pull via compliance.
Chemical recycling (depolymerisation; thermochemical routes for residuals) [67,68]	Selective / emerging. Gaps: limited CE-scale deployment; high CAPEX and permitting complexity; uncertain net benefits without robust assessment; needs stable offtake and strict input control.	Only where: (i) residual mixed streams exist at scale, (ii) strong industrial offtake (refinery/chemical clusters), (iii) strict control of contaminants.	Prioritise depolymerisation for targeted polymers and thermochemical routes only for residuals; require transparent mass-balance and environmental performance checks; develop regional “hub” projects. Funding: private + innovation support (Horizon Europe for pilots), national schemes, blended finance.
Testing & compliance labs (recyclate quality, substances of concern, trace contaminants) [57,123]	Under-supplied in many areas. Gaps: insufficient capacity for routine testing; limited methods for legacy additives/contaminants; weak interoperability of test protocols.	Countries are building recycled-content supply chains and upgrading sorting/recycling; cross-border trade routes require comparable QA.	Create/expand accredited labs; harmonise protocols; support SME access; link lab results to data systems for traceability. Funding: national/regional innovation funds; ERDF, private (industry associations).

Table 12: (continued).

Infrastructure area	Status & key gaps (qualitative)	Priority focus (countries/regions)	Short-medium term actions + likely funding
Digital infrastructure (traceability, data exchange, product information) [104]	Fragmented. Gaps: inconsistent material/packaging data; low interoperability; weak link between product design info and end-of-life operators.	Cross-border supply chains; regions with strong manufacturing + waste management interfaces.	Build interoperable data standards; implement traceability platforms; prepare for Digital Product Passports and harmonised reporting. Funding: EU digital/innovation streams, national digitalisation budgets, private platforms.

Footnotes:

Qualitative status scale: High = broadly adequate and scalable; Mixed = uneven performance with clear gaps; Bottleneck = systemic constraint; Emerging = early-stage/limited deployment.

Abbreviations:

ERDF = European Regional Development Fund; RRF = Recovery and Resilience Facility; EPR = Extended Producer Responsibility; CAPEX = Capital expenditure

Note on chemical recycling: The table reflects the strategy logic you used earlier: chemical routes are not a replacement for mechanical recycling, and should be prioritised only for residual streams where better options are not viable and where performance is demonstrably robust [67,68].

7.7. Innovation ecosystems and funding mechanisms

The EU has made plastics circularity a priority for research and innovation, with significant funding available through **Horizon Europe**, the **Innovation Fund**, **LIFE**, cohesion funds and Interreg programmes.

Key elements of the innovation landscape relevant to Central Europe include:

- Horizon Europe and related research programmes supporting circular plastics, advanced recycling, circular packaging and digitalisation [14,18].
- European project networks and training initiatives that help spread knowledge, strengthen skills and accelerate uptake across the plastics value chain.
- The Innovation Fund and national support schemes for large-scale demonstration projects in chemical recycling, depolymerisation and advanced sorting, although access remains difficult for many small and medium-sized enterprises [18,121].
- Interreg and regional programmes, including GreenChemForCE, INCIRCULAR and PLASTICE, which support pilot actions, joint solutions and digital tools for circular plastics in Central Europe.

To fully benefit from these instruments, Central European stakeholders need:

- **coordinated innovation agendas** that link regional needs with EU funding priorities;

- **support structures** (innovation agencies, cluster organisations, chambers of commerce) to help SMEs prepare proposals and manage projects;
- **mechanisms to scale successful pilots**, including public-private partnerships, green procurement and supportive regulation.

7.8. Strategic priorities for technology, innovation and infrastructure

Based on the analysis above, Central Europe can define the following priorities under Pillar 4:

- Build a regional network of advanced sorting and mechanical recycling hubs to supply stable, high-quality secondary materials.
- Develop targeted chemical and thermochemical recycling for streams that are difficult to recycle mechanically, with public support tied to transparent environmental performance and climate alignment.
- Strengthen regional leadership in recycled polymers and regenerated nylon by building on existing capacities and linking recyclates with local manufacturing.
- Invest in digital infrastructure for Digital Product Passports, traceability and eco-design, supported by shared platforms, data standards and links to Life Cycle Assessment and sorting systems.
- Create regional testbeds and living labs that combine pilot plants, demonstration sites, industrial symbiosis and stakeholder involvement.
- Align all technology deployment with eco-design requirements, European Union regulation and just transition principles, including support for skills development and workforce adaptation.

In addition to physical infrastructure, circular plastics require strong digital support systems that connect product design, material tracking, compliance and end-of-life management. Figure 14 shows how digital and physical infrastructures must work together to enable efficient and traceable circular plastics value chains [14,18].

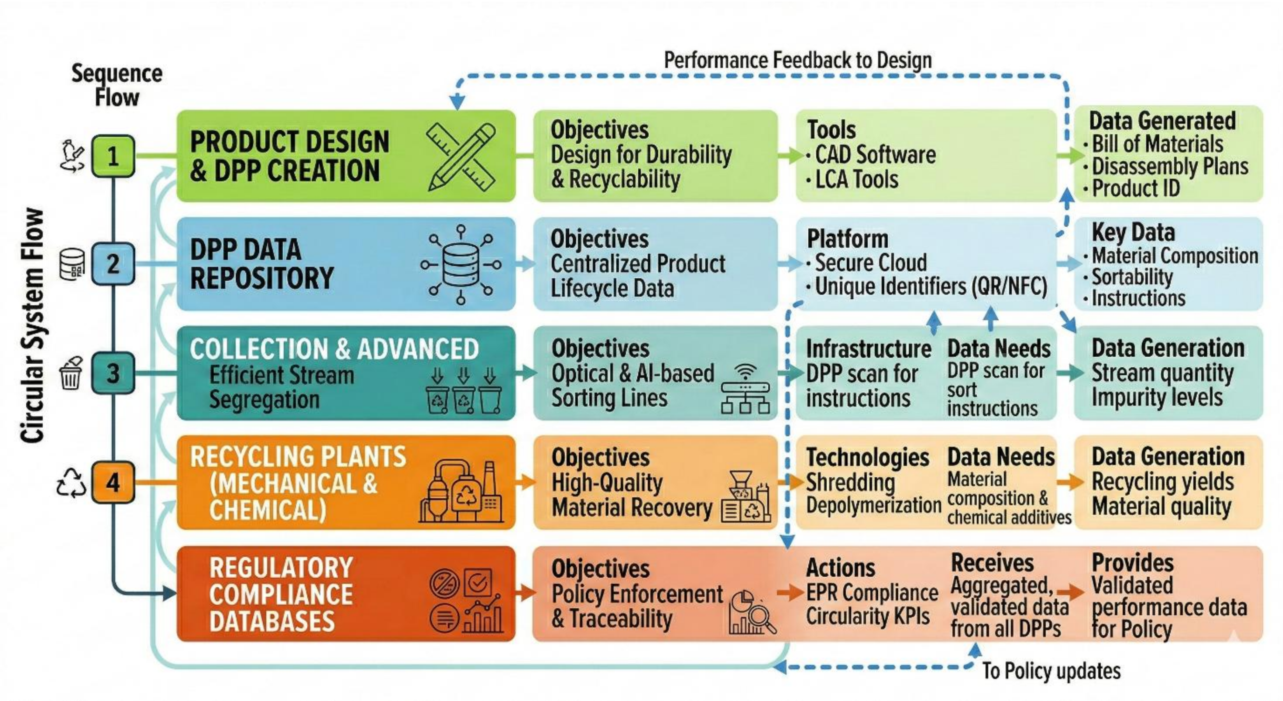

Figure 14: Digital and physical infrastructures supporting circular plastics [14].

If implemented coherently, these priorities will allow Central Europe to turn technological innovation into tangible progress on circular value chains, waste and by-product valorisation, sustainable feedstocks and eco-designed products. Pillar 4 thus provides the practical, physical and digital backbone of the strategy, enabling the ambitions of the other three pillars to be realised on the ground [14,18].

Chapter 8

8. Cross-cutting strategic priorities and synergies for Central Europe

The four pillars of this strategy – regulation and governance, regional collaboration, education and skills, and technology and infrastructure – are deeply interdependent. Likewise, the four technical themes – circular value chains, waste and by-product valorisation, sustainable resources and feedstocks, and sustainable product design / eco-design – cannot be advanced in isolation [41,42].

This chapter brings these strands together. It identifies cross-cutting priorities that should guide implementation across Central Europe, highlights key value chains where combined efforts can deliver the largest benefits, and shows how the strategy aligns with broader European Green Deal objectives on climate neutrality, zero pollution and the circular economy.

To visualise this integration, Figure 15 illustrates how the strategic pillars, technical themes, and priority value chains reinforce one another to drive systemic change.

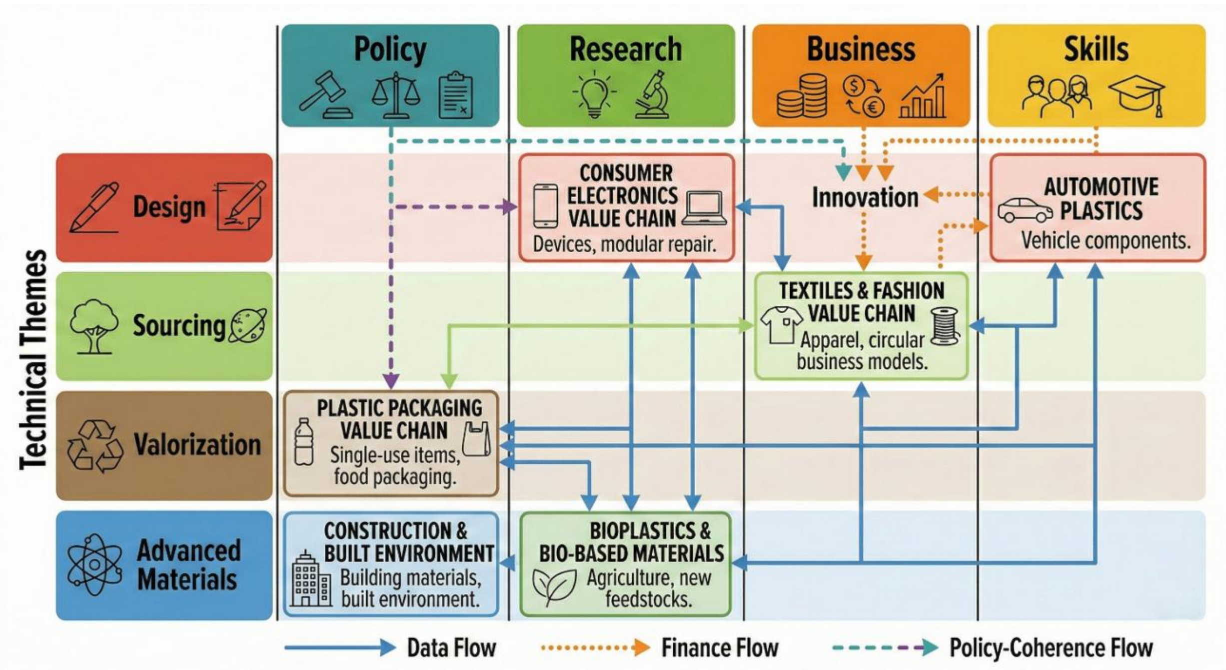

Figure 15: Integrated framework linking pillars, technical themes and value chains.

8.1. Why cross-cutting priorities are needed

European and international assessments of plastics and the circular economy converge on three messages that are particularly relevant for Central Europe. First, plastics are embedded in multiple high-impact value chains—such as packaging, construction, vehicles, electronics, textiles, and agriculture—which interact directly with climate, biodiversity, and pollution objectives [13,124]. Second, progress depends on comprehensive policy mixes and systemic action rather than single instruments or isolated projects. Achieving true circularity requires the careful alignment of recycling targets, eco-design rules, economic incentives, skills programmes, and infrastructure investments. Finally, the circular plastics transition is a core component of the European Green Deal, directly contributing to climate neutrality, the zero-pollution ambition, and a more competitive, resource-efficient economy.

In practical terms, implementing the four pillars and technical themes should be guided by cross-cutting priorities that focus efforts on priority value chains, mobilise horizontal enablers across sectors, ensure policy coherence, and address legacy pollution risks in an integrated manner.

8.2. Priority value chains and applications in Central Europe

The EU Circular Economy Action Plan identifies several product value chains where circularity measures can deliver the highest environmental and economic benefits [6,7]. For Central Europe, four specific application areas should be treated as strategic priorities for sustainable plastic management.

The most critical area is packaging and fast-moving consumer goods (FMCG). This sector represents the major share of plastic use and waste generation in the region and is central to EU measures such as the Packaging and Packaging Waste Regulation (PPWR) and the Single-Use Plastics Directive [11,80]. Its high public visibility and rapid innovation cycles offer strong leverage for implementing eco-design, recycled content, reuse systems, and improved collection. Construction and buildings also present a major opportunity. Large volumes of long-lived plastics (such as insulation, pipes, and window profiles) are heavily linked to energy efficiency targets. This sector requires active design for disassembly, material passports, selective demolition, and high-quality recycling to manage the incoming wave of construction waste.

Additionally, the automotive, transport, and electrical & electronic equipment (EEE) sectors rely on high-performance plastics and composites that are critical for lightweighting but challenging to recycle due to their complex, multi-material structures. Strong innovation dynamics here are driven by EU policies on vehicles and global supply-chain requirements. Finally, agriculture, food systems, and healthcare utilise plastics in mulching films, irrigation, and medical products. These applications raise specific concerns about microplastics in soils and contamination of organic fertilisers, highlighting a strong potential for targeted reduction and better integration with regional bioeconomy strategies.

Table 13 summarises how the four technical themes intersect with each of these priority value chains, demonstrating where specific circular interventions should be targeted.

Table 13: Priority plastic value chains in Central Europe and their relevance for the four technical themes

Value chain	Role & main impacts (very short)	Priority levers by technical theme*
Packaging / FMCG [125] [57,58,123]	Mostly short-lived plastics; high waste generation; litter leakage risk; climate impacts from virgin production and end-of-life treatment.	CV: prevention + reuse/refill; higher capture. WV: high-quality mechanical recycling (PET/HDPE/PP); film sorting/recycling upgrades. SR: recycled content; limited certified bio-based where system-fit. ED: mono-material where feasible; remove problematic additives; clear labelling/info.
Construction & buildings [68,123,125]	Long-life stock (pipes, insulation, membranes); future “waste wave”; legacy additives can constrain safe recycling; demolition contamination.	CV: design for disassembly + take-back; reuse in renovation. WV: source-separated demolition plastics; PVC/PE recycling; selective routes for composites where justified. SR: recycled polymers in non-critical applications; secondary materials in products. ED: modular components; material passports; avoid substances that block recycling.
Automotive + EEE* [67,68,125]	Engineering plastics and complex assemblies; safety/chemical constraints; end-of-life shredding produces mixed residues.	CV: dismantling + parts reuse; closed-loop streams (e.g., PP/PA where feasible). WV: targeted polymer streams; manage shredder residues; selective chemical routes for specific polymers. SR: recycled content in non-critical parts; qualified alternative feedstocks where performance fit. ED: standardise polymers; easy-to-remove parts; identification/traceability.
Agriculture & food [68,123,125]	Films and irrigation plastics; diffuse losses to soil/water; high contamination (soil/biomass); food-contact constraints for some uses.	CV: prevention; durable/reusable solutions; collection schemes. WV: mechanical recycling for clean films; controlled conversion routes for contaminated residuals (case-by-case). SR: recycled film grades where feasible; compostable/bio-based only where collection/treatment exists. ED: design for retrieval/cleaning; avoid additives that hinder recycling; clear instructions for farmers/users.

* Technical themes: CV = circular value chains; WV = waste & by-product valorisation; SR = sustainable resources & feedstocks; ED = eco-design.

** EEE = Electrical and Electronic Equipment.

Note (scope): All entries are qualitative and intended to guide prioritisation; final selection should reflect national baselines, market structure, and infrastructure maturity.

8.3. Horizontal enablers and cross-cutting levers

Several horizontal levers cut across all sectors and pillars. If developed coherently, these enablers will drastically increase the overall effectiveness of the strategy. Table 14 provides a comprehensive overview of these cross-cutting enablers, detailing their specific contributions to the four strategic pillars and technical themes, along with the indicative lead institutions responsible for their advancement.

Table 14: Cross-cutting enablers and their contributions to the pillars and technical themes.

Cross-cutting enabler	Contribution (Pillars + themes)*	Indicative lead institutions
Data and monitoring [42,68,123]	Pillars: P1-S (targets/reporting), P2-M (shared metrics), P3-M (literacy), P4-S (digital systems). Themes: CV-S, WV-S, SR-M, ED-M.	National environment ministries; statistical offices; waste agencies; producer responsibility organisations (PROs); universities/EEA-type knowledge bodies
Finance and investment [126-128]	Pillars: P1-M (incentives), P2-M (risk-sharing/offtake), P3-I, P4-S (infrastructure). Themes: CV-M, WV-S, SR-M, ED-M.	Cohesion policy managing authorities; national development banks; EIB; clusters; private investors/industry
Policy coherence [67,68]	Pillars: P1-S (alignment of rules), P2-M (cross-border consistency), P3-M (clear signals), P4-M (standards/data). Themes: CV-S, WV-S, SR-S, ED-S.	Environment + industry ministries; regulators; national circular economy councils; standardisation bodies
Risk and resilience [68,124]	Pillars: P1-M (risk rules), P2-M (cross-border contingency), P3-I, P4-M (redundant capacity). Themes: CV-M, WV-M, SR-S (secure secondary supply), ED-M.	National risk/civil protection authorities; customs/waste shipment authorities; regional governments; major operators
Territorial cohesion [68,126]	Pillars: P1-M, P2-S (regional cooperation), P3-M, P4-S (balanced infrastructure). Themes: CV-M, WV-S, SR-M, ED-M.	Regions/municipalities; cohesion policy managing authorities; cross-border structures; clusters/chambers
Just transition [128,129]	Pillars: P1-M, P2-M, P3-S (skills & jobs), P4-M. Themes: CV-M, WV-M, SR-M, ED-M (enables uptake via skills/jobs).	Just Transition Fund (JTF) managing authorities; social partners; employment agencies; VET providers; municipalities
Collaboration and learning [42,85]	Pillars: P1-I, P2-S, P3-S, P4-M. Themes: CV-S, WV-M, SR-M, ED-S.	Clusters; chambers; universities; VET providers; NGOs; industry platforms (e.g., CPA)

Footnotes

* **Rating scale: S** = strong contribution; **M** = moderate; **I** = indirect.

Pillars: P1 regulation & governance; **P2** collaboration & partnerships; **P3** education/skills & behaviour; **P4** technology/innovation & infrastructure.

Themes: CV circular value chains; **WV** waste & by-product valorisation; **SR** sustainable resources & feedstocks; **ED** eco-design.

Abbreviations: EEA = European Environment Agency; **EIB** = European Investment Bank; **JTF** = Just Transition Fund; **JTM** = Just Transition Mechanism; **PROs** = Producer Responsibility Organisations; **VET** = Vocational Education and Training.

8.3.1. Data, monitoring and indicators

Robust data is essential for understanding where plastics are used, how they move through the economy, and the impacts they generate. The European Environment Agency (EEA) and Plastics Europe stress that fragmented and inconsistent datasets remain a major barrier to evidence-based policymaking and investment [124]. Central Europe requires a coordinated approach to material flow analysis (MFA), establishing harmonised and periodically updated MFAs at the regional and national levels that disaggregate data by priority value chains. Tracking must also rely on robust circularity indicators—such as reuse rates, recycled content, environmental leakage, and climate impacts—that align seamlessly with EU monitoring frameworks [14]. Furthermore, the progressive rollout of Digital Product Passports and interoperable data standards will be critical for sharing product composition and end-of-life options safely across the value chain.

8.3.2. Finance and investment

Closing the plastics loop requires substantial, long-term investment in collection, sorting, recycling, eco-design, and digital systems. The European Investment Bank emphasises that these needs are particularly acute in regions where infrastructure remains underdeveloped [14]. Public finance must be firmly aligned with circular plastics objectives, utilising EU cohesion funds, InvestEU, and the Just Transition Mechanism to finance high-priority infrastructure while avoiding support for sub-optimal solutions like mixed-waste incineration. Simultaneously, private capital must be mobilised by de-risking investments in innovative recycling through blended finance and green bonds. Developing strong project pipelines is equally crucial, ensuring that municipalities and SMEs receive the support they need to prepare bankable, technically feasible circular projects.

8.3.3. Policy coherence and integration

The interface between plastics, chemicals, products, and waste legislation is highly complex. The Chemicals Strategy for Sustainability and the updated Circular Economy Action Plan explicitly call for coherent frameworks that avoid “regrettable substitutions” and ensure that circularity does not harm human health or biodiversity [6,7]. For Central Europe, this implies systematically integrating plastics into national climate plans, zero-pollution strategies, and regional bioeconomy agendas. Strengthening mechanisms for joint impact assessments will bridge chemicals, product, and waste policies, using digital tools to operationalise the “safe and sustainable by design” concept. Coherence also requires consistent implementation of EU rules across all Central European countries while still allowing for regional innovation.

Figure 16 illustrates how successful plastic strategies interface directly with these broader European environmental goals.

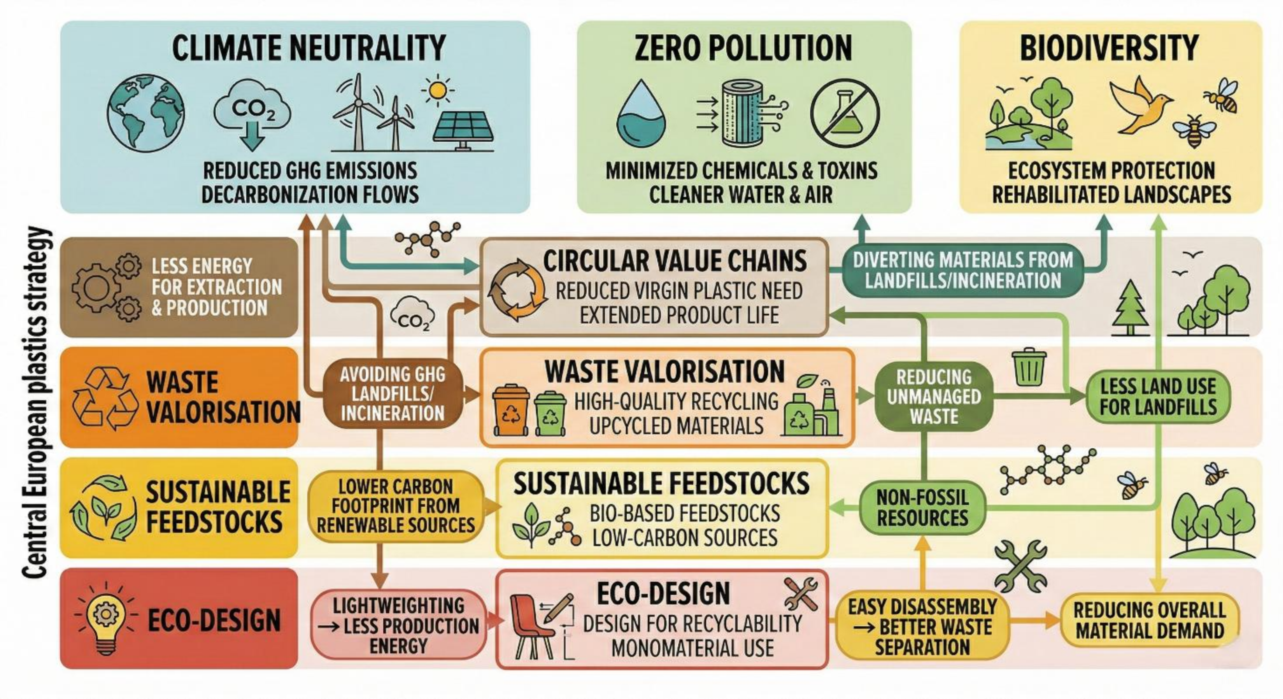

Figure 16: Synergies between plastics strategy and European Green Deal objectives

8.3.4 Risk, resilience and legacy pollution

Cross-cutting priorities must also address the darker side of the plastics story: accumulated pollution and emerging risks. The EEA's zero-pollution "cross-cutting story" on plastics and recent studies on microplastics in soils show how pervasive and long-lived plastic contamination has become, with implications for ecosystems, human health and food systems.

At the same time, ongoing debates on PFAS and other persistent chemicals used in plastics highlight the challenge of phasing out hazardous substances while maintaining essential functions. Investigative work on lobbying around PFAS restrictions illustrates the political and economic sensitivities involved.

Cross-cutting risk and resilience priorities for Central Europe should therefore include:

- integrating microplastics and hazardous additives into monitoring systems for soils, waters and food [43,44];
- prioritising prevention and substitution of problematic substances, in line with EU chemicals policy;
- addressing historical pollution (e.g. legacy landfills and contaminated sites) where plastics and associated chemicals pose long-term risks, particularly in flood-prone areas.

8.4. Territorial cohesion, urban-rural links and just transition

Plastic use and waste management patterns differ substantially between urban areas, industrial regions, and rural territories. European analyses stress that circular economy policies must be tailored to territorial realities to support regional cohesion. Urban and metropolitan regions, which feature a high concentration of consumption and waste generation, are ideal for piloting advanced collection schemes, digital deposit-return models, and circular construction initiatives. Industrial corridors, home to petrochemical and automotive sectors, offer strong potential for industrial symbiosis, shared infrastructure, and innovation clusters [10]. Meanwhile, rural regions can focus on managing agricultural plastics and developing bio-based value chains, provided these are evaluated through robust life-cycle assessments.

A just transition perspective is essential across all these territories to ensure that workers in plastic-intensive regions are not left behind. Early social dialogue, reskilling initiatives, and targeted support for vulnerable groups are necessary preconditions for a socially acceptable transition.

8.5. Integrated cross-cutting strategic priorities and recommended actions

Building on the insights of the previous chapters, Central Europe should adopt the following integrated strategic priorities to link all pillars and technical themes efficiently:

1. Focus on priority value chains with high leverage: Develop integrated roadmaps that combine regulatory measures, collaborative platforms, and technology investments specifically for packaging, construction, automotive/EEE, and agriculture.

2. Build a coherent data and monitoring framework: Establish a Central European plastics observatory to coordinate material flow analyses, indicators, and reporting, integrating data from EPR schemes and Digital Product Passports [43,44].

3. Align finance and investment with circular outcomes: Use EU and national funding exclusively for investments that advance the four technical themes, while developing regional project facilities to help SMEs prepare bankable proposals.

4. Strengthen policy coherence: Set up inter-ministerial coordination mechanisms to address the interface between chemicals, products, and waste, applying “do-no-significant-harm” principles to all plastics-related policies.

5. Integrate risk reduction and resilience: Incorporate microplastics and hazardous additives into monitoring frameworks and develop targeted remediation plans for legacy pollution hotspots [43,44].
6. Ensure territorial cohesion and just transition: Reflect circular economy objectives in regional development and Just Transition Plans, embedding specific measures for skills, employment, and social support.
7. Embed cross-cutting collaboration and learning: Create a Central European "Circular Plastics Forum" to regularly bring together policymakers, industry, and researchers to review progress, share lessons, and align with European alliances [10].

Taken together, these cross-cutting priorities provide the connective tissue of the strategy. They ensure that actions under each pillar reinforce one another, positioning Central Europe as a proactive and coherent region in the wider transition towards sustainable plastics.

Chapter 9

9. Implementation roadmap, governance and monitoring

This chapter translates the strategic directions of the previous chapters into a practical roadmap for Central Europe. It outlines how the four pillars and four technical themes can be implemented over time, who should lead key processes, and how progress will be monitored and reviewed. The aim is to move from a “strategy on paper” to a living, adaptive implementation framework.

9.1. Purpose and guiding principles of the roadmap

The implementation roadmap serves three core purposes: sequencing actions to distinguish short-term "no-regret" steps from long-term transformations; clarifying the responsibilities of regional and national actors; and establishing a monitoring cycle to enable course corrections.

In line with the EU circular economy and plastics strategies, the roadmap is guided by the following principles:

- **Coherence with the European Green Deal**: actions should support climate neutrality, zero pollution and resource efficiency, and must not undermine other environmental goals.
- **Subsidiarity and multi-level governance**: responsibilities should be allocated to the lowest effective level (local, regional, national, EU), with clear coordination mechanisms.
- **Science- and evidence-based decision making**: policies, investments and technology choices must be informed by robust data, life cycle assessment and transparent monitoring [52,53].
- **Prevention and waste hierarchy first**: prevention, reuse and high-quality recycling are prioritised over energy recovery and disposal, consistent with EU waste law.
- **Just transition and territorial cohesion**: implementation should create opportunities for workers, SMEs and regions, and address social impacts proactively (see Chapters 5 and 6).
- **Adaptive governance**: the roadmap is not a fixed plan; it is designed to be updated in light of new data, technologies, regulations and societal expectations [43,44].

9.2. Time horizons and key milestones

The transition to sustainable plastic management is a comprehensive shift spanning at least two decades. To structure these efforts, the roadmap relies on three partially overlapping phases. Table 15 provides a consolidated view of the overarching

Table 15: ***Phased implementation roadmap for sustainable plastics in Central Europe***.

Phase	Main objectives	Key actions by pillar (P1-P4)*	Priority value chains**	Expected outputs/milestones
2025-2027 (foundation + quick wins)	Establish governance and a baseline; reduce leakage; unlock high-quality recycling; scale reuse [68,125].	P1: align national plans with EU rules; define targets/indicators; tighten EPR incentives [58,59]. P2: launch regional platforms (clusters/PROs) + cross-border specs [67]. P3: fast-track training for operators/SMEs/inspectors [68]. P4: upgrade collection & sorting “hotspots”; pilot reuse/refill; improve mechanical recycling feed quality [57].	Packaging/FMCG first, plus Agriculture films in hotspot areas.	Baseline + monitoring system; harmonised sorting specs; first reuse pilots; upgraded sorting lines; measurable contamination reduction; early recycled-content offtake agreements [57,125].
2028-2030 (scale to 2030 targets)	Meet 2030 packaging requirements; scale circular business models; strengthen the secondary materials market; reduce dependence on landfill/incineration [57,68].	P1: full implementation of packaging rules + enforcement; green public procurement for circular products; coherent rules for shipments/compliance [57,61]. P2: long-term contracts across value chains; cross-border infrastructure planning [68]. P3: micro-credentials/CPD for design-for-recycling, LCA literacy, compliance [68]. P4: expand mechanical recycling (incl. flexibles where feasible); deploy targeted depolymerisation pilots (polymer-specific); build labs/traceability [57,66].	Packaging/FMCG + Construction (renovation flows) + Automotive/EEE (dismantling streams).	2030-aligned packaging compliance achieved; higher quality in separate collection and recycling; functioning recyclate markets; DPP-ready data foundations in priority sectors [57,66].
2031-2040 (system shift + low-impact plastics economy)	Mainstream high-value circularity; near-zero leakage; manage legacy additives safely; residual treatment only where justified [67,68].	P1: phase-out/strict control of problematic materials; stable long-term market signals; adaptive tightening based on monitoring [68]. P2: mature cross-border circular supply chains; shared standards and procurement pools [68]. P3: circular skills embedded in VET/HE and lifelong learning; citizen norms for reuse/separation [68]. P4: region-wide best-available sorting; high-quality recycling at scale; selective chemical routes for residual streams; full digital traceability where required [61,66].	All four chains, with Construction and Automotive/EEE becoming dominant end-of-life flows.	Near-zero landfilling of plastics; high reuse in packaging; high-quality recyclate supply for industry; safe handling of legacy substances; sustained emissions and litter reduction verified by monitoring [68,125].

Footnotes:

* Pillars: P1 regulation & governance; P2 collaboration & partnerships; P3 education/skills & behaviour; P4 technology/innovation & infrastructure.

** Value chains: PKG/FMCG = Packaging/Fast-moving consumer goods; CON = Construction & buildings; AUTO/EEE = Automotive + Electrical and Electronic Equipment; AGRI = Agriculture & food.

Abbreviations: EPR = Extended Producer Responsibility; PROs = Producer Responsibility Organisations; DPP = Digital Product Passport; LCA = Life Cycle Assessment; CPD = Continuing Professional Development; VET = Vocational Education and Training; HE = Higher Education.

Note: Phases are indicative; detailed timing should follow the rollout of delegated acts and national implementation schedules under EU instruments.

9.2.1. Phase I (2025-2027): Kick-off and alignment

The first phase focuses on aligning policies, filling critical data gaps, and initiating rapid, visible improvements. Regulatory priorities include transposing recent EU plastics legislation (PPWR, ESPR, microplastics restrictions) and updating national waste management plans [80]. Collaborative efforts will launch a Central European Circular Plastics Partnership alongside sectoral working groups to draft priority value-chain roadmaps [43,44]. In parallel, initial skills mapping and pilot training programmes on Life Cycle Assessment (LCA) and eco-design will be rolled out for SMEs and public officials. Technologically, this phase centres on conducting regional infrastructure inventories and preparing feasibility studies for upgrading material recovery facilities (MRFs) and digital tracking pilots.

9.2.2. Phase II (2028-2030): Scaling and consolidation

The second phase scales proven pilot models to widespread implementation, aligning closely with impending 2030 EU targets for recycling, recycled content, and Digital Product Passports. Circular value chains will be expanded through regional "circular plastic hubs" connecting sorting and recycling with industrial symbiosis platforms [18,110]. Eco-design and LCA will be mainstreamed into corporate product development and green public procurement. To secure sustainable resources, regional joint sourcing mechanisms for recycled polymers will be operationalised alongside targeted, environmentally sound deployments of bio-based plastics [43,44]. Public behaviour-change campaigns will also be intensified to normalise single-use reduction and robust sorting habits [14].

9.2.3. Phase III (2031-2040): Deep transformation

The final phase consolidates Central Europe’s transition into a climate-neutral, low-toxicity plastics economy, aligned with 2050 climate goals and global plastics treaties [5]. This involves a structural decoupling of plastic services from virgin fossil feedstocks through peak prevention, reuse, and high-quality alternative carbon sourcing [43,44]. Legacy pollution and remaining high-risk chemical uses will be phased out and remediated. These deep transformations will ultimately integrate the circular plastics sector entirely into broader socio-economic and regional development plans, maintaining progress through adaptive revision rather than relying solely on fixed quantitative targets [43,44].

9.3. Governance architecture and roles

Effective implementation requires a clear, flexible governance architecture that bridges EU-level frameworks with actionable national and local responsibilities. Previous monitoring of European circular economy strategies highlights that diffuse responsibilities slow down structural progress [6,7]. Figure 17 outlines the structured, multi-level governance architecture proposed for Central Europe.

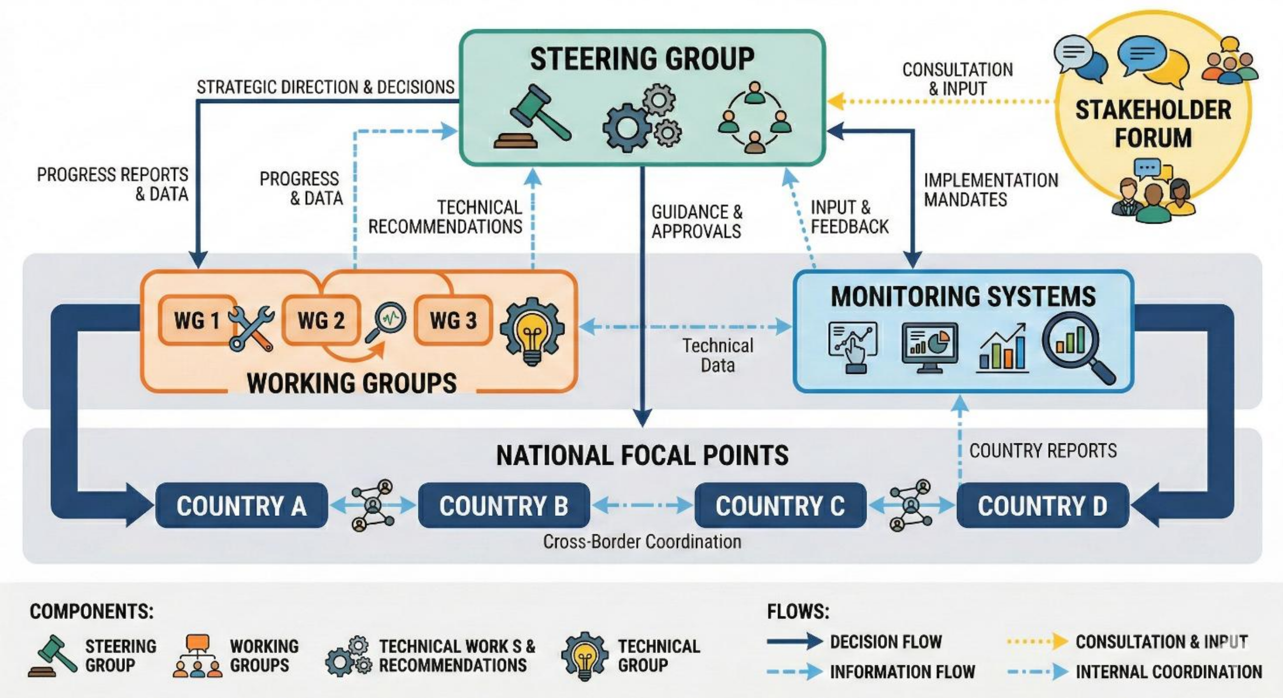

Figure 17: Implementation architecture for the strategy.

This structured architecture relies on dedicated roles across four key operational layers to coordinate and execute the strategy effectively:

- **Central European Steering Group on Sustainable Plastics:** A core coalition of ministries, regional authorities, and industry associations mandated to endorse roadmaps, oversee monitoring, and synchronise EU-level positions.
- **Pillar-specific and sectoral working groups:** Dedicated task forces responsible for drafting implementation guidelines and roadmaps for specific areas like packaging, construction, and education [41,42].

- **National focal points and coordination units:** Embedded ministry officials or platform coordinators responsible for connecting transnational objectives to national policy cycles and funding streams.
- **Stakeholder forum and advisory panels:** A broader, consultative body that meets regularly to integrate scientific, social, and industry perspectives and review regional progress objectively.

9.4. Main implementation instruments and processes

The strategy will be implemented through an aligned mix of regulatory, economic, informational, and voluntary instruments. Because many of these tools already exist in fragmented states, implementation focuses heavily on synchronising them.

Progress relies on executing through four core channels:

- Legislative and regulatory processes: Transposing EU regulations into national laws utilising tailored economic instruments (such as eco-modulated EPR fees and targeted taxes) and updating national waste management plans.
- Strategic planning and programming: Directly embedding circular plastics targets into national cohesion programmes, Just Transition Plans, and Smart Specialisation Strategies.
- Funding and investment mechanisms: Deploying EU and national funds (e.g., Horizon Europe, InvestEU) to support infrastructure and innovation, combined with blended finance and green bonds aligned with the EU Taxonomy [41,42].
- Procurement and advisory support: Utilising green public procurement to shape market demand for recycled and low-chemical products, supported by regional competence centres to guide SMEs on compliance and technology adoption.

9.5. Monitoring, indicators and evaluation

Accurately monitoring progress is both a technical and a political necessity. Central Europe will align its evaluation frameworks with existing models, including Eurostat’s circular economy monitoring and the European Environment Agency's Circularity Metrics Lab [6,7,44].

To capture critical dynamics effectively without overwhelming administrators, the strategy establishes a core set of regional indicators:

- **Circular value chains:** Track per capita plastic consumption, product reuse rates, and strict recycling capture rates for essential fractions.

- **Waste and by-product valorisation:** Measure the share of waste directed toward high-quality mechanical recycling versus energy recovery, and quantify materials exchanged via industrial symbiosis.
- **Sustainable resources and feedstocks:** Monitor recycled content shares in priority sectors and the certified adoption volumes of bio-based or CO_2-based alternative plastics.
- **Eco-design and product traceability:** Evaluate the integration of agreed eco-design guidelines in new products and track the operational uptake of Digital Product Passports [13,42].

Data collection will rely on official statistics, EPR schemes, and updated flow analyses, coordinated by national statistical offices [31]. These streams will feed a Central European Plastics Observatory, responsible for aggregating regional metrics and minimising redundant reporting efforts through smart digital infrastructure [43,44].

To maintain transparency and momentum, the governance architecture will execute clear review cycles:

- Publish a regional plastics progress report every three years to outline indicator trends and lessons learned [43,44].
- Conduct a comprehensive mid-term evaluation around 2030 to assess policy effectiveness and investment coherence.
- Use empirical findings from these reviews to actively adjust future targets and instruments.

9.6. Learning, adaptation and risk management

Given the rapid pace of regulatory, technological, and global trade developments, the implementation framework must be treated as dynamic and highly adaptable [43,44]. Figure 18 visually details this vital monitoring and learning cycle, which ensures continuous improvement.

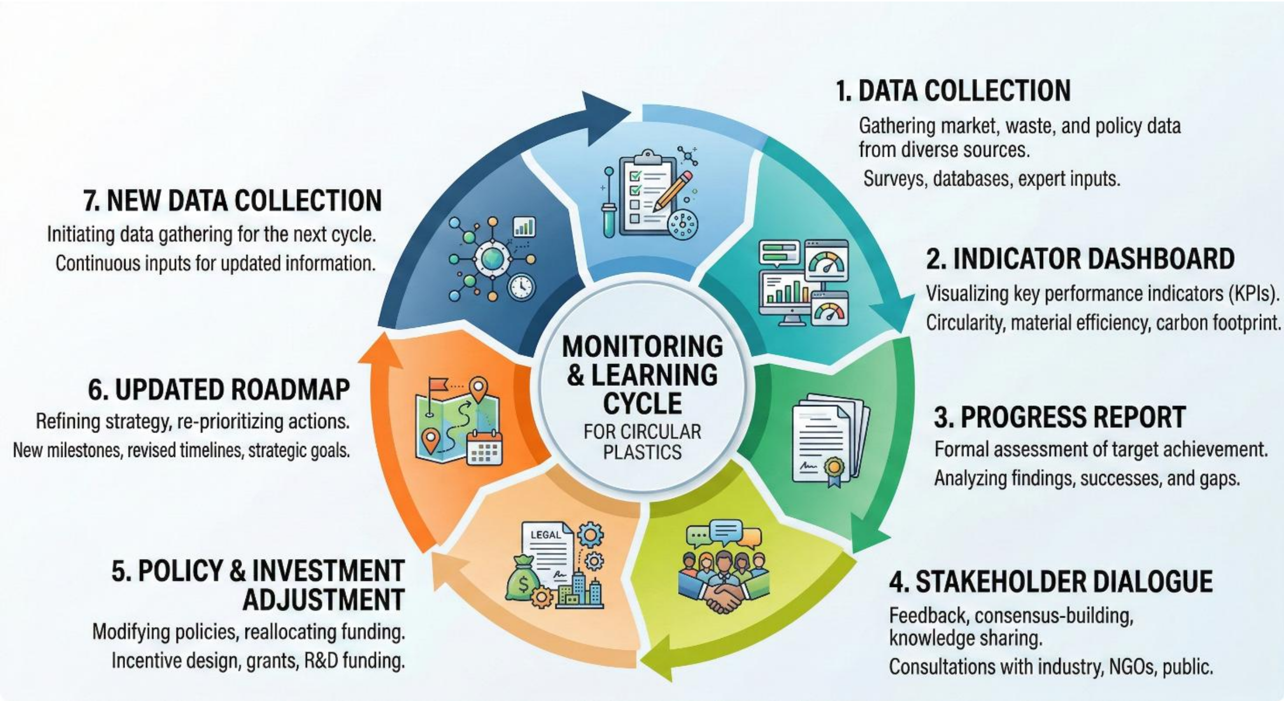

*Figure 18: **Monitoring and learning cycle for circular plastics** [14,43,44].*

This cycle of adaptation is operationalised through the following embedded mechanisms:

- **Structured learning:** Peer-learning workshops and communities of practice to review local pilot outcomes and scale successful approaches rapidly.
- **Scenario foresight:** Periodic strategy stress-tests against alternative future scenarios for feedstock availability, climate policy, and macroeconomic trends.
- **Agile risk management:** Flexible funding and regulatory clauses designed to pivot if favoured technologies or policy approaches fail to deliver verifiable environmental benefits.
- **Stakeholder feedback loops:** Regular consultations with SMEs, unions, and affected communities are embedded directly into the review cycle to ensure fairness and social backing.

Chapter 10

10. Conclusions and key messages for Central Europe

This chapter distils the main insights, priorities, and action imperatives emerging from the strategy for sustainable plastic management in Central Europe. It summarises how the four strategic pillars and the four technical themes fit together, provides concise messages for key stakeholder groups, and highlights the specific added value of a transnational approach under GreenChemForCE.

10.1. Strategic vision: what Central Europe wants to achieve

The strategy developed in this deliverable is built around a simple but ambitious vision:

Central Europe transitions from predominantly linear, fossil-based plastic value chains towards circular, low-impact, and socially just plastic systems that support the European Green Deal, strengthen regional competitiveness, and protect human health and ecosystems.

In practical terms, this means:

- **Reducing dependence on virgin fossil-based plastics** through prevention, reuse and high-quality recycling, complemented by sustainable alternative feedstocks where appropriate.
- **Designing plastics and plastic-containing products for circularity** so that they are durable, repairable, recyclable and free of unnecessary hazardous substances.
- **Transforming waste into resources** using a portfolio of mechanical, chemical and other valorisation technologies that meet clear environmental, climate and health criteria.
- **Strengthening resilience and justice** by creating decent jobs in circular plastics activities, avoiding pollution hotspots, and ensuring that regions, workers and citizens are not left behind in the transition.

The four strategic pillars - regulatory framework and governance, regional collaboration and value-chain partnerships, education and behavioural change, and technology, innovation and infrastructure - are the main levers to realise this vision. The four technical themes - circular value chains, waste and by-product valorisation, sustainable resources and feedstocks, and sustainable product design / eco-design - describe the core transformation domains [124].

10.2. Summary of priorities across the four pillars

The previous chapters set out detailed recommendations. This section summarises the essential priorities under each pillar, as a high-level “compass” for implementation.

10.2.1. Pillar 1 - Regulatory framework and governance

Central Europe needs a regulatory and governance environment that is clear, predictable and aligned with EU ambitions, while leaving space for regional innovation. Key priorities are to [124]:

- Fully implement and, where possible, go beyond EU requirements on plastics, packaging, waste, chemicals and eco-design.
- Use coherent policy mixes, combining regulatory measures (bans, standards, targets), economic instruments (EPR, taxes, incentives) and public procurement to reinforce circular plastics outcomes [50].
- Strengthen multi-level governance, with clear coordination between EU, national, regional and local authorities and structured mechanisms for stakeholder participation.
- Integrate plastics into broader Green Deal strategies, including climate, bioeconomy, zero-pollution and industrial policies, to avoid contradictory signals and competing objectives.

10.2.2. Pillar 2 - Regional collaboration and value-chain partnerships

Collaboration is the backbone of circular plastics. No single actor can redesign value chains alone. Central Europe should:

- **Organise structured value-chain partnerships** for priority sectors (packaging, construction, automotive/EEE, agriculture/food), involving producers, converters, brand owners, recyclers, waste operators, authorities and civil society.
- **Scale up industrial symbiosis and recyclate platforms**, linking waste generators, recyclers and end-users at the regional level.
- **Harmonise key expectations and practices** (e.g. recyclability criteria, recyclate quality classes, data requirements) to support cross-border markets and investments.
- **Build on existing Interreg projects, clusters and alliances**, using them as foundations for a more permanent Central European Circular Plastics Partnership.

10.2.3. Pillar 3 - Education, skills and behavioural change

People and institutions are the real drivers of change. The strategy emphasises:

- **Embedding circular plastics competences into VET and higher education**, with modules on eco-design, recycling technologies, LCA, circular business models and industrial symbiosis [52,53].
- **Scaling continuous professional development (CPD)** for company staff and public officials on LCA, carbon footprinting, eco-design tools, regulatory compliance and collaboration skills.
- **Designing evidence-based public awareness and behaviour-change campaigns** to reduce unnecessary single-use plastics, improve sorting and increase acceptance of circular products [11,14].
- **Ensuring a just transition**, by providing reskilling opportunities, supporting social innovation (e.g. repair and reuse initiatives) and addressing the needs of vulnerable groups and regions.

10.2.4. Pillar 4 - Technology, innovation and infrastructure

Technological and infrastructural choices will determine whether the strategy delivers measurable results. Central Europe should:

- **Invest in high-performance collection and sorting systems**, including sensor-based sorting, digital watermarking and other advanced technologies.
- **Consolidate and expand mechanical recycling capacity** for PET, polyolefins and selected engineering plastics, focusing on high-quality, specification-grade outputs.
- **Deploy chemical and thermochemical recycling selectively**, for fractions that cannot realistically be handled by prevention, reuse or mechanical recycling, and only where robust assessments show clear environmental and climate benefits [14].
- **Strengthen testing, certification, digital and R&D infrastructures**, including Digital Product Passports, recyclate quality labs, pilot plants and design tools that integrate LCA and circularity criteria [52,53].

10.3. Key messages and action checklists by stakeholder group

Although the transition requires collective effort, different stakeholder groups have distinct responsibilities and opportunities. This section summarises tailored messages and suggested action checklists.

10.3.1. Industry and business (producers, converters, brand owners, retailers, recyclers)

Key messages: Circular plastics are not only a compliance issue; they are a core competitiveness and risk-management issue in global markets. Early movers in eco-design, recycled content, and circular business models will be better positioned as EU regulations tighten and customer expectations rise. Collaboration across the value chain is not optional; it is a precondition for reliable access to recyclates, alternative feedstocks, and circular infrastructure.

Indicative action checklist

- Integrate **eco-design and life cycle thinking** into product and packaging development, with clear internal guidelines and decision criteria.
- Set **quantitative targets** for prevention, reuse and recycled content in key product lines; monitor and report progress.
- Participate actively in **regional value-chain partnerships**, industrial symbiosis platforms and sectoral roadmapping processes.
- Invest in **data and traceability systems** (e.g. DPP-ready product information) and share relevant information with recyclers and authorities.
- Offer **training and CPD** for staff on circular plastics topics, including design, operations, data and collaboration skills [41,42].

10.3.2. Policy makers and public authorities (EU, national, regional, local)

Key messages: Policies on plastics must be coherent across waste, products, chemicals, climate, agriculture, and regional development; isolated measures risk shifting problems. Public authorities are not only regulators but also major market actors: procurement decisions and partnership roles matter. Stable, predictable frameworks are essential to encourage long-term investments in circular plastics infrastructure and innovation [124].

Indicative action checklist

- Ensure timely **transposition and implementation** of EU plastics-related legislation, with clear guidance for businesses and municipalities.
- Use **economic instruments** (EPR, fees, taxes, incentives) to reward prevention, reuse, high-quality recycling and safer material choices.
- Embed plastics and circular economy targets in **regional and national development plans**, and align funding programmes accordingly.

- Strengthen **enforcement and market surveillance** to tackle free-riding, greenwashing and non-compliant products.
- Act as **neutral facilitators** of regional collaboration platforms and stakeholder dialogues, including cross-border initiatives.

10.3.3. Business-support organisations, clusters and innovation agencies

Key messages: You are pivotal intermediaries. Without your support, many SMEs will not have the capacity to engage in circular plastics transitions. Your programmes can turn abstract policy goals into practical support services, training, matchmaking, and project development.

Indicative action checklist

- Develop or expand **advisory services** on eco-design, recycled-content integration, regulatory compliance and funding opportunities.
- Organise **peer-learning networks and communities of practice** on circular plastics among member companies.
- Help companies prepare **bankable project proposals** for circular plastics investments and innovation projects.
- Facilitate **cluster-based pilots** (e.g. shared recyclate sourcing, joint packaging redesign, industrial symbiosis projects) and disseminate results.

10.3.4. Research organisations, universities and VET providers

Key messages: Your role goes beyond technology development: you are critical for skills formation, independent assessment, and knowledge brokerage. Interdisciplinary approaches are essential because plastics sit at the intersection of chemistry, engineering, design, economics, and social sciences.

Indicative action checklist

- Integrate circular plastics content into curricula at all levels, linking theoretical knowledge with real-world case studies and projects.
- Align research agendas with regional needs for advanced recycling, eco-design tools, sustainable feedstocks and risk assessment.
- Offer LCA and eco-design services or partnerships to companies and authorities, especially SMEs and smaller municipalities.

- Participate in regional and European research networks focused on circular plastics, and ensure that results are translated into practice and policy.

10.3.5. Civil society organisations, social partners and citizens

Key messages: Civil society and citizens play a crucial role in driving demand for better products, holding institutions accountable, and co-creating solutions. A just transition requires the active engagement of workers' representatives, NGOs, and community organisations.

Indicative action checklist

- Monitor and publicise **progress and gaps** in plastics policies and industry commitments, using transparent and evidence-based methods [124].
- Promote and participate in **reuse, repair and community-led circular initiatives** that complement formal recycling systems.
- Engage in **social dialogue** about the distribution of costs and benefits of the plastics transition, including job impacts and regional implications.
- Support educational and awareness activities that help citizens adopt **more sustainable consumption and sorting behaviours**.

10.4. Added value of regional cooperation and of GreenChemForCE

This strategy is rooted in Central Europe and leverages opportunities offered by the Interreg CENTRAL EUROPE framework and the GreenChemForCE project. Regional cooperation adds value in several key ways:

- Critical mass and shared learning: Combining the capacities and experiences of several Central European countries creates a richer knowledge base and stronger demonstration projects than isolated national efforts. Successful pilots in one region can be replicated and adapted in others, significantly reducing duplication of effort.
- Coherent messages in EU and global fora: A coordinated Central European voice on plastics—grounded in this strategy—can directly influence EU-level rulemaking and the implementation of the global plastics treaty. Shared positions on topics such as chemical recycling, bio-based plastics, and recyclate quality standards can help shape future frameworks [18,121].
- Cross-border value chains and infrastructure: Plastics production, product markets, and waste flows are inherently transnational. Regional cooperation makes it easier to plan and finance cross-border infrastructure (e.g., joint sorting hubs, shared recycling

capacity) and to manage transboundary movements of waste and secondary materials transparently and in line with the law [5,14].

- Coordinated skills and innovation ecosystems: Joint training programmes, research networks, and innovation projects can rapidly accelerate the development of expertise in circular plastics technologies and green chemistry across the region [124].

Within this context, GreenChemForCE plays a catalytic role by: providing the analytical basis (through D.1.1.1 and this D.1.1.2 strategy) for coordinated action; piloting concrete technological and organisational solutions in participating regions and companies; building bridges between plastics management, sustainable feedstocks, and green chemical processes; and offering tools, methodologies, and communication channels that can be used well beyond the project’s lifetime.

10.5. Final remarks and outlook

The strategy developed in this deliverable is both ambitious and realistic. It accepts that plastics will remain indispensable in many applications for the foreseeable future, but insists that their production, use, and end-of-life management must change fundamentally.

Several overarching messages emerge:

- The window for incremental change is closing. Regulatory pressures, market expectations, and environmental realities will increasingly penalise linear, high-impact plastics practices. Central Europe can choose to anticipate these shifts and turn them into a competitive advantage.
- There is no single “magic” technology or policy. Successful implementation will come from carefully designed combinations: prevention and reuse where possible; high-quality mechanical recycling wherever feasible; and targeted chemical recycling and new feedstocks where justified. All must be underpinned by strong governance, skills, and collaboration [42].
- Data, transparency and trust are essential. Without robust data and open dialogue, it will be difficult to prioritise investments, evaluate trade-offs, or maintain public support. Monitoring and communication are therefore integral parts of the strategy, not afterthoughts [43,44].
- The transition can create value for the region. If managed well, sustainable plastic management can help Central Europe strengthen its industrial base through innovation in materials, recycling, and green chemistry. It will create skilled jobs in circular economy activities, reduce environmental and health costs associated with

pollution, and position the region as a frontrunner in circular plastics within the EU and globally.

The implementation roadmap outlined in Chapter 9 provides an initial pathway that will need to be continuously refined and updated in light of new evidence, technologies, and policy developments. The most important success factor will be the willingness of stakeholders to engage continuously, learn from practice, and turn early pilots into scalable, mainstream solutions [124]. If Central Europe follows through on the priorities set out in this strategy, the region can demonstrate that robust industrial activity, high environmental ambition, and social fairness are not competing goals, but mutually reinforcing dimensions of a modern plastics system perfectly aligned with the European Green Deal and global sustainability ambitions.

11. Executive Summary: Strategy for Sustainable Plastic Management in Central Europe

This strategy outlines how Central Europe can transition from predominantly linear, fossil-based plastic value chains to circular, low-impact, and socially just plastic systems. Developed within the Interreg CENTRAL EUROPE project GreenChemForCE, it provides a comprehensive, evidence-based roadmap for industry, public authorities, education providers, and civil society.

Central Europe’s plastics challenge

Plastics are integral to Central Europe’s economy, enabling energy-efficient buildings, safe food packaging, and modern mobility. However, the current system is highly dependent on virgin fossil feedstocks. It is constrained by low effective recycling rates, product designs that hinder reuse, and significant environmental risks, including microplastic pollution. As the regulatory landscape rapidly tightens through the European Green Deal and the Circular Economy Action Plan, Central Europe must actively modernise its plastics systems to maintain industrial competitiveness, ensure compliance, and protect regional ecosystems.

Strategic vision and objectives

The overarching vision is for Central Europe to become a frontrunner in circular and sustainable plastics, combining strong industrial capabilities with ambitious environmental standards. The strategy sets four core objectives:

- **Decouple plastics services from virgin fossil feedstocks** by reducing unnecessary plastic use, scaling reuse systems, and increasing high-quality recycling.
- **Design plastics and products for circularity and safety** so they can be reused, repaired, and recycled without spreading hazardous substances.
- **Turn waste and by-products into resources** using advanced valorisation routes that meet robust environmental, climate, and health criteria.
- **Ensure a just and inclusive transition** by creating quality jobs, protecting workers, and ensuring territorial cohesion across Central Europe.

The four technical themes

To focus efforts where leverage is highest, the strategy applies four mutually reinforcing technical themes to priority value chains (packaging, construction, automotive/electronics, and agriculture):

- **Circular plastic value chains:** Shifting from "make-use-dispose" models to closed-loop and open-loop reuse systems, supported by sector-specific roadmaps and robust extended producer responsibility (EPR) schemes.
- **Waste and by-product valorisation:** Optimising separate collection and deploying industrial symbiosis to transform plastic residues into secondary resources, strictly guided by life cycle assessments (LCA) to avoid sub-optimal lock-ins.
- **Sustainable resources and feedstocks:** Prioritising high-quality recycled plastics as the primary alternative feedstock, complemented by the targeted use of bio-based and CO_2-based plastics where environmental benefits are demonstrable.
- **Sustainable product design / eco-design:** Mainstreaming eco-design requirements, LCA tools, and practical design guidelines to ensure new products are durable, recyclable, and resource efficient.

The four strategic pillars

To operationalise these technical themes, the strategy mandates coordinated actions across four enabling pillars:

- **Pillar 1 - Regulatory framework and governance:** Fully implementing EU legislation, establishing coherent policy mixes (combining EPR, taxes, and green procurement), and integrating plastics into broader climate, zero-pollution, and industrial strategies.
- **Pillar 2 - Regional collaboration and value-chain partnerships:** Establishing a Central European Circular Plastics Partnership, scaling cross-border industrial symbiosis networks, and harmonising recyclability standards and data-sharing practices.
- **Pillar 3 - Education, skills and behavioural change:** Embedding circular competences into vocational and higher education, scaling professional training for industry and public authorities, and driving public behaviour change toward reuse and correct sorting.
- **Pillar 4 - Technology, innovation and infrastructure:** Investing heavily in modern sensor-based sorting, expanding high-quality mechanical recycling capacity, selectively deploying advanced chemical recycling, and building robust digital traceability systems (e.g., Digital Product Passports).

Cross-cutting priorities and implementation roadmap

Implementation is guided by systemic cross-cutting priorities, including the establishment of a Central European Plastics Observatory for data monitoring, the alignment of public and private finance with circular objectives, and targeted risk management for legacy pollution.

The transition is structured into three indicative phases:

- 2025–2027 (Kick-off and alignment): Building shared governance structures, filling critical data gaps, upgrading baseline collection infrastructure, and initiating regional pilot programmes.
- 2028–2030 (Scaling and consolidation): Deploying major infrastructure investments, mainstreaming eco-design requirements across supply chains, and achieving or exceeding key EU targets for packaging recycling.
- 2031–2040 (Deep transformation): Achieving substantial decoupling from virgin fossil plastics, fully integrating circular plastics into climate-neutral development pathways, and remediating legacy pollution.

Added value of GreenChemForCE and regional cooperation

Transnational cooperation provides a unique platform to pool regional expertise, coordinate cross-border investments, and establish a unified voice in European policy discussions. By treating plastics as a systemic priority rather than a narrow waste management issue, Central Europe can demonstrate that robust industrial activity, high environmental ambition, and social fairness are mutually reinforcing dimensions of a modern, resilient economy.

Summary

12. Policy-maker Summary: Action Plan for Central Europe

The Strategic Imperative Central Europe's plastics sector faces rapid regulatory tightening (e.g., EU Green Deal, PPWR, ESPR, microplastics restrictions) alongside persistent challenges of fossil-fuel dependence, low circularity, and environmental leakage. To safeguard industrial competitiveness, ensure regulatory compliance, and protect regional ecosystems, policy-makers must shift plastics from a linear waste problem to a systemic resource priority.

Key Deliverables Across the Four Pillars

- **Pillar 1 - Regulation:** Implement EU waste and product laws ambitiously, enforce eco-modulated Extended Producer Responsibility (EPR) fees, and mandate green public procurement.
- **Pillar 2 - Collaboration:** Establish a Central European Circular Plastics Partnership to harmonise cross-border recyclability standards, data tracking, and industrial symbiosis.
- **Pillar 3 - Skills & Behaviour:** Direct national and EU funds toward updating vocational training and reskilling the industrial workforce for eco-design and circular business models.
- **Pillar 4 - Infrastructure:** Prioritise public funding and blended finance exclusively for advanced separate collection, sensor-based sorting, high-quality mechanical recycling, and Digital Product Passport (DPP) testbeds.

Immediate Actions for Policy-Makers

- **Adopt integrated strategies:** Update national circular economy and regional development plans with explicit, cross-cutting plastics targets aligned with climate and zero-pollution goals.
- **Upgrade economic instruments:** Restructure national EPR schemes to actively penalise non-recyclable designs and financially reward the use of recycled content.
- **Coordinate governance:** Mandate inter-ministerial task forces to oversee PPWR and ESPR implementation seamlessly across environment, industry, and economic portfolios.

- **Build the data baseline:** Establish a Central European plastics observatory with harmonised indicators to monitor effective recycling rates, material flows, and leakage.
- **Target public investments:** Screen all cohesion and national funding to ensure capital flows strictly to circular infrastructure, preventing technological lock-in to low-value energy recovery or landfilling.

13. Transparency statement

This report was developed through an iterative drafting and revision process in which artificial intelligence tools were used to support the initial preparation of selected sections, improve text structure and clarity, and assist with language editing. All content was subsequently reviewed, revised and validated by the authors. The authors retain full responsibility for the final content, interpretations and conclusions presented in this report. All images for which no other source is explicitly indicated were created using Google Gemini 3.1 Pro generative artificial intelligence based on author-developed text prompts.

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