



Handbook for Circular Machine Industry

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Responsible Partner: CLUSTERO

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1. The Plan-C project and the EU Strategy for the Danube Region

The **Moving Plastics and mAchine iNdustry towards Circularity (Plan-C)** project is a pioneer initiative in the field of circular economy under the EU Strategy for the Danube Region - **Priority Area 8: Competitiveness of enterprises and cluster development - Working Group Circular Economy and Circular Bioeconomy**. The project brings together 14 partners from 9 countries from the Danube Region (Austria, Germany, Czech Republic, Slovakia, Hungary, Serbia, Bosnia and Herzegovina, Romania and Moldova) to transform the plastics and machine industry towards a circular economy. Innovative ideas for advancing the circular economy will be generated through technology transfer and the design thinking process. The partners will co-create and demonstrate circular plastic prototypes, resulting in a Circular Plastics Guideline to build regional knowledge and capacities. Strategic partners and policy stakeholders will help integrate this strategy into Regional Innovation Strategies (**RIS3**). Similarly, project partners and machine engineering companies will develop circular solutions for each phase of the machine lifecycle, and create digital business models summarized in a Guideline for Circularity in the Machine Industry.

The project aims to foster transnational cooperation and support SMEs and enterprises in adopting circular principles for plastics and machine industry. Through cooperation among plastics processors, producers and the machine industry, Plan-C seeks to develop innovative solutions that emphasize reuse, recycling, and long-term value retention. The Transnational Action Plan for boosting circularity in the entire plastics value chain, including machinery industry, is based on the latest EU regulations and developed in close cooperation with the national and regional policy level in each country. It will ensure transfer to the RIS3 of the partner countries by intensifying awareness-raising activities and proposing new support measures for local SMEs.

The core objectives of Plan-C include:

- **Co-creating circular plastic solutions through collaboration and design thinking**, resulting in practical prototypes and guidelines for SMEs.
- **Redesigning machinery** for reuse and recycling, covering the entire lifecycle and exploring digital opportunities.
- **Developing a transnational joint strategy and action plan for enhancing circularity in plastics and machine industry** that aligns with EU regulations and national strategies, ensuring long-term impact through policy integration and SME support.

Plan-C aims to address significant barriers such as the weak recycling infrastructure, outdated waste systems, and gaps in expertise. By promoting reuse, repair, remanufacturing, and smart recycling, the project aspires to accelerate clean growth in manufacturing sector and strengthen business competitiveness across the region.

2. Rationale

The scope of this handbook for the circular machine industry is to provide an overview of the topic of circularity in the machine industry. It includes the assessed needs and challenges, the co-creation approach based on design thinking methodologies, and the circular machine life cycles, summarized in the *Guideline for circularity in machine industry (D.2.2.4)*, along with the related *Business models for circularity (D.2.3.1)*. The Plan-C project partners collected business models for circular machine industry which are presented in Chapter 8. Following the activities carried out within the Plan-C project, several future actions have been identified, such as:

- **Mobilizing local authorities and all stakeholders for the development of a circular economy in the Danube Region**

Mobilizing local authorities and all stakeholders within the circular economy value chain in the countries of the Danube Region is of particular importance. Systemic and systematic change requires complex cooperative interactions between local authorities and businesses at the local level. There are several ways of mobilizing local actors, such as the creation of circular economy clusters or the set up and management of a web-based circular economy cooperation platform.

- **Strengthening local businesses in circular economy, including those in the machine industry**

The availability of circular economy resources in the Danube Region represents a solid basis for the development of viable business models. However, the lack of knowledge about the circular economy sector in general, limited funding opportunities, and the insufficient involvement of the local authorities lead to a reduced interest among producers in shifting towards a circular economic model.

- **Raising awareness about circular economy processes**

The success of circular economy processes at the regional level is strongly related to community involvement. In addition, the exchange of best practices from other regions/countries facing similar challenges is one of the most effective ways to drive structural changes. Many regions develop small- or large-scale awareness-raising and dissemination activities to support the deployment of the circular economy. Events are

also an important tool to bring together all stakeholders in the circular economy innovation ecosystem.

- **Setting up the regional/national policy framework with support instruments for SMEs, including a financial and non-financial incentive to foster the circular economy**

The development of dedicated national/regional policies and strategies is vital for the creation of circular economy ecosystems. The strategy for enhancing circularity in machine industry across the Danube Region, which will be developed in the Plan-C project, could serve as a model for other industrial sectors in a medium-term perspective.

3. Importance of circularity in the Machine Industry

Key principles of circularity in the machine industry include eco-design and durability, remanufacturing and refurbishment to extend product lifecycles, and product-as-a-service business models that foster long-term customer relationships and greater resource efficiency. Adopting these strategies also boosts brand reputation, drives innovation, and helps companies comply with growing Environmental, Social, and Governance (ESG) regulations.

Circularity offers economic, sustainability and environmental benefits, as well as operational and strategic advantages — e.g. enhancing economic performance through reduced costs, new revenue streams, and supply chain resilience, while also improving environmental sustainability by minimizing waste and greenhouse gas emissions.

Economic Benefits

- **Cost Savings:** Circularity can lower operational costs by reducing raw material expenses through recycling, minimizing waste and disposal costs, and extending the productive lifespan of machines.
- **New Revenue Streams:** Manufacturers can generate additional income by selling remanufactured products or offering service-based models, such as leasing or pay-per-use, where the machine's performance is directly linked to the company revenue.
- **Enhanced Resilience:** Utilizing recycled and repurposed materials and extending product lifecycles makes companies less vulnerable to volatile global supply chains, material shortages, and price fluctuations.

- **Competitive Advantage:** Companies embracing circularity can differentiate themselves in the market, gain a competitive edge, and foster innovation in materials, processes, and business models.

Sustainability and Environmental Benefits

- **Reduced Waste and Pollution:** The core aim of circular strategies is to eliminate waste and pollution by keeping products and materials in use for longer, thereby reducing the need for new raw materials.
- **Lower Emissions:** By using more recycled content and designing for durability, circular supply chains significantly reduce carbon emissions and the environmental footprint of machinery.
- **Resource Efficiency:** Circularity promotes resource efficiency by maximizing the value of materials and components through design, reuse, repair, and remanufacturing, creating a closed-loop system.

Operational and Strategic Advantages

- **Innovation:** The shift to circular business models necessitates innovation in product design, manufacturing processes, and material sourcing, leading to higher rates of technological development and improved efficiency.
- **Improved Brand Reputation:** Demonstrating a commitment to sustainability through circular practices enhances a company's brand image and resonates positively with environmentally conscious consumers and stakeholders.
- **Stronger Customer Relationships:** Service-based circular models, which focus on machine performance and longevity, can build closer, long-term relationships with customers.
- **Regulatory Compliance:** Companies are better positioned to meet increasingly stringent environmental regulations and reporting requirements by building greater transparency and traceability into their value chains.

4. The basics of design for circularity approaches within the machine industry

Design for circularity in the machine industry focuses on principles such as designing out waste, keeping products and materials in use, and restoring natural systems. Key approaches include designing for durability, modularity, reparability, and disassembly to extend product life and facilitate end-of-life recovery. Material selection plays an essential role, prioritizing recyclable and non-hazardous materials, while business models that support product-as-a-service can further drive circularity.

Core Principles of Design for Circularity

- **Eliminate Waste and Pollution:** Prevent waste and pollution from the outset by designing products and processes that are inherently cleaner and more efficient.
- **Circulate Products and Materials:** Keep products and materials in use for as long as possible at their highest value through strategies like reuse, repair, remanufacturing, and recycling.
- **Regenerate Natural Systems:** Support the regeneration and health of natural ecosystems, moving away from a linear “take-make-dispose” model.

Practical Design Strategies for Machines

- **Design for Durability and Longevity:** Create machines that are built to last longer and withstand significant wear and tear, reducing the need for replacement.
- **Design for Modularity:** Break down machines into modular components that can be easily upgraded, repaired, or replaced, extending their overall service life.
- **Design for Repair and Maintenance:** Ensure machines are easy to repair and maintain by providing accessible components and using standardized, readily available parts.
- **Design for Disassembly and Reassembly:** Design machines that can be easily taken apart at the end of their life, to recover components and materials for reuse or recycling.
- **Material Selection:** Choose materials that are durable, non-hazardous, and can be easily recycled or reused.
- **Upgradability and Adaptability:** Design machines to be adaptable and upgradable so they can evolve with changing needs and technologies, instead of becoming obsolete.

Integration within the Machine Industry

- **Product Life Cycle Thinking:** Consider the entire product life cycle, from material sourcing and manufacturing to use and end-of-life recovery, to identify opportunities for circularity.
- **Business Model Innovation:** Explore product-as-a-service (PaaS) models where the manufacturer retains ownership and responsibility for the product's use and maintenance, incentivizing longer lifespans and efficient resource use.
- **Collaboration and Systems Thinking:** Work with suppliers, customers, and other stakeholders to create closed-loop systems for materials and components.

Integrating design for circularity within the machinery industry not only extends product lifecycles and reduces waste but also fosters innovation, strengthens supply chains, and enhances competitiveness, ultimately supporting the transition toward a sustainable industrial future.

5. Summary of identified challenges and needs in the machine industry in the Danube Region

The primary challenges and needs for the plastics machinery sector in the Danube Region include the lack of robust waste management and recycling infrastructure, insufficient integration between industry players, and the need for significant investment in circular economy technologies. Key needs focus on developing robust circular economy models, enhancing technological capacity for recycling secondary materials, fostering transnational collaboration, implementing eco-design principles for machinery, and leveraging digital tools like AI to improve efficiency and reduce costs.

Key Challenges

- **Inadequate Circular Infrastructure:** Many countries, particularly in the southern and eastern areas of Danube region, lack the necessary infrastructure for waste management and the efficient processing of secondary plastic materials.
- **Environmental Concerns and Regulations:** The industry faces increasing pressure from environmental issues like plastic pollution and evolving EU Green Deal regulations, which require a transition from a linear to a circular economy model.

- **Technological & Efficiency Gaps:** Existing recycling technologies are often inefficient, prone to contamination, and energy-intensive, making large-scale implementation challenging.
- **Economic and Political Constraints:** Challenges include the high cost of bio-based raw materials, limited funding opportunities, and economic barriers that hinder investment. Moreover, there are fewer political incentives for circular practices in the machine sector compared to other industries.
- **Limited Industry Integration:** The lack of cooperation between plastics manufacturers, recyclers, and end-users, limits the effective transformation of the value chain and slows the adoption of circular principles.
- **Low awareness of the circular economy:** Both machinery manufacturers and users in the plastics industry often lack awareness and understanding of circular economy concepts and their relevance to the machinery sector as a whole.

Key Needs

- **Circular Economy Transformation:** The main need is to transform the entire plastics machine value chain towards circularity, focusing on reuse, maintenance, remanufacturing, and recycling of both products and equipment.
- **Technological Development and Adoption:** There is a strong need for advanced technologies, including those for efficient and high-quality recycling of secondary plastic materials, as well as energy-efficient processing solutions.
- **Eco-design for Machinery:** Manufacturers need to design machines that is robust, long-lasting, repairable and adaptable, in order to align with circular economy principles.
- **Transnational Cooperation:** Enhanced cooperation among countries in the Danube Region is essential to share best practices, knowledge, and resources, to achieve a coordinated transformation.
- **Investment and Digitalization:** Increased investment in circular economy initiatives is needed, along with the adoption of digital tools and AI to improve cost efficiency, optimize processes, and enable new circular business models.
- **Capacity Building and Awareness:** Efforts are needed to strengthen knowledge and capacity within companies to implement circular solutions, encouraging a shift in mindsets and business practices.

While each country faces unique challenges in their transition towards a circular economy, there are significant similarities in the needs that can be leveraged across the region. Common needs include advancing technological capabilities, implementing supportive policies, enhancing public awareness, and fostering cross-sectoral collaboration. Addressing these challenges while capitalizing on shared needs can accelerate progress towards a more sustainable and circular economy across the Danube Region, benefiting both the environment and economic competitiveness.

6. The co-creation approach with design thinking methodologies

The **Plan-C project**, co-funded by **Interreg Danube Region Programme**, applies a co-creation approach based on design thinking to drive the circular transformation of the plastics and machinery industries in the Danube Region. By bringing together plastics producers and machine manufacturers, Plan-C facilitates the development of circular concepts for products and machines designed for reuse and remanufacturing. Through design thinking workshops and transnational cooperation, the project promotes circular economy practices that turn waste into new value while enhancing industrial competitiveness across the region.

Key Aspects of the Approach

- **Focus on Circularity:** The core goal is to transform the plastics and machinery sectors into circular systems, moving beyond traditional recycling to design for longevity and value retention.
- **Cross-Sector Collaboration:** The project fosters co-creation by uniting plastics producers and machine manufacturers in a collaborative effort to generate practical circular solutions.
- **Design Thinking Workshops:** Within the project, interactive design thinking workshops serve as the main methodological framework for co-developing circular concepts for products and machinery, supporting creativity, empathy, and problem-solving iterative learning.
- **Tangible Solutions:** The initiative focuses on creating tangible solutions, including prototypes and innovative business models that demonstrate how waste can become new value.
- **Regional Development:** Plan-C aims to create a framework that connects more advanced circular regions with those at earlier stages of transition, fostering

mutual learning and promoting a uniform approach to circularity across the Danube Region.

By embedding design thinking in industrial innovation, Plan-C contributes to building a resilient and sustainable manufacturing ecosystem in the Danube Region. The approach not only accelerates the transition towards circularity but also provides a replicable model for cross-sector collaboration and policy alignment at the European level. It helps advance competitiveness, innovation, and sustainability in the regional machine and plastics sectors.

7. A Roadmap for Circular Transformation in the Machine Industry

Transitioning from a linear to a circular model represents a profound strategic shift for companies operating in the machine industry. Plan-C project offers practical guidance for companies on how to begin their circular transformation. It outlines the steps they can take, the enabling conditions they need to foster internally and externally, and the new business models — especially Product-as-a-Service — that can drive the shift toward a more sustainable, regenerative, and competitive industrial ecosystem. The Guideline for circularity in machine industry provides a comprehensive roadmap that companies, especially SMEs, can follow to implement these changes effectively.

Mapping the Machine Life Cycle

The entry into circular transformation does not require immediate, radical restructuring. Companies should first conduct an analysis of their current operations by mapping each of the eight phases of the machine life cycle: design and development, material sourcing, manufacturing and assembly, distribution and logistics, use and maintenance, end-of-life management, refurbishment and reuse, and waste management.

This mapping should identify key points where resource inefficiencies, design bottlenecks, or waste generation are most critical. The circular machine life cycle demands systems thinking, long-term planning, and a willingness to innovate in both products and business models. It also implies rethinking relationships with suppliers, customers, regulators, and even competitors.

Implementing Transformations in Each Phase

Translating the circular life cycle concept into practice requires companies to undertake specific transformations in each phase of their operations. These transformations are cumulative and often interdependent. For most companies, the challenge is not one of awareness, but of implementation. The question is not why circularity matters, but how to begin the transformation in a way that is both economically viable and operationally feasible.

Identifying Priorities and Pilots

The next step is to identify which of these life cycle phases offers the most accessible starting point for improvement. For some companies, this may be the design phase, where modular product development could allow for greater reuse of components. For others, the use phase might offer the best opportunity, particularly through predictive maintenance systems or upgrade programs. The aim is to make targeted interventions that can demonstrate both environmental and business value.

Internal Task Forces and Capacity Building

Once opportunities have been identified, companies should form internal circular economy task forces — cross-functional teams that include product designers, procurement specialists, supply chain managers, and marketing professionals. This group's role is to coordinate the development of circular pilots, integrating sustainability targets into key performance indicators (KPIs), and fostering a culture of experimentation and innovation. Simultaneously, companies should seek partnerships with technology providers, research institutions, and service partners that can complement their expertise. Access to data analytics tools, remanufacturing facilities, or secondary raw material suppliers is often necessary, but these may not be available in-house.

Capacity building is another internal prerequisite. Circular transformation requires new skills — such as life cycle analysis, modular product design, or materials engineering — that are not always present in traditional manufacturing teams. Companies should invest in training programs and professional development to ensure that employees are equipped to contribute meaningfully to circular objectives.

Pilot Implementation and Monitoring

Pilot implementation is a crucial phase. It involves designing and testing small-scale initiatives that apply circular principles in a controlled, measurable way. For example, a company might develop a prototype machine designed for disassembly and test it under real-use conditions. Another company might implement a closed-loop material sourcing program with one supplier. These pilots serve as real-world laboratories for learning,

allowing companies to gather insights about feasibility, cost-effectiveness, and customer acceptance before scaling up. Monitoring and evaluation systems must be put in place from the beginning. The success of circular transformation does not rest solely on a company's internal capabilities. The transition is deeply dependent on the broader ecosystem in which a business operates. As such, building an enabling environment — both within and outside the organization — is essential. Executive teams must articulate a clear vision for circularity, integrated with the company's mission and long-term business strategy. This vision should be reflected in company policies, investment priorities, procurement strategies, and employee incentives.

Transparency, Traceability, and Digital Tools

Transparency and traceability are critical enablers of circularity, especially in the machine industry where components are often sourced globally and managed through complex supply chains. Investing in digital infrastructure supports better decision-making and enables new business models such as leasing or take-back schemes.

External Enablers: Policy, Financing, and Collaboration

Externally, regulatory coherence and public policy support are essential. Companies often encounter barriers due to fragmented regulations on waste, materials classification, cross-border shipments, and product standards. National governments, regional development agencies, and local authorities all have roles to play in creating a harmonized regulatory framework.

Access to financing is another significant enabler. Circular transformation involves upfront investments that may not yield immediate returns. Traditional financial institutions may be reluctant to support business models that deviate from linear asset-based logic. To overcome this, companies can explore green financing instruments, impact investment funds, and EU-level funding programs such as Horizon Europe or the LIFE Programme.

Collaboration platforms and industry clusters also provide essential support. Through joint projects, shared infrastructure, and peer learning, companies can reduce the costs and risks of experimentation. Participation in circular economy hubs or sectoral alliances can accelerate innovation and facilitate access to best practices.

System-Level Change

Ultimately, circular transformation is a systems-level change. It requires cooperation between businesses, governments, research institutions, and civil society to create feedback loops that reinforce sustainable behavior.

The journey toward circularity is complex. It demands more than technical adaptation; it requires a rethinking of how value is created, captured, and sustained. It challenges traditional supply chains, procurement policies, and customer relationships.

This transformation cannot be achieved by companies acting in isolation. It necessitates a supportive ecosystem: forward-thinking regulation, accessible financing, robust partnerships, skilled labor, and open knowledge flows.

Governments and public institutions must create the policy frameworks and incentives that reward circular investment. Research institutions must continue to develop and test new solutions. Industry platforms must facilitate dialogue and cooperation. And education systems must train the next generation of circular economy professionals.

Circularity must not be seen as an isolated activity or an add-on to existing practices. It must become a defining feature of how the machine industry designs, produces, delivers, maintains, and retires its products. This guide offers a starting point. The responsibility for continuing the work lies with everyone: businesses, policymakers, researchers, and citizens. Together, they can shape a machine industry that is not only productive and profitable but also regenerative and resilient.

8. The circular machine life cycle

The machine life cycle is divided into eight interconnected phases, each offering an opportunity to apply circular strategies. Adopting a circular approach requires rethinking relationships with suppliers, customers, regulators, and even competitors, while emphasizing systems thinking, long-term planning, and innovation in both products and business models. The following sections describe each of the eight phases and the corresponding strategies that companies can implement to enhance circularity throughout the machine life cycle:

8.1. Design and Development

Design for Longevity: Create machines with a longer lifespan by using durable materials and modular designs that allow for easy upgrades and repairs;

Design for Disassembly: Ensure that machines can be easily disassembled into components for repair, refurbishment, or recycling at the end of their life;

Eco-design: Incorporate sustainable materials and energy-efficient technologies into the design phase to reduce environmental impact throughout the machine's life cycle;

Standardization of Parts: Use standardized components that can be easily replaced or upgraded, reducing the need for customized parts and simplifying repairs.

8.2. Material Sourcing

Use of Recycled Materials: Prioritize recycled or renewable materials in manufacturing to reduce reliance on virgin resources;

Sustainable Material Sourcing: Source materials from suppliers who adhere to sustainable practices, ensuring the minimization of environmental impacts and ethical labor practices;

Closed-Loop Material Systems: Implement closed-loop systems that allow materials to be continuously recycled and re-used into new products without losing performance.

8.3. Manufacturing and Assembly

Additive Manufacturing (3D Printing): Produce parts on demand using 3D printing to minimize waste and enable on-site production of components;

Lean Manufacturing: Adopt lean manufacturing techniques to reduce waste and energy consumption, also to optimize resource use during production;

Remanufacturing: Implement remanufacturing processes where used machines or components are restored to like-new condition, extending their lifecycle.

8.4. Distribution and Logistics

Efficient Transportation: Optimize logistics to reduce transportation emissions, through route planning, load optimization, and use of electric or low-emission vehicles;

Local Production and Distribution: Encourage local production to shorten transportation distances and associated emissions, while supporting regional economies;

Reusable Packaging: Implement reusable or returnable packaging solutions to minimize packaging waste in the supply chain.

8.5. Use phase and Maintenance

Predictive Maintenance: Utilize IoT and AI technologies to monitor machine performance and predict maintenance needs, reducing unplanned downtime and extending machine life;

Shared Ownership Models: Promote shared ownership or leasing models where machines are used by multiple entities, maximizing utilization and reducing the need for new machines;

Upgrading and Retrofitting: Provide options to upgrade or retrofit machines with the latest technologies rather than replacing them, prolonging their useful life.

8.6. End-of-life Management

Recycling and Material Recovery: Develop systems for the effective recycling of components and recovery of valuable materials at the end of the machine's life;

Reverse Logistics: Implement reverse logistics systems to take back used machines for refurbishment, remanufacturing, or recycling;

Product-as-a-Service (PaaS): Transition from selling machines to offering them as a service, where the manufacturer retains ownership and responsibility for maintenance, upgrades, and end-of-life disposal.

8.7. Refurbishment and Reuse

Component Reuse: Encourage the reuse of functional components from decommissioned machines in the manufacturing of new or refurbished machines;

Refurbishment Programs: Establish refurbishment programs to restore used machines to working condition and resell them, reducing the need for new production;

Marketplaces for Used Machines: Create platforms or marketplaces for selling refurbished or second-hand machines, promoting reuse.

8.8. Waste Management

Zero Waste to Landfill: Implement strategies to ensure that no components of the machine are sent to landfills, through recycling, composting, or other waste management techniques;

Biodegradable or Compostable Components: Design certain components to be biodegradable or compostable, reducing the impact of waste disposal;

Material Recovery Facilities: Develop specialized facilities for recovering and processing materials from end-of-life machines.

9. Business models for circularity in the machine industry

9.1. AUSTRIA

Title of the business model	Cooling system as a service for supermarkets
Business model	Product-as-a-Service model
Business Model Owner website	RUBBLE MASTER HMH GmbH https://www.rubblemaster.com (served as inspiration)
Impact of circular business model: Economic-Ec Social-S Environment-Env Technologic-Tech	Ec: medium S: medium Env: high Tech: medium
Short description of business model:	
<p>The „Cooling-as-a-service“ model encourages the producer to develop long-lasting, modular and efficient cooling system (machine) that facilitates quick and easy replacement or maintenance of components.</p> <p>For producing the machine, the company can use recycled material such as copper and iron. With the modular design, fully functional parts can be reused multiple times, minimizing waste and optimizing resources. In the long run, also other parts, like electronic platins or still usable pipes can be reused, as the material goes always back to the original producer. The risk remains with the provider, driving continuous improvement.</p> <p>Testing will be done firstly in-house. After that, first on premise test with pilot customers will be rolled out, before the product goes onto the market.</p> <p>Customers benefit from after-sales services, including maintenance, upgrades and energy cost sharing based on actual energy usage.</p> <p>This circular business model is in place at RUBBLE MASTER (enterprise) that is a manufacturer of high-performance mobile crushing and screening equipment, and it can be transferred to other companies.</p>	

9.2. BOSNIA AND HERZEGOVINA

Title of the business model	Circular robot lifecycle service
Business model	Circular lifecycle service model
Business Model Owner website	DKR d.o.o https://www.dkr.ba
Impact of circular business model: Economic-Ec Social-S Environment-Env Technologic-Tech	Ec: high S: medium Env: high Tech: medium
Short description of business model:	
<p>Company DKR from Tuzla enables companies in Bosnia and Herzegovina to purchase used industrial robots (mostly from the EU market) that are more affordable than new ones.</p> <p>When selecting a robot, higher-quality components are preferred in view to require fewer replacements and repairs in the long term.</p> <p>In addition to distributing used robots in accordance with the market demand, DKR carries out regular maintenance and servicing processes, which significantly extends their service life.</p> <p>DKR also replaces defective or obsolete parts on robots making them functional again instead of purchasing completely new robots or components. When preparing automated cells, DKR optimizes robot movement in advance and initially purchases quality components in order to avoid failures due to bad parts and extend the life of the system. Parts separated from scrapped robots are tested, overhauled and used as replacements in other robots that need service or repair. In this way, robots and components are given an additional life cycle reducing waste and production costs.</p> <p>Proper waste management significantly reduces the negative environmental impact by reducing electronic waste.</p> <p>This circular business model is in place at DKR and it can be transferred to other companies.</p>	

9.3. CZECH REPUBLIC

Title of the business model	PlastMach EN-SAVE: a set of energy saving measures within plastics technologies
Business models	Database-as-a-Service Model (for energy-saving measures) Knowledge-Based/Training and Instruction model Energy Efficiency Consulting
Business Model Owner (website)	Tomas Bata University in Zlin (Czech Plastics Cluster)
Impact of circular business model: Economic-Ec Social-S Environment-Env Technologic-Tech	Ec: medium S: medium Env: medium Tech: high
Short description of business model:	
<p>The proposed solutions are focused mainly on injection molding and extrusion technologies, which are the two most used and at the same time the most energy-intensive sub-technologies in the field of plastics processing.</p> <p>Every manufacturer has components and parts in their technologies that require attention in terms of their energy consumption and/or efficiency.</p> <p>The business model will focus on creating guidelines and instructions on how to assess (audit) these technological components in terms of their energy sustainability; it will also contain guidelines, instructions and a database of measures that would be appropriate to implement to reduce this energy intensity.</p> <p>The phases of this circular business model are the followings:</p> <ol style="list-style-type: none"> 1) analysis of the condition of electrical components within the company; 2) ECO-design, i.e., selection and characteristics of more energy-efficient components; 3) decarbonization impact; 4) creation of a circular guide for plastics technologies; 5) instruction and training. <p>Dissemination and promotional activities of the system (i.e. the proposed PlastMach ENSAVE solution) are in the preparation phase and their widespread application will take place from 2026.</p>	

9.4. GERMANY

Title of the business model	Closed-Loop Mechanical Recycling for Post-Consumer Plastics
Business model	Closed-loop model
Business Model Owner website	VOGT-PLASTIC GmbH https://vogt-plastic.de
Impact of circular business model: Economic-Ec Social-S Environment-Env Technologic-Tech	Ec: high S: high Env: high Tech: high
Short description of business model:	
<p>Vogt Plastic operates a fully circular business model focused on the mechanical recycling of post-consumer plastic packaging waste, primarily from Germany’s Yellow Bag system. As both a recycler and plastics manufacturer, the company transforms household plastic waste into high-quality secondary raw materials, such as regrinds and granulates, which are then reintroduced into the production cycle.</p> <p>This closed-loop model significantly reduces dependence on virgin materials, lowers CO₂ emissions and conserves natural resources. The core of the model lies in a self-developed, chemical-free recycling process that enables the efficient separation, cleaning and processing of rigid and flexible plastic fractions. The output materials meet stringent quality standards and are used by converters and brands owners across various industries.</p> <p>Vogt Plastic’s approach integrates economic viability with environmental responsibility by creating value from waste and supporting partners in achieving their own circularity goals. As such, the company is not only closing material loops but also actively shaping a resilient and sustainable plastics economy.</p> <p>This business model is in place in Vogt-Plastic GmbH and can be transferred to other companies.</p>	

9.5. HUNGARY

Title of the business model	PLA filaments to replace traditional materials
Business model	On-demand customization model
Business Model Owner website	Filaticum Kft. www.filaticum.com
Impact of circular business model: Economic-Ec Social-S Environment-Env Technologic-Tech	Ec: high S: medium Env: high Tech: medium
Short description of business model:	
<p>Plasticum develops new PLA-based filaments on-demand and based on their own property research.</p> <p>Their 30+ filaments can be further tailored to meet specific industrial needs (i.e., thermal or electric conductivity; antibacterial or antiviral properties; chemical resistance; impact resistance; weight requirements etc.).</p> <p>The PLA base is created from corn starch, a renewable resource; end products, after correct treatment, are usually compostable or mechanically/chemically recyclable.</p> <p>The PLA filaments have been proven to be able to replace materials with high environmental costs, such as aluminium, oil-based petroleum, glass or gypsum.</p> <p>The additive process of 3D printing ensures minimal waste, shortened supply chains, quicker feedback, and more precise control of the end product-and through on-the-spot printing of machinery parts, empowers users to repair their own machines.</p> <p>The business model is in place in Filaticum Kft. and can be transferred to other companies.</p>	

9.6. REPUBLIC OF MOLDOVA

Title of the business model	Circular business Model for sustainable
Business model	Circular lifecycle business model
Business Model Owner website	MGM Moldova https://www.mgm.md
Impact of circular business model: Economic-Ec Social-S Environment-Env Technologic-Tech	Ec: medium S: medium Env: medium Tech: medium
Short description of business model:	
<p>MGM LTD adopts a circular business model by integrating circular economy principles into the lifecycle of plastic processing machinery.</p> <p>The company focuses on designing durable, repairable and upgradeable machines, extending product life through maintenance services and reintroducing used equipment into the market through refurbishment and resale.</p> <p>Moreover, MGM supports clients in transitioning to circular plastic use by offering customized solutions that enable recycling, reuse and energy-efficiency processing.</p> <p>Through modular design, closed-loop service systems and strategic partnerships for material recovery and repurposing, MGM shifts from a linear „make-use-dispose“ model to a regenerative model that minimizes waste, maximizes resource efficiency and creates long-term value for both the company and its clients.</p> <p>MGM begins by designing machines with a focus on durability, modularity and easy repair and upgrade. This approach extends the machine’s lifespan and reduces waste.</p> <p>The business model is in place in MGM SRL, a private company operating in the manufacturing sector, specializing in machinery for the plastics industry.</p>	

9.7. ROMANIA

Title of the business model	Sustainable and efficient industrial automation through modular design and interchangeable components
Business model(s)	Modular design model
Business Model Owner website	EURODAC SRL https://eurodac.ro
Impact of circular business model: Economic-Ec Social-S Environment-Env Technologic-Tech	Ec: medium S: medium Env: medium Tech: medium
Short description of business model:	
<p>The circular business model of EURODAC is based on the use of interchangeable components, simple and efficient designs and easy maintenance. The working teams ensure a complete production cycle, from design to commissioning, minimizing waste and maximizing the lifespan of equipment. The model contributes to sustainability and operational efficiency.</p> <p>The phases of the circular business model are the following:</p> <p>Design and planning: Simple and efficient construction solutions are selected using interchangeable components to ensure durability and ease of maintenance.</p> <p>Execution and production: Equipment is manufactured using high-quality materials and parts are machined and assembled in house to reduce waste and optimize resources.</p> <p>Testing and validation: After assembly, the equipment undergoes functional testing to ensure performance and reliability. Commissioning and training: EURODAC teams install the equipment at the client’s site and train staff for operation and maintenance.</p> <p>Ongoing support and maintenance: EURODAC provides fast technical support and spare parts to maximize equipment efficiency.</p> <p>This circular business model is implemented by EURODAC and can be transferred to other companies.</p>	

9.8. SERBIA

Title of the business model	Modular Machine Design Platform
Business model(s)	Modular design model
Business Model Owner website	Innovation Center Faculty of Mechanical Engineering ICMF Belgrad www.inovacionicentar.rs
Impact of circular business model: Economic-Ec Social-S Environment-Env Technologic-Tech	Ec: high S: medium Env: high Tech: medium
Short description of business model:	
<p>The Modular Machine Design Platform is a cloud-based design system that enables engineers to create industrial machines using a library for standardized, modular and eco-friendly components.</p> <p>Each component is designed for ease of disassembly, recyclability and environmental sustainability.</p> <p>The platform includes integrated tools for real-time environmental impact assessment, guiding users to minimize the carbon footprint, water consumption and material waste of their designs.</p> <p>By promoting modularity, eco-design and circularity from the very beginning of a machine's life cycle, this solution facilitates repair, reuse and refurbishment, extending the machine's lifespan and radically reducing environmental impact.</p> <p>Its scalability allows application across a wide array of industries with high implementation potential in Serbia's evolving industrial ecosystem.</p> <p>This circular business model is developed within the Innovation Center of the Faculty of Mechanical Engineering ICMF of Belgrad.</p>	

9.9. SLOVAKIA

Title of the business model	Sustainable Recycling Process of Plastic Materials
Business model(s)	Recycling business model
Business Model Owner website	Faculty of Manufacturing Technologies, Technical University of Kosice https://slovnaft.sk/sk/o-nas/pre-media/tlacove-spravy/?1=1&start=10#spolocnost-slovnaft-vyvinula-vlastny-inovativny-material-pre-3d-tlac
Impact of circular business model: Economic-Ec Social-S Environment-Env Technologic-Tech	Ec: medium S: high Env: high Tech: medium
Short description of business model:	
<p>Recycling plastics is the one way to reduce their negative impact on the environment, limit the extraction of raw materials and reduce the amount of waste in landfills.</p> <p>Sustainable Recycling Process of Plastic Materials is focused on:</p> <ul style="list-style-type: none"> • Energy consumption is reduced compared to the production of new plastics. • The carbon footprint of the process is reduced. • The loss of material quality is minimized so that it can be reused in production (so-called closed loop). • The recycling rate is increased through efficient sorting and technologies. • Social and economic aspects, such as the availability of infrastructure and the motivation of residents to sort waste, are considered. <p>Recyclability and remanufacturing of plastics are key strategies to reduce the plastic industry's ecological footprint. This circular business model is in place in the Faculty of Manufacturing Technologies, Technical University of Kosice.</p>	

10. Conclusions

The transition towards **circularity in the machine industry** is no longer optional but essential for **economic resilience, environmental sustainability, and long-term competitiveness**. The **Plan-C project** demonstrates that through **collaboration, design thinking, and innovative business models**, the Danube Region can take meaningful steps toward a **circular economy**.

Key findings of this handbook highlight that:

- **Circularity brings tangible economic benefits**, including cost savings, new revenue opportunities, and greater supply chain resilience.
- **Design for circularity**—focusing on durability, modularity, repairability, and resource efficiency—offers practical pathways to extend machine lifecycles and reduce waste.
- Successful transformation requires systemic **cooperation across borders, industries, and stakeholders**, with strong **policy support** and investment in circular infrastructure.
- **Innovative business models**, from “product-as-a-service” to modular design platforms, are already being tested in the Danube region and can serve as **replicable examples** for wider industry adoption.

Looking ahead, **integrating circular principles** into regional and national strategies, along with targeted **capacity building** and **awareness-raising**, will be decisive. By embracing these practices, the **machine industry in the Danube Region** can position itself as a **driver of sustainable growth**, turning today’s challenges into tomorrow’s opportunities.

The approaches, tools, and business models presented in this handbook provide a **replicable framework for other regions and industries**, demonstrating that sustainable industrial transformation is both feasible and economically viable. Through collective effort, knowledge sharing, and continued innovation, the circular transition can become a defining feature of modern manufacturing, **creating resilient, regenerative, and competitive industrial ecosystems**.