Interreg Danube Region

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Business model development for circularity in the machine industry

Deliverable 2.3.1.

Responsible Partner: CLUSTERO

Table of Contents

INTRODUCTION 3
SHORT INTRODUCTION TO THE PLAN-C PROJECT 5
AUSTRIA 6
BOSNIA AND HERZEGOVINA 7
CZECH REPUBLIC 8
GERMANY 9
HUNGARY 10
REPUBLIC OF MOLDOVA 11
ROMANIA 12
SERBIA 13
SLOVAKIA 14
CONCLUSION 15
ANNEXES - CIRCULAR BUSINESS MODELS OF THE PARTNERS 17
AUSTRIA 17
BOSNIA AND HERZEGOVINA 23
CZECH REPUBLIC 29
GERMANY 34
HUNGARY 41
REPUBLIC OF MOLDOVA 44
ROMANIA 48
SERBIA 53
SLOVAKIA 56

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INTRODUCTION

A circular business economy is a sustainable economic model that shifts away from the traditional "take-make-dispose" approach, aiming to minimize waste and pollution by keeping products and materials in use for as long as possible. This is achieved through strategies like reuse, repair, refurbishment, remanufacturing, and recycling, effectively creating a closed-loop system.

The key aspects of a circular business economy are:

Core Principles:

- **Reduce**: Minimizing material use and waste generation from the outset.
- **Reuse**: Extending the lifespan of products through various means like repair, refurbishment, and remanufacturing.
- **Recycle**: Recovering materials from discarded products to create new ones.
- **Regenerate**: Restoring natural systems and ecosystems, going beyond simply reducing harm to actively improving them.

Business Models:

Circular economy principles can be integrated into various business models:

- **Product as a service**:

Instead of selling products, businesses offer access to them through leasing, renting, or subscription models, retaining ownership for maintenance and end-of-life management.

- **Sharing economy**:

Facilitating the sharing of underutilized products like vehicles or equipment through platforms.

- **Product life extension:**

Designing products for durability, repairability, and upgradability.

- **Material recovery:**

Implementing systems to collect and recycle or reuse materials from products at the end of their useful life.

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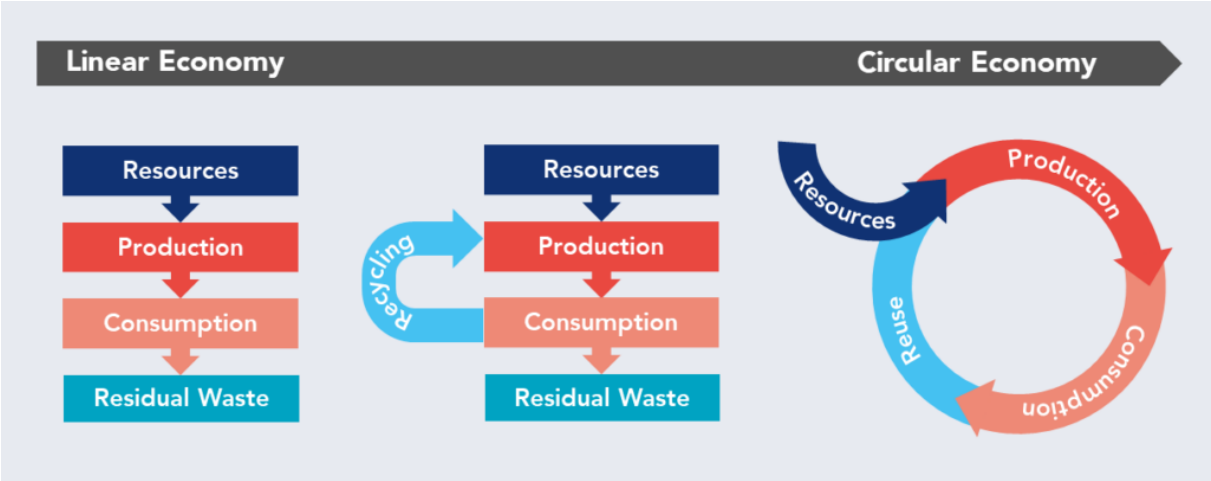
Benefits:

- **Resource efficiency**: Reduces reliance on virgin resources and conserves natural resources.
- **Waste reduction**: Minimizes the amount of waste sent to landfills and incinerators.
- **Environmental protection**: Reduces pollution, greenhouse gas emissions, and other environmental impacts.
- **Economic opportunities**: Creates new markets for recycled materials, repair services, and innovative business models.
- **Supply chain resilience**: Reduces dependence on volatile global markets for raw materials.
- **Brand value**: Enhances brand reputation and customer loyalty by demonstrating commitment to sustainability.



The transnational mapping and analysis of status quo in machine (plastics) industry as well as the circular business models in the Danube region contribute to the identification of the state-of-the-art in the plastics machine industry, to the assessment of challenges and opportunities from key actors and stakeholders in regards of the development of a circular plastics industry and the analysis of machine life phases of the current linear economy.

In each of the participating countries in the Danube Region, machine-engineering (plastics) companies can be found that have implemented aspects of the circular economy in their production processes, waste management and corporate policies in general and can thus set an example for other companies across the region and Europe.

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SHORT INTRODUCTION TO THE PLAN-C PROJECT

Moving PLastics and mAchine iNdustry towards Circularity (Plan-C) is an INTERREG project focusing on the Danube region. The project consortium consists of 14 project partners from 9 countries (AT, BiH, CZ, DE, HU, MD, RO, RS, SK) whose regions are part of the Danube Region.

Specific objective 2 of the Plan C project is to demonstrate the MACHINE INDUSTRY in the Danube Region how to transform towards a circular economy in practice using a design thinking methodology. To cope with the challenges of the machine industry in regard to circularity (problem space), project partners and companies create and prototype innovative machine life cycle phases (solution space) and derive business models from that, along the whole machine life cycle, summarized as circular machine solution (transfer phase). The machine industry has just started to move towards circular economy in most of the Plan-C countries.

Activity 2.3 Transfer Phase: from life cycle solutions to the co-creation of circular business models for the regional/transnational (plastics) machine industry of the Danube Region has as a main purpose in the period 3 to transfer the results from A 2.1 (Problem space: From a joint understanding of machine industry challenges to a synopsis of industry/user demand) and A 2.2 (Solution Space: From design thinking of the life cycle phases to the development of circular solutions in the machine industry) into **business models for circularity in machine industry** for the aspects

- back to producer &remanufacturing and
- regional centres for refurbishment and
- the business models for end-of-life solutions for re-use and
- waste management & recycling.

Deliverable 2.3.1 presents different types of business models in the machine (and plastics) industry both developed by the project partners and by companies that adopt circular concepts because they are profitable for their business and which can be transferred to other companies.

The developed circular business models are in the annex of this report, with detailed explanations of each circular business model phase (design and development; material sourcing; manufacturing and assembly; distribution and logistics; use and maintenance; end-of-life management; refurbishment and reuse; waste management and recycling) and their economic, social, environmental and technological impact . In this report we present shortly the business models and their owner.

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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:

„Cooling as a service" model encourage the producer to develop long-lasting, modular and efficient cooling system (machine) that facilitates quick and easy replacement or maintenance of components.

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 platines 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.

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.

Customers benefit from after-sales services, including maintenance, upgrades and energy cost sharing based on energy usage.

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.

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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** **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:	
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. When selecting a robot, higher quality components are preferred in view to rerquire fewer replacements and repairs in the long term. 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. DKR also replaces defective or obsolete parts on robots making them functional again instead of purchasing completly 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. Proper waste management significantly reduces the negative environmental impact by reducing electronic waste. This circular business model is in place at DKR and it can be transferred to other companies.	

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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)	**Thomas 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:

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.

Every manufacturer has components and parts in their technologies that require attention in terms of their energy consumption and/or efficiency.

The business model will focus on creating guidelines and instructions on how to assess (audit) these technological components in terms of their energy sustainability; and will also contain guidelines, instructions and a database of measures that would be appropriate to implement in order to reduce this energy intensity.

The phases of this circular business model are the followings:

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+training.

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.

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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:	
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. This closed-loop model significanly 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 brans owners across various industries. 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. This business model is in place in Vogt-Plastic GmbH and can be transferred to other companies.	

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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:

Plasticum develops new PLA-based filaments on-demand and based on their own property research.

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).

The PLA base is created from corn starch, a renewable resource; end products, after correct treatment, are usually compostable or mechanically/chemically recyclable.

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.

The additive process of 3D printing ensures minimal waste, shortened supply chains, quicker feedback, more precise control of the end product-and through on-the-sport printing of machinery parts, empowers users to repair their own machines.

The business model is in place in Filaticum Kft. And can be transferred to other companies.

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:	
MGM LTD adopts a circular business model by integrating circular economy principles into the lifecycle of plastic processing machinery. 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. Moreover, MGM supports clients in transsitioning to circular plastic use by offering customized solutions that enable recycling, reuse and energy-efficiency processing. 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. 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. The business model is in place in MGM SRL, aprivate company operating in the manufacturing sector, specializing in machinery for the plastics industry.	

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:

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.

The phases of the circular business model are the followings:

Design and planning: Simple and efficient construction solutions are selected using interchangeable components to ensure durability and ease of maintenance.

Execution and production: Equipment is manufactured using high-quality materials and parts are machined and assembled in house to reduce waste and optimize resources.

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.

Ongoing support and maintenance: EURODAC provides fast technical support and spare parts to maximize equipment efficiency.

This circular business model is in place in EURODAC company and can be transferred to other companies.

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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:

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-frinedly components.

Each component is designed for ease of disassembly, recyclability and environmental sustainability.

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.

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.

Its scalability allows application across a wide array of industries with high implementation potential in Serbia's evolving industrial ecosystem.

This circular business model is developed within the Innovation Center of the Faculty of Mechanical Engineering ICMF of Belgrad.

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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:

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 land fills.

Sustainable Recycling Process of Plastic Materials is focused on:

- 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.

Recyclability and remanufacturing of plastics are key 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.

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CONCLUSION

In the Danube Region countries have different levels of development of the plastics processing machinery industry and of the stage of transition to the circular economy. However, the principles of the circular economy promise significant environmental, social, technological as well as economic benefits and increased competitiveness.

The analysis of the circular business models of the 9 project countries reflects the following aspects:

- **Diverse approaches reflect local industry needs and different strategies**

The nine circular business models presented reflect a broad spectrum of strategies tailored to local industrial capabilities and environmental priorities. While some countries emphasize reuse and refurbishment (e.g., Bosnia and Moldova), others lead with advanced recycling (Germany, Slovakia) or eco-design platforms (Serbia).

- **Common commitment to circular economy as a key to economic resilience and sustainability**

Despite different approaches, all models share a commitment to circular economy principles such as design for longevity, reuse, modularity, and closed-loop systems. This alignment suggests a growing regional awareness of circularity as a key to economic resilience and environmental sustainability.

- **Variation in maturity and technological readiness that highlights the uneven maturity of circular practices across the Danube Region**

Countries like Germany, Hungary, and the Czech Republic present highly technical or well-established models with strong environmental and technological impacts, while others such as Moldova and Romania focus more on modularity, efficiency, and practical implementation.

- **Economic and environmental impact lead the way**

Most models report high economic and environmental benefits, validating that circularity is not only an ecological imperative but also a business opportunity. Technological and social impacts are generally moderate, indicating potential for future development in workforce engagement and innovation.

- **Transferability of models**

A significant number of models are already implemented in real companies and proven to be functional. This confirms their scalability and transfer potential across borders and industries, enabling broader uptake in the Danube region and beyond.

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- **Role of research and education**

Models initiated by universities and innovation centers (e.g., Czech Republic, Serbia, Slovakia) underline the importance of academic institutions in piloting and disseminating circular practices through knowledge transfer, training, and platform development.

- **Need for policy and infrastructure support**

Several models (e.g., Slovakia, Czech Republic) imply that policy alignment, citizen participation, and infrastructure (e.g., for recycling or repair) are essential for circular strategies to succeed at scale. Effective regulation and incentives will further encourage companies to adopt such models.

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ANNEXES - CIRCULAR BUSINESS MODELS OF THE PARTNERS

AUSTRIA

TITLE OF THE CIRCULAR BUSINESS MODEL	Cooling system for supermarkets (Hauser GmbH) – Cooling System as a Service

1. DESCRIPTION OF CIRCULAR BUSINESS MODEL

During the workshop, we looked into the Product-as-a-Service model with the company and participants and called it "Cooling as a Service". The aim is to increase system longevity and efficiency while building stronger customer relationships. Customers benefit from after-sales services, including maintenance, upgrades and energy cost sharing based on energy usage. Furthermore, in case of sustainability, the company plans to make use of the heat by introducing a heat recovery system.

Under this circular approach, the producer is encouraged to develop long-lasting, modular and efficient cooling system (machine). The risk remains with the provider, driving continuous improvement.

2. DESCRIPTION OF CIRCULAR BUSINESS MODEL PHASES:

Design:
The company will design a long-lasting and efficient cooling system / machine with a modular design that facilitates quick and easy replacement or maintenance of components.

Production & Sourcing:
For producing the machine, the company can use recycled material such as copper and iron. Moreover, 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 platines or still usable pipes can be reused, as the material goes always back to the original producer.

Testing and Validation:
Testing will be done firstly in-house, to validate the full functionality of the system and to ensure a closed system, in a modular machine. After that, first on premise test with pilot customers will be rolled out, before the product goes onto the market.

Distribution:
Alongside its well-established repair and maintenance services, the company is adopting new logistics approaches to manage the pickup and delivery of machines after customer use.

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Ongoing Support and Maintenance:
After customer use, machines are returned for inspection, maintenance, and potential upgrades or retrofitting. With support from data tracking systems, maintenance needs can be predicted in advance.

Reuse, Refurbishment & Remanufacturing:
Modular, long-lasting design enables easy part replacement and remanufacturing. Furthermore, as long as the machine remains reusable, it will be refurbished, with reusable parts being utilized again.

Then the machine will be distributed to a new customer, with as good as new label.

Waste management:
After a machine/part cannot be used again, the material within the part will be recovered through established contractor for material recovery.

2.1 Design and development (Design for Longevity, Design for Disassembly, Eco-design, Standardization of Parts)

Design for Longevity:
By combining optimized process parameters with expert maintenance, the machine's lifecycle is significantly extended. Its design emphasizes durability, robustness, and long-term reliability—supporting both sustainability and cost-efficiency.

Design for Disassembly:
Modular cooling systems are designed with standardized, tool-free connections to enable easy disassembly, simplifying maintenance and accelerating repairs.

Eco-Design:
The cooling system is designed to minimize energy use, waste, and harmful materials. Its modular construction and efficient components enable easy maintenance, longer lifespan, and lower environmental impact. Additionally, the company plans to make use of the heat by introducing a heat recovery system.

Standardization of Parts:
The cooling system, designed for use across all supermarkets, features modular and standardized components. This approach enables easy maintenance, lower operational costs, and fast availability of spare parts.

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2.2 Material sourcing (Use of Recycled Materials, Sustainable Material Sourcing, Closed-Loop Material Systems)

Use of Recycled Materials:
Using recycled materials like copper and iron is a viable option in producing the machine. Furthermore it is possible to use recycled material for the different parts of the machine, as long as they are still in good shape (especially safety concerns).

Sustainable Material Sourcing:
The company uses high-quality materials and creates a smart design to ensure longevity and durability and energy efficiency.

Closed-Loop Material Systems:
Replaced parts can be refurbished or recycled, and the modular design allows fully functional components to be reused multiple times for other machines, which contributes to reducing waste and maximizing resource efficiency.

2.3 Manufacturing and assembly (Additive Manufacturing, Lean Manufacturing, Remanufacturing)

Lean manufacturing:
The company applies lean principles by offering durable, easy-to-maintain cooling systems as a service, reducing waste and boosting energy efficiency through proactive care and a heat recovery system.

Remanufacturing:
The cooling system / machine is designed modularly. This facilitates the reuse, repair or replacement of the components, minimizing costs and extending the lifecycle.

2.4 Distribution and logistics (Efficient Transportation, Local Production and Distribution, Reusable Packaging)

Efficient Transportation:
The company plans to use efficient transport and offers machine pick-up and delivery after customer use, complementing existing repair services.

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Local Production and Distribution:
As the company offers services today, they can use their different locations to distribute and return the machines and maintenance services. That could include the inspection and replacement of parts, at the end-of-life the machine will be transferred to a main hub (in Europe the production site), to recycle parts and material.

Reusable Packaging:
Using reusable packaging for transporting machines would support sustainability and lead to significant cost savings.

2.5 Use and maintenance (Predictive Maintenance, Shared Ownership Models, Upgrading and Retrofitting)

Predictive Maintenance:
During the use phase there is a black box in the machine, in which data is collected. Thus, it is possible to predict when maintenance is needed. Further, AI prediction systems can be used, to evaluate the data to make maintenance more efficient.

Shared Ownership Models:
In the case of PaaS, the product is owned by the producer.

Upgrading and Retrofitting:
As the machine is modularly designed and has standardized parts, it can be easily upgraded, maintained and repaired. The modular design significantly helps extend the machine's lifecycle.

2.6 End-of-life management (Recycling and Material Recovery, Reverse Logistics, Product-as-a-Service)

Recycling and Material Recovery:
Recycled materials are used where possible, and the modular design enables easy repair and remanufacturing. When parts are no longer usable, materials are recovered by contractors to maximize economic and environmental benefits.

Reverse Logistics:
Customers receive after-sales services such as maintenance, upgrades, and energy cost sharing based on usage. The machine is always returned to the provider, who handles refurbishment, replacement, and upgrades, thereby reducing waste.

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Product-as-a-Service:
This circular business model focuses on customized leasing or rental solutions that include maintenance, reducing initial investment and maximizing long-term use. The company retains ownership of the machine and assumes the risk in case of failure. After customer use, machines are returned for repair or refurbishment using existing capacity.

2.7 Refurbishment and reuse (Component Reuse, Refurbishment Programs, Market for Used Machines)

Component Reuse:
Thanks to the modular design, fully functional parts can be reused multiple times, minimizing waste and optimizing resources.

Refurbishment Programs:
The company keeps updating, refurbishing and focusing on maintaining the cooling system.

Market for Used Machines:
With the constant maintenance, retrofitting and refurbishment, they are able to sell the cooling system to new customers as good as new.

2.8 Waste management and recycling (Zero Waste to Landfill, Biodegradable or Compostable Components, Material Recovery Facilities, Circular Waste-to-Resource Solutions)

Zero Waste to Landfill:
By optimizing production processes and efficient design, the company is able to minimize generated waste. Furthermore, with the modular design it is possible to reuse components and also increase recycling in the production.

Material Recovery Facilities:
In the first part, the producer itself will disassemble the machine and reuse parts, which are still fit to be used. All other parts will be given to a recycling factory, to recover valuable materials like iron, copper and other metals (main materials of the machines).

Circular Waste-to-Resource Solutions:
Returned machines undergo assessment following customer use. Defective or worn parts are checked for potential refurbishment or reuse. Parts unsuitable for reuse are recycled and replaced with new, high-quality material.

<table>
<tr><td colspan="7">3. IMPACT OF CIRCULAR BUSINESS MODEL</td></tr>
<tr><td rowspan="2">Economic impact</td><td colspan="6">It supports cost savings through optimized resource use and waste reduction, aligning with circular economy principles. For providers, it creates steady and predictable revenue streams through ongoing service contracts, enhancing financial stability.
Customers benefit from lower upfront costs by switching from buying to leasing or subscription models, which makes the product more affordable and improves cash flow.</td></tr>
<tr><td>☐</td><td>reduced</td><td>☒</td><td>medium</td><td>☐</td><td>high</td></tr>
<tr><td rowspan="2">Social impact</td><td colspan="6">By lowering initial costs, PaaS makes quality products accessible to more companies. It also fosters long-term customer relationships. Since providers retain ownership, there is greater incentive to offer high-quality, durable products and responsive service, improving the overall user experience.</td></tr>
<tr><td>☐</td><td>reduced</td><td>☒</td><td>medium</td><td>☐</td><td>high</td></tr>
<tr><td rowspan="2">Environmental impact</td><td colspan="6">Offering Product-as-a-Service systems helps reduce environmental impact by extending product life through regular maintenance, upgrades, and repairs, resulting in less waste. Furthermore, the modular design allows for easy disassembly and reuse of components.</td></tr>
<tr><td>☐</td><td>reduced</td><td>☐</td><td>medium</td><td>☒</td><td>high</td></tr>
<tr><td rowspan="2">Technological impact</td><td colspan="6">The cooling system is designed to be modular, durable, and upgradeable, allowing for longer use and easier servicing. A built-in black box collects performance data during operation, enabling predictive maintenance and energy optimization. Continuous feedback supports faster improvements and targeted upgrades, benefiting both provider and customer.</td></tr>
<tr><td>☐</td><td>reduced</td><td>☒</td><td>medium</td><td>☐</td><td>high</td></tr>
<tr><td>4. Is there already circular business model in place that can be implemented for a pilot solution, and which can be transferred to other companies?</td><td colspan="6">YES:
• RUBBLE MASTER (enterprise): Manufacturer of high-performance mobile crushing and screening equipment
Mobile Crushers & Screens | RUBBLE MASTER</td></tr>
</table>

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BOSNIA AND HERZEGOVINA

TITLE OF THE CIRCULAR BUSINESS MODEL	DKR d.o.o. - Circular robot lifecycle service

1. DESCRIPTION OF CIRCULAR BUSINESS MODEL

Company DKR from Tuzla enables companies in Bosnia and Herzegovina to purchase used industrial robots that are more affordable than new ones. In addition to distributing used robots in accordance with market demand, DKR carries out regular maintenance and servicing processes, which significantly extends their service life. 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.

2. DESCRIPTION OF CIRCULAR BUSINESS MODEL PHASES:

Material sourcing:

- Procurement of used robots (mostly from EU market).
- When selecting a robot, higher quality components are preferred that will require fewer replacements and repairs in the long term.

Manufacturing & assembly:

- After procurement, the robot undergoes an initial assessment of its technical condition, necessary interventions are identified and damaged or defective parts are replaced to make the robot functional again.
- At this stage, individual components or larger robot assemblies are replaced if necessary.

Distribution & logistics:

- After overhaul, the used robot is distributed to the client within Bosnia and Herzegovina.
- Logistics for delivery and installation of the robot in the user's production facility are organized.

End-of-life management:

- In the event of major failures or technical problems, instead of replacing the robot with a new one, DKR again performs a detailed assessment of the possibility of repair or replacement of parts.
- If a robot is deemed unprofitable for further use in its original state, useful parts are separated from it and can be reused.

Refurbishment & reuse:

- 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.

Waste management & recycling:

- Parts that are not suitable for reuse are separated and recycled in accordance with local regulations.
- Proper waste management significantly reduces the negative environmental impact by reducing electronic waste.

2.1 Design and development (Design for Longevity, Design for Disassembly, Eco-design, Standardization of Parts)

Design for Longevity:
DKR initially procures and uses high-quality components when preparing automated robot systems in order to prevent failures caused by poor quality parts. With regular preventive maintenance (maintenance & servicing), the long-term functionality of the robots is ensured and their overall lifespan is significantly extended.

Design for Disassembly:
DKR performs robot servicing in a way that allows for easy replacement of parts. The robot is designed so that components can be quickly and easily dismantled and replaced, without the need for complex procedures and special tools.

Eco-design:
Already in the design and maintenance phase of the robot, DKR identifies components that can later be recycled or reused. This reduces the amount of waste generated after the end of the useful life of the components.

Standardization of Parts:

DKR prefers and applies standardized, high-quality components, which allows for easier replacement and maintenance of robot parts.

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2.2 Material sourcing (Use of Recycled Materials, Sustainable Material Sourcing, Closed-Loop Material Systems)
Use of Recycled Materials: DKR reuses high-quality parts taken from defective or scrapped robots, which reduces the need for new raw materials. **Sustainable Material Sourcing:** When sourcing used robots from the EU and other markets, DKR selects higher-quality robots and components that require fewer replacements in the long run, reducing overall material consumption. **Closed-Loop Material Systems:** By reusing robot parts in the overhaul process, DKR maintains a closed material loop that maximizes the use of existing resources.
2.3 Manufacturing and assembly (Additive Manufacturing, Lean Manufacturing, Remanufacturing)
Remanufacturing: DKR performs the remanufacturing process through a detailed assessment, refurbishment and replacement of parts of used robots to make them functional again.
2.4 Distribution and logistics (Efficient Transportation, Local Production and Distribution, Reusable Packaging)
Efficient Transportation: DKR organizes logistics for the delivery of refurbished robots to clients in BiH with optimization of transport routes. **Local Production and Distribution:** Robot servicing, maintenance and refurbishment are carried out locally in Tuzla, reducing transport distances and emissions associated with transport.
2.5 Use and maintenance (Predictive Maintenance, Shared Ownership Models, Upgrading and Retrofitting)
Predictive Maintenance: DKR carries out preventive and regular maintenance ("maintenance & servicing") with the aim of timely detection of potential failures and extending the service life of the robot.

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Upgrading and Retrofitting: DKR replaces defective robot parts with new or repaired parts, thereby improving the performance of existing equipment and extending its service life.
2.6 End-of-life management (Recycling and Material Recovery, Reverse Logistics, Product-as-a-Service)
Recycling and Material Recovery: After a detailed assessment, robot parts that are no longer suitable for repair or refurbishment are sent for recycling in accordance with local regulations.
2.8 Refurbishment and reuse (Component Reuse, Refurbishment Programs, Market for Used Machines)
Component Reuse: DKR systematically tests and repairs parts extracted from scrapped robots, and returns them to use. **Market for Used Machines:** DKR responds to market demand in BiH by offering refurbished used robots, providing local companies with a more affordable alternative to purchasing new equipment and getting closer to digital transformation.
2.8 Waste management and recycling (Zero Waste to Landfill, Biodegradable or Compostable Components, Material Recovery Facilities, Circular Waste-to-Resource Solutions)
Zero Waste to Landfill: Through reuse and recycling of parts, DKR significantly reduces the amount of waste destined for landfills. **Material Recovery Facilities:** DKR collaborates with specialized local recycling facilities to which it hands over unusable parts for material recovery. **Circular Waste-to-Resource Solutions:** Through the renovation and reuse of robot parts, DKR continuously maintains a circular system that transforms potential waste into a resource for further production and servicing.

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3. IMPACT OF CIRCULAR BUSINESS MODEL Please describe the impact of circular business model and check (the box) the degree of impact (reduced, medium, high)						
Economic impact	DKR's circular approach significantly reduces upfront investment costs for companies in Bosnia and Herzegovina by providing refurbished robots, making automation accessible for SMEs and enterprises that would otherwise not invest in expensive new equipment.					
	☐	reduced	☐	medium	☒	high
Social impact	By providing more affordable robotic solutions, DKR enables local companies to sustain competitiveness and maintain or potentially increase employment. Additionally, this approach actively supports the advancement of Industry 4.0 and facilitates digital transformation, making these concepts more accessible and understandable to B&H society.					
	☐	reduced	☒	medium	☐	high
Environmental impact	The refurbishment, reuse, and maintenance services significantly extend the life span of industrial robots, therefore reducing electronic waste and the environmental impact associated with manufacturing new robots. This approach leads to fewer resources consumed and less waste generated.					
	☐	reduced	☐	medium	☒	high
Technological impact	DKR's model demonstrates the feasibility of optimizing robotic systems for longevity through quality component selection and regular maintenance, creating a replicable technical framework for other companies in the region. It promotes a wider acceptance of automation technologies through practical and affordable solutions.					
	☐	reduced	☒	medium	☐	high

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4. Is there already circular business model in place that can be implemented for a pilot solution, and which can be transferred to other companies?	Yes: DKR d.o.o. SME www.dkr.ba

CZECH REPUBLIC

TITLE OF THE CIRCULAR BUSINESS MODEL	PlastMach EN-SAVE: a set of energy saving measures within plastics technologies

1. DESCRIPTION OF CIRCULAR BUSINESS MODEL

Producers in the plastics industry an unrivalled range of particularly efficient plant and system technology. In view of the massive rise in energy prices and the Energy Efficiency Act passed last year, our range of services is in high demand. This means that plastics processors can find system technology from cooling systems to heat recovery, ventilation and clean room technology to dynamic mould temperature control, all geared towards the efficient and sustainable use of energy.

The proposed solutions are focused mainly on injection molding and extrusion technologies, which are the 2 most used and at the same time the most energy-intensive sub-technologies in the field of plastics processing.

Absolutely every manufacturer has components and parts in their technologies that require attention in terms of their energy consumption and/or efficiency. ***The business model will focus on creating guidelines and instructions on how to assess (audit) these technological components in terms of their energy sustainability; and will also contain guidelines, instructions and a database of measures that would be appropriate to implement in order to reduce this energy intensity.***

2. DESCRIPTION OF CIRCULAR BUSINESS MODEL PHASES:

Phase 1 – Analysis of the condition of electrical components within the company:

This phase must always be carried out for individual machines and equipment and individual components must be defined; it also includes measuring or estimating energy consumption.

Phase 2 - ECO-design - i.e. selection and characteristics of more energy-efficient components

In this phase, an optimized solution is proposed with the participation of experts and an impact study and investment plan are prepared.

Phase 3 - Decarbonization impact:

Not all partial measures can have a positive decarbonization effect from the point of view of various co-sequences; here it is necessary to perform a comprehensive Dual Importance Analysis and it is necessary to take into account all aspects including:

- is it really necessary to replace the part in terms of its age?!
- are the newly designed components sustainable in the long term in terms of maintenance, service life, serviceability, etc.?!

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- am I able to effectively and meaningfully recycle the original (replaced) components or pre-recycle them?!

Phase 4 - Creation of a circular guide for plastics technologies:

Based on the input analyses described above, a manual will be created containing instructions, guidelines and models on how to assess one's own technological energy efficiency and, most importantly, what measures can be implemented in a sophisticated way to achieve a real decarbonization effect in this area as well - i.e. production technologies and machines.

Phase 5 - Instruction + training

Here, the focus is on dissemination on the one hand, but also on offering companies some oversight of the entire process of analysis, design and implementation.

2.1 Design and development (Design for Longevity, Design for Disassembly, Eco-design, Standardization of Parts)

The proposed (and in the future applied) solution will have the effect of reducing the consumption of electrical energy for these processes by up to 20% of the total consumption. It is also essential that both components of the solution are portable and can be used as modules for other or similar or reconditioned technologies. Their service life is therefore not related to the technological service life of a specific device.
It is clear that the application of the technological additions described within PlastMach ENSAVE individual projects will clearly lead to energy cost savings and thus to a reduction in overall production costs and an increase in the competitiveness of the manufacturer. At the same time, it is a tool for reducing carbon emissions, which will be monitored from 2025 (for energies within SCOPE 1 and 2 in ESRS reporting) in all large and later medium-sized and small enterprises.

2.2 Material sourcing (Use of Recycled Materials, Sustainable Material Sourcing, Closed-Loop Material Systems)

The contribution of the proposed solution to achieving the goals of the circular industry lies in the area of reducing the energy intensity of production and thus in reducing CO2 emissions calculated per unit of production. The proposed solution enables the long-term (even permanent) use of this technological innovation within the framework of long-term low-emission goals.

The proposed solution (implemented according to the instructions developed within the framework of PlastMach ENSAVE rules) best fits the category of minimizing inputs to the production process - it is not on the material side, but on the energy side. At the same time, the implemented partial measures must have a positive effect on the machine components used - in terms of service life, their recyclability or reuse, etc.
2.3 Manufacturing and assembly (Additive Manufacturing, Lean Manufacturing, Remanufacturing)
In this area, the proposed PlastMach ENSAVE solution does not set any high ambitions. Of course, it is likely and expected that AM technologies will be used, there will be an effort to use components that are reusable, etc.
2.4 Distribution and logistics (Efficient Transportation, Local Production and Distribution, ~~Reusable Packaging~~)
The proposed solution PlastMach ENSAVE will be tested on several model cases in companies. The benefits and actual efficiency will be quantitatively evaluated, including the calculation of the carbon footprint and the impact on the economics of operation/production. It is not necessary to seek local supplies and cooperation for this solution. However, the group that proposed this solution included representatives of technology manufacturers who promised cooperation not only in the area of verification, but also intend to serially apply the results and incorporate them into their business activities.
2.5 Use and maintenance (Predictive Maintenance, Shared Ownership Models, Upgrading and Retrofitting)
All new circular and energy-efficient components and/or measures in companies must meet the requirements for easy, fast and affordable serviceability, replacement or upgrade. This will be evaluated in phases 2 and 3.
2.6 End-of-life management (Recycling and Material Recovery, Reverse Logistics, Product-as-a-Service)
This is not a relevant angle for assessing the proposed solution.
2.9 Refurbishment and reuse (Component Reuse, Refurbishment Programs, Market for Used Machines)
The nature of the proposed solution allows for very long-term use not only within the installation of the given technology, but also within subsequent installations after the end of

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the service life of the first one. It can therefore be reused regardless of the condition and service life of the basic processing technology itself.

If the designers and manufacturers (suppliers) of these technological units agree on a positive evaluation of the pilot projects, it can be assumed that they will benefit from the widespread supply of these units to many other interested parties in the future.

2.8 Waste management and recycling (Zero Waste to Landfill, , Material Recovery Facilities, Circular Waste-to-Resource Solutions)

The proposed solution is purely technical (technological) in nature. It has an impact on:

1. Energy consumption - or rather energy efficiency.

2. It includes innovative electrical components with low energy requirements.

3. It ensures the extension of the machine's service life, improves its serviceability and at the same time will try to use components from European manufacturers in partial projects.

3 IMPACT OF CIRCULAR BUSINESS MODEL

Economic impact	Maintenance costs are low, downtime is reduced thanks to fast technical support, and the equipment can be adapted or expanded without significant additional investments.					
	☐	reduced	☒	medium	☐	high
Social impact	The equipment is designed for durability, can be upgraded or refurbished, and parts can be easily replaced.					
	☐	reduced	☒	medium	☐	high
Environmental impact	By using interchangeable components, modular design, and parts reuse, Eurodac minimizes waste and optimizes material consumption.					
	☐	reduced	☒	medium	☒	high
Technological impact	Local production, efficient logistics, and component recycling contribute to a reduced carbon footprint and sustainable resource use.					
	☐	reduced	☐	medium	☒	high

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4 Is there already circular business model in place that can be implemented for a pilot solution, and which can be transferred to other companies?	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.

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GERMANY

TITLE OF THE CIRCULAR BUSINESS MODEL	Closed-Loop Mechanical Recycling for Post-Consumer Plastics

1. DESCRIPTION OF CIRCULAR BUSINESS MODEL

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.

This closed-loop model significantly reduces dependence on virgin materials, lowers CO_2 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 brand owners across various industries.

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.

2. DESCRIPTION OF CIRCULAR BUSINESS MODEL PHASES:

2.1 Design and development (Design for Longevity, Design for Disassembly, Eco-design, Standardization of Parts)

Vogt Plastic follows a comprehensive circular business model that covers key lifecycle phases, from design to material sourcing and beyond. The model enables the transformation of plastic waste into high-quality recyclates that re-enter industrial production, minimizing resource consumption and emissions.

Vogt Plastic is not a producer of end-consumer products but plays a crucial upstream role in enabling circular design by supplying high-quality, application-specific secondary raw materials. Nevertheless, the company actively contributes to the design phase through:

Eco-Design Support: Vogt Plastic collaborates with downstream manufacturers by providing recyclates tailored for eco-design and circular product development.

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Standardization of Input & Output: By standardizing the types of input waste streams and the quality parameters of its regrinds and granulates, Vogt Plastic ensures predictable, consistent material behavior—supporting downstream disassembly, reusability, and material traceability.

2.2 Material sourcing (Use of Recycled Materials, Sustainable Material Sourcing, Closed- Loop Material Systems)

At the heart of Vogt Plastic's business model is a resource-efficient, closed-loop approach to material sourcing:

- **Use of Recycled Materials**: 100% of the raw materials processed by Vogt Plastic are post-consumer plastic waste, mainly collected via the German "Gelber Sack" (Yellow Bag) system.
- **Sustainable Material Sourcing**: The company maintains long-term partnerships with dual systems and waste management companies to secure a reliable and sustainable stream of feedstock.
- **Closed-Loop Material Systems**: Vogt Plastic's mechanical recycling process closes the loop by turning plastic waste back into secondary raw materials that replace virgin plastics in new products, thus reducing the extraction of fossil-based resources.

2.3 Manufacturing and assembly (Additive Manufacturing, Lean Manufacturing, Remanufacturing)

Vogt Plastic operates state-of-the-art recycling and compounding facilities that represent the backbone of its circular business model. The company's manufacturing approach is defined by efficiency, innovation, and the consistent delivery of high-quality secondary raw materials.

- **Lean Manufacturing**: Vogt Plastic integrates lean principles throughout its production process to minimize waste, energy consumption, and resource use. Automated sorting, shredding, washing, and extrusion lines are optimized to reduce material losses and maximize output quality with minimal environmental impact.

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Remanufacturing (in the context of plastics): While Vogt Plastic does not remanufacture finished products, it plays a crucial role in enabling remanufacturing across industries by providing manufacturers with recyclates that can replace virgin materials. These high-quality granulates and regrinds are suitable for use in the production of new durable goods, packaging, and construction components.

Technology Integration: The company continuously advances its proprietary mechanical recycling technologies. These are designed to process complex, heterogeneous plastic waste into standardized, high-performance materials without the need for chemical additives or energy- intensive reprocessing.

2.4 Distribution and logistics (Efficient Transportation, Local Production and Distribution, Reusable Packaging)

Vogt Plastic integrates sustainable practices into its distribution and logistics strategies to support its circular business model and reduce environmental impact across the value chain.

Efficient Transportation: The company prioritizes efficient logistics by optimizing transportation routes and partnering with regional waste management providers. By focusing on bulk deliveries and minimizing empty runs, Vogt Plastic reduces fuel consumption and associated emissions**.**

Local Production and Distribution: With strategically located production sites in Germany (Rheinfelden, Rickenbach, Hottingen, and Premnitz), Vogt Plastic processes materials close to the source of waste generation. This decentralized model not only shortens transport distances but also strengthens local value creation and contributes to regional circular economy networks.

Reusable Packaging: Whenever possible, Vogt Plastic employs reusable or recyclable packaging for its regrinds and granulates. This reduces packaging waste and complements the company's overarching aim to design out waste at every stage of the product life cycle**.**

2.5 Use and maintenance (Predictive Maintenance, Shared Ownership Models, Upgrading and Retrofitting)

As a recycler and material supplier, Vogt Plastic does not directly produce consumer goods but plays a crucial role in enabling circular use and maintenance strategies through the high quality and consistency of its recycled materials.

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Upgrading and Retrofitting: By supplying high-grade regrinds and granulates that meet industry standards, Vogt Plastic supports manufacturers in producing components and products that are durable, repairable, and suitable for future upgrades or retrofitting. This prolongs product lifecycles and reduces the need for virgin material inputs.

Predictive Maintenance Support: The consistency and traceability of Vogt Plastic's recyclates contribute to more predictable material performance. This enables downstream partners to implement predictive maintenance strategies more effectively in their manufacturing and product use phases.

Shared Ownership Models: While not directly engaged in shared ownership models, Vogt Plastic's materials are well-suited for products that are designed for multiple life cycles, leasing models, or industrial product-service systems—facilitating their repeated use in different contexts without compromising quality.

2.6 End-of-life management (Recycling and Material Recovery, Reverse Logistics, Product- as-a-Service)

Vogt Plastic's core business is centered around End-of-life plastic waste, making this phase the cornerstone of its circular business model.

Recycling and Material Recovery: Vogt Plastic specializes in the mechanical recycling of post-consumer plastic waste from household collections such as the Yellow Bag. Through in-house developed processes, the company transforms plastic packaging waste into high-quality regrinds and granulates. These recyclates are reintroduced into the market as raw materials, significantly reducing the need for virgin plastics.

Reverse Logistics: Vogt Plastic operates within a network that ensures the systematic collection, sorting, and transportation of used plastics to its recycling facilities. By collaborating with dual systems, municipalities, and logistics partners, the company contributes to an efficient reverse logistics chain that feeds sorted material back into the production cycle.

Product-as-a-Service (PaaS): While Vogt Plastic itself does not offer PaaS models, its recyclates support companies that implement such concepts. By providing recyclable input materials, the company enables the creation of products designed for disassembly and reuse—key elements in successful PaaS models.

2.7 Refurbishment and reuse (Component Reuse, Refurbishment Programs, Market for Used Machines)

While Vogt Plastic's primary focus lies in material recycling, elements of refurbishment and reuse are strategically integrated into its operations and broader impact:

Component Reuse: Vogt Plastic actively supports the reuse of secondary raw materials—specifically plastic regrinds and granulates—which are processed to such high quality that they can be reused in the manufacturing of durable plastic products, replacing virgin components. This extends the life cycle of plastic as a material.

Refurbishment Programs: Internally, the company maintains a strong culture of equipment upkeep and longevity. Machinery and sorting equipment are regularly upgraded or refurbished to ensure continued high performance, avoiding unnecessary replacement and contributing to resource conservation.

Market for Used Machines: Vogt Plastic follows a resource-efficient philosophy that includes reusing or reselling operational equipment. Instead of discarding functioning machinery, it is often reintegrated into other facilities or made available to industry partners where possible, further extending product lifecycles and promoting sustainability in the value chain.

2.8 Waste management and recycling (Zero Waste to Landfill, Biodegradable or Compostable Components, Material Recovery Facilities, Circular Waste-to-Resource Solutions)

Vogt Plastic is a pioneer in industrial-scale waste management and material recycling, consistently applying advanced methods to close the loop on plastic waste:

Zero Waste to Landfill: A core principle of Vogt Plastic's operations is to prevent plastic waste from ending up in landfills. By mechanically processing over 10% of Germany's Yellow Bag contents, the company diverts large quantities of post-consumer plastics from landfill and incineration.

Material Recovery Facilities (MRFs): At its state-of-the-art sites in Rheinfelden, Rickenbach, Hottingen, and Premnitz, Vogt Plastic operates advanced MRFs where plastics are sorted, washed, and processed into high-quality regrinds and granulates. This infrastructure allows for high recovery rates and efficient separation of complex waste streams.

Circular Waste-to-Resource Solutions: The company transforms post-consumer plastic packaging into new raw materials that re-enter the production cycle. These closed-loop solutions reduce the need for virgin plastics, conserve resources, and significantly cut emissions.

Biodegradable or Compostable Components: While not a focus of Vogt Plastic's current mechanical recycling processes, the company actively monitors developments in biodegradable materials and assesses their recyclability to ensure compatibility with established recycling streams.
Through these integrated waste management strategies, Vogt Plastic exemplifies how industrial players can contribute meaningfully to a circular, low-waste future.

3 IMPACT OF CIRCULAR BUSINESS MODEL						
Economic impact	By converting plastic waste into high-quality raw materials, Vogt Plastic reduces dependency on volatile virgin plastic markets and supports stable supply chains for the plastics industry. The model promotes cost savings, drives innovation in material reuse, and creates long-term economic value by transforming waste into a resource.					
	☐	reduced	☐	medium	☒	high
Social impact	The company contributes to employment and skill development in the green economy, especially in regions where its plants operate. Its work raises awareness of sustainable practices and supports behavioral shifts toward recycling and circularity among consumers and industry partners.					
	☐	reduced	☐	medium	☒	high
Environmental impact	Through large-scale diversion of plastic waste from landfills and incineration, the company significantly reduces greenhouse gas emissions and environmental pollution. The reuse of recycled plastics further conserves natural resources and lowers the carbon footprint of plastic products.					
	☐	reduced	☐	medium	☒	high
Technological impact	Vogt Plastic drives innovation in sorting, washing, and reprocessing technologies. Its continuous investment in advanced recycling infrastructure and process optimization contributes to the evolution of efficient circular solutions for complex plastic waste streams.					
	☐	reduced	☐	medium	☒	high

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4 **Is there already circular business model in place that can be implemented for a pilot solution, and which can be transferred to other companies?**	NO: N/A

HUNGARY

TITLE OF THE CIRCULAR BUSINESS MODEL	Filaticum - PLA filaments to replace traditional materials

1. DESCRIPTION OF CIRCULAR BUSINESS MODEL

Filaticum develops new PLA-based filaments on-demand and based on their own proprietaty research. Their 30+ filaments can be further tailored to meet specific industrial needs (e.g., thermal or electric conductivity; antibacterial or antiviral properties; chemical resistance; impact resistence; weight requirements; etc.) The PLA base is created from corn starch, a renewable source; end products, after correct treatment, are usually compostable or mechanically/chemically recyclable. The PLA filaments have been proven to be able to replace materials with high environmental costs, such as aluminum, oil-based petroleum, glass, or gypsum. The additive process of 3D printing ensures minimal waste, shortened supply chains, quicker feedback, more precise control of the end product - and through on-the-spot printing of machinery parts, empowers users to repair their own machines.

2. DESCRIPTION OF CIRCULAR BUSINESS MODEL PHASES:

2.1 Design and development (Design for Longevity, Design for Disassembly, Eco-design, Standardization of Parts)

Design for Longevity: The custom-made PLA filaments undergo rigorous testing ensuring that they meet the customer's requirements in durability and longevity.
Design for Disassembly: 3D-printing is conducive towards modularity, and the right (and ability) to repair.
Eco-design: Filaticum's filaments are made from corn starch, which in itself is sustainable; further development could be sourcing it from waste product(s) of a different value chain.
Standardization of Parts: N/A

2.2 Material sourcing (Use of Recycled Materials, Sustainable Material Sourcing, Closed-Loop Material Systems)

The lactic acid from PLA can either be chemically reclaimed via hydrolysis. PLA can also be mechanically ground and either reused immediately as filament, or as raw material for other PLA products. PLA can also be composted industrially.

2.3 Manufacturing and assembly (Additive Manufacturing, Lean Manufacturing, Remanufacturing)

The filaments are the fundamental requirement of additive manufacturing.

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2.4 Distribution and logistics (Efficient Transportation, Local Production and Distribution, Reusable Packaging)	
Efficient Transportation: being able to produce spare parts individually and on one's own greatly decreases reliance on transportation. Local Production and Distribution: the corn starch granules can be produced locally with investment (Filaticum currently ships the raw material from the US). 3D-printing enables local production of whatever is currently in demand.	
2.5 Use and maintenance (Predictive Maintenance, Shared Ownership Models, Upgrading and Retrofitting)	
3D-printing enables all of these; Filaticum's thoroughly tested filaments and the items printed thereof have a narrowly defined duration that promotes predictive maintenance.	
2.6 End-of-life management (Recycling and Material Recovery, Reverse Logistics, Product-as-a-Service)	
The lactic acid from PLA can either be chemically reclaimed via hydrolysis. PLA can also be mechanically ground and either reused immediately as filament, or as raw material for other PLA products. PLA can also be composted industrially.	
2.7 Refurbishment and reuse (Component Reuse, Refurbishment Programs, Market for Used Machines)	
N/A	
2.8 Waste management and recycling (Zero Waste to Landfill, Biodegradable or Compostable Components, Material Recovery Facilities, Circular Waste-to-Resource Solutions)	
The lactic acid from PLA can either be chemically reclaimed via hydrolysis. PLA can also be mechanically ground and either reused immediately as filament, or as raw material for other PLA products. PLA can also be composted industrially.	
3. IMPACT OF CIRCULAR BUSINESS MODEL *Please describe the impact of circular business model and check (the box) the degree of impact (reduced, medium, high)*	
Economic impact	• Cost efficient • Flexibility (time, resource, raw materials, end product variability based on user feedback). • Shortened supply chain, cheaper production. • Simplified and more accurate quality management.

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	☐	reduced	☐	medium	☒	high
Social impact	• Reduced reliance on problematic sources					
	☐	reduced	☒	medium	☐	high
Environmental impact	• Corn starch is the primary ingredient • Chemically and mechanically recycleable • Compostable • Input material and production process requires less energy • Bioplastic feedstocks do not compete with food crops for land use • 1.6 KG maize/corn produces 1 KG filament					
	☐	reduced	☐	medium	☒	high
Technological impact	The filaments can supplant traditional problematic raw materials.					
	☐	reduced	☒	medium	☐	high
4. Is there already circular business model in place that can be implemented for a pilot solution, and which can be transferred to other companies?	Filaticum Kft. SME filaticum.com					

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REPUBLIC OF MOLDOVA

TITLE OF THE CIRCULAR BUSINESS MODEL	Circular Business Model for Sustainable – MGM LTD

1. DESCRIPTION OF CIRCULAR BUSINESS MODEL

MGM LTD adopts a circular business model by integrating circular economy principles into the lifecycle of plastic processing machinery. 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. Moreover, MGM supports clients in transitioning to circular plastic use by offering customized solutions that enable recycling, reuse, and energy-efficient processing. 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.

2. DESCRIPTION OF CIRCULAR BUSINESS MODEL PHASES:

MGM LTD 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.
The manufacturing phase emphasizes efficient use of resources, recyclable materials, and energy reduction to minimize environmental impact.
Besides selling machines, MGM offers leasing, maintenance, and upgrade services to extend equipment use and support customers in optimal operation.
Regular maintenance and repairs are essential for long-term machine function. MGM provides spare parts and technical support to avoid full machine replacements.
Used machines are taken back for refurbishment and resale, reducing the need for new production and offering cost-effective options to customers.
At the end of the machine's lifecycle, components are recycled through partnerships with specialized recyclers, ensuring materials are recovered and reused in production.
Finally, MGM supports clients in adopting circular practices by providing solutions that enable the use of recycled plastics and waste reduction in the manufacturing process.

2.1 Design and development (Design for Longevity, Design for Disassembly, Eco-design, Standardization of Parts)

MGM SRL prioritizes **Design for Longevity** by creating machines built to last, using durable materials and robust construction to extend operational life.
The company implements **Design for Disassembly**, ensuring that machines can be easily taken apart for repair, upgrade, or recycling, which simplifies maintenance and end-of-life processing.

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Eco-design principles guide the selection of energy-efficient components and recyclable materials to minimize environmental impact during production and use.
Standardization of parts allows MGM to streamline manufacturing, reduce costs, and facilitate easy replacement or upgrading of components, supporting a circular lifecycle for the machines.

2.2 Material sourcing (Use of Recycled Materials, Sustainable Material Sourcing, Closed-Loop Material Systems)

MGM LTD integrates the use of recycled materials in machine components whenever possible, reducing dependence on virgin raw materials and lowering environmental impact.
The company emphasizes sustainable material sourcing by selecting suppliers who follow responsible practices, such as using renewable, non-toxic, and ethically produced materials.
MGM is committed to developing closed-loop material systems, collaborating with recycling partners to recover and reuse materials from end-of-life machines, thus creating a circular flow of resources.

2.3 Manufacturing and assembly (Additive Manufacturing, Lean Manufacturing, Remanufacturing)

MGM LTD incorporates **Additive Manufacturing** techniques to reduce material waste and enable the production of complex, lightweight machine parts with minimal environmental impact.
The company applies **Lean Manufacturing** principles to optimize resource use, minimize waste, and improve process efficiency throughout production.
MGM also integrates **Remanufacturing** by refurbishing used machine components to like-new condition, extending product life and reducing the need for new raw materials.

2.4 Distribution and logistics (Efficient Transportation, Local Production and Distribution, Reusable Packaging)

MGM LTD optimizes efficient transportation by planning routes and loads to reduce fuel consumption and emissions during delivery.
The company favors local production and distribution to shorten supply chains, decrease transportation distances, and support regional economies.
MGM implements reusable packaging solutions to minimize waste and promote sustainability throughout the product delivery process.

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2.5 Use and maintenance (Predictive Maintenance, Shared Ownership Models, Upgrading and Retrofitting)
MGM LTD employs predictive maintenance technologies to monitor machine health in real time, preventing breakdowns and extending equipment lifespan. The company explores shared ownership models, such as leasing or equipment sharing, to maximize machine utilization and reduce the need for new purchases. MGM supports upgrading and retrofitting of existing machines, enabling clients to improve performance and adapt to new requirements without replacing entire systems.
2.6 End-of-life management (Recycling and Material Recovery, Reverse Logistics, Product-as-a-Service)
MGM SRL ensures **recycling and material recovery** by partnering with specialized recyclers to reclaim valuable materials from decommissioned machines. The company implements **reverse logistics** systems to efficiently collect used equipment from clients for refurbishment, recycling, or proper disposal. MGM also promotes **product-as-a-service** models, retaining ownership of machines to facilitate their return and circular management at the end of their lifecycle.
2.7 Refurbishment and reuse (Component Reuse, Refurbishment Programs, Market for Used Machines)
MGM LTD prioritizes **component reuse** by salvaging and reusing functional parts from old machines in new or refurbished equipment. The company runs **refurbishment programs** that involve thorough inspection, repair, and upgrading of used machines to extend their service life. MGM supports a **market for used machines**, offering refurbished equipment as cost-effective and sustainable alternatives to new purchases for clients.
2.8 Waste management and recycling (Zero Waste to Landfill, Biodegradable or Compostable Components, Material Recovery Facilities, Circular Waste-to-Resource Solutions)
MGM LTD strives for **zero waste to landfill** by implementing strict waste segregation and recycling protocols within its operations. Where applicable, the company uses **biodegradable or compostable components** to reduce environmental impact at the end of product life. MGM collaborates with **material recovery facilities** to ensure efficient sorting and processing of waste materials from production and end-of-life machines. The company invests in **circular waste-to-resource solutions**, converting waste streams into raw materials for manufacturing, closing the resource loop.

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3. IMPACT OF CIRCULAR BUSINESS MODEL

The circular business model enables MGM SRL to significantly reduce its environmental footprint by minimizing raw material consumption and waste generation. By extending the lifespan of machines through repair, refurbishment, and upgrades, the company lowers resource depletion and greenhouse gas emissions associated with manufacturing new equipment.
Economically, this model opens new revenue streams from services like maintenance, leasing, and refurbished equipment sales, while improving customer loyalty through long-term support. It also reduces operational costs by optimizing resource use and waste management.
Socially, MGM SRL promotes sustainable industrial practices, contributing to local job creation in refurbishment and recycling sectors. Additionally, by supporting clients' circular transitions, the company helps build a more resilient and environmentally responsible plastics industry.
Overall, MGM's circular business model creates lasting value for the company, its customers, and the environment, aligning profitability with sustainability.

Economic impact						
	☐	reduced	☒	medium	☐	high
Social impact						
	☐	reduced	☒	medium	☐	high
Environmental impact						
	☐	reduced	☒	medium	☐	high
Technological impact						
	☐	reduced	☒	medium	☐	high
4. Is there already circular business model in place that can be implemented for a pilot solution, and which can be transferred to other companies?	Yes: Name: **MGM SRL** Type of Organization: Private company operating in the manufacturing sector, specializing in machinery for the plastics industry (SME) Website: https://www.mgm.md/					

ROMANIA

TITLE OF THE CIRCULAR BUSINESS MODEL	EURODAC – Sustainable and efficient industrial automation through modular design and interchangeable components

1. DESCRIPTION OF CIRCULAR BUSINESS MODEL

The circular business model of Eurodac is based on the use of interchangeable components, simple and efficient designs, and easy maintenance. Our teams ensure a complete production cycle, from design to commissioning, minimizing waste and maximizing the lifespan of equipment. This model contributes to sustainability and operational efficiency.

2. DESCRIPTION OF CIRCULAR BUSINESS MODEL PHASES:

Design and Planning: Simple and efficient construction solutions are selected, using interchangeable components to ensure durability and ease of maintenance.

Execution and Production: Equipment is manufactured using high-quality materials, and parts are machined and assembled in-house to reduce waste and optimize resources.

Testing and Validation: After assembly, the equipment undergoes functional testing to ensure performance and reliability, thereby minimizing the need for frequent repairs.

Commissioning and Training: Eurodac teams install the equipment at the client's site and train staff for operation and maintenance, ensuring a longer equipment lifecycle.

Ongoing Support and Maintenance: Eurodac provides fast technical support and spare parts to maximize equipment efficiency and extend its lifespan.

2.1 Design and development (Design for Longevity, Design for Disassembly, Eco-design, Standardization of Parts)

Eurodac integrates circular principles right from the design phase:

Design for Longevity: Equipment is built to operate over the long term, using high-quality materials and reliable technical solutions.

Design for Disassembly: Machines are designed in a modular way, allowing parts to be easily replaced or repaired without complex interventions.

Eco-Design: Simple and efficient solutions are chosen to reduce energy consumption and production losses, while also optimizing material usage.

Standardized Components: We use standard, interchangeable industrial components available on the local market, enabling easy maintenance, lower costs, and quick availability.

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2.2 Material sourcing (Use of Recycled Materials, Sustainable Material Sourcing, Closed-Loop Material Systems)
Use of Recycled Materials: Depending on technical requirements and equipment safety, Eurodac integrates recycled materials wherever possible, without compromising performance. **Sustainable Material Sourcing**: We collaborate with local and regional suppliers to reduce carbon footprint and ensure traceability and sustainability of raw materials. **Closed-Loop Material Systems**: Worn or replaced parts can be refurbished or recycled, and the modular design allows components to be reused in other projects—reducing waste and extending the material lifecycle.
2.3 Manufacturing and assembly (Additive Manufacturing, Lean Manufacturing, Remanufacturing)
Lean Manufacturing: Eurodac applies efficient production principles, reducing waste of materials, time, and energy at every stage of the process. **Remanufacturing**: Equipment is designed modularly, allowing certain components to be reused, repaired, or replaced at minimal cost, thereby extending their lifespan. **Additive Manufacturing**: While not a primary method in current production, Eurodac can integrate 3D-printed parts for rapid prototyping or specific components, contributing to resource efficiency and customized solutions.
2.4 Distribution and logistics (Efficient Transportation, Local Production and Distribution, Reusable Packaging)
Efficient Transportation: Equipment is designed to be compact and modular, reducing transport volume and logistics costs while optimizing loading and delivery. **Local Production and Distribution**: All equipment is designed and manufactured in Romania, ensuring short delivery times, lower costs, and a reduced carbon footprint. **Reusable Packaging**: Upon request, Eurodac uses reusable packaging and protective solutions for equipment transport, helping to reduce packaging waste.

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2.5 Use and maintenance (Predictive Maintenance, Shared Ownership Models, Upgrading and Retrofitting)
Predictive Maintenance: Equipment is designed to allow easy monitoring of operations, and Eurodac's technical team provides fast support to identify and prevent issues before failures occur. **Shared Ownership Models**: While the primary model involves delivery to end clients, the equipment can also be adapted for flexible partnerships or shared use within production networks. **Upgrading and Retrofitting**: Eurodac equipment can be easily updated or adapted for new production processes thanks to its modular design and use of standardized components, thereby extending its lifecycle.
2.6 End-of-life management (Recycling and Material Recovery, Reverse Logistics, Product-as-a-Service)
Recycling and Material Recovery: Thanks to the use of standard components and high-quality industrial materials, equipment can be easily disassembled, and metal and electronic parts can be efficiently recycled. **Reverse Logistics**: Eurodac provides technical support and after-sales service, and worn components can be returned for refurbishment or replacement, helping to reduce waste. **Product-as-a-Service**: Although not the main model, Eurodac can offer customized leasing or rental solutions with included servicing, reducing initial investment and optimizing long-term use.
2.7 Refurbishment and reuse (Component Reuse, Refurbishment Programs, Market for Used Machines)
Component Reuse: Thanks to modular design and the use of standardized parts, components from old equipment can be disassembled and reused in new projects or as spare parts. **Refurbishment Programs**: Eurodac offers the possibility to upgrade and refurbish existing equipment, extending its lifespan and improving performance. **Market for Used Machines**: Eurodac equipment is durable and can be resold or put back into operation in other industrial processes, providing long-term added value and supporting the circular economy.

2.8 Waste management and recycling (Zero Waste to Landfill, Biodegradable or Compostable Components, Material Recovery Facilities, Circular Waste-to-Resource Solutions)
Zero Waste to Landfill: By optimizing production processes and efficient design, Eurodac minimizes generated waste and encourages its reuse or recycling. **Material Recovery Facilities**: Metal, electronic, and packaging waste are selectively collected and sent to specialized recycling centers to recover valuable materials. **Circular Waste-to-Resource Solutions**: Worn or defective components are evaluated for refurbishment or reuse, while those that cannot be reused are directed to recycling, replacing new raw materials and reducing environmental impact. **Biodegradable or Compostable Components**: Although not commonly used in industrial equipment made of metal and technical plastics, more sustainable alternative materials can be considered where applicable.

3. IMPACT OF CIRCULAR BUSINESS MODEL						
Economic impact	Maintenance costs are low, downtime is reduced thanks to fast technical support, and the equipment can be adapted or expanded without significant additional investments.					
	☐	reduced	☒	medium	☐	high
Social impact	The equipment is designed for durability, can be upgraded or refurbished, and parts can be easily replaced.					
	☐	reduced	☒	medium	☐	high
Environmental impact	By using interchangeable components, modular design, and parts reuse, Eurodac minimizes waste and optimizes material consumption.					
	☐	reduced	☒	medium	☐	high
Technological impact	Local production, efficient logistics, and component recycling contribute to a reduced carbon footprint and sustainable resource use.					
	☐	reduced	☒	medium	☐	high

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4. Is there already circular business model in place that can be implemented for a pilot solution, and which can be transferred to other companies?	Yes: EURODAC SMEs https://eurodac.ro/

SERBIA

TITLE OF THE CIRCULAR BUSINESS MODEL	Modular Machine Design Platform

1. DESCRIPTION OF CIRCULAR BUSINESS MODEL

The Modular Machine Design Platform is a cloud-based design system that enables engineers to create industrial machines using a library of standardized, modular, and eco-friendly components. Each component is designed for ease of disassembly, recyclability, and environmental sustainability. 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. 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. Its scalability allows application across a wide array of industries, with high implementation potential in Serbia's evolving industrial ecosystem.

2. DESCRIPTION OF CIRCULAR BUSINESS MODEL PHASES:

2.1 Design and development (Design for Longevity, Design for Disassembly, Eco-design, Standardization of Parts)

The platform is built around eco-design principles, enabling the creation of machines with standardized modular parts that are easy to disassemble, upgrade, and reuse. Real-time environmental impact analytics inform design decisions, allowing engineers to reduce the ecological footprint of machines from the outset. The shared library of parts promotes standardization and design for longevity, ensuring compatibility and repairability across product generations.

2.2 Material sourcing (Use of Recycled Materials, Sustainable Material Sourcing, Closed-Loop Material Systems)

Each component on the platform is associated with a database of materials, prioritizing those that are recyclable, biodegradable, or sourced from closed-loop systems. Designers are encouraged to select materials based on traceable sustainability credentials. This supports a shift away from virgin resource extraction toward sustainable alternatives.

2.3 Manufacturing and assembly (Additive Manufacturing, Lean Manufacturing, Remanufacturing)

The modular design simplifies manufacturing processes, allowing for component production via additive manufacturing and remanufacturing. As modules are standardized, manufacturers can optimize lean production lines with reduced waste and energy usage. Reuse of existing parts in new designs is facilitated, thus lowering the need for virgin material inputs and reducing environmental impacts from assembly processes.

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2.4 Distribution and logistics (Efficient Transportation, Local Production and Distribution, Reusable Packaging)
The platform supports local production through integration with regional 3D printing hubs, which reduces transportation emissions. Components are designed for compact packaging, which can be reusable and tracked via digital logistics systems. This promotes circular logistics with reduced reliance on long-distance shipping and single-use packaging.
2.5 Use and maintenance (Predictive Maintenance, Shared Ownership Models, Upgrading and Retrofitting)
Because machines are modular, components can be upgraded or retrofitted without replacing the entire machine. This simplifies maintenance and enhances product adaptability. Integration with IoT technologies enables predictive maintenance systems that help users monitor machine health, reduce downtime, and extend the functional life of equipment.
2.6 End-of-life management (Recycling and Material Recovery, Reverse Logistics, Product-as-a-Service)
At end-of-life, modular components can be removed, sorted, and recycled individually. The platform includes disassembly guides and component tracking, which facilitate reverse logistics and high-value material recovery. Integration with product-as-a-service models is possible, enabling manufacturers to retain ownership and ensure responsible end-of-life handling.
2.7 Refurbishment and reuse (Component Reuse, Refurbishment Programs, Market for Used Machines)
The system encourages a robust secondary market by designing components for easy refurbishment. Used parts that meet quality standards can be recertified and reintegrated into production cycles or sold through marketplace channels supported by the platform. This significantly reduces industrial waste and improves access to lower-cost machinery for small and medium enterprises.
2.8 Waste management and recycling (Zero Waste to Landfill, Biodegradable or Compostable Components, Material Recovery Facilities, Circular Waste-to-Resource Solutions)
By utilizing recyclable and biodegradable materials, and enabling easy separation of materials at the disassembly stage, the platform supports zero-waste strategies. The component-based architecture ensures minimal material loss, and recovered materials can be fed back into the production loop via local recovery partners or facilities.
3. IMPACT OF CIRCULAR BUSINESS MODEL

Economic impact	Reduces costs through reuse of components, minimizes material waste, and opens new revenue streams via refurbishment and design services.

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	☐	reduced	☐	medium	☒	high
Social impact	Creates high-skill design and engineering jobs, supports knowledge-sharing networks, and promotes sustainable business practices across SMEs and large enterprises.					
	☐	reduced	☒	medium	☐	high
Environmental impact	Drastically lowers raw material use, reduces energy consumption in production, and minimizes waste through recycling and reuse.					
	☐	reduced	☐	medium	☒	high
Technological impact	Drives adoption of digital design platforms, promotes eco-design thinking, and supports integration of advanced materials and real-time environmental analytics.					
	☐	reduced	☒	medium	☐	high
4. Is there already circular business model in place that can be implemented for a pilot solution, and which can be transferred to other companies?	N/A					

SLOVAKIA

TITLE OF THE CIRCULAR BUSINESS MODEL	Sustainable Recycling Process of Plastic Materials

1. DESCRIPTION OF CIRCULAR BUSINESS MODEL

The sustainability of the plastics recycling process is a key topic in environmental policy and the mainstream economy. Recycling plastics is therefore one way to reduce their negative impact on the environment, limit the extraction of raw materials, and reduce the amount of waste in landfills. Sustainable plastic recycling is focused on:

- 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.

2. DESCRIPTION OF CIRCULAR BUSINESS MODEL PHASES:

3D printing support used extruder for plastic materials. Recyclability and remanufacturing of plastics are key to reducing the plastic industry's ecological footprint. These approaches help extend equipment life, reduce costs, and promote sustainability throughout manufacturing. It is important to look at

- Quality of separation: Mixed or contaminated plastics are difficult to recycle.
- Plastic types: Not all plastics are easily recyclable (e.g. composites)
- Downcycling: Many recycled plastics are of lower quality than the original, which limits their reuse.
- Economics of recycling: Recycling is not always economically viable without subsidies or legislative support.
- Market dependence: The market for recycled plastics is unstable.

2.1 Design and development (Design for Longevity, Design for Disassembly, Eco-design, Standardization of Parts)

Regarding the proposed technologies, we used the Extruder. The EX2 Extruder Setup is a device that opens up new opportunities in 3D printing by enabling effective plastic recycling and innovative use of plastics. It provides a small-scale solution to a significant environmental challenge and makes sustainable production accessible.

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2.2 Material sourcing (Use of Recycled Materials, Sustainable Material Sourcing, Closed-Loop Material Systems)
Use of Recycled Materials The input materials are thermoplastics materials, e.g. PLA, PETG, PVB. This device is used for granulating processing to fabricate filament from recycled granulates. The filament production itself begins when the pellets are poured into the pellet's hopper, and then the pellets are fed into the extrusion screw. The pellet extruder has several heating zones; in the first part of the extrusion screw, the temperature is usually higher to ensure uniform material melting.
2.3 Manufacturing and assembly (Additive Manufacturing, Lean Manufacturing, Remanufacturing)
Additive Manufacturing It is important to provide options such as remanufacturing or refurbishing critical components that can be cost-effective and environmentally friendly. Remanufacturing machines and components can be designed to process recycled materials, thus promoting their reuse. These approaches can significantly increase the ability of products to be reused or upgraded, therefore contributing to a more sustainable economy. The target audience: the plastics industry, machine industry researchers, research institutions, and stakeholders. Important testing will focus on input materials, extrusion processes, and 3D printing of new products from recycled materials. From the proposed solution's perspective, we can contribute to increasing the ability to reuse and upgrade in several ways, mainly by creating products with modular components. This allows easy replacement or updating of individual parts, extending the product's life. Recycling and reusing materials reduce waste and increase ecological sustainability.
2.4 Distribution and logistics (Efficient Transportation, Local Production and Distribution, Reusable Packaging)
After the production of plastic filament – most often for 3D printing or further processing – a key phase: its distribution to the end user. Efficient and sustainable logistics contribute not only to lower costs, but also to reducing the ecological footprint.

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2.5 Use and maintenance (Predictive Maintenance, Shared Ownership Models, Upgrading and Retrofitting)
The goal is to prevent failures before they occur and optimize machine downtime. In practice, for an extruder, this means: Monitoring motor vibrations, heating zone temperature and melting pressure. Analyzing screw and barrel wear through production data. Using thermal cameras or wear sensors. Connecting to IoT platforms or MES systems that can evaluate machine status in real time.
2.6 End-of-life management (Recycling and Material Recovery, Reverse Logistics, Product-as-a-Service)
Effective End-of-life management of plastic products at the end of their life is essential for environmental protection and the transition to a circular economy. The aim is to minimize waste, maximize the reuse of raw materials, and create systems that support responsible consumption and production.
2.7 Refurbishment and reuse (Component Reuse, Refurbishment Programs, Market for Used Machines)
Refurbishment and reuse are among the best circular economy strategies. Component reuse involves dismantling old equipment and selecting functional parts that can be used in new or refurbished products. This process has several advantages, like a cost savings – used components tend to be cheaper than new ones. Reduction in raw material consumption – there is no need to manufacture a new component from base materials. Speed of delivery – the component (filament) is available immediately, without the need for manufacturing.
2.8 Waste management and recycling (Zero Waste to Landfill, Biodegradable or Compostable Components, Material Recovery Facilities, Circular Waste-to-Resource Solutions)
1. Sustainability and reduction of carbon footprint • Using recycled materials reduces the demand for new plastics, which contributes to protecting natural resources. • Recycling plastics requires less energy than producing new plastics, reducing greenhouse gas emissions. 2. Circular economic impact and increasing awareness and social responsibility • Using recycled materials shows a company's commitment to sustainability, which can strengthen the brand and attract environmentally minded customers.

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<table>
<tr><td colspan="7">Introducing regulations to encourage the use of recycled materials can be an additional incentive for businesses.</td></tr>
<tr><td colspan="7">3. IMPACT OF CIRCULAR BUSINESS MODEL</td></tr>
<tr><td rowspan="2">Economic impact</td><td colspan="6">Recycled material is playing an increasingly important role in the modern economy. Its use has not only environmental but also significant economic consequences, affecting costs, innovation, employment and the competitiveness of companies.</td></tr>
<tr><td>☐</td><td>reduced</td><td>☒</td><td>medium</td><td>☐</td><td>high</td></tr>
<tr><td rowspan="2">Social impact</td><td colspan="6">The use of recycled materials affects people's lives, working conditions, education, health, and the values of society.</td></tr>
<tr><td>☐</td><td>reduced</td><td>☐</td><td>medium</td><td>☒</td><td>high</td></tr>
<tr><td rowspan="2">Environmental impact</td><td colspan="6">Using recycled raw materials instead of new materials significantly reduces the environmental burden associated with the extraction, production and disposal of materials.</td></tr>
<tr><td>☐</td><td>reduced</td><td>☐</td><td>medium</td><td>☒</td><td>high</td></tr>
<tr><td rowspan="2">Technological impact</td><td colspan="6">Modern technologies have a fundamental impact on the entire life cycle of recycled materials – from their collection and sorting, through processing, to reuse in production. Thanks to technical progress, the efficiency of recycling processes increases, the quality of output raw materials improves and new possibilities for the use of more complex or contaminated materials open up. Technology thus plays a key role in the transformation of the linear model into a circular economy.</td></tr>
<tr><td>☐</td><td>reduced</td><td>☒</td><td>medium</td><td>☐</td><td>high</td></tr>
</table>

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4. Is there already circular business model in place that can be implemented for a pilot solution, and which can be transferred to other companies?	Faculty of Manufacturing Technologies, Technical University of Košice, Bayerova 1, 08001 Prešov, Slovakia. Best practice: Cooperation with Slovnaft https://slovnaft.sk/sk/o-nas/pre-media/tlacove-spravy/?1=1&start=10#spolocnost-slovnaft-vyvinula-vlastny-inovativny-material-pre-3d-tlac