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Document Content

Introduction

The main aim of this activity was that high-developed regions, in 3 thematically grouped teams, share their know-how and lessons-learnt from the piloting (circular, design thinking workshops for the machine industry representatives) and beyond with less developed regions. The 3 teams were formed based on the outcome of the piloting, and relevance in the regions.

The machine industry in Europe is undergoing a significant transformation as it seeks to align with circular economy principles. Many companies are recognizing the need to shift away from traditional linear production models toward more sustainable practices that emphasize resource efficiency, waste reduction, and extended product lifespans. This transition is driven by stringent EU regulations, such as the Circular Economy Action Plan and the European Green Deal, which set ambitious targets for material reuse, recycling, and emissions reduction. Additionally, increasing pressure from consumers, investors, and supply chain partners is pushing manufacturers to rethink their design, production, and end-of-life strategies. However, while awareness is growing, full-scale adoption of circular business models remains a complex and gradual process, requiring significant investment in research, innovation, and infrastructure.

One of the biggest challenges preventing effective circular transformation in the machine industry is the high cost of redesigning products and manufacturing processes to meet circular economy standards. Many companies still rely on materials and components that are difficult to recycle or refurbish, making it challenging to close the production loop. Additionally, the lack of standardized policies and cross-border collaboration creates inconsistencies in how circular strategies are implemented across different European countries. Supply chain disruptions and limited access to secondary raw materials further hinder progress, while outdated business models, built around planned obsolescence, continue to dominate the industry. Another critical barrier is the reluctance of some businesses to shift toward circularity due to uncertainty about financial returns and the complexity of integrating circularity into existing operations.

Despite these challenges, companies that successfully implement circular business models stand to gain significant benefits. Circular strategies can lead to reduced production costs by lowering dependence on raw material extraction and minimizing waste management expenses. Businesses that embrace circularity can also enhance their brand reputation and secure a competitive advantage by appealing to environmentally conscious customers and investors. Additionally, regulatory compliance with EU sustainability policies can open up new funding opportunities and partnerships, fostering long-term financial resilience. Moreover, circular innovation can drive new business models, such as product-as-a-service or remanufacturing, which create

additional revenue streams while promoting sustainability. By adapting to circular principles, industry leaders can future-proof their businesses, contribute to global sustainability efforts, and position themselves at the forefront of the evolving European industrial landscape.

As it was emphasized, the goal of this activity was the exchange of experiences and lessons-learnt from implemented design thinking workshops for machine industry representatives. During the workshops, but also within the activities that preceded the workshops themselves, current challenges were observed that can generally represent an obstacle to a successful and efficient process of circular transformation. In addition, there are certain country-specific barriers and challenges, observed during the implementation of workshops at the national level, in the PPs countries. Of course, positive sides were also observed, that is, possibilities and chances to improve and even speed up the process of circular transformation. These very conditions were discussed within the transnational peer-level capacity building workshops, in which the project partners exchanged experiences and provided a chance to learn from each other, especially from examples of good practices in certain developed countries. Project partners worked in 3 groups:

1. Austria, Czech Republic, Slovakia
2. Germany, Hungary, Bosnia and Herzegovina
3. Romania, Republic of Moldova, Serbia

Each group started by discussing the implemented design thinking workshops for machine industry representatives, with a special focus on how aware and educated the workshop participants were about the principles of the circular economy and how easily they managed to reach pilot solutions. After that, the following points were discussed:

- Challenges and strategies for circular economy development in each country;
- Social challenges and society's awareness of the circular economy in each country;
- Education about circular economy in each country;
- Regulations in each country related to the machine industry, which can be an obstacle in the adoption of circular principles;
- Innovation challenges and opportunities;
- What can we learn from each other, and how can we transfer the results more efficiently between countries and regions.

An overview of the work, discussion, and conclusions from all three groups is provided below.

Austria, Czech Republic, Slovakia

Discussion on the implemented workshops for machine industry representatives, with a special focus on how aware and educated the workshop participants were about the principles of the circular economy and how easily they managed to reach pilot solutions:

In Austria, the awareness of CE among participants was not universal at the beginning. However, as the workshop progressed, many realized that they already had some processes in place that could be seen as part of the CE (regular maintenance, recycling, etc.). In contrast, in Slovakia, a few companies were already engaged in refurbishment as a business, operating a pure circular model by changing electronics of the machine and selling them again. This business model was not well-known in Austria. Slovakia also highlighted predictive maintenance as a part of CE, where companies worked closely with the original producers. They utilized additive manufacturing to reproduce parts through reverse engineering.

Meanwhile, in the Czech Republic, the focus was on measuring sustainability. Companies aimed to calculate the emission profile of a production line to identify weak links, such as insulation, cooling systems (oil/water consumption), and energy usage. They sought to predict and avoid replacements and overconsumption through data analysis, using SCOPE1/2 data to track key environmental impact numbers, making it less cost-intensive for companies and optimizing the use-phase.

In Austria, two main topics emerged. One company was buying back its own machines and needed more information on them. However, customers were reluctant to provide the data, so the company tried to convince them of the benefits of sharing data and making money from it. Another topic was cooling in supermarkets, where companies wanted to extend the lifetime of cooling systems beyond the regular 15 years. They explored a new business model, cooling-as-a-service, where the company remains the owner of the technology and updates it for their own benefit (saving costs and prolonging lifetime directly correlates with own business success).

In Czech Republic and Slovakia, it was easy to get participants for the workshops as companies were eager to participate since they are regularly organizing conferences and meetings for SMEs partly with academic participants. In Austria, however, it was difficult to attract participants due to economic challenges and the topic not being a priority in the machine industry. Focusing on financial benefits proved to be a better trigger, with regulations or financial incentives serving as motivators.

Challenges and strategies for circular economy development in each country:

The development of a circular economy in Austria faces significant challenges, particularly regarding the mindset of participants. Compared to the plastic industry, there is a noticeable reluctance to adopt circular practices. This is compounded by the bureaucratic burden of ESG (Environmental, Social, and Governance) and CSRD (Corporate Sustainability Reporting Directive) requirements for larger companies. Currently, these companies are not yet recognizing the opportunities these frameworks present. The mindset remains a critical barrier, as the green transition is often viewed as idealistic rather than a practical business opportunity. There is a need for a shift in perspective to see the financial benefits of sustainable business models. The partners from Slovakia had similar experiences and see the same challenges in this regard.

In the Czech Republic, steering companies towards greater sustainability involves the use of ESG reports for local factories. However, a major challenge is the reluctance to share know-how, as companies are protective of their data. This issue is exacerbated by the fact that a significant portion of the GDP comes from the rubber and plastic processing industry, which lacks machine producers (machines coming from different countries, therefore the data is missing). Consequently, obtaining data on machine consumption is particularly difficult.

Social challenges and society's awareness of the circular economy in each country:

Generally, society as itself is aware of the topic in each of the three countries. But as described before, the mindset—especially in areas where political forces are not yet established—is not focused on doing business with circular business models. But all partners described a certain demand from customer side for more sustainable products.

Education about circular economy in each country:

In Slovakia, while there is widespread awareness of the circular economy, integrating these principles into the production process remains a significant challenge. Similarly, in Austria, although the principles of the circular economy are recognised, applying them within existing processes proves to be a different and more complex task. Further some processes are not declared as part of circular economy, even when they can be seen as a part of it (regular maintenance, recycling of parts, etc.) In the Czech Republic, the knowledge about the circular economy is present, but there is a lot of discussion without much action. Companies are first trying to gather data to understand what steps to take. Some recognize the competitive advantage that could come with adopting circular economy practices, but the initial costs and commitment required make it difficult to get started. ESG reports are seen as a potential leverage point, providing a reason for companies to adopt more sustainable practices.

Regulations in each country related to the machine industry, which can be an obstacle in the adoption of circular principles:

At the regional level, EU regulations are more often seen as obstacles. The AI Act is seen as a threat especially in the machine industry.

Innovation challenges and opportunities:

One significant challenge is data monitoring and analysis over time, which is crucial for tracking progress and making informed decisions. Education is another key area, starting from schools to ensure that future generations are well-versed in circular economy principles. Furthermore, the initial investment costs to get started can be high, posing a barrier for many companies. Finding the right partners is also not trivial, as there are many agencies involved, making it difficult to identify the most suitable collaborators. Governmental hurdles, particularly through procurement issues for state-owned entities, further complicate the process. Slow processes and the lack of common knowledge about data on machine and technology availability add to the difficulties. Despite these challenges, there are significant opportunities, such as sharing capacity in waste sorting, which can enhance efficiency and resource utilization. And probably the greatest opportunity offered by innovation in the circular economy is the competitive advantage over competitors both outside and within Europe.

What can we learn from each other, and how can we transfer the results more efficiently between countries and regions?

The countries of Austria, Slovakia, and the Czech Republic face similar challenges in developing a circular economy, with mindset being a significant barrier. Despite these challenges, there is much to learn from each other. Projects and clusters play a crucial role in transferring data and results more efficiently between countries and regions. By collaborating on shared initiatives and leveraging the collective knowledge and experiences, these countries can overcome common obstacles and accelerate the adoption of circular economy practices. This collaborative approach can help shift mindsets and demonstrate the tangible benefits of circular economy models, making it easier to implement sustainable practices across different sectors.

Key conclusions:

Austria:

- Initial awareness of CE was not universal, but participants realized existing processes aligned with CE principles during the workshop.
- Economic challenges and low priority of the topic made it difficult to attract participants; financial benefits and regulations served as better motivators.

Slovakia:

- Some companies were already engaged in refurbishment as a business, operating a pure circular model.
- Emphasis on predictive maintenance as part of CE, working closely with original producers and using additive manufacturing for reverse engineering.
- Easy to get workshop participants due to regular conferences and meetings.

Czech Republic:

- Focus on measuring sustainability, calculating emission profiles, and optimizing production processes through data analysis.
- Reluctance to share know-how and lack of machine producers in the rubber and plastic processing industry made data collection difficult.
- Knowledge about CE exists, but action is limited; companies first gather data to understand necessary steps.

All:

- Mind-Set within the machine industry is not yet there to transform to more circular business models

- Collaboration through projects and clusters is key to transferring data and results efficiently between countries and regions.
- Leveraging collective knowledge and experiences can help overcome common obstacles and accelerate the adoption of circular economy practices.

Germany, Hungary, Bosnia and Herzegovina

Discussion on the implemented workshops for machine industry representatives, with a special focus on how aware and educated the workshop participants were about the principles of the circular economy and how easily they managed to reach pilot solutions:

Germany: Chaotic, with a lot of filtering needed. There were more plastic people than machines, and the latter were overwhelmed. Injection moulding producers don't really think in circularity.

In Germany, particularly in the TZ Horb, Nordschwarzwald Region, workshops were conducted to educate representatives from the machine industry on circular economy principles. The level of awareness among participants varied significantly:

- Large enterprises and industry leaders had a higher baseline knowledge, often due to existing sustainability strategies and regulatory compliance requirements.
- SMEs and regional manufacturers showed a mixed understanding, with some companies having well-integrated circular economy principles, while others were just beginning to explore sustainable practices.
- Overall engagement was positive, with many participants showing a strong interest in reducing material waste, improving resource efficiency, and exploring alternative business models such as leasing and remanufacturing.

The ease with which participants managed to develop pilot solutions depended on several factors:

- Companies with prior sustainability initiatives were quicker in formulating actionable pilot solutions, leveraging existing frameworks.
- Financial and regulatory support played a crucial role in facilitating pilot project initiation. Companies that had access to funding or incentives from programs like "Zirkuläre Wertschöpfung Deutschland" moved faster towards implementation.
- Technical feasibility and supply chain constraints sometimes slowed down progress, particularly for SMEs that lacked in-house expertise or faced dependency on linear production processes.
- Collaboration with academic institutions and research centers, such as the Fraunhofer Institutes, enabled smoother transitions into pilot projects by providing necessary knowledge and technological backing.

Hungary: In November 2024, a workshop was organized with 35 participants, including representatives of manufacturing companies and digital solution providers in the machinery industry. The workshop generated a lively debate, there were 5 presentations, with the active engagement of the attendees. Most participants were already familiar with the principles of the circular economy, especially in the context of maintenance and lifecycle extension strategies. Discussions focused particularly on the different levels of repair: reactive, preventive, and predictive maintenance.

It was highlighted that while knowledge exists at decision-maker level, implementation of innovative circular solutions is often limited by several factors:

- Lack of financial resources,
- Insufficient access to EU-level indirect funding (particularly in Hungary),
- Technological or human capacity constraints.

There is a growing demand for new types of industrial equipment that support circularity—not just within the machinery sector itself, but also in response to the needs of plastics manufacturers and recyclers. Equipment such as shredders, washing systems, optical and density sorting and separating lines, and compounding extruders are essential to close the loop in plastics recycling.

However, due to legal uncertainty and capital constraints, many companies prefer to buy recycled raw materials (e.g. regranulate) from a few large-scale recyclers, instead of investing in in-house recycling solutions. In Hungary, this situation has been further centralised by the entry of MOHU, which has monopolised the collection and distribution of post-consumer plastic waste.

Bosnia*:* The development of the circular economy in Bosnia and Herzegovina faces several interconnected challenges. One of the primary issues is the limited public and institutional understanding of circularity beyond basic waste management and recycling—particularly within the machinery and industrial sectors. Concepts such as reuse, refurbishment, and product-life extension are not yet embedded in business strategies or public discourse.

Another challenge lies in the absence of structured market mechanisms for circularity. There are no dedicated platforms or official channels for sourcing verified spare parts or refurbished machinery. As a result, companies are often forced to “make do” through informal or alternative procurement channels, including international online platforms, due to the lack of access to local authorized suppliers or cost-effective parts. This reactive approach to maintenance reflects a form of circular practice in reality, but one that is not formally recognized or supported by the system.

In parallel, Bosnia and Herzegovina currently lacks a comprehensive regulatory framework or national strategy for circular economy development, and there are no tax

incentives or subsidies targeted at circular product design, refurbishment, or repair. As a result, industrial companies have few legal or financial motivators to integrate circular practices.

Challenges and strategies for circular economy development:

Participants broadly agreed that, although Europe contributes far less to global pollution compared to regions such as Asia or Africa, it still has a key responsibility to lead by example. Europe currently has the highest global share ratio in the use of recycled plastics and biopolymers, and this pioneering role must be reinforced through the implementation of best practices, supportive policy frameworks, and technology-driven innovation.

Despite this leading position, the transition to circular models in the machinery and plastics sectors faces considerable challenges:

- The acquisition and installation of industrial machinery that supports circular processes (e.g. refurbishment, recycling) remains prohibitively expensive for many companies, particularly small and medium-sized enterprises.
- When a machine needs to be replaced, the costs are not limited to purchasing new equipment. Additional steps such as re-technologisation, commissioning, compliance testing, and auditing often become necessary, further increasing the total investment.
- A critical concern is: how can customer needs be met when production is interrupted due to machine replacement or refurbishment? In many cases, companies are reluctant to initiate such transitions out of fear of delivery delays or operational setbacks.
- Machine stoppages typically generate secondary negative effects, including the need to reorganise production shifts, reschedule internal logistics, or adapt facility conditions (e.g. heating and ventilation). These indirect impacts often make the transition even more complex and costly.
- Once a machine is discarded, it often qualifies as hazardous industrial waste due to its size, material composition, and potential contamination. Without proper end-of-life management systems, this creates environmental and regulatory risks, and limits the circularity of machinery itself.

Social challenges and society's awareness of the circular economy

In all participating countries, a recurring theme was the limited public understanding of what the circular economy truly means—particularly beyond household-level recycling. This is especially relevant in the context of machinery and industrial plastics, where circularity is rarely associated with end-users or non-specialists.

In **Hungary**, circular economy awareness is significantly below the EU average, both in terms of the quantity and quality of collected recyclable waste. According to available data, an estimated 25–30% of materials placed in selective bins are incorrectly sorted—including items such as CDs, plastic toys, or complex multi-material products that cannot be effectively separated or processed. A major contributing factor is the inconsistency of selective waste collection systems across different regions. For example, in some municipalities, beverage carton boxes are considered paper waste, in others they belong in the plastics bin—or are not accepted at all. Although the recent establishment of MOHU, Hungary's national waste management coordinator, has helped to standardise accepted material categories, significant regional variations still exist. In Budapest, paper and plastic waste are collected separately, whereas in several parts of Central Hungary, they are collected together. There is also a notable regional divide in public motivation and participation. Residents in the more affluent central and western parts of the country typically show greater commitment to selective collection, while engagement is significantly lower in eastern, economically less-developed regions.

In the context of the machinery industry in **Bosnia and Herzegovina**, social awareness of circular economy principles is very limited. Most industrial stakeholders do not associate circularity with machinery or production equipment. Instead, the concept is still narrowly understood as being related to recycling—mainly of plastics—rather than reuse, refurbishment, or extended lifecycle management of machines.

There is no structured culture of preventive or predictive maintenance in most companies. Maintenance is typically reactive—equipment is repaired only after it fails. Companies often lack clear technical documentation for used or imported machines, which contributes to suboptimal operation and earlier breakdowns. This is not always a result of planned obsolescence, but rather of an informational gap between manufacturers and machine users, especially when equipment is second-hand or lacks local technical support.

Repairability is also a significant issue. Due to high costs or limited availability, many spare parts are sourced informally—often from international online platforms like eBay. This reflects a kind of informal circular practice motivated by economic necessity, but without systemic support or quality assurance.

Moreover, the concept of leasing or shared use of machinery is still underdeveloped. Industrial equipment is primarily viewed as capital expenditure and long-term property. Functional economy models—such as rent-a-factory services, shared production lines, or machine-as-a-service—are largely unfamiliar and rarely implemented.

There are no dedicated awareness campaigns, educational programs, or public initiatives focused on promoting circular economy concepts within the machinery sector. While some general donor-funded programs target green economy or SME competitiveness,

they do not address the specific circular challenges or opportunities in the industrial machinery domain.

In **Germany** large enterprises and industry leaders have a higher baseline knowledge, often due to existing sustainability strategies and regulatory compliance requirements. SMEs and regional manufacturers show a mixed understanding, with some companies having well-integrated circular economy principles, while others were just beginning to explore sustainable practices. Collaboration with academic institutions and research centers, such as the Fraunhofer Institutes, enables smoother transitions into pilot projects by providing necessary knowledge and technological backing.

Education about circular economy in each country:

Education plays an important role in how quickly circular economy principles spread in industry. In many cases, companies only use recycled plastics because regulations require them to do so. If more people understood the real environmental and economic benefits, the use of recycled materials could become more widespread—even without legal pressure.

Better awareness could lead to increased demand for recycled plastics. This, in turn, would support the plastics recycling sector and also benefit the machinery industry. More companies would need machines that can handle recycled materials, such as shredders, washing, sorting, and separating equipment, or compounding extruders. As demand grows, so does the need for reliable, specialised equipment to process these materials.

Education can also help promote more local, closed-loop systems within factories. If manufacturers understand how they can collect and reuse their own production waste on-site, they can reduce raw material costs and environmental impact at the same time. This requires not only machines that can do this work, but also people who know how to operate and manage them effectively.

In this context, the academic sector has a key role. Universities and research institutes can support industry by sharing up-to-date knowledge, organising training programmes, and developing pilot projects. Academic actors can also raise awareness through outreach activities, such as public events or campaigns targeting students, engineers and future decision-makers.

According to the *White Paper on Circular Economy in Bosnia and Herzegovina* (2022), circular economy topics are rarely addressed in formal curricula, particularly in industrial and engineering contexts. While environmental awareness is sometimes included in general education, technical and vocational education and training programs, as well as university-

level engineering studies, do not systematically incorporate circular economy concepts such as repairability, design for durability, reuse of machinery, or circular business models.

However, in recent years, Bosnia and Herzegovina has seen a gradual but encouraging shift toward supporting innovation and digital transformation through programs that enable SMEs, public administrations, and educational institutions to explore circular economy principles. While formal education and policy frameworks for circularity are still under development, the availability of digital transformation grants and voucher schemes represents a practical entry point for embedding circular practices into industrial operations.

Regulations in each country related to the machine industry, which can be an obstacle in the adoption of circular principles:

Bosnia and Hungary has no legislation about circular economy. However, European Union regulations apply to Hungary, but there is no government subsidy or incentivisation for circular products. Bosnia and Herzegovina currently lacks a specific legal or policy framework that promotes the adoption of circular economy principles in the machinery and industrial equipment sectors. There are no dedicated national strategies, regulations, or tax incentives that support circular economy practices.

The legal framework does not recognize or promote the circular use of machinery and production equipment, nor does it provide any form of subsidy or fiscal relief for companies adopting circular business models. This creates an uneven playing field where purchasing new equipment is often simpler from a regulatory and logistical perspective than maintaining or reusing existing machinery.

While Germany has strong policies supporting circular economy principles, navigating compliance frameworks (e.g., Verpackungsgesetz, Kreislaufwirtschaftsgesetz) can be challenging for SMEs. Providing clearer guidelines and reducing administrative burdens for circular economy initiatives can help companies implement changes more effectively.

Innovation challenges and opportunities:

For **Hungary**, transitioning to a circular economy in the plastics and machinery sectors presents several important innovation challenges—but also major opportunities. In many parts of the region, plastics recycling is still heavily dependent on manual sorting, which is slow, inconsistent, and prone to human error. Investing in automated sorting technologies—such as shredders, density separation systems (e.g. float-sink tanks), and optical sorting machines—is essential for improving efficiency and the quality of recyclate.

At the same time, the machinery industry can support circularity by offering equipment that:

- enables waste and emission reduction,
- reduces cycle times,
- consumes less energy,
- is suitable for refurbishment and long-term use, which is significantly better for the environment than producing entirely new machines,
- and incorporates inline equipment-monitoring systems, so that potential malfunctions can be detected early—focusing not only on product quality but also on machine condition and process stability.

Another area of opportunity is training and knowledge development. When staff understand the logic and benefits of circularity, they are more likely to operate and maintain machines responsibly, contributing to longer lifecycles and lower failure rates.

Altogether, innovation must focus on creating a system where waste is minimised, processes are optimised, and equipment is designed for a circular life cycle. This not only supports sustainability goals but also creates new business opportunities for technology developers and machine manufacturers alike.

Innovation in the machinery sector **in Bosnia and Herzegovina** is still developing and faces several key challenges. One of the primary barriers is the limited availability of structured support for research, development, and adoption of circular technologies, such as condition monitoring, predictive maintenance systems, or refurbishment processes. Most industrial innovation remains focused on cost reduction or basic automation, while systemic circular solutions are rarely prioritized.

Another major challenge is the fragmented innovation ecosystem—cooperation between industry, academia, and research institutions is still relatively weak, and funding mechanisms for applied industrial innovation are limited or highly competitive. Start-ups and SMEs in particular struggle to test or pilot circular business models, due to the lack of access to prototyping facilities, advisory support, or seed funding.

There is also a lack of digital infrastructure and data transparency needed to enable advanced circular practices, such as machine lifecycle tracking, digital twin technology, or AI-based diagnostics. Without accessible and reliable data, companies find it difficult to make informed decisions about when and how to repair, reuse, or replace equipment.

Despite these challenges, there are promising opportunities. The growing number of programs supporting digital transformation can be used as an entry point for circular practices in industry. There is also a potential for regional or sector-specific platforms—such as an AI-powered catalogue of used machine parts or a marketplace for refurbished industrial equipment—providing safer and more efficient ways to exchange and reuse machinery.

Furthermore, cross-border collaboration within the Danube and Western Balkan regions offers an opportunity to share expertise, develop joint solutions, and scale best practices. Creating innovation hubs or demonstration labs focused on circular machinery solutions could serve as a catalyst for broader adoption and experimentation.

What can we learn from each other, and how can we transfer the results more efficiently between countries and regions?

Although countries face different levels of industrial development and infrastructure, many of the challenges related to circularity are shared. By exchanging practical experiences, participants were able to identify common gaps—such as the lack of reliable spare parts, low repairability, and limited knowledge about circular business models.

Germany provides us with examples of how circular practices in the machinery sector can be scaled through strong institutional support, collaboration with research institutions, and viable business models like machine refurbishment, as seen with Kieserling. Networks like INNONET Kunststoff and initiatives from the Fraunhofer Institutes can facilitate best practice exchange and cross-industry learning. Hungary also offers a relatable case for Bosnia and Herzegovina, showing how a country with limited regulatory and financial instruments can still move toward structured circular solutions through practical, low-cost approaches such as promoting repair and reuse. A common challenge in all three countries is the gap between machine producers and users, which makes repairability and information-sharing difficult. To transfer results more efficiently, it's not enough to just present good examples, we need to focus on what actually worked in practice and why.

Key conclusions:

The discussions confirmed that circularity is still a developing concept in the machinery industry, particularly when linked to plastics recycling. Circular economy in the machinery sector is still at an early and experimental phase, but relevant practices already exist, some structured, others informal. Across all countries, companies face similar barriers: limited awareness, lack of regulation, and missing information about repairability and optimal machine use. Despite that, there is clear interest and existing experience with reuse, refurbishment, and alternative maintenance approaches. While some progress has been made, real implementation is often hindered by economic, regulatory and technical barriers. The disconnection between machine producers and end-users, along with the lack of repair and reuse strategies, continues to be a major challenge.

At the same time, examples like Kieserling show that circular business models can be not only environmentally beneficial, but also economically stable. Refurbishment, predictive maintenance, and local reuse of industrial waste all represent practical ways to extend the life of machines and materials.

To move forward, stakeholders across countries and sectors should focus on improving knowledge exchange, investing in suitable machinery, and promoting education at all levels. With better coordination and targeted innovation, circularity can become a competitive advantage rather than just a compliance requirement.

Key Barrier	Infrastructure Issue	Proposed Strategy	Collaborational Potential
Regulatory Complexity	Fragmented or nonexistent compliance frameworks for circular initiatives	Simplify guidelines and reduce administrative burdens. Introduce government subsidy and/or programs.	Government bodies, legal advisors
Financial Barriers	High upfront costs for new recycling technology	Increase subsidies, low-interest loans for circular projects	Funding agencies, sustainability programs
Market Demand Issues	Customers prioritize cost over sustainability	Awareness campaigns to highlight benefits of circular products	Industry associations, consumer advocacy groups
Technical Limitations	Challenges in material separation, recycling efficiency	Invest in R&D for better recycling processes	Research institutions, Fraunhofer Institutes
Suppy Chain Depedencies	Linear supply chain structures hinder circular adoption	Develop closed-loop systems with local suppliers	Manufacturers, logistics providers

Romania, Republic of Moldova, Serbia

Discussion on the implemented workshops for machine industry representatives, with a special focus on how aware and educated the workshop participants were about the principles of the circular economy and how easily they managed to reach pilot solutions:

Overview of Awareness & Education Levels Across Countries:

- **Serbia (ICMF)**: Participants had a moderate-to-high level of awareness regarding circular economy principles. Many were already familiar with eco-design, material traceability, and component reuse but needed guidance on business models for circularity (e.g., machine-as-a-service).
- **Romania (CLUSTERO, ICMPP)**: Participants showed high awareness of circular economy practices in plastic processing, material recovery and recycling, but required support in integrating energy efficiency measures, predictive maintenance, and optimizing industrial processes to enhance the sustainability of machines.
- **Moldova (SORINTEX)**: Awareness was moderate but limited to basic concepts like recycling and reuse. Advanced concepts like remanufacturing, modular design, and reverse logistics were new to many participants, requiring significant guidance.

Ease of Reaching Pilot Solutions:

- **Serbia (ICMF)**: Pilot solutions were developed relatively quickly due to strong industry engagement and familiarity with circular concepts. The use of blockchain for material traceability and smart returnable packaging were particularly well-received.
- **Romania (CLUSTERO, ICMPP)**: Participants effectively collaborated in teams and leveraged their expertise in plastics processing to propose innovative solutions, such as solvent recovery systems, energy-efficient upgrades, and novel shredding techniques (e.g., freezing plastics before chopping). Their solutions required technological refinement but were realistic.
- **Moldova (SORINTEX)**: While the solutions developed (e.g., modular automotive components) had strong potential, participants needed more technical guidance to ensure feasibility. The workshops highlighted the need for further capacity building in circular economy strategies.

Challenges and strategies for circular economy development in each country:

Serbia (ICMF)

Challenges:

1. **Low Awareness & Adoption:** Many businesses in Serbia are not fully aware of circular economy principles and their economic benefits.
2. **Regulatory Gaps:** While some EU-aligned environmental policies exist, there is still a lack of clear incentives for circular business models.
3. **Limited Infrastructure:** Serbia lacks advanced recycling and material recovery facilities, making it challenging to implement closed-loop systems.
4. **Traditional Business Mindset:** Many manufacturers still focus on linear production models (produce, use, dispose), making transitioning to circular models slow.

Strategies:

1. **Education & Training:** Organizing workshops, accelerator programs, and case studies to demonstrate circular economy success stories.
2. **Public-Private Collaboration:** Engaging government agencies, industry stakeholders, and academia to create regulatory incentives for circularity.
3. **Pilot Projects:** Encouraging modular design, material traceability via blockchain, and machine rental models to prove their business viability.
4. **EU Integration:** Aligning local policies with EU circular economy regulations, ensuring access to funding and cross-border knowledge exchange.

Romania (CLUSTERO, ICMPP):

Challenges:

1. **Energy-Intensive Manufacturing:** Many plastic-processing plants still rely on outdated machinery, consuming excessive energy.
2. **Slow Policy Implementation:** Romania has a National Circular Economy Strategy, but implementation is not yet widespread.
3. **High Dependence on Imports:** Many plastic processing machines are imported without circular design, limiting upgrades for sustainability.
4. **Technological Gaps in Machinery Recycling**: Limited infrastructure and expertise in refurbishing or repurposing old plastic processing machines hinder circularity efforts.

Strategies:

1. **Industry-Specific Circular Solutions:** Focus on plastic reuse across industries (asphalt, furniture, equipment) to create demand for recyclates.

2. **Energy Efficiency and Machinery Upgrades:** Support machine retrofitting & predictive maintenance, and design for modularity to reduce energy consumption and improve circularity.
3. **Stronger Government Incentives:** Expand tax breaks and investment incentives for businesses adopting energy-efficient technologies and circular design principles in machinery.
4. **Collaboration with EU Partners:** Leverage EU funding programs and cross-border partnerships to improve circular economy practices.

Moldova (SORINTEX)

Challenges:

1. **Lack of circular economy awareness**—most businesses are only familiar with basic recycling, not advanced strategies like modular design, remanufacturing, or closed-loop systems.
2. **Underdeveloped recycling and remanufacturing infrastructure**—companies lack access to modern waste-processing technologies.
3. **Weak policy support**—no Extended Producer Responsibility (EPR) scheme, making businesses less accountable for product end-of-life management.
4. **Limited financial incentives**—companies struggle with the upfront costs of adopting circular technologies.

Strategies:

1. **Developing targeted educational programs**—workshops and training for businesses and universities on remanufacturing, circular design, and modularity.
2. **Investing in infrastructure**—collaborating with regional partners (Serbia & Romania) to establish shared recycling and remanufacturing hubs.
3. **Policy reform**—introducing EPR schemes and standardized regulations to encourage sustainable product design.
4. **Creating financial incentives**—grants and subsidies for businesses adopting circular practices, particularly in automotive and plastics industries.

Summary of Challenges & Strategic Solutions

CATEGORY	SERBIA	ROMANIA	MOLDOVA
Main Challenge	Limited financial incentives & regulatory gaps	High energy consumption & logistics inefficiencies	Low awareness & lack of infrastructure
Key Barrier	Lack of industry collaboration	Outdated machinery & lack of funding for SMEs	Weak policy & enforcement
Infrastructure Issue	Low adoption of digital traceability tools	Limited infrastructure for retrofitting & recycling logistics	Lack of advanced recycling & remanufacturing facilities
Proposed Strategy	Align policies, promote blockchain traceability, expand circular business models	Energy audits, funding for SMEs, logistics improvements	EPR implementation, financial incentives, education & training
Collaboration Potential	Serbia can share knowledge on blockchain traceability & modular machine design	Romania can assist Moldova with plastic processing & logistics efficiency	Moldova can integrate Serbian and Romanian expertise to build a stronger policy & infrastructure framework

Social challenges and society's awareness of the circular economy in each country:

Serbia (ICMF)

Social Challenges:

1. **Low Public Awareness:** The general population still views waste as disposable rather than as a resource. There is little public pressure on industries to adopt circular economy practices.
2. **Consumer Behavior & Mindset:** Preference for new products rather than refurbished/reused goods is widespread, making it hard to promote circular models.

3. **Lack of Educational Programs:** Schools and universities do not include circular economy principles in curricula, leading to a knowledge gap among young professionals.
4. **Limited Public Incentives:** No strong government campaigns or financial incentives to encourage citizens to support circular economy efforts.

Awareness & Engagement Strategies:

1. **Educational Campaigns:** Introducing circular economy concepts in schools, universities, and public institutions.
2. **Media & Public Influence:** Increasing media coverage, social media campaigns, and influencer partnerships to promote awareness.
3. **Encouraging Responsible Consumption:** Creating public incentives for using refurbished products and adopting waste reduction behaviors.
4. **Community Initiatives:** Partnering with NGOs, local governments, and businesses to launch pilot programs in waste reduction and sustainable product use.

Romania (CLUSTERO, ICMPP):

Social Challenges:

1. **Moderate Awareness with Limited Action:** There is growing awareness of sustainability and climate change, but circular economy adoption remains low in daily life.
2. **Skepticism Toward Recycled Materials:** Many consumers and businesses lack trust in the quality of recycled products, affecting their demand.
3. **Insufficient Public Engagement:** The Romanian public rarely participates in circular economy programs because incentives and enforcement are weak.
4. **Socioeconomic Barriers: Lower-income groups** prioritize affordability over sustainability, making eco-friendly and circular products less accessible.

Awareness & Engagement Strategies:

1. **Improving the Market for Recycled Products:** Promoting success stories of companies using recycled materials and offering certifications for quality assurance.
2. **Public Incentive Programs:** Providing financial rewards for citizens and businesses adopting circular economy practices.

3. **Educational & Vocational Training:** Encouraging technical schools and universities to teach about circular manufacturing and waste recovery methods.
4. **Retail & Consumer Campaigns:** Partnering with large retailers to increase visibility of eco-friendly products and promote refurbished goods.

Moldova (SORINTEX)

Social Challenges:

1. **Low public awareness of circular economy beyond basic recycling:** concepts like remanufacturing, modularity, and closed-loop systems are largely unknown.
2. **Limited public trust in recycled products:** people perceive new materials as superior.
3. **Lack of government-led awareness programs:** no large-scale campaigns or financial incentives for circular practices.
4. **Weak consumer engagement:** minimal demand for repair, leasing, and refurbished products.

Awareness & Engagement Strategies:

1. **National circular economy awareness campaign:** similar to Romania's waste reduction initiatives.
2. **Integrate circular economy into school and university curricula:** introduce subjects on eco-design, resource efficiency, and closed-loop production.
3. **Create financial incentives for circular consumption:** discounts or tax breaks for leasing, remanufactured goods, and waste reduction practices.
4. **Public-private partnerships for community projects:** local initiatives on repair workshops, textile recycling, and modular furniture could engage citizens.

Comparison of Social Awareness & Challenges

FACTOR	SERBIA	ROMANIA	MOLDOVA
Public Awareness	Moderate (focused on recycling, lacks circular business understanding)	Moderate (better awareness in plastics sector, gaps in industrial sectors)	Low (circular economy not widely understood)

FACTOR	SERBIA	ROMANIA	MOLDOVA
Consumer Behavior	Prefers cheap new products over sustainable alternatives	Growing demand for sustainable products, but businesses slow to adopt	Distrust in recycled materials, low adoption of repair & reuse models
Challenges	Lack of education, business hesitation, low government incentives	Uneven adoption across industries, skepticism about recycled materials	Weak policy support, no large-scale awareness programs
Best Strategies	Public education, incentives for sustainable purchasing, business awareness programs	Green procurement, pilot projects, expanding awareness campaigns in rural areas	Large-scale education, financial incentives, partnerships for community-based projects

Education about circular economy in each country:

Serbia (ICMF)

Current Status:

1. **Limited Integration in Education System:** Circular economy is not yet systematically included in Serbian school or university curricula.
2. **Industry-Specific Knowledge Gaps:** Many professionals in manufacturing and engineering are unfamiliar with circular design, sustainable sourcing, and waste management.
3. **Few Training Programs for Businesses:** While some universities and innovation hubs offer sustainability courses, most companies still lack structured training on circular business models.
4. **Policy & Governmental Support is Lacking:** Serbia's environmental policies align with the EU, but circular economy education is not a government priority.

Strategies to Improve Circular Economy Education:

1. **Incorporate Circular Economy into School Curricula:** Introduce sustainability and circularity topics in STEM education (science, engineering, and business programs).
2. **Launch Business Training Programs:** Universities and innovation hubs should collaborate with industry players to provide hands-on training in circular production and sustainable sourcing.
3. **Public-Private Partnerships:** Encourage corporations to invest in workforce training on circular economy practices and create knowledge-sharing networks.
4. **Government Incentives for Circular Education:** Introduce grants for schools and businesses that develop circular economy learning modules.

Romania (CLUSTERO, ICMPP):

Current Status:

1. **Moderate Awareness with Some University Programs:** Some Romanian universities offer courses in sustainability and environmental engineering, but circular economy education **is not yet mainstream**.
2. **Growing Interest in Industry Training:** Clusters and business associations have started offering workshops and training, especially in plastics processing and recycling.
3. **EU Policy Influence:** Romania's National Circular Economy Strategy emphasizes education as a key pillar, but implementation is slow.
4. **Lack of Skilled Workforce:** Many companies struggle to find workers with expertise in sustainable production and circular design.

Strategies to Improve Circular Economy Education:

1. **Expand University Courses & Vocational Training:** Introduce specialized degrees & certifications in circular manufacturing, waste recovery, and eco-design.
2. **Industry-Academic Partnerships:** Connect universities with businesses to develop real-world case studies & research collaborations.
3. **EU-Funded Educational Initiatives:** Utilize EU funds to support training programs for students, entrepreneurs, and SMEs.
4. **Digital Learning Platforms:** Develop online courses and webinars to make circular economy knowledge more accessible to a wider audience.

Moldova (SORINTEX)

Current Status:

1. Minimal integration of circular economy topics in formal education.
2. Only basic environmental sustainability concepts are covered in universities.
3. Industry knowledge is limited—most businesses associate circularity only with waste recycling and not with remanufacturing, closed-loop systems, or modular design.
4. Few training programs for industry professionals.

Strategies to Improve Circular Economy Education:

1. **Develop circular economy modules in higher education:** collaborate with Romanian and Serbian universities to design courses.
2. Establish vocational training programs for professionals in automotive, plastics, and machinery industries.
3. Launch government-backed awareness campaigns on the importance of remanufacturing and material recovery.
4. Encourage industry-academia partnerships to facilitate internships and hands-on learning.

Comparison of Circular Economy Education in Serbia, Romania, and Moldova

FACTOR	SERBIA	ROMANIA	MOLDOVA
University Programs	Some universities offer courses, but focus is still growing	Stronger academic presence, but mostly in large cities	Minimal presence, mostly covering basic sustainability
Vocational Training	Limited and needs expansion to include practical experience	Some training available, but lacks focus on circular business models	Almost no vocational training available

FACTOR	SERBIA	ROMANIA	MOLDOVA
Industry Involvement	Industry engagement is low but improving	Industry-driven programs exist but need better SME participation	Very little collaboration between businesses and education
Public Awareness of Circular Business Models	Moderate—recycling is understood, but business models (leasing, remanufacturing) are not	Moderate-to-high—plastics and waste management well understood, but circular finance is still emerging	Low—only basic recycling is recognized
Best Strategy for Improvement	Develop specialized courses & SME training	Expand outreach to SMEs and small universities	Build circular economy education from the ground up

Regulations in each country related to the machine industry, which can be an obstacle in the adoption of circular principles:

Serbia (ICMF)

Regulatory Obstacles:

1. **Lack of Circular Economy-Specific Legislation:** Serbia follows some EU environmental policies but does not have specific regulations that support circular business models in the machine industry.
2. **Weak Enforcement of Waste Management Laws:** While Serbia has laws on waste management and extended producer responsibility (EPR), enforcement remains weak, making it hard for companies to prioritize reuse and refurbishment.
3. **Import & Export Restrictions for Used and Refurbished Machinery:** Strict customs regulations on importing and exporting used industrial equipment make it difficult to adopt machine refurbishment and component reuse strategies.
4. **Bureaucratic Barriers to New Business Models:** Leasing, rental, and product-as-a-service models for machinery face legal uncertainties, slowing down their adoption.

Possible Solutions:

1. Align Serbian regulations with EU Circular Economy Action Plan to create incentives for machine refurbishment, reuse, and extended product lifecycles.
2. Strengthen enforcement of waste management laws to promote component recovery and recycling.
3. Simplify customs procedures for cross-border trade in used and refurbished industrial equipment.
4. Introduce financial incentives for manufacturers that adopt circular design and sustainable sourcing practices.

Romania (CLUSTERO, ICMPP):

Regulatory Obstacles:

1. **Slow Implementation of Circular Economy Policies:** Romania has a National Circular Economy Strategy (adopted in line with EU directives), but many provisions are not fully implemented.
2. **Complex Bureaucracy for Sustainable Manufacturing Certifications:** Companies that want to produce eco-friendly or refurbished machine parts face lengthy approval processes.
3. **Energy & Waste Regulations Not Favorable for Circularity:** While Romania has waste management and industrial emissions regulations, they do not provide enough incentives for companies to switch to low-waste production models.
4. **Limited Support for Recycling Infrastructure:** The government has not sufficiently invested in recycling facilities, making it harder for industries to close material loops.

Possible Solutions:

1. Accelerate the implementation of the National Circular Economy Strategy with clear timelines and measurable targets.
2. Streamline administrative procedures for companies applying for sustainability and eco-certifications.
3. Introduce tax reductions or subsidies for companies that adopt remanufacturing, refurbishment, and waste reduction strategies.
4. Invest in regional recycling infrastructure to support closed-loop material systems in industrial production.

Moldova (SORINTEX)

Regulatory Obstacles:

1. **No Extended Producer Responsibility (EPR) for Machines**
    - Moldovan law does not require manufacturers to handle machine disposal.
    - This removes incentives for companies to focus on product longevity and repairability.
2. **Weak Enforcement of Circular Economy Regulations**
    - Recycling and waste management policies exist but are not enforced consistently.
    - Many companies still dispose of old machinery instead of refurbishing it.
3. **Lack of National Standards for Circular Manufacturing**
    - No guidelines on how to certify and integrate remanufactured machine parts into production.
    - Creates uncertainty for businesses interested in adopting circular strategies.
4. **Minimal Financial Support for Circular Economy Businesses**
    - No tax incentives or investment grants for circular economy initiatives.
    - Businesses lack financial motivation to adopt sustainable manufacturing.

Possible Solutions:

1. **Introduce EPR laws** to ensure that **manufacturers take responsibility for machine end-of-life management**.
2. **Develop national certification standards** for **remanufactured and reused machine components**.
3. **Create financial incentives** (e.g., **tax breaks or grants**) for companies that **adopt circular manufacturing**.
4. **Strengthen enforcement of recycling regulations** and ensure that **machine disposal laws** encourage reuse and refurbishment.

Comparison of Regulatory Challenges & Solutions

REGULATORY CHALLENGE	SERBIA	ROMANIA	MOLDOVA
EPR Regulations for Machines	No clear requirements	Partial EPR laws, but not applied to machines	No EPR framework
Certification for Remanufactured Parts	Unclear standards for second-life components	Complex, bureaucratic process	No national standards
Financial Incentives for Circularity	Few subsidies or tax incentives	Available but mostly for large corporations	No funding or tax benefits for circular businesses
Reverse Logistics & Take-Back Laws	No clear regulation for machine refurbishment	Unclear legal framework	No official guidelines
Waste Management Enforcement	Inconsistent, making compliance difficult	Well-regulated for plastics but unclear for machines	Weak enforcement, leading to wasteful disposal
Proposed Solution	EPR introduction, certification reform, tax incentives	Simplified compliance, SME financial support, reverse logistics law	EPR, financial incentives, and enforcement reform

Innovation challenges and opportunities:

Serbia (ICMF)

Challenges:

1. **Limited R&D Investment in Circular Economy Solutions:** Serbian companies still focus more on cost reduction than on sustainable innovation, leading to slow adoption of new circular technologies.
2. **Lack of Industry-University Collaboration:** There are few partnerships between research institutions and machine industry players to develop circular design and material recovery solutions.

3. **Financial Barriers to Innovation:** Many companies struggle to secure funding for projects related to machine remanufacturing, modular design, and sustainable sourcing.
4. **Resistance to Change in Traditional Manufacturing:** Many machine industry leaders prefer established linear production models, making it difficult to introduce circular business models.

Opportunities:

1. **EU Grants & Funding:** Serbia can access Horizon Europe, EIT Climate-KIC, and Circular Economy Accelerator programs to support circular innovation.
2. **Cross-Border Collaboration:** Partnering with companies and universities from EU countries can provide new knowledge and technology transfer.
3. **Adoption of Digital Tools:** Blockchain for material traceability, AI-driven waste reduction, and IoT for predictive maintenance can accelerate circular economy integration.
4. **Business Model Innovation:** Shifting towards Machine-as-a-Service, rental models, and repair/refurbishment programs can increase profitability and sustainability.

Romania (CLUSTERO, ICMPP):

Challenges:

1. **Slow Technology Transfer from Research to Industry:** Romania has strong academic expertise in plastics recycling and material science, but these innovations do not easily reach manufacturers.
2. **High Cost of Green Technologies:** Many circular innovations require upfront investment, and few companies are willing to take financial risks.
3. **Weak Market Demand for Circular Products:** The plastics and machine industries still prioritize low-cost over sustainable options, limiting the incentive for innovation.
4. **Fragmented Circular Economy Ecosystem:** There is no strong national platform connecting innovators, businesses, and policymakers, making it hard to scale new solutions.

Opportunities:

1. **Government Incentives for Circular Innovation:** Romania's National Circular Economy Strategy can provide grants for sustainable machine manufacturing.
2. **Industry 4.0 & AI Applications:** Integrating AI-powered process optimization, energy efficiency monitoring, and smart waste management systems can accelerate circularity.
3. **Collaboration with Clusters and Startups:** Supporting industrial symbiosis between machine manufacturers and recyclers can create new circular value chains.
4. **3D Printing & Additive Manufacturing:** Using bio-based and recycled materials in additive manufacturing can reduce material waste and increase product lifespan.

Moldova (SORINTEX)

Challenges:

1. **Low R&D funding for circular economy projects:** Moldova lacks public or private investment in circular economy research.
2. **Weak technological infrastructure for circular solutions**: Most companies lack access to 3D printing, blockchain, and IoT for circular manufacturing.
3. **No strong link between research institutions and industry**: Universities work in isolation, and few businesses engage with academic research on sustainability.
4. **Lack of skilled workforce for circular economy jobs**: Few training programs exist for engineers and workers in remanufacturing, reverse logistics, or biodegradable material development.

Opportunities:

1. **Attract foreign investment in circular economy infrastructure**—partner with Serbia & Romania to establish regional recycling hubs.
2. **Develop university-business collaboration programs**—adapt models from Romania & Serbia to turn research into real-world products.
3. **Encourage tech adoption in circular manufacturing**—introduce grants for Moldovan companies to implement 3D printing & blockchain for material tracking.
4. **Create vocational training programs for circular industries**—educate workers on remanufacturing, repair, and sustainable material use.

Comparison of Innovation Challenges & Opportunities

INNOVATION FACTOR	SERBIA	ROMANIA	MOLDOVA
R&D Funding for Circular Economy	Limited, mostly focused on traditional manufacturing	Some funding, but slow commercialization	Very low, almost no dedicated circular funding
Adoption of Digital Circular Solutions	Blockchain & AI adoption is slow	IoT & smart manufacturing growing, but expensive	Little to no access to advanced tech
Industry-University Collaboration	Fragmented, but improving	Stronger than Serbia, but still slow commercialization	Weak collaboration, almost no applied research in business
Workforce Readiness	Limited training for circular jobs	Some specialized programs, but not enough for all sectors	No structured workforce education
Best Strategy for Growth	Increase circular R&D funding & blockchain traceability	Create industry clusters & speed up certification of circular materials	Attract investment, develop university-business partnerships

What can we learn from each other, and how can we transfer the results more efficiently between countries and regions?

Lessons Serbia Can Learn from Romania & Moldova:

Streamlining Circular Economy Regulations (from Romania)

- Romania has clearer policies on recycling and waste management, which Serbia can adapt to improve EPR (Extended Producer Responsibility) for machines.
- Romania has government grants for SMEs adopting circular models, which Serbia can replicate.

Developing Interdisciplinary Circular Economy Clusters (from Romania)

- Romania has strong collaboration between plastics, automotive, and machinery industries to share recycling resources—Serbia can adopt this cluster model.

Adopting Low-Cost Training Models for SMEs (from Moldova)

- Moldova's grassroots training approach for small businesses can help Serbia educate more SMEs on circular manufacturing at low cost.

Lessons Romania Can Learn from Serbia & Moldova:

Using Blockchain for Circular Supply Chains (from Serbia)

- Serbia's blockchain traceability models for tracking recycled machine components can be adapted for Romania's plastics and manufacturing sectors.

Simplifying Circular Certification & Compliance (from Moldova)

- Moldova has simpler, more flexible compliance processes, making it easier for SMEs to adopt circular practices. Romania can reduce bureaucratic complexity in circular certification.

Increasing Public Awareness on Circular Economy (from Serbia)

- Serbia is more active in public awareness campaigns, particularly in waste management and circular finance models. Romania can implement similar awareness programs targeting consumers and businesses.

Lessons Moldova Can Learn From Serbia & Romania:

Creating Structured Circular Economy Regulations (from Romania & Serbia)

- Moldova lacks clear EPR and circular standards—it can replicate Serbia's and Romania's regulatory frameworks for waste management and remanufacturing.

Building University-Industry Collaboration (from Romania)

- Romania has stronger academic partnerships with industry, leading to practical circular solutions. Moldova can learn how to apply research findings to business applications.

Attracting Foreign Investment in Circular Economy (from Serbia)

- Serbia has been more successful in securing EU & foreign investments for green projects. Moldova can learn from Serbia's investment strategies to attract funding for circular startups and infrastructure.

How Can We Transfer Results More Efficiently Between Countries and Regions?

1. Create a Cross-Border Knowledge-Sharing Platform

- Develop an online hub where companies, universities, and policymakers from Serbia, Romania, and Moldova can share:
    - Best practices & case studies
    - Circular economy policies & funding opportunities
    - Business models & emerging technologies
- Hosted by a regional body (e.g., Interreg Danube Program) to ensure long-term collaboration.

2. Organize Joint Training & Capacity-Building Programs

- **Exchange programs for industry professionals**—Serbian and Romanian experts can train Moldovan SMEs on circular practices.
- **University-led cross-border training**—students and researchers from all three countries participate in shared circular economy courses and innovation labs.
- **Vocational training for workers**—hands-on programs in remanufacturing, recycling, and reverse logistics.

3. Establish a Regional Circular Economy Accelerator

- A startup accelerator focused on circular manufacturing, machine leasing models, blockchain traceability, and waste recovery.
- Supported by Serbian digital expertise, Romanian manufacturing knowledge, and Moldovan grassroots innovation.
- Funded through EU Horizon, EIT Circular Economy, or Interreg Danube projects.

4. Standardize Circular Economy Regulations Across Countries

- Align Serbia, Romania, and Moldova's EPR frameworks, remanufacturing certification, and recycling policies.
- Create mutual recognition of circular economy compliance so companies can easily operate across all three countries.
- Work together to lobby for more EU funding & policy support for circular economy initiatives.

5. Establish Regional Reverse Logistics & Material Recovery Networks

- Joint take-back programs for industrial machines, plastics, and auto parts to enable cross-border recycling & reuse.
- Logistics hubs shared between the three countries for efficient transport of recycled materials.
- Moldova can serve as a recycling & remanufacturing hub, while Serbia & Romania provide tech support & regulatory guidance.

Key conclusions:

The discussion highlighted significant progress in circular economy development across Serbia, Romania, and Moldova. Serbia has advanced blockchain solutions for material traceability and is focusing on modular machine design and leasing models. However, financial incentives and industry-wide collaboration remain challenges. Romania leads in plastics recycling, energy efficiency, and solvent recovery while benefiting from strong academic-industry partnerships. Nevertheless, funding access for SMEs and the complexity of regulatory processes need improvement. Moldova, in the early stages of circular economy adoption, has initiated modular automotive parts for circularity, but gaps in policy, infrastructure, and awareness limit large-scale implementation. Investment and training are crucial for building a structured circular economy framework in the country.

Several key challenges were identified across the three countries. Regulatory barriers pose significant obstacles, with Serbia and Moldova lacking Extended Producer Responsibility (EPR) policies, making it difficult to manage machines at the end of their lifecycle. In Romania, the bureaucracy involved in obtaining circular economy certifications slows down innovation. Funding limitations also hinder progress, as Serbia lacks tax benefits for circular business models, Romania's SME funding remains insufficient for transition, and Moldova has almost no financial support for circular economy adoption. Additionally, fragmented collaboration between industry and academia remains an issue, particularly in Moldova, where the absence of university-business partnerships slows the commercialization of circular solutions. While Serbia and Romania have stronger research-driven circular solutions, their implementation remains slow. Another major challenge is the low level of public awareness and workforce readiness, with Serbia and Moldova needing greater consumer and SME education about circular business models. Vocational training for circular economy jobs remains underdeveloped in all three countries.

Despite these challenges, there are numerous opportunities for joint collaboration. Establishing a cross-border knowledge exchange platform would enable companies, universities, and policymakers to share best practices, research, and case studies. A standardized regulatory framework for circular economy policies, particularly regarding remanufacturing certification, EPR, and recycling policies, would create a more harmonized approach across Serbia, Romania, and Moldova. A regional circular economy accelerator could support startups focused on circular manufacturing, leasing models, and material recovery, fostering innovation and investment in sustainable solutions. Strengthening circular economy education through vocational training programs in remanufacturing, recycling, and reverse logistics, as well as university courses on digital traceability and circular finance models, would prepare the workforce for new opportunities in sustainable industries. Another crucial initiative would be the development of a regional reverse logistics and material recovery network, creating joint industrial take-back programs for recycling and reuse, and establishing shared logistics hubs between Serbia, Romania, and Moldova.

By working together, Serbia, Romania, and Moldova have the potential to become leaders in industrial circularity in the Danube region. Their combined strengths in blockchain innovation, plastic recycling, modular machine design, and policy alignment can position them as a regional hub for sustainable manufacturing and resource efficiency. The collaboration will not only enhance environmental sustainability but also create economic opportunities through job creation, investment, and innovation in circular business models.

Conclusion

The transition toward circular economy practices in the machine industry is still in its early stages, with varying levels of awareness, implementation, and regulatory support across different sectors. While some companies have already integrated circular approaches such as refurbishment, predictive maintenance, and modular design, a widespread industry transformation remains slow. Economic constraints, the traditionally linear mindset, and the complexity of shifting existing production models continue to be major obstacles. Many companies prioritize data collection and sustainability assessment before committing to full-scale circular business strategies. Additionally, the fragmented relationship between machine producers and users makes circularity more challenging, as key stakeholders operate in silos with limited collaboration. The use of second-hand and refurbished machinery is a form of circularity already in practice, but it often goes unrecognized due to a lack of systematic tracking and integration into formal CE frameworks. A stronger emphasis on cross-industry collaboration, knowledge sharing, and coordinated policies is essential to overcoming these barriers and ensuring a more structured transition toward circular business models.

A critical challenge in the industry is the lack of focus on repairability and access to spare parts. Many machines are not designed with easy maintenance in mind, and essential information regarding optimal use, servicing, and repair is often unavailable. Even when machines can be repaired, sourcing spare parts remains a difficult process, as supply chains for remanufactured or reused components are underdeveloped and unreliable. Establishing a dedicated digital marketplace for machine parts and repair services could significantly improve access to quality components, extend product lifespans, and reduce industrial waste. Additionally, regulatory and financial constraints hinder progress, as circular business models often lack clear incentives, standardization, and supportive policies. Bureaucratic hurdles slow down certification processes, and funding for CE initiatives remains insufficient, particularly for small and medium-sized enterprises. Addressing these challenges requires a coordinated effort to streamline circular regulations, introduce Extended Producer Responsibility (EPR) policies for machinery, and develop financial mechanisms that encourage sustainable business practices. Industry-wide collaboration between manufacturers, users, policymakers, and research institutions is key to scaling up circularity and ensuring an efficient exchange of expertise, resources, and best practices.

Despite these challenges, the circular transformation of the machine industry presents significant economic and environmental benefits. Companies that embrace CE principles can reduce costs through resource efficiency, minimize waste, and create new revenue

streams through leasing models, remanufacturing, and product-as-a-service offerings. Moreover, shifting toward circularity enhances business resilience by reducing dependence on raw material extraction and supply chain vulnerabilities. Establishing structured initiatives such as cross-industry knowledge platforms, CE accelerators, and specialized training programs will be crucial in equipping businesses with the tools and expertise needed for this transition. The development of industrial reverse logistics, machine take-back programs, and material recovery networks will also support greater circularity and sustainability. As regulatory frameworks evolve and market demand for sustainable solutions increases, early adopters of circular business models will gain a strategic advantage in a rapidly changing industrial landscape. By fostering collaboration and innovation, the machine industry can transition toward a future where sustainability drives both economic growth and industrial resilience, ensuring long-term competitiveness in an increasingly resource-conscious world.