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Circularity in the machine industry

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Document Content

Introduction

The main aim of this activity was to write a practical guide on how companies in the machine industry can enter the circular economy, based on the developed circular machine life cycle concept. This document should be disseminated by the PPs, and also presented at the midterm conference in Smolenice Castle (SK) in frame of 10th International Conference on Polymeric Materials in Automotive (PMA 2025).

The machine industry, long considered a pillar of industrial development and technological progress, is currently navigating a critical crossroads. Global imperatives for climate action, resource efficiency, and sustainable production have begun to reshape the expectations placed upon traditional manufacturing and heavy industry. Amid this evolution, the transition to a circular economy emerges not as a trend, but as a strategic and systemic necessity.

In this context, the Plan-C project has explored ways to prototype and pilot circularity in the machine industry. Through a series of collaborative efforts, workshops, and analytical frameworks, project partners have elaborated a comprehensive circular machine life cycle concept and implemented design thinking methodologies to generate circular pilot solutions. These solutions were co-developed with industry stakeholders, demonstrating that circularity is both an accessible and valuable goal.

This document seeks to build on that momentum. It is a practical guide, rooted in the findings of Deliverables D.2.2.1, D.2.2.2, and D.2.2.3, that offers insight into how companies operating in the machine industry can begin or advance their journey toward circularity. It is addressed to both private-sector decision-makers and institutional stakeholders and aims to translate strategic ambitions into practical, operational steps that can lead to measurable and impactful transformation.

Importantly, the document also addresses how these circular approaches and knowledge should be disseminated—across borders, sectors, and institutional levels—to ensure that the transformation does not remain isolated but becomes systemic and scalable.

The machine industry faces complex environmental and economic challenges. Its dependence on finite raw materials, high energy intensity, and tendency toward planned obsolescence have historically contributed to linear economic models characterized by excessive resource extraction, short product lifespans, and large volumes of industrial waste.

However, this model is increasingly untenable. Regulatory pressure at the EU level, such as the European Green Deal and the Circular Economy Action Plan, is pushing

manufacturers to align with environmental goals. Meanwhile, customer demand for responsible products and investor interest in sustainable business models are reshaping market expectations. In this context, adopting circular practices is no longer a marginal endeavor—it is a strategic imperative.

Yet circularity is not only a compliance issue; it is also a pathway to resilience, innovation, and cost-efficiency. By designing for longevity, implementing maintenance systems that extend machine lifespans, adopting reverse logistics and refurbishment strategies, and shifting toward service-based business models, companies can significantly reduce their environmental footprint while generating new revenue streams. The industry has the potential not only to adapt but to lead.

The transformation is underway, but unevenly. While some companies and countries have made tangible progress, others are only beginning to explore circular strategies. This document offers some practical steps and suggestions on how to move from exploratory phase to structured, collective action.

The Circular Machine Life Cycle Concept

At the core of the Plan-C approach is a reimagined concept of the machine life cycle. Rather than seeing the life cycle as a linear progression from design to disposal, the circular machine life cycle is understood as a regenerative system in which materials, components, and value circulate as long as possible.

The life cycle is divided into eight interconnected phases. These are: design and development; material sourcing; manufacturing and assembly; distribution and logistics; use and maintenance; end-of-life management; refurbishment and reuse; and waste management. Each phase represents a specific opportunity to intervene and apply circular strategies.

A machine's life does not begin when it leaves the factory floor, nor does it end when it stops functioning. In a circular system, its design anticipates reuse, its materials are traceable and renewable, and its components are destined not for landfill but for remanufacturing, reuse, or transformation into new products.

The circular machine life cycle is not merely a technical reconfiguration—it is a redefinition of industrial logic. It implies rethinking relationships with suppliers, customers, regulators, and even competitors. It demands systems thinking, long-term planning, and a willingness to innovate in both products and business models.

Developing Circular Strategies Across the Life Cycle

Translating the circular life cycle concept into practice requires that companies undertake specific transformations in each phase of their operations. These transformations do not occur in isolation; they are cumulative and often interdependent. For instance, decisions made during the design phase have direct implications for end-of-life recyclability and refurbishment feasibility.

During design and development, circularity means more than using sustainable materials; it involves fundamentally rethinking how machines are structured. Modular design, for example, allows for easier disassembly, repair, and replacement. Designing with standardized parts ensures that components can be reused across multiple product generations. Eco-design principles reduce energy consumption and emissions not only in production but throughout the use phase.

Material sourcing, too, is a critical lever. Circularity in this phase means prioritizing recycled inputs, engaging in supplier due diligence, and participating in closed-loop systems that recover materials post-consumption. This reduces exposure to supply chain shocks while supporting the development of regional recycling ecosystems.

In manufacturing and assembly, lean production techniques can be enhanced by circular goals. The integration of additive manufacturing enables efficient, on-demand production, minimizing excess inventory and material waste. Remanufacturing—restoring used products to like-new condition—is especially relevant in the machine industry and presents a cost-effective, sustainable alternative to new production.

Distribution and logistics are often overlooked in circularity conversations, yet they hold great potential. Companies can reduce their carbon footprint by sourcing closer to production, optimizing transport routes, and implementing reusable packaging systems. Logistics also play a central role in reverse supply chains, where products are taken back for refurbishment or recycling.

During the use phase, circularity comes to life through predictive maintenance, retrofitting, and shared ownership. Predictive analytics, enabled by IoT technologies, allows companies to identify when machines require service before failures occur, thereby extending their lifespan. Business models based on leasing or machine-as-a-service arrangements support more efficient utilization and ensure that manufacturers retain responsibility for performance and end-of-life treatment.

End-of-life management is where circular intentions are either realized or lost. Without robust systems for take-back, disassembly, and material recovery, machines become waste. Establishing protocols for end-of-life treatment, from reverse logistics to partnerships with recycling centers, is essential for closing the loop.

Refurbishment and reuse strategies are increasingly being recognized as commercially viable alternatives to new production. Machines and components can be reconditioned, certified, and reintroduced into the market at a lower cost and environmental impact. Establishing trust in refurbished products is key, and this often requires third-party certification and transparent communication with customers.

Finally, waste management in a circular context is not about minimizing landfill alone—it is about valorizing waste. Material recovery facilities, industrial symbiosis, and biodegradable component design all contribute to creating a system where waste becomes input.

The Role of Design Thinking in Circular Transformation

To facilitate this systemic transformation, the Plan-C project adopted design thinking as a guiding methodology. Design thinking is an iterative, human-centered process for solving complex challenges. It is particularly effective in the context of circularity because it encourages stakeholders to rethink established norms, focus on end-users, and prototype innovative solutions quickly.

Workshops were organized across multiple countries, engaging a wide spectrum of stakeholders from different sectors of the machine industry. Participants were guided through a structured process that began with understanding the needs and barriers within each life cycle phase. They then defined specific problems, ideated potential solutions, created low-fidelity prototypes, and evaluated these against criteria such as environmental impact, scalability, and feasibility.

The success of these workshops demonstrated that companies are willing and able to engage with circularity when given the right tools and environments. Design thinking provided a structured yet flexible space where different stakeholders/machine industry representatives could collaborate creatively and practically. It shifted the focus from compliance to opportunity—from what companies must do to what they could achieve.

Insights from the Field: Regional Variability and Shared Learning

The circular transformation of the machine industry does not unfold uniformly across countries or regions. While circular economy principles offer a universal framework, their interpretation and implementation are deeply shaped by local economic structures, regulatory frameworks, industrial heritage, and societal mindsets. The Plan-C project, through its regional design thinking workshops and transnational peer learning sessions, revealed significant variability across countries in terms of circular economy awareness, readiness, and implementation in the machine industry.

However, rather than viewing these disparities as obstacles, the project framed them as opportunities for mutual learning and co-development. Countries with advanced practices served as reference points for those just beginning their transition, while less developed regions offered unique insights into informal circular practices, grassroots innovation, and context-sensitive adaptation.

In Austria, circular awareness within the machine industry is still emerging. Many companies initially did not recognize their existing practices—such as regular maintenance or part recycling—as elements of a circular economy. Through the design thinking workshops, they began to reevaluate these activities within a circular framework. One notable case involved a company exploring a business model around cooling-as-a-service, whereby they would maintain ownership of supermarket cooling systems and extend their lifespan through continual updates. This reflects a significant conceptual shift from product ownership to service provision. Austria's experience demonstrates that even in highly developed economies, mindset remains a major barrier, but also that financial and regulatory incentives can effectively catalyze interest in circular models.

In Slovakia, several companies were already practicing advanced forms of circularity, particularly in the refurbishment of machines and the application of predictive maintenance. These companies had integrated circularity into their core business models, often collaborating closely with original machine producers and using additive manufacturing to create spare parts. This illustrates a high level of technical readiness and openness to innovation. Slovakia's structured engagement with academic institutions and its emphasis on measurable environmental impact provide a model for others aiming to operationalize circular strategies.

In the Czech Republic, circularity was often approached from a technical and analytical standpoint. Companies focused on measuring the emission profiles of production processes to identify inefficiencies. However, despite this analytical capacity, there was a clear reluctance to share operational data or design knowledge—stemming from concerns about intellectual property and market competition. While circular awareness is present, it is often delayed by lengthy internal assessments and a lack of collaborative

culture. Nonetheless, the Czech approach underscores the importance of environmental data in making informed circular decisions and points to ESG reporting as a potential lever for engagement.

In Germany, the picture was somewhat mixed. Large enterprises, particularly those with international exposure and sustainability mandates, demonstrated higher circular maturity. They showed interest in models such as leasing, remanufacturing, and life-cycle services. However, smaller companies and regional producers were often overwhelmed by the complexity of circular transformation. The workshops revealed fragmentation between sectors, particularly between plastic and machine producers, and a lack of integrated thinking. Despite this, Germany's collaboration with applied research institutions such as the Fraunhofer Institutes offers a blueprint for how academic-industry partnerships can accelerate the development and testing of circular solutions.

In Hungary, the workshops gathered strong participation from both industrial companies and digital service providers. Participants were particularly knowledgeable about maintenance-related strategies, including reactive, preventive, and predictive maintenance. However, the major constraint was access to financial resources, especially indirect EU funding. Legal uncertainties and monopolistic control over plastic waste streams also limited the space for decentralized circular innovation. Despite these challenges, the Hungarian example shows the value of cross-sectoral dialogue and suggests that regulatory reform and decentralized access to secondary raw materials could be transformative.

In Bosnia and Herzegovina, circularity remains a largely unfamiliar concept within the machinery sector. Most companies equate circularity with basic recycling and are unfamiliar with advanced strategies such as refurbishment, leasing, or product-life extension. Maintenance is mostly reactive, and access to verified spare parts is limited, often forcing companies to rely on informal international markets. Despite these limitations, Bosnia offers valuable lessons in informal circularity and economic pragmatism. Companies often repurpose and extend the life of machines out of necessity. Supporting these practices with formalized refurbishment programs, technical documentation, and financing mechanisms could unlock significant circular potential.

In the Republic of Moldova, circular economy concepts are gaining traction primarily through donor-funded environmental programs, though their integration into the machine industry is still in its infancy. The workshops showed interest and willingness to engage, but also highlighted systemic barriers, including lack of technical capacity, fragmented industrial networks, and limited public-sector support. Moldova’s openness to regional cooperation and its need for capacity-building present a strong case for transnational mentoring programs and targeted investment in circular skills development.

In Romania, there is a growing institutional recognition of the importance of circular economy, particularly within academic and policy-making circles. The connection between universities and companies has proven valuable in raising awareness and providing technical assistance. However, the industry still faces difficulties translating knowledge into action, especially among small and medium-sized enterprises. The integration of circularity into technical education curricula and the mobilization of innovation ecosystems can play a key role in advancing Romania's circular transition.

In Serbia, circular economy principles are gradually gaining visibility. While isolated examples of sustainable innovation exist, particularly among startups and engineering companies, these efforts are rarely systematized or scaled. Companies face challenges related to outdated equipment, limited funding, and low demand for refurbished machines. Nonetheless, there is a growing interest in eco-design, energy-efficient production, and digital maintenance systems. Serbia's progress can be accelerated by connecting emerging innovators with industry associations, offering financial incentives, and establishing regional demonstration hubs.

Circular Transformation: Practical Guide for Companies

Transitioning from a linear to a circular model is a profound strategic shift for companies operating in the machine industry. It impacts every layer of operations—from design and supply chain management to customer engagement, ownership models, and end-of-life treatment. For most companies, the challenge is not one of awareness, but of implementation. The question is not why circularity matters, but how to begin the transformation in a way that is both economically viable and operationally feasible.

Here, the document provides a comprehensive roadmap that companies can follow to begin their circular transformation journey. Plan-C project offers practical guidance on the steps companies can take, the enabling conditions they need to foster internally and externally, and the new business models—especially Product-as-a-Service—that can drive the shift toward a more sustainable, regenerative, and competitive industrial ecosystem.

The entry into circular transformation does not require immediate, radical restructuring. In fact, the most successful transitions begin with a focused, well-scoped process of evaluation and experimentation. Companies should first conduct a baseline analysis of their current operations by mapping each of the eight phases of the machine life cycle—design, sourcing, manufacturing, logistics, use, end-of-life, refurbishment, and waste management. This mapping should identify points where resource inefficiencies, design bottlenecks, or waste generation are most critical.

The next step is to identify which of these life cycle phases offers the most accessible starting point for improvement. For some companies, this may be the design phase, where modular product development could allow for greater reuse of components. For others, the use phase might offer the best opportunity, particularly through predictive maintenance systems or upgrade programs. The aim is not to transform all aspects at once, but to make targeted interventions that can demonstrate both environmental and business value.

Once opportunities have been identified, companies should form internal circular economy task forces—cross-functional teams that include product designers, procurement specialists, supply chain managers, and marketing professionals. This group's role is to coordinate the development of circular pilots, integrating sustainability targets into key performance indicators (KPIs), and fostering a culture of experimentation and innovation.

Simultaneously, companies should seek partnerships with technology providers, research institutions, and service partners that can complement their expertise. Circular transformation often requires access to data analytics tools, remanufacturing facilities, or secondary raw material suppliers, which may not be readily available in-house.

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

Monitoring and evaluation systems must be put in place from the beginning. Metrics should go beyond traditional financial indicators and include material circularity, greenhouse gas reductions, maintenance frequency, customer retention, and environmental compliance. The insights gathered from pilots help shape the company's broader transformation strategy and inform the redesign of core business models over time.

The success of circular transformation does not rest solely on a company's internal capabilities. The transition is deeply dependent on the broader ecosystem in which a business operates. As such, building an enabling environment—both within and outside the organization—is essential.

Internally, leadership commitment is paramount. Executive teams must articulate a clear vision for circularity, integrated with the company's mission and long-term business strategy. Without top-down support, circular initiatives risk being seen as side projects or cost centers rather than strategic priorities. This vision should be reflected in company policies, investment priorities, procurement strategies, and employee incentives.

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

Transparency and traceability are critical enablers of circularity, especially in the machine industry where components are often sourced globally and managed through complex supply chains. Digital technologies, including blockchain and smart tagging, can enable real-time tracking of material flows, component usage, and environmental performance. Investing in digital infrastructure supports better decision-making and enables new business models such as leasing or take-back schemes.

Externally, regulatory coherence and public policy support are essential. Companies often encounter barriers due to fragmented regulations on waste, materials classification, cross-border shipments, and product standards. A harmonized regulatory framework that rewards circular practices, standardizes reporting requirements, and provides tax

incentives for reuse and recycling can accelerate adoption. National governments, regional development agencies, and local authorities all have roles to play in creating such a framework.

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

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

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

The Role of Product-as-a-Service in Circular Industry

Among the most promising business model innovations that support circularity in the machine industry is the concept of Product-as-a-Service (PaaS). Unlike the traditional ownership model—where value is generated through the one-time sale of a machine—PaaS shifts the focus to ongoing service delivery, performance optimization, and customer value over time.

Under a PaaS model, the manufacturer retains ownership of the machine while providing the customer with access to its functionality through leasing, renting, or subscription. This arrangement aligns the interests of the producer and the user: the manufacturer is incentivized to design durable, repairable, and energy-efficient products, while the customer benefits from up-to-date, well-maintained equipment without the burden of capital investment.

For machine industry companies, PaaS offers multiple strategic advantages. It creates recurring revenue streams, builds long-term customer relationships, and differentiates the company in a market increasingly concerned with sustainability and cost predictability. It also facilitates end-of-life management, since machines are returned to the producer, enabling refurbishment, component reuse, or material recovery within controlled channels.

Implementing a PaaS model, however, requires fundamental shifts in organizational culture, operations, and financial planning. Companies must develop new capabilities in service management, remote monitoring, and customer support. They need to invest in digital tools that can track machine performance in real time, issue predictive maintenance alerts, and provide usage analytics. Additionally, contractual frameworks must be redesigned to address issues such as liability, performance guarantees, and asset valuation over time.

A phased approach to PaaS implementation is often most effective. Companies can begin by offering service bundles or extended warranties as a transition toward full PaaS. Piloting the model with a limited number of clients, particularly those already engaged in long-term contracts or with sustainability goals of their own, allows the company to refine its approach and assess customer response.

Case studies from the Plan-C project and global industry leaders provide valuable evidence of the feasibility and benefits of PaaS in the machine sector. For example, some industrial equipment providers have adopted performance-based contracts, where clients pay based on equipment uptime or output, rather than outright purchase. These models have led to better resource efficiency, lower life cycle costs, and improved customer satisfaction.

For small and medium-sized enterprises (SMEs), adopting PaaS may initially seem daunting due to limited capital and operational bandwidth. However, partnerships with financial institutions, equipment management firms, or digital service providers can offer the necessary support. Moreover, SMEs often enjoy greater flexibility and agility in business model innovation, which can give them a competitive edge.

The shift to Product-as-a-Service represents more than a new sales strategy—it embodies a new philosophy of industrial production and consumption. It enables circularity by design, incentivizes performance over volume, and aligns value creation with sustainability.

Dissemination: Scaling Circular Knowledge and Practice

The implementation of circular economy principles within the machine industry cannot be confined to isolated pilot projects or progressive companies. If circular transformation is to have a meaningful impact—economically, environmentally, and socially—it must be scaled across industrial ecosystems, supply chains, and borders. Dissemination, therefore, is not merely a complementary task, but a strategic function that ensures knowledge, methodologies, and experiences are transferred, adopted, and adapted by a wide array of stakeholders. Dissemination must be understood as a continuous and multi-directional process that involves both the transfer of knowledge and the cultivation of capacity. It operates at multiple levels—within individual companies, across sectors, between countries, and throughout policy and education systems. Each of these dimensions requires tailored approaches and tools.

At the company level, internal dissemination should focus on embedding circular knowledge into core business units. This includes integrating circular economy goals into procurement criteria, product development strategies, maintenance protocols, and human resource development. Companies should take proactive steps to share learnings across departments and with their supplier and customer networks. Case studies, staff training modules, internal newsletters, and onboarding materials can be used to institutionalize these insights.

At the industry level, professional associations, chambers of commerce, and innovation clusters play a vital role in amplifying the results of successful circular pilots. These entities can act as multipliers, translating project-based outcomes into broader sectoral trends. Hosting thematic workshops, publishing technical guides, and organizing field visits to successful companies can create a ripple effect, encouraging replication and adaptation. Trade fairs and industrial expos provide further platforms for visibility and networking around circular innovations.

At the national and regional level, public institutions and policy bodies must be engaged as key dissemination partners. Regulatory agencies can embed circular requirements into public procurement and product standards. Ministries of economy, environment, or innovation can align funding programs to support circular business models and incentivize learning networks. Dissemination in this context means influencing not just practices, but the rules and incentives that shape market behavior.

Transnationally, the sharing of good practices, failures, and methodologies becomes especially important. EU-funded initiatives such as Plan-C already provide a framework for such cross-border learning. However, further institutionalization is needed. Establishing transnational communities of practice, digital repositories of circular

solutions, and standardized tools for measuring circular performance would facilitate more effective knowledge flows. Language barriers, legal differences, and infrastructure discrepancies must be addressed through capacity-building and translation support.

Academic institutions, faculties, institutes, and research centers must also be targeted in dissemination efforts. Including circular economy principles in engineering, business, and design curricula ensures that the next generation of professionals enters the workforce already equipped with the mindset and tools necessary for transformation. Partnerships between universities and companies can enable real-world testing of circular prototypes and provide a structured pipeline for innovation.

In addition to traditional dissemination channels such as reports, websites, and conferences, storytelling and communication are essential tools for reaching wider audiences. Narratives that focus on the tangible benefits of circularity—cost savings, new revenue streams, increased customer loyalty—are far more likely to resonate with decision-makers than abstract sustainability appeals. Visual materials, interviews with company leaders, video case studies, and interactive tools can make complex concepts more accessible and appealing.

Finally, dissemination must also be inclusive. SMEs, companies in economically disadvantaged regions, and those in early stages of digitalization must be supported to access and apply circular knowledge. Peer-to-peer mentoring programs, subsidized access to consultancy services, and modular learning formats can help level the playing field and avoid creating a divide between “circular pioneers” and “lagging adopters.”

To conclude—dissemination is the bridge between experimentation and transformation. It ensures that knowledge is democratized, that successes are not isolated, and that the transition to a circular machine industry becomes a collective and coordinated effort. Without effective dissemination, even the most innovative solutions risk remaining local, temporary, and insufficient to meet the scale of the environmental and economic challenges ahead.

Conclusion

The transition toward a circular economy in the machine industry is no longer a visionary concept—it is a practical necessity and a competitive opportunity. The findings and experiences from the Plan-C project, as consolidated and expanded in this document, demonstrate that circular transformation is not only possible, but already underway across diverse industrial and national contexts. Companies are experimenting with new materials, redesigning machines for longevity, creating leasing models, and extending the life of their products through refurbishment and predictive maintenance. These are not marginal innovations—they are early signals of a broader shift.

However, the journey toward circularity is complex. It demands more than technical adaptation; it requires a rethinking of how value is created, captured, and sustained. It challenges traditional supply chains, procurement policies, and customer relationships. Most of all, it requires a cultural shift from linear thinking focused on throughput and disposal, to circular logic grounded in regeneration, efficiency, and resilience.

This transformation cannot be achieved by companies acting in isolation. It necessitates a supportive ecosystem: forward-thinking regulation, accessible financing, robust partnerships, skilled labor, and open knowledge flows. Governments and public institutions must create the policy frameworks and incentives that reward circular investment. Research institutions must continue to develop and test new solutions. Industry platforms must facilitate dialogue and cooperation. And education systems must train the next generation of circular economy professionals.

Moreover, the role of cross-border and interregional collaboration cannot be overstated. As evidenced by the regional diversity within the Plan-C project, countries and companies are at different stages of circular maturity. This heterogeneity is not a weakness but a resource. The ability to learn from each other, adapt practices to local realities, and jointly solve shared challenges is one of the greatest assets of the European industrial landscape.

Moving forward, the priorities must be clear: to scale what works, to support those who are just beginning, and to integrate circular principles into the core of industrial strategy. Circularity must not be seen as an isolated activity or an add-on to existing practices. It must become a defining feature of how the machine industry designs, produces, delivers, maintains, and retires its products.

For companies, this moment offers a choice: to lead or to follow; to innovate or to adapt under pressure. Those who embrace circular transformation now will not only align with evolving regulatory demands and societal expectations—they will unlock new sources of value, build customer loyalty, reduce operational risks, and future-proof their business.

This guide offers a starting point. The responsibility for continuing the work lies with everyone: businesses, policymakers, researchers, and citizens. Together, they can shape a machine industry that is not only productive and profitable but also regenerative and resilient.