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WORLD ECONOMIC FORUM

Circular Transformation of Industries: Unlocking Economic Value

WHITE PAPER

JANUARY 2025

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Foreword

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We are experiencing a transformation of business models as many linear models[1] reach their limits and manufacturers and value-chain partners turn to circular solutions to improve sustainability, resilience, revenues and costs.

Linear business models are increasingly challenged by shortages of inputs, global disruptions and the triple planetary crisis.[2] While linear business models are unlikely to disappear, new circular ones are emerging. The need for transformative change has never been more pressing and the market will favour those who embrace change and new sources of value.

Circularity offers a path forward. In a circular economy, products and materials are kept in circulation, resource extraction is slowed down, and economic growth is decoupled from resource consumption.[3] Circularity allows businesses to increase their resilience – the ability to prepare, respond to and recover from disruptions – and reach new markets and customers, while reducing the impact of climate change, resource tensions and environmental degradation.

The shift towards a circular economy requires the participation of a diverse set of stakeholders, and accelerating momentum at the business level is vital to transform the entire system. While many of the capabilities needed for circular transformation are available today, a change in mindset is needed to transition from linear to circular business models.

The concept of circularity has been around for a long time, but has not yet scaled. Businesses and industries have focused mostly on replacing virgin with recycled materials without establishing holistic circular strategies. They have viewed circularity through the prism of sustainability and regulatory compliance, rather than as a means of creating broad value through increased resilience and revenues, and a greater control over costs. Our research, however, shows that not only are new models being adopted but that businesses are also increasingly achieving economic value from circularity.

The objective of this paper is to inspire businesses to embrace the potential of circular solutions by highlighting the opportunities for value creation including and beyond sustainability, specifically resilience, revenues and costs. It illustrates how and where businesses can create value with circular solutions, examines some of the barriers that stand in the way of circular transformations and highlights enabling strategies to accelerate the creation of circular ecosystems.

The findings in this paper stem from structured consultations with circularity thought leaders across a broad set of manufacturing industries and a global market survey. The survey draws from the responses of 420 participating global top executives engaged in circularity, of whom approximately 70% had more than five years of experience in their role, and were working in medium-sized to large businesses (with revenues greater than $500 million). It consulted executives from four regions (Asia, Europe, North America and South America) in 10 manufacturing industries.[4]

This paper has been developed by the World Economic Forum, Bain & Company and the University of Cambridge. We thank the members of the Circular Transformation of Industries community for their insights and valuable inputs to this paper.

Executive summary

Businesses active in 10 manufacturing industries expect their circular solutions to unlock value through sustainability, resilience, increased revenues and cost savings.

Businesses across industries are increasingly pursuing circularity and expect it to gain importance in the future as it provides an opportunity to boost competitiveness and unlock economic value. This sentiment comes through strongly in a survey of 420 top executives from 10 manufacturing industries across the globe. Only around 40% of businesses said they considered circularity important or extremely important three years ago, with significant variation across industries. Today, that number has risen to around 75%, and in three years, it is expected to reach around 95%.

FIGURE 1 **Growing importance of circularity**

Businesses across industries are increasingly embracing circularity

% of businesses engaging in circularity that consider it as important or extremely important

Source: Global market survey by Circular Transformation of Industries initiative of 420 top executives (conducted during the second quarter of 2024)

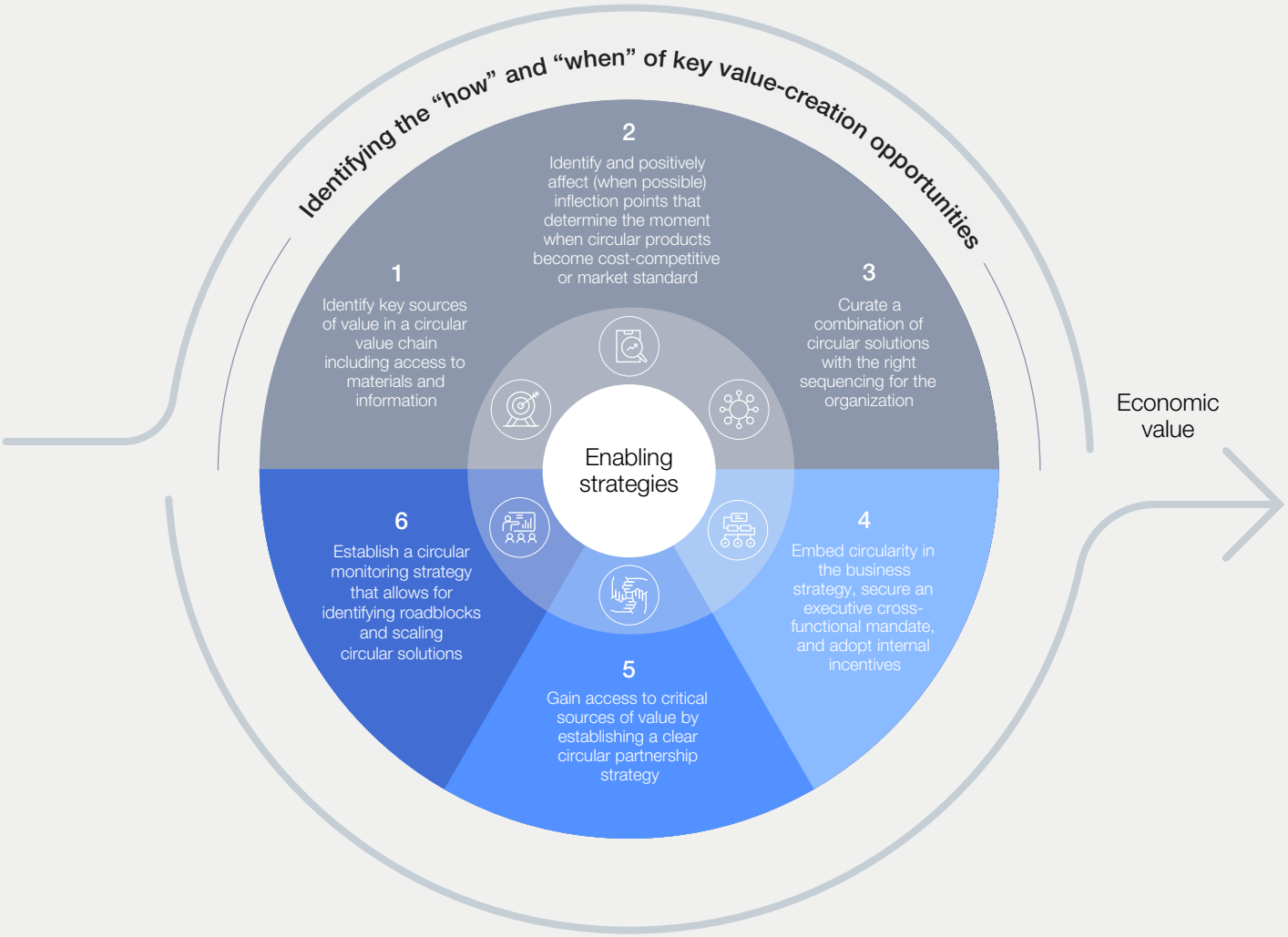
Businesses recognize circularity's potential for broad value creation. The survey finds that businesses pursuing circular solutions expect them to deliver positive economic value along four dimensions: sustainability, resilience, revenues and costs. The survey shows that businesses with mature circular strategies that encompass a variety of circular solutions are unlocking higher value compared to isolated approaches.

The case for circularity is clear – however, the path to a circular business model can be uncharted territory for businesses and involves trade-offs. To change their business model from linear to circular, businesses need to undergo a shift in mindset and invest substantial resources. This includes high upfront investments, allocating sufficient time and building necessary capabilities.

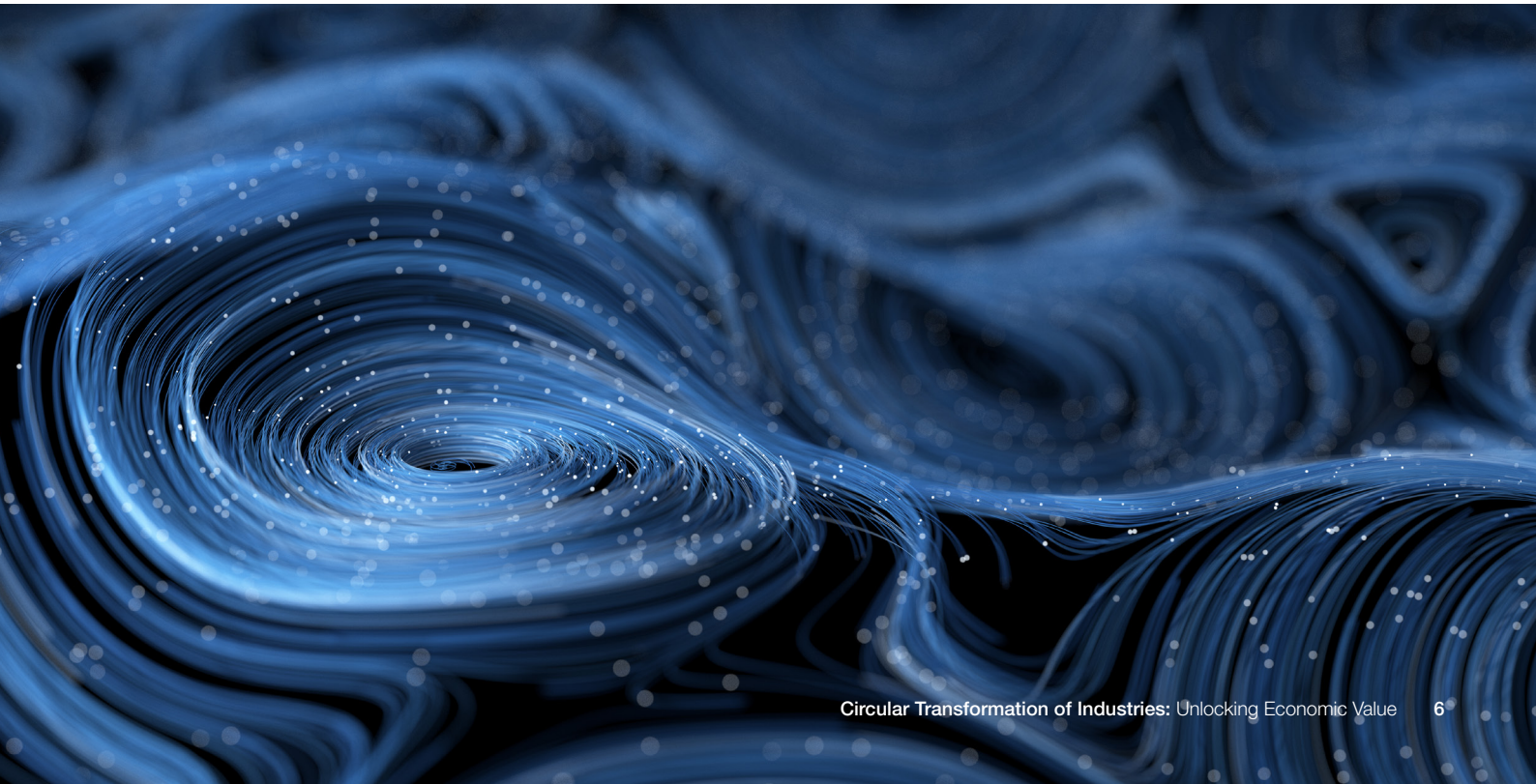
Despite the challenges, leading multinationals are showing that progress is possible. The research conducted suggests that businesses that are successfully mitigating challenges and unlocking broad economic value through circular solutions are applying some combination of the following enabling strategies.

With the following enabling strategies, businesses can navigate the complexities of circular transformation and unlock broad economic value.

FIGURE 2 | **Enabling strategies to unlock economic value through circular solutions**

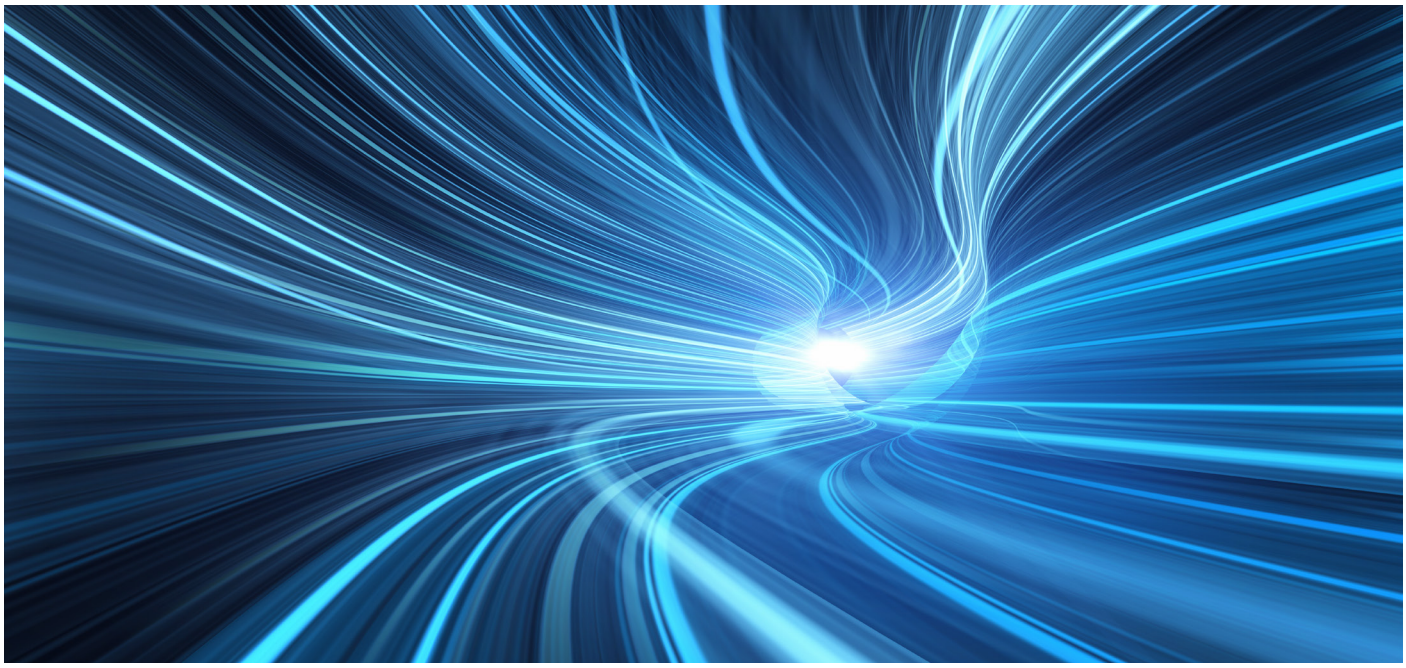


Source: Circular Transformation of Industries initiative



The circular path to value

The transition to circular business models involves trade-offs and requires a change in mindset as well as substantial resources.



The climate crisis and unsustainable resource consumption are existential threats to the planet and to the long-term productivity of businesses and industries. At current rates, humans are consuming 1.7 times more natural resources than the Earth can replenish each year.[5] This overconsumption will, sooner rather than later, drive supply shocks and shortages of key materials.

One solution, as explored in this paper, is a circular economy, which focuses on increasing the useful lifespan of manufactured goods, leveraging shared access to increase their utilization, as well as replacing the use of virgin materials with circular feedstock. The circular transformation will fundamentally reshape industries – a transformation in the world's business models that is already under way.

Circularity can unlock substantial value across stakeholders. Circular solutions can reduce the greenhouse gas (GHG) footprint of products. In fact, the Ellen MacArthur Foundation projects that by 2050, circular solutions could reduce emissions from the production of new products by 40% if applied to four key materials – plastic, aluminium, cement and steel.[6]

Additionally, reducing, reusing and recycling can lower the amount of waste generated, decrease pollution and preserve biodiversity by reducing the frequency with which products are replaced.[7] Furthermore, circularity can exert a positive impact on society by spurring innovation and employment. The International Labour Organization estimated in 2019 that the circular economy could generate seven to eight million new jobs around the world by 2030, as compared to a business-as-usual scenario.[8] In the business environment, circular models can create new revenue streams,[9] giving businesses a competitive edge and delivering profitability and resilience superior to those of existing linear systems.[10]

The shift towards a circular economy is a multifaceted process that requires the participation of many actors, from policy-makers and academics to scientists, innovators and the entire value chain.[11] But businesses are uniquely positioned to accelerate the momentum for circular transformation as they can influence both suppliers and customers to adopt circular practices.[12]

While acknowledging the substantial environmental and social benefits of circularity, this paper focuses on illustrating how a circular transformation can unlock substantial economic value for businesses and outlining enabling strategies to capture that value.

Unlocking broad economic value

Historically, businesses often looked at circularity only through the lens of waste collection/recycling and predominantly focused their circularity efforts on increasing sustainability or complying with regulations. As is clear now, circularity also generates economic value that extends beyond sustainability and regulatory compliance to resilience, revenue growth and cost savings to support long-term competitiveness in terms of customers, talent and scarce resources.

A survey of 420 global top executives in 10 manufacturing industries, completed in July 2024, outlines that executives understand the broader value creation opportunity that circularity can provide. It shows that today 3% of businesses pursue circular solutions for sustainability reasons only, while 97% of businesses adopt circular solutions for a broad set of reasons that may include sustainability but also extend to profitability and resilience. The survey shows that businesses expect broad positive economic value from their circular solutions three years from now.

As many as 73% of businesses in the survey expect circular solutions to deliver revenue gains. Repair, refurbishment and other lifespan extension services, as well as capacity-sharing such as the rental of heavy equipment, open the possibility of new revenue streams. Businesses also stand to gain access to new customer segments and increase demand among existing customers who opt for circular products and the services to maintain them.

Some 65% of businesses expect their resilience to improve with circular strategies, mainly by reducing their reliance on scarce raw materials, reducing complexity of supply chains and increasing predictability of supply and demand.

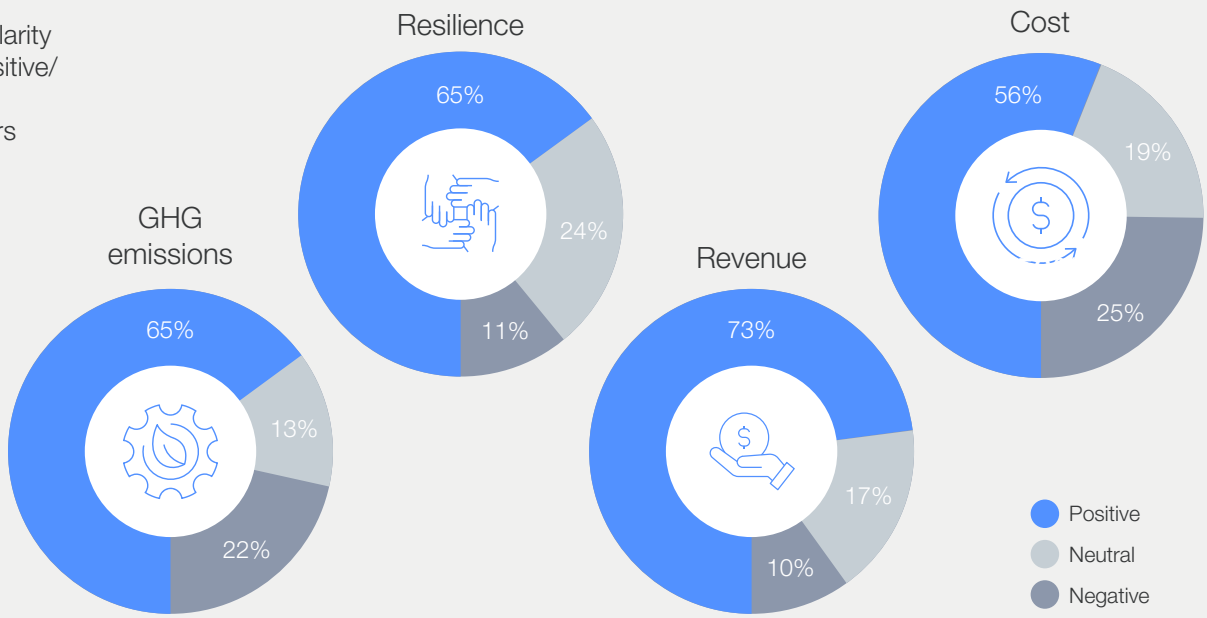
The same proportion of businesses expect their greenhouse gas (GHG) emissions to decrease with circular solutions. The size of emissions savings, however, depends on the products and the specific circular solutions being deployed. In contrast, 22% of businesses expect an increase in carbon emissions. In some circular models, businesses must account for emissions at a product's end of life which would have been outside their Scope 1 emissions in linear models – for example, the GHG output from transporting used products back to businesses' facilities for refurbishment and repair.

The anticipated impact on cost savings was slightly more balanced: 56% of respondents expect circular solutions to deliver cost savings, mostly driven by lower cost for customer acquisition and retention. Some businesses, however, anticipate higher costs due to initial investments in circular solutions and operational complexity.

FIGURE 3 **Circularity as an opportunity for value creation**

Businesses expect that circular solutions will unlock economic value

% of businesses engaging in circularity that expect a positive/ neutral/negative impact three years from now



Source: Global market survey by Circular Transformation of Industries initiative of 420 top executives (conducted during the second quarter of 2024)

Three archetypes, multiple strategies

An earlier paper from the World Economic Forum, Bain & Company and the University of Cambridge, "Circular Transformation of Industries: The Role of Partnerships,"[13] identified a set of circular solutions – for example, repair services and internal sourcing of circular feedstock – which can be clustered into three "archetypes" for circular value creation.

The first archetype centres on replacing virgin materials with circular ones – for example, using recycled plastic or aluminium. This strategy is appropriate for most manufactured goods, and especially those that have a short lifespan, such as packaging. The second archetype focuses on extending product lifespans to reduce the demand for, and therefore output of, manufactured goods. This strategy is relevant for high-value products that are durable and can be disassembled for repair, refurbishment and upgrades. The third archetype redefines business models by adopting more circular ways of working and refers to sharing models. It is most suited to high-value, upgradeable products, and services.

The 2024 survey shows businesses are starting to build circular models across multiple solutions, and archetypes. One-quarter of businesses have scaled solutions across all three archetypes, while an additional 20% of respondents have scaled solutions across two archetypes. This trend of combining a number of solutions is accelerating as businesses pilot more solutions.

The survey finds that businesses with mature circular strategies spanning all three archetypes are generating higher economic value than those that are active in only one or two archetypes. This bodes well for the future of circularity, as the benefits appear to accrue with experience. Circular models will go through the same experience curve benefits that linear models went through in the past.

As circularity transforms entire business and operating models, new value creation opportunities emerge across the value chain. For example, a circular economy requires advanced collection and sorting of valuable scrap or new logistics processes for end-of-life products. Emerging sectors with new players will not only foster innovation and create new job opportunities, but will also command a significant influence on value creation from circularity at scale.

Mitigating challenges and identifying enabling strategies

The transition from linear to circular business models is challenging and involves trade-offs. The survey finds that some businesses have not yet identified how to leverage circular solutions to reduce GHG emissions (35% of businesses), increase resilience (35%), grow revenues (27%) and decrease costs (44%). Businesses face high upfront investments, such as allocating sufficient time and building necessary capabilities, to advance along the experience curve. In fact, more than 65% of businesses identify financial concerns, particularly high upfront investment or ongoing costs, as major challenges.

Beyond those, organizational structures present obstacles. These include a lack of stakeholder engagement, insufficient time allocation, gaps in capabilities or knowledge and lack of common understanding on circularity, all of which are cited by another 60% of businesses. This is aligned with the significant shift businesses are undergoing from a multi-decade focus on optimizing costs, service levels and inventory to an expanded set of priorities that also includes resilience, responsiveness and responsible operations to stay competitive.

The research for this paper suggests that businesses that are successfully mitigating challenges and unlocking broad economic value through circular solutions are applying some combination of the following enabling strategies.

1. Identify the "how" and "when" of key value creation opportunities, as outlined in a previous paper by the World Economic Forum, Bain & Company and the University of Cambridge, entitled "The Circular Transformation of Industries: The Role of Partnerships":[14]

   – Identify key sources of value in a circular value chain (control points), which include access to materials (e.g. recycled materials and used products for disassembly) and access to information (e.g. technical knowledge of how to produce, repair and dispose of circular goods). Determine how to achieve access to these control points to differentiate from competitors and stakeholders along the value chain.

   – Identify crucial inflection points that determine the moment when circular products become cost-competitive with their non-circular equivalents, or when a circular solution becomes the market standard. Define which levers can positively affect inflection points with the goal of lowering production costs and accelerating consumer adoption of circular products and services.

   – Curate a combination of circular solutions with the right sequencing for the organization, for instance by leveraging the operational expertise gained from lifespan extension solutions when implementing capacity-sharing solutions.

2. Embed circularity in the business strategy and secure an executive cross-functional mandate with appropriate funding to develop and implement circular solutions. Define clear roles and decision rights, and engage and incentivize employees across levels to build excitement and ownership. In fact, around 70% of businesses identify organizational engagement as a key enabler for their circular solutions.

3. Create a clear circular partnership strategy to influence control points, for example, gaining access to materials and knowledge. More than 60% of surveyed businesses highlighted it as a key enabler. If necessary, build a value chain-wide coalition to tip inflection points and to set up the infrastructure necessary for change beyond their own organization at the industry and/or regional or national levels. This was outlined in an earlier paper by the World Economic Forum, Bain & Company and the University of Cambridge, entitled "Circular Transformation of Industries: The Role of Partnerships".[15]

4. Establish a circular monitoring strategy to identify roadblocks and the dynamics that prevent successful scaling of circular solutions. Double down on the lessons learned to accelerate the experience curve and, as a result, decrease production costs of circular products.

The three chapters that follow suggest enabling strategies for each archetype and describe how the circular transformation of industries can unlock value across sustainability (in this paper, sustainability is evaluated in terms of GHG emissions), resilience, revenues and costs. Each can be read independently, allowing readers to focus on the sections most relevant to their needs.

Archetype 1

Circular feedstock

The economic value unlocked from circular feedstock solutions varies significantly depending on the material and product being recycled.

In the past, circularity was mostly understood in terms of replacing virgin inputs with recycled materials.[16] As a result, many industries have adopted circular feedstock solutions and recycled materials can be found in a wide range of products from bottles to large machines.

More than 50% of businesses in the survey employ circular feedstock. Circular feedstock solutions are particularly urgent in industries and regions where either customers and regulators or both expect change. They are often more advanced[17] in industries that generate large volumes of waste (especially from single-use plastics) due to short product life cycles, such as in the packaging, chemicals and fast-moving consumer goods industries.

For example, the recycling rate for aluminium packaging in Lichtenstein, Estonia and Norway was as high as 100%, 97% and 94%, respectively, in 2021,[18] showing the potential for recycling if effective infrastructure and policies are in place. Circular feedstock is also employed where the residual value of materials is high and subject to scarcity or price volatility. For example, end-of-life recycling rates for gold were around 86% in 2021,[19] driven by its high value, limited supply and increasing demand within electronic and industrial applications.

1.1 The value of employing circular feedstock solutions

The surveyed businesses expect a positive impact of circular feedstock solutions three years from now, but the size of this effect varies significantly with the material or product being recycled.

GHG emissions: Circular feedstock has the potential to reduce GHG emissions when the carbon footprint of the circular value chain is lower than that of extraction and disposal in the equivalent linear value chain. However, recycling for circular feedstock can have negative externalities, for example by releasing contaminants, so businesses should carefully assess the overall sustainability impact on a case-by-case basis. Overall, the survey finds that significant carbon emissions abatement can typically be achieved when reusing materials versus disposing of them in a landfill.

There is another way to reduce carbon emissions, namely carbon capture and utilization (CCU), which can reduce and recycle carbon dioxide (CO_2). It refers to the process of capturing CO_2 emissions from sources like power plants and industrial processes, preventing it from entering the atmosphere, and utilizing it to create other products, such as fuels, chemicals or new materials. For example, enaDyne, a German start-up and Top Innovator of the World Economic Forum CCU UpLink Challenge, uses a cold plasma to transform CO_2 into green chemicals and fuels, which are then used by industry and in transportation.

Resilience: Especially in industries where long-term material capacity constraints are expected, using circular feedstock can strengthen resilience. By relying on materials that are already in circulation, businesses can reduce their dependence on raw material extraction, which can be subject to geopolitical, environmental and economic shocks. When recycled materials are supplied regionally, businesses additionally benefit from sourcing closer to manufacturing, which can enhance resilience and save GHG emissions. When and where materials are abundant, these solutions have a more limited impact on resilience, as is the case for some plastics in the packaging industry where the survey finds a less significant impact.[20]

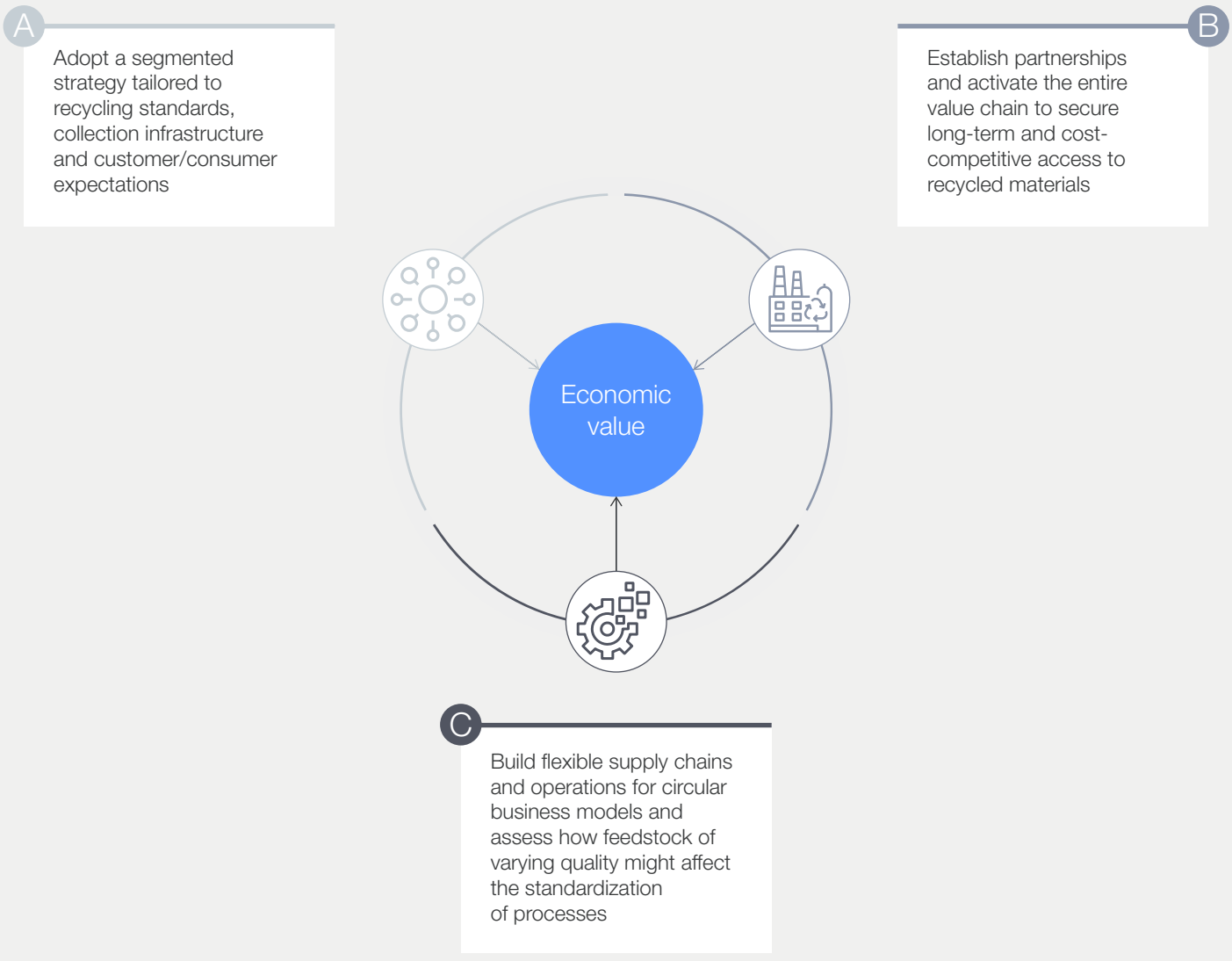
Revenue: When customers, regulators or both demand sustainable usage of materials, circular feedstock is a prerequisite to remain competitive. It also has the potential to increase revenues, as it allows businesses to enhance demand among environmentally conscious customer groups. However, increased demand for recycled content does not always translate to higher prices; the willingness to pay a price premium for recycled materials is contingent on customers clearly understanding the value proposition.

For example, in the fashion industry, responsible usage of resources is part of ecological fashion brands' identity and a key purchasing criterion for conscious customers.

Cost: The cost impact of circular feedstock solutions can vary based on material type and operational efficiency. Sourcing recycled materials alters the cost structure throughout the value chain with new cost pertaining to activities such as collection, sorting and transportation. When materials have a high residual value, are in high demand and have efficient recycling processes, as is the case for many metals such as cobalt, nickel and aluminium, recycling is cost competitive with virgin materials.[21] However, when complex collection, sorting and cleaning of materials are required, and the recycling process is energy-intensive (as for plastics) or has lower yields, it becomes less cost efficient.

Also, the cost of many recycled materials will rise as demand exceeds supply. This is already true for recycled PET (rPET), where prices have been rising since 2021,[22] since more industries are increasingly demanding rPET due to regulations and customer preferences.

FIGURE 4 **Enabling strategies – Circular feedstock**



Source: Circular Transformation of Industries initiative

The research for this paper suggests that businesses that successfully unlock economic value through circular feedstock solutions apply the following enabling strategies:

A Adopt a segmented strategy

Recycling standards and regulations, collection infrastructure, and customer and consumer expectations vary across markets and consumer segments, making it essential to adopt a tailored strategy. This segment-by-segment strategy will need to be re-evaluated regularly as dynamics evolve, especially changes in regulation, which was mentioned by around 30% of survey respondents as a critical variable – both as a barrier and as an enabler.

Indorama Ventures, one of the world's largest manufacturers and recyclers of PET, and the Philippine bottling arm of a leading beverage company operate a joint-venture recycling site in the Philippines and have tailored their approach for processing rPET to local market conditions. As the Philippines has a decentralized and largely informal collection system for plastic waste, Indorama has developed community-driven efforts and campaigns to raise awareness, and waste collection is undertaken in partnership with local communities to collect stockpiles of clear PET plastic bottles for recycling.

B Secure long-term and cost-competitive access to recycled materials

Especially when collection and processing capacity is limited, and demand for recycled materials is growing, it pays to activate the entire value chain to gain access to the key sources of value early. Partnerships are a key enabler to source valuable circular feedstock (mentioned by approximately 65% of businesses in the survey). For example, in the automotives industry, partnerships help companies comply with the mandated minimum recycled content in vehicles.

Dow Chemical recently entered a partnership with a recycler, in which the recycler builds an advanced recycling facility and provides Dow with approximately 65,000 metric tons of valuable circular feedstock (pyrolysis oil) annually to convert into new, virgin-grade equivalent plastics for packaging.

C Build supply chains and operations for circular solutions

Circular feedstock solutions require greater flexibility in the supply chain and manufacturing operations. Scrap and recycled materials have varying degrees of uniformity; therefore, businesses must assess how feedstock of varying quality might affect the standardization of their manufacturing processes. Around 30% of businesses consider limited capabilities (for example, processing materials of inconsistent quality and composition) as a key barrier. Advanced industries effectively adapt their operations for the usage of recycled materials and a circular versus linear model.

Archetype 2

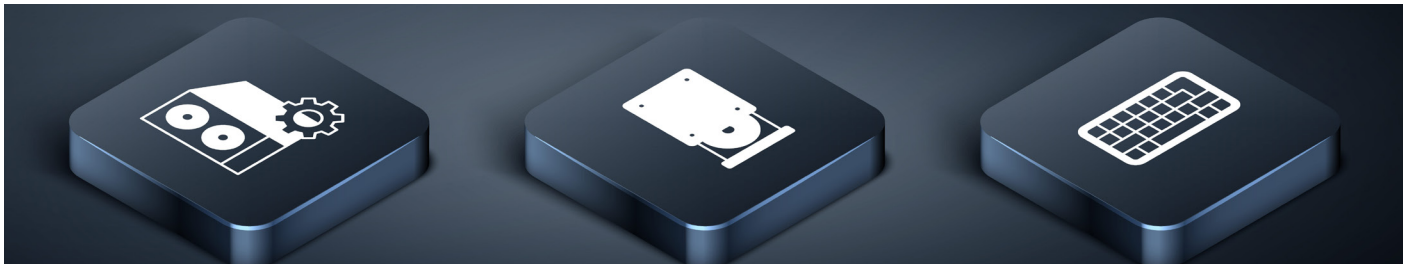
Lifespan extension

When products are durable, of high value and can be disassembled, the potential to unlock value from lifespan extension is particularly high.

According to the European Commission,[23] disposing of goods before they have reached the end of their useful life produces 261 million tons of CO_2-equivalent (CO_2eq) emissions, uses 30 million tons of resources, and creates 35 million tons of waste in the European Union (EU) each year. Consumers also lose about €12 billion yearly by replacing goods rather than repairing them.[24]

Given the regulatory changes in some regions and industries (for example, the emerging "right to repair" in the EU[25] and Canada)[26] and growing concern over the increasing volumes of waste, more businesses are expected to embrace lifespan extension strategies in the medium to longer term. While not as established as circular feedstock, the 2024 survey finds that lifespan extension solutions exist in almost every industry at varying scale.

Businesses can extend the lifespan of their products in many ways. They can design for circularity, offer repair, refurbishment or upgrade services, and/or promote marketplaces for used goods. Of all the lifespan extension solutions, businesses state that repair solutions generate the highest positive impact across GHG emissions, revenues and costs, possibly because repair services extend a product's lifespan with only minimal new materials or parts. Designing for circularity includes designing products that enable, for example, repair, refurbishment or recycling. In the survey, this approach had the highest adoption rate (on average across industries), as it provides synergies and is considered an enabler for other solutions.



Cisco, a global technology company, has adopted 25 circular design principles that range from circular feedstock ("use recycled instead of virgin materials") to lifespan extension ("ensure product structure allows for identification and accessibility of valuable components"). For example, the modular design of Cisco's Catalyst IR1101 rugged router provides customers with the flexibility to add or upgrade components as their customer needs and technologies evolve. The updated design also reduces idle power by 45% compared to a previous generation. Additionally, in 2019, Cisco removed oil-based wet paint from its Catalyst 9000 product; this resulted in eliminating approximately 40 million tons (MT) per year of volatile organic compounds (VOCs) and about 1,900 MT CO_2eq, while saving over $5 million from 2019 until the end of fiscal 2023. For some materials, such as plastics, removing oil-based wet paint can facilitate recyclability and the ability to remanufacture.

Lifespan extension solutions are especially advanced for industries that produce high-value, durable products that can be disassembled and often show a high degree of customization and configuration – such as in the machinery, automotives and consumer technology industries.

The scale of these solutions today is below potential, but anticipated to grow where value creation is likely. As sharing models become more prevalent, the momentum for lifespan extension is expected to increase as businesses often retain ownership and are trying to extend the useful life of their deployed assets.

2.1 The value of employing lifespan extension solutions

The businesses surveyed expect a positive impact from lifespan extension solutions three years from now, but the size of the effect varies significantly by industry and product.

GHG emissions: While lifespan extension solutions reduce the need for new products and their associated GHG footprint, the overall impact varies by solution and industry. There is high potential for GHG emissions savings when products are composed of durable materials – which enable a longer extension of the useful life of a product – with high levels of embedded emissions. As this is often the case in the machinery industry, the survey finds that carbon emission savings in this industry are particularly significant. When repairs or upgrades improve device performance and enhance energy efficiency, they further contribute to reducing GHG emissions.

Resilience: There is high potential for increased resilience when businesses handle a high share of scarce parts or materials and manage complex supply chains. This is often seen in the machinery industry, where the survey finds particularly significant resilience gains. Lifespan extension solutions mitigate the risk associated with raw material supply shocks and supply-chain disruptions and reduce the dependency on suppliers, as they redeploy parts from used products.

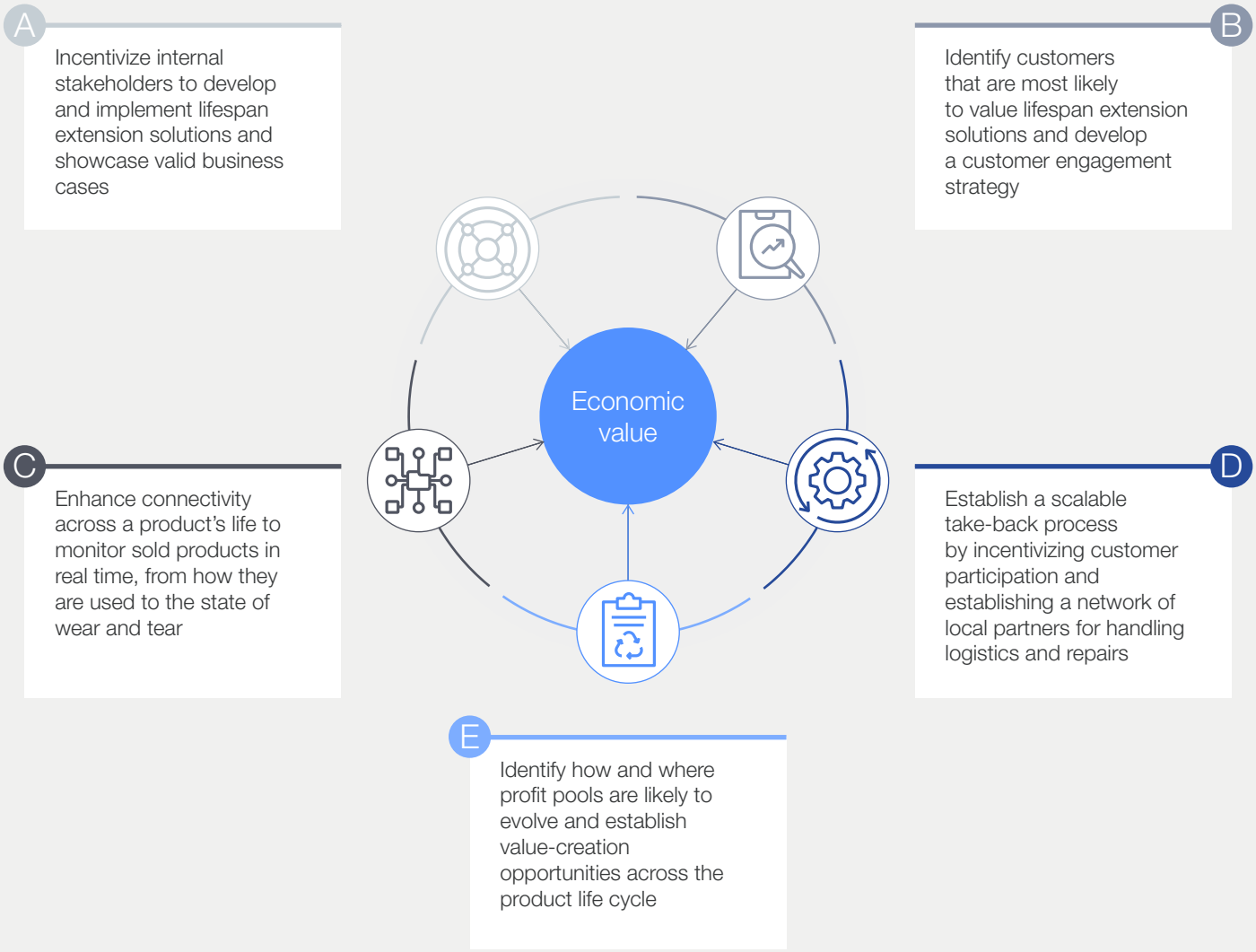
Rockwell Automation, a multinational provider of industrial automation and digital transformation technologies, offers repair services for industrial automation products. By repairing machinery for one consumer packaged goods client, Rockwell Automation was able to reduce CO_2eq Scope 3 emissions by around 90% compared with manufacturing a replacement.

Rockwell Automation also enhanced its resilience by repairing, remanufacturing and refurbishing products, which allowed the company to service customers even in case of material shortages in the market. As an example, Rockwell Automation reduced the turnaround time for one customer by 14 days, compared to the time needed to deliver a new device.

Revenue: Lifespan extension solutions can enable businesses to shift profit pools. For example, businesses can attract a new price-sensitive customer segment with refurbished goods. They can also increase customer engagement through repair and a wide variety of other services. However, businesses must build trust in the value of second-life products and ensure that the take-back process is smooth. There is particularly high potential for revenue increases when lifespan extension solutions increase a product's performance and lifespan substantially or when customers face long lead times for new products. This is often the case in the machinery or automotive industry (the business-to-business sector), where the survey finds that revenue increases are especially significant.

Cost: Lifespan extension solutions have the potential to reduce costs, but the cost impact varies significantly by company and depends on internal capabilities. These models are labour intensive and require high initial investments. Businesses are able to offset these when lifespan extension measures align with their core expertise and capabilities, especially if they already rely heavily on manual processes in their linear operations. This is often the case in the machinery industry, where the survey finds particularly significant cost decreases. Businesses successful with this archetype also decrease customer acquisition and retention expenditure through the circular solution's continuous life-cycle engagement, and leverage design for circularity to cut material input costs.

FIGURE 5 | **Enabling strategies – Lifespan extension**



Source: Circular Transformation of Industries initiative

Research for this paper suggests that businesses that successfully unlock economic value through lifespan extension solutions apply some combination of the following enabling strategies:

A Incentivize circular actions

Seek buy-in from the sales force and other internal stakeholders, given that around 45% of businesses consider internal stakeholder engagement a key enabler. As introducing lifespan extension solutions such as repair services shifts revenue streams from unit sales to lifetime servicing and delays purchase of new products, some stakeholders fear revenue cannibalization. Incentivize internal stakeholders to actively engage in developing and actioning lifespan extension solutions and showcase valid business cases to increase recognition for the emerging growth prospects.

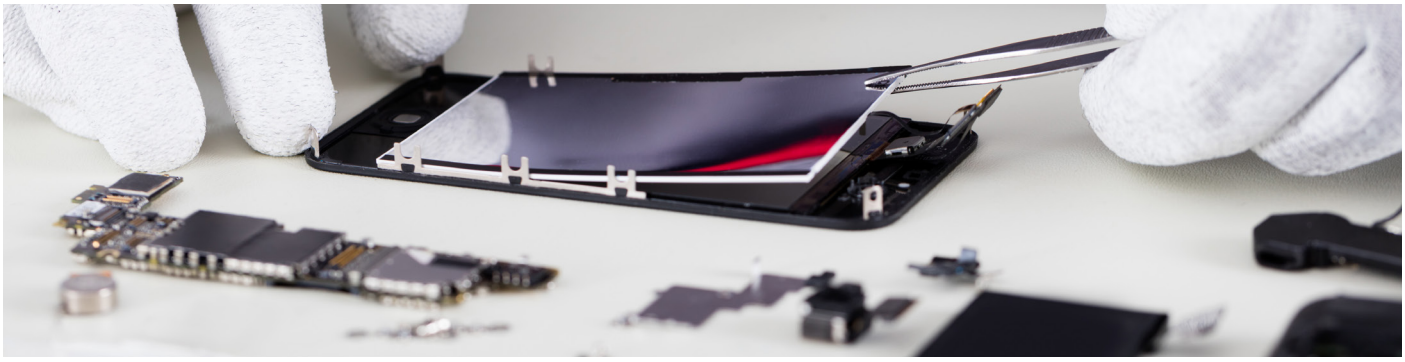
Cisco has a public goal to incorporate circular design principles in 100% of its new products and packaging by FY2025. To reach this ambitious goal, the company has employed a broad set of tactics to engage stakeholders and foster buy-in across functions and levels to accelerate implementation. Cisco has developed a scoring methodology that enables the company to track progress against the goal and to recognize employees for innovation. Additionally, over 7,000 employees had completed circular design training as of fiscal 2024 and the company has established a broad feedback mechanism to engage employees in the evolution of the circular design programme.

B Target strategically

Systematically identify the individual customers and customer segments that are most likely to value lifespan extension solutions. Clarify service offerings across the product life cycle through an encompassing customer engagement strategy tailored to their needs. Clearly demonstrate the value of second-life products (for example, quantifying lower costs, saved emissions or performance improvements) and build trust in product quality.

Agilent, a global provider of instruments, software, services and consumables for laboratories, also taps into new profit pools by selling refurbished laboratory equipment to price-sensitive customers (for example, academia and start-ups) or customers who don't need/want the latest product generation. The company achieved a 25% year-on-year increase in refurbished product sales, as it focused on building trust among customers by offering the same warranties for their refurbished products as for new products and investing in substantial quality controls.

Rockwell Automation engages customers in its repair solution with a sustainability calculator that can be accessed via the customer portal. This allows customers to track the CO_2, energy and waste savings of their repairs as compared to purchase of new products. It creates additional demand as customers can use data generated from the sustainability calculator in their own sustainability reports.



C Enhance connectivity across a product's life

Lifespan extension solutions depend on the ability to track and monitor used products, requiring businesses to leverage data and technology in innovative ways. Locating used products remains a key challenge that can be overcome by utilizing data and technology across the value chain. In addition, data connectivity is critical to monitor sold products in real time, from how they are used to the state of wear and tear. Internet of Things (IoT) applications help identify the right time for lifespan extension measures, helping to preserve assets at their maximum value for the longest possible time. The interplay between circular solutions and IoT can also generate positive feedback loops as businesses leverage insights from usage and other data to improve product design, performance and durability.

The luxury lifestyle company Ralph Lauren has collaborated with the World Economic Forum and select members to pilot its digital product identification system that will allow resellers to validate product authenticity quickly via a QR (quick response) code, increasing the desirability of reuse while preserving brand identity and enhancing the customer experience in the second-hand market.

D Establish a scalable take-back process

Getting sufficient used parts and products back is often an important part of lifespan extension solutions, so building a scalable take-back process right from the start is critical. Incentivize participation to engage customers at scale and reduce any potential participation barriers. For example, in the consumer technology hardware industry, lack of trust in data security is a key barrier for returning used laptops and mobile phones, which needs to be addressed to make the take-back process successful.

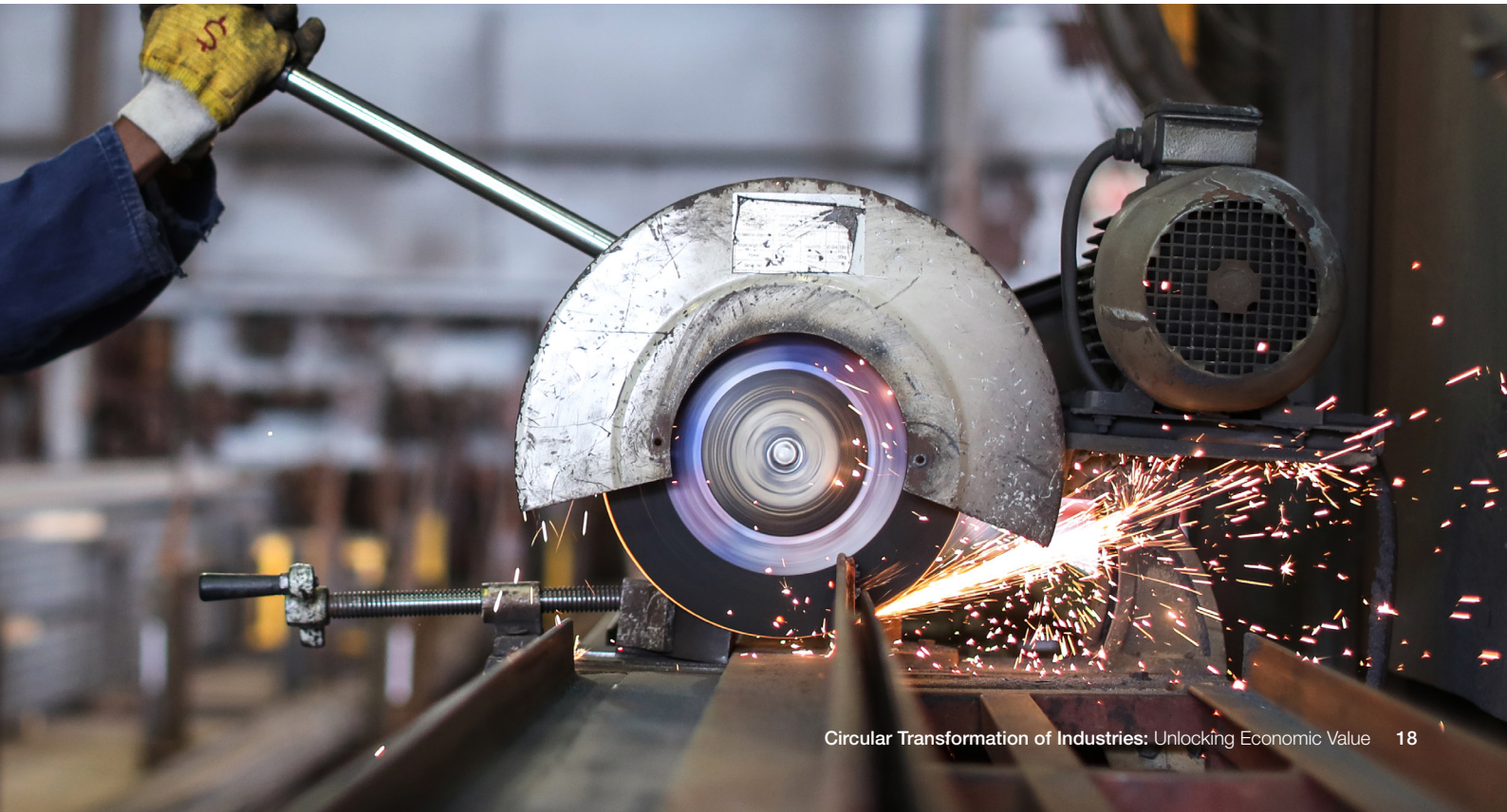
Scaling across geographies is a challenge, as handling products at their first end of life is often heavily regulated (for example, in cross-border waste management regulation). Around 30% of businesses report that regulations and standards are a key enabler and an important consideration when setting up the take-back process. Establishing a network of local partners for handling logistics and repairs helps to comply with local regulations, makes for shorter supply chains and ensures faster turnaround times. In fact, around 60% of businesses identify partnerships as a key consideration when developing lifespan extension solutions.

Agilent offers several incentives for customers who wish to return their used products to increase the number of participating customers. For example, they pay a residual value for the product or offer credits for future purchases. They make the take-back process even more convenient by, where possible, accepting the used products of competitors as well. To ensure availability across various markets while providing fast turnaround times and adhering to regulatory requirements, the take-back service is managed by local Agilent operations in each region.

E Capture and maximize life-cycle value

Lifespan extension solutions delay the purchase of new products and often raise cannibalization concerns (mentioned by around 15% of businesses and raised during conversations with circularity thought leaders). Therefore, businesses need to identify how and where the profit pools[27] are likely to evolve. They can complement the sale of first-life products with value-creation opportunities across the product life cycle. During a product's lifetime, value may be generated by charging customers for services such as repairs, upgrades and insurance. At the end of a product's life, businesses can also capture the residual value from components and materials, for example by monetizing post-consumer scrap or reusing parts.

HP, a global manufacturer of personal IT equipment, has found a way to successfully monetize refurbished devices, increasing the return on investment for customers while advancing their sustainability goals. Customer demand for solutions that combine both new and multi-life-cycle IT products is being driven by new regulations, sustainable procurement requirements, and lower total cost of ownership targets.



Archetype 3

Capacity sharing

As capacity-sharing solutions reinvent the business model, they should be tightly aligned to the business strategy.

New product sales and long-running service contracts still generate the largest share of manufacturers' profits today. While those business models are unlikely to disappear, new circular business models are emerging, unlocking lucrative new markets. Capacity-sharing solutions, such as product-as-a-service and pay-per-use, reinvent the business model by increasing usage frequency and often retaining ownership of products. These models de-emphasize the sale of physical goods and focus on the outcome that customers want.

While some disrupters have already proven the viability of sharing models, established businesses can struggle to adopt these new business models as they face structural challenges. They often have long-standing profit pools to defend, capital-intensive assets for which they must maximize returns and a legacy of marketing the value of ownership. Yet, there are examples where legacy players have successfully managed to bridge the transition of their capital structure to establish sharing models.

Capacity-sharing solutions are especially welcomed by industries with products that involve high cost and complexity of ownership, which have low utilization and where technology must be kept up to date. This is particularly true in industries such as consumer technology hardware, heavy industry, aerospace and defence, and machinery, where such solutions are particularly advanced. In aerospace, for example, fixing a broken engine can take around six months, but owning spare engines is expensive. Airlines, therefore, often pay a fee to draw spare parts from a shared regional pool rather than owning stock outright.

High-tech company Trumpf, for example, has introduced a pay-per-cut business model, where customers pay a fee for each metal part cut, instead of purchasing the machine. Trumpf addresses the challenge of transforming its capital structure and owning a large fleet of machines by partnering with an insurer, which finances the machines and bears the investment risk.

3.1 The value of employing capacity-sharing solutions

The businesses surveyed said they expect a positive impact from capacity-sharing solutions three years from now, but the size of the impact varies significantly depending on product usage behaviour.

GHG emissions: When capacity-sharing solutions increase a product's utilization and even increase its useful lifespan, these solutions can reduce GHG emissions. By sharing products among many users, a reduced number of products is required to satisfy customer demand. Additionally, the company manufacturing the product has high product expertise, so can maintain the product better and extend its lifespan. While there are fewer products in circulation with capacity-sharing models, the manufacturers must retain ownership until the end of life. They must document end-of-life emissions and their negative impact on their own Scope 1 emissions.

Resilience: Retaining asset ownership can increase resilience as it gives businesses control to better predict demand, manage resources and respond to disruptions. Capacity-sharing models increase financial resilience, when recurring revenue streams provide a more stable and predictable income compared to one-off sales models. Businesses operating capacity-sharing solutions can stabilize demand for resources through production load balancing, even during periods of low equipment sales. This can enhance supply-chain resilience, improve supplier relationships and increase price stability through long-term supply contracts.

Revenue: Capacity-sharing models shift profit pools to a recurring revenue model (earning revenue over time, for example through rental fees), which allows businesses to target new customer groups that prefer access over ownership, such as low-usage and trial customers.

Additionally, capacity-sharing models allow businesses to capture value from a larger share of customer needs through broader offerings, such as maintenance or health monitoring, while increasing satisfaction. Substantial potential for revenue growth exists when there is high willingness to pay for the use of critical devices. This is often seen in heavy industry and in aerospace and defence, for example in cases like spare-engine rental, where the survey finds that revenue increases are particularly significant.

Cost: Capacity-sharing models have the potential to reduce cost. However, these models require increased net working capital and higher ongoing costs due to operational complexity. For example, to enable capacity-sharing solutions, businesses must master the process of shipping the product from and to the customer at a higher frequency (for example for short-term rental of machines) while maintaining the product. Businesses that operate these models can offset these costs by leveraging their increased control over operational decisions thanks to retained ownership, which allows for reduced operational expenses. Additionally, they decrease customer retention costs through continuous engagement across the customer life cycle and lower the cost to access products at the end of life for recycling or reuse.

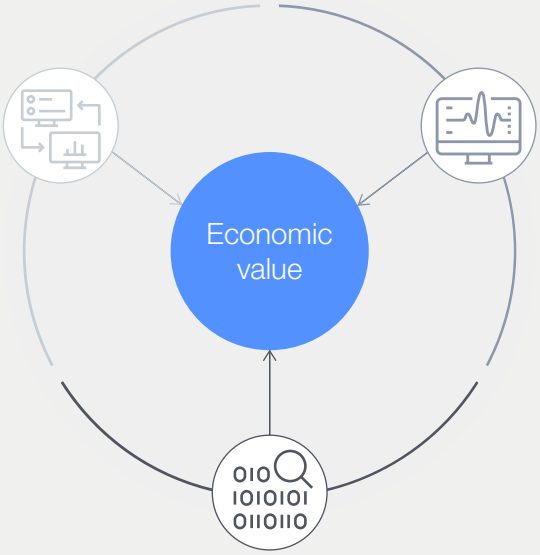
FIGURE 6 **Enabling strategies – Capacity sharing**

A

Establish a cross-functional mandate to align capacity-sharing solutions as a part of the business strategy

B

Leverage existing operational capabilities to extend the product lifespan and design products for various product use cases



C

Employ data-driven services to maximize value from deployed assets by increasing product utilization and reducing maintenance costs

Source: Circular Transformation of Industries initiative

Research for this paper suggests that businesses that successfully unlock economic value through capacity-sharing solutions are applying the following enabling strategies:

A Establish a cross-functional mandate to align capacity-sharing solutions as part of the business strategy

Access to human and financial resources is critical for building capacity-sharing solutions. The survey finds that organizational factors (including for example a dedicated time allocation) and financial considerations (especially high upfront investment and ongoing costs) are perceived as key barriers by around 65% of surveyed businesses. Given that sharing models are a revolution in existing business models, they must be tightly aligned to the business strategy and require a cross-functional mandate and company-wide mindset shift. Business leaders must communicate the benefits across functions and levels and possibly adjust incentive schemes.

B Extend product lifespan and design for sharing

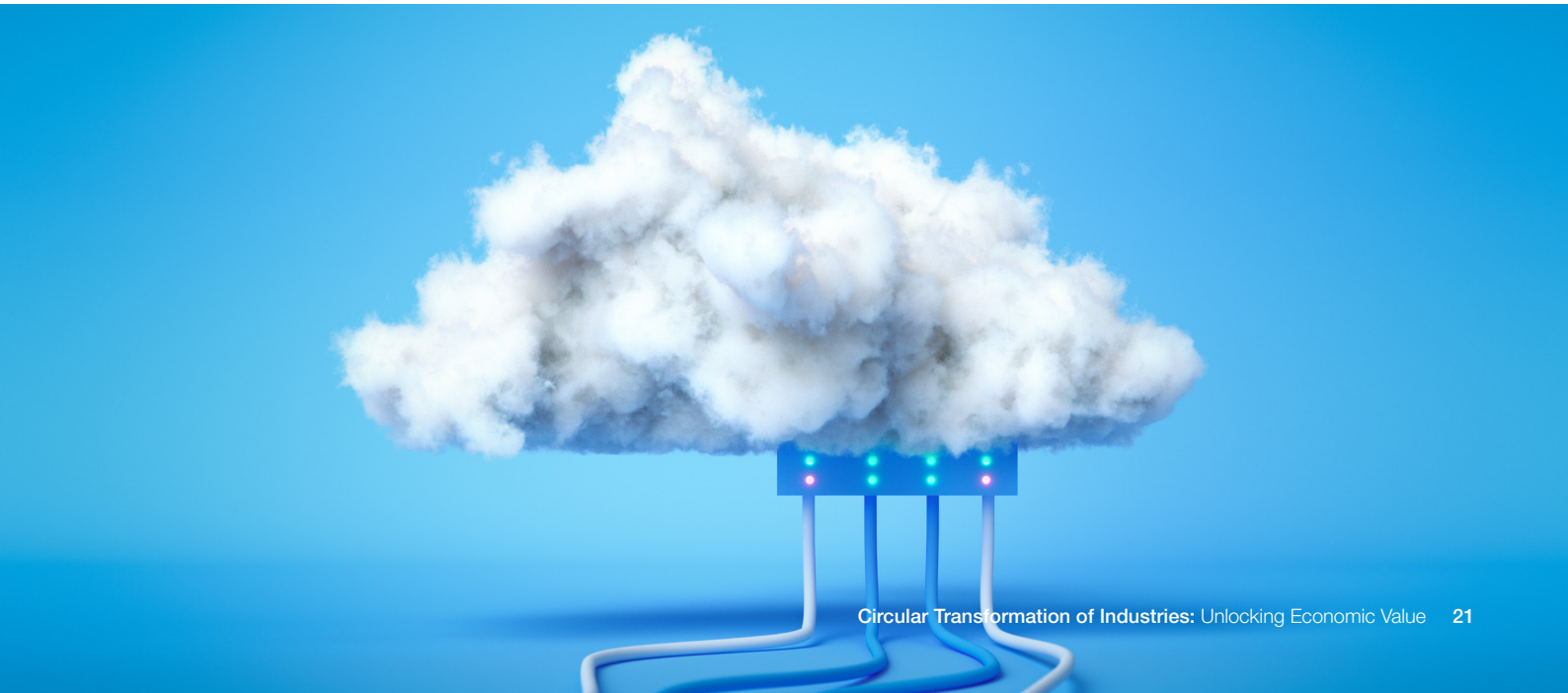
To maximize value from deployed assets and to offer customers access to shared devices with up-to-date technology, products need to be maintained, repaired and upgraded as required. Businesses should leverage existing operational capabilities to extend the lifespan of their products, enhance rental availability and improve product performance. Additionally, circular product design is a key enabler for implementing capacity-sharing models economically, as it allows modularity and more product use cases.

Agilent launched its pre-owned business line in 2013 and subsequently developed its rental business, starting in China about five years ago, before expanding to the US in late 2023. Existing lifespan extension capabilities were an enabler for establishing this new business model and lowered set-up costs, as the capabilities required were already available.

C Learn from data to maximize the value of deployed assets

Predictive and prescriptive maintenance and other data-driven services can maximize value by extending the useful lives of shared assets. They can also maximize value from deployed assets by increasing product utilization and reducing maintenance costs. Connected equipment can additionally be used to extract usage and customer data (regulation permitting), improve product design and enable businesses to offer dynamic pricing models. Businesses should partner with technology providers if these connected services cannot be provided internally.

Schneider Electric, a global energy management and automation company, demonstrates circular transformation through its energy-as-a-service (EaaS) offerings. By integrating microgrids with its EcoStruxure IoT platform, Schneider enables more efficient operation and extended lifespan of shared energy assets. This approach creates value by enhancing energy resilience, reducing upfront costs for customers and improving sustainability. The circular strategy not only addresses environmental concerns but also drives revenue growth through new service-based business models.



Conclusion

Businesses active across 10 manufacturing industries increasingly recognize that circular solutions can deliver broad economic value.

The world is about to experience an accelerated revolution in business models, with many linear models[28] reaching their limits and businesses having to respond to big shifts in the business environment – including labour challenges, supply shortages, broad demands for more sustainability, evolving customer expectations, evolving regulation and the emergence of transformative technologies such as artificial intelligence – which are obligating businesses to re-examine the way they operate. When the triple planetary crisis,[29] fuelled by the overconsumption of resources, is added to this mix, circularity offers a way forward.

Circularity creates a compelling value proposition for a broad set of stakeholders while allowing businesses to remain competitive and productive. It is more sustainable because it reduces resource extraction, waste and GHG emissions. It has the potential to enhance resilience in a world of near-constant turbulence and directly addresses what is possibly one of the biggest challenges of the future: scarcity. Moreover, circularity offers the opportunity to increase corporate revenues through growing customer demand and a shift from one-off sales to lifetime servicing. And while circularity may initially face high investment outlays, it can decrease costs in the long run.

Circular business models, however, do involve trade-offs. For businesses used to yearly product launches, making goods that last longer, are replaced less often and are used at a higher frequency will require not only a change in business models, but also a significant shift in mindset. It requires executives to allocate sufficient resources, including time to upskill employees and to acquire the necessary expertise and partnerships, for circular transformation. Ultimately, both operating models and monetization models have to evolve.

The research conducted gives reasons for optimism. A growing number of businesses are demonstrating that these challenges can be overcome and that circular transformations can deliver substantial economic value if done right. It suggests that businesses that successfully unlock economic value through circularity do the following:

- Understand which of the three archetypes (or combination of archetypes) can generate the most value from circular transformation, and consider the archetype-specific enabling strategies.
- Gain access to critical sources of value by establishing a circular partnership strategy.
- Embed circularity in the business strategy, secure an executive cross-functional mandate and adopt incentives.
- Establish a circular monitoring strategy that allows for identifying roadblocks and scaling circular solutions.

The World Economic Forum, together with Bain & Company and the University of Cambridge, launched the Circular Transformation of Industries initiative to support businesses with their circular transformations. In particular, the initiative seeks to help businesses overcome challenges, set up circular pilot programmes, and explore how to form ecosystems and partnerships to accelerate their circular transformations. Learn more and join the community on the Forum's Circular Transformation of Industries web page.[30]

Appendix

Archetype 1

Hydro

Industry	Aluminium and renewable energy
Employees	30,000+
Case maturity	Ongoing scaling and fully scaled

For Hydro, the recycling of post-consumer scrap through decarbonized operations is one of the main pathways to deliver aluminium with a CO_2 footprint of zero in industrial-scale production by 2030.

Among many other initiatives across industries, they launched their first automotive circular partnership in 2022, with the ambition to develop and supply low-carbon recycled aluminium for automotive vehicles. To achieve this, Hydro engaged the entire value chain. They built partnerships to gain early access to post-consumer scrap, developed proprietary sorting technology to obtain the highest quality and purest materials for their recycling process, and partnered with original equipment manufacturers (OEMs) such as Porsche, Mercedes-Benz and Polestar. This long-term collaboration has enabled the co-development of materials tailored to OEM needs and ensured that OEMs detail the new material in their component requirement specifications.

Implementation challenges

- Lack of transparency on the carbon footprint of materials, to allow customers to make informed decisions and demand more sustainable products.
- Lack of standardization to produce large-scale recycled materials that could be used for all customers and industries.
- Regional differences in regulatory requirements for end-of-life/recyclability of products and in collection rates, which limits the ability to recycle.
- Outflow of scrap from the Global North to the Global South, leading to diminished control over the sorting process and loss of a key source of value.
- Lack of willingness to pay a premium for low-carbon recycled minerals and products, driven by negative perception of quality.

Enabling strategies

- Partnerships to secure early access to scrap and to gain control of the sorting process.
- Development of proprietary sorting technology (HySort) to gain access to more scrap types and allow for high-value recovery of specific aluminium alloys.
- R&D in existing alloys to allow for higher share of recycled aluminium content in aluminium automotive components.
- Long-term partnerships with OEMs (with 20-30 years' horizons) to secure demand and mitigate risks from high investments.
- Circular design with partners to prioritize recyclability from the early stages of design and enhance circularity across product life cycles.

Impact

GHG emissions:

- Aluminium recycling only requires 5% of the energy used to produce primary aluminium. It also saves resources from the mine to the end-product. Recycling one tonne of aluminium saves six tonnes of bauxite and nine tonnes of CO_2 emissions.[31]
- By using a minimum of 75% post-consumer scrap, Hydro delivers recycled aluminium with an average carbon footprint of 1.9 kg CO_2eq per kg, about eight times less than the average in primary aluminium production. Hydro's 100% recycled aluminium carbon footprint is less than 0.5 kilo CO_2eq, though its output is only small-scale due to the complicated and time-consuming production process.

Resilience:

- As Hydro tailors its recycling solutions to meet the specific needs of OEMs, both parties enter long-term partnerships that secure consistent demand for recycled materials, driving financial stability and strengthening resilience.
- Due to a shortage of aluminium scrap, coupled with rising scrap exports to Asia, scrap prices in Europe have been rising, negatively affecting Hydro's resilience. Hydro is reducing its dependency on external scrap sources through long-term contracts for stable scrap access and expanding sorting capacity to process a wider range of scrap.

Revenue:

- Hydro's recycled aluminium products command premium prices and demand for recycled aluminium is expected to grow at double the rate for virgin aluminium, with annual growth of 5.4%.
- By 2030, Hydro therefore expects to almost double its annual post-consumer scrap usage to 850-1,200 kt by 2030, resulting in EBITDA in the range of approximately $470-750 million in 2030, depending on market developments and capital availability.

Cost:

- Achieving an EBITDA of approximately $470-750 million by 2030 requires significant investments in recycling facilities, securing access to scrap and developing advanced sorting capabilities. For example, Hydro opened a $150 million greenfield recycler in 2023 and approved an approximately $200 million investment into another in 2024.
- Furthermore, processing circular feedstock alters the cost structure with new cost components such as collection, sorting and transportation. This is partly offset by lower energy consumption in the production process versus primary aluminium.

Archetype 2
and beyond...

Siemens Mobility

Industry	Rolling stock (rail industry)
Employees	40,000+
Case maturity	Solution suite including fully-scaled solution and pilots

Rail transport, due to its high asset value and long asset lifespan, is a perfect case for the circular transformation of industries. Siemens Mobility has developed a full circular solution suite for rolling stock, unlocking both sustainability and cost-efficiency potentials. The suite covers the entire life cycle, focusing on three pillars of solutions. First, "doing more with less" – enhancing asset efficiency and availability through circular design and integrated business models. Second, implementing lifetime extension services from refurbishment to intelligent obsolescence and supply chain management. Finally, value recovery at the end of life for technical components, spare parts and materials, leveraging own technical expertise and MoBase marketplace,[32] as well as a comprehensive ecosystem of suppliers, sustainable material companies and recyclers.

Implementation challenges

- Need for transformation of linear value chain and business practices towards circularity.
- Further development of contractual and business models to enable circular solutions.
- Increasing requirements for data on materials, components and systems across the entire life cycle.
- Need for new competencies (e.g. value recovery) and collaboration within and beyond the current value chain.

Enabling strategies

- Comprehensive solution suite integrating sustainability and cost efficiency for operators aiming for fully circular product life cycles (cradle-to-cradle).
- New business models, such as life-cycle contracts, including Railigent X open ecosystem for intelligent rail asset management, full-service agreements and as-a-service models.
- Combining the real and digital worlds with data-driven services, from digital product passports to predictive maintenance, traceability and AI-based end-of-life strategies.
- Building partner ecosystem, including both operators (demand side) as well as suppliers, sustainable material companies and recyclers (supply side).

Impact for sustainability and competitiveness

GHG emissions:

- Smart repair of components, e.g. power electronics for traction systems, reduces CO_2 emissions by up to 40% compared to new production.
- Increased adoption of regional battery and hydrogen trains with zero local emissions, enabled by a “smart train lease” model that requires no capital expenditure (capex), allows for high flexibility and cost efficiency.
- Use of secondary instead of primary materials, e.g. through a circular supply chain for aluminium, can result in a reduction of CO_2 emissions of up to 90%.

Resilience:

- Intelligent obsolescence management and supply concepts, combined with the recovery of critical technical components increases the resilience and efficiency of rail transport.
- Value recovery of materials, e.g. aluminium and copper, at the end of the life cycle through a recycling ecosystem mitigates the risk associated with scarcity of materials, supply-chain disruptions and material cost increase.

Revenue:

- Leading in circular, resource efficient rail solutions is a clear differentiator to win major tenders, where circularity is gaining increasing importance as a supplier-selection criterion.
- Market trend towards circularity offers potential to strengthen and expand the position as a full-service provider, including new opportunities in life-cycle services in the late phases of an asset life cycle.

Cost:

- Predictive maintenance through Railigent-X services enables fleet availability of up to 100% as well as up to 15% reduction in maintenance costs and up to 40% saving in costs caused by service delays.
- Additive manufacturing supports 100% availability by keeping spare parts available for decades, even when the original parts have become obsolete. It drives cost savings through smart redesign of components (e.g. for weight reduction) and reduces material waste by up to 70% (versus traditional manufacturing and storage).
- Closing the loop regarding low-carbon, secondary materials can significantly reduce the cost for reaching ambitious supply-chain decarbonization targets.

Archetype 3

Trane Technologies

Industry	Industrial machinery manufacturing of heating, ventilation and air-conditioning and refrigeration systems
Employees	40,000+
Case maturity	Fully-scaled solution

Trane Technologies started its North America rental business in 1992, and in Europe, Middle East and Africa (EMEA) in 2011, under the Trane strategic brand, to service customers with seasonal needs who were challenged by ever-changing product efficiency regulations. Today, the rental fleet has grown over 10% year-on-year in the past three years. In addition to renting chillers to all industry types – including data centre, power generation, healthcare, retail, events and more – Trane Technologies repairs, refurbishes and upgrades devices, a service that is not limited to the rental fleet but expands to life extension services for all customers.

To gain access to parts and second-life components for its rental fleet, Trane repurchases used heating and cooling systems from customers. Trane Technologies has also started to establish remote connections to increase the useful life of its devices through remote maintenance. Their circularity ambitions are an integral part of their sustainability commitments, aiming to reduce 1 billion tonnes of customers' GHG emissions, and reduce total embodied carbon by 40% by 2030.

Implementation challenges

- Lack of customer awareness of the benefits and availability of circular solutions.
- High market saturation from third-party rental businesses.
- Access to useable second-life equipment to buy back and repair for use in the North America rental fleet.

Enabling strategies

- Clear communication of customer benefits to accelerate demand, including perceived environmental benefits, access to up-to-date technology, lower cost of ownership and product regulatory support given ever-changing chiller efficiency regulations in the EMEA; equipment-as-a-service offering.
- Leveraging in-house expertise and capabilities in product knowledge and repairs provides a competitive advantage over third-party rental businesses.
- Remote connection to rental devices helps to increase device lifetime utilization and reduce maintenance cost. By adopting predictive maintenance, Trane Technologies can mitigate issues before they affect productivity, often without on-site support.

Impact

GHG emissions:

- In cases of seasonal demand for cooling or heating, there are often customers with countercyclical needs. By sharing, Trane Technologies can decrease virgin resource consumption as well as embedded carbon emissions that would be required to build two separate pieces of equipment when only one is actually needed.
- In cases of continuous demand, renting offers access to efficient technology, thereby helping to reduce energy costs and carbon footprints. In fact, in EMEA, because of the Ecodesign for Sustainable Products Regulation, chiller efficiency has increased by 70% over the past seven years.
- Upgrading technology can even transform seasonal demand into continuous demand. Offering rental options for the latest heat pump technology instead of gas boilers helps reduce resource consumption and emissions while meeting heating and cooling needs. This eliminates the need for additional installation, transportation and heating alternatives that rely on natural gas.

Resilience:

- Renting allows Trane Technologies to quickly meet customer needs and mitigate supply-chain challenges.
- In the EMEA market, Trane Technologies enhances supply-chain resilience and price stability through more effective long-term planning and stronger relationships with suppliers. The rental service helps stabilize the demand for materials by maintaining consistent production levels.

Value added:

- Rental services unlock new opportunities that benefit customers, for example, by serving customers who need to mitigate short-term equipment downtime or those looking to try new equipment without being willing to make significant capital investments. Additionally, this circular business model enables a more transparent revenue pathway by providing customers accelerated equipment upgrades and helping customers comply with chiller efficiency regulations.
- Today, the rental segment is growing at a steady rate annually, with minimal cannibalization of linear sales.

Costs:

- In the EMEA market, by utilizing factory capacity to produce rental equipment, Trane Technologies can minimize the fixed cost-absorption challenges associated with underutilized production facilities.
- Improved end-of-life management of assets enables the recovery of valuable equipment, which would have otherwise resulted in capital investments in new systems.

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Acknowledgements

The authors thank the members of the Circular Transformation of Industries community for their insights and inputs that were invaluable in shaping the content of this paper. The paper does not necessarily represent the views of the organizations listed below.

Agilent Technologies

Cisco Systems

Dow Chemical Company

enaDyne

HP

Indorama Ventures

Norsk Hydro

Ralph Lauren Corporation

Rockwell Automation

Schneider Electric

Siemens

Trane Technologies

Trumpf SE + Co.

Production

Bianca Gay-Fulconis
Designer, 1-Pact Edition

Madhur Singh
Editor, World Economic Forum

Endnotes

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