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A PORSCHE COMPANY

MHP WHITE PAPER

ENABLE CIRCULAR ECONOMY

How to future-proof your business with the holistic implementation of a data-driven way of working

Due to self-motivation to operate more sustainably and due to increasing social and regulatory pressure, the transformation to a circular economy is becoming a strategic focus of more and more companies, especially in the mobility and manufacturing ecosystems. In addition to highlighting the potential, this white paper focuses on the question of how this transformation will succeed. To answer this question, a holistic approach to rethinking the linear economy towards the circular economy is proposed, especially in the implementation of processes and working methods.

Digitalization and use of information in the form of data are central to the transformation. The white paper therefore underlines the relevance of data and its consistent use as a prerequisite for the success of sustainable economic management through a circular economy.

Industries are considered on the basis of three dimensions:

1. processes
2. products (portfolios)
3. data

Based on these dimensions, components of industrial products that are currently attracting a lot of attention are examined in more detail in two examples:

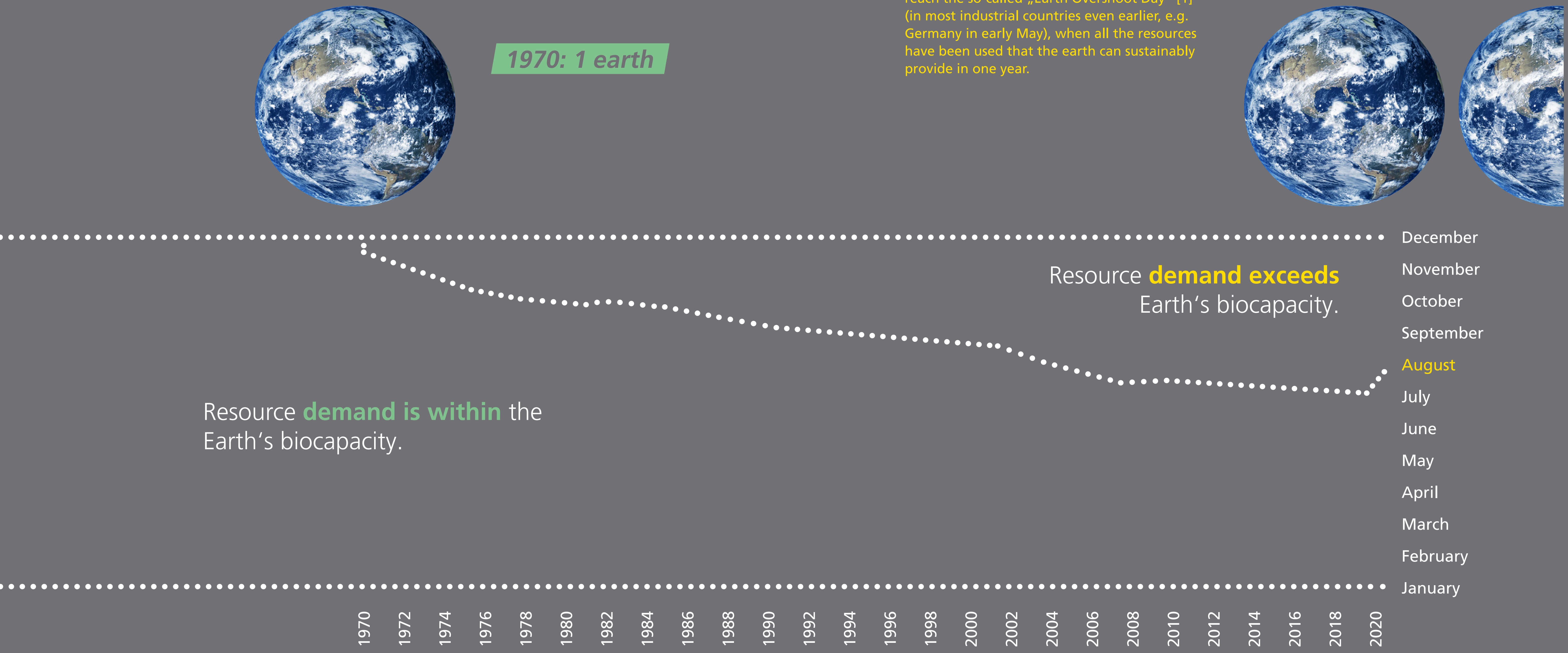
- High-voltage batteries
- Plastic recyclates

Content

Time of Earth Overshoot Day (worldwide) from 1970 to 2020

2020: 1.6 earths

In recent years, between July and August, we reach the so-called „Earth Overshoot Day" [1] (in most industrial countries even earlier, e.g. Germany in early May), when all the resources have been used that the earth can sustainably provide in one year.



It is increasingly the case that more resources are being consumed on Earth than are available. In order to reduce the participation of industries in this trend and reverse it in the medium term, there must be a transformation to a resource-saving yet profitable economy – this is the transformation to a circular economy.

Introduction

For companies, the question is: Is there a path to sustainable success, profitability and growth in harmony with the availability of planetary resources? What will determine how we do business in 2030 and beyond? The guiding principle for this future, the circular economy, was described as early as 1990 – and virtually all experts agree that the transformation from a linear to a circular economy is overdue and will result in an increasing number of legal requirements for companies and their products.

The linear economic model has brought about many of today's most pressing challenges. From climate change to plastic pollution, species extinction to health problems and global social inequality, all these consequences are devastating. Between July and August every year, we reach the so-called "Earth Overshoot Day"(in Germany, it is in early May), where all the resources that the world can provide on a sustainable basis in a year were used. In the short term, this highly symbolic day has to shift to the last quarter of the year and in the medium term should no longer appear on the calendar. From an economic perspective, the increasing scarcity of resources and the resulting price developments also pose a massive risk to industry[2].

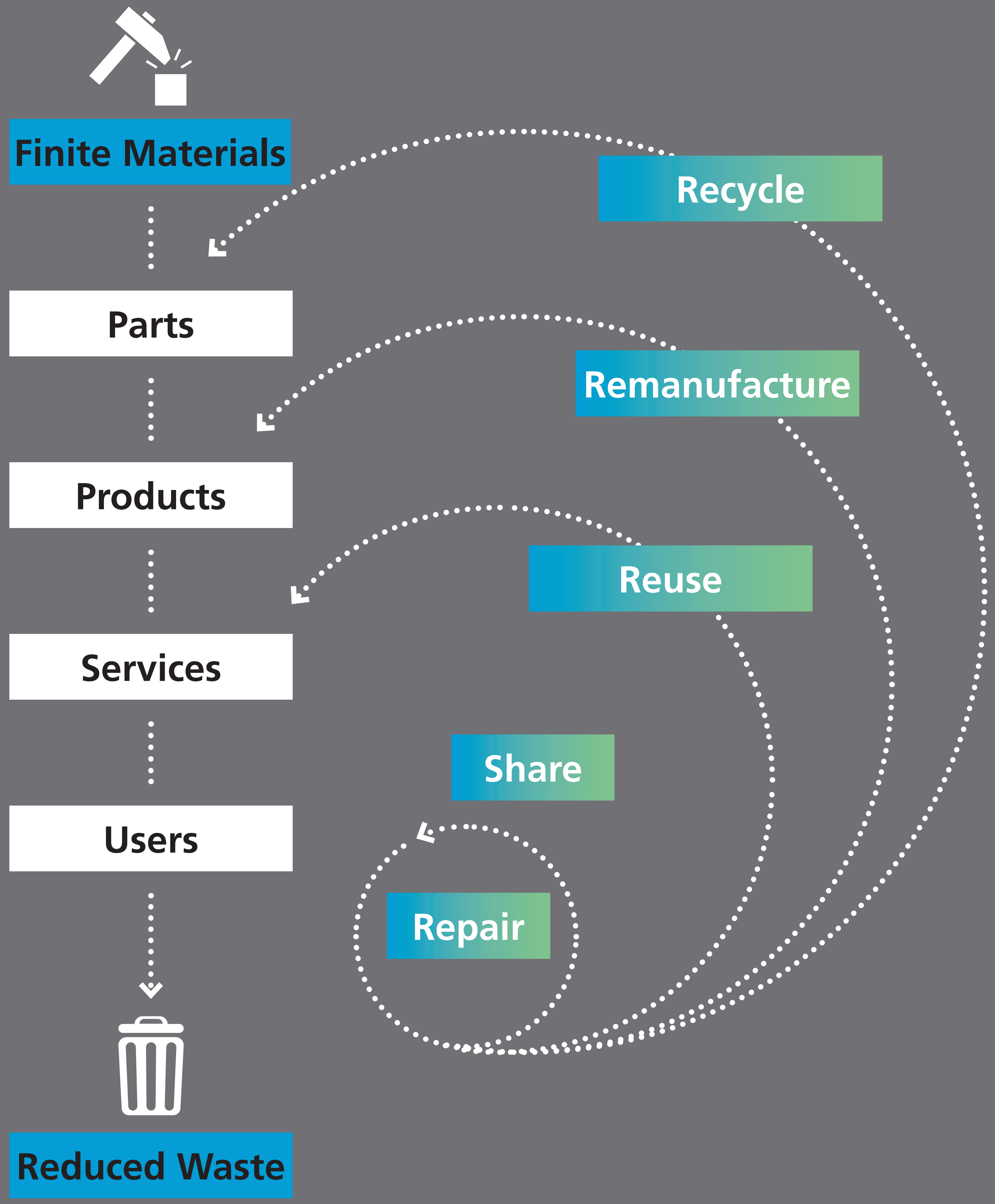
The circular economy and its central concept of preventing resource waste through reuse is a guiding principle of sustainable transformation and is becoming a central field of action in more and more corporate strategies. Today, the use of natural resources and materials is responsible for around 70 per cent of global greenhouse gas emissions[3]. A large part of the European Green Deal focuses on the transformation from a linear to a circular economy and therefore on the decoupling of economic growth from the use of resources. The so-called New Circular Economy Action Plan, published by the EU Commission in March 2020, contains several proposals for action. From the modernization of EU legislation on batteries to a ban on microplastics or mandatory rates of recycled plastic materials, the legislative framework for the change is undergoing constant development.

Digital transformation, a field of action that has been filling the balanced scorecards of companies for decades, is also increasingly realizing its true potential in relation to these challenges. The EU Commission is already talking about "Industry 5.0", combining digital and sustainable transformation. With this in mind, it is important that the added value of new technologies is made available for a sustainable future.

The objective of this white paper is not only to convey the benefits of digital technologies for the sustainable transformation to a circular economy, but also to illustrate the use of data in the current and, above all, the future economy and industry as a prerequisite for the transformation.

"Today's economy is divisive and degenerative by default. Tomorrow's economy must be distributive and regenerative by design."

Kate Raworth – Doughnot Economics



Circular economy diagram (based on the butterfly diagram of the Ellen MacArthur Foundation)

Goal number 12 of the Sustainable Development Goals , the United Nations strategic framework for sustainable development, as well as other recognized sources such as the Ellen MacArthur Foundation , present the transformation to a circular economy as a fundamental solution in an industrial context.

The circular economy describes a self-contained system for sustainable economic management, in which resources are not a limiting factor. Materials and products are returned to the original processing cycle after their end-of-life (EOL). For the industry, the preservation of resources through sustainable products is the priority. The aim is to allow materials to pass through product life cycles for as long as possible in order to minimize waste and the consumption of primary raw materials.

At the centre of the circular economy are the “Design for R” principles of Repair, Reuse, Remanufacturing, and Recycling. This means that entire product components or parts thereof are recycled and/or restored to their basic substances, which, after appropriate treatment, serve either the same or a different function or purpose. As the most energy-intensive process, recycling shall always be considered as the last option when it comes to reuse.

In the context of the circular economy, the idea of a second life is a key concept, i.e. the repeated use of components, for example after remanufacturing – or a different use of the product or its components. Extending the first life is, however, a central focus of the circular economy, particularly with regard to mechatronic or cyber-physical products and systems and their sustainability impacts.

Transformation to a Circular Economy

A holistic view

Industrial companies are faced with the global challenges described above in different ways: through their products and services, their complete life cycles, their employees and e.g. their approach to mobility, but also through their consumption of resources (in buildings, for example).

In view of changing global conditions, it is not just the regulatory requirements for industry that are becoming tougher. The reputation of industrial companies is also increasingly being measured by their contribution to sustainable development. Younger generations have a different lifestyle and expectations of companies – as their customers and employees. There is increasing talk of a "license to operate".

Without that license, companies lose their competitiveness in the labor and sales markets of tomorrow.

Climate change, scarcity of resources, demographic change and generational effects are thus increasingly affecting the economic world and, in particular, manufacturing companies. Due to the scale and complexity of the challenges, the solutions to these problems must be holistic and must address all aspects of industrial action.

Opportunities created by a Circular Economy

The shift toward sustainable economic management and a circular economy is not only to be seen as a solution or reaction to the above problems. Important arguments for the transformation lie also in the associated economic opportunities.

A circular economy provides the foundation for innovative business models, for example. Cost savings through reduced acquisition costs and resilience to supply chain fluctuations through the reuse of resources are further examples. The sustainable economic management of a company also promotes employee satisfaction, for example with regard to the working atmosphere and the attractiveness of employers.

A study by the Club of Rome concluded that, if implemented in the economy as a whole, material savings as a result of Circular Economy policies and measures could help to reduce greenhouse gas emissions by up to 70 per cent in each country, while at the same time increasing the number of workers by four per cent. The European Commission is also forecasting up to 700,000 new jobs within the EU by 2030 in conjunction with a circular economy[9].

Key question

How can industrial companies succeed in the transformation to a circular economy?

The answer to such a comprehensive question can only be found by an equally comprehensive and therefore holistic analysis of all the actions and interactions of industrial companies, in order to pursue the holistic perspective described above. To ascertain what these various complex interactions are, it helps to "zoom out" and imagine companies as "black boxes" and to derive an overview of their interactions. The "New St. Gallen Management Model" provides a recognized overview and illustrates the various links of a company. The categories defined in the St. Gallen Model are shown here in a simplified way:

From this process- and sequence-oriented perspective, products are already taken into account by "suppliers" and "customers." A company's core value-added processes are product-oriented. Companies generate revenue by selling their portfolio (consisting of products and/or services). In addition, the environmental impact of a company depends to a large extent on the environmental compatibility of its products and the consumption of resources during their production. Therefore, in addition to processes, this white paper addresses products as a second dimension.

Based on the two "classic" dimensions of products and processes, the question as to the importance of data arises due to the megatrend of digitalization and its applications such as artificial intelligence, virtual reality or the Industrial Internet of Things. The need for a holistic and, above all, future-oriented perspective is another reason to consider data more closely. Data is continuously generated and used in processes -and increasingly generated by products. The number of connected devices will have more than doubled from 22 to 50 billion between 2018 and 2030 . Other sources suggest there will be more than 75 billion devices. Even now, it is virtually impossible to market a product without connected digital services. In terms of processes, it is safe to assume that "non-digital" work steps – or activities in which no data is generated – will soon be a thing of the past in industrial contexts. According to forecasts, the amount of digital data generated annually worldwide will be 175 zettabytes (175 with 21 zeros) by 2025. In 2018, it was 33 zettabytes.

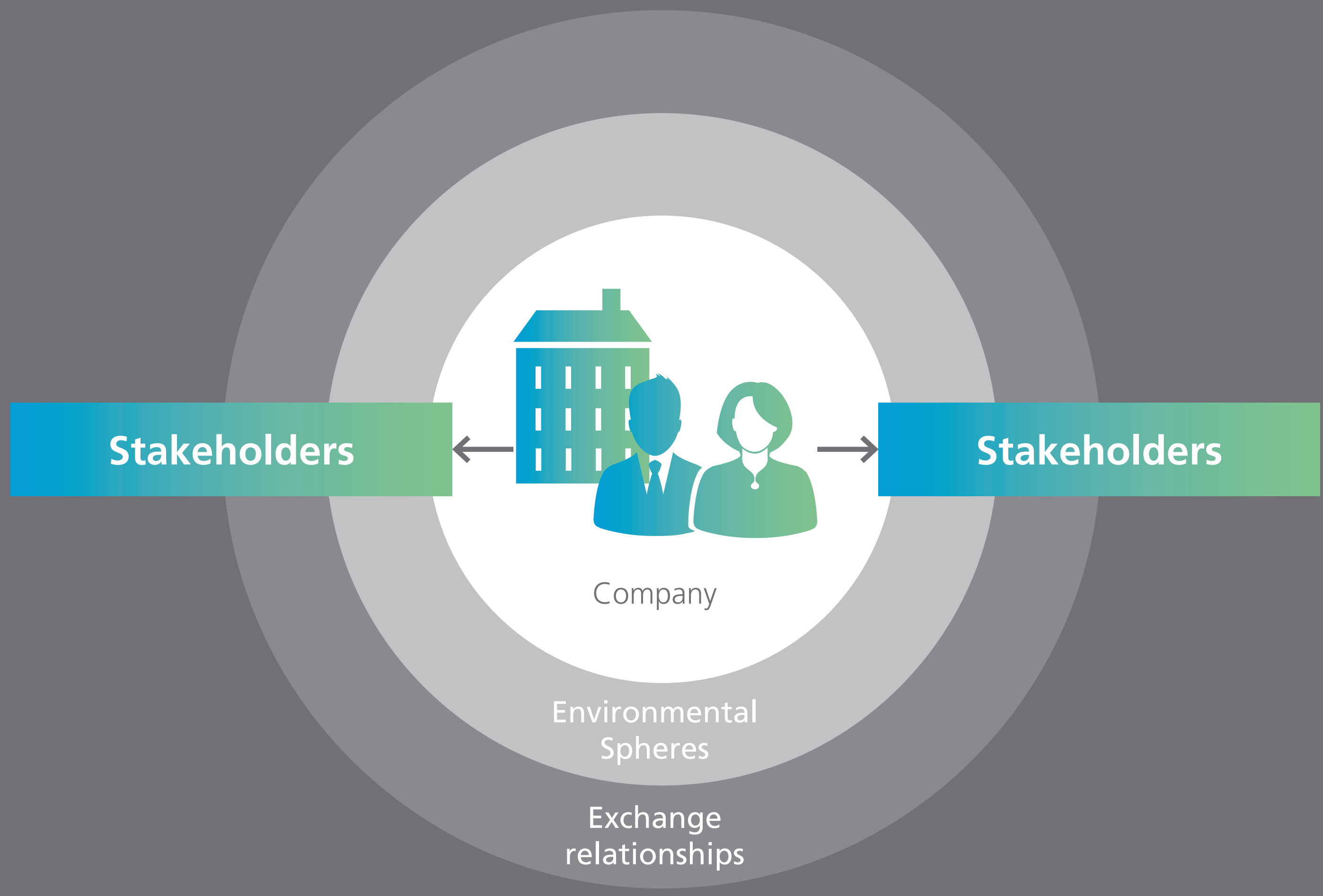
As a result of the increasingly digital and networked product life cycles, data must therefore be taken into account as a third essential, equal dimension in addition to the dimensions of processes and products.

Thesis

At MHP, we therefore argue that data and its intensive use are not only tools, but also the enablers for the transformation to a circular economy and for sustainable economic management due to their increasing relevance in products and processes.

With the objective of finding a holistic answer to the above key question, the three dimensions of data, products, and processes in the context of the transformation to a circular economy are considered in more detail below. These three dimensions overlap in practice – their purpose here is to enable clarification and to make relationstransparent.

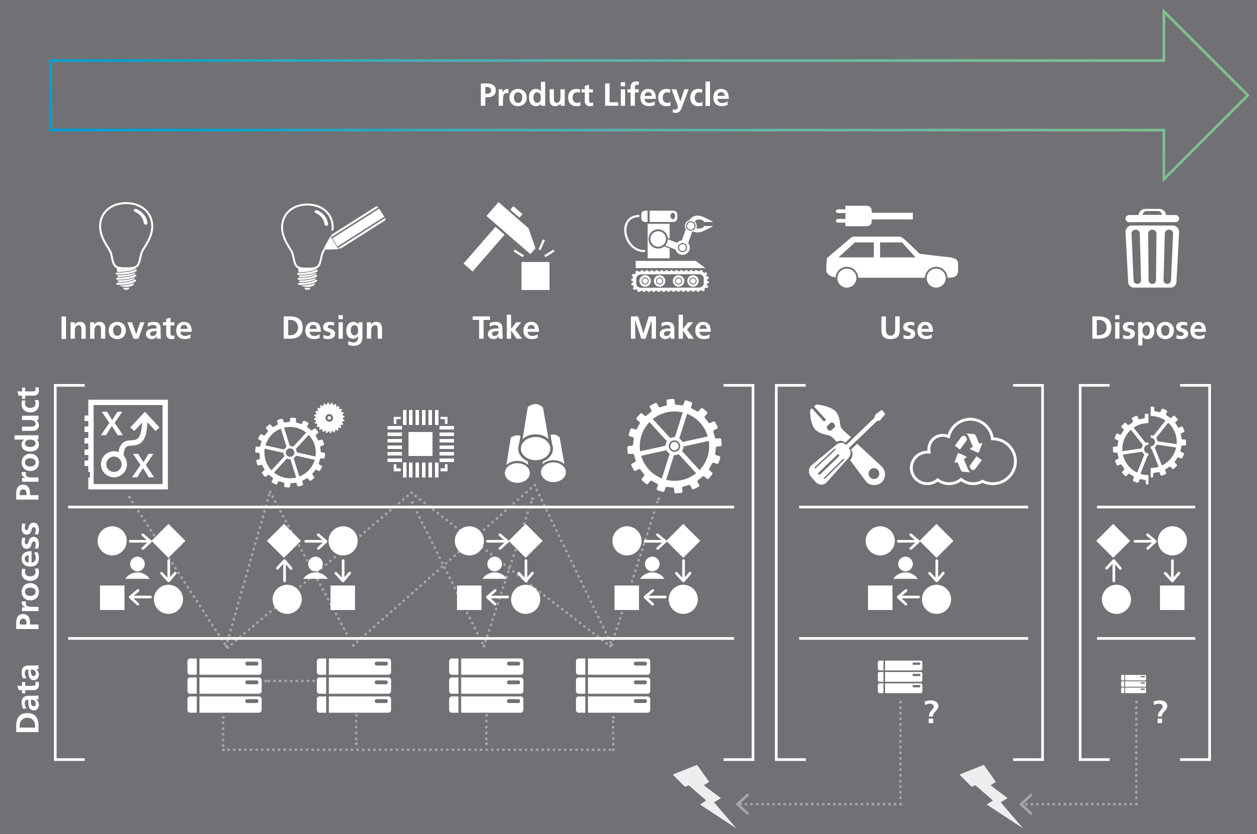
Company as a black box – schematic representation based on the "New St. Gallen Management Model"

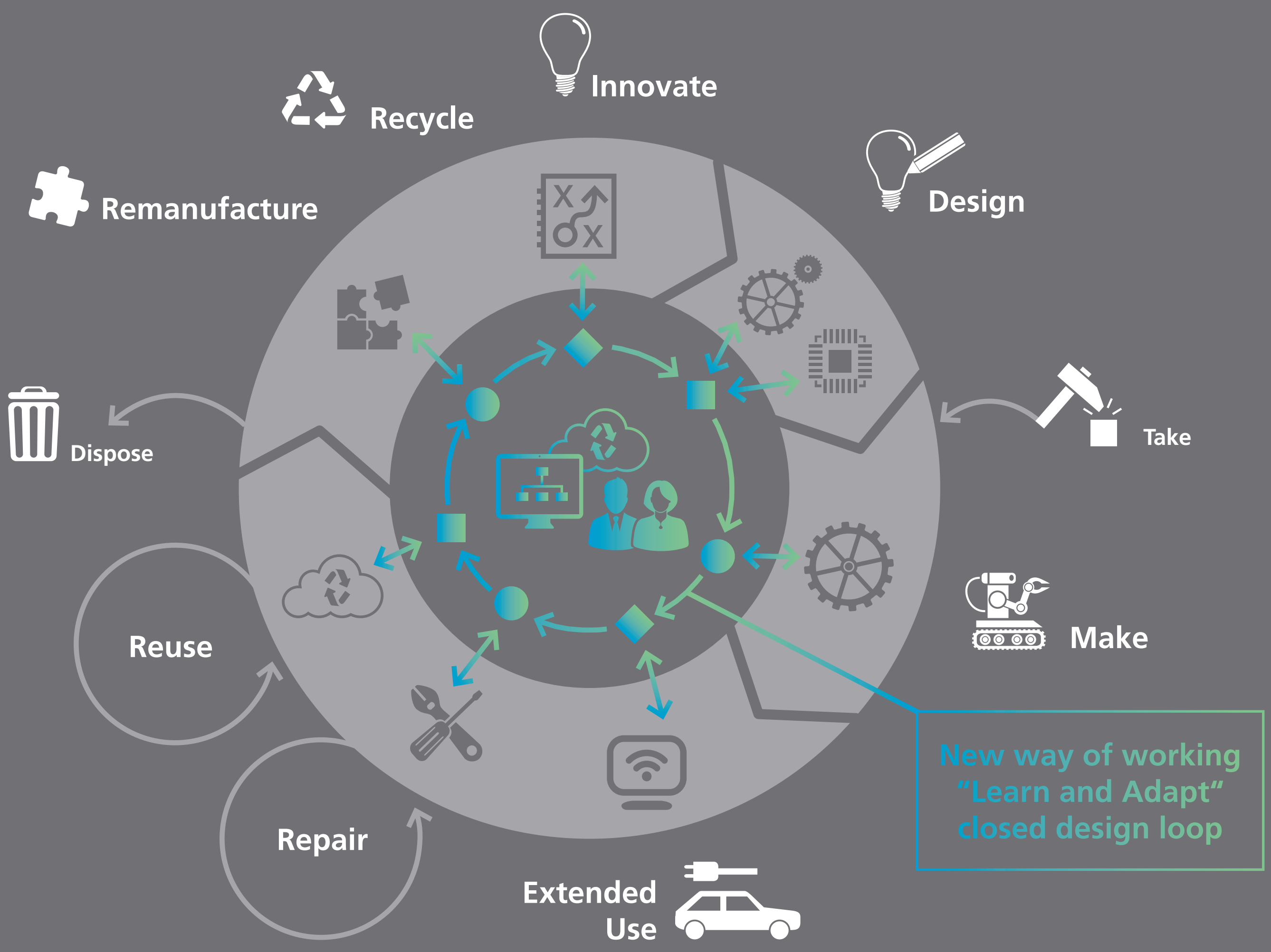


The New St. Gallen Management Model groups the interfaces and interactions of a company into:

- environmental spheres (society, nature, technology, economy),
- exchange relationships (resources, standards and values, concerns, and interests), and
- stakeholders (investors, suppliers, employees, state, competitors, public).

Comparison of a Linear Economy and a Circular Economy





Linear economic

The figure depicts linear economic management based on the three dimensions of process, product, and data. Products are developed for series production and manufactured either as an innovation or as a successor to an existing product. Following their usage phase (which varies greatly depending on the product), valuable amounts of the raw materials used in the product are not reused (or not as much as possible) and normally end up in landfills, albeit indirectly, with harmful effects on the environment. When it comes to new products, this means that primary raw materials must be obtained again. At data level, it is also apparent that the potential to gain information from the use of products directly in the field is being rarely or insufficiently exploited. Concepts such as predictive maintenance are increasingly being implemented as products become more and more connected. However, the findings are then mostly applied directly to the respective products – rarely are the findings consistently fed back into the innovation and design phases (R&D).

Paradoxically, although the idea of a cyclical model is anchored in the term "product life cycle," which is used every day in industry, most processes are anything but cyclical – instead they are linear.

Digital Circular Economy

Closed data cycles create "closed digital loops." When used to as a source of information as part of a "learn and adapt" working method for improving and updating products throughout all phases of their life cycle, data enables consistent and continuous learning from the way the products are used. This enables, for example, the useful life of products in the field to be extended by means of updates or repairs, the correct time for "second life" (reuse) approaches to be identified, and the knowledge gained to be fed back into innovation, design, and production.

The use of data in the innovation and design phase increases the reusability of components and raw materials (remanufacturing and recycling). According to the thesis that data and its intensive use are not only tools, but also the indispensable enablers for sustainable economic management and a circular economy due to their increasing importance in products and processes, data is right at the very center, implemented through cloud technologies, among other things, and forms the basis of the "Digital Circular Economy."

The Data Dimension

In addition to the increase in data, we are also observing another trend through digitalization: data is becoming increasingly valuable with regard to continuous improvement.

As shown above, data in product development has been generated since the introduction of the first computers – even though the amount of data and the manner and efficiency of data usage have changed dramatically (for example, by using 3D models).

The digitalization of products produces more and more data throughout the phases of their use. The increasing connectivity and functionalities of cloud technologies enable completely new ways of using data – for users, operators and, above all, for the manufacturers of the product. The main interest of manufacturers lies in learning from the acquired usage data. That data has to a large extend, so far been generated in tests during series development that have a limited proximity to reality and that cannot be conducted continuously. The findings from experience in the field can be used to improve products (and services) and to generate ideas for new products (for example, new variants or completely new portfolio segments). The implementation of such "learn and adapt" working methods requires the existence of digital twins and the integration of the findings into "closed digital loops."

Digital Twins

The idea of the digital twin was developed in large part in the early 2000s by Michael Grieves and others. It aims to create real-time representations of physical entities, such as products, based on real-time data that reflects the relevant properties without the need to analyze the actual physical entity. In 2016, Grieves and Vickers defined the digital twin as follows: "The digital twin is a set of virtual information constructs that fully describes a potential or actual physical manufactured product. As its optimum, any information that could be obtained inspecting a physical manufactured product can be obtained from its digital twin." For industrial companies, there is huge business potential in evaluating the data obtained through digital twins and "learning and adapting" – that is, using the information by applying it to innovation processes or in the ongoing further development of their portfolio. So in this case too, we can observe a trend from a sequence to a cycle. The fundamental prerequisites for this are the design of the corresponding processes and the technology setup within the companies.

Control Metrics

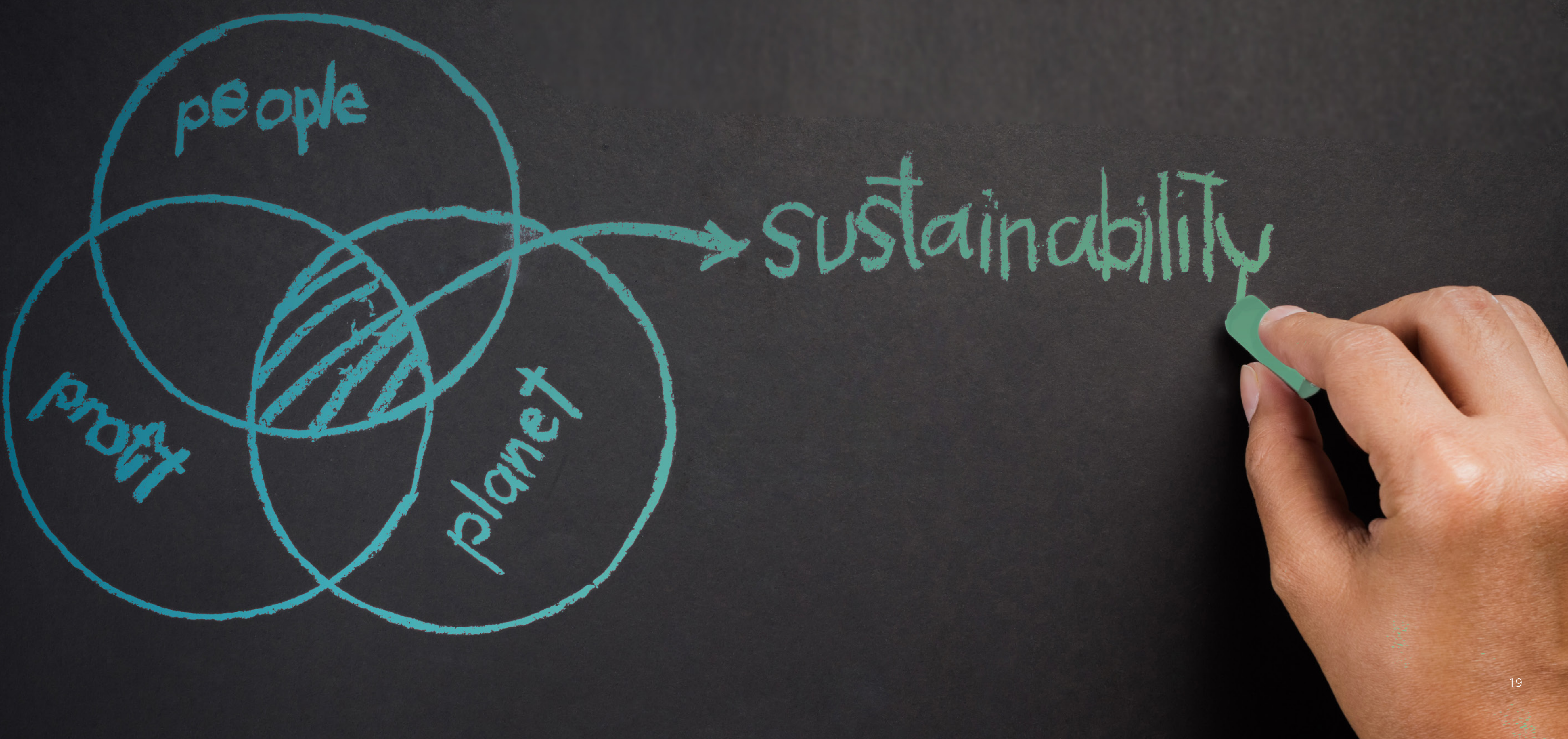
Another important, data-related topic with a direct connection to the two other dimensions of process and product, are reporting and control variables within the industrial processes. These metrics are derived from data that is generated or collected during the processes and that is used as the basis for decision-making and issuing of approvals and releases. Essentially, the control variables in today's product development areas continue to focus on time, cost, and quality. The impact on resource consumption and other sustainability-oriented key figures or KPIs has not yet become a central aspect of the industrial reality of internal reporting channels. Reporting at company level, however, is increasingly including KPIs on economic, environmental, and social impact. Two common frameworks for this are provided by the Global Reporting Initiative[14] or the German Sustainability Codex[15], the guidelines of which are being followed by more and more industrial companies in their reporting. The number of sustainability reports is increasing significantly; Of the 100 largest German companies, 69 published an independent sustainability report or an integrated annual report in 2018[16]. It is therefore necessary to integrate such KPIs into reporting within company divisions, especially within product development. We can also observe that the correct calculation of greenhouse gas emissions, for example in production or through the supply chain, is becoming increasingly important.

According to the principle of "you can only manage what you can measure," data can provide a deep understanding of business processes and fully map product portfolios, – provided that the right systems, processes, and logic are established within a company. This understanding will play an increasingly important role in the transformation toward sustainability – in this case too, as a result of increasingly detailed reporting requirements and regulations. However, according to the German Federal Environment Agency, the limited availability and quality of data in the implementation of life cycle analysis projects remains a problem[17].

It is not only within companies but also in working with suppliers and partner companies that data and its value as information is playing an increasingly important role. This follows the aforementioned holistic approach across company boundaries. In order to realize the positive effects of a circular economy, the totality of industrial material flows must be taken into account and transformed. Therefore, all companies involved in a circular economy, such as raw material, component, and system suppliers, as well as OEMs and recyclers, must be considered. The and policy-sponsored initiative "Catena-X" is currently gaining much attention. Its goal is "to create a uniform standard for data exchange along the supply chains. The industry wants (…) to ensure that sustainability targets are met – this requires more transparency."[18].

According to the "Climate effects of digitalization" study, commissioned by the digital association Bitkom, digital technologies can help Germany achieve half of its climate targets by 2030[19]. This requires a holistic approach, which is discussed in depth in the two further dimensions of product and process.

> **Sustainability is not a ‚nice to have', in contrary: I would say it's a license to operate and gaining, quarter by quarter, relevance. And we've completely integrated it in our financial reporting.**
>
> Dr. Nicolas Peter, CFO, BMW AG [20]



2 The Product Dimension

In Figure "Digital Circular Economy," (page 14) the product plays an important role in sustainable economic management, especially in terms of maintaining the value of products, components, and materials throughout their entire life cycle[21]. For manufacturing industries which are facing the challenges of resource scarcity and environmental pressures, it is important to reduce, reuse, and recover resources in production and consumption processes, as already described in the concept of a circular economy.

Circular Products

The transition to a circular economy, as shown in Figure on page 14 requires fundamental changes to production and consumption systems. In production, the goal is to shift the material cycle toward sustainable procurement, for example through the use of renewable or biodegradable raw materials. Material efficiency is another important aspect, or more precisely the function and design of the products, so that it becomes possible to "do more with less." More than 80 per cent of the environmental impact of products is defined in the design phase[22]. The resulting smart product design includes a modular design that makes it easier to repair, reprocess, and upgrade products. If just one part of a product can be removed, it can be more easily disassembled, reducing the cost and effort of replacing components in the event of damage. In addition, circular products offer the advantage of reduced dependence on procurement channels, which are often critical from a social point of view, and on effects such as price increases or decreasing availability of materials. From an ecological point of view, circular products also reduce the risk of environmental damage due to the release of chemicals that have not been reused or reprocessed (for example, battery fluids).

Various approaches that make circularity measurable and controllable already exist, such as the Material Circularity Indicator (MCI). This determines the product components that influence circularity. This MCI can be used as a criterion and input for design decisions in the design of new product architectures, while also enabling the comparison of products. Another positive is the fact that such control parameters can be used to document and reflect the results of the circularity evaluation. Action points can also be implemented to improve the circularity level of the product, such as setting minimum criteria for designers with regard to circularity – this can be done both for new products and for the further development of products with the aim of making them more circular in future[24].

Switching from products to services

The usage phase of products could change significantly in the future, as the culture of ownership shifts toward the temporary use of products. This is associated with a shift from product-based to service-based business models such as "product as a service," in which products are not purchased by customers, but are billed via service contracts (pay per use) on a usage or time basis[25].

A further step toward circularity is taking place politically at EU level: The Organisation for Economic Co-operation and Development (OECD) has defined an EPR ("Extended Producer Responsibility"), which requires manufacturers to take responsibility for the circulation of products and extends the life cycle of a product to the post-consumer phase. This makes manufacturers responsible for collecting or taking back used goods and for sorting and treating them for subsequent recycling.

The Process 3 Dimension

Replacing the term "circular" with "iterative," creates a familiar image of feedback loops, sprints, and follow-ups. However, iterative working methods are not the same as circular working methods. Rather, the iterative working method is a partial aspect of circular value creation, the process oriented aspects of which we will examine in more detail in this section.

In 2021, most processes within industrial companies continue to run on linear working principles. This applies not only to the documented processes in the company-wide process landscape, but also to everyday working methods, routines, and shadow processes. If the end-to-end and complete data landscape is established within a company, for example through the use of digital twins, new potential arises to increase the efficiency and sufficiency of value creation in the process landscape. Transparency is also particularly important when it comes to processes – just as it is for the data landscape.

As shown in Figure „Digital Circular Economy," (page 14) ," the gathering of data from production, from the field, from the customer, etc. is an inherent part of the circular working method. The utilization of this data allows conclusions to be drawn, which enables the product or service to be optimized. As such, aspects of the subsequent use of the product (reuse, repair, remanufacturing, recycling) can already be taken into account during product development (Design for R).

The prerequisite for this is that the process landscape enables or demands the recording and processing of this data. It is therefore crucial that all processes are described and the actual working method also corresponds to this documentation. In addition, existing processes must be adapted to a more flexible, circular working method. In particular, the greater integration of new roles such as suppliers, authorities, MRO (Maintenance, Repair, Overhaul) service providers and customers into the data and process landscape is imperative.

Suppliers

The increased integration of suppliers and MRO allows a more resilient supply chain to be established, thus protecting companies against exogenous shocks (events that occur outside their own system but have an impact on it, such as pandemics).

Customers

The circular working method means that companies are blurring the line between customers and suppliers, as customers supply the company with either data or material from the reuse, repair, or recycling of products already sold. In this way, customers are helping to further develop products and optimize business models. The correct integration of customers is therefore a decisive factor for the successful implementation of a circular working method – not only once, in product clinics, for example, but on a continual basis.

Circular economy does not only change existing processes, but requires new ones, such as repair and recycling processes, and makes other processes, such as scrapping, partially obsolete.

The transparency in the process landscape created by a circular economy allows not only the optimization of the product, but also of the processes themselves. Non-value-adding activities create significant costs for companies. As products become more complex, these effects would be intensified in future by following a linear working method. With a circular working method, the efficiency and the proportion of value-adding activities in the process is of particular importance, since processes are often run through several times over the course of a product life cycle. The "learn and adapt" approach improves products and processes more regularly and more frequently.

The transformation from linear to circular value creation is changing the entire process landscape within a company. Companies must also prepare themselves for this change on an organizational level. Since most organizational structures represent a linear way of working, changes must be made in this area and a cultural change must be established within the company. This involves, for example, the establishment of new roles or the creation of metrics and key figures (based on the current data landscape) in order to make the circularity or the desired effectiveness measurable and transparent.

Job-seekers and employees also want to identify more strongly with their employer and are paying more attention to sustainability when looking for jobs. In an online survey by StepStone, 76 per cent of the employees surveyed said that sustainability should be a high priority for their employer[26]. By introducing circular economic management, companies are therefore also increasing their attractiveness as employers and securing a decisive advantage in the war for talent.

Interim Conclusion and Examples

Considering the transformation toward a "Digital Circular Economy" based on the three dimensions reveals two sources of potential: On the one hand, it is essential to use data as information in a circular approach, and on the other hand, existing technologies such as platform approaches or cloud technologies must become part of the transformation.

Two current examples are now used to demonstrate how the transformation to sustainable economic management can succeed – provided that it is integrated holistically and takes into account the three dimensions of data, product, and process.

Example 1: High-Voltage Batteries

We are in the middle of a mobility revolution. Mobility is becoming more sustainable, flexible, and versatile – and this is happening at a rapid pace. Electromobility plays a central role in this context, particularly in terms of the energy storage systems that are needed. High-voltage batteries are one of the most important and exciting aspects of the mobility revolution. They have been known in the form of lithium cobalt dioxide accumulators since the 1980s and have been continuously developed since then. However, concepts for the development and production, initial operation, reuse, and recycling of batteries are comparatively under-established.

Challenges

There are various challenges associated with batteries. In addition to a comparatively limited amount of experience, the complicated way in which batteries age is particularly troublesome, as this can vary depending on usage, environmental parameters, battery design, and production aspects and must always be determined individually for every single battery. Issues such as dangers in the event of damage, a high environmental impact, the difficulty in diagnosing the actual state, and expensive recycling also need to be considered.

Furthermore, batteries cannot be easily replaced, but are often suitable for other applications in the context of a circular economy after they have been used in a vehicle. However, the latter requires very precise testing of each individual battery.

The use of high-voltage batteries in vehicles therefore requires completely new and, above all, holistic approaches with regard to the dimensions of product, process, and data – throughout the entire battery life cycle. Several concepts do already exist, but from the present point of view, the digital twin approach seems the most promising and forward-looking. All relevant data is collected centrally and in near real-time for each individual battery in order to continuously create as accurate and complete a virtual image as possible of the real battery. What is important here is that this is not just a simple compilation of all the collected data. Rather, the data is interpreted in such a way that an image is created in the sense of a digital simulation. This simulation can be used to determine the current state of the battery, but above all to simulate potential future scenarios and to optimize the operation of the battery in terms of both cost-effectiveness and sustainability.

The use cases resulting from the digital twin approach are extremely diverse. Here are just a few of the many possible examples:

> **"The transformation to sustainable and profitable economic business via a Circular Economy approach will be successful if it is lived as a new way of working and implemented holistically across all three dimensions of product, process, and data – as a Digital Circular Economy."**
>
> Nikolas Bradford
> Head of Sustainability Services at MHP

First Life

Using the digital twin, the optimum operating concept for a specific battery can be calculated under the given usage and environmental conditions. The concept can be transferred to the vehicle's battery management system "over the air." As usage and environmental conditions change, the battery management is adjusted almost in real-time – with a positive effect on the performance and longevity of the battery. Knowledge of the current state of each cell of the battery also allows predictive maintenance to be performed before damage and failure occurs. Depending on the scope of the repair, the potential of the "Design for R" principles of repair and remanufacture is clear. This potential can be realized by means of a design that facilitates access to the battery modules and cells. This is an aspect that has rarely been taken into account in the development and production of batteries to date.

These examples relate to an important application of the circular economy – extending the first life. They also offer positive economic benefits to manufacturers and customers/users, for example by reducing the complexity and costs of maintenance.

As an example of a circular "learn and adapt" working method, accumulated knowledge can be fed back to R&D by consistently learning from the operating data of the batteries. This enables existing usage profiles to be adapted or expanded. In addition to being fed into already active vehicles, the new data can be used to define a new delivery condition, in particular for future vehicles. Due to the strong influence of factors such as temperature on the performance and longevity of a battery, for example, companies could feed temperature-dependent usage profiles into the vehicles in accordance with the climatic conditions of the target country.

Second Life

If batteries reach a too low proportion of their original capacity as they age, they are no longer powerful enough to be operated in vehicles. However, they can still be reused in other applications – for example, for storing energy from a photovoltaic system. Capacity and performance play only a minor role in these applications compared to their use in a vehicle. However, the question arises as to how safely such a battery can be operated and whether its continued use makes economic sense. In these cases, the digital twin can establish clarity. With very little diagnostic effort, it indicates the actual state of the battery and can use a kind of battery passport to determine whether a specific battery is suitable. Due to the difficulty in determining the actual state of a battery, this applies to virtually all operating concepts for batteries in the context of a circular economy. In this case, too, knowledge of the current battery state enables the potential of the "Design for R" principle of reuse to be exploited in order to estimate the "whether" and "when" of the transition from first to second life and to determine which repairs may need to be made, for example, at cell level. As the level of knowledge and predictability of a second life transition increases, data also enables new business models to be established.

Conclusion

Robust approaches to data strategy, data management, and data analysis are essential for a circular economy. When using batteries, digitalization is one of the most important drivers for increased sustainability. For this particularly valuable component, data and its use as information enable the potential of the Design for R principles to be realised.

Example 2: Plastics

The second example relates to a subject that, as a result of its direct association with oil production and environmental pollution, is attracting growing attention worldwide: plastics. "It is widely known that there are microplastics in the oceans. But what fewer people realize is that soil and fresh water pollution is between 4 and 23 times higher than in the sea, depending on the environment."[27] Recycling plastics is one approach to addressing this problem.

Challenges

Plastics are so omnipresent in our lives that we rarely worry about how available or finite they are – from synthetic material for clothing to packaging to smartphones. Cars also comprise around 12 to 15 per cent plastic . Since most plastics are produced from fossil resources, their availability is finite. However, it is not only the production of plastics that is problematic, but also their disposal. The consequences range from microplastics in food and toxins in soils to greenhouse gas emissions from waste incineration. As such, end consumers' awareness of more sustainable products has grown in recent years. The majority of the above consequences can be mitigated by circular value creation in the form of plastic recycling. In this case, primary plastics are replaced by recycled plastic materials.

First Life

Plastics or compound materials are widely used in production due to their different material properties, such as weight, electrical conductivity or shielding, acoustic damping, infrared transparency, etc. As such, their importance for industry and consumer goods is steadily increasing. The properties of recycled plastic materials differ only marginally from those of primary materials when properly treated. Since the processes of extracting and disposing of primary materials are very expensive, the use of recycled materials can also make sense from an economic point of view. However, this requires a rethink in product development. First of all, a process and data landscape must be implemented that enables the proportion of recycled content to be recorded, tracked, and increased. On the basis of this data, target values and measurable criteria can be defined, such as the proportion of recycled materials in the product or the rate of recycled production waste. Design guidelines can then be implemented during development to facilitate the use of recycled plastic materials – for example, through a simpler separation of different materials in the product in the form of a differential construction, or by designing components in such a way that recycled plastic materials can also meet the necessary requirements (Design for R). Ideally, these characteristics, data, and design specifications are integrated holistically into company-wide circular economy concepts, enabling companies to achieve even greater synergy effects.

Second Life

The use of recycled plastic materials can be increased by various means. In principle, as many approaches as possible should be combined:

1. Recycling production waste:
Plastic waste may be produced during production, such as in the form of offcuts or rejects. To scrap this waste or to sell it only as fuel would be a waste at the expense of the environment. Through the established approaches to a circular economy in product development and production planning, companies can separate this waste in a practical way and feed the extracted, pure-grade plastics either into the original production process in a closed circuit or into another open-circuit processing sequence.

2. Purchasing near-to-prime instead of prime plastics:
The increased use of recycled materials can be taken into account as early as the procurement stage. In the best case, plastic recycled materials meet all requirements for a component and can be procured cost-neutrally or, in some cases, even more cheaply. In many cases, a closer exchange between product development and procurement must be established with this in mind, as the purchasing of materials in future will no longer be based on a material designation, but on a collection of material properties. The established target value system creates incentives for employees to be open to new materials and to seek consensus between ecological and economical materials.

3. Recovering end-of-life waste:
Even after the end of the product life cycle, products offer great potential with regard to the treatment of materials, in particular plastics. However, this requires new operating concepts that allow products to be bought back from customers at the end of their life cycle or for ownership to remain with the manufacturer during the life cycle. Adapting the business model, for example by moving from selling per unit to selling the value of a product, could be an essential step in the development of circular products and services.

Conclusion

There are various approaches to and methods of increasing the use of recycled plastic materials as an economical and ecological competitive advantage. However, a transparent process and data landscape and the anchoring of the concept in the business model, in the product strategy, and in process control are necessary prerequisites for all methods.

Primary plastics (also known as virgin plastics) are unprocessed – apart from the steps required to obtain them. They offer the best material properties (“prime”).

In recycled plastic materials, pre-used plastics are treated by means of mechanical and chemical processes. The properties of the recycled materials, if properly utilized, are close to those of primary plastics (“near to prime”), but are often more expensive than primary plastics due to the complex recycling processes used for their production.

Source: https://www.umweltbundesamt.de/kunststoffe

Summary

A circular economy improves portfolios and industrial practices – within a company, at its interfaces, and in terms of products and services "in the field." In order to subdivide this far-reaching transformation into manageable and thus feasible elements, a holistic view as well as an integrated implementation of the dimensions of processes (workflows, interactions, and organizations), products (portfolios), and data (information) is required as an integral part of all industrial considerations and processes in the future. Furthermore, with this white paper, we have shown that the "data world" and all that digitalization has provided up to now can already be used to implement use cases for Circular Economy.

Sustainability as a goal and a circular economy as a solution are increasingly gaining ground in corporate strategies, defined by the Oxford Dictionary as "A detailed plan for behavior that serves to achieve a goal and seeks to take all factors into account from the outset." As "factors" for implementation, we have proposed three dimensions that represent all of the relationships in the context of industrial products and their life cycles. The examples given demonstrate that all three dimensions must be considered equally and form an integral part of any implementation of a Circular Economy approach. In addition, they clarify that, in an increasingly digital and networked world, the potential of a circular economy cannot or can only be insufficiently realized without the correct and consistent use of data. The derivation of data, process, and product should enable industrial companies to find connecting factors for their transformation more easily.

In summary, we would like to highlight five positive effects that can be achieved through the holistic implementation of a Digital Circular Economy:

1. Through linear management, companies lose control over their products usually rather early in the product life cycle. Circular economy enables access to one's own products or services throughout the entire product life cycle.

2. The increasing demand of customers for sustainable products and services is forcing companies to look at innovative circular business models. Examples such as second-life approaches and product-as-a-service are key to long-term customer loyalty. This strengthens trust in brands and companies and paves the way for sustainable, environmentally friendly and profitable value creation.

3. Companies are faced with an increasing number of regulations and legal requirements with regard to sustainability. Consistent data sovereignty in a circular way of working enables these challenges to be addressed proactively. This ensures a long-term "license to operate."

4. In a global economy, resilient supply chains are critical to the continuity of production and distribution. Circular management minimizes dependence on primary raw materials. This reduces susceptibility to fluctuations in the price of raw materials and transport and automatically makes products more sustainable.

5. Circular economic management enforces transparent and efficient process and data landscapes, for example through the consistent application of digital product representations. This enables the proportion of value-adding activities to be maximized.

Outlook and Recommendations

The transformation to sustainable and circular economic management will only succeed if the need for a rethink within companies and the considerable opportunities are understood and recognized. This must be followed by concrete and holistic changes to value creation, which are also the prerequisites for the holistic and consistent use of data. We would like to make the following recommendations:

1. Create an orchestrated and holistic "target system" for the transformation by integrating the product, process, and data dimensions by means of a transparent implementation plan.

2. Create space for innovative thinking and forward-looking decisions. Question the sustainability of your products and business model. Circularity thus becomes not only an integral part of your value creation process, but also the control variable for your long-term business success.

3. Introduce metrics to measure the transformation to sustainability. Use data at all times and in all places. A closed economic cycle requires a closed data cycle or "closed digital loops". This allows you to further develop products and services on the basis of facts.

4. Challenge and promote the creativity of your employees so that existing linear structures, processes, and workflows are questioned and transformed into circular working methods. This increases both the satisfaction of your employees and your attractiveness as an employer.

The transformation to sustainability is not just a necessity, it is a clear business case:

"(…) for every dollar we spend doing this we return three to four more back to the economy. (…) This may be the single biggest business opportunity in human history."

Dr. Jonathan Foley, Leader Project Drawdown [29]

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