9 PRINCIPLES FOR A CIRCULAR ECONOMY

German Environment Agency

Umwelt Bundesamt

Imprint

Publisher:
Umweltbundesamt
Wörlitzer Platz 1
06844 Dessau-Roßlau

/umweltbundesamt.de
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/umweltbundesamt
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Layout:
le-tex publishing services GmbH

Publications as a pdf:
www.umweltbundesamt.de/publikationen

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As at: October 2020

Last updated: Dessau-Roßlau, February 2020

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Foreword

"In Germany, the notion of a circular economy is closely associated with the idea of a well-functioning waste management system. Uncontrolled dumping of waste has been a thing of the past in this country for a good 50 years. Over time, we have got used to reliable waste collection and treatment. During the past decades, separate waste collection and ever more sophisticated sorting and treatment plants paved the way for a world-leading recycling economy that considers waste as a resource and seeks to complete material cycles. All this was achieved while giving priority to the safe elimination of pollutants, thus minimising risks to humans and the environment. This evolution is reflected in the names of the relevant pieces of legislation. The *Abfallbeseitigungsgesetz* (Waste Disposal Act, 1972) was followed by the *Abfallgesetz* (Waste Management Act, 1986), then the *Kreislaufwirtschafts- und Abfallgesetz* (Circular Economy and Waste Management Act, 1996), which was finally replaced in 2012 by the *Kreislaufwirtschaftsgesetz* KrWG (Circular Economy Act).

Circular economy as defined in the latter piece of legislation expressly includes the prevention, recovery and proper disposal of waste. When looking at the language and interpretation of the act, it describes the circular economy as a well-functioning, effectively regulated waste and secondary raw material managing economy.

In December 2015, the European Commission published an action plan entitled Closing the Loop (COM(2015) 614 final) within a circular economy package. This led to new questions about the scope and objectives of a circular economy. On the one hand, the circular economy legislation package, which came into force in July 2018, contains concrete requirements to encourage waste prevention and recycling. On the other hand, the action plan aims at the transition towards a circular economy, tantamount to a profound change in the economic system, as it addresses policy areas such as employment and growth, climate and energy, the social policy agenda, industrial innovation, product design, processing and last but not least resource efficiency and resource protection. It is a concerted approach by various departments, which also covers the respective

areas of law, far beyond the scope of the German KrWG (Circular Economy Act). This has posed organisational challenges for ministries and authorities whose waste management departments had so far been dominating the remit.

In the German-speaking political world, the paradigmatic idea of a circular economy was therefore rendered not as *Kreislaufwirtschaft* ("circular economy"), but rather as *zirkuläres Wirtschaften* ("economic activity in cycles") or even "*EU* circular economy" in contrast to the KrWG-defined "German circular economy". Although since 2015, the lively political, societal and scientific discourse led to a convergence of concepts and ideas, as partly reflected in the amendment of the KrWG (expected for 2020) that took into account the amended EU Waste Framework Directive (2018), there is still a need to flesh out and illustrate the new direction and meaning of *Kreislaufwirtschaft* or circular economy. Not least, the European Commission's new Circular Economy Action Plan (2020) is an important reason for this.

This is precisely what this paper is aiming to do. It outlines a circular economy, based on the experience and interdisciplinary discussions of experts from the Sustainable Production and Products, Waste Management Division at the German Environment Agency. Nine interlinked principles have been developed to systematically define objectives, scope and maxims for action, important parameters, requirements and success factors.

The nine principles ("P.") are meant to give some orientation when implementing a circular economy and serve as a common denominator – regardless of whether it is interpreted as a strategy, vision, approach to a solution, design principle or a policy area."

Short version – an Overview of the 9 Principles

1

Definition

The circular economy is part of a resource-efficient, sustainable way of life and management, encouraging the implementation of the UN's agenda 2030 for sustainable development and respecting planetary boundaries.

2

Scope

The concept of a circular economy encompasses not only traditional waste management, but all phases of material and product life cycles. It must be viewed from a global perspective, including cross-border flows of raw material, goods and waste and their associated environmental and social effects as well as long-term aspects such as stocks of goods and resulting material flows.

3

Objectives

The circular economy helps to protect natural resources and the climate, as well as the environment and human health, following the precautionary principle. In addition, it aims at securing raw material supplies. The circular economy is meant to reduce negative impacts along the life cycle of materials and products – by economising on primary materials and substituting them with secondary materials – and of waste generation and waste management.

4

Measuring expenditure

The expenditure for circular economy measures should be compared to the expenditure of the primary raw materials industry with associated environmental impact, including external social and environmental costs, for producing the same materials or materials or goods fulfilling the same function.

5

Material cycles

The circular economy aims at managing materials in same or higher value cycles so that primary materials can be replaced by secondary material of suitable quality, thus economising on primary material. However, cascading use and final disposal of materials is also required to achieve the objectives (3) and expenditure criteria (4).

6

Prevention

Avoiding the generation of waste and residual materials is generally preferable to recycling, as the latter is always associated with loss of material and the use of energy. Prevention measures must be evaluated in terms of achieving the objective (3) and expenditures (4) required.

7

Design

Designing products for a circular economy means retaining the functional and economic value of products, their components and materials as long as possible in order to minimise negative impacts on humans and the environment. Design concepts should sustain the reorganisation of ways of production and consumption within society. Optimum design must be evaluated in terms of achieving the objective (3) and expenditures (4) required.

8

Pollutants

It must be avoided to place products on the market that contain substances that have an adverse effect on the public interest and, in particular, on human health and the environment. If such substances cannot be substituted, are already contained in products or are only later identified as harmful, the substances must be destroyed or stored safely in final sinks. Alternatively, after weighing up the objectives (3) and expenditure (4), they can also be transferred into safe cycles that prevent the accumulation of harmful substances.

9

Responsibility

In a circular economy, all players within product life cycles and along material value chains bear responsibility for achieving the objectives of the circular economy. Where responsibility is not assumed otherwise, legal requirements must be implemented.

1 Definition

The circular economy is part of a resource-efficient, sustainable way of life and management, encouraging the implementation of the UN's agenda 2030 for sustainable development and respecting planetary boundaries.

The term "circular economy" stands for a closed-loop economy. The schools of thought behind it are ecological economics and industrial ecology, which study interactions between economic systems and the environment. In contrast to a linear flow economy, which, since the beginning of industrialisation, was geared towards the extraction of raw materials, production and goods throughput as target parameters and welfare guarantors, but evidently leads to a high consumption of resources and noticeable decline in environmental quality, a circular economy draws attention to the value of goods and materials and their associated impact on the environment. Raw materials should be used more efficiently and more effectively, products should have a longer lifetime, waste and emissions should be avoided where possible. Beyond that, recycling should have priority, or waste and emissions should be energetically converted, maintaining safe material cycles and eliminating pollutants. A circular economy is thus modelled on natural material cycles in which waste provides resources for other organisms or is transformed by bio-geo-chemical processes without having noxious effects. Thus defined, it is a consistent strategy that aims not just at efficiency increases, but at shaping an overall nature-compatible and resource-saving economic system and all processes in the anthroposphere.

When fleshing out a circular economy, the planetary boundaries define a safe operating space for action. Since the beginning of the great acceleration in the middle of the 20th century, we have been living in the Anthropocene, in a geological era shaped by humans, during which we already overstepped this safe operating space to a certain extent. This has become particularly apparent not only in the loss of species and genetic diversity, but also in climate change, erosion, the increase in impervious surfaces replacing natural land, as well as in the disruption of nutrient cycles by an overload of phosphate and nitrate. Against this background, the circular economy provides a promising concept for solutions in line with the United Nations' Agenda 2030 for Sustainable Development. The Agenda is there to ensure that globally, economic progress harmonises with social justice and does not exceed the ecological limits of our planet. The circular economy is a cornerstone when establishing sustainable production and consumption patterns (SDG 12). In addition, there are great expectations that it will help to achieve further targets of the 17 laid out in the Agenda – targets that are integrated and indivisible. These include work compatible with human dignity and growth (SDG 8), renewable energy supply (SDG 7), combatting climate change (SDG 13) and the conservation of ecosystems (SDG 14 and SDG 15). It is, however, by no means certain that a circular economy can fulfil all these expectations. Given the uneven distribution of prosperity in the world and the growing world population, it is equally uncertain to what extent a consistent circular economy will imply a moderation of consumption, a more sufficient way of life resulting in an overall reduction of goods and material throughput, as has been discussed in the context of a post-growth economy.

Apart from its interpretation as a strategy, vision or solution approach for sustainable development of the entire economic system, the circular economy is interpreted in other contexts as an underlying principle for designing products and as a concrete, definable field of political and economic action. Thus, the notion has been traditionally closely associated with waste management approaches such as the 3Rs (Reduce-Reuse-Recycle) or zero-waste campaigns, i. e. initiatives for the prevention of waste, re-use of products and recycling, and, derived from that, five- or even nine-tier hierarchies. This connotation has been established in the German-speaking world by the "Act to Promote Circular Economy and Safeguard the Environmentally Compatible Management of Waste" (KrWG 2012).

2

Scope

The circular economy encompasses all phases of material and product life cycles, going beyond waste management in its scope. It must be viewed from a global perspective in terms of raw material, goods and waste flows with their environmental and social effects, as well as from a long-term perspective, looking at stocks of goods and resulting material flows.

The circular economy takes a systemic view of the entire socio-economic metabolism. It encompasses all material flows and stocks within the anthroposphere – the living space shaped and influenced by humans – and those flows that are exchanged with the natural environment. It is essentially about technical systems and their material foundations.

The shape and orientation of a circular economy takes its cue from the resilience capacity of the natural environment, taking into account the burden and impact it may endure. These are linked to social effects and distributional disequilibria that must be considered when developing a circular economy that is based on intra- and intergenerational justice. Only within these boundaries is it possible to run a sustainable economy.

As technical systems such as material management are shaped by socio-economic factors – its drivers are human activities, preferences, needs and ultimately consumption patterns – these must be considered when implementing a circular economy. As in environmental politics, the DPSIR causal framework also applies to the circular economy: Driving forces (D) cause pressures (P) which alter the state (S) of the environment, resulting in negative impacts (I) that call for societal responses (R) through adaptive measures.

When looking at systems such as individual economies, sectors, companies, technologies, categories of goods, products or materials, care must be taken that burdens are not shifted unwittingly onto connected economic and technical systems. Although the focus may be on just one such system within the socio-economic metabolism, the system boundaries must be drawn wider than just the metabolism within the system – otherwise known in life-cycle and resource efficiency assessment as gate-to-gate perspective – but must include upstream and downstream systems. This applies above all to material exchange with the natural environment by extracting raw materials and the release of emissions. Thus, in view of Germany's intricate trade connections and its dependency on imports of raw material and semi-finished products, it is not sufficient for the country to develop a circular economy on territorial principles, which would include domestic direct material flows only. Instead, the environmental impact of imported goods and the final destination of produced and used goods, including their effects along their life cycles up to their disposal requirements, must be studied at an international level. This could lead to a change of priorities in domestic waste management and the provision of recyclates.

At the level of products and technologies, this expansion of system boundaries is equivalent to a life cycle perspective where associated expenditures in the functional domains extraction, processing, design, production, logistics, use and waste management (preparation for re-use, recycling, other use or removal) are taken into account (see Figure 1). This is independent of the actual site of production or product release.

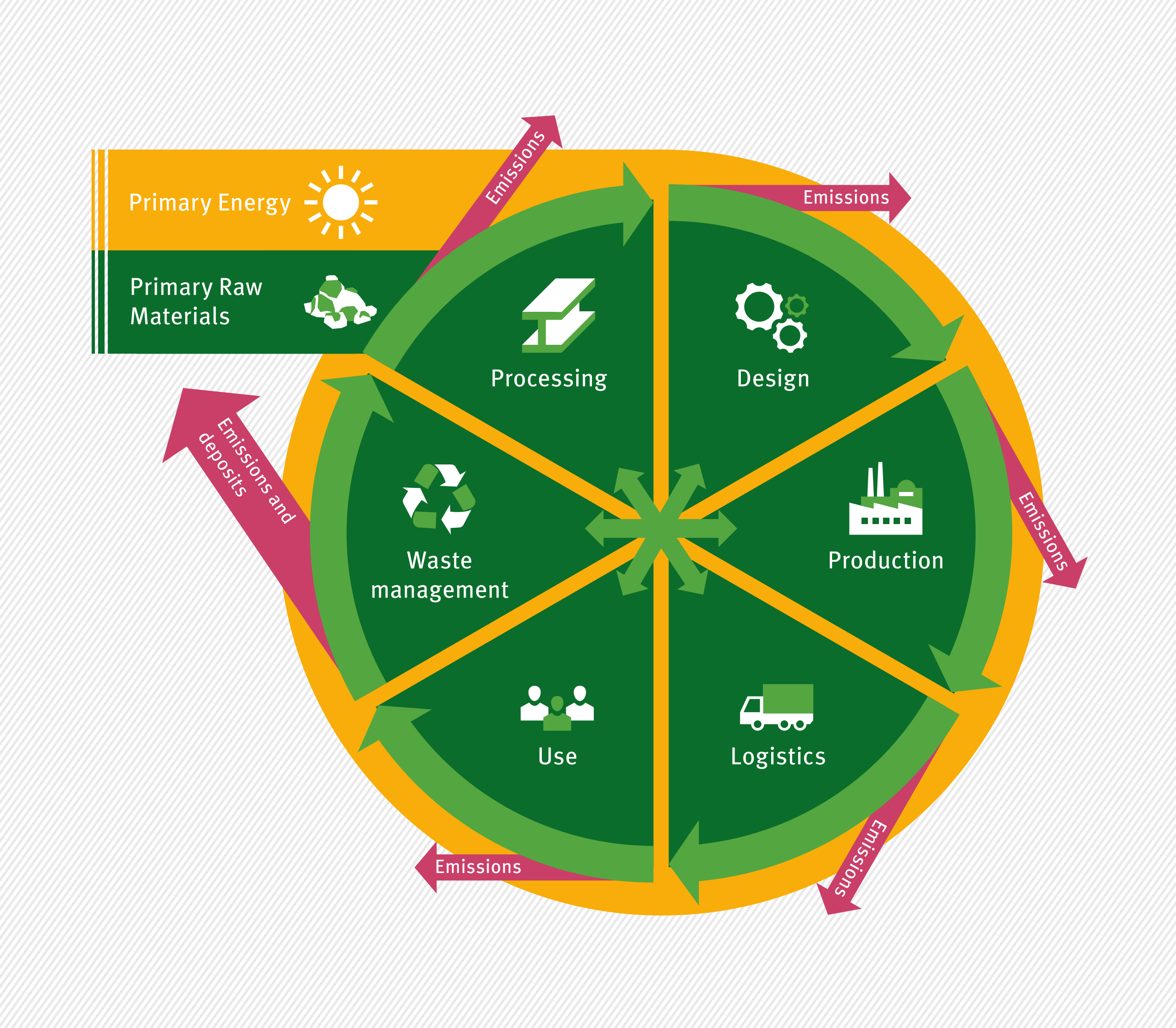
Life cycles of materials are a different matter, as they can only be adequately described as a function and synopsis of all product life cycles and losses of material, as these shift and transform. Nearly all economic activities generate emissions and waste and the end of material life cycles does not coincide with the end of product life cycles. Where the conservation of value of materials and their function in the anthroposphere is concerned, the material flow perspective provides a deeper insight into material cycles, recording material loss such as dissipation as well as secondary material flows. The product perspective, on the other hand, is important to establish the polluter-pays principle and to identify unequivocally the economic players responsible for the burdens that arise over the life cycle of a product, whether they consume a product or invest in it. In addition, this perspective is helpful when it comes to enhancing efficiency and evaluating substitution alternatives – at a purely material, functional or technological level – as well as lengthening the lifespan or identifying alternative or secondary use options. These are aspects to be considered when first designing intelligent and resource-saving products or product-service systems (see P. 7). The product perspective comes into its own when looking at the development and dynamics of anthropogenic material stocks. Materials are locked into these over a long period of time, depending on the usage horizon of product groups, and the secondary raw material potential depends of the type and duration of product use. This is shown in retention time distribution models.

As a field of policy, the circular economy has cross-sectional characteristics, being closely interconnected with energy and climate policies, as a fossil or nuclear-based energy industry is incompatible with the principles of a circular economy in the long term, nor would any sustainable development be conceivable without a renewable energy system. At the same time, however, some sectors in a circular economy require extra energy because firstly, they must ensure the infrastructure for renewable energy can be expanded, and secondly, they must provide the logistics and IT infrastructure for sufficient information flow as well as reprocessing and recycling technology, thus closing material cycles. Furthermore, building up a renewable energy system poses new challenges for material management in terms of raw material availability, which must also be overcome in a circular economy (cf. Figure 1). In many other policy areas such as sustainable building, chemical management or the agriculture and food sector, the circular economy provides fundamental implementation approaches that permit the prevention of waste and managing the relevant valuable material in material cycles, thus preserving their value. Other policy areas such as bioeconomics and urban mining, by contrast, fall entirely within the scope of a circular economy.

All these different interrelations lead to very different legal frameworks that serve to implement measures for the development of a circular economy.

Figure 1

Schematic representation of a product and technology-centred circular economy



3

Objectives

The circular economy helps to protect natural resources and the climate, as well as the environment and human health, following the precautionary principle. In addition, it aims at securing raw material supplies. The circular economy is meant to reduce negative impacts along the life cycle of materials and products – by economising on primary materials and substituting them with secondary materials – and of waste generation and waste management.

By transforming the socio-economic metabolism into a circular economy (cf. P. 2), natural resources will be protected, i. e. wherever possible, they will not be consumed or overused. The protection of natural resources includes everything nature provides for human use. It includes material resources in the lithosphere (mineral resources) and biosphere (biomass), land, the environmental media soil, water, air, and even whole ecosystems that provide us with numerous services – for example the atmosphere and the oceans, which provide us their increasingly limited capacity to absorb greenhouse gases. In other words, the circular economy must protect the environment that enables humans to lead a good life and contribute to the protection of human health.

Natural resources and health are protected, for instance, during waste generation and management, by using disposal methods that protect the climate and environment and by selectively removing pollutants from material cycles. This sink function of the waste management sector is an integral part of a circular economy. Above all, negative effects on humans and the environment elsewhere can be avoided by making secondary raw materials available to replace primary raw material.

In any case, the objectives mentioned should be achieved not only by measures to enhance circularity in the generation and management of waste, but also in all other economic and social activities. These also include the design and use phase of products, using material sparingly, lengthening product life spans, enhancing recyclability and substituting harmful substances (cf. P. 6, P. 7, P. 8), as well as activities in production outside the waste regime. This applies to by-products and secondary materials that are not or – once they have fulfilled the end-of-waste criteria – no longer waste, and to the exchange of recycled material within the production process and between processors of primary materials.

Furthermore, the circular economy pursues the independent objective of securing raw materials through establishing cycles so that they can be utilised for as long as possible, i. e. maintaining the value and functionality of products, materials and substances within the economy as long as possible. In particular, early-industrialised countries like Germany, which built up their prosperity during a long period of ample raw material and energy availability, have a special responsibility to develop systems ensuring that materials in the anthroposphere are used effectively with minimum loss so as not to inhibit development options for other countries and future generations. This applies in particular to what is known as critical raw materials, which are essential on the one hand for products, sectors or economies, and on the other, associated with multiple supply risks. Although including them in a circular flow may only marginally contribute to resource and health protection by substituting for primary raw material, using them can have overall societal benefits, such as environmental technology, and contribute to sustainable development. This is particularly true for technology metals that are used in relatively small quantities and are often extracted as by-products in primary raw material extraction.

The precautionary principle provides guidance for early and proactive action to avoid future environmental and health impacts or to conserve natural resources for future generations, even if knowledge of the nature, extent and probability of the impacts and cause-effect relationships is incomplete or uncertain. The precautionary principle thus has a direct effect on the objective definition.

Further basic environmental policy principles are applied when implementing and realising the objectives of a circular economy. The polluter-pays principle ensures that any burdens, damage and resulting social costs are borne by the polluter. In this way, less environmentally damaging processes and activities that contribute to the objectives (cf. P. 9) of the circular economy will be incentivised. The cooperation principle is there to ensure that the objectives will be reached with the greatest possible unanimity. State and societal players will be involved so that their expertise comes into play and results in an effective implementation of measures. Cooperation can also help to avoid law enforcement measures by the relatively soft means of voluntary agreement.

The circular economy described by the EU Commission in its first action plan (COM(2015) 614 final) includes the range of objectives described. In addition, it emphasizes economic and social objectives such as innovation, competitiveness, employment, (local) added value and growth, which do not have priority from an environmental perspective or, in the case of growth, could even counteract the above-mentioned ecologically motivated objectives. In any case, the circular economy faces the challenge of having to reconcile multiple conflicting objectives. Thus, with increasing circularity, the energy required increases more than proportionately, so that an optimum degree of circularity can be derived (cf. P. 5). Economic viability can also conflict with the objective described above (cf. P. 4 and P. 9) in case of negative externalities. Conflicting objectives can rarely be reconciled at a scientific level, but societal and political standards are needed that are not universally applicable. The circular economy as defined in the KrWG (2012) is derived from waste management and only partially covers the objectives and instruments mentioned. Securing raw materials, for instance, has

so far not been the purpose of the legislation and the instruments focus on the management of waste that arises at the end of product life cycles.

Macroeconomic indicators are necessary to monitor and evaluate whether all overarching objectives have been achieved. These indicators should reflect the use of the protected assets and actual cause-effect relations. In conjunction with this, appropriate meaningful indicators and complementary sets of indicators must be derived at all societal action levels – for products, materials and sectors. The indicators to be derived integrate and relate to all life cycle phases, not just the end-of-life phase. It is essential that the indicators are relevant to decision-making and policies that help to achieve the objectives. Thus, they accurately reveal progress in achieving particular objectives of the circular economy as well as representing circular economic activities and development trends in a credible, plausible and transparent manner. One-dimensional target values alone – such as recycling mass rates and other structural information from the waste disposal industry – don't usually meet the criteria, as they give insufficient information about the resulting environmental impact, actual mitigation effects seen at home and abroad, secondary material quality and product properties suitable for a circular economy.

For indicators to be able to shape societal, political and economic action and to develop circular economy strategies, they must be underpinned by stringent reporting, based on clear definitions of the terms and the system section covered. When defining the indicators, data validity, collectability, expenditure for data collection and reproducibility must be kept in mind. If official reporting on the circular economy is insufficient, then science-based knowledge on data generation and data evaluation can be used.

4 Measuring Expenditure

The expenditure for circular economy measures should be compared to the expenditure of the primary raw materials industry with associated environmental impact, including external social and environmental costs, for producing the same materials or materials or goods fulfilling the same function.

To what extent activities and measures contribute to the objectives of a circular economy (cf. P. 3) is measured by whether the expenditure is lower than in a reference system encompassing the entire life cycle. The reference system consists of equivalent activities in a linear economy where materials and product functions are exclusively produced from primary raw materials.

Including the linear economy as reference system when evaluating beneficial measures means expanding the system compared to the circular economy defined in KrWG. Expenditure here does not mean business costs, but the global cost of environmental impacts all over the world caused by linear economic activities which are not or not fully included in the business costs if not internalised. These are called negative externalities and result in the deterioration of ecosystem quality and their negative impact on human health. They could lead to a drop in social acceptability of primary raw material extraction and thus cause restrictions in raw material availability as well as possibly higher production costs for future generations. Primary raw material expenditure needs particular consideration when recovering raw materials that constitute a relatively high environmental hazard potential during primary extraction and are essential for products, sectors or economy, known as environmentally critical raw materials. The environmental impact through loss of materials in partially open systems must also be accounted for, such as plastic input and dissipation of pollutants and impurities into the environment, as well as contamination through circulating pollutants. The expenditure mentioned can be classified in environmental and socio-environmental impact categories and calculated with methods of life cycle assessment from impact to aggregated damage potentials, which can then be used for evaluation.

In some cases, the calculated damage potential can be monetarised. This means that the damage to some extent imposes real monetary costs on society, such as the health service, which, however, are not necessarily borne by the polluter. In a monetary expenditure calculation, external environmental and social costs must be added to the business costs of the polluter. This means that measures in a circular economy are profitable from an environmental economics perspective if the benefits, including avoided external social and environmental costs, exceed the actual costs. This applies also to micro-economically non-profitable measures. Accordingly, many circular economy measures require a change of the economic framework provided by the state in order to attribute external costs to the polluter, for example measures on extended producer responsibility (cf. P. 9).

By the same token, what can reasonably be expected from a company in terms of economic and technical expenditure for circular economy activities must be redefined, for instance in existing legislation and regulations. So far, the interpretation of what is reasonable to expect from the various players in a recycling system often varies widely.

5

Material Cycles

The circular economy aims at managing materials in same or higher value cycles so that primary materials can be replaced by secondary material of suitable quality, thus economising on primary material. However, cascading use and final disposal of materials is also required to achieve the objectives (3) and expenditure criteria (4).

The production of secondary raw materials, slowing down material cycles and re-use are key to a circular economy. They are, however, not an end in themselves, but only worthwhile if they contribute to achieving the objectives (cf. P. 3). As a rule, attainment is high if the waste hierarchy is adhered to, waste is avoided as far as possible and high-value cycles are implemented, where material quality or functionality is comparable to primary materials. At recycling level, the desired quality of the recyclate is crucial when comparing different recycling processes. Downcycling should be avoided wherever possible, so as not to produce lower-quality recyclates where functionality would be irretrievably lost or impurities would accumulate. Such material could only be used in less ambitious technical applications and would not have the same potential for reducing environmental stress, unless a sufficient amount of primary material is added so that they meet the stringently defined technical quality requirements.

Exceptions from the waste hierarchy should only have priority if the lower-hierarchy option contributes more to the objectives of a circular economy than the higher option. With regard to its objectives and expenditures the circular economy must therefore also look at cascading use and the final disposal of materials as integral parts of a cycle.

When evaluating material cycles, all life cycle phases of a product must be considered. A lower use of resources in the production and use phase – for example in light composite materials – may well result in a lower recyclability of the product but could be justified because the raw material savings outweigh the benefits of a functional circular flow.

Establishing a feedback mechanism between recycling procedures and product design (cf. P. 7) and production is an important adjusting tool to make material and product cycles more efficient. In addition, development efforts towards efficient recycling processes and a clear assignment of responsibilities (cf. P. 9) can enhance the circular flow.

Three cycles can be distinguished: re-use in the usage phase, pre-consumer recycling in production and processing, and the recycling of waste after the usage phase. Closing the three cycles mentioned is associated with great – and, depending on the cycle – diverse challenges, such as consumer behaviour, logistics, information flow and technology that hinder achievement of the objectives (cf. P. 3).

Although, within the production line, knowledge about the material properties of production waste make it easier to develop high-value, functional cycles without down-cycling, priority is given to material efficiency enhancement to avoid waste because any additional material cycle – even if effective with high efficiency factors – would result in thermodynamically inevitable energy consumption and usually also loss of material (cf. P. 6).

Post-consumer waste is particularly challenging to collect and sort, as well as reclaiming material. This waste can often only be separated and processed at huge expenditure, reclaimable material partly occurs only in small quantities or it may contain pollutants and impurities that make it difficult to meet the required recyclate quality standards. At the same time, the acceptability and use of recycled material must be increased, which can be done, among other things, using fiscal instruments as well as public procurement regulations.

What hampers a circular economy are long retention times and dynamics in the anthropogenic material stocks. As material is locked for years or even decades into durable goods in the anthropogenic stock, such as buildings, capital, investment and consumer goods, cycles can be closed only with a large time lag after construction or putting on the market. The better the qualitative and quantitative knowledge about locked-in material and its retention times, the better the players involved can adapt to arising new waste flows and recycling needs, and plan ahead to create logistical and legal frameworks for a high-value, functional circular economy that includes the safe elimination of pollutants (cf. P. 8). The relevant strategic approach can be found in urban mining.

6

Prevention

Avoiding the generation of waste and residual materials is generally preferable to recycling, as the latter is always associated with loss of material and the use of energy. Prevention measures must be evaluated in terms of achieving the objective (3) and expenditures (4) required.

Waste prevention has priority in a circular economy. Its aims are quantitative as well as qualitative. They include a reduction of waste volume on the one hand, which ultimately also leads to a reduction of new material flows entering the system concerned, and on the other hand, waste prevention aims at reducing pollutants in materials and products (cf. P. 8) as well as reducing a negative impact of the generated waste on the environment and human health (cf. P. 3).

Important steps towards reducing waste volume include the extension of the usage period of products and buildings as well as encouraging re-use. When a product or building is designed, its lifespan is predetermined, and reparability and dismantlability should give products the longest lifespan possible, while in buildings, the ease of demolishing them should additionally be considered (cf. P. 7). This includes the material and resource-efficient design of products and buildings – ensuring that the objectives will be achieved over the entire life cycle (cf. P. 3).

Qualitative waste prevention such as producing products low in or free from pollutants will result in reduced pollutant emissions during the usage period and prevents accumulation of pollutants in the circular flow.

In European and German waste legislation, waste prevention is at the highest level of the waste hierarchy. Accordingly, priority is given to waste prevention, and, where this is not possible, the waste must be prepared for re-use. Only where this option is not available must waste be recovered (primarily recycled) or disposed of. At policy level, objectives are specified and further developed in waste prevention programmes. The German Waste Prevention

Programme (AVP) points to waste prevention instruments and measures for different life cycle stages of products. One of its main objectives is the decoupling of economic growth from negative impacts of waste generation on humans and the environment. To come closer to this goal, waste intensity must be significantly reduced. To make waste prevention measurable, relevant indicators must be defined (cf. P. 3).

To achieve the waste prevention goals, regulatory measures are needed, and in particular measures based on the cooperation principle (cf. P. 3). After all, waste prevention is a process that involves the entire society. Active dialogue with citizens from all walks of society is an essential instrument to strengthen acceptability and awareness of waste prevention. This includes in-depth exchange between experts in industry, science, politics, the media, environmental and consumer protection organisations and Federal Government, Federal States and local authorities. Improved product information for consumers is equally important.

As consumers, citizens play a pivotal role in sustainable consumption. By promoting an eco-sufficient lifestyle, sustainable consumption can contribute to waste prevention, by encouraging substitution, reduction or abstinence. Substitution means in this context that conventional products and services are substituted with environmentally and, where possible, also socially more compatible alternatives. These include, for instance, reusable packaging systems and products that are free from pollutants, use less raw material and energy and are not produced or supplied by socially irresponsible companies. Reduction essentially means fewer new products being put on the market. This can be achieved by extending the lifespan of used products with the help of repairs, donations, barter schemes, resale, or communal use. Abstinence is the ultimate reduction and categorically excludes the consumption of environmentally and socially incompatible goods and services. It is important that the cost savings made through reduction and abstinence do not result in further consumption – i. e. rebound effects. To establish behaviour patterns of sustainable consumption, a supportive structure is needed that provides alternative supplies and reuse services for sustainable consumption.

Public procurement can also promote waste prevention by encouraging reuse, firstly by making used products that would otherwise be discarded available for further use (supply) and secondly by providing a legal framework for the procurement of used and reconditioned products (demand) by the public sector.

7

Design

Designing products for a circular economy means retaining the functional and economic value of products, their components and materials as long as possible in order to minimise negative impacts on humans and the environment. Design concepts should sustain the reorganisation of ways of production and consumption within society. Optimum design must be evaluated in terms of achieving the objective (3) and expenditures (4) required.

Design is a key instrument for establishing a circular economy. A large proportion of environmental impacts from products, services and systems – be they settlements or transport systems – is already defined in the design process. The design will decide whether a product has a long lease of life, whether it can be serviced and possible defects repaired, whether regular technical overhaul is possible and whether components or materials can be recovered with reasonable expenditure at the end of the product's life. The selection, use and processing of materials play a decisive role, as they determine over and above the longevity of products to what extent damaging impacts on humans and the environment can be avoided during the extraction and processing of raw materials, as well as during product usage. They also determine to what extent the materials used can be retained through several cycles in order to protect natural resources in the future.

Design for a circular economy aims at using products for a long time and maintaining their function and reliability, retaining the value of products, product parts and ultimately the material in closed-loop cycles, while ensuring that the smallest possible burden is put on the environment per utility unit. At product level, this means design for reuse and recycling on the one hand, and on the other to ensure the most enduring product integrity possible.

Game-changing approaches in product design either optimise certain aspects, such as energy consumption in the use phase, or reduce negative environmental impacts of a product along its life cycle (cf. P. 2), which is generally preferable. Another criterion for good design in a circular economy is optimal recyclability and the use of recyclates in line with the objectives (cf. P. 3). Easily separable materials that are free from pollutants and impurities and as homogenous as possible, as well as fulfilling the technical requirements for reprocessing, facilitate recycling.

Design can have an effect beyond this technical level by increasingly taking the socio-cultural context into account and focusing on users. Their needs must be considered and become the starting point for product design. A maxim in design says "form follows function." Accordingly, function and purpose of a product must be the main consideration and result in the appropriate form. It is therefore necessary to find out if at all and how urgently a product is needed and what factors contribute to a prolonged use of the product. Stronger emotional attachment to products generates appreciation and prevents short-term fads. Furthermore, design approaches can help to promote more sustainable behaviour by flagging up high energy consumption or encouraging users to collect products for recycling or reuse.

New, circular flow-oriented business and usage models are needed to establish a circular economy. These models are subject to an overarching design process that can be shaped by all participants on the producer as well as the user side. Examples include product service systems that are centred around the lease of products and thus set incentives for low-maintenance, high-value products with a high use value. There is, for instance, a scheme that combines particularly durable products with services such as maintenance, repair or upgrades and innovative reusable packaging systems for products, product parts or materials so that these can be reused or recycled.

All these design approaches for a circular economy also apply to large systems with circular flow potential and contribute to successful implementation. As the perspective shifts from the product level to system innovation, from small-scale technical improvements to a holistic perspective, the design process becomes ever more complex.

Design for a circular economy is a multi-disciplinary task that can only be accomplished satisfactorily if the players involved such as users, producers and the recycling industry come together and freely exchange information. What is needed is a different, iterative approach to design beyond the classical model of idea – prototype – product development, so as to adapt to rapidly changing requirements and conditions. Producers in particular are required to take more responsibility.

8

Pollutants

It must be avoided to place products on the market that contain substances that have an adverse effect on the public interest and, in particular, on human health and the environment. If such substances cannot be substituted, are already contained in products or are only later identified as harmful, the substances must be destroyed or stored safely in final sinks. Alternatively, after weighing up the objectives (3) and expenditure (4), they can also be transferred into safe cycles that prevent the accumulation of harmful substances.

Avoiding and reducing pollutant release into the environment is a main environmental policy objective. Where pollutants are irreplaceable because, for instance, they are flame retardants and thus fulfil legally defined purposes or are unavoidable since they are contained as a background contamination in primary raw materials, at least relevant information must be made available and possible disposal routes considered. When replacing pollutants, which is generally advisable, care must be taken not to substitute them with substances with a similarly critical profile or substances that may be classified critical in the long run – which would be a regrettable substitution.

Waste is often a heterogeneous mixture of materials, which could lead to a situation where no reliable information about the material contained in it and possible pollutants is available. This is why waste treatment and recycling processes cannot always be targeted with precision. In addition, there could be impurities that could hamper or prohibit reuse or recycling, or, as in the case of carbon fibre-reinforced plastics and other novel functional materials, there are no appropriate treatment or disposal schemes yet.

A safe recovery of pollutant-containing waste is guaranteed if the extent of contamination and the type of recycling are not expected to affect humans and the environment, the accumulation of pollutants in the material cycle is avoided, and any separated pollutant-containing fractions are properly treated and disposed of. The legal framework for the isolation and removal of pollutant-containing waste fractions is based on statutory restrictions for substances (such as REACH, RoHS, POP Regulation) in conjunction with waste regulations. From these, exceptional rules can be derived that permit the controlled circulation of pollutants such as heavy metals (e. g. cadmium, lead) in safe, process-focused cycles with defined tolerance thresholds. Such regulations can be beneficial if, while weighing up the objects of protection, they can contribute to the objective of a circular economy (cf. P. 3) in a better way.

The conditions under which the safe recovery of waste is possible must be thoroughly scrutinised and evaluated. This type of scrutiny can prove to be a great challenge for waste-generating companies and competent authorities alike in view of the lack of information about pollutants contained in products and waste. The regulations that govern the classification of waste in chemicals and waste legislation are highly complex in themselves and require a thorough knowledge of relevant legislation. Furthermore, the European List of Waste must continue to be developed and updated to accommodate best available techniques and include new industrial processes and technologies as well as new types of waste, such as lithium batteries.

The energy recovery or disposal of pollutant-containing waste may be preferable to recycling if this is the best way to protect natural resources as well as human health and the environment (cf. P. 3 and P. 5). For energy recovery or thermal waste disposal, processes and installations must be used that have a high level of operational safety and ensure the safe destruction of organic pollutants as well as a concentration and safe elimination of heavy metals and their compounds, thus enabling the recovery of incineration residues. This will be accomplished by incinerators for hazardous waste, municipal waste or co-incineration plants, applying best available techniques.

The availability of transparent information on the chemicals used in products is vital for players along the value-added chain, including the waste management sector, in order to ensure material flows are managed in a way that protects health and the environment and prevents the uncontrolled circulation of hazardous substances. The amended EU Waste Framework Directive (2018) stipulates that information on substances of very high concern (SVHCs) be made available not only to consumers, but also to waste-managing companies. The European Chemicals Agency (ECHA) will make a database available from 2021, which contains information on substances of concern in products (SCIP).

It is a particular challenge to retrieve information about products with a long lifespan and from earlier use. Legacy products sometimes contain substances that were regulated only later. Since substances that are subject to use restrictions must be kept at the lowest possible level in a circular economy, the initial recycling potential decreases unless pollutants can be targeted for elimination. Therefore, this waste cannot be recycled as a whole, but must be subject to energy recovery or thermal waste disposal. To fulfil the ambition of a largely comprehensive circular flow of pollutant-contaminated material, further technical procedures for the elimination of pollutants must be developed.

9 Responsibility

In a circular economy, all players within product life cycles and along material value chains bear responsibility for achieving the objectives of the circular economy. Where responsibility is not assumed otherwise, legal requirements must be implemented.

Assigning responsibility in a circular economy must include all life cycle phases of products and basically follows three overlapping attribution criteria: the polluter-pays principle, best suitability, and influence on the life cycle phases.

Environmental policy requires the attribution of the cost of environmental burdens to the polluter, using suitable measures. The legislator refers to the polluter-pays principle when attributing responsibility for life cycle environmental impacts to those involved in the product life cycle. In the case of producers and distributors, for instance, their responsibility includes quantitative and qualitative waste prevention and a design suitable for a circular economy, environmentally friendly production applying best available techniques, product information, data collection and proper recovery or disposal, and, as of late, cleaning up litter if products have not been disposed of appropriately. Distributors can be held responsible for taking back the products they have been distributing at the end of their use or the product's packaging, as far as this makes sense in the waste flow concerned. Consumers, including public procurement, are responsible for consumption decisions and the service life of products. Like all other waste generators, they must try to minimise waste and send waste to the right disposal routes. In addition, science and education institutions as well as associations and standardising committees bear responsibility in achieving the objective of a circular economy.

Responsibility can also be given to a party that is most reliable or best suited to achieving the objectives of a circular economy. This could be actors of the public sector or private waste management companies and take back systems, conducting collection and proper waste recovery and disposal applying best available techniques and guidance on waste disposal and recycling. Holding individual organisations responsible can generally have strong repercussions on other life cycle phases of a product. In practice, however, it may also be helpful to assign responsibility collectively so that certain activities, such as waste collection, can be organised and streamlined more efficiently.

The way responsibilities for products are assigned can shape the environmental impact of products along their life cycle. For example, being financially and, where applicable, organisationally responsible for the disposal of a product should motivate manufacturers to use opportunities in the design and production phase to create a resource-efficient product that generates little waste and is low in pollutants and emissions, while having a long life span and high re-usability, reparability and recyclability. Packaging, too, has high optimisation potential in this context.

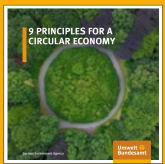
State institutions at global, European and national level must provide legal frameworks for tasks such as assigning responsibility, banning substances and products, or standards for best available techniques in order to achieve the objectives of a circular economy (cf. P. 3). This must be ensured through legal enforcement such as the licensing of plants, registration of players, monitoring players fulfilling their responsibilities and set targets. Regulatory intervention measures – such as adapting the legal economic framework or target quota – are always needed if there are no other market drivers or these are not sufficient.

Extended producer responsibility (Sections 23–27 KrWG, Art. 8, 8a EU Waste Framework Directive) is a well-established instrument in waste management policy, which often focuses on assigning the (financial) responsibility for the proper disposal of their product to manufacturers. This is expanded by introducing manufacturer responsibility for cases of inappropriate user behaviour, such as cleaning up littered areas, and duties of care.

Alongside the responsibility for material flows, the responsibility for providing information plays an important role. This includes information from manufacturers about the products, their composition – including chemicals, use of recyclates, pollutants, reusable or recyclable material – and handling during the use and disposal phases. This requires data collection about product, material, and waste flows, including the whereabouts or losses of material in the environment, and making target group-relevant information available for consumers as well as waste treatment operators.

The constant change of products and material flows makes it very challenging to assign and legally enshrine responsibilities, monitoring them and assuming them effectively. Therefore, already when developing new products (and their packaging) and services, all phases of their life cycle must be considered. This, among others, means providing spare parts over a long period of time, allowing for repair, and making product information available. Further, the timely provision of appropriate techniques and options for waste treatment, reuse and recycling must be ensured.

Looking at the international dimension of the circular economy (cf. P. 2), responsibility for life cycle phases must be exerted across borders, as raw material is often extracted and waste treated outside national and European territories. The aim is to attribute responsibilities to actors along global supply chains in an achievable, fair, and enforceable manner.



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