CHEMIE³

THE SUSTAINABILITY INITIATIVE OF THE GERMAN CHEMICAL INDUSTRY

GUIDE

LAUNCHING THE CIRCULAR ECONOMY IN THE CHEMICAL INDUSTRY

EXPLANATION ON THIS GUIDANCE DOCUMENT

This Guide document wants to give companies in the chemical-pharmaceutical industry pragmatic support for the transition to a circular economy. Entrepreneurial approaches to solutions form the basis. Supplemented by case studies, they should provide great practical benefits.

The Guide gives emphasis on motivating medium-sized enterprises to take up circular economy as an opportunity and to reduce the barriers to launching their own circular economy management through pragmatic approaches and proposals for solutions.

The main focus of the Guide is on medium-sized enterprises manufacturing fine and specialty chemicals, e.g. for, paints and coatings, construction chemicals, adhesives, agrochemicals, and consumer and pharmaceutical chemicals.

The Guide primarily examines the concerns of medium-sized enterprises that have little or no experience in the circular economy. Also, companies which can already resort to existing experience in this field will find useful suggestions and practical approaches for the circular economy.

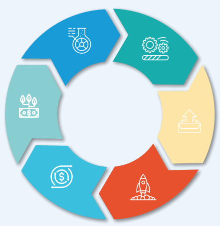
Note on terminology

For the sake of simplicity, the Guide uses the term "circular economy" as an economic model that aims to minimise the consumption of energy and resources in value creation or to run them in loops. The term "recycling" takes into account all processes, i.e. both chemical and mechanical recycling. Chapters 3 to 9 describe concrete approaches to the circular economy in companies, with the following structure:

- What is it about?
- Implementation in the company
- What must be observed?
- For advanced users
- Where are the limitations?
- Example

The following companies contributed to the development of the Guide by participating in expert interviews, case studies and workshops ("Virtual World Cafés"):

Akzo Nobel Deco GmbH
Altana AG
Ardex GmbH
Aurubis AG
Avient Colorants Germany GmbH
Baerlocher GmbH
BASF Polyurethanes GmbH
CHT Germany GmbH
Cirplus GmbH
Compo Expert GmbH
Covestro AG
DAW SE
Dow Deutschland Inc.
Dr. Babor GmbH
Dr. Schnell GmbH & Co. KGaA
Ecolab GmbH
Epple Druckfarben AG
Evonik Nutrition & Care GmbH
Evonik Operations GmbH
Emil Frei GmbH & Co. KG
GHC Gerling, Holz & Co. Handels GmbH
Grillo Werke AG
KRAHN Chemie Deutschland GmbH
LANXESS AG
Lifocolor Farben GmbH & Co. KG
Medice Arzneimittel Pütter GmbH & Co. KG
Merck KGaA
Pamira (RIGK GmbH)
Pulcra Chemicals GmbH
Sto SE & Co. KGaA
Umicore AG & Co. KG
Wacker Chemie AG
Weilburger Graphics GmbH
Worlée-Chemie GmbH
Zeller+Gmelin GmbH & Co. KG



CHEMIE³
THE SUSTAINABILITY INITIATIVE OF THE GERMAN CHEMICAL INDUSTRY

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THE INITIATIVE CHEMIE^3

Under the umbrella of the sustainability initiative Chemie^3, we – that is the German Federation of Chemical Employers' Associations (BAVC), the Mining, Chemical and Energy Industrial Union (IGBCE) and the German Chemical Industry Association (VCI) – are working for sustainable development in the chemical and pharmaceutical industry. We understand sustainability as an obligation to present and coming generations and as a strategy for the future where economic success is linked with social justice and ecological responsibility.

With the Chemie^3 initiative, we want to promote sustainable action in our industry – from small establishments to large groups. This is because shaping a sustainable future needs the commitment of industry. As the motor of innovation for German business overall, the chemical industry wishes to expand its contributions to a future worth living and sustainable development and to sharpen its profile for sustainability.

At the centre of our initiative are the "Sustainability Guidelines for the Chemical Industry in Germany". These aim to strengthen sustainability as a guiding principle within the industry. The guidelines already reflect important requirements of the later adopted global Sustainable Development Goals (SDGs) of the United Nations. Together, the SDGs and the Chemie^3 guidelines set the framework for companies and staff in the chemical and pharmaceutical industry to operate sustainably.

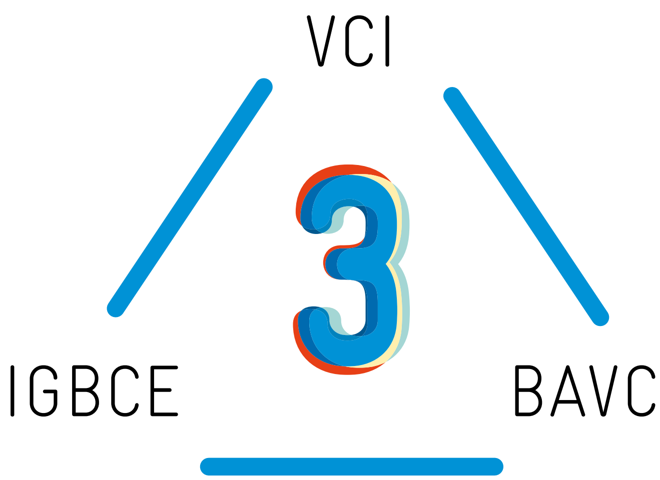
Chemie^3 has developed comprehensive action tools to support companies of the industry in applying the guidelines and the SDGs. These include, amongst others, a sustainability check for the industry's companies, webinars with examples from corporate practice and guidance documents for

- applying the SDGs,
- linking sustainability with education and training,
- sustainable supply chain management,
- sustainability reporting, and
- this Guide on the circular economy.

More information is given at www.chemiehoch3.de

In order to make the progress of sustainable development in the chemical-pharmaceutical industry in Germany measurable and thus verifiable, we have developed 40 indicators. The progress indicators refer to the sustainability topics addressed in the Chemie^3 guidelines. They range from the competitiveness of the chemical industry on global markets to greenhouse gas emissions and the rate of apprentices being offered further employment after the completion of their apprenticeship. We publish the collected indicator data in the Chemie^3 progress report on the website
www.chemiehoch3.de

Another element of Chemie^3 is the dialogue with stakeholders from politics, business, science and society – because solutions for sustainable development presuppose understanding the concerns of others and identifying conflicting goals. Only then can solutions be sought together. That is why we seek continuous dialogue with other interest groups.



PREFACE

Dear Reader,

The high consumption of resources and advancing climate change require further efforts and contributions from business and society. A central building block on the path to climate neutrality is the circular economy, with the aim of decoupling economic growth from resource consumption. By changing the raw material base, by developing products that support a circular economy, and by providing product-related services such as take-back systems, new business opportunities arise for companies. In order to make the most of these, enterprises need a strategic reorientation.

From the development of new products, procurement, logistics, production and sales to marketing and product-related services, all operational functions are impacted by the transition to a circular economy. In this context, the stronger networking of companies also plays an essential role, as processes in the meaning of the circular economy go beyond their own value creation. The early transition of business models offers an opportunity to gain a competitive edge and to maintain the future viability of one's own company.

With this Guide, Chemie³ – the sustainability initiative of the German chemical-pharmaceutical industry – wants to provide strategic and operational support for companies to switch to a circular and sustainable management style. The document contains proposals for solutions along six action fields, ranging from the selection of products, manufacturing, design and recycling to approaches on how the products from one's own company can promote circular management at customers or how end-of-life products can be taken back. Practical examples show which starting points for solutions are already being pursued by companies. These examples want to be both motivation and inspiration.

Particularly for small and medium-sized enterprises, the transition from a linear to a circular economy is a challenge. Therefore, this Guide addresses especially medium-sized enterprises. However, advanced and larger companies, too, will find suggestions for reviewing the way they have taken so far and, if necessary, treading new paths.

We hope that many businesses will be encouraged by the suggestions in this Guide to embark on the road towards a circular economy.

Dr. Andreas Ogrinz
Managing Director
Education, Innovation, Sustainability

German Federation of Chemical Employers' Associations

Dr. Martin Pohl
Director Transformation, Sustainability, Digitalization

IGBCE

Berthold Welling
Executive Director
Law and Taxation, Sustainability

German Chemical Industry Association

01 THE CIRCULAR ECONOMY IN THE CHEMICAL-PHARMACEUTICAL INDUSTRY

The departure from a purely linear management style with the steps of exploration, production, consumption and disposal is a paradigm shift. This development is already progressing at full speed. The triggers and drivers of this fundamental transformation of the economy towards a sustainable and circular way of operating are manifold and apply to the manufacturing industry in general and to the chemical-pharmaceutical industry in Germany in particular. The drivers include:

- A change in corporate self-image and increased motivation for sustainability among partners/shareholders, entrepreneurs and management.
- Rising demand from end consumers and changing procurement factors of industrial customers with regard to products and solutions that are oriented to circular economy and sustainability.
- Pressure for change from competitors and use of the circular economy as an opportunity for innovation & new business.
- ESG (Environment, Social, Governance) requirements in corporate funding, financial statements and corporate disclosure obligations.
- Higher attractivity as an employer brand.
- Regulatory requirements from the EU's "Green Deal" and other EU-wide and national programmes.

The connected changes, challenges and opportunities are already the subject of long-term strategic orientation and short- and medium-term operational activities at many companies in the industry. Multinational groups, in particular, are addressing the topic as a shaping field for top management, also because of advantages regarding resources. The resulting diverse and comprehensive activities are the subject of detailed strategy and sustainability reporting, especially by stock exchange listed companies.

Most of the businesses in the chemical and pharmaceutical industry, which is characterised by small and medium-sized enterprises, have recognised the fundamental importance of this topic too. However, adapting sustainable and circular approaches to their own management style and for products and services is usually a particular challenge for management. Especially small and medium-sized enterprises are often positioned in specialty markets with innovative and varied products. The diversity in the product portfolio and the complexity of value creation, which come with the above, turn the necessary transformation into a multi-layered challenge.

To overcome such challenges, a fundamental understanding of the three basic principles of the circular economy is helpful:[1,2]

1) Cp. European Commission, Circular Economy Action Plan, 2015, revised 2021; Dr. Wieselhuber & Partner, Geschäftsmodelle für die Kreislaufwirtschaft, 2020; Lacy et al., The Circular Economy Handbook, 2020.

2) For easier reading, the term „product" is used in the following for all chemical-pharmaceutical products and their deployment in downstream uses.

Reduce
Minimising the consumption of fossil and finite resources in the manufacture of products, in products themselves, and in the use of products.

Reuse
Maximising the use of recyclables and products, with minimal input of resources, through multiple use, reprocessing and life cycle extension.

Recycling
Closing recyclable material loops and value chains with the return or recovery of recyclable materials for the production cycle after end-of-life and through recycling-oriented product design.

These three principles of the circular economy provide a first structuring of entrepreneurial shaping options: In addition, the connected goals of the circular economy that are to be achieved are essential for the assessment of steering and success.

In a broader view, which is also taken in this Guide, the following goals are pursued with the circular economy for companies individually and for the chemical-pharmaceutical industry as a whole:

- Reuse and recycling/recovery of finite resources
- Use of renewable and regenerative resources
- Phasing out or minimising the consumption of fossil and finite resources
- Climate neutrality of own business activities

This „Circular Economy Guide" is intended to provide a pragmatic and easy to grasp assistance for entrepreneurs and management in order to support the transition to a management agenda with a closed loop orientation.

02 ENTREPRENEURIAL SHAPING OF THE CIRCULAR ECONOMY

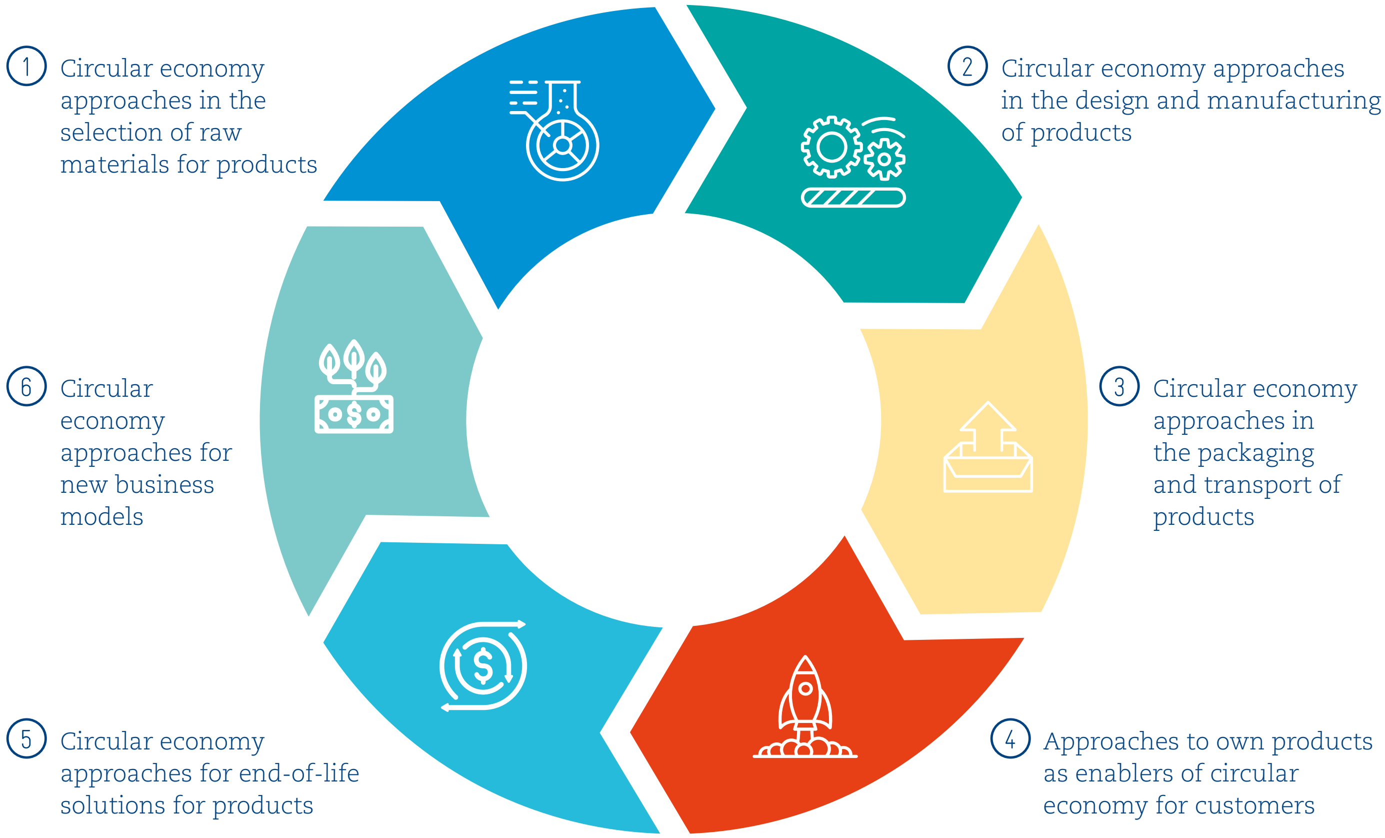
Concrete action fields for management are needed to implement the circular economy in one's own company. These are oriented to the value creation in the company, which begins with the raw materials and extends to the end of the product life cycle.

In addition, the transformation to a circular economy also offers opportunities for business model innovations in the chemical industry. Therefore, potential starting points for this are outlined too. The Guide is based on a breakdown of the approaches to the entrepreneurial implementation of the circular economy into six action fields.

1. Circular economy approaches in the selection of raw materials for products
2. Circular economy approaches in the design and manufacture of products
3. Circular economy approaches in the packaging and transport of products
4. Approaches to own products as enablers of circular economy for customers
5. Circular economy approaches for end-of-life solutions for products
6. Circular economy approaches for new business models

Within each of these approaches, the respective strategic initiatives and operational measures for concrete and industry-specific implementation in the company are highlighted.

Operational measures are primarily aimed at operational implementation in selected functions and business units. Strategic initiatives address the networking with upstream and downstream stages of the value chain as well as possible industry-specific solutions for the circular economy by means of cooperation.


1 Circular economy approaches in the selection of raw materials for products
2 Circular economy approaches in the design and manufacturing of products
3 Circular economy approaches in the packaging and transport of products
4 Approaches to own products as enablers of circular economy for customers
5 Circular economy approaches for end-of-life solutions for products
6 Circular economy approaches for new business models

03 CIRCULAR ECONOMY APPROACHES IN THE SELECTION OF RAW MATERIALS FOR PRODUCTS

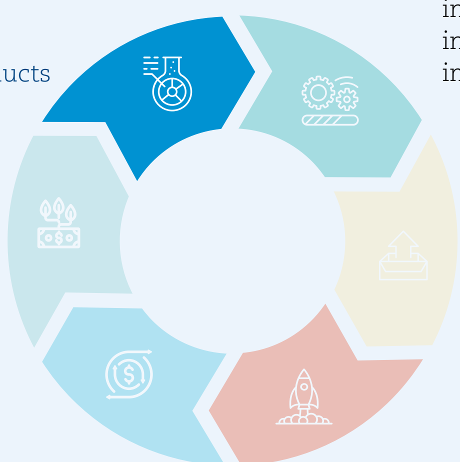
The fundamental concept of the circular economy comes with the goal of reusing raw materials. Accordingly, the aim is to deploy them as secondary raw materials in new products and thus successively replace the consumption of primary raw materials. In particular, using renewables is also a way of substituting petrochemical primary raw materials.

At the same time, the use of renewable or secondary raw materials offers many opportunities to open up new target groups and market segments through product innovations or to meet changing customer expectations for resource-efficient products and solutions.

Alongside the opportunities, entrepreneurial considerations also include the disadvantages of renewable and secondary raw materials that partly persist in direct comparison to primary raw materials. In terms of price, availability and quality properties, secondary raw materials are not always equal to established primary raw materials.

A frequent argument against the use of more expensive secondary raw materials is the refusal of customers to accept the higher price.

1 Circular economy approaches in the selection of raw materials for products



Products with circular-based raw materials are innovations for which the right target groups must be addressed. They see added value in such products. Conversely, it is not surprising that simply offering these innovations as "one-to-one substitution products in green" at a higher price does not work.

However, potential drawbacks in direct comparison to established primary raw materials and individual experiences should not be reasons to ignore this topic. Societal pressure and the growing demand for sustainable products are not a temporary phenomenon of the zeitgeist. Moreover, new standards are being defined. Novel technologies enable better and more consistent qualities, and the offer is increasing in terms of available quantities.

From a corporate strategy viewpoint, the question is therefore whether one wants to contribute to shaping the use of renewable and secondary raw materials as an innovator – or whether one should try to be successful in competition at a future time as a "late follower" with imitation products.

3.1

Replacing primary raw materials by renewable or secondary raw materials

What is it about?

- Complete substitution of primary raw materials in products.
- Partial replacement of primary raw materials by mixing primary and secondary raw materials or replacing individual components in formulations by secondary raw materials.
- Drop-in solutions where primary raw materials are substituted by secondary raw materials without modifying the formulation.

Implementation in the company:

Replacing primary raw materials by secondary raw materials is always a product development or an innovation project. Accordingly, such initiatives must be implemented in the same manner to realise all opportunities and master the challenges for the development of products that are marketable and can be industrialised.

What must be observed?

- New formulations with secondary raw materials can necessitate adaptations in procedures and processes.
- At least temporarily, additional raw materials and quantities in operation which lead to greater complexity in production and increasing capacity requirements in operational and storage logistics.
- Resilient sales and production planning including procurement (S & OP) for new products with secondary raw materials in order not to stumble into the market.
- Development of resilient suppliers and supply sources.
- Careful pilot customer and product launch planning.

For advanced users:

- Innovation focus on tapping into new, previously not used or unavailable secondary raw materials.
- Backward integration to own production of secondary or renewable raw materials, alone or in cooperations.

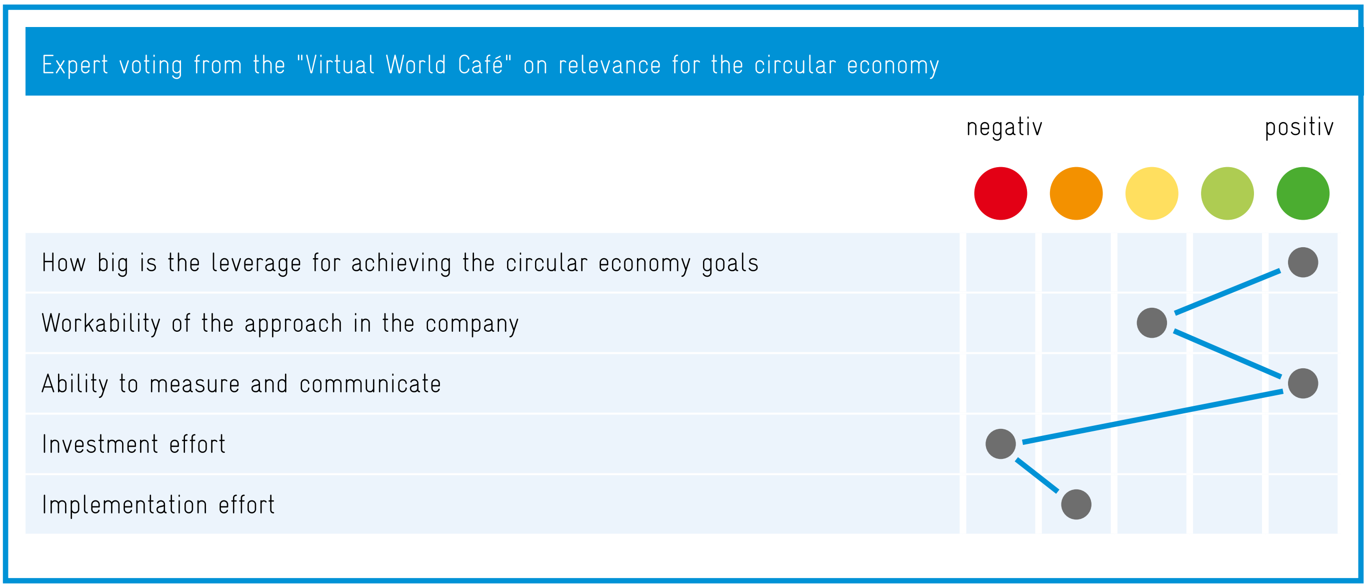
Where are the limitations?

Secondary or renewable raw materials do not automatically have a better energy balance or lower resource consumption compared to primary raw materials.

The availability and consistency of quality properties remain a challenge for industrial use, at least in the short term.

EXAMPLES

- Recycling or extraction of secondary raw materials, e.g. zinc, sulphur dioxide, phosphate, etc. from by-products and industrial wastes, such as those generated in the production of platform and fine chemicals upstream of the speciality chemicals sector.
- Use of camelina oil as a sustainable raw material in the paint industry.



3.1

CASE STUDY DR. SCHNELL GmbH & Co. KGaA

OBJECTIVE

To secure the future of our society and life on our planet as we know it, it is necessary to decouple our economy from finite fossil raw materials. In the field of cleaning and maintenance products, decoupling is achieved by changing from fossil raw materials (e.g. surfactants, solvents etc.) to renewable sources or by recycling fossil materials (e.g. containers).

The implementation of these goals should not have any influence on product properties and performance. Furthermore, a comprehensible positive climate effect should be ensured for customers and the company. For example, due to long transport routes or higher input quantities for an analogous performance, the use of surfactants from renewable sources can have a stronger environmental impact than the use of small quantities of modern high-performance surfactants on a fossil basis.

To ensure a genuine benefit and quantification, a product carbon footprint (PCF) was determined for the entire Dr. Schnell product range. To do so, CO_2 balancing was carried out for all raw materials used and all raw materials identified for substitution from renewable sources (approx. 500) as well as all containers and labels (approx. 2,000). Since data available at manufacturers are not (yet) very advanced, it was resorted to databases and studies. The complete life cycle (production, transport and degradation) was taken into account in the calculation. Calculation and documentation were made according to ISO 14067 and realised using an Access database. The calculation took over a year, followed by implementation in the R&D's formulation management software and in the ERP (Enterprise Resource Planning) software. In this way, the CO_2 balance of each article can be drawn up automatically, and alternative raw materials can be examined for their real environmental impact at the click of a mouse.

"LESSONS LEARNED" IN IMPLEMENTATION

For this project, R & D worked together with IT across departments. Only through this symbiosis, which is new for Dr. Schnell, was it possible to manage and correctly evaluate the extensive data volumes. On the technical side, it became clear that it is feasible to draw up a correct CO_2 balance certified according to ISO 14067 even without concrete CO_2 values from upstream suppliers. It also made sense not to retain external consulting firms, as they are costly and slow for such extensive projects and would only allow inflexible action when using new raw material alternatives.

In particular, the analysis of the CO_2 values shows that mainly renewable raw materials from the Far East partly have miserable climate balances due to their long transport routes and production conditions.

ADDED VALUE AND BENEFIT FOR THE CIRCULAR ECONOMY

In our experience, the substitution of fossil raw materials by (often more expensive) renewable alternatives can be brought about – internally and externally – especially where the positive environmental impact can be precisely quantified. By calculating the CO_2 values, it was possible to create a climate-ideal portfolio which was optimised with regard to the share of sustainable raw materials and low CO_2 emissions. Customers can adjust their portfolios accordingly and thus reduce real CO_2 emissions by up to 50%. Previously unavoidable emissions can be determined using our CO_2 calculator (https://www.dr-schnell.com/Co2calculator) and offset with the help of allowances.

CASE STUDY COVESTRO AG

OBJECTIVE

By gradually switching our production to renewables, we contribute to running carbon in loops – and we are moving closer to our vision of circularity. The mass-balanced raw materials we use meet the high sustainability requirements of the ISCC-PLUS standard (International Sustainability & Carbon Certification) along the whole supply chain. A complete check of the raw materials with the help of sustainability criteria as well as mass balance certification across the entire value chain create transparency and trust. By taking the step of having the most important production sites in Germany and China certified by independent testing organisations, we enable our customers to use more sustainable raw materials that significantly reduce the carbon footprint. A certification of further sites is planned.

"LESSONS LEARNED" IN IMPLEMENTATION

The certification of the raw material chain up to the plastic polycarbonate and the precursors MDI and TDI for rigid and flexible foam production strengthens the use of alternative raw materials at Covestro. MDI is applied, for example, to produce rigid polyurethane foam, which has been providing efficient thermal insulation for cooling devices and buildings for decades. The gradual shift to renewable raw material sources is part of a comprehensive programme with which Covestro, together with the company's partners, wants to drive forward the transformation to a circular economy and become fully circular itself.

ADDED VALUE AND BENEFIT FOR THE CIRCULAR ECONOMY

We are convinced that the new mass balance certification will allow a step towards a trustworthy use of circular and bio-circular raw materials without compromising the performance of plastics. This will provide plastics processors and B2C producers with more sustainable plastic products that will ultimately enable climate-neutral products. Thus, we want to combine resource conservation and climate protection in a certified and sustainable manner.

covestro

3.2

Establishing cycle-oriented strategic procurement

What is it about?

- Building up know-how on markets for renewable and secondary raw materials and how they work.
- Establishing long-term partnerships with suppliers for renewable and secondary raw materials and for innovative resource-efficient primary raw materials.
- Well-balanced opportunity and risk management in strategic procurement to develop new raw material sources and avoid excessive dependencies.
- New raw materials as an impulse for innovations in the circular economy.

Implementation in the company:

In principle, strategic procurement does not differ for primary and secondary raw materials. However, the experience base with new raw materials and suppliers is usually limited. For secondary raw materials, there is also the fact that many raw materials and markets themselves are still in a dynamic development process – in contrast to markets for primary raw materials, which have been established for decades.

The targeted build-up of know-how is essential for developing a cycle-oriented strategic procurement.

What must be observed?

- Regulatory requirements or possible restrictions for secondary raw materials as well as relevant certifications.
- Quality characteristics and availability.
- Markets including online sources/marketplaces and upstream suppliers as well as external influences such as seasonality.
- Quantities, prices, procurement methods and delivery options.
- Identification of suppliers (longlist).

As there will be – foreseeably or permanently – parallel procurement of primary and renewable or secondary raw materials, the assessment and steering instruments in supplier management must be designed uniformly.

The strategic opening up of markets and suppliers for renewable and secondary raw materials can secure lasting competitive benefits. In the medium term, comprehensive know-how creates an information advantage and thus a competitive edge. Similarly, emerging raw material sources can be developed into main customers and exclusively tied to the company. This, in turn, brings opportunities for innovation and for attracting new target groups.

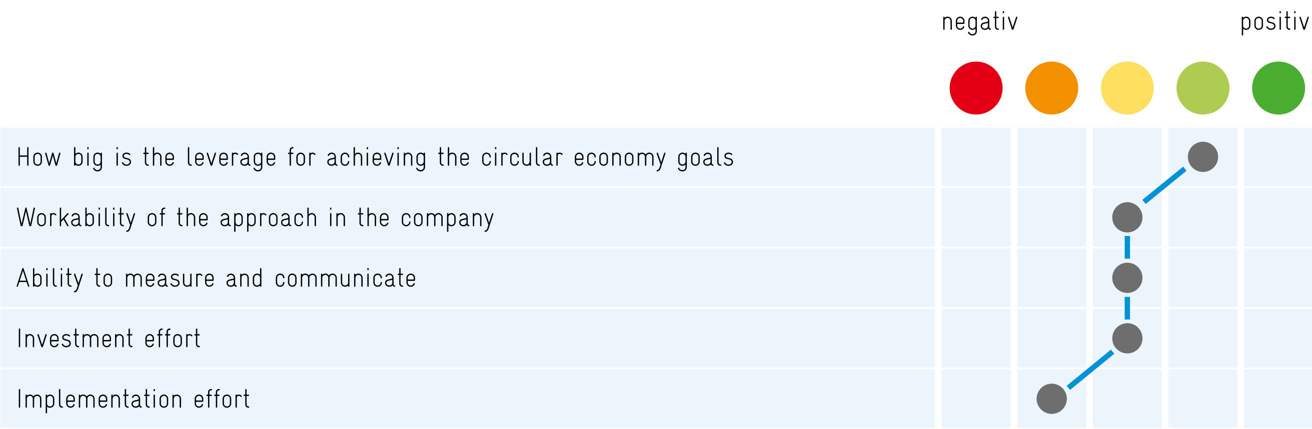
For advanced users:

- Expansion of customer-supplier relationships through exclusive contracts, cooperations up to joint ventures.
- Focus on upstream suppliers or even the collection of recyclables before recycling up to active backward integration.
- Focus not only on raw materials, but also on auxiliary and operating materials as well as packaging and transport containers.

EXAMPLES

- Backwards integration up to farms with exclusive purchase contracts for renewable raw materials.
- For purchased raw materials, stipulating CO_2 values as mandatory information for all suppliers and storage as product properties in the ERP system (Enterprise Resource Planning).
- Serves as a basis for the assessment of the company and product carbon footprint and as a threshold for reducing the carbon footprint in R&D.

Expert voting from the "Virtual World Café" on relevance for the circular economy



3.2

CASE STUDY CHT GERMANY GmbH

OBJECTIVE

Use of recycled silicone oils for the production of modern processing aids

Silicone has great economic importance as a versatile material in a wide range of applications. Global sales in the silicone market amounted to over USD 16.3 billion in 2017. In textile finishing, the use of silicones as softeners, water repellents, defoamers or lubricants has become indispensable. Silicones are also considered essential in the personal care products industry, especially in skin and hair care.

The production of silicones is highly energy-intensive. In order to fully exploit the value of this resource, end-of-life silicones are increasingly being recycled. This means that today's silicone waste can be turned into an important alternative raw material for tomorrow.

Silicone recycling is done in several steps according to the "waste-to-value" principle. End-of-life polymers are catalytically split into silicone monomers, modified and finally polymerised e.g. into a new amino-modified silicone of virgin quality, which can be formulated into a textile softener, for example.

Furthermore, the CHT Group itself, as a manufacturer of silicone specialities, has expanded the portfolio of recycled silicone raw materials. Common silicone raw materials contain silicone cycles from the preliminary processes - known as D4, D5 and D6 for short - and these are largely removed from all silicone raw materials by means of distillation. The distillate is then not disposed as waste, but it is used as a raw material in silicone synthesis at CHT.

In 2021, around 150 tonnes of raw materials were gained in this way. In consequence, waste was avoided.

Textile softeners from recycled silicone

Formerly, only linear concepts were pursued for the production of textile silicone softeners. With the development and production of Tubingal RISE (Recycled Innovative Silicone Emulsion), the first textile softener worldwide is available on the market that consists of over 60% of recycled silicone waste and renewable emulsifiers. Its product quality is identical to that of silicone softeners made from primary raw materials.

Additive for the personal care products industry

Silicones in hair care products provide combability, shine and softness. With CHT BeauSil Re-AMO, a common silicone raw material is not only modified using natural sugar variants – there is also one that consist of over 90% of recycled silicone raw materials. The goal of CHT with its product developments is to close the loop and to avoid waste.

CASE STUDY CHT GERMANY GmbH

“LESSONS LEARNED” IN IMPLEMENTATION

- Availability of recycled raw materials (silicones) is limited; demand exceeds supply.
- Usually, customers are not willing to pay a higher price.
- Product marketing is difficult, as many finishers see an "inferior quality" of products with recycled raw materials and the chemical recycling approach is not understood.
- The market is slow to accept products; the approach only works through nomination by brands.
- The industry needs to communicate more, explain and create the overall context of the circular economy.

ADDED VALUE AND BENEFIT FOR THE CIRCULAR ECONOMY

The trend exists; the demand for recycled silicone oils far exceeds the current supply. But there are still reservations about products based on recycled raw materials. Quite often, it is wrongly assumed that these products are of inferior quality – which, of course, is not true.

However, consumers and trade have become aware of the responsible use of raw materials. Therefore, the demand for circular production processes and products will increase.

CHT
SMART CHEMISTRY
WITH CHARACTER.

04 CIRCULAR ECONOMY APPROACHES IN THE DESIGN AND MANUFACTURING OF PRODUCTS

The closed loop design of products in the chemical industry is one of the strongest levers for the transformation towards a circular economy.

The main lever for resource efficiency, reusability and recyclability is laid in the formulation of chemical products. For the chemical industry, which manufactures many inputs for different end uses, this applies directly to its own products but equally to further use up to the final product.

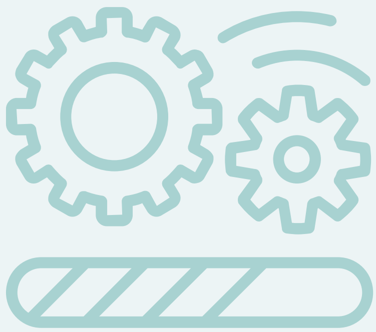
The manufacture of products in the chemical industry relies on energy- and equipment-intensive process engineering. Therefore, resource consumption and energy efficiency have always been in the focus of optimisation efforts.

In addition to the “classic” advantage criteria for plants and investment decisions (e.g. production costs, scalability, plant variability and flexibility), this is new in the meaning of a circular economy: Now, criteria for promoting and implementing the circular economy must be explicitly taken into account in management decisions.

Thus, existing methods and company routines to optimise process engineering have to be self-critically reflected upon and further developed. For achieving the circular economy goals, dormant potential needs should be tapped, in particular, for the following:

- Energy and resource efficiency in production plants, and
- use of regenerative energy sources and maximum utilisation or recycling of raw materials, auxiliary and operating materials.

2 Circular economy approaches in the design and manufacturing of products



4.1

4.1 Closed loop product design

What is it about?

- Product design to minimise resources
- Development of product design geared to recycling
- Focus on recyclability of products, which contain the company's own products, in end use
- Product design for resource- and energy-minimised production
- Products based on renewable and secondary raw materials (see approach 3).

Implementation in the company:

Closed loop product design can be implemented in two approaches: in the design or the formulation of the products themselves, and with a focus on their manufacture.

Circularity of products focuses on the resources used and consumed as well as recyclability. Thus, the necessary expertise includes raw materials, application know-how, knowledge of end-of-life and recycling technologies.

What must be observed?

- Action in focused, up to customer-specific solutions – due to the highly specific relevance to applications of the individual product-use-combinations.
- Building up know-how on recycling technologies and existing solutions in the market.

The second approach for closed loop product design aims at the manufacture and processing of the company's own products.

What must be observed?

- Full exploitation of opportunities to enable more resource- and energy-efficient production through modified formulations or other raw materials.
- Reduction of impurities, rejects, waste products and by-products as well as efficient use of energy and resources.
- Conscious involvement of customers, as such product innovations typically and invariably necessitate releases or even adaptations of customer products.
- An innovation focus also on modified formulations which positively influence processing by customers or at downstream value-adding stages in the meaning of a circular economy.

For advanced users:

- Development of specific platform solutions in the company's own range of products and solutions.
- Cooperations with downstream processors and recyclers to be able to exploit circular economy potential in product design.

Where are the limitations?

In end use, in particular specialty chemical products often become part of complex combinations and composite materials. The degree of effort required for recycling increases accordingly.

Comparative analyses across life cycles show that there can also be a deterioration in resource and energy efficiency for individual closed loop-oriented products and in existing recycling technologies.

However, in view of the rapid technical progress in recycling technologies, today's results of life cycle analyses should be critically reviewed on a regular basis.

EXAMPLES

- Use of mono-materials in product design to improve the recyclability of products.
- Use of raw materials and other materials that help improve the carbon footprint.
- Designing products for optimised separation of materials in sorting and recycling processes.

Expert voting from the "Virtual World Café" on relevance for the circular economy

	negativ				positiv
How big is the leverage for achieving the circular economy goals					●
Workability of the approach in the company		●			
Ability to measure and communicate		●			
Investment effort		●			
Implementation effort		●			

4.2

4.2 Energy- and resource-efficient production plants and process engineering

What is it about?

- Benefiting from the opportunities to optimise production and process technology when introducing closed loop-oriented product innovations.
- Intensified investment to reduce the resource and energy demand in production plants by changing production and process parameters.
- Reduction, storage or reuse of energy resources used in the production process.

Implementation in the company:

It is well known in the plant- and energy-intensive chemical industry that resource-efficient production facilities and process technology can both save costs and use resources efficiently.

However, where criteria for implementing the circular economy are taken into account in the selection of raw materials, auxiliary and operating materials in the company's own value chain, then further savings potential in energy and resource consumption can be identified in a holistic examination.

What must be observed?

- Potential and relevant investment can be additionally justified with the benefit of implementing the circular economy goals and included in the company's sustainability reporting.
- Exploiting potential for optimising production and process parameters in product innovations that are recyclable or based on renewable or secondary raw materials.
- Optimising resource efficiency by reducing impurities, rejects, waste products and by-products.

For advanced users:

- The more precisely process parameters and resource use can be analysed, the more consistently can production plants be optimised. Accordingly, initiatives for the digitalisation of value creation (Industry 4.0) must be linked with circular economy initiatives and approaches.
- The more differentiated resource consumption, raw materials, auxiliary and operating materials as well as impurities, rejects, waste products and by-products are recorded in product controlling, the more specifically can measures be launched.

Where are the limitations?

Already now, production efficiencies are almost fully optimised in many companies and hold only little potential.

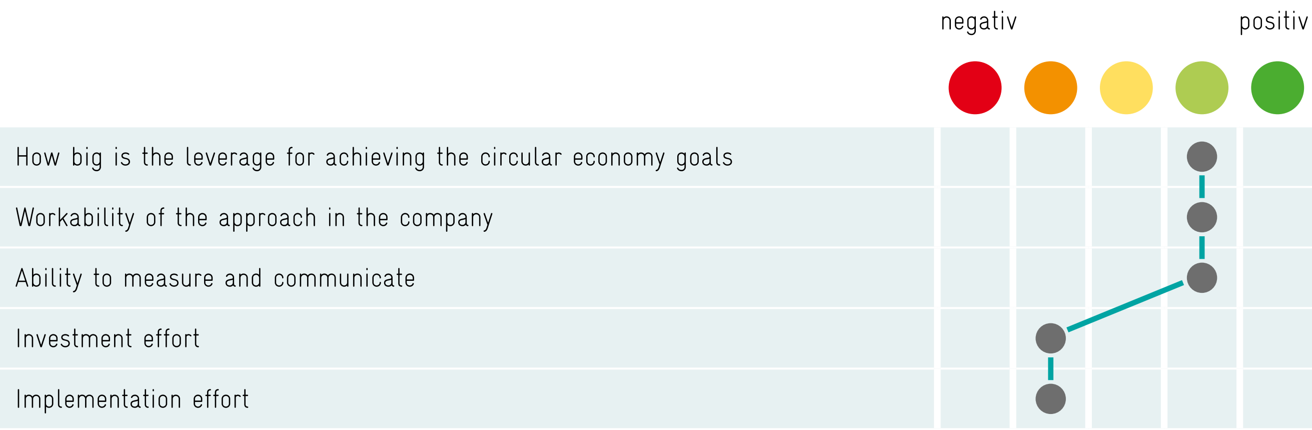
Product innovations open up additional potential for optimisation that not only influences the costs but also promotes circular economy goals and can thus bring competitive advantages.

A change in production and process parameters can entail considerable investment to fundamentally alter the production infrastructure.

EXAMPLES

- Recovery of process heat and use as effective energy.
- Replacement of centrally fired thermal oil systems to provide the necessary process heat by decentralised electric heating systems in production plants.

Expert voting from the "Virtual World Café" on relevance for the circular economy



CASE STUDY DR. BABOR GmbH

OBJECTIVE

Dr. Babor GmbH – also BABOR BEAUTY GROUP – has firmly anchored sustainability as a success factor in its corporate strategy. "We are definitely convinced that sustainable management – ecologically, economically and socially – makes a company successful," says CEO Horst Robertz. For this reason, the company has set itself concrete sustainability targets in a "Green Agenda" and assigned them with objectively measurable KPIs. The focal points: 50 % less CO_2 emissions by 2025, more sustainable packaging and a 30 % reduction in the consumption of virgin plastic by 2023, and using ingredients that are even environmentally sounder.

“LESSONS LEARNED” IN IMPLEMENTATION

For the BABOR BEAUTY GROUP, data is the key to change. Ranging from the travel to work of staff up to suppliers, data collection was at the beginning of the effort. Then it was about transparent communication to involve the teams. Today, almost all relevant departments have one employee working on the “Green Agenda” goals.

ADDED VALUE AND BENEFIT FOR THE CIRCULAR ECONOMY

Production has already been CO_2-neutral since 2015 thanks to the use of green electricity, and the entire company has been so since 2020 because of the partnership with ClimatePartner – across the entire supply chain. The BABOR BEAUTY GROUP compensates for what cannot yet be saved. In order to find out where there is remaining potential for savings, the company has analysed itself in accordance with the international standard of the Greenhouse Gas Protocol and now monitors its CO_2 emissions on a daily basis via a dashboard. A new production facility, which is currently being built, will be largely energy self-sufficient in the medium term and will work without fossil fuels. Robertz: "We are constructing the most sustainable cosmetics factory in the world."

BABOR
BEAUTY
GROUP

4.3

4.3 Use of CO_2-neutral or regenerative energies

What is it about?

- Use of regenerative energies generated exclusively by own energy production plants.
- Use of renewable energies that are partly produced in-house and partly purchased externally.
- Use of energies that are purchased externally and come exclusively from renewable resources.

Implementation in the company:

By switching to renewable and CO_2-neutral energies, companies make contributions to resource efficiency and climate neutrality that go beyond the circular economy goals.

What must be observed?

- Assessment of options for energy production with a focus on security of supply.
- Availability, infrastructure and connection to renewable energy sources must be given.
- Analysis of options for changeover to and use of regenerative energies as the main energy source in the company.
- Assessment of existing infrastructure and necessary investments for energy production facilities.

For advanced users:

Combining initiatives for the electrification of necessary heating and cooling in process engineering with the identification of options to switch to closed loop-oriented products.

Where are the limitations?

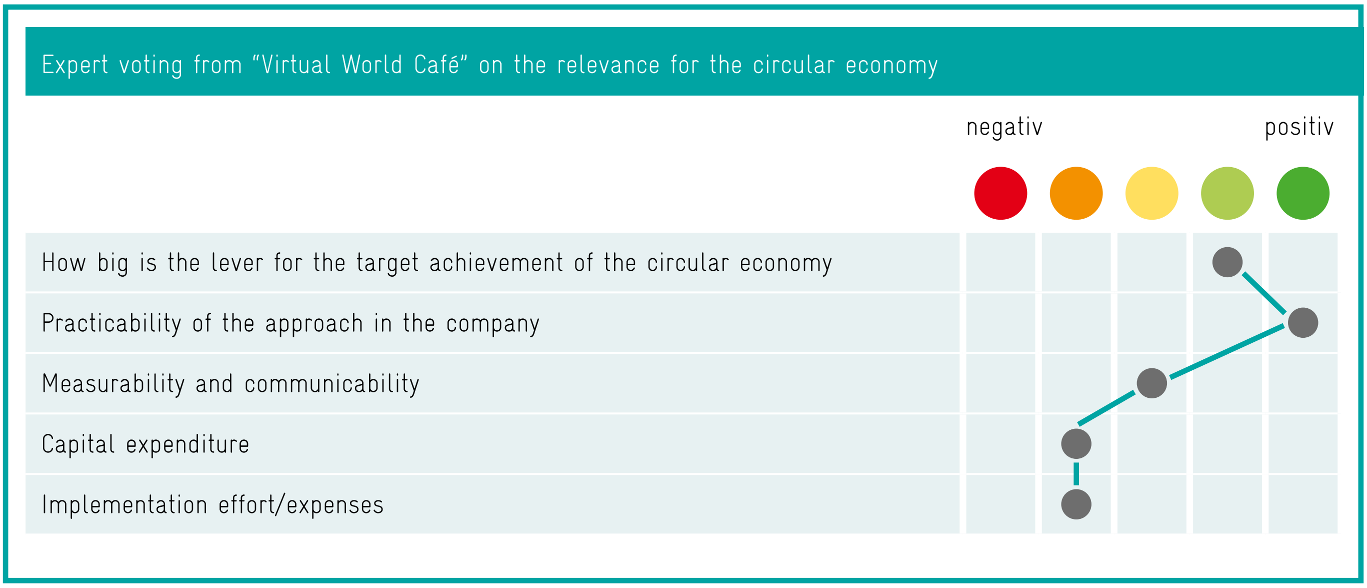
The partial or exclusive production of energy by the company's own energy production facilities involves high investment.

Where energy is generated from renewable energy sources (e. g. wind power or photovoltaic plants), there are dependencies on the existing weather situation. This causes uncertainties in supply.

There are shortcomings in the availability and infrastructure for supplying companies with regenerative energies.

EXAMPLES

- Energy supply from photovoltaics in combination with heat pumps and heat recovery to reduce dependence on electricity and energy markets.
- Energy-autonomous and CO_2-neutral production from regenerative energy sources with coordinated production processes where fine-tuning in production planning is steered by the availability of energy sources (e. g. wind and sun).



CASE STUDY EMIL FREI GmbH & Co. KG

OBJECTIVE

For us, sustainability is a decisive element for long-term business success and helps us deliver yet more competitive products and solutions for our customers. In this context, increasing energy, material and resource efficiency is seen as a central element of sustainable corporate development. A primary goal since the first environmental certification according to EMAS III in 1996 has been the "sustainable use of water" in order to consistently and sustainably reduce fresh water consumption throughout the company.

“LESSONS LEARNED” IN IMPLEMENTATION

In many technical projects, considerations were made and solutions developed in which processes water consumption can be significantly reduced and, above all, replaced by the use of rainwater in a meaningful and sustainable manner.

Long years of experience in the use of rainwater were continuously taken into account in many plans for the operation of technical facilities and in new construction projects. As a result, it was possible to significantly reduce water consumption and – with the help of the energy medium "water" – to use the generated thermal energy from production for heating purposes, deploying heat pumps.

ADDED VALUE AND BENEFIT FOR THE CIRCULAR ECONOMY

With the targeted and consistent use of rainwater instead of fresh water, water consumption in cleaning and cooling processes was reduced immensely (approx. 10,000 m³/a).
An extremely economical and, above all, highly sustainable additional success was achieved with the energetic use of the cooling water circuit – where heated cooling water from productions (100 % from rainwater) substitutes classic heating in the form of fossil combustion technologies in a CO_2-neutral way with the help of heat pumps. Since 2010, there has been an annual reduction in electricity of about 1.2 million KWh or the equivalent of 313 tonnes of CO_2.

4.4

Optimised production with maximum raw material utilisation and a minimum of rejects

What is it about?

- Focus on maximum utilisation within the production process and minimisation of internal raw material losses.
- Collection and reuse of reject materials from production processes for return or separate raw material collection.
- Approaches for (partial) reuse of faulty batches or unsold stock goods
- Use/reprocessing of auxiliary/operating materials.

Implementation in the company:

Efforts to achieve a maximum utilisation rate in production processes and to avoid faulty batches and complaint products are firmly embedded. In addition to the above approach to resource- and energy-efficient production, further criteria for implementing the circular economy can be included in maximum raw material utilisation. For example, additional potential can be exploited for raw materials and auxiliary and operating materials. By taking into account auxiliary and operating materials, which are not usually in the focus of resource efficiency, it is also possible to cut costs and to utilise input raw materials more efficiently.

What must be observed?

- Identification of reasons for rejects and analysis of faulty batches and causes for complaint products.
- Assessment of investments for the further development of process technology in terms of how these promote the achieving of circularity targets.
- Focused analysis of opportunities for reuse, purification or savings of auxiliary and operating materials that are not in the focus.
- Analysis of waste streams/options for reduction, recycling/recovery and return to production.

For advanced users:

Focused building up of know-how on the collection and reprocessing (including technologies) of consumables and rejects (raw materials, auxiliary and operating materials) in order to recover them as inputs.

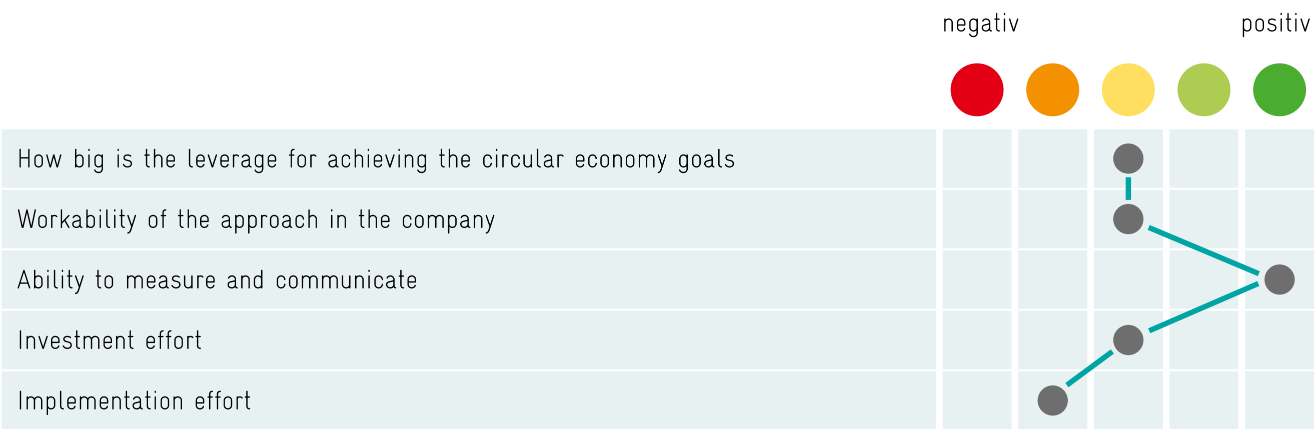
Where are the limitations?

- Production efficiencies and reject rates are already very good in many companies.
- The reprocessing of faulty batches, complaint products and reject materials is often only possible by using complex and elaborate processing and reprocessing methods.

EXAMPLES

- 100 % reprocessing and integration of complaint products and faulty batches.
- Recovery of solvents, dusts or powders lost in the manufacturing process, for example, through filters in exhaust air systems.

Expert voting from the "Virtual World Café" on relevance for the circular economy



05 CIRCULAR ECONOMY APPROACHES IN THE PACKAGING AND TRANSPORT OF PRODUCTS

In addition to products and processes as starting points for the circular economy in companies, these can also be found in the packaging and transport of goods.

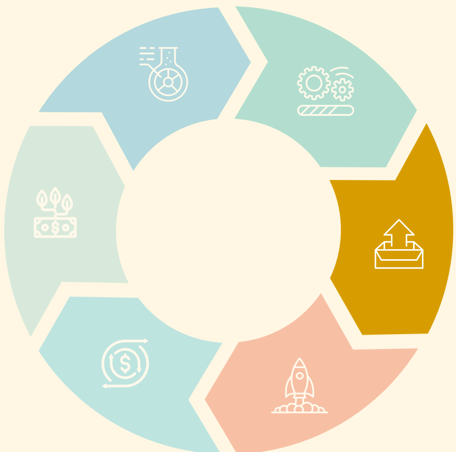
For example, the influence of one's own company on reuse and recycling solutions for packaging is usually greater than for products that become part of downstream and multi-stage applications.

Furthermore, packaging opens up opportunities to ensure the traceability of own products for end-of-life solutions and recycling.

In fact, there are already many solutions in the chemical industry for the reuse of transport containers, such as IBCs (intermediate bulk containers) and drums and canisters which are reconditioned and run in loops.

However, with the focus on containers close to end-users, disposable packaging still dominates frequently and only a small proportion is kept in cycles so far.

This is precisely where opportunities arise for companies to use packaging in loops as well as innovative and resource-minimised packaging in the meaning of the circular economy.



3 Circular economy approaches in the packaging and transport of products

5.1

Packaging in loops

What is it about?

- Use of reusable and refillable packaging to reduce waste volumes.
- Establishment or use of return systems with deposit and take-back options.

Implementation in the company:

Basically, it must be distinguished between the use of recyclable materials for packaging and the direct return and reuse of packaging after use/emptying by users.

In the case of the multiple use of packaging, which is in the focus here, this can either be done as an industry-specific solution or on the company's own initiative.

What must be observed?

- Listing and assessment of used packaging with a view to substitution by recyclable materials and reuse options.
- Chances for the joint development of recyclable packaging with packaging manufacturers.
- Identification and use of packaging and transport containers with existing take-back systems for a switch.
- Identification of potential partners and market participants for developing one's own / sector-specific approach for a closed loop system.

For advanced users:

- The use of sustainable packaging or packaging materials can bring competitive advantages in the long term through access and control if market availabilities are limited.
- Establishing closed loop systems with cooperation partners for the collection, return and reprocessing or recycling of packaging and transport materials.

Where are the limitations?

The collection, return and reprocessing of packaging and transport materials must be considered in a holistic manner to be able to verify the positive effect on eco-balance and carbon footprint.

EXAMPLES

- Ensuring up to 100 % recyclability of packaging in existing recycling and material loops.
- Use of recycled plastics for packaging, e. g. 40 % in plastic IBCs, up to 100 % in packaging for cosmetic chemicals or paint containers.
- Recycling of blister packaging for tablets to recover aluminium and reuse in product packaging in the pharmaceutical industry.

CASE STUDY PAMIRA (RIGK GmbH)

OBJECTIVE

PAMIRA takes back completely emptied and rinsed packaging of plant protectants and liquid fertilisers from the agricultural sector which is labelled with the PAMIRA mark. Next, PAMIRA recycles such packaging in a way which is environmentally sound and adequate regarding health. Costs for the collection, logistics and recycling/recovery of packaging are borne by the manufacturers of plant protectants and liquid fertilisers. The agricultural trade provides the collection points. The project is supported by Chemie Wirtschaftsförderungs-Gesellschaft mbH, Frankfurt am Main. PAMIRA wants to give farmers a nationwide and safe option for disposing of their plant protectant and liquid fertiliser packaging. Packaging is taken back on fixed dates, usually immediately after application of the products when packaging waste is generated. According to independent studies, the organisation of take-back is currently the optimal solution in economic and ecological terms.

"LESSONS LEARNED" IN IMPLEMENTATION

At the collection points, a check for compliance with the PAMIRA acceptance criteria (rinsed, emptied of residues and licensed) by independent staff of the operator of the take-back system is required. Only in this way can a high-quality material stream be collected which is suitable for recycling.

ADDED VALUE AND BENEFIT FOR THE CIRCULAR ECONOMY

Initially, returned packaging was used exclusively for energy in steel works or as substitute fuel in the cement industry. Meanwhile, almost 95% of packaging collected in the PAMIRA system go into material recycling. For example, PAMIRA is a supplier of high-quality plastics which are used, inter alia, for cable conduits. Through continuous optimisation of the collection structure, the return rate was increased to about 80% of packaging placed on the market. This is a remarkable rate for a voluntary bring-back system. Over the years, the number of distributors (licensees) participating in the system has grown to over 100, representing the majority of packaging placed on the market in the plant protectant and liquid fertiliser segment.

PAMIRA®

5.2

Innovative and resource-minimal packaging

What is it about?

- Use of renewable or secondary raw materials for packaging.
- Use of recyclable packaging.
- Development and use of packaging that reduces material residues in the packaging through innovative packaging design.
- Use of innovative packaging that contributes to reducing downstream resource consumption, for example, through lightweight construction properties.

Implementation in the company:

Innovations in packaging can come about through closed loop product design, ecological manufacturing processes, sustainable and recyclable materials, and increased resource efficiency.

What must be observed?

- Identification of suppliers and offers of recyclable packaging.
- Recyclability of materials, ideally mono-materials.
- Identification of alternative, innovative packaging suppliers.
- Communication about added value in product application.
- Cooperation with packaging manufacturers to optimise own packaging in terms of resource efficiency, closed-loop orientation and recyclability.

For advanced users:

Integration of several cooperation partners along the value chain to develop packaging solutions for specific market requirements.

Where are the limitations?

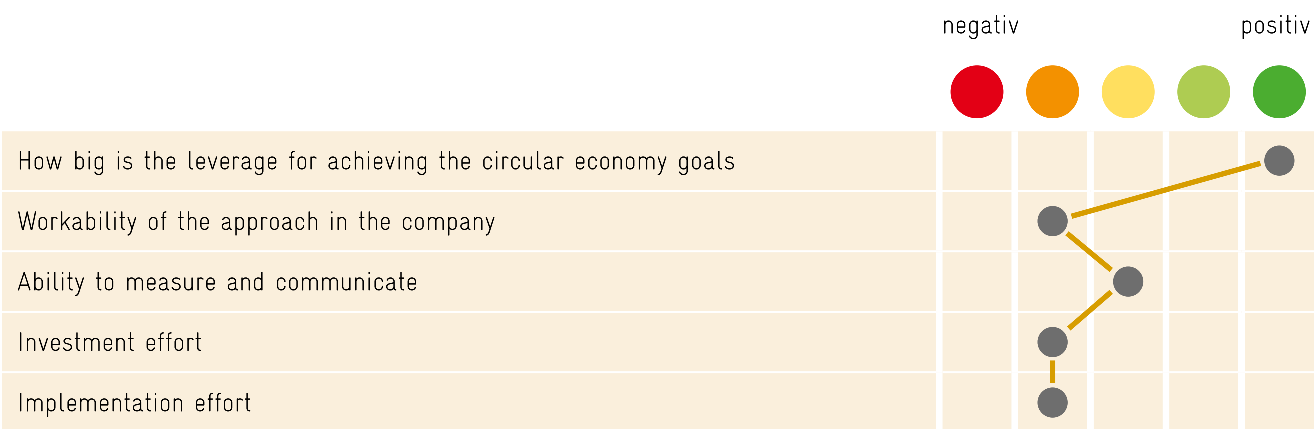
Packaging that guarantees transport properties and product protection properties cannot be found for all products and applications or fields of use.

Innovative packaging, like cycle-oriented products, is often more expensive and requires more explanations. This makes targeted innovation marketing necessary to gain market and customer acceptance.

EXAMPLES

Use of silica aerogel composite sheets for innovative packaging in pharmaceutical and biopharmaceutical sectors.

Expert voting from the "Virtual World Café" on relevance for the circular economy



5.3

Traceability of own products

What is it about?

- Tracking of products by means of labelling on packaging and transport containers.
- Integration of own products into existing systems and solutions.
- Identification of raw materials and other materials in the sorting and recycling process.
- Acquiring data on the product life cycle.

Implementation in the company:

Traceability means the ability to track a product in downstream processing stages and, ideally, to identify the product as a component in end use.

Because of multi-stage value creation stages where, in particular, products from the chemical industry are often used in early stages or in comparatively small quantities, participation in industry- or sector-specific solutions is the central starting point for companies.

Many initiatives and solutions are currently being established that are open to companies who want to participate in or use the systems.

What must be observed?

- What systems and solutions are available for the company's own products and fields of application?
- What prerequisites are needed in the company's own IT infrastructure for connection and integration?
- What technical means are required for the labelling and tracking of products, e.g. labelling on packaging?

For advanced users:

Initiating cooperations with suppliers, market participants, customers and IT businesses to develop industry-specific solutions for the traceability of products and raw materials.

Where are the limitations?

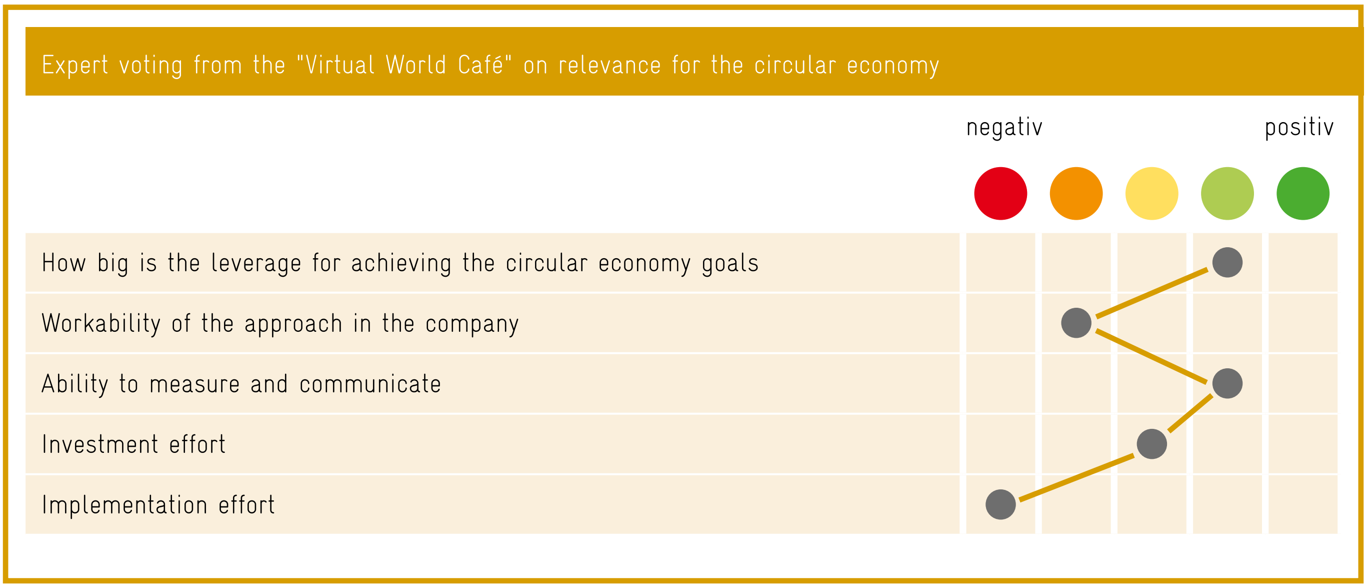
Data are of enormous importance for the traceability of products and materials.

Establishing a digital system for tracking products usually involves a considerable input of resources in terms of time, investment and IT skills.

At present, there is no legal framework for passing on data along the value chain. Here, data protection content must be examined and taken into account.

EXAMPLES

- R-Cycle Initiative (digital product passport)
- SCTT (Supply Chain Track & Trace)
- Holy Grail 2.0 (digital watermark for material identification in the recycling process)
- ReCarbonX system (digital twin of products including documentation of the carbon footprint per product)
- Madaster (digital platform in the construction industry for materials and products used in buildings)
- Packwise (sensor for measuring fill levels, temperatures and locations as well as automatic re-ordering)


Expert voting from the "Virtual World Café" on relevance for the circular economy
negativ
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How big is the leverage for achieving the circular economy goals
Workability of the approach in the company
Ability to measure and communicate
Investment effort
Implementation effort

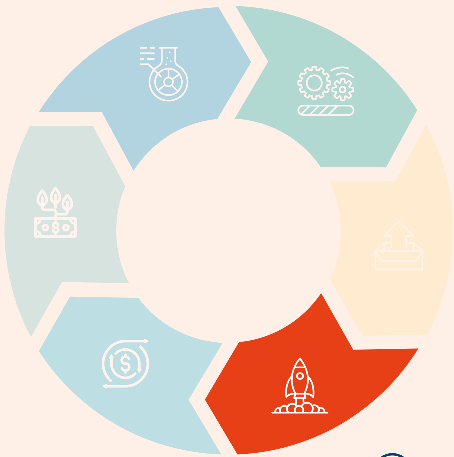
06 APPROACHES TO OWN PRODUCTS AS ENABLERS OF CIRCULAR ECONOMY FOR CUSTOMERS

In the manufacturing of products, companies can exert significant influence on the circular economy goals of customers. Businesses can impact their customers' circular economy by means of product properties, manufacturing processes and certifications.

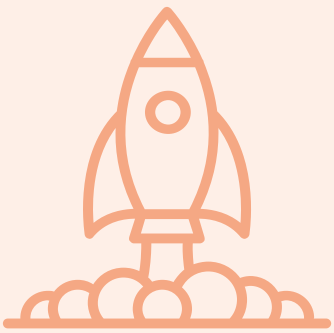
With improved product properties, specifically manufactured products help achieve the circular economy goals of customers, for example, thanks to longer life cycles or higher yields.

Manufacturing products with optimised properties can improve the customers' downstream processing activities, reduce the number of processing steps, or cut the amount of product consumed. In each case, this has a positive impact on the circular economy of customers.

When the compliance and certification requirements of customers regarding the circular economy are met and renewable and secondary raw materials are used, this also supports customers in reaching their circular economy goals.



4 Approaches to own products as enablers of circular economy for customers



6.1

Own products as enablers of the circular economy

What is it about?

- Enablers for improving product properties in respect of sorting capability and recyclability.
- Enablers to extend the service life of customer products.
- Enablers to increase yields and area performance of customer products.
- Meeting and adhering to the customer's certification requirements and compliance specifications as regards the circular economy.

Implementation in the company:

As enablers, closed-loop products can lead to higher utilisation in further processing by customers in downstream production steps: Rejects can be minimised through better utilisation of cycle-oriented materials and products. The use of cycle-oriented products can enable reductions in the consumption of raw materials and resources in the customer's production or processing operations.

Longer product life cycles and higher area performance have a positive influence on cuts in resource consumption, but usually this means higher sales prices due to the changed product properties.

What must be observed?

- Developing an understanding of the manufacturing processes that customers use for their products.
- Developing an understanding of the customer's processing and application processes.
- Analysis of potential needs for optimisation.
- Cooperations and networks with customers for closed-loop product improvement, for example, to extend the product life cycles.

For advanced users:

- Information about the CO_2 balance of individual products to support the circular economy goals of customers.
- Communication about the added value of products as enablers in the customers' circular economy, including marketing arguments for customers.

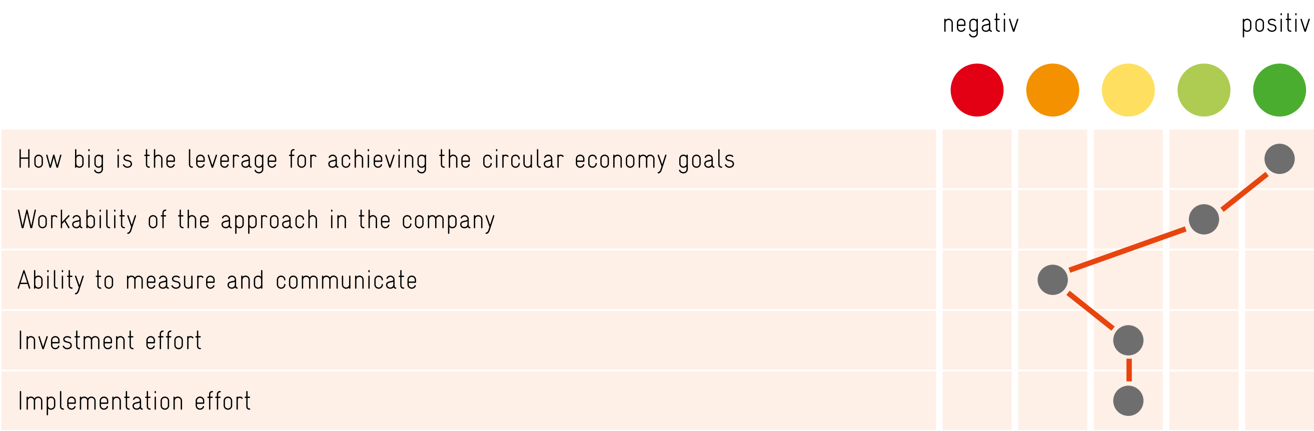
Where are the limitations?

Own products as circular economy enablers are only possible if there is cooperation or close networking with customers, as additional costs and added value are often difficult to communicate.

EXAMPLES

- Modification of product properties of agrochemicals to reduce the number of processing and application operations at the customers.
- Concentrates to reduce freight and the resulting consumption of resources and energy.

Expert voting from the "Virtual World Café" on relevance for the circular economy



6.2

Improvement of manufacturing processes and savings of raw materials, auxiliary and operating materials at the customers

What is it about?

- Optimisation of manufacturing processes at the customers.
- Resource-efficient use of raw materials, auxiliary and operating materials at the customers.

Implementation in the company:

Closed-loop products can optimise process parameters in manufacturing processes of products at the customers.

They can also bring savings in raw materials, auxiliary and operating materials in production processes.

Similar to the section "Products as enablers for the circular economy", the following points need to be considered when improving manufacturing processes:

What must be observed?

- Developing an understanding of the manufacturing processes that customers use for their products.
- Developing an understanding of the customer's processing and application processes.
- Analysis of potential needs for optimisation.
- Cooperations and networks with customers for closed loop-process improvement.

Rejects are often generated in production processes. These can constitute valuable inputs for other businesses. Selling waste materials and rejects that are not used by the company itself can open up sales opportunities. The following points should be considered in savings of raw materials and auxiliary and operating materials:

What must be observed?

- Analysis of rejects for potential fields of use, both internally and externally.
- Assessment of the necessary quality requirements, quantities and processing.
- Identification of potential buyers and cooperation partners.

Disposal costs can be reduced through waste avoidance, and a contribution to resource efficiency and conservation can be made. Turnover potential can be exploited by selling secondary raw materials, and new target groups can be addressed.

For advanced users:

- Reprocessing or recycling of rejects for sale as inputs to customers.
- Sale of rejects from the manufacturing process that cannot be used for the company's own purposes.

Where are the limitations?

The reject rate in manufacturing companies is already very low and is being continuously optimised.

Recycling and reprocessing of rejects from production are often only possible in complex and costly processing procedures.

A comparison should be made of the effort in terms of investment, time and personnel on the one hand and the real benefit and yield on the other.

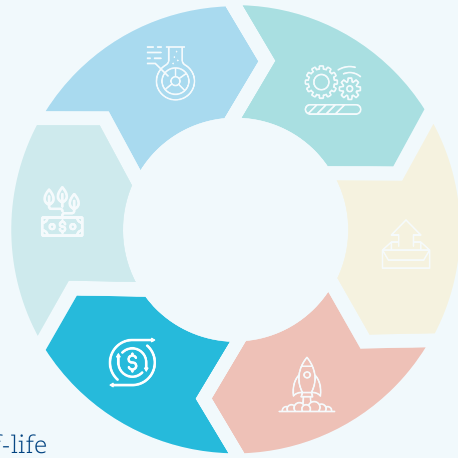
EXAMPLES

Provision of process additives for energy-efficient manufacturing processes, e.g. lower temperatures, shorter process cycles.

07 CIRCULAR ECONOMY APPROACHES FOR END-OF-LIFE SOLUTIONS FOR PRODUCTS

At the end of the product life cycle, recycling and recovery measures are starting points for exploiting any potential for further use of products and product components.

Already in the phases of product design and product formulation, the selection of materials and material compositions influences the options for later use or recycling. Problems regarding end-of-life capabilities often arise only at a later time in downstream applications.



5 Circular economy approaches for end-of-life solutions for products

7.1

Return of used materials

What is it about?

- Reprocessing and further processing of returned, used materials and products and by-products.
- Use of returned, used materials as raw materials/inputs.

Implementation in the company:

The main approach for the return of used materials lies in development and in the end-of-life capability in product design.

The return of used materials is not possible in every company and not for all materials.

A prerequisite for product return is a direct and close downstream processing stage.

What must be observed?

- Identification, for example, through traceability of the end use of products.
- Analysis of returned materials regarding recyclability.
- Analysis and assessment of processing infrastructure.
- Assessment of product quality from reprocessing.

On the one side, taking back materials can reduce the volumes for disposal. On the other, the recovery of raw materials generates inputs for reuse, resulting in savings of costs and resources. However, take-back, return and reprocessing of used materials call for additional bodies in charge of quality. These must inspect and assess the taken-back materials, in order to ensure that they can be reprocessed.

The return of used materials causes higher costs due to the reprocessing steps and the necessary quality assurance. However, this is offset by achieving recycling targets, which can be positively reflected in the marketing prices of the products.

For advanced users:

The return of used materials and by-products must be taken into account as early as in the development and design of new products.

Where are the limitations?

Qualities of returned, used materials can vary largely. Contaminated materials often cannot be identified at all or only with great effort.

EXAMPLES

- Use of mono-materials in insulating and facade systems for an optimised return of used materials.
- Collection and reprocessing of solvents consumed in application processes and filtered from the air downstream.
- Return and reprocessing of electroplating sludges.
- Return of catalysts for the recovery of raw materials in basic chemistry.

7.1

CASE STUDY COVESTRO AG

OBJECTIVE

Our goal is to make the world a better place to live in with a wide range of innovative products and solutions. In line with our sustainability principle "People, Planet, Profit", we do everything we can to make the circular economy a reality and to become climate neutral as a company. In addition to purchasing more sustainable raw materials and renewable energies, the development of innovative recycling technologies plays a crucial role in continuously reducing the carbon footprint of our materials and in creating new solutions for dealing with plastic waste.

"LESSONS LEARNED" IN IMPLEMENTATION

Covestro has developed an innovative process for the chemical recycling of flexible polyurethane (PU) foam from used mattresses. The method builds on experience gained from participation in the publicly funded PUReSmart[1] project. Mattresses contain an average of 15 to 20 kg of foam, resulting in large amounts of waste at the end of their service life. Flexible foam is made from two important raw materials. While other chemical recycling approaches focus primarily on the reprocessing of one raw material, the Covestro process now enables the recovery of both components. A key to success was the interaction between value creation partners from waste reprocessing to our customers!

ADDED VALUE AND BENEFIT FOR THE CIRCULAR ECONOMY

Since 2021, Covestro has also been operating a pilot plant for flexible foam recycling at its Leverkusen site to confirm the positive laboratory results achieved so far. Covestro's goal is to industrialise chemical recycling processes for used flexible foams and, ultimately, to remarket both recovered inputs – with the aim to replace mineral oil as a raw material and to reduce the carbon footprint of our materials and sales products. "The development of this innovative recycling technology and the investment in the pilot plant are further milestones towards realising our vision of fully steering Covestro towards the circular economy," says CEO Dr Markus Steilemann.

covestro

[1] PUReSmart: www.puresmart.eu

7.2

Return of unused materials

What is it about?
- Reprocessing and further processing of unused materials and products.
- Recovery of raw materials from returned, unused products and materials.
- Return of products that cannot be further processed by customers due to changed properties.

Implementation in the company:
The return of unused materials and products can result, for example, from opened containers, material residues from packaging or due to changed properties of the products.

What must be observed?
- Creating added value for users and customers for returning unused materials.
- Identification of products that have not been completely processed.
- Analysis of returned materials with regard to incorporation and further processing.
- Analysis and assessment of processing infrastructure.
- Assessment of quality of reprocessed products.

Taking back unused materials can reduce the waste volumes in the company and generates inputs for reuse through reprocessing, resulting in savings of costs and resources. However, take-back, return and possible reprocessing of unused materials call for additional bodies in charge of quality. These inspect and assess the taken-back materials, in order to ensure reprocessing.

As with the return of used materials, the return of unused materials causes higher costs due to steps for reprocessing and quality control. However, this is offset by achieving recycling targets, which can be positively reflected in the marketing prices of the products.

Where are the limitations?
The quality of the returned materials must be examined and safeguarded, so that contaminations and product changes can be excluded.

EXAMPLES

Materials which
- have changed their aggregate state due to moisture;
- cannot be further processed by customers but are suitable for recovery as raw materials.

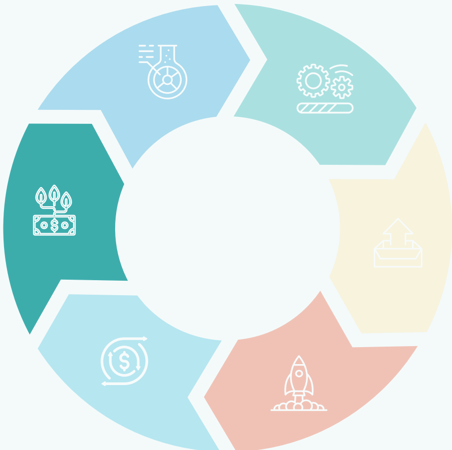
08 CIRCULAR ECONOMY APPROACHES FOR NEW BUSINESS MODELS

The transition to a circular economy will absolutely require digital tools to better coordinate material and information flows and to provide more transparency. Data and information on volumes, prices, product quality and raw materials contained must be collected with the help of digital media and made available in a transparent and uniform manner. The industry experts involved all agree on this.

Here, the main challenge is to effectively collect, process and make available again the mass of information on the material composition of each individual product, its usage patterns, its fate in the waste system, etc. This is a prerequisite for establishing functioning loops in the next step.

The above can be achieved in new business models based on digital technologies, digital marketplaces, efficient use of resources as well as cooperations and industry-specific solutions.

6 Circular economy approaches for new business



8.1

Chemicals Leasing

What is it about?

- Incentivising reduced chemicals consumption and resource-efficient use of chemicals.
- Use of chemicals as a service while there is no change in ownership of the products.

Implementation in the company:

As a matter of principle, there is no change in ownership in chemicals leasing. Here, the use of a chemical is defined as a service. Thus, the income is not generated by the quantity sold but by the service which includes technically and environmentally sound use, take-back, reprocessing and disposal.

What must be observed?

- Transparency and communication about the added value of chemicals leasing among users and customers.
- Life cycle analysis and assessment of the carbon footprint to identify potential fields of application within the value-adding process.
- Identification of suppliers and potential partners.

By resorting to chemicals leasing, cost and resource potentials can be utilised and corporate growth can be decoupled from resource consumption.

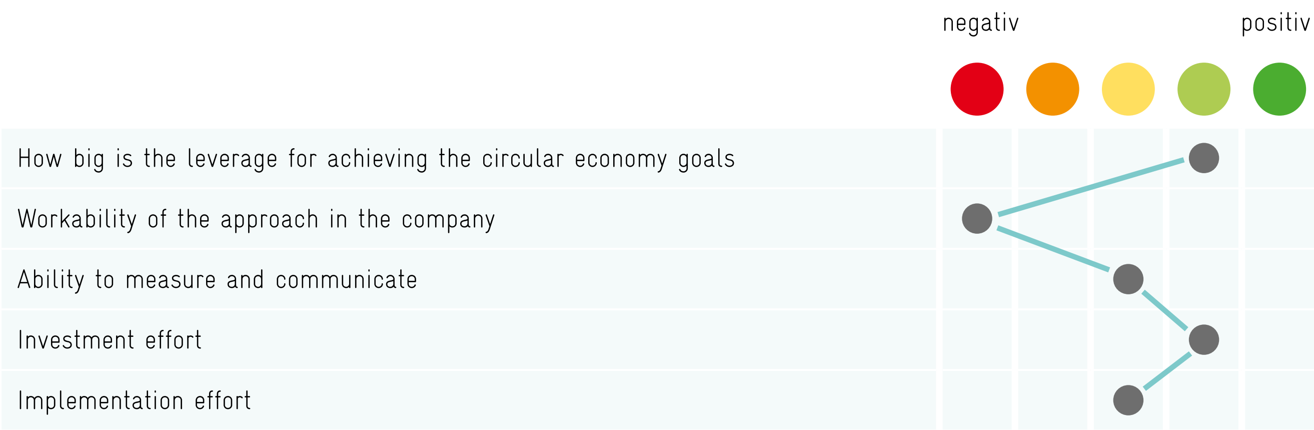
Where are the limitations?

Chemicals leasing often means extra efforts for companies, for example, in logistics.

EXAMPLE

Chemicals for metal processing and textile cleaning together with collection and supply containers.

Expert voting from the "Virtual World Café" on relevance for the circular economy



8.2

Cooperations and industry-specific solutions for packaging, material and product loop systems

What is it about?

- Building cooperations with competitors or across sectors/industries for the development of packaging, material and product loop systems.
- Long-term opening up and development of cooperations along the value chain from suppliers to buyers, consumers to disposal companies.

Implementation in the company:

Successful loop systems for packaging, materials and products can be developed and closed together with upstream and downstream market players. Quite often, production rejects or disposal materials from one company are valuable raw materials and resources for others.

What must be observed?

- Identification of relevant and potential cooperation partners along the value chain and within and outside the own industry.
- Internal process analysis to identify possible uses and potentials of raw materials and rejects.
- Transparent communication of needs along the value chain.
- Cooperations across sectors/industries between companies and associations.

Cooperations of product, material and packaging loops can save resources, minimise waste volumes and cut disposal costs. Investment costs are reduced, too. The chances of success increase with larger quantities of substances/materials, constant mass flows and shared risks.

For advanced users:

Formation of alliances for secure and cross-company data exchange, as shown on the example of CatenaX in the automotive industry which creates and presents uniform data and information flows of the entire value chain.

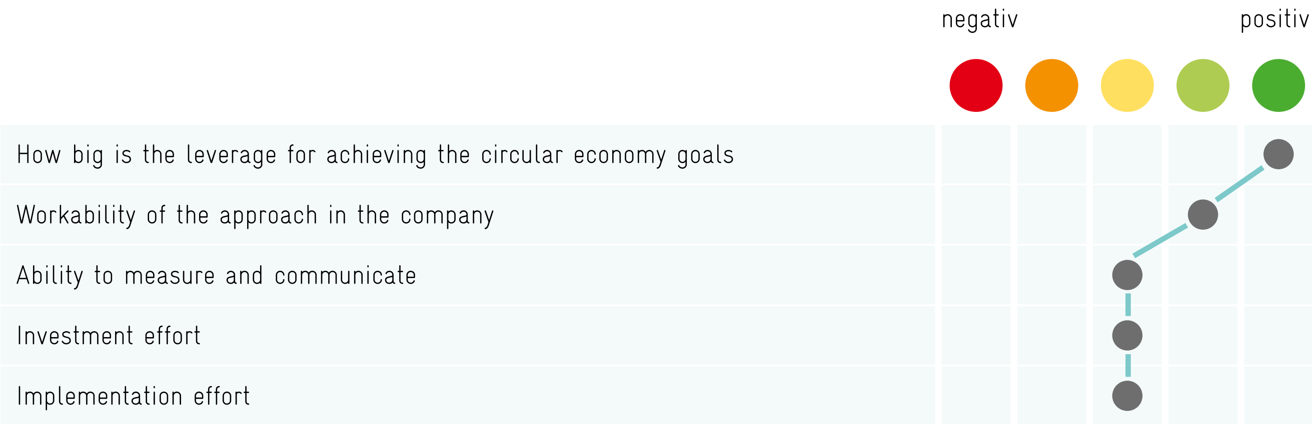
Where are the limitations?

Functioning and successful cooperation presupposes transparency. However, such transparency is often not wanted within an industry and between competitors.

EXAMPLES

- "Closing-the-loop" of the Companies Grillo-Werke and Aurubis.
- PAMIRA take-back system in Germany for plant protectant and liquid fertiliser packaging.
- Loops and reconditioning of plastic canisters, drums and IBCs.

Expert voting from the "Virtual World Café" on relevance for the circular economy



CASE STUDY AURUBIS AG/GRILLO-WERKE AG

OBJECTIVE

The shared "closing-the-loop" approach of Aurubis AG (an expert in multi-metal recycling) and Grillo-Werke AG (a specialist in zinc chemistry) ensures a verifiable, complete cycle for copper, zinc and other valuable metals with state-of-the-art technology. The recycling process at Aurubis AG produces copper cathodes from recycling raw materials. The thus obtained zinc-rich oxide product is used by Grillo-Werke as a raw material for the manufacture of zinc sulphate. In the processing of the filter dust into zinc sulphate at Grillo-Werke, a residue is then obtained that contains other valuable ingredients such as copper, tin and lead in enriched form. Aurubis AG take back this residue, utilise the metals in the form of products, and thus close the loop for recyclable materials.

“LESSONS LEARNED” IN IMPLEMENTATION

- This long-term partnership is not only a commercial but also a technological cooperation.
- The composition of the zinc oxide changes from time to time due to process optimisations. Grillo-Werke know the qualities of the filter dusts very well and can adapt their own processes to a changed composition.
- Investments in the latest and most modern recycling plants are of enormous importance for companies such as Aurubis AG and Grillo-Werke alike.

ADDED VALUE AND BENEFIT FOR THE CIRCULAR ECONOMY

Based on the "closing-the-loop" approach, considerable added value can be created for the circular economy, for example

- recycling as an ecological and technical benchmark;
- CO_2 reduction;
- efficient use of the complexity of raw materials;
- return of valuable metal resources into the cycle;
- long-term planning security.

8.3

Digital marketplaces for raw materials

What is it about?

- Long-term opening and development of suppliers for renewable and secondary raw materials as well as for innovative, resource-efficient primary raw materials.
- New raw materials as a stimulus for innovation in the circular economy.
- Creating transparency with regard to prices, qualities and availability of raw materials and suppliers.

Implementation in the company:

Digital market platforms create market transparency and increase efficiency along the entire value chain. Such platforms not only mean new sales potential for often small, local suppliers of specialty products; they also pave the way for new sales channels and value-add services. So far, the existing experience base with new raw materials and digital marketplaces is still mostly limited in practice.

What must be observed?

- Identification and analysis of existing marketplaces.
- Standardised framework conditions as regards orders, shipping and deliveries.

Digital marketplaces can be used to identify and build up long-term sources of raw materials. This brings opportunities for innovation and for tapping into new target groups.

Sufficient numbers of actors (providers and users) must exist in the digital marketplace so that it can be implemented successfully.

For advanced users:

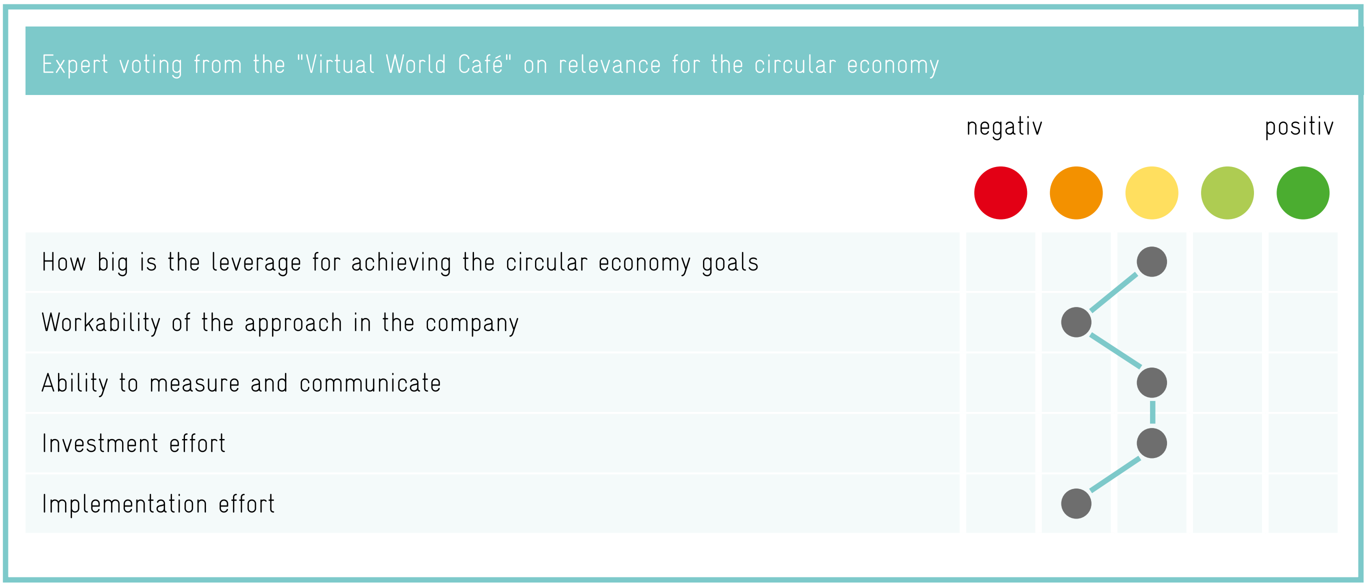
Use of digital marketplaces as a new procurement branch for raw materials and other materials – but also as a new sales opportunity for own products.

Where are the limitations?

The success of digital marketplaces depends on the number of actors who actively participate in the marketplace. This requires legal framework conditions as well as a user-friendly and reliable platform. Furthermore, mutual trust among marketplace participants must be built.

EXAMPLES

- Chemondis as B2B marketplace for chemicals
- Cirplus as B2B marketplace for recyclates
- Chembid as B2B platform and commercial meta search engine for chemicals and plastics
- Plastic Bank as a distributor and marketplace for secondary raw materials



CASE STUDY CIRPLUS GmbH

OBJECTIVE

The ultimate goal is to reduce the amounts of plastic waste entering the environment to zero, using digital technology. Building digital networks in the value chain is crucial to achieving this goal.

In view of the shortcomings in the loops for plastics (inter alia, high costs of high-quality recyclates compared to virgin material, poor availability of volumes; fluctuating qualities), we quickly came up with the idea to connect the non-transparent waste and recyclate markets with processors and brand manufacturers via a B2B platform, to standardise the materials, and to modernise the processes of purchasing and distribution. With our digital technology, we can significantly reduce the transaction costs in the use of recycled plastics and thus decisively contribute to establishing stable supply chains in the recyclate market. Only if a lasting business case can be made for industry in all aspects of the use of recyclates a higher economic value will be attached to waste. Then, no disposal company in the world will have any longer an incentive to simply burn, export or landfill waste materials – but to process them into high-quality recyclates as the key to stopping the plastic flood.

"LESSONS LEARNED" IN IMPLEMENTATION

Developing B2B software is complex, both in programming and in dealing with the value creation participants for whom the software is programmed, because: Each actor pursues different strategies regarding the circular economy and digitalisation. All attitudes exist from "sitting out/not relevant for us" to "we want to be pioneers in both areas". Moreover, a start-up from "outside" the industry faces the initial problem that nobody knows it. However, this has the advantage of being free from any personal or company-specific interest of the individual value creation participants – a fact whose importance cannot be overstated. Neutrality, professionalism, steep learning curves about plastics, experience in software development and freedoms of entrepreneurs that can only be found in start-ups were the core competences with which we were able to overcome the initial hesitation of clients.

ADDED VALUE AND BENEFIT FOR THE CIRCULAR ECONOMY

More than 1.3 million tonnes of listed materials, more than 1,200 users from over 100 countries; up to 80% CO_2 savings through each tonne of recyclates sold as compared to virgin material; the publication of DIN SPEC 91446, 15 staff from 5 nations; €4.5 million in investments, two pilot projects in Indonesia, Vietnam and Mexico; participation in the K trade fair with an own stand: In little over 2 years of live operation of the platform (since March 2020), major milestones have been achieved. And this is just the beginning.

cirplus

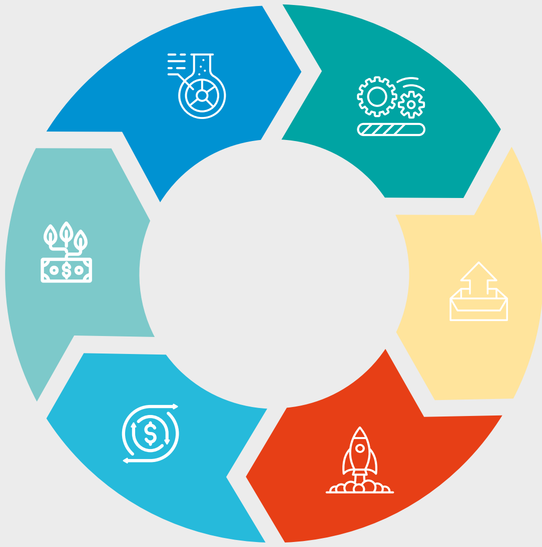
09 LAUNCHING THE CIRCULAR ECONOMY IN YOUR COMPANY

9.1

Obstacles and points being self-evident

OBSTACLES

- Unclear and vague definition of circular economy goals and inconsistent pursuit of these goals.
- Working without measurable goals and clear key figures/indicators.
- Development only from a marketing and sales perspective (→„greenwashing").
- Definition of unrealistic assumptions and unachievable goals.
- Communication through assertions.
- Only an abstract view of the circular economy not aimed at implementation.
- Accepting ignorance about circular economy and recyclability in the company.
- No allocation of investments for projects and for implementing the circular economy.
- Circular economy only concerns individual areas or departments inside the company.
- Reluctance towards new ways of thinking and further education/training opportunities.
- Leaving the circular economy only to specialist departments.
- Development of products and processes without considering targets of and impact on circular economy and end-of-life capability.
- Single-phase CO_2 focus only at company level but not at product level, too (including upstream and downstream).
- Unreflected substitution of primary raw materials by renewable or secondary raw materials, without any real added value in the product or for circular economy goals.
- Using short-term customer/supplier relationships to market circular products.
- Underestimating the degree and scope of change in the company.
- No open or unspecific communication on the topic of circular economy.
- Implementing circular economy solutions alone without partnerships, often costly and difficult to implement.



POINTS BEING SELF-EVIDENT

- Clear definition and communication of closed loop goals; consistent and rigorous pursuit of them.
- Definition of target values and creating the prerequisites for measurability.
- Development with a focus on function, benefit and impact for the circular economy.
- Making realistic assumptions and defining realistic goals.
- Fact-based communication.
- Product-specific consideration and search for solutions to implement the circular economy.
- Building and promoting an understanding of recyclability.
- Making available financial resources for the necessary transformation towards a circular economy – investment in the future viability of the company.
- Active participation throughout the entire company and across all levels of hierarchy.
- Building and promoting know-how and willingness to change within the company.
- Responsibility for the circular economy in top management.
- Taking end-of-life capability into account in development.
- Recording and reducing the carbon footprint of individual raw materials.
- Circular economy does not mean complete raw material supply from recycled materials.
- Long-term customer/supplier relationships help in the marketing of innovations; so do suitably addressed target groups.
- Starting on a small scale and taking the circular economy into account in work instructions, descriptions of functions.
- Customers and partners expect precise answers on the topics of circular economy and sustainability.
- Cooperations with partners within and outside a sector/an industry.

9.2

Checklist for action fields

CHECKLIST FOR ACTION FIELD 1: "APPROACHES TO RAW MATERIALS OF PRODUCTS"

- Does the R&D department have know-how on product development and process technology for the use of renewable and secondary raw materials?
- Are the development and purchasing departments prepared for procurement and development with secondary and renewable raw materials?
- Have development tests with alternative raw materials already been carried out?
- Is there a supplier network for secondary and renewable raw materials?
- Is attention given to local procurement?
- Is the CO_2 balance of individual raw materials known?
- Are there suitable infrastructure and operational logistics for secondary or renewable raw materials?

CHECKLIST FOR ACTION FIELD 2: "APPROACHES TO DESIGN AND MANUFACTURING OF PRODUCTS"

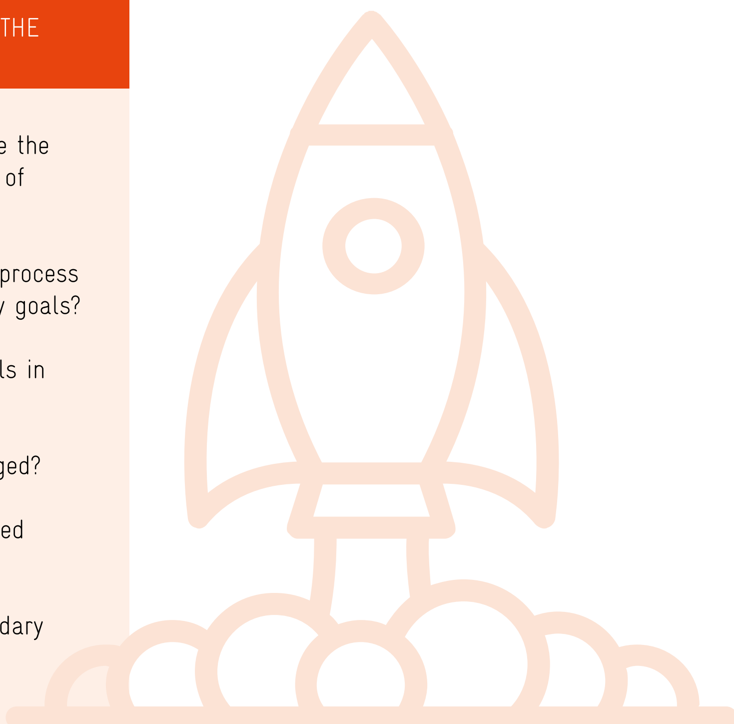
- Can alternative raw materials be processed in existing production plants?
- Can utilisation rates in production stages be improved?
- Are there options to produce required energy in own regenerative energy generation plants?
- Can rejects be collected and reused as raw materials?
- Is there the possibility of using energy storage facilities to store and reuse consumed energy?
- Can process technology be (further) optimised for more resource and energy efficiency?

CHECKLIST FOR ACTION FIELD 3: "APPROACHES TO PACKAGING AND TRANSPORT OF PRODUCTS"

- Can packaging be partly or completely switched to renewable or secondary raw materials?
- Is packaging already partly or completely made of recyclable materials?
- Are there awareness and know-how in procurement with regard to alternative packaging?
- Are there cooperations and partnerships in product packaging?
- Are there participations in packaging cycle systems?
- Can the CO_2 balance of the individual packaging be measured and improved?

CHECKLIST FOR ACTION FIELD 4: "APPROACHES TO OWN PRODUCTS AS ENABLERS OF THE CIRCULAR ECONOMY FOR CUSTOMERS"

- Can improving the product properties enhance the functional benefit for circular economy goals of customers?
- Can changed product properties optimise the process parameters of customers for circular economy goals?
- Can the share of recyclable or mono-materials in own products be increased?
- Can the life cycle of own products be prolonged?
- Are there options to reprocess rejects and used materials?
- Can rejects be collected and resold as secondary raw materials?



CHECKLIST FOR ACTION FIELD 5: "APPROACHES TO CIRCULAR ECONOMY FOR END-OF-LIFE SOLUTIONS FOR PRODUCTS"

- Is the end-of-life capability considered in the development?
- Beside product use, is the focus also on reuse of the product or recycling/recovery of potentially generated waste?
- Can used materials be returned and reprocessed/reused?
- Is the recycling of used materials considered in the development?

CHECKLIST FOR ACTION FIELD 6: "APPROACHES TO CIRCULAR ECONOMY WITH INNOVATIVE BUSINESS FIELDS"

- Can products with a closed loop-orientation be offered additionally or better through new digital distribution channels and run in cycles?
- Can raw materials with a closed loop-orientation be purchased additionally or better through digital platforms?
- Can benefit-oriented services (e.g. advice, minimisation of consumption, process optimisation, flat rate use) be offered additionally to product sales?
- Is there expertise in digital procurement and marketplaces?
- Can cooperations for packaging, materials or products be established or joined inside or outside a sector/an industry?
- Which rejects are generated and can these be raw materials for companies from other sectors/industries?

FURTHER PRACTICE TIPS

INITIATIVES AND ORGANISATIONS

Chemie³
www.chemiehoch3.de

Circular economy principles
https://www.umweltbundesamt.de/themen/uba-veroeffentlicht-leitsaetze-fuer-die-kreislaufwirtschaft

Circular economy
https://www.europarl.europa.eu/news/de/headlines/economy/20151201STO05603/kreislaufwirtschaft-definition-und-vorteile
https://www.bmwi.de/Redaktion/DE/Textsammlungen/Industrie/entsorgungs-und-kreislaufwirtschaft.html
https://www.umweltbundesamt.de/daten/ressourcen-abfall/abfall-kreislaufwirtschaft

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GLOSSARY

Reuse of products and recovery / recycling of waste

Reuse reflects the reuse approach where effort and materials are saved and no longer needed in one place but used elsewhere. This is broken down into reconditioning, refurbishment, retrofit and reusability. One speaks of recovery when the aim is to use wastes in their property as materials. In general language, material recovery is also called recycling.

Value chain

Value chain means the entire life cycle of a product, from the extraction of raw materials through the process of creation to delivery to end consumers and disposal at a later stage. Depending on the complexity of the product, value chains can include just a small number of companies while they can also comprise global networks of suppliers.

Sustainability

Sustainability is a principle of action which, in the long-term perspective, wants to create positive effects for the environment and society from one's own success-oriented business activities and to consistently minimise negative effects.

Circular economy

The circular economy is an economic model that aims to minimise or circularise the consumption of energy and resources along the value chain (instead of linear consumption).

Impurities

Impurities are materials and products that impair or prevent the proper recovery/recycling of waste.

Primary, secondary and renewable raw materials

Primary raw materials are natural resources. They are unprocessed – apart from the steps needed to extract them.

Secondary raw materials are raw materials that are obtained from disposed materials by way of recycling.

Renewable raw materials, so the definition, are products produced by agriculture and forestry that are not used as foodstuffs or animal feed but as materials or to generate heat, electricity or fuels.

However, the use of renewable raw materials does not mean that these raw materials are biodegradable at the end of the product's life.

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Königsworther Platz 6
30167 Hannover
www.igbce.de

Bundesarbeitgeberverband Chemie e.V.

Abraham-Lincoln-Straße 24
65189 Wiesbaden
www.bavc.de

CONCEPT, CONTENT AND DESIGN

Dr. Wieselhuber & Partner GmbH
Unternehmensberatung, München

Dr. Stephan Hundertmark
Partner, Head of Chemical
and Plastics Industry
hundertmark@wieselhuber.de

www.wieselhuber.de

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CHEMIE³

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