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CIRCULAR  
FOAM

# Rethinking Plastics

## Workbook on Sustainability Challenges, Circular Solutions, and Scenario Analysis



## Introduction

This workbook contains a series of three modules created within the context of the EU-funded research project “CIRCULAR FOAM – Systemic expansion of territorial CIRCULAR Ecosystems for end-of-life FOAM” (<https://circular-foam.eu/>). They are designed to support learning and training for scientific audiences from various disciplines at universities, including lecturers and students, and for practitioners in industrial settings. The modules can be worked through independently or consecutively. The first module gives a general introduction to sustainability science. It serves as a knowledge foundation, especially for the second module, which deals with the concept of circular economy as well as R-strategies, such as reduce, reuse or recycle. The last module delves into the qualitative scenario analysis, explains the method and gives an overview of how and where to apply it.

Further knowledge about those topics and concise examples can be found in the deliverables of the CIRCULAR FOAM project. Deliverable 1.5 applies the qualitative scenario analysis to the project scope and thus analyses the future of plastics recycling and possible circular systems for high-performance plastics, refrigerators and construction materials.

Whilst the Deliverables 1.1-1.6 predominantly contain regional and socio-economic analyses, quantitative environmental and economic analyses can be found in the Deliverables 7.1-7.8. Furthermore, other Deliverables delve deeper into aspects such as

chemical recycling, design and logistics, as well as economic exploitation of the results.

The contents of the modules were developed and applied in the context of the seminar “Future Skills” at the Ruhr University Bochum in Germany in the summer term of 2025 (for details see Deliverable 8.5<sup>1</sup>).

There are three types of boxes that can be found throughout the workbook and that provide additional information:



This box contains definitions and important details, notes and further information about the topic.



This box illustrates the topic and methods by giving exercises that can be done individually or in groups to deepen the understanding.



This box contains further literature to delve deeper into scientific research and current discussions on the topic.

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<sup>1</sup> Available at <https://circular-foam.eu/>

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## Sustainability Challenges of the Plastics Economy

Plastic materials, in technical language known as synthetic polymers, are a material class that has revolutionized the way products can be designed, produced and used, since their modern industrial development at the beginning of the 20<sup>th</sup> century (Rasmussen, 2018). Today, their production represents a significant aspect of the chemical industry and technology in modern society (ibid.), and thus, contributes extensively to the socio-economic development of countries worldwide.

Due to their diversely adjustable mechanical and functional properties, as well as high performance-cost-ratio, plastic materials are used in every consumer and industrial market, e.g. for applications in packaging, textiles, household appliances and everyday products, industrial machinery, electrical and electronic devices, transportation or building and construction (Stegmann et al., 2022).

Despite the technical and economic advantages of the plastics economy, there are several environmental challenges connected to the life cycle of plastics. For example, millions of tons of plastics in the form of macro, micro, and nano plastics are leaked into oceans and freshwater reservoirs, terrestrial environments, biological systems and food webs (Bank and Hansson, 2022; Ellen MacArthur Foundation et al., 2016). Furthermore, the plastics economy significantly contributes to global greenhouse gas emissions (GHG) that drive climate change, because they are, still to date, mostly produced using finite fossil resources, such as gas and oil, and often incinerated at the end of their life (EoL) (Bachmann et al., 2023). Unfortunately, only a small fraction of 5-20 %, significantly depending on the region, is recycled,

and often into lower-value materials and applications (Amadei et al., 2025; Sheldon and Norton, 2020).

Another dimension that exacerbates the challenges of the environmental sustainability issue is the expected future development and increase of plastic production, use and waste generation. On a global scale, Stegmann et al. (2022) estimate that the annual plastic production will more than double by the year 2050, and thus accordingly, the waste generation follows this trend. They also show, based on plausible scenario assumptions, that the majority of plastics in use will accumulate in the building and construction sector, where, among other engineering plastics, Polyurethane (PUR) rigid foam is used for insulation applications. Another look at the projected plastic use until 2050 was recently taken by Dokl et al. (2024), revealing that the European Union might be able to stabilize its annual plastic consumption at around 70-80 megatons (Mt) until 2050 assuming significant improvements in terms of recycling infrastructure, recycling technology and rates.



“1. Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

- the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and

- the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

[...]

3. Development involves a progressive transformation of economy and society. A development path that is sustainable in a physical sense could theoretically be pursued even in a rigid social and political setting. But physical sustainability cannot be secured unless development policies pay attention to such considerations as changes in access to resources and in the distribution of costs and benefits. Even the narrow notion of physical sustainability implies a concern for social equity between generations, a concern that must logically be extended to equity within each generation." (WCED, 1987, p. 41)

The short overview on the trade-off between the techno-economic advantages and environmental challenges of the plastics economy illustrates that the predominantly fossil-based business model of the plastics economy is highly unsustainable for the environment. This is why an increasing number of scientists, policymakers, NGOs and industrial initiatives alike call for more systemic and impactful changes. Exemplary for this, the industrial agenda "The New Plastics Economy – Rethinking the Future of Plastics" called for this already in 2016 and demanded "a new approach".



"To move beyond small-scale and incremental improvements and achieve a systemic shift towards the New Plastics Economy, existing improvement initiatives would need to be complemented and guided by a concerted, global collaboration initiative that matches the scale of the challenge and the opportunity. Such an initiative does not exist today, and therefore would need to be set up, driven by an independent coordinating vehicle." (Ellen MacArthur Foundation et al., 2016, p. 23)

The essential question remains, as was recently and distinctively formulated by the European Joint Research Centre (JCR, 2025): "Can the plastics sector become more sustainable?". A study by Amadei et al. (2025) investigated material flows for the whole value chain of plastics in the 27 EU member states in 2022 and showed that "incineration and landfilling still represent the dominant waste management options in the EU-27". Therefore, the JCR recommends the pursuit of key strategies for a circular plastic value chain:



"Improved plastic waste collection and sorting would reduce plastic losses to the environment, enhance recycling and ultimately promote a more circular value chain. The study highlights that the combination of mechanical and chemical recycling could prove fundamental. Chemical recycling, which currently makes up a negligible share of the sector, can in fact enable the management of materials that could not be recycled using other methods." (Joint Research Centre, 2025)

In summary, industrial agendas and roadmaps like “The New Plastics Economy” (Ellen MacArthur Foundation et al., 2016) or “The Plastics Transition” with ambitious goals such as “net-zero emissions by 2050” (Plastics Europe, 2024), in line with recent scientific studies show that the sustainability challenges of the plastics economy require more collaborative, transformative and systemic changes, in order to reduce the current and prevent the expected increase of environmental impacts until the year 2050.



### Academia and teaching

What research approaches are most critical for your discipline to develop sustainable alternatives or strategies concerning the life cycles and environmental impacts of plastics?

From your academic perspective, what are the most significant systemic barriers to achieving a more environmentally friendly plastics economy?

How can your research or teaching initiatives foster the necessary collaborative and transformative changes within your field or with other disciplines to address these barriers?

### Industry

How can your company leverage the technical advantages of plastics while innovating product design, material selection, and manufacturing processes to significantly reduce reliance on finite fossil resources?

If your company operates in the plastics economy, e.g., in high-volume and long-life cycle sectors, what specific engineering challenges and opportunities do the above-mentioned sustainability issues create?

How can your engineering department or technical team actively contribute to a more systemic shift for sustainability, e.g., within your company's strategies, operations, supply chain network, or product development?

What specific engineering solutions or process optimizations can your company implement to reduce its carbon footprint, and other environmental impacts, related to plastic production, use, or end-of-life management?



If you want to find out more about systemic approaches for the improvement of environmental sustainability, you can explore the following concepts and respective studies:

- Sustainable Development Goals (SDGs) (United Nations Department of Economic and Social Affairs, 2025)
- Planetary Boundaries and Health (World Economic Forum et al., 2025)
- Ecological Footprint and Overshoot Day (Global Footprint Network, 2025)

# Circular Economy and R-Strategies

## Circular Economy

Environmental sustainability challenges are fundamental to circular economy (CE) approaches, since CE strategies often aim to reduce natural resource consumption, minimize waste and emissions, or foster the recycling of matter and recovery of energy. Systemic circular solutions even extend beyond recycling and recovery, focusing on smarter product use and manufacturing, extending lifespans of products and its parts, and creating useful application of materials (Potting et al., 2017).

For the term “circular economy”, there are key concepts and approaches that have been proposed and investigated by academia and industry alike. From a systemic perspective, CE can be understood as the vision of an economic system that strives for a paradigm shift - replacing the linear end-of-

life (EoL) concept (cradle to waste) with a circular system that preserves the value of materials and products for as long and as highly as possible throughout the value chain. What is more, CE solutions should create, in line with sustainable development, a fair balance between economic interests, environmental protection and aspects of social fairness (Bachmann et al., 2023; Kirchherr et al., 2023).

A more holistic example for a CE concept that focuses on this systemic interplay is the Cradle to Cradle (C2C) concept by (McDonough and Braungart, 2002), which is visualized in Figure 2 (Müller, 2022). From the C2C perspective, the overall goal for material, product and system design is to strive for fully closed biological or technical material loops. On the left side, displaying the biological cycle, regenerative and eco-positive



In academia, the interest in CE has risen significantly, especially in between the years 2014 and 2024, as can be seen in this figure:

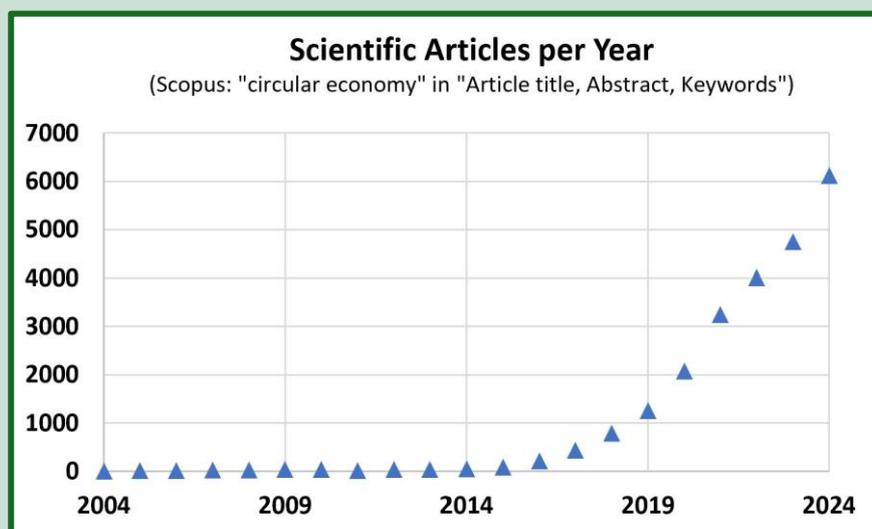


Figure 1: Scientific articles about circular economy between 2004 and 2024

processes should foster circularity throughout manufacturing and after consumption, until

the products become organic nutrients again. On the right side, the technical cycle requires more coordinated CE strategies and measures, e.g., for disassembly and separation, before product parts can be reused or technical nutrients can be recycled. Central motivations for both cycles are also, to prolong material and product lifetimes as effectively and efficiently as possible, as well as minimizing systemic leakage and environmental impacts, e.g. of toxic or hazardous substances or GHG emissions.

Furthermore, the role of the “consumer” or “user” differs significantly in alignment with the regenerative or technical business models. As part of the biological cycle, consumers ideally need to worry less about consuming and disposing of their green products, since they are for example designed as biodegradable nutrients or for biochemical processes without releasing harmful or unhealthy substances into the environment (Braungart et al., 2007). As part of the technical cycle, the users’ participation is crucial for collecting and sorting parts of the product or the entire product, in order to close the highly valuable material loops and for applying fitting CE solutions. For designers and engineers, this further requires rethinking material, system and product design by “remaking the way we make things” (ibid.) – products and processes need to be beneficial and positive, not only for the economy, but equally so for the environment and society.

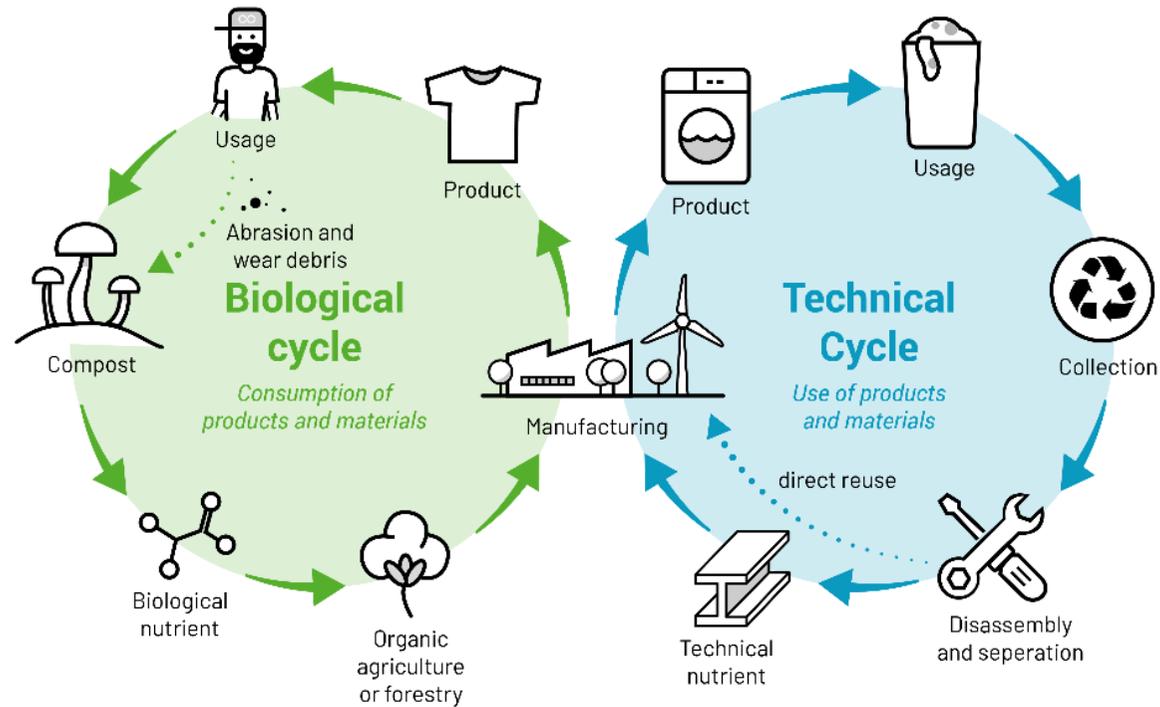


Figure 2: "Cradle to cradle", visualisation of a circular economy systems diagram (Müller, 2022, based on: Braungart & McDonough)

## R-Strategies

R-Strategies, such as reduce, reuse or recycle, have become established CE approaches that can help academia, consumers, companies and policymakers alike to tackle sustainability challenges and inspire them to find circular solutions. The R-strategy logic provides a low-threshold entry into CE concepts. It can, for example, invite you to rethink linear business models more fundamentally – like sharing or renting products instead of buying them. It can also help you to explore concrete ideas for circular solutions tackling specific sustainability challenges – like the reduction of plastic waste incineration through new recycling processes. Scientific and/or industrial development, implementation and evaluation of potential circular solutions can then build upon this and help you to investigate the sustainability issue more thoroughly.

The guiding question can be:

Which R-strategy fits best to solve your sustainability challenge, by means of smarter product use and manufacturing, extending lifespans of products and its parts, and/or creating useful application of materials (cf. Potting et al., 2017)?



If you want to dive deeper into the academic discussion of CE concepts and get a good scientific literature overview, you can consult the study “Conceptualizing the Circular Economy (Revisited): An Analysis of 221 Definitions” by Kirchherr et al. (2023), from which the following quote is taken:

“Consensus has grown regarding the core principles underpinning CE, with 70 to 80 percent of articles recognizing ‘reuse’ and ‘recycle’ as the two fundamental principles of CE, similar to the 2017 analysis. Most notably, an increasing share of definitions now also features calls for fundamental systemic shifts to foster CE transition. As such, CE seems less capable of being implemented through only incremental changes.” (Kirchherr et al., 2023, p.9)

A good starting point to better understand and select R-Strategies can be the policy report ‘Circular Economy: Measuring Innovation in the Product Chain’ (Potting et al. (2017). The authors developed a conceptual framework that evaluates the role of innovation in CE transitions and applied it to various hypothetical and practical cases, including plastic packaging and electrical and electronic equipment. A major result of the report is a list of 10 R-Strategies presented in a priority order, from high circularity (low R-number) to low circularity (high R-number), resembling the “Ladder van Lansink” for waste treatment (WasteOnline, 2022). The principle and main hypothesis of this framework is that more circularity generally leads to more environmental benefits.

The ranked R-Strategies have been grouped into three CE strategy categories. The first group “smarter product use and manufacture” of highest circularity priority comprises Refuse (R0), Rethink (R1), and Reduce (R2). The middle category consists of R-Strategies that “extend [the] lifespan of product[s] and

its parts” through Reuse (R3), Repair (R4), Refurbish (R5), Remanufacture (R6), and Repurpose (R7). The “useful application of materials” includes Recycle (R8) and Recover (R9), which are already well established industrial circular solutions to close material loops and recover thermal energy (Kirchherr et al., 2023). An excerpt from the R-strategy framework illustration by Potting et al. (2023, p. 5) can be seen in figure 3, also providing definitions for each of the strategies.



Have a closer look at the R-strategy framework by Potting et al. (2017). By the example of the case studies “plastic packaging” and “electrical and electronic equipment” (Potting et al., 2017, pp. 23–28) you can familiarize yourself with the R-strategy framework, and learn more about specific examples, like how to refuse or reuse plastic bottles as a consumer, or when to apply remanufacturing to refrigerators and freezers.

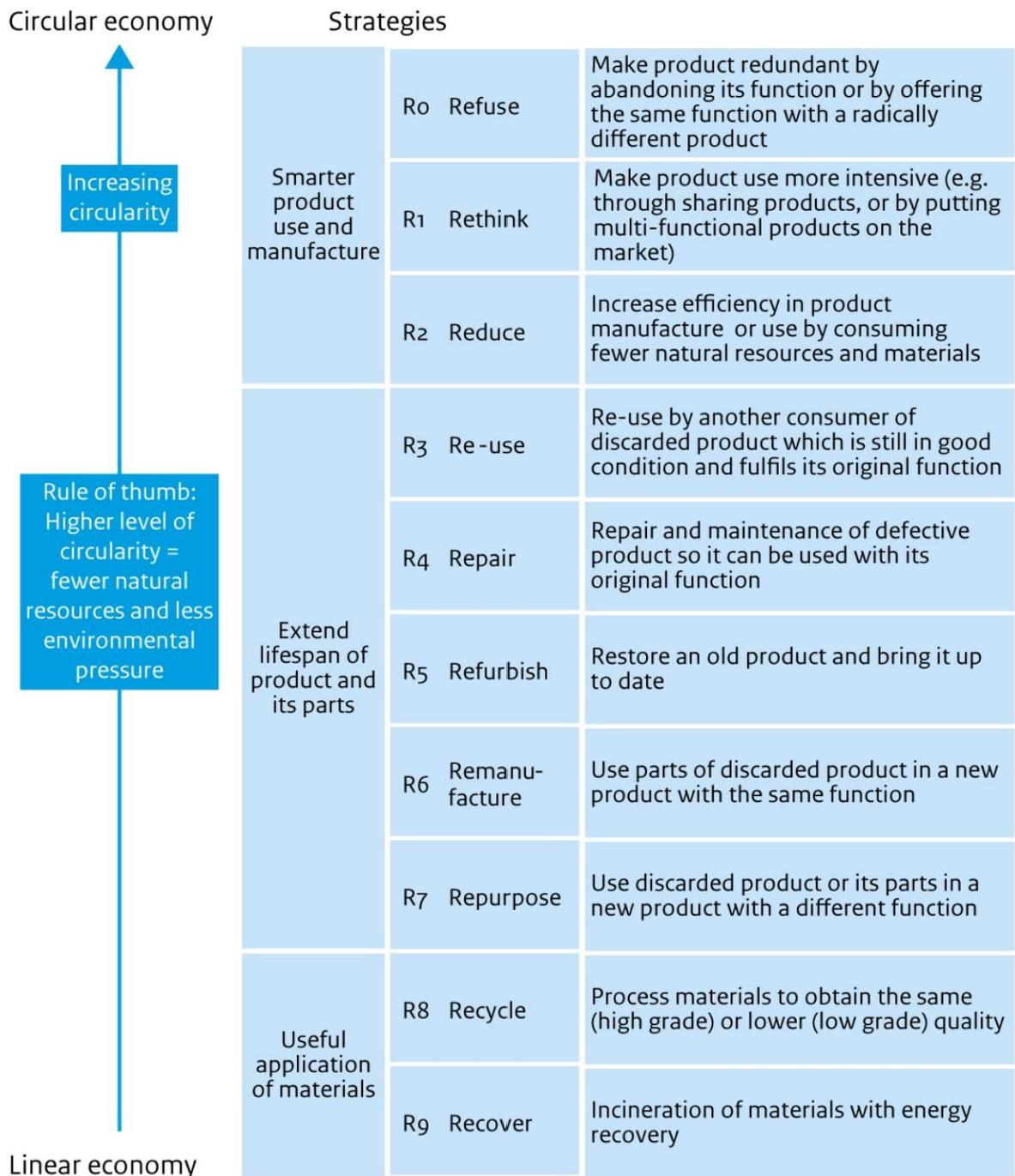


Figure 3: Circularity strategies within the production chain, in order of priority (Potting et al., 2017, p. 5)



### Academia and teaching

Considering the significant rise in academic interest in CE between 2014 and 2024, have you already worked on CE challenges in research projects, or have you used CE concepts and literature in teaching? Which aspects of investigating/ teaching CE are most challenging? Why?

What do you think about the following claim: “CE solutions should create, in line with sustainable development, a fair balance between economic interests, environmental protection and aspects of social fairness”? Do you agree? Don’t you? Please discuss from your disciplinary point of view, if a fair balance is achievable, and/or discuss possible trade-offs together with your team/students.

How can the Cradle to Cradle (C2C) concept, which strives for fully closed biological or technical material loops, be effectively used in educational settings to illustrate the differing roles of consumers and the specific design requirements for products in each cycle?

What types of case studies or practical exercises from your discipline, similar to the examples of "plastic packaging" and "electrical and electronic equipment" in Potting et al. (2017), come to your mind? Prepare and discuss fitting examples with your research team/ students applying the guiding question: "Which R-strategy fits best to solve your sustainability challenge?"

How can the academic community contribute to the interdisciplinary scientific development, implementation, and evaluation of potential circular solutions based on specific R-strategies, particularly those less commonly applied in industry, like "Refuse" (R0), "Rethink" (R1), and "Reduce" (R2)?



## Industry

How does your company currently interpret and implement "circular economy" approaches, particularly in striving to reduce natural resource consumption, minimize waste and emissions, or foster the recycling of matter and recovery of energy?

In what ways could your company's product design and manufacturing processes be re-evaluated through the lens of the Cradle to Cradle (C2C) concept to move towards fully closed biological or technical material loops? Is this idealistic concept applicable? If not, why? Which types of economic, environmental, or social challenges would you face, when you rethink your business model, or the materials and products you use/produce?

How is your organization addressing the challenge of involving consumers and users of products to ensure their participation for collecting and sorting parts to close valuable material loops? Do they benefit from your business model, maybe in an economic, environmental, or psychological way? If not, why, and how could you maybe change it?

What challenges or opportunities do you see in shifting from incremental changes in sustainability efforts to embracing more fundamental systemic shifts required for a comprehensive application of diverse R-strategies across your value chain?

Beyond established industrial solutions like Recycle (R8) and Recover (R9), how is your company actively exploring and implementing higher-priority R-strategies such as Refuse (R0), Rethink (R1), and Reduce (R2) to achieve "smarter product use and manufacture"?

Which r-strategies from the "extend lifespan of products and its parts" category – Reuse (R3), Repair (R4), Refurbish (R5), Remanufacture (R6), or Repurpose (R7) – offer the most significant potential for environmental benefits and economic value within your current product portfolio, and what steps are promising and feasible to integrate them?

If you produce or use high-value, complex, and/or engineering materials – such as advanced alloys, composites, or high-performance plastics/polymers – which R-strategy fits best to your material system and life cycle? Why? Which trade-offs and/or synergies do you see for the application of a specific R-strategy concerning economic, environmental, and societal sustainability goals of your company?

How do you and your company ensure that high-value materials are collected, separated and treated in a way that maximizes their material value retention and allows for high-grade recycling back into similar quality applications, rather than being downgraded to lower-value uses?

## Qualitative Scenario Analysis

Scenario analysis is a method used in different contexts and branches, such as the interdisciplinary field of future studies in the scientific context, or as a strategic decision-making tool in areas like crisis management, policy making and businesses. It can be classified as a transdisciplinary application field and future methods are gaining broad popularity and relevance due to the dynamic and rapidly changing global situation (Greeuw et al., 2000, p. 6; Bradfield et al., 2005, p. 796). The scenario methodology deals with anticipated structural developments in the future and their effects. There are many different approaches, definitions and techniques used, leading to a diversity of possible designs of the method tailored to specific topics (Bishop et al., 2007; Bradfield et al., 2005, p. 795; Gausemeier et al., 1998; Kosow & Gaßner, 2008, p. 9, 18; van Notten et al., 2003, pp. 424).



A scenario is a plausible, reasonable and possible depiction of the future. Scenarios do not claim to be predictions, self-fulfilling or complete. The focus is not only on a plausible image and the systematic way to get there, but on several alternative paths and images that should be outlined and justified. It shows alternative development options and provides decision rules.

Therefore, the objective of the scenario methodology is to describe several possible developments up to a specific point in the future. (Geschka & Schwarz-Geschka, 2012, p. 3; Kosow & Gaßner, 2008, p. 9).

### Approaches: Qualitative vs. Quantitative vs. Mixed

There are different approaches that can be used to develop scenarios, causing the absence of a singular, universally applicable approach. A basic distinction is made between systematic-formalized and creative-narrative approaches. The former clearly defines the key factors and then varies and combines them to open the scenario funnel and develop the scenarios. All influencing factors of the topic are identified to compare the individual factors and consider their interaction. In this way, the mutual relationship is determined for each pair. This approach is also known as the model-based approach, as it is often used with the aid of supplementary software. Classic techniques of this approach are the influence analysis, consistency analysis and cross-impact analysis (Kosow & Gaßner, 2008, pp. 38; van Notten et al., 2003, p. 427).

The creative-narrative approaches are grounded in intuitive logic and depict scenario development as a process driven largely by creativity and participants' knowledge. After all, creativity and techniques such as brainstorming are valuable and important components of serious future thinking (Pillkahn, 2008, p. 190).

At the same time, a scenario funnel is also applied to the formalized characteristics of the key factors. In this context, creative techniques and implicit knowledge are intentionally employed. The process is designed as a participatory approach, adhering to the

same fundamental principles as the systematic-formalized approach. Common techniques used in this method include intuitive logics and normative-narrative scenarios.

In the design practice of the scenario process, however, it should be noted that the boundaries between the two approaches are fluid. The concrete design of the individual analysis is rarely ideal-typical, and techniques of one approach can be more formalised, or techniques of the other can be developed more creatively, creating a mixed approach.

There is a variety of approaches and techniques that can be chosen to carry out a scenario analysis. This is because the scenario process must be individually adapted to the situation at hand and the research question to be answered, which is why there can be no universally valid and applicable approach.

This choice is based on three parameters that are essential for the process design: The objective of the project, the available resources and the content to be achieved (Bradfield et al., 2005; Kosow & Gaßner, 2008, pp. 61).



An overview of possible techniques and tools in more qualitative or quantitative settings can be found in:

Kosow, H., Gaßner, R., 2008. Methods of Future Scenario Analysis. Overview, Assessment, and Selection Criteria. [https://www.idos-research.de/uploads/media/Studies\\_39.2008.pdf](https://www.idos-research.de/uploads/media/Studies_39.2008.pdf).

## Purpose of Scenario Analysis

The scenario analysis systematically examines possible consequences for the present. Its aim is to explain transformation processes and to support the perception and understanding of change. Furthermore, it explores the potential for change through specific actions and the opportunities to influence emerging trends.

It is based on a set of different influencing factors and outlines possible future scenarios depending on certain assumptions. These scenarios take into account expected developments, uncertain changes, and new influences that may come into play. As a result, it does not offer a complete picture of the future, but rather insights into specific, particularly relevant aspects of it.

A scenario analysis can serve various purposes. It is important to consider the different alternatives before undergoing the analysis to concretise the process and shape the research design in a concise manner (van Notten et al., 2003, pp. 426).

Four main functions of scenario creation can be identified (Kosow & Gaßner, 2009, pp. 18):

- Explorative and/or scientific function
- Communicative function
- Target concretisation and creation function
- Decision-making and strategy formation function

Firstly, scenario analysis can support in the conception and understanding of the research topic as it helps to identify limits of knowledge like insecurities, gaps and complexity and explains processes of change. It can explore possibilities of intervention and avoidance of potential catastrophic impacts

of influencing factors. Therefore, it deepens the knowledge and reveals the limits of that knowledge. Scenarios can be created as part of a communication process and serve as a tool to support the understanding of a topic or problem for a diverse group. They can also enhance communication and information and that way expand the understanding. The third function of scenario analysis is to support the development and concretization of specific goals that should be aimed for or kept in mind. They can serve as a tool to develop normative ideal images of the future or to help reflect about the desirability of future developments. Lastly, scenario analysis is a tool that can be integrated into decision-making and strategic planning processes as it helps to identify limits of knowledge and decrease uncertainty and complexity. It creates concise alternatives for taking action and identifies possible risks and possibilities.

Qualitative scenario analysis is often transdisciplinary and includes relevant stakeholders in the process. This enriches the analysis and increases the robustness of the possible scenarios created.

One limit of the qualitative scenario analysis is that it generally does not create forecasts or prognoses, because it aims for the creation and description of alternative futures in an imaginable space from the present to a certain point in the future. Independent of the chosen approach, to some extent the scenario analysis always includes subjective decisions.



### **Identify a research topic and reflect on the purpose and limitations of qualitative scenario analysis.**

#### Step 1: Identify Research Topic

Think of a specific research topic for qualitative scenario analysis (e.g., climate change, digitalization, healthcare).

#### Step 2: Define Purpose

Note down three goals you want to achieve with scenario analysis (e.g., identifying knowledge gaps, exploring intervention possibilities).

#### Step 3: Reflect on Limitations

Consider which subjective decisions you will need to make and how you can make them transparent. Briefly discuss how involving stakeholders can increase the robustness of your scenarios.

#### Step 4: Practical Implementation

Develop an example of how you can use the results to avoid negative impacts. Create a short list of intervention possibilities.

## Scenario Cone of Plausibility

Scenarios are design work and are based on hypothetical assumptions. A common depiction of the scenario analysis is the cone of plausibility, also called funnel.

This approach assumes that systematically looking into the future creates a space of possible future developments. As the time horizon extends, the number of potential outcomes increases, causing this space to expand in a cone or funnel shape. Examining the development possibilities from a specific point, considering the various factors or aspects that shape the research topic, reveals that these possibilities become increasingly diverse as the time horizon extends. Individual factor-related funnels emerge for each influencing factor (Figure 4, left graphic). These factor-related funnels constitute the common space of possible futures for the research topic. This is represented by the scenario funnel, with the funnel's boundaries delineating the limits of the possibilities (Figure 4, right graphic).

The scenario methodology looks at the scenario funnel at a specific point in time.

Various characteristics or courses of the factors up to this point in time are selected, combined and condensed into scenarios. The selection of factors and their characteristics depends on the research project's interest in knowledge.

The scenario cone, which shows the range of possible future developments, is spanned along the extreme scenarios, which display the limits of the possible future developments in the most positive (desirable) and negative (undesirable) manner.

In general, there are almost infinite pictures of the future that can be created within the scenario analysis. Typically, the number of scenarios is held rather small to keep the analysis manageable. In the literature the number of scenarios varies, but it is generally recommended to keep it between 4 and no more than 10, unless the research topic itself specifically requires more (e. g. if it is highly complex and highly uncertain or the goal is to create a broad range of different scenarios for a specific purpose). The number should not be less than four as having only three scenarios creates the risk of orientation towards the middle scenario. Two scenarios appear as two extremes, one positive and one negative, which leaves only little space for creativity and open discussion on the

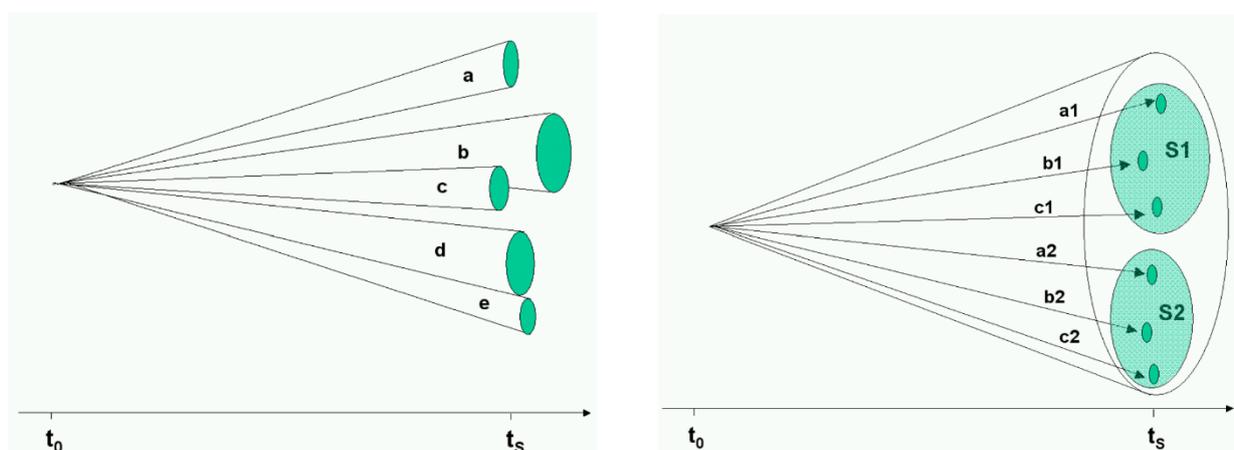


Figure 4: Factor-related funnel and scenario funnel (Kosow & Gaßner, 2008, pp. 15)

research topic. Creating only one scenario will make the scenario appear like the most likely scenario (Pillkahn, 2008, pp. 200).



Additional introductions to the concept of future and scenarios can be found here:

“How to navigate our uncertain future” by April Rinne at TEDxFrankfurt (06.01.2020):

<https://www.youtube.com/watch?v=mlzyH8kodCs>

“Coping With Uncertainty” by MindToolsVideos (28.10.2019):

<https://www.youtube.com/watch?v=S3CU2kOBt3s>

“Futurist Peter Schwartz on planning for the unthinkable” by INSEAD (27.04.2012):

[https://www.youtube.com/watch?v=hzEVNeIH\\_Z4](https://www.youtube.com/watch?v=hzEVNeIH_Z4)

## Phases of the Scenario Analysis

In general, the scenario process can be divided into five phases, which are designed using different techniques depending on the approach taken (Figure 5; Gausemeier et al., 1998, pp. 115; Kosow & Gaßner, 2008, pp. 24).

In the first phase, the scenario field is defined by identifying the object of study and establishing the boundaries of the analysis. This step outlines what the created scenarios aim to explain and defines the object of research and the topic delimitation for the development of the scenarios as well as the limitations for the scenario analysis. In addition, the scope of the scenario analysis is defined, which concretizes the project. The perspective to be adopted regarding the investigation is determined: In a closed design field such as an organization, primarily internal factors are relevant. An environmental perspective focuses primarily on external factors such as environmental influences, while so-called system scenarios examine the interrelationships between the two types.

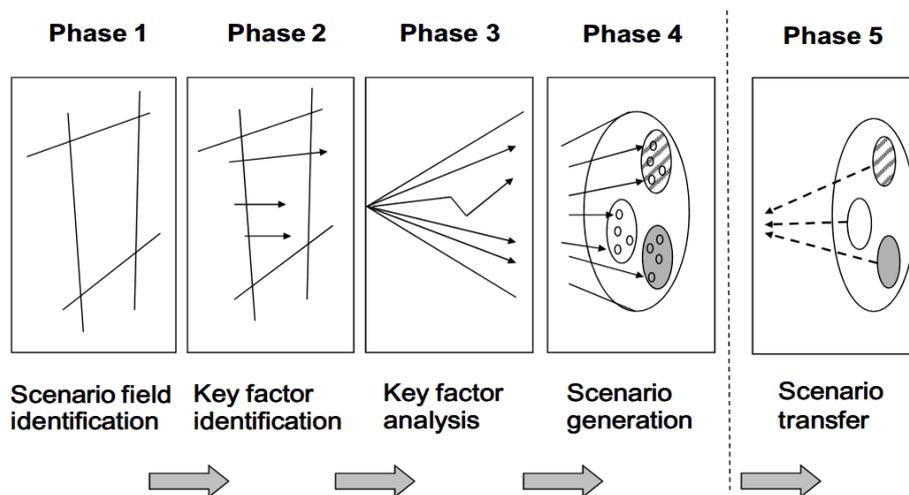


Figure 5: Five phases of the scenario analysis (Kosow & Gaßner, 2008, p. 25)

It is important to choose a concrete and unmistakable topic with a clear definition, which emphasises the need for a precise description of what the scenarios should explain.

**EXAMPLE**

Exemplary topics in the context of this workbook could be:

- The future of plastics recycling - A sustainable circular system for high-performance plastics
- The future of plastic waste management in urban areas,
- Circular business models for the fashion industry,
- Food waste reduction in households.

In the second phase, key factors are identified that describe the scenario field and have an impact on it or with which the field has an external impact. They represent the central consideration during the process and can be trends, variables, parameters, developments or even events. They can be identified with the help of in-depth desk research or also in a participative manner such as expert interviews, which can also be used for external validation of desk research findings. There are also numerous other techniques which may be feasible, depending on the object of the scenario analysis.



Another useful tool is the PESTEL analysis. It is an environmental analysis that identifies influencing factors based on six categories, which give the analysis its name: political, economic, socio-cultural, technological, environmental-geographical, and legal (European Commission, n. d.; Karadzhov & Patarchanova. 2025; Kaufmann, 2021, p. 19).

It can support the collection and systematisation of factors in the process of this phase (Wegener et al., 2025, pp. 27).

It is crucial to reduce all possible influencing factors of the topic to a manageable number of the most important influencing factors, which are called key factors. A possible method to achieve this is by using a Wilson matrix, which will be introduced in the following chapter. The key factors are those factors which are most important for the future development of the research topic and are the most unpredictable ones regarding the possibilities of future development (Pillkahn, 2008, p. 202).

**EXAMPLE**

In the context of the future of plastics recycling in the EU, plausible key factors can for example be: global responsibility and coordination (political factor), development of digital services and data availability (economic factor), awareness for circular economy (socio-cultural factor), design for circularity (technological factor), importance of ecological transformation for companies (environmental-geographical factor) and financial incentive systems for collection (legal factor).



An in-depth scenario analysis on “The future of plastics recycling – A sustainable circular system for high-performance plastics” with all necessary steps for the conduction of the analysis can be found in: Wegener et al.. 2025.

In the third phase, the key factors are analysed further, and their possible future characteristics are recorded. The focus here is on determining and describing the characteristics. This step is carried out in different ways

in the literature and always includes intuitive and creative aspects for imagining various future developments: Desk research and interviews are broadly used but also creative-intuitive approaches such as brainstorming techniques are possible. Expert interviews can be carried out to validate the findings. The goal of this phase is to identify possible developments of each key factor, which are called characteristics, projections or variations.

**EXAMPLE**

In the context of the future of plastics recycling, the importance of ecological transformation for companies may be considered a low priority in the future, resulting in a “service by the book” approach, which can be considered the first projection. Alternatively, this key factor could be given high priority, prompting companies to take on the role of pioneers and change agents – projection 2.

Scenarios are now developed and condensed during scenario generation in phase four. Here, in addition to the identified key factors, their characteristics are also systematically presented. This involves the creation of consistent factor bundles, for which one characteristic of each key factor is combined in a systematic manner to consistent and possible scenarios. The aim is to create different scenarios, which are inherently consistent but diverse between the different scenarios, illustrating the funnel of the scenario analysis. This phase concludes the scenario analysis in a narrower sense and can be done using a morphological field, which illustrates the analysis and gives an organised overview on the key factors and its projections.



“The general morphological analysis (GMA) is a method for systematically structuring and analyzing the total set of relationships contained in multi-dimensional, non-quantifiable problem complexes.”

Parameters are identified and defined, and a range of relevant values or states are assigned creating a morphological field as the parameters are set against each other in a table format.

In context of scenario analysis, it can illustrate the key factors and their projections and help examining all the configurations that are plausible, consistent and important (Ritchey, 2009, pp. 1; Ritchey, 2001, pp. 83).

Parameter A	Parameter B	Parameter C	Parameter D
Condition A1	Condition B1	Condition C1	Condition D1
Condition A2	Condition B2	Condition C2	Condition D2
Condition A3	Condition B3	Condition C3	
Condition A4		Condition C4	
		Condition C5	

Figure 6: Morphological field (Ritchey, 2009, p. 3)

The fifth phase is optional and represents the scenario transfer. It is therefore not directly part of scenario creation but is the further use or processing of the generated scenarios. It can help fulfil different functions that the scenario analysis should meet and can be used as a communication tool to further transfer, explain and help permeate the

different scenarios. Possible designs of the transfer can be illustrations, narrations or videos. Qualitative scenario transfer is conducted in a creative manner.



Demonstrative illustrations of possible scenario transfers can be found here: Friedrich-Ebert-Stiftung, Global Future and International Organization for Migration. Tomorrow's World of Migration. Geneva, Switzerland: FES, Global Future, IOM, 2017.



**Apply the phases of the qualitative scenario analysis to a manageable topic.**

#### Step 1: Determine the Scenario Field

Topic: Choose a small, manageable topic. Set the Scope: Determine the perspective (internal, external, or system factors) and the time frame for your analysis.

#### Step 2: Identify Key Factors

Identify the critical factors of your topic using a desk research, expert interviews and PESTEL-Analysis.

#### Step 3: Analyse Key Factors

Based on your research and interviews, describe possible future characteristics of the key factors. You can also use brainstorming techniques to imagine various future developments and conduct a joint expert workshop to validate and refine your findings.

#### Step 4: Generate Scenarios

Use a morphological box to systematically combine key factors and their characteristics and select a manageable number of scenarios (e.g., 2-3) that represent the most plausible and relevant futures.

#### Step 5: Transfer

Based on your scenarios, outline possible measures or recommendations for your topic.

Reflect on how the scenarios can be used to inform decision-making or strategy development.

## Minimal, Standard and Maximum approach

According to Pillkahn (2008, pp. 200), there are different approaches that can be undertaken for scenario analysis: Minimal Approach, Standard Approach, and Maximum Approach. They represent increasing levels of methodological depth and structural diligence in strategic scenario planning. Each approach suits different levels of complexity, available resources, and desired depth of analysis, ranging from low-complexity, resource-efficient methods to highly sophisticated, research-driven procedures.

The **Minimal Approach** represents the most streamlined form of scenario analysis, focusing exclusively on the essential steps necessary to generate preliminary insights. It is typically applied in situations where time and resources are limited, or when the objective is to gain a quick orientation within a volatile or uncertain strategic environment.

In this approach, only the most critical influencing factors are identified and used to formulate a small set, often only consisting of two uncertain factors. Techniques employed include rapid desk research, short and focused expert workshops, simple qualitative projections and a four-quadrants matrix. While this method sacrifices granularity for speed and efficiency, it can be highly valuable as an entry point into more elaborate scenario work.

The **Standard Approach** typically begins with the systematic identification and analysis of key factors and uncertainties, which typically range between 3 to 8 uncertainties. The scenario development process often yields multiple plausible future configurations that are still manageable, including not only extreme outcomes but also intermediate possibilities. Methodologies such as matrix-based scenario building like a Wilson matrix, morphological analysis, interdisciplinary expert panels, and structured workshops are commonly used. The Standard Approach is particularly suitable for applications in corporate strategic planning, public policy design, and other decision-making contexts where moderate complexity and uncertainty must be addressed without embarking on a fully resource-intensive research design.



A widely used tool for the standard approach is the Wilson matrix (Pillkahn, 2008, p. 202).

Each influential factor is evaluated according to its degree of uncertainty regarding the continued development and the possible impact of the factor on the potential development of the topic.

The factors with a high degree of uncertainty and a high degree of impact are especially important. They are considered “critical factors” and become the key factors of the analysis. Factors with high impact but low uncertainty are considered certain factors and are the same for every scenario that will be created. Irrelevant factors have a low impact and can vary between a low and a high degree of uncertainty. They are also the same for every scenario.

The Wilson matrix can be used in participative settings to identify the key, certain and irrelevant factors and as a general visualisation tool.

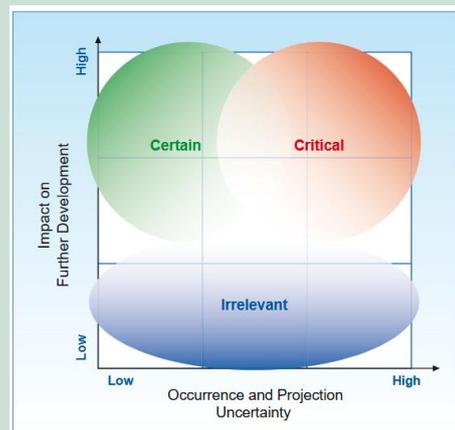


Figure 7: Wilson matrix (Pillkahn, 2008, p. 202)

The **Maximum Approach** represents the most methodologically rigorous and resource-demanding form of scenario analysis. It is generally reserved for contexts that demand high precision, comprehensive coverage of uncertainties of usually more than 8 uncertain factors, and the capacity to model complex interrelationships such as large-scale policy frameworks, high-stakes corporate strategies, or research-driven foresight

projects. Here, the analytical process encompasses a broad set of phases: identifying relevant factors, performing dynamic system modelling, analysing cross-impacts, and iteratively refining scenarios through multiple expert workshops. Quantitative methods such as cross-impact analysis, consistency analysis, Wilson matrix, morphological analysis are frequently combined with qualitative expertise. The result is a set of robust scenarios that not only capture extreme possibilities but also reflect nuanced, multi-dimensional developments. This approach facilitates early detection of weak signals, the exploration of systemic risks, and the identification of resilient strategies under conditions of profound uncertainty.

These three approaches provide a versatile methodological spectrum, enabling analysts to align the scope, depth, and complexity of their scenario analysis with strategic needs, resource availability, and decision-making context. While the Minimal Approach prioritises speed and feasibility, the Standard Approach balances practicality with analytical richness, and the Maximum Approach delivers the highest level of methodological robustness at the cost of substantial resource investment.



Reflect on a recent strategic decision or planning challenge in your organization, research or daily life. Identify which scenario approach would be most suitable, and explain your choice based on context, available resources, and the complexity of uncertainties involved.

Which factors led you to select this approach, and how could the scenario analysis process improve decision quality in your specific case?

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