Interreg
Danube Region

Co-funded by
the European Union

Plan-C

Guideline for circularity in plastics industry

Deliverable D.1.2.5

Responsible Partner: Plastr & Omnipack / DBH

PURPOSE & PREFACE :

Any circular solutions (including those proposed within the Plan-C project) are already in the EU in their essence limitedly declared by a set of legislative measures in the form of valid or currently negotiated directives and regulations. At the same time, the JRC (EU Join Research Center) together with the European Commission is gradually publishing sets of delegated acts and its own guidelines, which are intended to serve to better orient a specific company in the requirements and obligations.

However, these guidance documents are not completely and sufficiently specific, especially from the perspective of transparency for SMEs. Therefore, this step and point was also incorporated into the concept of the Plan-C project, the aim and purpose of which is to define, characterize and further disseminate GUIDELINES for companies in an appropriate manner with the ultimate goal of unifying, optimizing, streamlining and shortening innovations in the field of developing circular solutions.

Basic EU documents defining the conditions for sustainable and circular solutions:

The main and basic document valid in the EU is the Regulation (EU) 2024/1781 of the European Parliament and of the Council of 13 June 2024 establishing a framework for the setting of ecodesign requirements for sustainable products, amending Directive (EU) 2020/1828 and Regulation (EU) 2023/1542 and repealing Directive 2009/125/EC. Here and in subsequent EU documents, the basic aspects are described that should always be observed in any design of a circular and sustainable project in companies and chains of companies:

- **durability;**
- **reliability;**
- **reusability;**
- **upgradability;**
- **repairability;**
- **the possibility of maintenance and refurbishment;**
- **the presence of substances of concern;**
- **energy use and energy efficiency / water use and water efficiency;**
- **resource use and resource efficiency;**
- **recycled content;**
- **the possibility of remanufacturing;**
- **recyclability and/or the possibility of the recovery of materials;**
- **environmental impacts, including carbon footprint and environmental footprint;**
- **expected generation of waste.**

All the above aspects of circular solutions (projects) should be monitored and evaluated from the perspective of the final impact.

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For this purpose, this document has been developed, which formulates guidelines for SMEs and describes a set of relevant good practice examples that SMEs will use as exemplary (indicative) examples.

CONTENT :

I. Circular solution-innovation categories

A systematic categorization of approaches and affected areas with the greatest positive impact on achieving circular goals was published by the European Commission in 2021.

Circular solutions, also known as circular economy solutions, are categorized by their focus on resource efficiency and waste reduction, with a core principle of keeping materials and products in use for as long as possible. These categories broadly include design and production innovations, use and life extension strategies, and waste management approaches.

There are commonly accepted Four Pillars on Circular Solution´s as published by *Plastic Recyclers Europe – Ann.Report - 2024 EU key figures* – source:

1st PILLAR : **RECYCLABILITY :** Maximum support for products capable of multiple recycling X Conversely, banning products that are difficult or not recyclable at all

2nd PILLAR : **RECYCLED CONTENT :** Mandating mandatory recycled content in product groups - especially for packaging materials with the exception of food-contact

3rd PILLAR : **REUSE :** It mandatorily determines the product groups and the materials contained in them that must be used in a circular/repeated manner.

4th PILLAR : **COLLECTION :** To achieve circular solutions, the cornerstone of success is mainly the setting up of collective and other collection and sorting systems for plastic waste.

These 4 pillars are inseparable from each other and the outlined effects can only be achieved by combining them, interconnecting them and combining them.

CATEGORISATION SYSTEM FOR THE CIRCULAR ECONOMY published by European Commission in details is available and well well understood HERE :

categorisation_system_for_the_ce.pdf

II. Necessity of preparation - input data

From the perspective of the manufacturer (SME), preparation for the implementation of a "circular solution" is essential. Preparation means a CORRECT UNDERSTANDING OF THE PRINCIPLES AND UNDERSTANDING THAT THE PRINCIPLES ARE NOT SEPARATE FROM EACH OTHER - see above. This internal analysis can be carried out through and using the models for the Design Thinking Workshop DTW). At the same time, the SME is expected to manage and implement the project with awareness and understanding of all the objectives of the Circular Economy and with knowledge of the relevant legislation :

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The DTW phase was part of the Plan-C project in previous stages and the sequence of steps can be used for any other, different, similar project.

» creative & defining intention phase «

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Nowadays, AI modules can be very advantageously used to assess the connections and links to legislation, as they are capable of relatively comprehensively and truthfully compiling information on a specific product category - meaning in relation to legislation, standards and other documents.

» mapping of external environment and requirement s«

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Last but not least, SMEs must understand and quantify not only the proposed circular solution, but also the existing solution and status within industrial production, services, market position, etc. It is also necessary to assign parameter values that have an impact on the main monitored pillars to the existing status/solution, as mentioned above.

» mapping of internal environment and capabilities «

III. Working with a guidelines & Factsheets

In the context of the above, case studies of good practice are subsequently presented in Chapter VI and can be systematically classified into four categories according to the basic pillars for a correct circular solution:

PILLAR OF THE CIRCULAR SOLUTION PROPOSED :	Germany	Romania	Austria	Moldovia	Slovakia	Hungary	Serbia	Bosnia i Herzegovina	Czechia
1ST - RECYCLABILITY									
2ND - RECYCLED CONTENT (BIO sources)									
3RD - REUSE									
4TH - COLLECTION									

From the perspective of greater impact detail, the guidelines described below (chapter IV) can then be processed into this impact map :

THE MAIN FOCUS ON :	Germany	Romania	Austria	Moldovia	Slovakia	Hungary	Serbia	Bosnia i Herzegovina	Czechia
Recycled plastics USE in the formulation and production :									
ReUSE of End-of-Life products and their new utilization :									
BioBased material use (compostability) :									
Reduction of the raw material use (lightweighting) :									
Waste reduction ref to the landfil restrictions :									
R&D support, Building Circular Economy Infrastructure :									
Reduction of the energy consumption (electricity, water, gass etc.) :									
Acceleration of the innovation cycle / business support :									

- the main, strongest impact
- related and/or subsequent impact
- additional impact

IV. Basic rules for prototyping

Here are the basic rules to follow when designing a prototype:

1. Understand Your Idea Thoroughly (Problem, Goal, Target Audience, Hypotheses)

- Define the Problem: Clearly articulate the specific problem the prototype is meant to solve. For instance, addressing hazardous plastic waste sludge, single-use plastics, inefficient polymer foam waste management, the high carbon footprint of petroleum-based plastics in robotics, overwatering houseplants, or discarding valuable production material.
- State the Goal/Purpose: Establish what the prototype aims to verify or demonstrate. This could be verifying material processing principles, demonstrating a sustainable alternative to fossil-based foams, showcasing the feasibility of bioplastics in industrial applications, validating a smart watering can concept, or repurposing high-quality materials into new valuable products.
- Identify the Target Audience: Pinpoint who will benefit from the prototype's solution. Examples include recycling plants, packaging companies, robotics manufacturers, plant owners, the plastics industry, construction professionals, or existing and eco-conscious customers.
- Formulate Hypotheses: Define specific statements to be tested and validated by the prototype. These relate to material composition, processability, mechanical strength, economic viability, environmental superiority, or user acceptance.

2. Define Core Functionality and Necessary Features

- Outline Core Functions: Determine the essential capabilities the prototype must possess to achieve its goal. This might include properties suitable for technical applications, high mechanical performance, shock absorption, lightweight structure, or waste reduction.
- Identify Necessary Features: Specify the characteristics required to deliver the core functions. Examples include processability with conventional technologies, moldability, sufficient compressive strength, precision engineering, a built-in sensor, or quality assurance mechanisms.
- Consider Future Additions: Think about functions that could be integrated in later iterations, allowing for a focused initial prototype while planning for growth. This could include color customization, fire retardancy, smart material integration, app integration, or a mentorship program.

3. Select Appropriate Technology, Materials, and Inputs

- Choose Technologies/Tools: Identify the methods, platforms, or equipment needed for prototyping. This can range from laboratory and test plastics technologies and compression molding to 3D printing or AI-powered 3D modeling software.
- Select Suitable Materials: Determine the best materials for the prototype, often prioritizing recycled or bio-based options in the context of circular economy. Examples include waste

sludge, industrial hemp fibers, mycelium cultures, PLA/PHA bioplastics, recycled plastic from the Yellow Bag, or thermoplastics like PLA/PETG.

4. Define the Type of Prototype (Fidelity Level)

Determine Fidelity: Decide whether a low-fidelity (e.g., sketches, wireframes, paper models) or high-fidelity (e.g., functional models, interactive mockups) prototype is appropriate for the current stage. Low-fidelity is often for early conceptualization and testing ergonomics, while high-fidelity is for demonstrating real material behavior and functional performance.

5. Plan a Comprehensive Testing Strategy¨

- How to Test: Outline the methods for evaluating the prototype. This includes mechanical property tests, pilot testing with companies, laboratory drop tests, dynamic robotic testing, user testing, or virtual simulations.
- Metrics and Feedback: Define what will be measured and how feedback will be collected. Examples include comparison with traditional materials, cushion curves, weight reduction, user satisfaction surveys, waste reduction rate, or funding success rate.

6. Establish an Iterative Development Process

- Post-Prototype Steps: Detail the actions to be taken after the initial prototype and testing. This typically involves analysis of results, redesign, optimization, and production of next iterations.
- Feedback Integration: Describe how feedback from testing and stakeholders will be used to refine the prototype. This ensures continuous improvement, addressing identified weaknesses and enhancing performance.

7. Incorporate Circularity and Sustainability from the Start

Impact Assessment: Evaluate how the prototype contributes to circularity, sustainability, and circular economy requirements. This includes considerations like using recycled materials, reducing consumption of primary raw materials, lowering carbon footprint, enabling biodegradability, facilitating reuse and upgrade, and promoting efficient resource use. This focus on circularity often forms a core part of the value proposition for these solutions.

V. Choice of prototype design

Based on the information in the demo-realized prototyping , here are key considerations for a business model, as demonstrated by the prototypes:

1. **Problem Solved and Value Proposition: A business model begins with identifying a specific problem and offering a solution that provides significant value.**

Examples: Using plastic waste sludge that is currently hazardous and expensive to dispose of to create building elements. Addressing the overwhelming presence of single-use plastics by offering biodegradable hemp-based alternatives. Tackling the low use of recycled materials in packaging and inefficient polymer foam waste management with mycelium-based foams. Reducing the environmental impact and energy consumption in robotics by using lightweight bioplastics. Solving overwatering issues for indoor plants with a smart watering can. Repurposing high-quality production waste into new valuable products. Enhancing energy efficiency in buildings with modular insulation panels from recycled plastic. Facilitating access to funding and collaboration for circular economy projects.

2. **Target Audience: Clearly defining who will benefit from and purchase the product or service is essential.**

Examples: Recycling production plants and manufacturers of technical plastic parts. Companies in the packaging industry, eco-conscious startups, public institutions, and end consumers. Packaging manufacturers, logistics companies, and product designers seeking eco-friendly alternatives. Robotics manufacturers, automotive sectors, and R&D teams. Plant owners, smart home enthusiasts, and environmentally conscious consumers. The plastics industry, machine industry researchers, and research institutions. Construction professionals, architects, building owners, environmental experts, and investors. Existing customers, eco-conscious customers, and companies seeking uniform product lines. Researchers, SMEs, and policymakers in the circular plastics sector.

3. **Economic Viability and Cost Considerations: The ability for a solution to be economically feasible is a recurring theme.**

Insights: Prototypes aim to prove that technology is reliable and effective, materials can be economically viable to produce, and recycled materials can be cheaper than new raw materials, leading to lower production costs. Cost analyses are performed to ensure commercial viability. The FOGGARA watering can example specifically mentions the need for a "cost-effective, scalable prototype" for crowdfunding and direct online sales. Solutions can lead to reduced energy consumption and lower material expenses. Companies investing in recycled materials can gain a competitive advantage and create new business models.

4. **Circularity and Sustainability Impact: A strong emphasis is placed on how the prototype contributes to circularity and sustainability, which forms a core part of the value proposition in these cases.**

Insights: Solutions aim to reduce waste (e.g., landfilling, incineration), lower consumption of primary raw materials, decrease carbon footprint, and support closed-loop material cycles. This aligns with growing market demand for sustainable products and can strengthen a company's brand and attract environmentally-minded customers. The FOGGARA prototype is designed to be disassembled for recyclability.

5. **Scalability and Production Feasibility: Prototypes assess whether the solution can be scaled for production, including material selection, processing technologies, and integration into existing systems.**

Insights: This includes verifying material processability using conventional technologies, assessing existing infrastructure, ensuring feasibility under small-scale conditions, testing compatibility with existing robotic arms, and validating manufacturing processes like blow molding for cost-efficiency. For instance, the EX2 Extruder provides a small-scale solution to enable effective plastic recycling and sustainable production.

6. **Market Entry and Customer Adoption: The sources touch upon how the product will reach the market and gain acceptance.**

Insights: This includes business evaluation by marketing, comparison with existing products, and economic calculations. Hypotheses test if users will accept and integrate new parts into existing production lines. Pilot production runs can be initiated in partnership with companies. The FOGGARA example explicitly outlines a multi-stage market launch strategy: crowdfunding, direct sales via webshop, and marketplaces like Amazon, followed by scaling through design and smart home retailers. Market introduction may involve launching to a select group of businesses (pilot market entry) and gathering real-world data. Feedback from target customers is crucial for modifying parameters and reducing requirements regarding material properties.

In summary, while the sources do not provide a "how-to" guide for selecting a business model, they consistently highlight the importance of deeply understanding the problem, identifying the target audience, proving economic viability, emphasizing environmental benefits, ensuring production scalability, and strategizing market entry. These elements collectively form the foundation upon which effective business models for circular economy solutions are built and evaluated.

VI. Back-checking circular principles

Material Sourcing and Waste Stream Diversion:

◦ Using Recycled/Waste Materials: Procedures use materials that would otherwise be discarded, such as plastic waste sludge, recycled plastic from the "Yellow Bag", production scraps, or agricultural by-products as growth substrates for bio-based foams. This directly reduces waste ending up in landfills or incinerators.

◦ Reducing Virgin Material Consumption: By incorporating recycled or bio-based content, there's a decreased demand for new, primary raw materials obtained from fossil sources. This contributes to protecting natural resources.

◦ Transforming Waste into Resources: The process often reuses waste (e.g., sludge, production scraps, agricultural residues) by transforming it into valuable new products or raw materials.

Resource Efficiency and Environmental Footprint Reduction:

◦ Lower Energy Consumption: Producing materials from recycled plastics or through bio-based processes often requires less energy than manufacturing new plastics, thereby reducing greenhouse gas emissions and carbon footprint.

◦ Optimized Resource Use: Design focuses on material efficiency, such as using existing space within a punching grid or minimizing water/chemical inputs in cultivation processes (e.g., hemp).

◦ Lightweighting: For products like bioplastic components in robotics, reducing weight leads to lower energy consumption during operation and reduced CO_2 emissions.

End-of-Life Management and Product Design for Circularity:

◦ Biodegradability and Compostability: Many bio-based solutions are designed to naturally decompose at the end of their life, returning nutrients to the soil and avoiding long-term waste accumulation.

◦ Recyclability and Disassembly: Products are designed to be easily disassembled for material recovery and recycling. Materials are tested for reusability and mechanical recycling potential.

◦ Modularity and Upgradeability: Designing products with modular components allows for easy replacement or updating of individual parts, extending the product's lifespan and reducing the need for complete replacements.

◦ Reuse Potential: Some designs allow for multiple uses of the product itself or its components.

Economic and Systemic Impact:

◦ Cost-Effectiveness: Using recycled materials can be cheaper than new raw materials, leading to lower production costs and a competitive advantage.

◦ New Business Models: Investing in recycled materials can enable the creation of new business models.

◦ Market Alignment: Procedures align with growing market demand for sustainable products and stricter environmental regulations (e.g., EU targets).

◦ Fostering Collaboration and Investment: Platforms like "CircularPlastHub" demonstrate circularity by facilitating funding and research-industry partnerships that accelerate the development and implementation of circular technologies.

Verification and Measurement through Testing and Metrics:

◦ Performance Metrics: Prototypes undergo various tests (e.g., mechanical properties, accelerated aging, application behavior, compression resistance, tensile strength, biodegradability, durability, impact resistance).

◦ Comparative Analysis: Performance is often compared against traditional materials to demonstrate superiority or equivalence.

◦ Environmental Assessments: Digital lifecycle assessments (LCA) quantify environmental benefits, such as carbon footprint reduction and energy consumption.

◦ Specific Circularity Metrics: Waste reduction rates, material efficiency, production yield from repurposed waste, cost savings, and recycling success rates are measured.

◦ Stakeholder Feedback: Gathering feedback from target customers, environmental organizations, and industry experts helps validate the perceived circularity benefits and guides further iterations.

By demonstrating these impacts and validating them through specific tests and metrics, the proposed procedures in the sources show that they effectively meet circular economy requirements.

VII. Demo case factsheets

All guidelines and factsheets form Annexes 1 to 9 of this document:

- D1.2.5 - GUIDELINE NO.1 - RECYCLABILITY
- D1.2.5 - GUIDELINE NO.2 - RECY-BIO CONTENT
- D1.2.5 - GUIDELINE NO.3 - RECY-BIO CONTENT
- D1.2.5 - GUIDELINE NO.4 - RECY-BIO CONTENT
- D1.2.5 - GUIDELINE NO.5 - RECY-BIO CONTENT
- D1.2.5 - GUIDELINE NO.6 - REUSE
- D1.2.5 - GUIDELINE NO.7 - REUSE
- D1.2.5 - GUIDELINE NO.8 - REUSE
- D1.2.5 - GUIDELINE NO.9 - COLLECTION