



Development of a prototype concept and demonstration case for circular plastics solution.

Deliverable D.1.2.4

Responsible Partner: Plastr &
Omnipack / DBH

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Four Pillars on Sustainability

2024 EU key figures


source: Plastic Recyclers Europe – Annual Report

FIRST PILLAR: RECYCLABILITY

Starting from January 1, 2038, packaging that is not recyclable according to classes A or B **may no longer be placed on the market**.

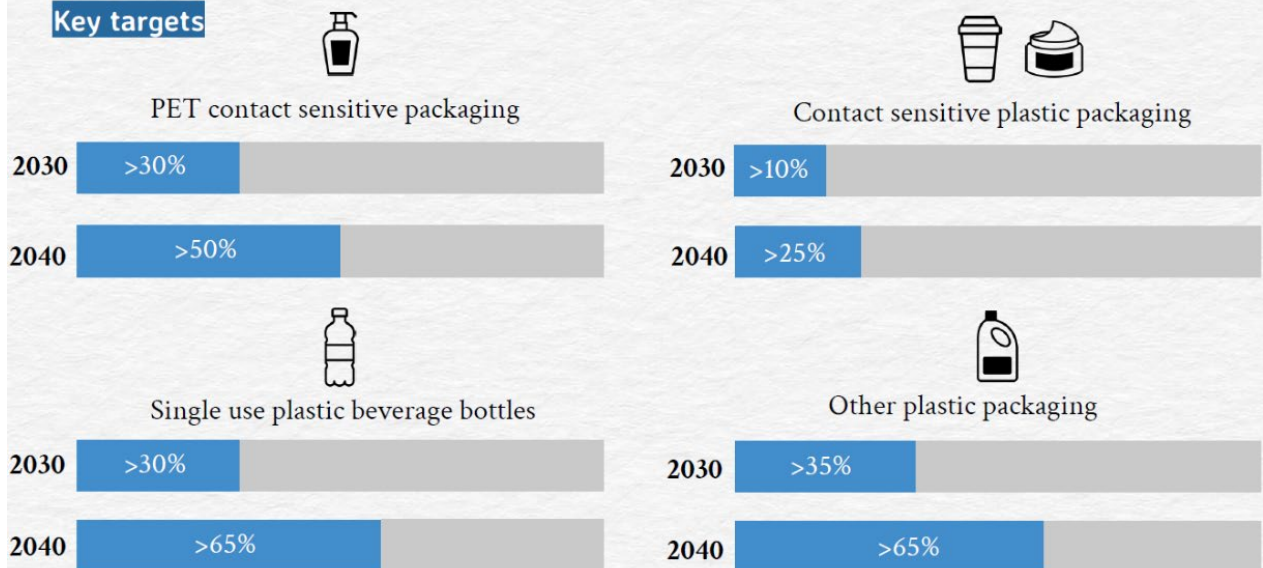
By 2038
All packaging units must be
'designed for material recycling'

	A	B	C	Not recyclable
Assessment of recyclability per unit, in weight	95%	80%	70%	<70%
Comments	Can be placed on the market		Not recycled at scale – cannot be placed on the market	



SECOND PILLAR: RECYCLED CONTENT

Key targets



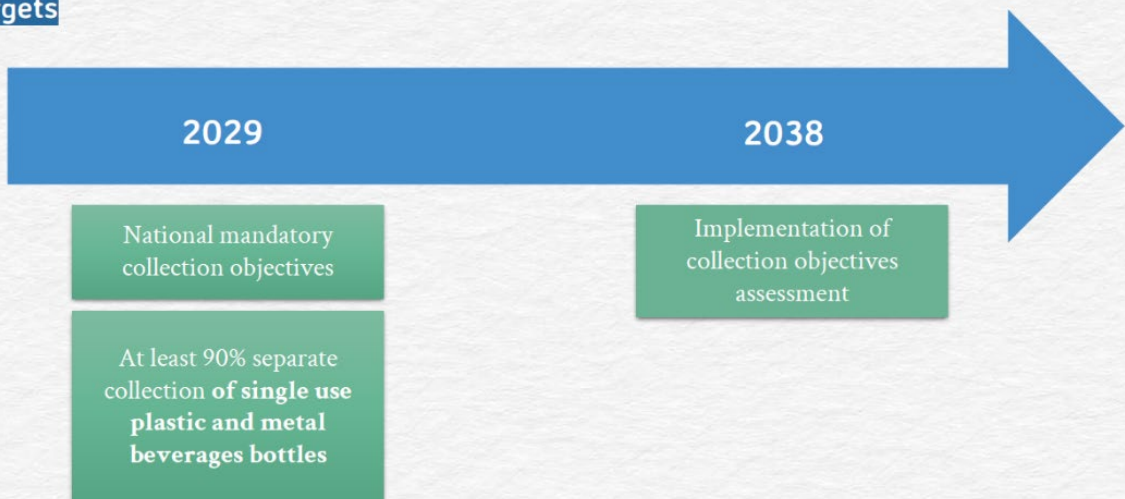
THIRD PILLAR: REUSE

	Transport and sales packaging <u>in total</u> *	Grouped packaging in the form of boxes (excluding cardboard)	Beverages in sales packaging	Intra-company and intra-Member State operations of transportation
2030	40%	10%	10%	100%
2040	70%	25%	40%	

* Includes pallets, foldable-plastic boxes, boxes, trays, plastic crates, intermediate bulk containers, pails, drums and canisters of any size or material, including **flexible formats or pallet wrappings or straps for stabilisation** and protection of products put on pallets during transport.

FOURTH PILLAR: COLLECTION

Key targets

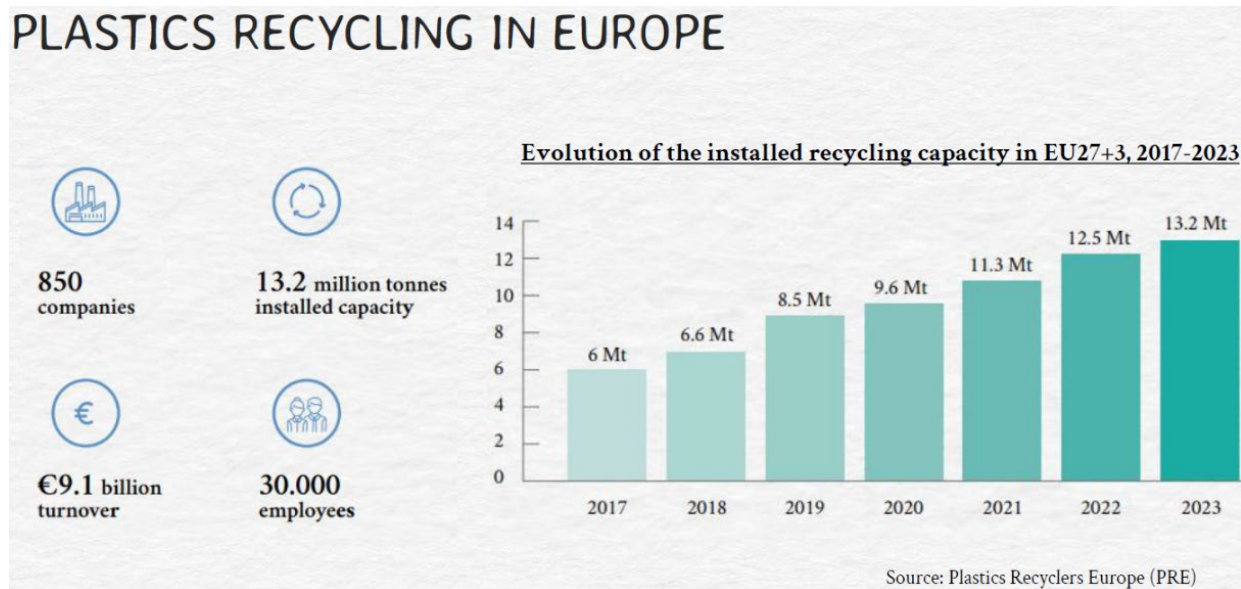


Circular Market Landscape

2024 EU key figures

source: Plastic Recyclers Europe – Annual Report

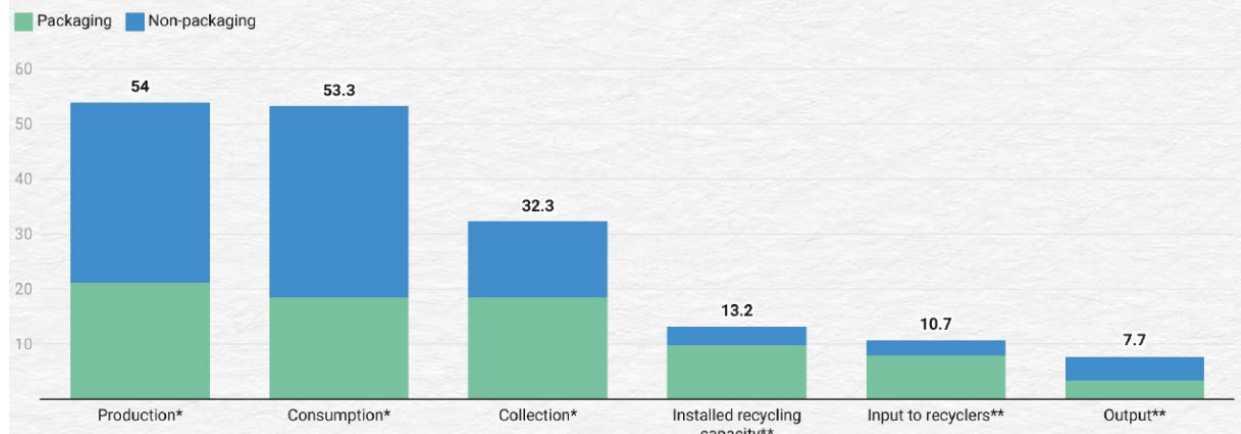
PLASTICS RECYCLING IN EUROPE



PLASTIC MATERIAL FLOW

Around 40% of the collected plastic packaging waste reaches plastics recyclers

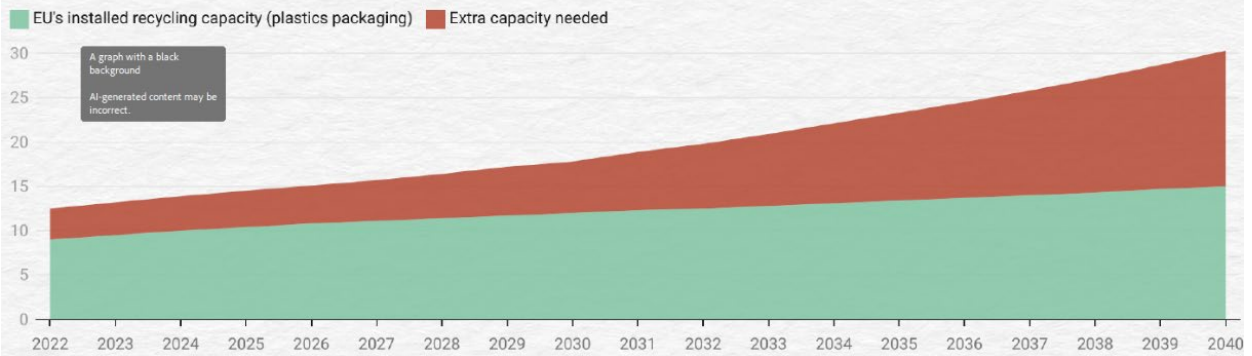
Plastic material flow in millions of tonnes in EU27+3 countries, 2023



RECYCLING CAPACITY REQUIRED BY PPWR TARGETS

Current capacity projections vs PPWR targets

Installed plastics recycling capacity in EU27+3 countries in plastics packaging, 2022-2040



Key points to improve plastics recycling in Europe

- Increase collection rates for plastic waste through more separate collection schemes.
 - *These are the current collection rates:*
 - *PO Films: 40% (2020)*
 - *HDPE&PP: 50% (2023)*
 - *PET: 60% (2023)*
- Enhance and spread “designing for recycling” in order to improve sent-to-recycling rate for plastic waste: 27% (2022).
- Better sorting and recycling technologies to improve the yields.
- Higher uptake of recyclates.
- Local-for-local recycling.

Sorting as only way to efficient recycling



AVAILABILITY OF RECYCLATES

60% OF THE PLASTIC PLACED ON THE MARKET IS COLLECTED

PACKAGING REPRESENTING 75% INPUT TO RECYCLERS

ROLE OF SORTING AND RECYCLING TECHNOLOGIES

1/3 OF ALL COLLECTED PLASTIC WASTE REACHES RECYCLERS

PACKAGING REPRESENTING 45% OF TOTAL RECYCLATES PRODUCTION

UPTAKE OF RECYCLATES TO NEW PACKAGING APPLICATIONS

Prototyping Workshop – Intro

The goal is to complete the phase of real prototyping of the designed solution so that the output meets the requirements of industrial implementation and also fulfils the aspects of future successful dissemination.

From the previous activities and design thinking workshops, as well as the conceptual evaluation of the approach of individual PPs to defining and proposing solutions it is clear that the approaches may differ in terms of systemicity or, conversely, specificity. Both approaches to the solution are correct and their combination is appropriate: a *specific* solution must always meet industry assumptions and requirements; contrariwise, a *systemic* solution must respect the technical and design possibilities of specific applications and products.

The Outputs should be structured and ordered sequentially in the same way as the prototype design was created - i.e., they should contain descriptions of the designs, justifications and agreed outputs for individual steps.

The Deliverables summarize the result of prototyping and predict applicability, possibilities of wide use, and basic parameters needed for successful commercialization.

There are a large number of online apps and tools that can be part of the whole process and that can be used for this physics of prototyping.

PPs' Prototyping Workshop – outcomes

(Prepared by using AI Notebook LM)

Prototyping Workshops – 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 landfill 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

Summary of the involvements – Using of recyclates (plastic waste)

Based on the source documents, several countries' prototype proposals explicitly mention and utilize plastic waste or recyclates as part of their solution:

Czech Republic (PLASTR Czech): The prototype directly addresses the issue of **waste sludge generated during plastic recycling**, which is currently classified as hazardous waste and landfilled. The solution focuses on processing this sludge, which contains plastic parts and contaminants, to **reuse it for the production of building elements or grass grates**. The main impact is the **use of recycled material**, reducing the consumption of primary raw material and decreasing landfilling and incineration.

Moldova (SORINTEX): The proposed solution is a **Modular Insulation Panel System Made from Recycled and Reusable Plastic**, which aims to tackle the significant amount of plastic waste in the construction industry by **using recycled plastic as the primary material** for the panels. It promotes **material reuse** and reduces the amount of plastic waste that would otherwise end up in landfills or the environment.

Germany (TZ Horb x FOGGARA): This prototype features a smart watering can called FOGGARA that is **made from recycled plastic**. The use of recycled materials, specifically post-consumer plastics, supports a **closed-loop recycling system**. The design is **recyclable**, allowing components to be easily disassembled for material recovery at the product's end-of-life.

Slovakia (TUKE): The prototype supports **3D printing using an extruder for plastic materials**, with a key emphasis on **recyclability and remanufacturing of plastics**. It utilizes **recycled material** to reduce the demand for new plastics and allows for the **fabrication of filament from recycled granulates** using the EX2 Extruder Setup. This approach supports the concept of a circular economy by reusing and renewing materials, extending their lifespan, and transforming waste into raw material.

Austria (aws Biz-up): This prototype focuses on **repurposing high-quality industrial leftovers**, specifically **reusable punching remnants from automotive interior production**. The solution involves **using the available free space within the punching grid for new products**, and **recycling the production scraps to manufacture customizable plastic films**. This transforms production scraps into valuable products, reducing waste and the use of virgin materials.

Other prototypes are oriented toward replacing plastics with bio-based alternatives (Serbia, Germany - Daniacompact) or addressing the end-of-life of bioplastics through recycling (Bosnia and Herzegovina). Romania's prototype is a digital platform that supports circular economy projects, including recycling and waste reduction, but is not itself a physical product made from waste.

Therefore, the prototypes from the **Czech Republic, Moldova, Germany (TZ Horb x FOGGARA), Slovakia, and Austria** directly involve the utilization or processing of plastic waste and/or recyclates in their core solution concepts.

Summary of applications / markets

Based on the provided sources and our discussions, the most frequently mentioned application areas for the circular plastics solutions prototypes are:

- 1. Packaging Industry:** This sector is highlighted by several countries as a significant source of single-use plastic waste and a key target for sustainable alternatives.

Serbia focuses on developing natural composite materials from industrial hemp to replace plastic packaging in various consumer products; for example, a molded tray specifically designed as a sustainable replacement for plastic trays used for food, electronics, cosmetics, and other consumer products.

Bosnia and Herzegovina mentions bioplastics in 3D-printing can be used for packaging applications.

Hungary specifically addresses the challenges in the packaging sector, particularly managing polymer foam waste and overdesign. Their prototype is a mycelium-based foam intended as a sustainable alternative to fossil-based polymer foams used for protective packaging.

Germany (Daniacompact) is developing biopolymer materials from agricultural by-products aimed at replacing conventional plastics, with packaging being one of the primary target industries, including flexible films and food packaging.

- 2. Automotive Industry:** The automotive sector is identified as an area where traditional plastics can be replaced by new, circular materials or where valuable waste is generated.

Serbia sees potential for using hemp composite materials in the automotive industry to replace plastic parts.

Bosnia and Herzegovina lists "Bioplastic Components in Automotive Manufacturing" as one of their proposed solutions and mentions utilizing bioplastics for components like interiors, dashboards, or structural reinforcements. Robotic grippers, which they are prototyping using bioplastics, are often used in the automotive sector.

Austria's prototype directly utilizes reusable punching remnants from **automotive interior production**, recycling the production scraps into customizable plastic films for other industries.

Germany (Daniacompact) mentions automotive parts as a possible future application for their biopolymer materials.

- 3. Construction Industry:** This sector is recognized both as a source of plastic waste and a potential market for recycled or bio-based materials.

Serbia mentions construction as an industry where waste hemp fibers could be upcycled.

Czechia's prototype focuses on processing waste sludge from plastic recycling to produce **building elements (tiles, blocks, etc.) or grass grates**.

Moldova's prototype is a **Modular Insulation Panel System Made from Recycled and Reusable Plastic**, specifically addressing plastic waste in the construction industry and aiming to improve building energy efficiency.

Germany (Daniacompact) lists construction as one of the target industries for their biopolymer materials.

- 4. Consumer Goods:** This broad category covers various products for end consumers.

Serbia mentions consumer goods (e.g., electronics, cosmetics) as target areas for hemp composite packaging.

Bosnia and Herzegovina lists consumer goods (packaging, customized products) as a potential application for bioplastics in 3D printing.

Germany (TZ Horb x FOGGARA) developed a **smart watering can** which is itself a consumer product, made from **recycled plastic**.

Germany (Daniacompact) targets manufacturers and businesses in the consumer goods industry who rely on traditional plastics.

5. Less frequently, but significantly, mentioned applications include:

3D Printing: Mentioned by Bosnia and Herzegovina as a technology that can use bioplastics and by Slovakia, whose prototype supports 3D-printing using an extruder for plastic materials with an emphasis on recyclability.

Robotics: Explicitly mentioned by Bosnia and Herzegovina for using bioplastics in components like grippers.

Plastics Industry (General): Romania's prototype is a digital platform designed to facilitate funding and collaboration for circular economy projects within the plastics industry, supporting sustainable materials, recycling technologies, and waste reduction. The Czech Republic's prototype processes waste generated *during* plastic recycling. Slovakia's prototype supports 3D-printing for the plastics industry, machine industry researchers, and stakeholders.

Main Prototype Application Areas (Most Frequently Mentioned) – Hierarchy :

- |—— Packaging Industry
 - | |—— Serbia: Hemp Composite Trays (plastic packaging replacement)
 - | |—— Bosnia and Herzegovina: Bioplastics for 3D Printing (potential for packaging)
 - | |—— Hungary: Mycelium Foam (replacement for foam packaging)
 - | |—— Germany (Daniacompact): Biopolymers from agricultural by-products (for packaging, films)
- |—— Automotive Industry
 - | |—— Serbia: Hemp Composites (plastic parts replacement)
 - | |—— Bosnia and Herzegovina: Bioplastic Components, Robotic Grippers (automotive use)
 - | |—— Austria: Utilization of interior production remnants (recycling into films)
 - | |—— Germany (Daniacompact): Biopolymers (future automotive applications)
- |—— Construction Industry
 - | |—— Serbia: Upcycling of waste hemp fibers

/ |—— Czech Republic: Processing of plastic recycling sludge (into building elements/blocks)

/ |—— Moldova: Modular Insulation Panels (from recycled plastic)

/ |—— Germany (Daniacompact): Biopolymers (target industry)

/

|—— Consumer Goods

|—— Serbia: Hemp Composite Packaging (for electronics, cosmetics, food)

|—— Bosnia and Herzegovina: Bioplastics for 3D Printing (customized products)

|—— Germany (FOGGARA): Smart Watering Can (made from post-consumer recycled plastic)

|—— Germany (Daniacompact): Targeting consumer goods manufacturers

Less Frequent/Specific Areas

|—— Plastics Industry (General): recycling waste, support for 3D printing recyclates, platform

|—— 3D Printing: use of bioplastics and recyclates

|—— Robotics: bioplastic components like grippers

Proposed solutions across countries

1. Solutions Utilizing Recycled Plastic Waste: mentioned by 5 countries

- **Processing and recycling of waste sludge from plastic recycling** to create building elements or grass grates (Czech Republic). This prototype focuses on turning waste generated *during* the recycling process into new products.
- **Modular Insulation Panel System Made from Recycled and Reusable Plastic** (Moldova). This solution directly uses recycled plastic to create building materials for energy efficiency.
- A **smart watering can** made from **post-consumer recycled plastics** (Germany - FOGGARA). This prototype demonstrates using recycled waste for a new consumer products.
- **Repurposing reusable punching remnants from automotive interior production** by using the free space in the punching grid for new products or recycling scraps to manufacture customizable plastic films (Austria). This focuses on valorizing production waste from a specific industry.
- **3D printing support used extruder for plastic materials**, focusing on recyclability and creating filament from **recyclate granulates** (Slovakia). This provides technology to enable the use of recycled plastics in 3D printing.

2. Solutions Based on Bio-based Materials: Mentioned by 4 countries

- **Natural composite materials from industrial hemp** (Serbia). This aims to replace plastic parts and products, primarily in packaging and automotive industries, using natural fibers and resins.
- **Bioplastic Components in Automotive Manufacturing, Bioplastics for 3D Printing, and Bioplastic Grippers in Robotics** (Bosnia and Herzegovina). While listed as separate points, these all involve the use of **bioplastics** in different applications, with a focus on robotics.
- **Mycelium-based foam** as a sustainable alternative to fossil-based polymer foams (Hungary). This material is grown from agricultural by-products and is intended for protective packaging.
- **Biopolymer materials** from agricultural food production by-products (Germany - Daniacompact). This solution aims to transition away from conventional plastics by using natural biomaterials for various applications like packaging, construction, and consumer goods.
- **Solutions Focusing on Enabling/Process Improvement:** Mentioned by 1 country.
- **Simplified Funding for Circular Economy Projects and Research-Industry Collaboration** (Romania). This is a **digital platform** ("CircularPlastHub") designed to facilitate funding access and partnerships for circular economy solutions in the plastics industry.

In summary, while there is variety, the development and application of solutions using **recycled plastic waste** and **bio-based materials** represent the most common themes among the proposed circular plastics solutions in these documents.

Proposals for broader implementation

1. Solutions Utilizing Recycled Plastic Waste

- Prototypes focusing on processing and reusing plastic waste streams, such as the Czech Republic's solution for **recycling waste sludge from plastic recycling**, the Moldovan **modular insulation panels from recycled plastic**, and Germany's FOGGARA **smart watering can from post-consumer recycled plastic**, address a universal problem: plastic waste generation. Plastic waste is a significant issue across all EU countries. The target applications (building materials, consumer goods) and the technologies used (processing waste, conventional building techniques, consumer product manufacturing) are widely applicable.
- The Austrian solution for **repurposing reusable punching remnants from automotive interior production** is tied to a specific industrial waste stream. While the automotive industry is present across the EU, the exact waste streams and processes might differ. However, the underlying principle of **valorizing industrial production waste** and turning it into new products or materials is a concept highly relevant and applicable in manufacturing sectors across the EU.
- Slovakia's prototype focusing on a **3D-printing support extruder for recycled plastic materials** addresses the growing use of 3D-printing and the need to integrate recycled materials into this process. As 3D-printing is a technology used globally and across various industries and for personal use, this type of solution has **high transferability** to any country with a 3D-printing ecosystem and sources of plastic granulate for recycling.

2. Solutions Based on Bio-based Materials

- Solutions developing materials from natural or agricultural sources, such as Serbia's **natural composite materials from industrial hemp**, Bosnia and Herzegovina's **bioplastics** for automotive, 3D printing, and robotics, Hungary's **mycelium-based foam**, and Germany's Daniacompact **biopolymers from agricultural food production by-products**, tackle the reliance on fossil-based plastics.
- The **industries targeted** (packaging, automotive, construction, consumer goods, robotics) are present throughout the EU.
- The **transferability of these solutions** depends partly on the **availability of the specific biomass feedstock** in different regions¹. For example, Serbia highlights the suitability of industrial hemp for growing in Vojvodina, and Hungary mentions the availability of agricultural by-products like rice husks and wheat hulls locally. However, many agricultural by-products and biomass sources are common across different EU countries.
- Importantly, prototypes like Daniacompact explicitly mention the goal that the biopolymer granulate **can be scaled and adapted to fit existing plastic processing technologies**, making them compatible with manufacturers across the EU who already possess standard plastic processing equipment. The potential for **cross-country application within the consortium** is also noted for the Daniacompact solution.

3. Solutions Focusing on Enabling/Process Improvement

- The Romanian solution, the **"CircularPlastHub" digital platform**, is designed to facilitate **funding access and research-industry collaboration** for circular economy projects in plastics. While developed to address a specific gap in, the challenges it aims to solve (difficulties in securing funding, lack of collaboration) are common in many regions and sectors. A digital platform is inherently scalable and the concept of a central hub to connect stakeholders and funding opportunities is highly transferable across the EU, requiring localization for specific funding schemes and national/regional networks.

In conclusion, while some solutions may have specific local advantages related to resource availability or existing industrial processes, the **fundamental problems they address (plastic waste, reliance on fossil resources, need for sustainable materials and processes) and the types of solutions proposed (recycling waste into new products, developing bio-based alternatives, facilitating collaboration) are relevant and needed across all EU countries.** The prototypes demonstrate the feasibility of these concepts, paving the way for potential adaptation and implementation more broadly within the EU's framework for a circular economy.

Conclusion – Summary

The documents (Reports from National Prototyping WS) serve as record sheets for evaluating and detailing prototype concepts and demonstration cases for circular plastics solutions. Across the different participating regions, the proposed solutions address the environmental challenges posed by traditional plastics, focusing primarily on **reducing waste, utilizing sustainable materials, and promoting circular economy principles**.

The prototypes can broadly be categorized into several key areas:

Development and Use of Bio-based Materials: Several prototypes focus on replacing conventional plastics with materials derived from natural or agricultural sources. Examples include:

- *Natural composite materials from industrial hemp for automotive and packaging applications (Serbia)*
- *Exploring various bioplastics (PLA, PHA, PBS) for use in automotive components, 3D printing filaments, and robotics grippers (Bosnia and Herzegovina)*
- *Developing mycelium-based foam from agricultural by-products (like rice husks and wheat hulls) as a sustainable alternative to polymer foams for protective packaging (Hungary)*
- *Creating biopolymer materials from agricultural food production by-products (like starch production leftovers and brewery residues) as a plastic-free base material for industries like packaging, construction, and consumer goods (Germany - Daniacompack)*

Utilizing Recycled Plastic Waste: A significant portion of the prototypes focuses on giving new life to plastic waste, including challenging waste streams or production scraps. Examples include:

- *Processing waste sludge generated during plastic recycling into building elements (tiles, blocks) or grass grates (Czech Republic)*
- *Designing a Modular Insulation Panel System made from recycled and reusable plastic for the construction industry (Republic of Moldova)*
- *Producing a smart watering can from post-consumer recycled plastics (Germany - FOGGARA)*
- *Repurposing reusable punching remnants from automotive interior production and recycling production scraps into customizable plastic films (Austria)*

◦ *Developing a 3D printing support extruder that allows the production of filament from recycled granulates (Slovakia)*

Enabling Platforms and Processes: One prototype focuses on improving the ecosystem for circular solutions.

◦ The "**CircularPlastHub**" digital platform is proposed to simplify access to funding and foster research-industry collaboration for circular economy projects in the plastics sector (Romania)

Overall, the documents demonstrate diverse, practical approaches to circularity in plastics, ranging from developing new sustainable materials and finding innovative uses for challenging waste streams to creating platforms that facilitate the implementation of these solutions. A common thread is the aim to reduce reliance on virgin fossil-based plastics, minimize waste, and create products that fit within a more regenerative system

An alternative categorisation could be along the concept of 9Rs (refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, recover) central to circularity, especially taking into account the time required to implement (finalise, scale, fund, etc.) the proposed prototypes. While certain proposals could be implemented almost immediately (e.g., supplanting oil-based polymers with bio-based materials or manufacturing the smart watering can), others would require a longer development. It is also important to take into account the mindset change required from stakeholders to implement the proposals – for example, enhancing trust in biobased materials, or certifying recyclates or biobased polymers as foodgrade.

PP	SHORT TERM	MID TERM	LONG TERM
Plastr			<i>RECOVER</i> creative material sourcing
Sorintex		<i>REUSE</i> extend lifespan of construction plastic	
TzHorb / Foggara	? <i>REDUCE</i>		<i>RECYCLE</i> creative material sourcing
TUKE			<i>RECYCLE</i> creative material sourcing
AWS & biz-up	? <i>REDUCE</i>	<i>REPURPOSE</i> extend lifespan	
ICMF	<i>REDUCE</i> smart product use		
FITT	<i>REDUCE</i> smart product use and smart manufacturing		
DBH	<i>REFUSE</i> smart product use		
TZ-Horb / Daniacompact	<i>REFUSE</i> smart product use		
Clustero			
SPK	<i>REFUSE</i> smart product use		