Interreg Danube Region

Co-funded by the European Union

Plan-C

# Creating a joint picture of the future of plastics value chain

## Deliverable D.3.1.2

## Responsible Partner: TUKE

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## Introduction to the Plan-C project

Moving PLastics and mAchine iNdustry towards Circularity (Plan-C) is an international project focusing on the Danube region. The project consortium consists of 14 project partners from 9 (AT, BiH, CZ, DE, HU, MD, RO, RS, SK) countries whose regions are part of the Danube Region. As the project name suggests, the main objective of the project is to support the transformation of the plastics value chain in the Danube Region towards a circular economy through transnational cooperation. In addition to the core consortium of project partners, a number of other actors are involved, ranging from associated strategic partners to stakeholders representing plastics processors and manufacturers of plastics processing machinery.

The joint effort is to develop a vision of a transformed plastics value chain designed for the circular economy and to demonstrate the benefits of plastics reuse/recycling and maintenance, redistribution, refurbishment/remanufacturing and recycling of machinery. The final Transnational Action Plan for anchoring the circular economy in a holistic plastics value chain addresses SMEs, large enterprises, public sector organisations, sector agencies and public authorities.

## Objective and scope of creating a joint scenario of the future plastics value chain

For the road mapping process, scenarios of the future of the plastics value chain will be created, including two main views: *the plastic processors as system enablers for the machine industry, and *the machine industry as system enablers for the plastics processor industry, including defining the role of each in the other.

For the scenario building, one workshop during the Mid-term conference in frame of the 10th International Conference on Polymeric Materials in Automotive (PMA 2025) in Smolenice, SK, on 22nd project partners, associated partners and external experts was held. In this frame, a picture of the future was drafted and will lead to the vision as the starting point and goal of the roadmap.

The vision will include the role of plastics processors in creating a circular machine industry and the role of plastics processing machine manufacturers in developing and optimising machines to allow easy and fast processing of recycled materials, sorting and washing technologies, colour detecting technologies, digitalisation, and technologies for improving the predictability of material quality of recycled plastics.

## 1. Preparation Phase

In preparation of the workshop in Smolenice, in successive iterations, project partners have been asked to analyse the plastics processors/machine industry value chains as follows:

- SWOT Analysis
- Identification of the central issue
- Key Factors influencing the central issues

SWOT Analysis, Identification of the central issue and Key Factors influencing the central issues were presented in D.3.1.1. As followed, the key factors have been clustered into 7 categories relevant for the whole Danube Regions, i.e Workforce, RDI &Technology, SupplyChain, Funding, Digitalisation, Policy, Market and Innovation Ecosystem.

## 2. Workshop

Around 33 representatives of clusters, SMEs, and RDI organisations attended the workshop in Smolenice, moderated by Lucia Knapcikova (TUKE) and Daniel Cosnita (CLUSTERO).

First, the pre-identified results have been discussed. Additional interventions from the audience identified further factors such as

- Funding regulations added to Policy & regulations
- Global direction added to Market
- Cost of recycling added to Funding

During the workshop, some possibilities of scenarios, analysis and visioning of a circular plastics value chain - plastics producer/processer as enabler and system supporter for a circular machine industry (Fig. 1) were discussed. Participants have been asked to rank the key factors according to Importance and Efficiency of Intervention.


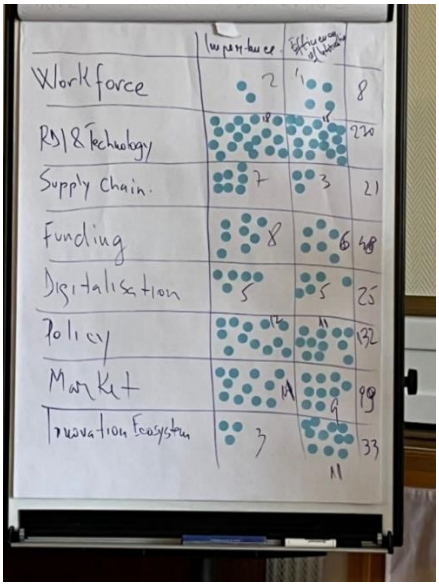


**Fig. 1 and 2:** Possible scenario, analysis and visioning of a circular plastics value chain and machine industry

Plastics processors play a crucial role in recovering waste plastics and converting them into reusable raw materials. Their approach to sorting quality, material conditioning and the development of new blends of recycled plastics is crucial to ensuring that the recyclate meets the demanding processing requirements and mechanical properties of the final products. Processors must also work closely with technology manufacturers to define the criteria for processing machines that take into account the specificities of recycled materials.
On the other hand, manufacturers of processing machines are at the forefront of innovations that enable the efficient and stable processing of recyclates. Their task is to design and optimise technologies (e.g. extruders, injection moulding machines, granulators) that can respond to the variability of recycled materials, in terms of purity, viscosity or impurity content. Flexibility, automation, digital process control and the ability to quickly reconfigure machines will be decisive factors for success in the processing of secondary raw materials.
This joint picture is the result of strong cooperation between both parties. Plastics processors and machine manufacturers must work closely together already in the development phase of new technologies and materials to ensure compatibility between raw materials and machine park. The goal is to create a closed material cycle in which plastics are efficiently returned to the production process at the end of the product's life, with minimal loss of quality and energy.

This vision is not only a technical goal, but also a challenge to create a responsible industrial ecosystem that can combine economic efficiency with environmental sustainability. Both groups—plastics processors and machine manufacturers—have a unique opportunity to shape the future of mechanical engineering, making it a pillar of the circular economy.

## 3. Results and Discussion

The vision will include the role of plastics processors in creating a circular machine industry and the role of plastics processing machine manufacturers in building and optimising machines to allow easy and fast processing of recycled materials, sorting and washing technologies, colour detecting technologies, digitalisation, and technologies for improving the predictability of material quality of recycled plastics.

Tab. 1 Discussed Key Factors during the workshop

| | Key Factors | Importance | Efficiency of Intervention | Score Importance X Efficiency |
|---|---|---|---|---|
| 1 | **Workforce & Education**<br>• Technical Universities and Dual Education Programmes play a key role in preparing the future workforce to operate and maintain circular-ready machinery (HU)<br>• Targeted educational offer for green jobs (RO)<br>• Invest in continuous education and training programs to align the local workforce with future digital and technological demands (DE)<br>• Have training programs in mechanical engineering, materials science, and digital technologies making a significant impact on both sectors' capacities for co-developing circular solutions (BH) | 2 | 4 | 8 |
| 2 | **RDI & Technology**<br>• Adoption of advanced technologies to enhance efficiency and scalability in circular plastics processing (MD)<br>• Access to and integration of international expertise and innovations (MD)<br>• Leverage the region's advanced engineering know-how and | 18 | 15 | 270 |

| | | | | |
|---|---|---|---|---|
| | reputation for precision to enter new global markets (DE)<br>• Scalability (from small to large scale) of developed processes (AT) | | | |
| 3 | **Supply Chain Security**<br>• Developing local and circular material supply chains to reduce external dependencies (DE) - Dwindling of natural resources and availability of critical raw materials (AT)<br>• Supply chain security for recycle (collection, sorting, and distribution) (AT) | 7 | 3 | 21 |
| 4 | **Funding**<br>• Ensuring access to financing mechanisms (RS)<br>• Leveraging EU integration goals to secure funding and align with circular economy standards (MD)<br>• Security of funding (private and public) towards circular economy (AT)<br>• EU-backed de-risking instruments (e.g., EIB circular economy financing, InvestEU) tailored for SMEs adopting advanced recycling machinery (HU)<br>• Cost of recycling | 8 | 6 | 48 |

| | | | | |
|---|---|---|---|---|
| 5 | **Digitalisation**<br><br>• Transparent data and material traceability systems (HU)<br>• Mandate digital product passports (DPPs) for plastics and equipment (HU)<br>• Development of new circular business models heavily rely on digital innovation, smart manufacturing (Industry 4.0) etc (RS)<br>• Investments in digitalisation and automation of production (SK)<br>• Drive the digital transformation of small and medium-sized enterprises (DE) | 5 | 5 | 25 |
| 6 | **Policy & Regulations**<br><br>• Coherent policy towards circularity (incentives, standardisation, awareness campaigns etc) (RO)<br>• Clarity and consistency in regulations related to recycling, waste management, and circular economy practices (MD)<br>• Government incentives (e.g., tax breaks, subsidies) to promote sustainable manufacturing and recycling (MD)<br>• Harmonisation of national and EU-level regulations (AT)<br>• Funding Regulation | 12 | 11 | 132 |

| | | | | |
|---|---|---|---|---|
| 7 | **Market**<br><br>• Mitigating economic challenges (inflation, currency fluctuations) to ensure financial viability of circular projects (MD)<br>• Capitalizing on growing global demand for sustainable products to expand market opportunities (MD)<br>• Consumers and industries skepticism towards recycled plastics (AT)<br>• Low demand for recycled products is a major barrier; Raising awareness and trust in recycled goods (RS)<br>• Demand creation through green procurement & eco-labelling (HU)<br>• Functionality and cross-sectoral expansion of DRS (RO)<br>• Global Calibration | 11 | 9 | 99 |
| 8 | **Innovation Ecosystems**<br><br>• Creation of plastics clusters in the SEE Region (RO)<br>• Strengthen partnerships between regional companies, local universities, and applied research institutes (bridging the gap between research institutions and industry is critical to developing and applying circular innovations) (DE)<br>• Increased cooperation in the Black Sea Region based on the Transnational Programme Black Sea (RO) | 3 | 11 | 33 |

In an open discussion, it was decided to select the first three highest-ranked factors:

- Policy
- Market
- RDI

Participants, who were experts from academia, research institutes and the practice field, developed a scenario in which RDI would experience positive development, while Market and Policy would see negative outcomes. The results present an interesting finding: research and development are advancing, while the market and political environment are lagging. This entails increased investment in basic research and enhanced cooperation with academia. It may reflect the instability of the legislative framework, insufficient support for research or regulation, which hinders the application of innovations. This indicates weakened demand, instability, perhaps due to economic crises, inflation, or technological mismatch with market needs.

### Title of Scenario: „Batmobile on the bumpy road"

The joint scenario created for the entire Danube Region represents the basis for the further strategy-building process at the regional/country level. Advancements in RDI & Technology are accelerating, particularly in sectors like clean energy, AI, biotechnology, and sustainable manufacturing. Increased investment in innovation ecosystems, open-source platforms, and cross-border research collaborations has also fueled progress. Influence is visible in the new technologies, which increase productivity, reduce costs, and open new markets. Green technologies support decarbonization and energy efficiency. Regulatory frameworks often lag behind technological progress. Inconsistent or overly restrictive policies (e.g., unclear data privacy laws, delays in approving sustainable projects, or heavy bureaucratic red tape) can stifle innovation and delay market adoption. Influence is visible in the lack of harmonised international standards, which limits scalability. Private sector players may hold back due to policy instability or high compliance costs. Market volatility, short-term investor focus, and inequitable access to funding (especially for startups or in developing regions) are negative trends. Additionally, monopolistic behaviour and a lack of market incentives for sustainability slow long-term progress. The influence is visible in the SMEs and low-income countries, which struggle to compete or adopt new technologies. Markets prioritise fast returns over sustainable, long-term innovation. Essential but unprofitable may be ignored.

Tab.2 Scenario Proposal

| **Batmobile on a bumpy road** | | |
|---|---|---|
| **RDI & Technology** | **Policy & Regulations** | **Market** |
| Positive Development | Negative Development | Negative Development |
| • international cooperation between research organisations<br>• knowledge transfer<br>• academia-industry works well<br>• availability of researchers<br>• available funding for research<br>• available technologies for processing new materials<br>• public investments in research facilities seen as backbone of innovation<br>• increase in supporting<br>• available raw materials for the research activity<br>• green technology | • overregulation/unclear regulation<br>• low public support from policy makers<br>• regional policy not aligned with the EU policy<br>• no cooperation on the policy level or a clash of interests between countries<br>• unstructured funding policy<br>• lack of standards<br>• lack of regulations enforcement<br>• targets are not realistic<br>• inconsistent or overly restrictive policies<br>• unclear data privacy laws<br>• relatively bureaucratic<br>• the lack of harmonised international standards, which limits scalability | • customers do not want/do not care about recycled materials<br>• lack of knowledge on the customers' side<br>• companies lack motivation / demand for recycled materials<br>• high costs/price sensitivity<br>• market disruptions due to global uncertainties<br>• tariffs/protectionism<br>• dependence on foreign markets<br>• short-term investor focus<br>• monopolistic behaviour and lack of market incentives for sustainability<br>• markets prioritise fast returns over sustainable manufacturing |

## Conclusion

The joint scenario-building process within the Plan-C project has demonstrated the strategic importance of aligning the plastics and machinery industries to enable a circular economy in the Danube region.

Key factors such as RDI & Technology, Policy & Regulations, and Market dynamics were identified as critical drivers and barriers. While research and innovation show promising development, policy frameworks and market acceptance of recycled materials remain challenging. The analysis shows strong potential to integrate plastics processors and machinery makers into circular value chains, turning plastics from burden to resource through good practices, new technologies, and regulations.

During a workshop involving project partners and external experts, a joint picture of the future plastics value chain was developed, which presents how plastics processors and producers can actively contribute to a circular machine industry by creating a closed-loop system. The jointly developed scenario titled "Batmobile on a bumpy road" reflects the current imbalance. Technological innovation is advancing rapidly, while regulatory clarity and market readiness lag behind. This scenario highlights the need for stronger alignment between technological advancements, supportive regulation, and market demand.

Moving forward, this joint picture will serve as the foundation for regional and transnational strategies aimed at embedding circularity into the plastics and machinery industries. Continued cooperation, targeted investments, and supportive policy environments are essential to realize the vision of a resilient and circular plastics value chain across the Danube Region.