

Framework conditions in the Danube region

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Responsible Partner: UTB

Document Content

Introduction.....	2
Legal framework	2
Consistency with the EU Strategy for the Danube Region	7
Economic readiness of the machinery industry	10
Conclusion consistent with the Transnational mapping	19

Introduction

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.

Legal framework

All regions involved in the project recognise the need to coordinate the transition to a circular economy at a Europe-wide level and are implementing EU legislation into their national policy. The Green Deal for Europe is the overarching legislative framework into which the transition to the circular economy is integrated.

The **European Green Deal** is Europe's sustainable growth strategy and aims to transform EU into a fair and prosperous society, with a modern, competitive, climate-neutral, circular economy and toxic-free environment in compliance with the United Nation's 2030 Agenda and the sustainable development goals. It sets the ambitious objective of making Europe the first climate neutral continent by 2050. Products play a pivotal role in this green transition. However, current production processes and consumption patterns remain too linear and dependent on a throughput of new materials extracted, traded and processed into goods that are finally disposed of as waste or emissions. The European Green Deal emphasises the urgent need of transition to a circular economy and sustainability model, as shown in Fig. 1.



Fig. 1 The elements of European Green Deal ([The European Green Deal](#), by European Commission, [CC BY 4.0](#) licence)

In addition to the New **Circular Economy Action Plan** for a cleaner and more competitive Europe, which is one of the cornerstones of the Green Deal and an important document related to the plastics industry and the sustainability of plastic products, the Industrial Plan is also important for the plastics machinery industry. The **Green Deal Industrial Plan** was introduced by the European Commission to boost the competitiveness of Europe's net-zero industry and support the transition to climate neutrality. It is built under the initiatives European Green Deal and REPowerEU. The plan involves establishing a supportive environment to boost the EU's manufacturing capacity for net-zero technologies and products, in order to reach their aspiring climate targets. It is based on four pillars, as shown in Fig. 2.

BOOSTING SUSTAINABLE COMPETITIVENESS

The Green Deal Industrial Plan will simplify, accelerate and align incentives to preserve competitiveness and attractiveness of the EU as an investment location for industry and manufacturing, acting on all fundamental factors.

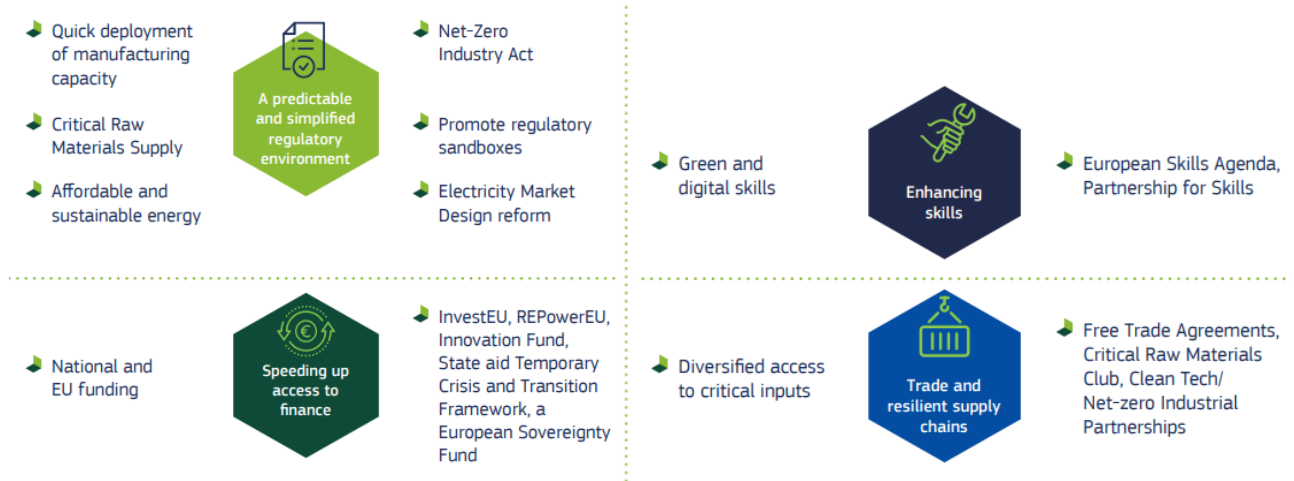


Fig. 2 Four key pillars of Green Deal Industrial Plan ([The Green Deal Industrial Plan](#), by European Commission, [CC BY 4.0](#) licence)

European Critical Raw Materials Act concerning on sustainable supply of raw materials is a significant part of the Green Deal Industrial Plan. To meet climate and digital objectives of the European Green Deal, sourcing, processing and recycling critical raw materials in Europe and securing supply chains are the challenges ahead. Lithium, cobalt and nickel are used to produce batteries; gallium is used in solar panels; raw boron is used in wind technologies; titanium and tungsten are used in the space and defence sectors. With the European Raw Materials Act, the EU aims to ensure the secure and sustainable supply of critical raw materials for Europe's industry and significantly lower the EU's dependency on imports from single country suppliers.

EU legislation related to the engineering industry is well integrated into the Green Deal for Europe strategy. The following legislative documents can be named:

- **Regulation EU 2023/1230 on machinery** updates the original Directive 2006/42/EC in the form of a Regulation. The new version regulates the basic health and safety requirements for machinery in the EU. The Regulation focuses on the free movement of machinery and on ensuring a high level of safety for workers and citizens. The rules are designed to enhance the competitiveness and reputation of machinery manufactured in the EU. Machinery products will receive the CE marking, which indicates that they meet the health and safety requirements and can be traded on the market without restriction. Safety information must be provided for each product, digital instruction is a standard (in accordance with the digital transformation). The new regulation sets out the legal framework covering also new risks associated with

emerging technologies such as autonomous mobile machinery, the Internet of Things (IoT) and artificial intelligence (AI).

- **EU AI Act is Regulation EU 2024/1689** laying down harmonised rules on artificial intelligence. The European Union is the first territory in the world where a similar regulation has been approved. The regulation applies an approach based on an assessment of the degree of risk of impact on health, safety, or interference with the fundamental rights of EU citizens (unacceptable, high, limited, minimal and an additional category is general-purpose AI). EU AI Act is extraterritorial which means that the rules and regulations are applicable not only to organisations and individuals within the EU, but also to those located outside if their activities impact EU markets or citizens. The aim is to ensure that AI systems used in the EU are safe, trustworthy, transparent, and non-discriminatory. Furthermore, they must be in accordance with EU values and principles, environmentally friendly and used in a responsible manner with human involvement. Finally, the intention is to foster innovation and make Europe a leader in this field.
- **Directive EU 2024/1799 on common rules promoting the repair of goods** is intended to encourage consumers to have defective products repaired. It should simplify the repair of goods in terms of availability and cost for consumers. In addition, its intended effect is to encourage manufacturers to develop and implement more sustainable business models and to revitalise the repair sector. In addition to the savings for consumers, it is also intended to reduce the volume of waste produced in the EU, thereby saving the environment.
- **CBAM – Carbon Border Adjustment Mechanism Regulation EU 2023/956** is the EU's tool to put a fair price on the carbon emitted during the production of carbon-intensive goods that are entering the EU, and to encourage cleaner industrial production in non-EU countries. As the EU raises its own climate ambition, and as long as less stringent climate policies prevail in many non-EU countries, there is a risk of so-called 'carbon leakage'. Carbon leakage occurs when companies based in the EU move carbon-intensive production abroad to countries where less stringent climate policies are in place than in the EU, or when EU products get replaced by more carbon-intensive imports. The CBAM will initially apply to imports of certain goods and selected precursors whose production is carbon intensive and at the most significant risk of carbon leakage: cement, iron and steel, aluminium, fertilisers, electricity and hydrogen. The current transitional phase lasts between 2023 and 2025, while the definitive regime will be applied from 2026. This gradual introduction of the CBAM is aligned with the phase-out of the allocation of free allowances under the EU Emissions Trading System (ETS) to support the decarbonisation of the EU industry.
- **ESPR – Ecodesign for Sustainable Products Regulation EU 2024/1781** will replace as well as extends the current Ecodesign Directive 2009/125/EC, introducing more Ecodesign criteria for a broader range of products. "A fully functioning internal market

for sustainable products is a pre-requisite for the establishment of a circular economy in the Union. Common ecodesign requirements at Union level would enable the development, deployment and scaling-up of new circular economy business models throughout the internal market. Such measures would also alleviate the burden on companies and provide industry and consumers with access to reliable and clear data, thereby allowing for more sustainable choices to be made". (<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32024R1781&qid=1719580391746>) The main objective of the Regulation is to go well beyond the original focus on energy and material efficiency by emphasising other key aspects such as durability, reliability, reusability, ease of retrofitting, reparability, recyclability and product maintenance. In addition to the carbon footprint, it will be mandatory to issue a digital product passport in selected categories. This is intended to provide manufacturers, key actors in the supply chain, consumers and market surveillance authorities with information on product sustainability.

- **CSRD – Corporate Sustainability Reporting Directive EU 2022/2464** sets the standard by which nearly 50,000 EU companies will have to report their climate and environmental impact. CSRD is a sustainable development tool that promotes the competitiveness of companies. It provides them with: Easier access to capital (Banks require a guarantee that their capital will be used in lending in accordance with sustainable development principles.), Faster company growth (Non-financial reporting opens up new opportunities for companies, both on the path to capital, and in communicating with potential customers and partners.), Compliance with legislation, Prestige and branding (Perception of the company by its environment, employee and management engagement.), Data management (What we measure can be controlled. By evaluating data, companies can optimize their processes.).
- **CS3D or EU Supply Chain Act – Corporate Sustainability Due Diligence Directive EU 2024/1760** introduces legal obligations for corporations to conduct human rights and environmental due diligence in their global supply chains. The Directive requires companies to proactively identify adverse impacts on human rights and the environment and work to remedy them, as well as to monitor and prevent future adverse impacts. The obligation applies both to the company's own operations and to the value chain of which supply chains are a part. Companies must also have a plan to ensure that the company's business model is consistent with reducing the impact of global warming and the goal of maintaining a maximum temperature increase of 1.5°C. The Directive includes several steps, ranging from integrating due diligence into company policies and risk management systems (strategy, implementation, control and follow-up), to identifying actual and potential adverse human rights and environmental impacts (both in own operations and in value chains), to taking appropriate measures to stop actual adverse impacts (e.g. developing an action plan).

- **WEEE – Waste electrical and electronic equipment Directive 2012/19/EU.** “The purpose of this Directive is to contribute to sustainable production and consumption by, as a first priority, the prevention of WEEE and, in addition, by the re-use, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste and to contribute to the efficient use of resources and the retrieval of valuable secondary raw materials. It also seeks to improve the environmental performance of all operators involved in the life cycle of EEE, e.g. producers, distributors and consumers and, in particular, those operators directly involved in the collection and treatment of WEEE.” (<https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32012L0019>) This directive does not only apply to electrical and electronic goods used by consumers, but also involves the mechanical engineering sector.

ISO standards on environmental management are an important part of the normative regulations governing European industrial enterprises, including plastics machine engineering companies. These standards help companies to systematically improve environmental protection, bringing them economic benefits, but also enabling them to identify and eliminate various weaknesses in their operations. Using this way of managing companies can also help in the transition to a circular economy. **Environmental management is covered by the ISO 14000 family standards:** ISO 14001 Environmental management systems, ISO 14006 Environmental management systems – Guidelines for incorporating ecodesign, ISO 14020 to 14025 Environmental labels and declarations, ISO 14040 & 14044 Environmental management – Life cycle assessment etc.

Consistency with the EU Strategy for the Danube Region

The EU Strategy for the Danube Region (EUSDR) is a macro-regional strategy adopted by the European Commission in December 2010 and endorsed by the European Council in 2011. The Strategy was jointly developed by the Commission, together with the Danube Region countries and stakeholders, in order to address common challenges together. The Strategy seeks to create synergies and coordination between existing policies and initiatives taking place across the Danube Region.

The EU Strategy for the Danube Region (EUSDR) provides an integrated framework for strengthening cooperation between countries in the Region. The participating countries include nine EU member countries (AT, BG, HR, CZ, DE, HU, RO, SK, SI) and five accession countries (BA, MD, ME, RS, UA). Certain dissimilarities between countries and within countries highlight the need for collective solutions to challenges which cannot or can only be solved to a limited extent by the countries themselves, starting with climate change, through demographic change and migration to digitalisation and beyond.

The main goal of the EUSDR Action Plan¹ is to open and strengthen the full potential of the Danube Region. This can be contributed to by mobilisation of funding possibilities that have not yet been realised, building networks, offering mutual learning, striving for harmonisation, aligning policies, building capacities, strengthening civil society and voluntary service, etc. The common aim of every action is to mutually benefit and generate factual improvements in the Danube Region.

The governance and structure of EUSDR² is based on four Pillars (Connecting the Region, Protecting the environment, Building prosperity, Strengthening the Region) and twelve Priority Areas (PAs), as shown in Fig. 3.

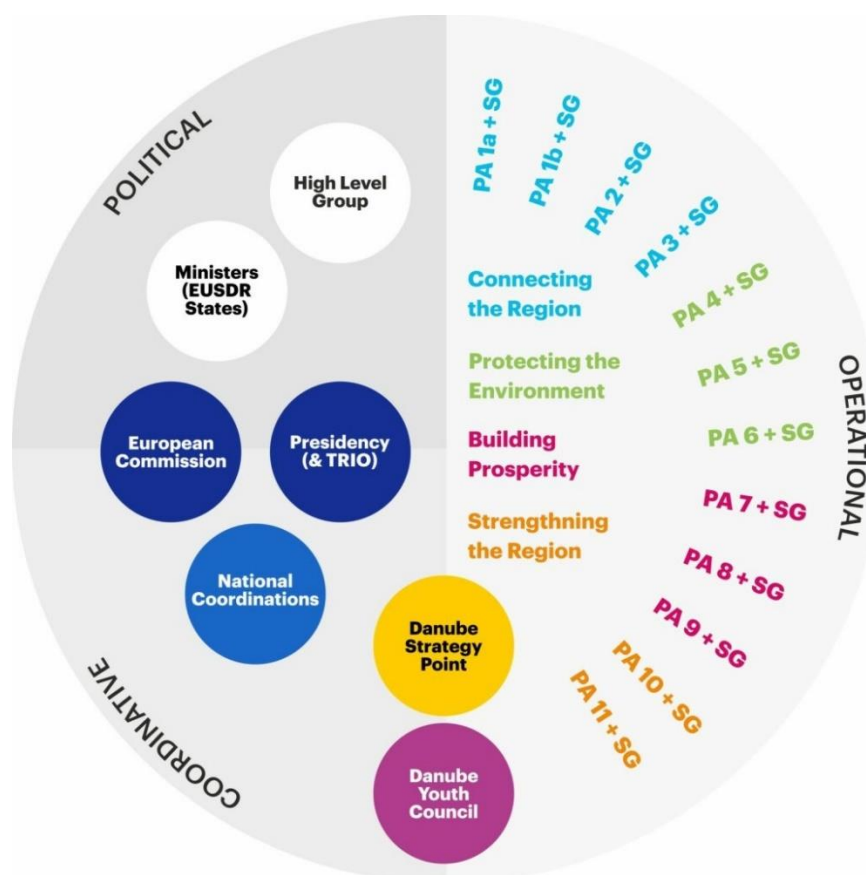


Fig. 3 The governance of the EUSDR (source: <https://danube-region.eu/about/governance>)

There are 85 actions defined in 12 Priority Areas. Priority Area 8 Competitiveness of Enterprises is consistent with the PLAN-C project's scope. The mission of PA 8 is to support the competitiveness of enterprises and clusters' development. Although the economic level of each economy in the Danube Region is not equal, all of them strongly rely on SMEs. Therefore, their support is needed to overcome economic disparities, be it in the

¹ <https://danube-region.eu/wp-content/uploads/2020/04/EUSDR-ACTION-PLAN-SWD202059-final-1.pdf>

² https://danube-region.eu/wp-content/uploads/2023/11/EUSDR-Governance-Architecture-Paper_updated_2023-11_endorsed-2.pdf

field of digitalization, transition to a circular economy or other areas related to promoting sustainable development of the Region. The same applies to professional clusters, which can be a platform for building national and transnational networks to exchange knowledge and promote innovation and competitiveness.

The alignment between the PLAN-C project and EUSDR PA 8 is demonstrated by awarding the Danube Strategy Flagship Certificate to PLAN-C³.

The Plan-C meets the objectives of Priority Area 8 by contributing to Action 1 “To foster cooperation and exchange of knowledge between SMEs, creative industry, academia, the public sector and civil society in areas of competence in the Danube Region”. The project aims to boost the transformation of the plastics value chain in the Danube Region towards a circular economy through the transnational cooperation of the plastics and machinery industry participating partners. The innovative ideas for the circular economy will be created using technology transfer and a design thinking process. The partners will co-create and demonstrate circular plastic prototypes, resulting in a Circular Plastics Guideline to build regional knowledge and capacities. Strategic partners and policy stakeholders will help integrate this strategy into regional innovation strategies (RIS3).

Similarly, project partners and machine engineering companies will develop circular solutions for each phase of the machine lifecycle, and create digital business models summarized in a Guideline for Circularity in the Machine Industry.

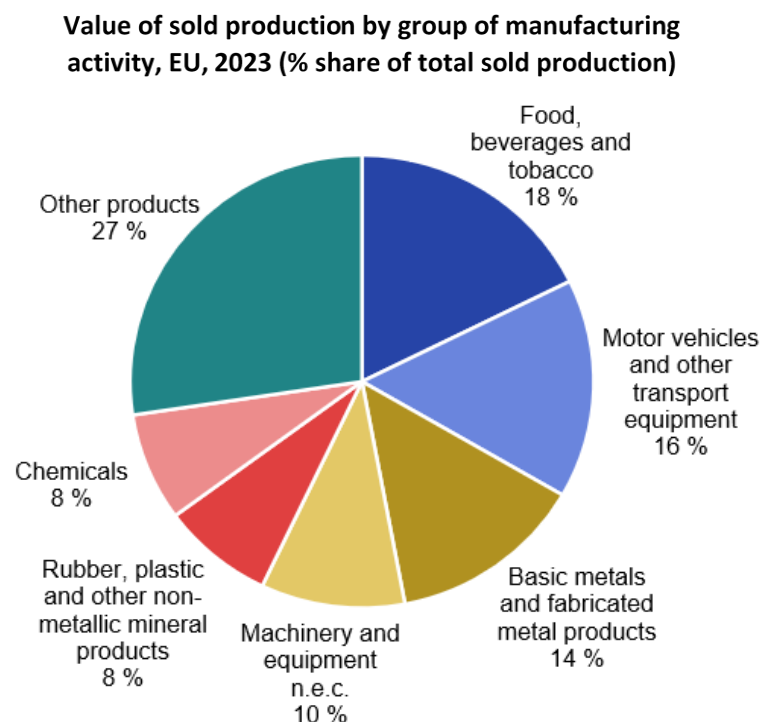
These objectives aim at fostering cooperation and knowledge exchange between SMEs, clusters and research sector (institutes and universities). The digitalization of processes in SMEs, but also the introduction of cutting-edge technologies including the use of machine learning, artificial intelligence, IoT, etc. co-creates and enriches the innovation ecosystem of the Danube Region.

The Transnational Action plan for boosting circularity in the entire plastics value chain including machinery industry, based on the latest EU regulations and in close cooperation with the national and regional policy level in each country will ensure transfer to the RIS3 of the partner countries with intensified awareness raising and proposing new support measures for local SMEs.

³ <https://danube-region.eu/projects-and-funding/eusdr-strategic-projects/>

Economic readiness of the machinery industry

According to data published by Eurostat, the statistical office of the European Union, European industrial production declined by 1.2% in 2023 compared to 2022. After a significant drop in industrial production in 2020 due to the restrictive measures resulting from the outbreak of the COVID-19 pandemic, EU industry has recovered rapidly, with industrial production growing by 8.5% YoY in 2021 and by 0.4% in 2022. A decline in industrial production in 2023 was recorded in 15 industries with the biggest decrease in the manufacturing of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials, followed by the manufacturing of chemicals and chemical products, the manufacturing of basic metals and the manufacturing of paper and paper products.



Note: EU except Cyprus, Luxembourg, Malta

Other products: Wood and paper, and printing; Furniture, other manufacturing and installation of machinery and equipment; Electrical equipment; Computer, electronic and optical products; Textiles, wearing apparel and leather;

Pharmaceutical products; Mining

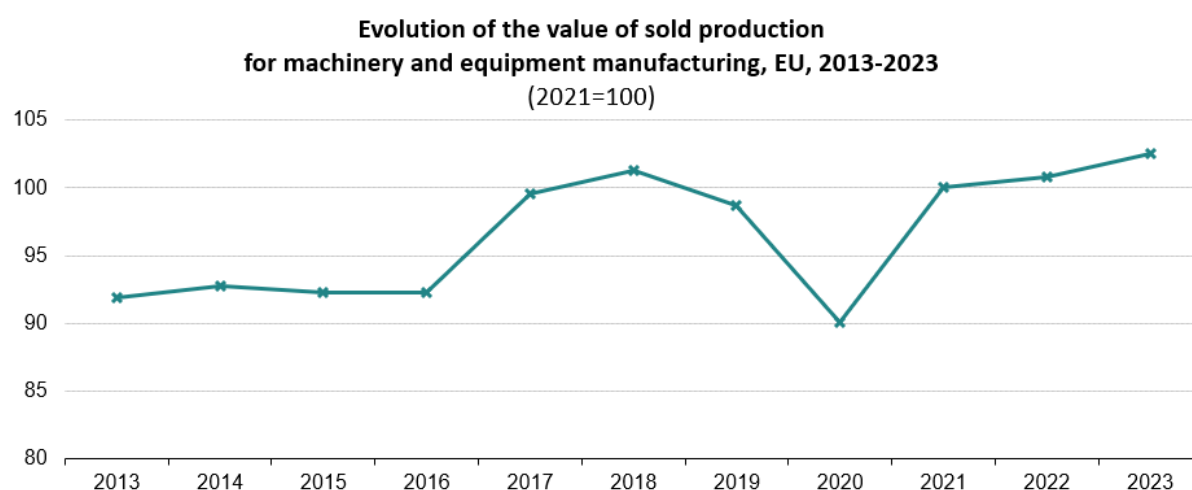
Source: Eurostat (online data code: DS-056120)

Fig. 4 Industrial production by sector in 2023 ([https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Value of sold production by group of manufacturing activity, EU, 2013 and 2023 \(%25 share of total sold production\)1.png](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Value_of_sold_production_by_group_of_manufacturing_activity,_EU,_2013_and_2023_(%25_share_of_total_sold_production)1.png))

Despite the decline in output of industry, the value of production sold in the European Union in 2023 is EUR 5 992 billion, an increase of 1.6% compared to EUR 5 895 billion in 2022 (in current prices).

In terms of sectoral representation, almost three-quarters of industrial production (by value of output sold) belonged to six sectors: food, beverages and tobacco products, manufacture of motor vehicles and other transport equipment and manufacture of basic metals and fabricated metal products, machinery and equipment, rubber and plastic products and chemicals. The machinery industry ranks fourth among them with a 10% share, as can be seen in the chart in Figure 4.

Based on constant prices (base year 2021), the manufacturing of machinery and equipment registered increase by 11% in 2023 compared with 2013 (see Fig. 5). In terms of nominal value of the sold production in 2023 compared with 2022, the manufacturing of machinery and equipment went up by EUR 44 billion.



Note: y-axis does not start at zero.

EU except Cyprus, Luxembourg, Malta

Source: Eurostat (online data code: DS-056120)

Fig. 5 Evolution of European machinery industry (2013–2023)

([https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Evolution_of_the_value_of_sold_production_for_top_5_manufacturing_activities_EU_2013-2023_\(2021%3D100\)_1.png](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Evolution_of_the_value_of_sold_production_for_top_5_manufacturing_activities_EU_2013-2023_(2021%3D100)_1.png))

According to data from the German Engineering Federation VDMA (<https://www.vdma.org/mechanical-plant-engineering-figures-charts>), the turnover of the EU sector of machines, machine parts, components and systems in 2023 was approximately EUR 908 billion. This corresponds to roughly 28 % of global machine sales. Approximately one third of the production was sold to countries outside the EU single market (value of EUR 301 billion), while imports were around EUR 140 billion.

The EU machinery and equipment market had a volume of EUR 745 billion in 2023, with approximately 80 percent of products originating from the single market. The European market was dominated by machinery and equipment from Germany, representing 36 % of the share. Italy (14 %), France (6 %), Sweden (4 %), Austria (3 %) and Denmark (3 %) shared the other approximately 30 % of the market. In terms of imports into the EU, China has traditionally led the way (5 %) ahead of the USA (3 %), Japan (2 %) and the UK (2 %).

Machinery and equipment manufacturing is the third largest industry after the automotive and food industries, with the electrical engineering and chemical industries in the following ranks. Between 2022 and 2023, EU machinery and equipment manufacturing showed a growth of 0.7 % (see Figure 6). Romania's machinery industry achieved the highest double-digit growth, while Bulgaria was at the opposite end of the ranking. Austria also performed well, while machinery in Germany or Italy saw a slight decline, as did production in Hungary or the Czech Republic.

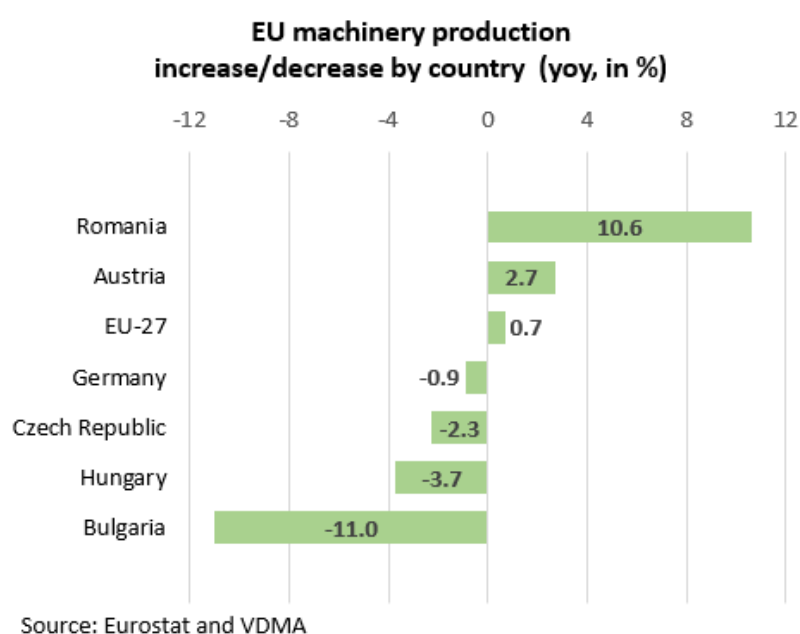


Fig. 6 EU machinery production: increase/decrease by country
(<https://www.vdma.org/mechanical-plant-engineering-figures-charts>)

European companies are world market leaders in many areas of engineering. This is directly reflected in their specific global trade shares. Areas, where EU-27 companies have a market share of more than 50% (including intra-EU trade), include food and packaging machinery with 61.7 %, cleaning systems – 61.2 %, agricultural machinery with 57.6 % share and woodworking machinery having a share of 56.3% (2021 data).

Europe Industrial Machinery Market Size study by Global Market Insight released in July 2024 (<https://www.gminsights.com/industry-analysis/europe-industrial-machinery-market>) focuses on industrial machines, which are divided by operation into categories automated

machinery, semi-automated machinery, manual machinery and robotic machinery. According to the study the Europe industrial machinery market size was approximately USD 102.8 billion in 2023. This market can be expected to register a CAGR of 4% between 2024 and 2032. This growth will be driven by the automotive sector, but also by innovations in advanced technologies, the use of digital technologies, artificial intelligence, increasing investments in renewable energy projects or the integration of Industry 4.0, etc. The ongoing supply constraints for semiconductors will probably act as a certain slowing element in 2024 but may challenge manufacturers and force them to diversify their supply chains.

According to Global Market Insight, the trend towards increased sustainability and improved energy efficiency will also continue in the engineering sector, following the European Union's goal of achieving carbon neutrality by 2050. Manufacturers are investing in developing machines that use less energy and reduce their environmental impact. There is also a dramatic increase in the adoption of automation and robotics as companies strive to improve productivity, speed up production cycles, improve precision, reduce human error and address labour shortages. The demand for advanced automation and robotics is also increasing with better availability of these machines. The automated industrial machinery segment was worth over USD 45.5 billion in 2023 and is expected to reach USD 66.3 billion by 2032, which is attributed to the convincing combination of precision and reduced costs, including labour, of automated machines. It is estimated that automation can reduce the scrap rate in manufacturing by up to 30%.

Germany is a leader in industrial machinery, not only in Europe but also globally. The German industrial machinery market size exceeded USD 20.3 billion in 2023 and is expected to reach USD 31.9 billion by 2032. This growth is attributed to Germany's strong industrial base and quality of engineering. The country has a long tradition of precision engineering, advanced manufacturing and technological innovation. According to the VDMA (<https://www.vdma.org/mechanical-plant-engineering-figures-charts>), the engineering sector in Germany is the largest in Europe with more than 6600 companies and almost 1.3 million employees. The emphasis on research, development and innovation and the promotion of the development of high-tech and high-quality machinery is also illustrated by R&D expenditure, which the German Federal Statistical Office has estimated at more than USD 105 billion in 2020 (more than 3.2% of GDP).

The economic experts and analysts of the VDMA federation point to a worrying fact that affects not only Germany but practically the entire European engineering industry, namely the shortage of professional labour. Immigration, which means an influx of professional labour, can partly help to solve this problem, but there is a lack of employees in academic STEM professions, especially in engineering and IT, who would focus on digitalisation, the development of environmentally friendly products or the transformation of industry in general. They also point to an alarming loss of interest among young people in technical

education (perhaps outside IT), but also a decline in the skill levels of the new generation of graduates. In terms of long-term impact, it is particularly important to improve STEM education. The ageing population of European countries is another issue that is beginning to manifest itself across the European industry. Extending the retirement age and education to an older age or bringing more women into the engineering industry may be a partial solution.

The PLAN-C project focuses on the plastics and plastics processing machinery industry. According to data collected by VDMA (<https://www.vdma.org/mechanical-plant-engineering-figures-charts>), the European plastics and rubber machinery sector covers about 45.5% of the world market. Almost 48 % of this volume is accounted for by German manufacturers.

According to a study by Precedence Research named Plastic Processing Machinery Market Size, Share, and Trends 2024 to 2033, released in January 2024 (<https://www.precedenceresearch.com/plastic-processing-machinery-market>), the global plastic processing machinery market size was USD 23.02 billion in 2023. With a projected CAGR of 4.5 % over the period 2024–2033, it is expected to reach USD 35.58 by 2033.

According to this study, the Asia-Pacific region accounted for the largest share of the plastics processing machinery market at nearly 42 %, equivalent to a value of USD 9.66 billion. At an expected CAGR of 4.7 %, it may reach USD 15.23 billion by 2033.

According to this study, Europe has a 22 % share of the plastics machinery market and a value of USD 5.06 billion. From a vertical industry perspective, the main driver for European manufacturers is the rapidly growing construction sector, both residential and non-residential, in addition to the world's most important and dynamic and in Europe really robust automotive industry and packaging. The region's focus on sustainability and stringent environmental regulations, as well as Europe's commitment to technological innovation coupled with investment in Industry 4.0 technologies, lead to the development of advanced machinery that promotes environmentally friendly practices, energy efficiency, safety or the use of recycled raw materials.

The increase in demand for plastics processing machinery is supported by the versatility and cost-effectiveness of plastic materials. Continued progress towards the integration of automation, robotics and digital control systems is contributing to increased efficiency and productivity. Advanced technologies are attracting industries seeking precision, speed and improved manufacturing processes. In addition, the market is responding to the industry's commitment to reduce environmental impact, as well as meet stringent regulations and standards regarding product quality and safety. Compliance with these regulations requires the adoption of advanced machinery that meets or exceeds industry standards. The requirement for flexibility and rapid adaptation to production dynamics, changing product specifications and materials being processed is also essential.

In terms of machinery itself, the injection moulding machines segment held the largest, 51% market share in 2023, and in terms of growth rate of each segment (injection moulding machines, extrusion machines, blow moulding machines and others), the extrusion machines segment is expected to achieve the highest CAGR of 4.16 %.

Although it is possible to detect a trend towards the use of injection moulding machines, especially for precise and complex products for the automotive industry or consumer goods, extrusion machines for construction & building materials and packaging, especially for films, tubes and profiles and sheets & plates of various thicknesses and compositions, and blow moulding or thermoforming machines especially for packaging, the automotive industry can be considered the world's biggest driver of the development of machinery for plastics processing. From interior parts to exterior body panels, plastic components used in vehicles are being produced with an emphasis on precision and efficiency. Given the automotive industry's focus on sustainability, a significant requirement is the use of lightweight and durable plastics to contribute to fuel efficiency, environmentally friendly materials and energy efficient processes.

The healthcare segment will grow fastest during the forecast period. Trends in this segment include increasing demand for specialized machinery capable of producing complex and biocompatible medical components with the required precision, cleanliness, and regulatory compliance.

It should also be noted that machinery and equipment for the plastics industry includes not only basic processing machines, but also other equipment ranging from storage, feeding and transport equipment to recycling equipment, crushers or e.g. magnetic metal separators. 3D printing of plastic parts is also becoming a very widespread processing technology. Robotic workstations for handling finished products, for example, are also in demand.

Finally, information on the dynamics of the plastics processing machinery market in terms of the main drivers, restraints and opportunities can be summarised:

- The main **drivers** supporting the plastics processing machinery market can be considered to be the growing demand for plastic products, but also the increasing emphasis on sustainability.
The robust automotive market requires sophisticated machinery to produce precision complex products or plastic parts that reduce vehicle weight and increase fuel efficiency. Multi-component injection moulding with short production cycles or the production of composite parts are also in demand. The possibility of automating the production cycle, safe handling, remote transmission of production data, etc. should not be forgotten. All this is not only driving production, but also the development and innovation of advanced plastics processing machines.

Plastic packaging is also fuelling the development of the market for plastics machinery with short production cycles for rapid distribution of large volumes of packaging to consumers. Plastic packaging is lightweight, provides protection and safety to products, can eliminate odours due to its tightness, extend shelf life (e.g. of food), etc. Other areas supporting market growth are increased production of consumer goods and electronics or rapid global industrialisation.

The emphasis on sustainability is driving the production of machines with low energy consumption, automated control processes, and the ability to process recycled plastics and biodegradable materials. The emphasis on sustainability is also contributing to an increase in the production of recycling equipment from shredders and crushers to large recycling systems.

- In contrast, the main **restraints** include fluctuating raw material prices and high initial investments for the acquisition of advanced machinery, as well as environmental concerns related to plastic waste or competition from more sustainable alternative raw materials and strict regulations on the use of plastics. The fluctuating prices of polymer materials affect the production costs and profitability of manufacturers, but also the profitability and pricing strategies of plastics processing equipment manufacturers. Feedstock price volatility is particularly relevant for oil-based plastics and also reflects the availability of feedstock, which may be caused by supply chain disruptions or geopolitical tensions. The environmental impact of plastic waste has become a global issue, which is being addressed through regulation in addition to the development of sustainable techniques for its waste management and reuse.

The acquisition of advanced plastics processing machinery requires significant initial investment, which can be a problem for SMEs. This will reduce their competitiveness, but at the same time inhibit the growth of the processing equipment market. Safety and quality regulations and product standards or emission regulations can also be a barrier to the expansion of the plastics machinery market. Manufacturers have to invest in equipment development to meet the required standards, which can increase the expense and therefore the price of the machines and increase the time to introduce the equipment to the market. Manufacturers of plastics processing machinery must also face the challenge of using sustainable alternatives to conventional plastics.

- **Opportunities** include investment in the circular economy initiatives, both in the materials to be processed and in the equipment itself or the need for some independence of producers.

Machinery manufacturers can take advantage of the often government-backed investment in the development of machines for recycling plastic waste, but also machines that are able to process recycled plastics in accordance with circular economy principles. The development of equipment suitable for processing

alternative materials such as bioplastics, hybrid polymers or specific sustainable composites is also a challenge. The machines themselves should also be sustainable and meet the principles of the circular economy in terms of low energy consumption, eco-design for reparability and durability, use of sustainable or recycled materials and ensuring sustainable operation of the equipment.

The need for some independence

In today's globalised world, international trade in raw materials, components and finished products is both a reality and a necessity. Nevertheless, European manufacturers need to maintain a certain level of independence in the production of at least critical products. Evidence of the risks of over-dependence on foreign production can be seen, for example, in the vulnerability of global supply chains during the COVID-19 pandemic, or in fluctuations in the supply and prices of strategic raw materials caused by trade disputes or geopolitical tensions. A certain degree of independence can thus help to protect technological know-how, secure supply in times of crisis or preserve jobs in the region.

In the context of sustainability and the principles of the circular economy “the second life of machinery”, i.e. the market with used machinery, should also be mentioned.

Although Europe, led by Germany, is a major producer of advanced machinery, particularly industrial machinery and equipment in the context of the PLAN-C project, not all companies can afford to buy them. Advanced machinery is an investment with a high purchase price. Especially for some small or medium-sized enterprises, this investment is too high. This fact is the main driver of the used machinery market. A significant factor contributing to the growth of this market segment is the fact that well-maintained, high-quality used machines often provide comparable performance at a fraction of the price. The resale of equipment extends machine life and reduces waste. Sustainability, environmental friendliness and the drive towards circularity is therefore also a major contribution to the growth of the used machinery market.

However, the resale market is also facing a number of issues and challenges that may restrain it. The primary one is ensuring the quality and safety of used machinery. Resellers, auctioneers and second-hand marketplaces play a key role in this regard. Although all three groups of actors in the machinery resale market have the same task, i.e. to arrange and facilitate the sale and purchase of used machinery, their role is somewhat different:

- **Resellers** (individuals or companies) buy used machines and sell them to secondary users. They ensure and guarantee the quality of the machines. They often offer services such as inspection, refurbishment or evaluation.
- **Auctioneers** operate on a slightly different model. They conduct live or online auctions where companies can bid for their used machines. The competitive

nature of auctions can lead to lower prices, but the buyer's expert judgement is important to know the value of the machines.

- Online **marketplaces** offer a platform to connect sellers and buyers directly. They provide a wide range of options and price transparency, making it easier for businesses to find the right machine at the optimal price.

The market for used machinery is likely to follow the market for the primary products of the machinery industry, whose growth will be driven by higher demand for automation, robotics, the incorporation of Industry 4.0, the use of AI and virtual control (generally digitalization) or the transition to more sustainable and circular production techniques. The implementation of these factors is a prerequisite for maintaining the competitiveness not only of machinery manufacturers but also of machinery users.

Maintaining the competitiveness, independence and sustainability of the European machinery industry requires systematic positioning and strengthening. Here are some key strategies:

- **Investing into innovation and R&D:** To keep machinery competitive, it is necessary to foster innovation and invest in research, development and implementation of advanced technologies such as artificial intelligence, robotics or the Internet of Things.
- **Promoting skills and training:** Investing in education and training is a high return investment. The machinery industry will need an increasing number of employees with new skills, from data analysis to robotics. Supporting training in this area can prevent a brain drain. The focus should be on academic STEM education.
- **Strengthening supply chains:** increasing the resilience of supply chains to crisis situations can include diversifying suppliers, stockpiling strategic or critical goods and using technologies to increase transparency (blockchain).
- **Embracing sustainable production:** Building on sustainability is not an option but a necessity today. Europe is a strong player but also a strict supervisor in the field of sustainable production. As a result, they should be able to meet regulatory requirements, accommodate changing consumer preferences and reduce dependence on fossil fuels.
- **Support SMEs:** SMEs are an important part, if not the cornerstone, of the European manufacturing sector. Therefore, policies need to be developed at European level to support SMEs, e.g. to ease bureaucracy or to ensure that they can access financial support.

(EXAPRO. The Machinery Market in Europe and Resale of Machines. Online. EXAPRO. Exapro Hub. 2023. Available from: <https://hub.exapro.com/the-machinery-market-in-europe-and-resale-of-machines>. [cit. 2024-08-22])

Conclusion consistent with the Transnational mapping

The Danube region is an area that runs through the territory of nine countries. The economy of each of these countries or regions is differently strong and mature, which is also reflected in the machinery industry. It is not only the turnover achieved by the machinery industry in general, but in this case also the ratio of the production of machinery for the plastics industry to the total machine production. Due to the different levels of each economy, it is difficult to find a complete consensus on the key questions posed by each region in the context of the transition to a circular economy.

Germany, or Baden-Württemberg, and Austria are strong players in the field of machinery for the plastics industry, especially in terms of core processing equipment and large technological units such as injection moulding machines and lines, extrusion equipment, blow moulding lines, etc. Other regions are more dependent on imports of such equipment, with own production concentrating more on the production of moulds and other tools, smaller technological units, as well as servicing and repair of production equipment.

It can also be noted that Germany and Austria are well ahead of the others on the path towards a circular economy. Although they have managed many challenges well, they still face various obstacles, ranging from the complexities of regulation to the high initial investment costs of sustainable technologies and the need for continuous innovation to keep manufacturers ahead in a competitive global market.

Austria also identifies the lack of political incentives and the need for a change in mindset as barriers to transformation. Addressing these challenges demands a concerted effort from industry, policy makers and society as a whole. Without adequate support and incentives from policy makers, businesses may hesitate to embark on the path of transformation towards a circular economy. Education, awareness campaigns that value sustainability and cross-sectoral collaboration are essential for the adoption of circular economy principles in society.

Hungary also sees a significant challenge in expanding the knowledge base and education, but also in establishing a supportive economic environment. They state that the availability of regional public financing to support R&D&I activities in the field of machinery industry is low. There are limited funds through local government initiatives, and only occasional funding from the European Regional Development Fund or other EU programs.

Romania has identified the high share of imports of equipment, especially advanced technologies, as one of the challenges it faces in the transition to a circular economy. The industry is thus vulnerable to fluctuations in global supply chains and foreign exchange rates, affecting the cost and availability of essential equipment. The introduction of digital technologies and smart manufacturing solutions can increase operational efficiency, reduce costs and improve product quality. Investing in Industry 4.0 initiatives, such as predictive maintenance and real-time data analysis, can be crucial to maintain competitiveness.

The Slovak Republic also foresees the need to focus on improving production techniques. In addition to the use of advanced materials and technologies, it also relies on developing more intelligent, adaptable, and collaborative robotic systems and enhancing automation technologies for improved efficiency, safety, and flexibility in manufacturing processes. The adoption of digital technologies and the principles of Industry 4.0 can be beneficial as well as developing smart, interconnected systems, utilising big data analytics, artificial intelligence, or machine learning for predictive maintenance etc. This may involve designing eco-friendly manufacturing processes, reducing resource consumption, improving recycling and waste management practices, and integrating renewable energy sources into machinery operations.

Bosnia and Herzegovina, Moldova and Serbia are European Union candidate countries and are therefore committed to integrating EU legislation and strategic plans into national policies and strategies. They are therefore well prepared for the transition towards a circular economy and sustainability. However, like other countries, they face challenges such as high initial investments, insufficient infrastructure or low awareness. Nevertheless, Serbia, for example, sees the machinery industry as one of the sectors of their economy that has a high potential to transition to a circular economy. Moldova emphasises the need for training and support for research and innovation. Bosnia and Herzegovina also mention limited stakeholders' awareness and availability of sustainable materials as a problem. However, educational initiatives and investment in research offer solutions. Other obstacles are outdated technologies and inadequate waste management infrastructure, but the adoption of energy efficient technologies and advanced recycling methods can help solve these problems.

The Czech Republic is the last of the participating countries. They also identify the problem of low awareness of the circular economy in society, but also among technology producers. There is a need to talk and educate not only about the use of renewable resources or the recycling of plastics, but also about water consumption or the toxic impacts of technologies and waste. They consider the eco-design of production facilities, which reflects well on all phases of the life cycle and leads to the design of robust

machines with long life, repairability and energy-efficient operation, as an outstanding support on the way to the circular economy.

In conclusion, the Danube region faces many challenges on the path to circular transformation of the machinery industry. However, the principles of the circular economy promise significant environmental as well as economic benefits and increased competitiveness.