"Analysis of dependencies and challenges"

DELIVERABLE D1.2	Version 1.0 03 2026

Project Number: 101236716

Project Acronym: MAT4EU

Project title: Advanced Materials for a Sustainable European Future

Starting date: 01/10/2025

Duration in months: 36

Call: SMP-COSME-2024-CLUSTER

Type of action: SMP Grants for Financial Support

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

Technical reference

Deliverable: D1.2 Analysis of dependencies and challenges	
Work Package:	*1*
Due Date:	*31.03.2026*
Submission Date:	31.03.2026
Start Date of Project:	01.10.2025
Duration of Project:	36 months
Organisation Responsible for Deliverable:	Plast Center Danmark (PCD)
Version:	*1.0*
Status:	*Final version*
Author name(s):	*Dorte Walzl Bælum* *Dr. Katharina Schöps*
Type:	☒ Report ☐ Other
Dissemination level:	☒ PU ☐ SEN

History of Changes:

Date	Comments	Version
31.03.2026	*submitted to Participant Portal*	V1.0

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

ABSTRACT

This deliverable presents the analysis of dependencies and challenges within the European advanced materials (AM) ecosystem, conducted in the framework of the MAT4EU project. Recognising the strategic importance of advanced materials for Europe's industrial competitiveness, sustainability, and technological sovereignty, the report aims to identify key priorities that align regional industrial needs with European policy objectives.

The analysis is based on a combined bottom-up and top-down methodology. Regional workshops, stakeholder consultations, surveys, and company interviews across partner countries were complemented by the review of European strategic initiatives, including the IAM4EU Strategic Research and Innovation Agenda. This approach ensured a comprehensive understanding of both industry-driven needs and policy-driven priorities.

The findings highlight that the AM sector is strongly shaped by interdependencies related to raw material availability, processing and manufacturing capabilities, and access to advanced technologies and innovation. Dependencies on critical raw materials, global supply chains, and limited industrial scale-up capacities pose significant challenges to European autonomy and resilience.

Despite regional differences, a strong convergence of strategic priorities was identified. Key areas include the development of circular and sustainable materials, substitution of hazardous substances and critical raw materials, advancement of high-performance functional materials, digitalisation of materials development and manufacturing, and improved support for industrial scale-up and validation.

These priorities are translated into the MAT4EU roadmap, structured around five innovation pillars, which guide the design of the project's open calls. Through targeted support to SMEs, the project aims to accelerate innovation, foster cross-sector collaboration, and strengthen Europe's capacity to develop and deploy advanced materials.

Overall, MAT4EU contributes to building a more resilient, competitive, and sustainable European advanced materials ecosystem by addressing critical dependencies and enabling the green and digital transition of industry.

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

LIST OF ACRONYMS

AM	Advanced Materials
SSbD	Safe and sustainable by Design
SRIA	Strategic Research and Innovation Agenda
IAM-I	Innovative Advanced Materials Initiative
RTS	Research and Technology Organisation
OITB	Open Innovation Testbeds
CRM	Critical Raw Materials

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

Table of contents

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

1.MAT4EU- project concept, objectives and scope of the report

Advanced materials (AM) are recognised as crucial for the competitiveness of the European industries. Since then, AM have been included in the list of the 10 critical technology areas for the Union's economic security. AM are thus key to contribute to the European Strategic Plan for European Industrial competitiveness. As important drivers of innovations in the energy, electronics, construction, and mobility sectors, they are also crucial for the EU sustainable and digital transitions. The „Draghi report"[1], mentions AM as one key to boost EU industrial leadership on Advanced Materials. To achieve this, the report recommends building on the Advanced Materials Initiative and ensure that EU funds effectively reinforce and steer investment in technology development through direct support by mobilising stakeholders – R&I, industry, policy, support organisations – and build new partnerships under Horizon Europe.

MAT4EU as a cross-disciplinary partnership contributes to achieve that goal by

-**bringing together 6 European Clusters** active in the materials sector for mobility, aerospace & defence, construction, agri-food, renewable energy and health industrial ecosystems,

- identifying the key partnerships necessary to establish a larger ecosystem to promote the development and uptake of AM aiming at improving the strategic autonomy and competitiveness of the European industry.

- **leveraging connections** with the Technology Council on Advanced Materials and the pan sectoral nature of its cluster members to identify the priorities and challenges to be addressed to improve the autonomy of the AM industry and drive its digital and green transition.

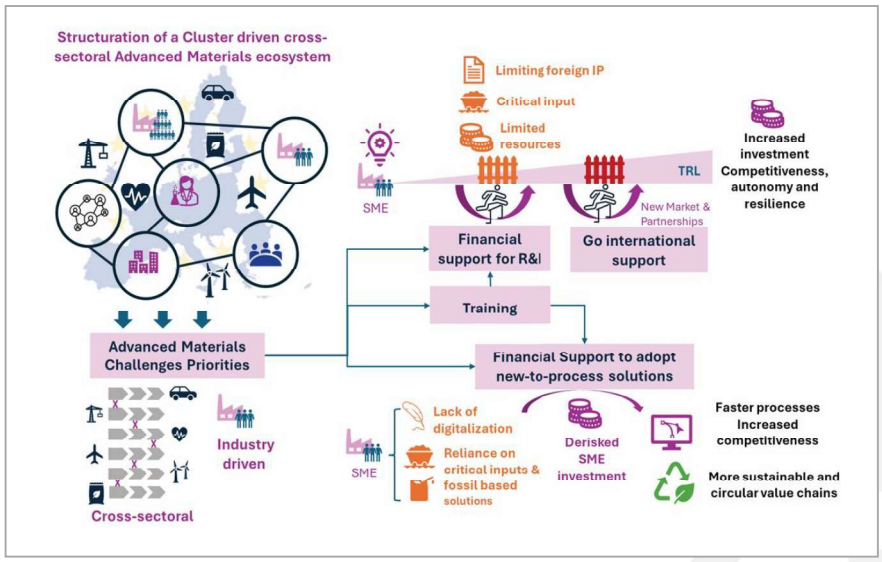


FIGURE 1: MAT4EU Project concept

[1] The Draghi report on EU competitiveness

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

Based on these findings, MAT4EU supports SMEs across Europe to develop new innovative products/services, train their workforce and adopt new to firm solutions and international markets, including digital ones, to fully embrace the AM potential.

This deliverable presents the methodology used to identify the key priorities and challenges addressed by the MAT4EU project. The aim is to ensure that the research, innovation, and capacity-building activities supported by the project respond to both regional industrial needs and European strategic priorities in advanced materials (AM).

2. Description of the analysis methodology applied

2.1 Analysis approach

The consortium applied a twofold approach combining bottom-up and top-down perspectives. Through national workshops and consultations, cluster partners engaged with their regional ecosystems to identify industry needs related to:

- Research and innovation for advanced materials development
- Sustainable technologies supporting greener value chains
- Digital solutions improving industrial competitiveness and sustainability
- Associated skills and training needs

This approach ensured that identified priorities were driven by industry requirements, in line with the Strategic Research and Innovation Agenda (SRIA) of IAM-I. In parallel, the consortium monitored developments within key European initiatives, including the IAM4EU partnership and the Technology Council on Advanced Materials. Exchanges with national representatives and cluster members helped validate the identified challenges and ensure

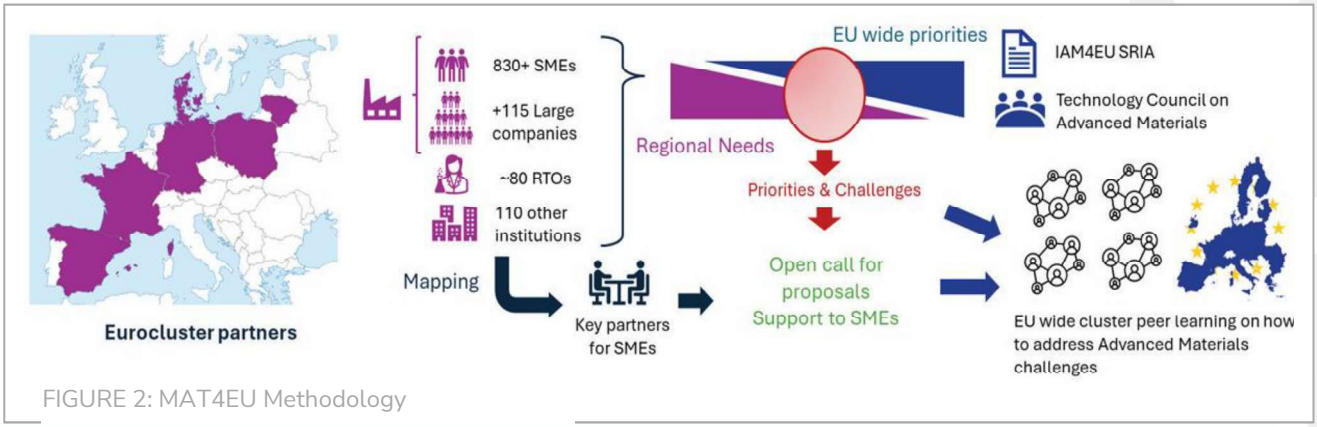


FIGURE 2: MAT4EU Methodology

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

alignment with EU priorities, particularly those related to strengthening European capabilities in advanced materials and reducing strategic dependencies.

The activities were carried out by all beneficiaries under the coordination of POLYMERIS (POL). National workshops organised by each partner gathered cluster members and stakeholders to identify priorities within the advanced materials ecosystem. These events also included pitching sessions where Research and Technology Organisations (RTOs) presented relevant expertise and technological capabilities.

The identification of priorities and challenges was based on a shared consultation methodology applied across the partner regions, while allowing each partner to adapt the process to the characteristics of its national ecosystem. The methodology combined the following elements:

- National and regional workshops
- Thematic meetings and conferences
- Direct interviews with companies
- Cluster member consultations
- Surveys and discussion sessions

These activities aimed to identify:

- Key materials of interest
- Priority sectors
- Industrial bottlenecks and market needs
- Technological challenges for research and deployment
- Digital and sustainability-related needs.

Based on these consultations, Plast Center Danmark (PCD) and RKW Sachsen GmbH (RKW), with support from all partners, developed a roadmap defining the main challenges and priorities to be addressed through the open calls under WP2 and WP3.

WP2 – Product innovations supporting European autonomy

This work package aims at leveraging private investments of SMEs in the targeted sectors and to promote innovation activities regarding the development, processing and implementation of advanced materials. Following the priorities of the European strategies, such as IAM4EU SRIA, the research and innovation supported by MAT4EU focus on advancing materials performance, functionalisation, recyclability, safety, sustainability, and

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

circularity with the goal to promote Europe´s autonomy and strategic sovereignty in the materials and related manufacturing sectors.

WP3 – Mastering green and digital transformation

The activities related to WP 3 aim at the identification of the priorities and challenges for the improvement of circularity and material efficiency in the targeted sectors as well as at increasing the level of digitalization of material-focused SMEs. We address challenges in fields of the adoption of Green and Digital Solutions, which focus on deploying existing technologies and cross-enabling tools which finally will lead to an improvement of sustainability and industrial competitiveness of the SMEs. Furthermore, we will facilitate the connections of SMEs with Open innovation Testbeds (OITB) and other technology and innovation infrastructures to support testing, validation and demonstration activities. They are crucial to achieve a significant speeding-up of the take-up and reducing the time to-market of innovative products and processes from Europe.

2.2 Findings of the analysis - main dependencies of the AM sectors

The European advanced materials sector is highly interconnected and dependency-driven relying on a mix of upstream resources, industrial capabilities and global supply chains.

These dependencies relate mainly to 3 factor groups:

1. The availability and affordability of raw materials,
2. Processing and manufacturing capabilities,
3. The availability of competitive technologies and innovations.

All these factors are addressed in the strategic documents of the EU by demanding the development of advanced materials by

- the use of raw materials which can be sourced locally as well as the consequent implementation of resource-efficiency principles, like circularity and the substitution of critical raw materials (CRM) .

- the development of regional circular value chains, which enhance the resilience and independency of European industry and includes all processing and refining process

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

steps including the use of renewable energies or circular energy supply for processing and manufacturing.

- strengthening technology developments and innovations in the advanced materials fields towards smart and functionalised materials, high performance materials for special applications which comply with high requirements to properties regarding safety, recyclability, sustainability and system integration.

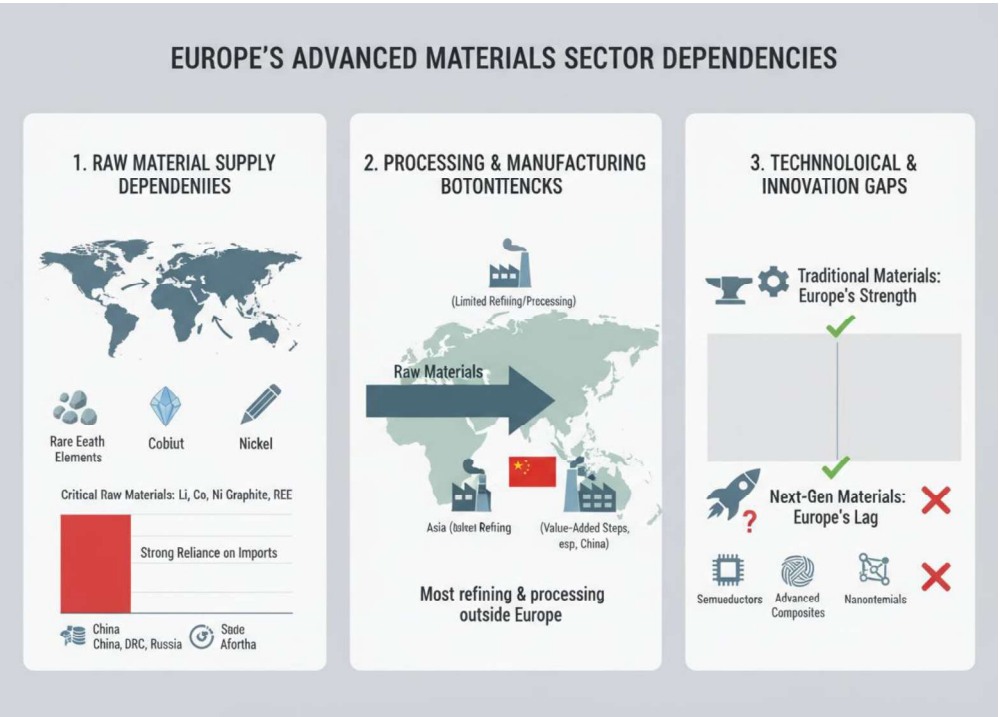


FIGURE 3: Materials Sector dependencies

MAT4EU addresses these dependencies with the services for SMEs which are under development, such as the support of innovation projects, that focus on the substitution of CRM, the development of circular solutions, the development of sustainable recycling processes and knowledge-sharing through the network of the involved clusters and linkages with other related European projects and initiatives.

The regional workshops conducted by MAT4EU have reflected, that Europe's material dependency risks are unevenly distributed. The industrialised core bears the brunt of global supply disruption exposure, while peripheral and resource-rich areas could become key to resilience — if EU-wide investment and integration succeed. Subsequently, also against the background of the specific national and regional strategies and industry policies, the presented challenges and priorities vary from region to region. Generally, we see at the one hand direct dependencies and implications concerning scarcity of raw materials and volatility of prices. Those regions and clusters

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

strive to promote circularity, substitution of critical raw materials, strategic cross-cluster partnerships to enable the development and the supply of high-performance advanced materials for industries.

At the other hand, indirect dependencies and implications call for the use of alternatives and niche materials for processing and significant investments for innovation infrastructures, what would create a conducive ecosystem for competitive material innovations, related processes and services.

We consider that variety as a great potential for the development of resilience and competitiveness of European materials-related industry as it creates the opportunity to develop a complementary portfolio which can combine the strengths of the regions and compensate shortcomings and weaknesses. The project MAT4EU is a great opportunity to take steps towards diversity and combination of strengths in fields of materials innovations through the development impulses for a conducive materials innovation ecosystem in Europe.

2.3 Key facts of conducted regional workshops

Spain
Advanced Materials Cluster of Catalonia

Barcelona, 28.01.2026

Methodology applied	Participants
Co-creation workshop A total of **23 innovation challenges** were collected from companies, RTOs, and universities within the cluster ecosystem **8 challenges were selected** for in-depth discussion and collaborative ideation in small working groups	Nr. participants 56 Companies 29 RTO 27

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

Challenges	Priorities
Recycling and upcycling, PFAS substitution, sustainable-by-design approaches, emissions reduction	**1. Industrial Circularity of Advanced Materials** *Key materials:* Composites, technical polymers, advanced fibres, Bio-based materials, battery materials *Sectors:* Automotive, aerospace, construction, energy
Pilot lines and demonstration, industrial qualification, end-user validation, reduced time-to-market	**2. Industrial Scale-up and Validation** *Key materials:* Functional materials, coatings, advanced metals and polymers *Sectors:* Manufacturing industry, mobility, aerospace
Decarbonisation, CCU (carbon capture and utilization), energy efficiency, reduced dependency on critical raw materials	**3. Materials for Energy and the Green Transition** *Key materials:* Battery materials (Li, Na, Zn), catalysts, advanced ceramics, thermal management materials *Sectors:* Energy, renewables, construction, mobility
Material–device integration, industrial sensing, sustainable electronics, validation in real-world environments	**4. Functional Materials, Printed Electronics and Sensors** *Key materials*: Organic semiconductors, 2D materials, printable polymers *Sectors:* Industry, healthcare, energy, packaging
Regulatory compliance (e.g. EURO 7, PFAS restrictions), high-performance lightweighting, certification and reliability	**5. Lightweight Materials for Regulated Sectors** *Key materials:* Lightweight composites, technical fibres, functional coatings *Sectors:* Automotive, aerospace, defence

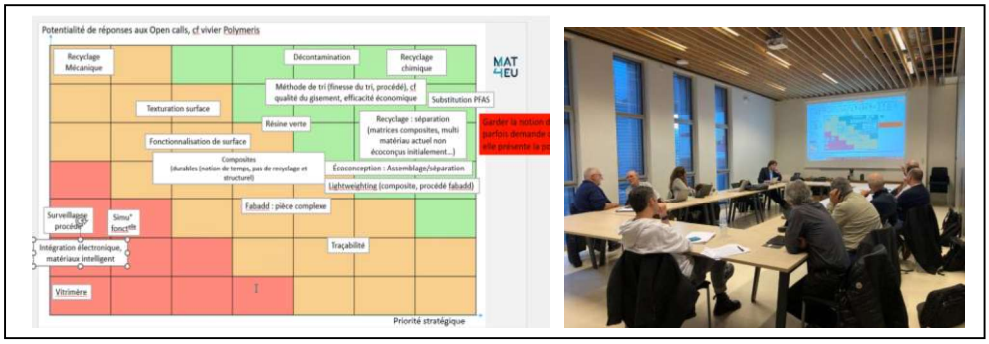
Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

POLYMERIS

France POLYMERIS

Besançon,
08.12.2025



Methodology applied	Participants
Scientific Committee Workshop Discussions and utilization of a matrix to organize the themes depending on the level of strategic importance and on the representativity of the topic inside the French value chain. 	No. of participants 15 + 2 online

Challenges	Priorities
Availability/costs of raw materials Enabling circularity and use of secondary raw materials (recycled materials) • Ecodesign • Self-healing materials **High-performance materials** • Controlled properties • Smart materials, functionalisation **Advanced manufacturing technologies** for high complexity (3D-Printing, simulation)	• IA for chemistry of materials • Materials for extreme conditions • Ecodesign, assembly/disassembly, • Traceability for recycled content • Controlled properties (triggerable) • Decontamination and sorting • Chemical recycling processes • Mechanical recycling • Reparability (end of life) and self-healing materials • Sustainable composites • Surface texturing • Surface functionalization • Functional simulation • Additive manufacturing (complex parts)

EURO CLUSTERS
Co-funded by the European Union
Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

Poland
Bydgoszcz Industrial Cluster
Tool Valley

Bydgoszcz,

02./03.12.2025, 16.12.2025, 08.01.2026

Methodology applied	Participants
BIC combined inputs from a dedicated MAT4EU workshop, direct discussions with companies during a larger industry conference, and two cluster members' meetings (16.12.25,08.01.26). This approach ensured that the proposed challenges reflected both broad ecosystem input and direct SME needs.	No. of participants 177 + 36 Companies113

Challenges	Priorities
• AI-driven injection moulding optimisation • Smart moulds with embedded sensors • Validation of recycled materials • Energy-efficient production	**Circular and Digital Transformation of Plastics Processing** *Key materials:* Engineering polymers, recyclates, bio-based polymers
• Mono-material packaging structures • Redesign-for-recycling solutions • Delamination technologies	**Sustainable Packaging Materials** *Key materials:* Advanced polyolefines, PA substitution
• Sustainable energy storage materials • Reduction of critical raw materials	**Materials for Energy Transition** *Key materials:* Battery materials, fuel-cell membranes, insulation materials

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

• Recycling of battery materials • Safe-and-Sustainable-by-Design integration • Mitigation of antimicrobial resistance • Development of European supply chains • Lightweight composites • Lightweight composites • Precision laser welding technologies • Certification and industrial scaling • Economic modelling of supply chain resilience • Integration of EU-based raw materials • Development of regional value chains	**Safe and Sustainable Antimicrobial Materials** *Key materials:* Functional polymers, antibacterial coatings **Advanced Lightweight Materials and Joining Technologies** *Key materials:* Composites and advanced fibres **European Sustainable Raw Materials** Key materials: Bio-based polymers

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

LINPRA

Lithuania
LINPRA – Engineering and Technology Industries Association of Lithuania

Kaunas, 27.01.2026

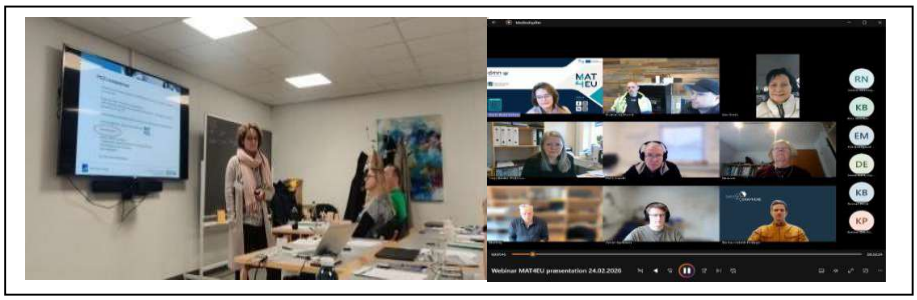
Methodology applied	Participants
LINPRA organised a workshop with representatives from the plastics and metal industries. The methodology included a project introduction, an online survey, and moderated discussion sessions to collect company needs, market challenges, and potential open call topics.	No. of participants

Challenges	Priorities
• Limited capacity to transform research and innovation results into market-ready solutions in advanced materials. • Skills gaps and need for upskilling and reskilling to support the green and digital transition of industry. • Low level of digitalisation among SMEs, limiting the adoption of advanced and smart manufacturing solutions. • Challenges in implementing green and sustainable production processes, particularly in traditional manufacturing sectors. • Limited access to international markets and the need to strengthen global competitiveness and partnerships	• Improvement of energy efficiency, • Integration of recycled materials, • Adaptation of digital manufacturing solutions. • Development of higher value-added products • Strengthening innovation capabilities • Improvement of resource efficiency and sustainability in manufacturing processes

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

Denmark
Plast Center Danmark



24.02.2026

Methodology applied	Participants
PCD combined several input channels: an online workshop, presentations to sector groups, direct company interviews, and stakeholder dialogue through the Danish Materials Network. Companies were asked to identify priority materials, sectors, and key technological challenges. This ensured that the selected focus areas reflected both strategic and practical industrial needs.	Online workshop: 17 companies, 2 RTOs

Challenges	Priorities
• Closed-loop recycling of high-performance plastics from complex products • Chemical recycling of mixed and contaminated polymer waste • Recycling and circular use of thermoset composites • Advanced surface engineering and coating technologies • Circular product design and mono-material solutions	• Advanced recycling technologies • Chemical recycling processes • Multifunctional coatings • Sustainable composites • Industrial implementation of circular material systems • Digital tools for material selection and lifetime prediction • Improved recycling systems • Adoption of lightweight materials

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

RKW Sachsen

Germany
RKW Sachsen

Dresden, 03.12.2025

Methodology applied	Participants
RKW has combined a co-creation workshop at 03.12.2025 with 8 meet-up sessions with the relevant clusters and networks of the regional ecosystem. Furthermore, 4 key enterprises (SMEs) have been interviewed.	No. of participants: 23 (on-site workshop)

Challenges

Materials and products

- Development of CO2-negative materials at affordable costs
- Shaping material properties (hybridisation, etc.)
- Functionalisation (sensors, actuators)
- Substitution (biobased, recycled, bio-inspired)
- Circularity, re-use, use of pre-consumer waste

Processes and business intelligence

- Material efficiency, AI-based material management system
- Process simulation
- Faster upscaling
- Multi-material 3D-Printing
- Simulation of material removal
- CRM/CMS-Systems

Facilitating circularity

- Development of regional circular value chains

Priorities

Mobility applications:

- Lightweight materials
- Circularity (materials-technologies-business models) processing of recycled materials
- Biobased materials
- Smart functional materials
- Energy harvesting materials
- Structural health monitoring
- Self-healing materials

Energy generation & storage

- Structural health monitoring
- Circularity
- Energy storage
- Material efficiency/ CMS

Civil construction/ civil safety

- Lightweight materials
- Robust materials
- Circularity, life- time extension
- Real-time condition monitoring
- Energy efficiency
- Faster building processes
- New biobased materials/prepregs

Manufacturing/automation

- Material efficiency, AI-based material management, CMS
- Fast mass customisation
- Integrated sensor networks, business intelligence
- Digital / AI-supported process monitoring/steering

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

3. Joint strategic priorities and challenges

Despite differences in industrial structures, technological maturity, and sectoral specialisation across the partner regions, the consultation process revealed a strong convergence around several shared innovation priorities for advanced materials.

These priorities emerged consistently across workshops, company interviews, surveys, and stakeholder discussions organised by the consortium partners. They reflect both the practical needs of companies operating in advanced materials value chains and the strategic objectives defined at European level, particularly within the IAM4EU Strategic Research and Innovation Agenda (SRIA) and broader EU initiatives supporting green and digital transitions.

The identified priorities therefore provide a strong foundation for defining the thematic focus of the MAT4EU open calls.

Circular and Sustainable Materials

One of the most prominent themes emerging from the consultation process is the need to accelerate the transition towards circular and sustainable materials systems.

Companies across all partner regions reported increasing pressure to reduce environmental impacts, improve resource efficiency, and develop materials that can be effectively recovered and reused at the end of product life. This challenge is particularly relevant for materials used in complex industrial products where recycling remains difficult.

A key innovation priority concerns the development of technologies capable of managing complex, multi-material, or contaminated waste streams that cannot easily be processed through conventional recycling methods.

In this context, chemical recycling was identified by some partners and several stakeholders as a particularly promising solution. Chemical recycling technologies can enable the recovery of high-value materials from mixed or difficult waste streams, including advanced polymers, multilayer packaging, and composite materials.

Innovation needs identified under this priority include:

- Chemical recycling technologies for mixed and contaminated polymer waste
- Depolymerisation and advanced material recovery processes
- Circular product design

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

- Recycling and circular use of composites
- Integration of recycled materials into high-performance applications
- Development of bio-based and lower-impact materials

These innovations are essential to support the European transition toward a circular economy and climate-neutral industry.

Substitution of Hazardous Substances and Critical Raw Materials

Another major priority concerns the replacement of hazardous substances and the reduction of dependency on critical raw materials (CRMs).

Across several partner regions, companies highlighted the need to replace substances that may become restricted under EU regulation while maintaining material performance and industrial competitiveness. Attention was given to the substitution of PFAS and other substances of concern, especially in coatings, functional polymers, and advanced materials applications.

Key innovation directions include:

- PFAS-free materials and coatings
- Safe and Sustainable by Design (SSbD) materials development
- Alternative functional additives and surface technologies
- Reduction of CRM use in advanced materials systems
- Development of resilient European raw material supply chains

These innovations contribute directly to strengthening European strategic autonomy and supply chain resilience.

Functional and High-Performance Materials

Stakeholders also highlighted the continued importance of developing advanced materials capable of meeting demanding technical and performance requirements. Such materials enable innovation across a wide range of sectors, including mobility, energy, construction, electronics, and healthcare.

Key innovation areas include:

- Lightweight materials for mobility, mechanical engineering, civil construction, and packaging applications
- Advanced coatings and surface engineering technologies
- Smart materials with sensing or responsive functionalities

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

- High-barrier materials for packaging applications
- Materials supporting energy efficiency and thermal management

These materials are essential for maintaining Europe's technological leadership in high-value industrial sectors.

Digitalisation of Materials Development and Manufacturing

The consultations also highlighted the growing role of digital technologies in materials development and industrial manufacturing processes. Digitalisation can significantly improve productivity, quality control, and sustainability performance in materials processing.

Relevant innovation areas include:

- AI-based tools for materials design, process optimization and business intelligence integration
- Smart moulds and embedded sensor technologies
- Digital twins for materials and process simulation
- Digital traceability systems and Digital Product Passports
- AI-based monitoring systems for manufacturing processes

Digital tools can accelerate innovation cycles and enable data-driven decision-making in industrial production.

Industrial Scale-Up and Validation

Finally, stakeholders emphasised the need for improved support mechanisms enabling advanced materials technologies to move from laboratory research to industrial deployment. Many SMEs face challenges accessing pilot infrastructures, demonstration environments, and validation services necessary for industrial adoption.

Priority areas include:

- Pilot testing of new materials technologies
- Industrial validation and certification processes
- Demonstration activities in real industrial environments
- Access to Open Innovation Test Beds (OITBs) and testing infrastructures
- Reduced time-to-market for innovative materials technologies

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

Addressing this gap is essential to ensure that research results can be translated into industrial impact.

4. The MAT4EU-Roadmap

Challenges and priorities to be addressed with the open calls

The MAT4EU roadmap translates the results of regional consultations and stakeholder engagement activities into a structured strategic framework guiding the implementation of the project's cascade funding programme.

The roadmap provides a bridge between the challenges identified across partner regions and the thematic focus of the MAT4EU open calls under WP2 and WP3. It ensures that the project supports innovation areas where regional industrial needs, technological opportunities, and European strategic priorities strongly converge.

More specifically, the roadmap supports:

- The identification of common technological priorities across regions
- The translation of consultation outcomes into open call themes
- Coordination between research activities and industrial deployment
- Alignment with IAM4EU and other European advanced materials initiatives

The roadmap is organised around five innovation pillars.

MAT4EU Innovation Pillars

Pillar 1 – Circular and Sustainable Advanced Materials

This pillar focuses on materials and technologies enabling circular economy principles and reduced environmental impact across industrial value chains. It comprises all innovations and material developments, which enable the full circularity of material flows as well as the facilitation of closed regional material loops. The proposed innovations should comply with the regional and national preconditions and strategies:

Important elements of that pillar are:

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

- Circular and sustainable design (9R-Strategies)
- Material identification, sorting, de-manufacturing concepts
- Upscaling of recycling processes, such as industrial adoption of chemical recycling technologies

One element of this pillar is the development and industrial adoption of chemical recycling technologies, which enable the recovery of materials from waste streams that are difficult to process through conventional recycling approaches. Chemical recycling technologies are especially relevant for:

- Mixed polymer waste streams
- Contaminated plastic waste
- Multilayer packaging materials
- Thermoset composites
- High-performance polymer systems

Innovation priorities include:

- Circular product design and mono-material solutions
- Closed-loop recycling systems for plastics and composites
- Bio-based and renewable materials alternatives
- Advanced recycling technologies for complex materials
- Chemical recycling technologies and depolymerisation processes

By addressing these challenges, MAT4EU contributes to the development of circular materials systems that reduce waste and dependence on virgin raw materials.

Pillar 2 – Safe and Sustainable Material Design

This pillar focuses on materials aligned with Safe and Sustainable by Design (SSbD) principles.

Examples include:

- PFAS-free coatings and materials
- Safer additives and material formulations
- Bio-compatible materials
- Environmentally safe functional surfaces

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

Pillar 3 – High-Performance Functional Materials

This pillar supports materials enabling advanced industrial applications.

Examples include:
- Lightweight composites
- Functional coatings
- Smart materials with sensing capabilities
- Materials for energy systems and thermal management

Pillar 4 – Digitalisation of Materials Development and Manufacturing

This pillar focuses on digital tools improving materials development, manufacturing and material efficiency management.

Examples include:
- AI-based materials discovery tools
- Smart manufacturing monitoring systems
- Digital twins for materials simulation
- Digital Product Passports

Pillar 5 – Industrial Scale-Up and Validation

This pillar addresses the gap between research results and industrial deployment.

Examples include:
- Pilot material validation
- Industrial demonstration activities
- Certification and testing support
- Integration with Open Innovation Test Beds

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

Link to MAT4EU Open Calls and Roadmap

The MAT4EU roadmap directly informs the design of the cascade funding programme implemented through the open calls under WP2 and WP3.

WP2 focuses on research and innovation activities related to advanced materials development, while WP3 focuses on the industrial adoption of green and digital solutions. Together, these work packages support different stages of the innovation chain.

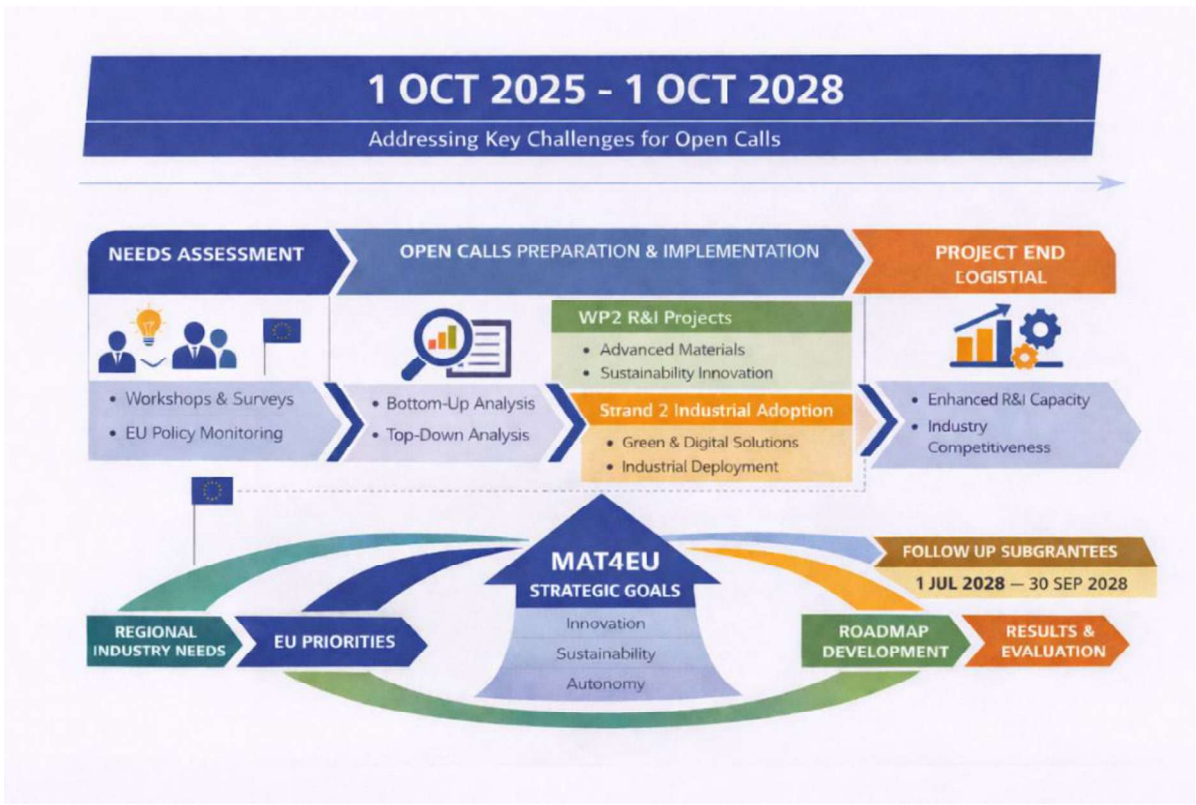


FIGURE4: MAT4EU Roadmap

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

From Roadmap Pillars to Open Call Themes

Roadmap Pillar	Strand 1 Product innovations supporting European autonomy Development & Innovation	Strand 2 Mastering green and digital transformation Industrial Adoption
Circular and sustainable advanced materials	• Development of new sustainable and circular advanced materials, substitution of CRM • Technologies for identification, characterisation, sorting of materials • Development of advanced recycling technologies (e.g. chemical recycling, de-polymerisation)	• Recycling/ reindustrialisation technologies for AM (e.g.re-purpose, re-use, refurbishment) • Circular ecosystem platforms enabling regional material loops and cross-sector collaboration
Safe and sustainable material design and processing materials	• Substitution of hazardous materials, • SSbD materials and increase of consumer safety	• Process optimisation & industrial scaling (circularity, energy &material efficiency, simulation, process stability, component quality)
High-performance functional materials	• Functionalisation and performance enhancement of materials for high-value applications (stress-tolerance, conductivity/smart textiles, safe and long-life buildings, smart facades, extending lifetime)	• Smart sensors and real-time monitoring systems, integration of business intelligence technologies
Digitalisation of material development and processing	• AI tools for materials design and traceability	• AI-based materials selection and matching tools • Digital traceability, monitoring and certification of materials and processes • Smart sensors and real-time monitoring systems, integration of business intelligence technologies
Industrial scale-up and validation	• Pilot testing validation • Upscaling of industrial advanced recycling technologies	• Industrial upscaling • Integration with OITBs and advanced testing and validation infrastructures

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

Role of WP2

The WP2 open call will support development and innovation projects focusing on materials development and technological validation.

Emphasis may be placed on advanced recycling technologies and chemical recycling approaches addressing complex polymer waste streams and enabling circular materials systems.

Projects may involve collaboration between SMEs, RTOs, and universities to develop innovative materials solutions with strong industrial potential.

Role of WP3

The WP3 open call will support the industrial adoption of green and digital technologies improving sustainability and competitiveness.

This may include:

- Implementation of digital monitoring technologies
- Adoption of smart manufacturing tools
- Deployment of recycling solutions
- Integration of circular material systems in industrial processes

5. Conclusion

The consultation process carried out across the MAT4EU partner regions provided valuable insights into the challenges and opportunities facing the European advanced materials ecosystem.

Despite differences in regional industrial structures, the consultations revealed strong convergence around several strategic innovation themes. These include circular and sustainable materials, substitution of hazardous substances, high-performance functional materials, digitalisation of manufacturing processes, and the need for improved industrial scale-up and validation.

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

Importance was given to reindustrialisation and recycling technologies, such as to chemical recycling as a strategic enabler of circularity of complex polymer and composite waste streams that cannot be efficiently processed through conventional recycling methods.

The MAT4EU roadmap translates these findings into a structured framework guiding the implementation of the project's cascade funding programme. Through the open calls under WP2 and WP3, MAT4EU aims to support innovative projects that accelerate the development and adoption of sustainable advanced materials technologies across Europe.

By strengthening collaboration between industry, research organisations, and innovation infrastructures, MAT4EU contributes to building a more competitive, resilient, and sustainable European advanced materials ecosystem.

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

LIST OF FIGURES

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.